Ministry of the Environment
of the Czech Republic

MINERAL COMMODITY SUMMARIES OF THE CZECH REPUBLIC 2024

STATISTICAL DATA TO 2023

(Data deadline: October 31, 2024)

Czech Geological Survey

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INTRODUCTION

The yearbook “Mineral commodity summaries of the Czech Republic” is the only publication that informs the Czech and foreign interested public about the state and use of the domestic mineral base in the world context and within the legal framework of mineral exploration and mine production in our country through economics, environmental protection to resources and mining of mineral commodities in our country in historical development and including association with geology.

This year, it's beeing published the 31st. edition of the Mineral Commodity Summaries of the Czech Republic. It was published and distributed on behalf of the Ministry of Economy until 1996, and on behalf of the Ministry of the Environment from 1997 till present.

After the dissolution of the state-funded organization Czech Geological Survey – Geofond on 31 December 2011, the semi-budgetary organization Czech Geological Survey was charged with compiling the publication *Mineral Commodity Summaries of the Czech Republic*. With isolated interruption in 2011, the Ministry of the Environment commissions the compilation and distribution of the publication, by increasing the budget of the Czech Geological Survey, under which continues to compile the yearbook. This enables the continuation of the unique research (and its publication) regarding the geological evolution of the area of the Czech Republic, economic situation of domestic mining companies, relation of mining to nature protection and regarding the expenses of rectifying negative impacts of mining in the Czech Republic.

The publication is published and distributed only in electronic form.

The publication continues to provide information for those interested in the research, exploration and mining of mineral deposits in the Czech Republic and in the environmental impact of mining in the Czech Republic. It of course continues to cover the most important minerals of the Czech Republic that are or have recently been of industrial importance, but also those minerals, whose reserves or (approved and unapproved) resources have not been mined in the Czech Republic in the past. The listed minerals also include minerals unmined in the present and past, without existing resources and reserves, which are items of Czech foreign trade that can be monitored via tariff items. The publication includes basic data on the status and changes in the mineral reserves of the Czech Republic taken from the Register of Mineral Deposit Reserves of the Czech Republic *(Bilance zásob výhradních ložisek nerostů České republiky)* (hereinafter “the Register”), which is published for a limited number of state administration agencies.

Additional information on domestic prices of minerals, imports and exports, major mining companies, and the location of mineral deposits is intended to assist in understanding the mineral potential of the Czech Republic and to stimulate investment in the minerals industry. This is also aided by the listed prognostic resources, both officially approved by the Commission for Projects and Final Reports of the Ministry of the Environment *(Komise pro projekty a závěrečné zprávy – KPZ)* in categories P_1, P_2, P_3 and unapproved by KPZ (mentioned only in expert reports).

The mineral reserves presented are geological reserves, also called *total reserves*, i.e. original reserves (in situ) within individual deposits, estimated according to the given classification and technical-economic conditions of their exploitability. The initial data come from mineral reserve estimates, which were approved or verified in the past by the Commission for Classification of Mineral Reserves and/or by the Commission for Exploration and Mining of Reserved Minerals of the former MHPR ČR and MH ČR, or by former commissions for management of mineral reserves of individual mining and processing industries. Uranium reserves and reserve estimates were approved by the Commission for Classification of Radioactive Mineral Reserves of the former Federal Ministry of Fuels and Energy. Currently, an approval of a reserve estimation lies within authority of the subject financing the estimation. If the subject is a private company, the company itself approves its reserve estimation. If the subject is the state, the KPZ approves the estimation. In accordance with section 14, article 3) of the Mining Act no. 44/1988 Coll. as amended also the private company submits its reserved mineral reserve estimation to the KPZ via the Ministry of the Environment of the Czech Republic, so that the KPZ may review if the estimation report contents comply with the provisions of the Mining Act.

There are reserved and non-reserved minerals and deposits as defined by the Mining Act no. 44/1988 Coll., as amended. Reserved minerals always form reserved deposits which are owned by the Czech Republic. Non-reserved deposits are owned by landowners. Non-reserved minerals (construction minerals) can form both reserved and non-reserved deposits. Until 1991, (important) deposits of non-reserved minerals of sufficient mineral quantity and quality were proclaimed „suitable for the needs and development of the national economy", hence reserved as defined by the Mining Act at that time. Since 1991, the newly recognised and explored deposits of non-reserved minerals always form non-reserved deposits.

In 1993–2001, the Ministry of the Environment along with the Ministry of Industry and Trade undertook a fundamental economic revaluation of the mineral wealth of the Czech Republic. In 2003–2006, the task has continued to a smaller extent. Therefore compared to past years, many considerable changes have occurred in the number of deposits and registered reserves of many minerals (especially metallic ores).

The *Mineral Commodity Summaries of the Czech Republic* includes selected minerals according to whether they are or were mined in the territory of the Czech Republic. Currently mined minerals also include approved prognostic resources, if existing. Currently unmined minerals are divided into those that were mined in the past and those that have never been mined. In both cases, it is distinguished whether their resources and reserves are known or not and, generally, also whether they are metallic ores or industrial minerals. Separate chapters are dedicated to each mineral, or mineral grouping common in its deposit. Each chapter is structured identically – consists of eight parts.

Part 1. – Characteristics and use – provides a basic description of the mineral raw material, its abundance in nature, important minerals and mineral deposit types, worldwide and European Union reserves, general use and allocation to the critical raw materials of the European Union.

Part 2. – Mineral resources of the Czech Republic – describes to the extent necessary major regions of occurrence, characteristics of deposits, ore types, mining and its economic aspects of the given mineral.

Part 3 – Registered deposits and other resources of the Czech Republic – is based on the inventory of mineral deposits of the Czech Republic and, for the majority of minerals, includes a list of deposits and their location. The names of exploited deposits are given in bold. As for energy minerals and some industrial minerals, only regions and basins rather than single deposits are given. As for dimension stone and construction minerals, which are scattered in hundreds of deposits over the whole territory of the Czech Republic, their groupings are located in the subdivisions of reserved, non-reserved, exploited and unexploited deposits.

Part 4 – Basic statistical data of the Czech Republic as of December 31 – are extracted especially from the Register. There are 3 groups of minerals (ores, energy minerals, and reserved industrial and construction minerals) registered in the Czech Republic. Mine production of non-reserved deposits has been monitored since 1999. Approved prognostic resources are stated, too, if proved they exist.

NOTE: The *Register* presents the *reserves* data in the categories on exploration (prospected, explored) and economic use (economic, potentially economic), as stipulated by relevant statutes starting with the Mining Act. *Reserves* include *potentially economic reserves*, i.e. reserves which are currently not recoverable and which are, therefore, *potentially economic resources*. Consequently, *total mineral reserves* are in reality *total mineral resources*. The term *reserves* as used, by contrast, in standard international classifications represents only the parts of explored resources which are available for immediate extraction. All other registered parts are resources, not reserves, of a given mineral. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter of this yearbook *"Mineral reserve and resource classification in the Czech Republic and its evolutional comparison with international classifications"***.**

Part 5 – Foreign trade – provides information on import and export, and on average import and export prices of important tariff items of the given raw material (and cites international numeric codes of the tariff items). The foreign trade data are the latest (continuously reviewed) data of the Czech Statistical Office (ČSÚ) – without analyses of their reliability.

Part 6 – Prices of domestic market – provides indicative prices on domestic production, import and export prices. Domestic prices do not include VAT.

Part 7 – Mining companies in the Czech Republic as of December 31, 2023 – provides a list of companies mining the given mineral in the territory of the Czech Republic. The companies are listed according to the production level. Their addresses are available at the Czech Geological Survey.

Part 8 – World production and world market prices – provides data on mining and production of commercial products for the last 5 years, and lists significant world producers, i.e. the top ten countries in world production. Evolution of world prices is mentioned as current quoted or indicative prices in the last five years.

Numerous domestic and foreign data, used in compiling the present yearbook, came from journals, expert literature and the latest editions of various international statistical yearbooks.

EXPLANATORY NOTES

List of abbreviations, symbols and technical units

AOPK ČR Nature Conservation Agency of the Czech Republic (Agentura ochrany přírody a krajiny České republiky)

API American Petroleum Institute

API degrees Degrees of crude oil specific gravity defined by the API (°API)
API gravity formulas:

$$°API = \frac{141.5}{SG \text{ at } 60°F} - 131.5$$

$$SG \text{ at } 60°F = \frac{141.5}{°API + 131.5}$$

SG = specific gravity (t/m^3)
60° F = 15.6° C

a.s. initials after a Czech company name indicate that it is a joint stock company (akciová společnost)

bbl barrel of crude petroleum, 158.99 dm^3; 1 tonne of crude petroleum is approximately 7 bbl (6.76–7.75 bbl for crude petroleum extracted in the Czech Republic)

bn billion, 10^9

BP British Petroleum, British multinational oil and petrochemical company

BP SRWE British Petroleum Statistical Review of World Energy, energy yearbook including energy minerals

CFR Cost and Freight (named port of destination)

CHKO protected landscape area (Chráněná krajinná oblast)

CHLÚ protected deposit area (Chráněné ložiskové území)

CHOPAV Protected area of natural accomodation of water (chráněná oblast přirozené akumulace vod) – see PANAW

CIF Cost, Insurance and Freight (named port of destination)

CIS Commonwealth of Independent States, in Russian: Содружество Независимых Государств

CMMI Council of Mining and Metallurgical Institutions

Coll. Collection of laws (Sbírka zákonů České republiky) of the Czech Republic

CSO Czech Statistical Office

CZK Czech crown (česká koruna)

CZ NACE Czech adoption of the General Industrial Classification of Economic Activities within the European Communities (Nomenclature générale des Activités économiques dans les Communautés Européennes)

ČBÚ Czech Mining Authority (Český báňský úřad)

ČGÚ Czech Geological Office (Český geologický úřad)
ČNB Czech National Bank (Česká národní banka)
ČNR Czech National Council (Česká národní rada) – former parliament of the Czech (Socialist) Republic
ČR Czech Republic (Česká republika)
ČSSR Czechoslovak Socialist Republic (Československá socialistická republika)
ČSÚ Czech Statistical Office (Český statistický úřad)
DERA Deutsche Rohstoffagentur (German Mineral Resources Agency) is a part of Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geosciences and Natural Resources)
DP mining lease (dobývací prostor)
EIA 1) Environmental Impact Assessment
2) Energy Information Administration, section of the Department of Energy of the USA providing energy statistics, data, analysis
EU European Union
EURATOM Euratom Supply Agency (ESA), European agency for common supply policy on the principle of regular and equitable supply of nuclear fuels for European Community users
EUROSTAT Statistical Office of the European Communities, organisational branch of the European Commission
FDI foreign direct investment
FMPE Federal Ministry of Fuels and Power (Federální ministersvo paliv a energetiky)
FNM National property Fund (Fond národního majetku)
FOB Free on Board (port) – seller pays for transportation of the goods to the port of shipment, plus loading costs
GDP Gross domestic product
GVA Gross value added (GVA) is a widely used indicator of the total economic performance of each branch. It is an indicator corresponding to the GDP in the whole national economy. It is calculated by subtraction of the intermediate consumption (consumption of the raw materials, energy, materials) from the total value of the production (in terms of accounting, this is the difference between the sales and other services of companies and their consumption of materials, energy and services, this is therefore the sum of their book values added)
IEA International Energy Agency
IM Industrial Minerals (journal)
IMF International Monetary Fund
JORC Joint Ore Reserves Committee – comprises representatives of each of the three parent bodies: The Minerals Council of Australia (MCA), The Australasian Institute of Mining and Metallurgy (The AusIMM), and the Australian Institute of Geoscientists (AIG); as well as representatives of the Australian Securities Exchange (ASX), the Financial Services Institute of Australasia (FinSIA) and the accounting profession, and an observer from Association of Mining and Exploration Companies (AMEC). The JORC Committee is responsible for the development and ongoing update of the JORC Code. The JORC Code provides a mandatory system for the classification of minerals

	exploration Results, mineral resources and ore reserves according to the levels of confidence in geological knowledge and technical and economic considerations in Public Reports.
KKZ	Commission for Classification of Mineral Reserves (Komise pro klasifikaci zásob)
k.s.	initials after a Czech company name indicate that it is a limited partnership company (komanditní společnost)
kt	kilotonne, 1,000 t
Ma	Million of years
MB	Metal Bulletin (journal)
MCS	Mineral Commodity Summaries, mineral yearbook of the US Geological Survey
MF	Ministry of Finance
MH ČR	Ministry of Economy of the Czech Republic (Ministerstvo hospodářství České republiky)
MHPR	Ministry of Economic Policy and Development (Ministerstvo pro hospodář-skou politiku a rozvoj)
mill	million, 10^6
MIT	Ministry of Industry and Trade
MoE	Ministry of the Environment
MoLSA	Ministry of Labour and Social Affairs (Ministerstvo práce a sociálních věcí)
MŽP ČR	Ministry of the Environment of the Czech Republic (Ministerstvo životního prostředí České republiky)
N	not available or not reliable data
NP	natural park (Národní park)
NPF	National Privatization Fund
OBÚ	Regional Mining Authority (obvodní báňský úřad)
OPEC	Organization of Petroleum Exporting Countries
o.p.s.	initials after a Czech organization name indicate that it is a not profit organization (obecně prospěšná společnost)
PANAW	Protected area of natural accomodation of water (chráněná oblast přirozené akumulace vod) – see CHOPAV
pcs	pieces
PKÚ	Palivový kombinát Ústí, s.p.
POPD	plan of mine development work of reserved mineral deposits (plán otvírky, přípravy a dobývání výhradních ložisek)
ppm	parts per million = 0.0001 = g/t
ROPO	Recognised Overseas Professional Organizations
Sb.	Collection of Laws (abbreviated as Coll.) of the Czech Republic
SD	Severočeské doly, a.s.
s.p.	initials after a Czech company name indicate that it is a state public enterprise (státní podnik)
spol. s r.o.	initials after a Czech company name indicate that it is a limited liability company (společnost s ručením omezeným), ditto initials s. r. o.
s. r.o.	initials after a Czech company name indicate that it is a limited liability company (společnost s ručením omezeným), ditto initials spol. s r.o.

SU	Sokolovská uhelná, právní nástupce, a.s.
t	metric tonne, 1,000 kg, 1,000,000 g
tce	tonne of coal equivalent, the energy unit representing energy 7 million kcal (29,3067 GJ) generated by burning one metric ton of coal; Czech steam coal 1 tce = 1.1–1.6 t, coke coal 1.0–1.3 t
ths	thousand, 10^3
UNFC	United Nations Framework Classification
USGS	United States Geological Survey – Geological survey of the USA
v.o.s.	initials after a Czech company name indicate that it is an unlimited company (general partnership) (veřejná obchodní společnost)
VAT	Value Added Tax
WBD	Welt Bergbau Daten (World Mining Data), mineral yearbook of Austrian Federal Ministry of Agriculture, Regions and Tourism
WNA	World Nuclear Association
ZCHÚ	specially protected area (zvláště chráněné území)

Exchange and inflation rates of currencies in which minerals are priced

Annual inflation rates (%) in the USA (US), the United Kingdom (UK), the Euro Area (EUR) and the Czech Republic (CZ)

	US	UK	EUR	CZ
1991	4.2	7.4	–	56.6
1992	3.0	4.3	–	11.1
1993	3.0	2.5	–	20.8
1994	2.6	2.1	–	10.0
1995	2.8	2.6	–	9.2
1996	2.9	2.4	–	8.8
1997	2.3	1.8	–	8.4
1998	1.5	1.6	–	10.6
1999	2.2	1.3	1.1	2.3
2000	3.4	0.9	2.1	3.8
2001	2.8	1.2	2.4	4.7
2002	1.6	1.3	2.3	1.8
2003	2.3	1.4	2.1	0.1
2004	2.7	1.3	2.1	2.8
2005	3.4	2.0	2.2	1.8
2006	3.2	2.3	2.2	2.5
2007	2.9	2.3	2.2	2.9
2008	3.8	3.6	3.3	6.3
2009	–0.3	2.2	0.3	1.0
2010	1.6	3.3	1.6	1.5
2011	3.1	4.5	2.7	1.9
2012	2.1	2.8	2.5	3.3
2013	1.5	2.6	1.3	1.4
2014	1.6	1.5	0.4	0.4
2015	0.1	0.0	0.2	0.3
2016	1.3	0.7	0.2	0.7
2017	2.1	2.7	1.5	2.5
2018	2.4	2.5	1.8	2.2
2019	1.8	1.8	1.2	2.9
2020	1.3	0.9	0.3	3.2
2021	4.7	2.5	2.6	3.8*
2022	8.0	7.9	9.2	15.1
2023	4.1	6.8	6.4	10.7

*Notes: * Czech Statistic Office*

- *source – IMF. World Economic Outlook. October 2024*
- *inflation rates based on average annual changes of consumer price indices*

Average yearly exchange rates of CZK against EUR, USD and GBP

	EUR	USD	GBP
1991	–	29.5	52.0
1992	–	28.3	49.9
1993	–	29.2	43.8
1994	–	28.8	44.0
1995	–	26.5	41.9
1996	–	27.1	42.3
1997	–	31.7	51.9
1998	–	32.3	53.5
1999	36.9	34.6	56.0
2000	35.6	38.6	58.4
2001	34.1	38.0	54.8
2002	30.8	32.7	49.0
2003	31.8	28.2	46.0
2004	31.9	25.7	47.1
2005	29.8	23.9	43.6
2006	28.3	22.6	41.6
2007	27.8	20.3	40.6
2008	24.9	17.0	31.4
2009	26.4	19.1	29.7
2010	25.3	19.1	29.5
2011	24.6	17.7	28.3
2012	25.1	19.6	31.0
2013	26.0	19.6	30.6
2014	27.5	20.7	34.2
2015	27.3	24.6	37.6
2016	27.0	24.4	33.1
2017	26.3	23.4	30.1
2018	25.6	21.7	29.0
2019	25.7	22.9	29.3
2020	26.4	23.2	29.7
2021	25.7	21.7	29.8
2022	24.6	23.4	28.8
2023	24.1	22.2	27.6

Source: Czech National Bank

Overview of the Czech mineral resources and reserves classification system and its comparison to the international classifications

Czech national mineral resources classification system and its development

Between 1952 and 1991, the system of classification of mineral resources and reserves in the former Czechoslovakia, adopted from the former USSR, was determined by the Commission for the Classification of Reserves (KKZ), which acted as the central state body for the approval of mineral resources and reserves. Under this system, the geological resources were divided into four categories, A, B, C1 and C2, according to the degree of knowledge of the geology and development of the deposit, the quality of the raw material and the mining conditions.

The 1991 amendment to Act No 44/1988 Coll. (the Act on the Protection and Use of Mineral Resources, hereinafter referred to as the Mining Act or MA), in Sections 13 and 14, newly regulated the principles for classifying reserves of Reserved Deposits and for assessing and approving the calculation of reserves. This repealed Government Decree No 80/1988 Coll. of 16 May 1988 on the determination of conditions (modifying factors), classification of reserves of Reserved Deposits and the assessment, approval and state expertise of their calculation, which were based on the ABC1C2 system.

According to the MA, minerals are divided into Reserved Minerals that constitute Reserved Deposits and belong to the state, and Non-reserved Minerals that constitute Non-reserved Deposits as an integral part of the land. Historically there are Reserved Deposits of Non-reserved Minerals. Extensive list of Reserved Minerals is stipulated in section 3 of the MA.

According to Section 13 of the MA, "The reserves of a Reserved Deposit are the identified and verified quantity of Reserved Minerals on the deposit or a part thereof corresponding to the conditions of its recoverability, regardless of the losses during its extraction". According to Section 14 of the MA, the calculation of reserves is part of the evaluation of the results of prospecting and exploration of Reserved Deposit. Reserves are classified as follows:

a) According to the degree of exploration of the Reserved Deposit and knowledge of the deposition conditions of the deposit or part thereof, the quality and technical properties of minerals, and technical mining conditions pertaining to Prospected Reserves and Explored Reserves. If a Reserved Deposit contains several utilizable components, their reserves are classified according to the attained degree of knowledge on and exploration thereof.

(b) According to the conditions of exploitability as Economic Reserves that are currently exploitable and that conform to the current technical and economic conditions for utilizing a Reserved Deposit, and Potentially Economic Reserves that are currently not exploitable because they do not conform to current technical and economic conditions, but which can be assumed to become exploitable in the future with the development of technical and economic circumstances.

Neither the amended MA nor any other regulation defines the content of the terms Prospected and Explored Reserves. Following the adoption of the 1991 amendment to the Mining Act, reserves in mineral deposits were administratively converted into new categories as follows: Explored Reserves = the sum of reserves of categories A + B + C1 (also called Industrial Reserves), Prospected Reserves = reserves of category C2. The definitions of the ABC1C2 categories were more precisely specified in the Mining Act before 1991 (for details e.g. Starý et al. 2022).

c) According to the possibility of extraction determined by the mining technology, operational safety and established protective pillars, as Free and Restricted Reserves. Restricted Reserves are those located within protective pillars of surface and underground structures, equipment and mine works, as well as within pillars established to ensure operational safety and protection of legally protected interests. All other reserves are Free Reserves.

Mineable Reserves are those that the organisation plans to recover. They are 'Economic Reserves less the quantity of expected mining losses connected with the selected extraction technology or with the effect of natural conditions'.

Prognosticated Resources are divided into categories P, R and Q in accordance with the Ministry of Environment Decree No. 369/2004 Coll. The P category for Reserved Minerals and the R category for Non-reserved Minerals include prospective mineral resources for which knowledge of the geological structure of the area of the prospective resource and the existence and quality of the mineral has been demonstrated by technical works. These Prognosticated Resources are considered to be prospective mineral deposits for the purpose of their protection in land-use decision-making. Category Q includes prospective resources independently defined outside an existing mineral deposit, identified by geological mapping in favourable geological conditions on the basis of a justified analogy with another deposit, without proof of existence based on technical works.

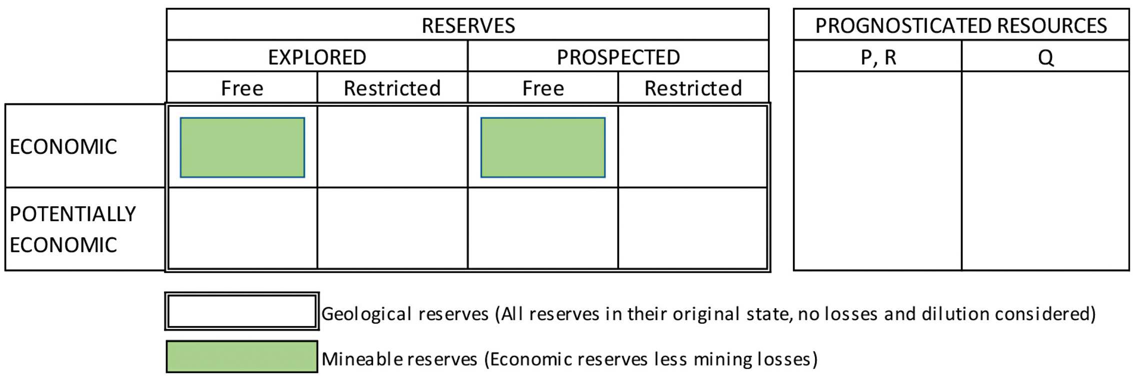

Figure 1. Overview of reserve and resource classification in the Czech Republic according to the Mining Act (adapted after Starý et al. 2022)

In the years 1993–2001 the task "Re-evaluation of Reserved Mineral deposits of the Czech Republic" was carried out (Molhancová, Novák 2001), followed by the task "Evaluation of Reserved Mineral deposits in the state reserve in the years 2003–2006" (Mojžíš, Novák, Novák 2006). These tasks reassessed most of the substantial deposits according to the classification established under the Mining Act as amended in 1991 and the ABC1C2 system thus lost its significance definitively.

The system of mineral classification currently used in the Czech Republic under the Mining Act is not compatible with any other existing system. The ABC1C2 system used in the past was largely compatible with the CRIRSCO principles (see below in the chapter Comparison of Czech and international classification systems), but the conversion between these two systems can be partly carried out indirectly through the UNFC classification based on the developed category-mapping methodology (Gabriel et al. 2023).

The originally Soviet ABC1C2 system was adopted by the countries of the so-called Eastern Bloc, where it underwent major or minor changes after 1989. An overview and more information can be found in the report by Vaněček et al. (2016).

In the Czech Republic, there is an obligation to report reserves and resources in the system according to the Mining Act, but exploration and mining organisations whose shares are listed on the stock exchange are also obliged to disclose the results of their activities in the corresponding system of the international CRIRSCO Template. There are currently two organisations of this type in the country.

International classification

CRIRSCO

The Committee for Mineral Reserves International Reporting Standards (CRIRSCO) is recognized as the international organization that represents the mining industry in matters relating to the standardization of codes for public statements, as a Strategic Partner of the International Council on Mining and Metals (ICMM) and also accredited by the United Nations Economic Commission for Europe (UNECE) and the International Accounting Standards Board (IASB), an organization that brings together stock exchanges around the world and dictates accounting rules, by international standards IFRS (International Financial porting Standards). (CRIRSCO 2024).

CRIRSCO finalized the first international model for consolidating terminologies and classifications in 2006, with the publication of the International Reporting Template (IRT) for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves. The last update was in June 2024. This international template is usually referred to as the 'CRIRSCO International Reporting Template', which integrates the minimum standards adopted in national or regional codes and standards. Currently, the CRIRSCO Template is followed by national organizations in 15 countries with developed mining industries. The international standard for the reporting of exploration results and mineral reserves has been called for primarily by stock exchanges, where many exploration and mining organisations raise funds by issuing their shares and the exchanges seek to protect investors from unfair practices in this area. The model itself has no legislative backing, but countries that have signed up to the standard have often integrated it into their national legislation. The JORC template was issued in Australia in 1999 (Australasian Joint Ore Reserves Committee) and last updated in 2012, followed by similar guidelines in Canada (CIM Guidelines and NI 43-101 Disclosure Standard), South Africa (SAMREC Code), the US (SME Guide), Chile (Certification Code) and other countries.

In 2001, the Pan-European Reserves and Resources Reporting Committee (PERC) published the Pan-European Standard for Reporting of Exploration Results, Mineral Resources and Mineral Reserves, and the PERC system (last update 2021) is now widely used in Europe (PERC 2021).

One of the countries that have also adopted the CRIRSCO standard is Russia with its national NAEN system. The bridging document includes a comparison of the CRIRSCO model with the original Soviet ABC1C2 system (CRIRSCO 2011).

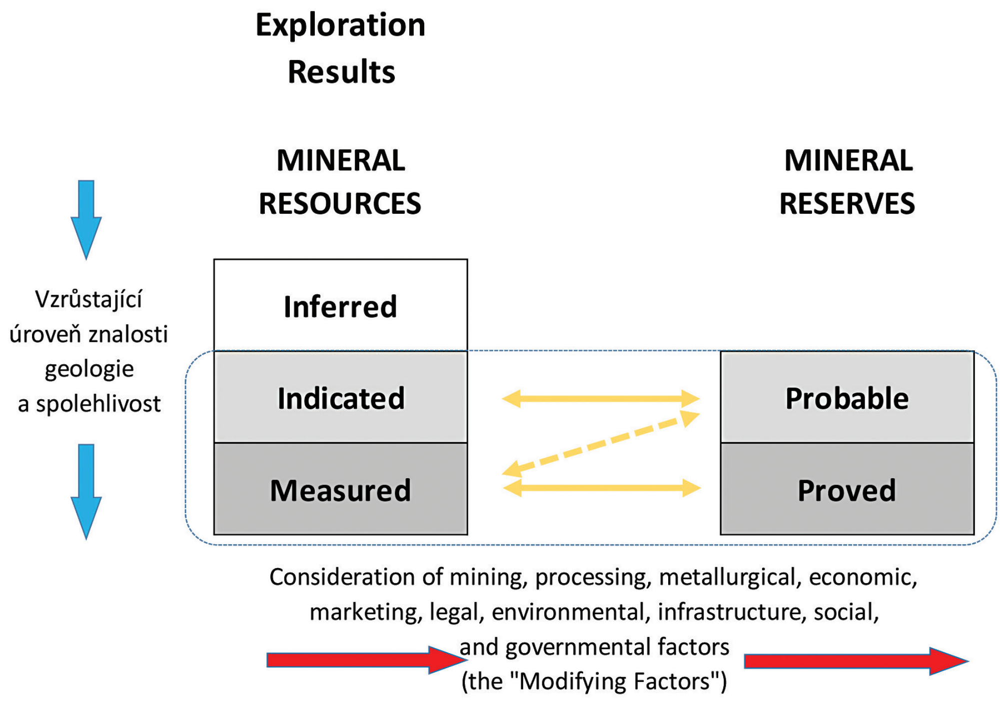

Figure 2. General relationship between Exploration Results, Mineral Resources and Mineral Reserves as set out in the CRIRSCO Template (CRIRSCO 2024).

UNFC

To facilitate European resource management, the European Union has adopted the United Nations Framework Classification for Resources (UNFC), which is widely applicable for the classification of mineral reserves as well as for the classification of anthropogenic and other resources such as alternative energy sources, or water resources. UNECE (United Nations Economic Commission for Europe) has been developing this classification system since 1992 and the latest update was published in 2019 (UNECE 2019). The 2019 UNFC Update and the UNFC Specification for Commodities (UNECE 2021) are the core documents for the application of the UNFC. Furthermore, the European Union has developed a Guidance for application of UNFC within its member countries with regard to a uniform database of national data on deposits and occurrences of critical raw materials (UNECE 2022). The adoption of the UNFC as a standard for the reporting of critical mineral resources and reserves within the EU by individual Member States is required by the European Union regulation known as the Critical Raw Materials Act (CRMA) (European Union 2024), which entered into force on May 3rd, 2024. Some countries have incorporated the UNFC into their legislation (e.g. Hungary, Romania, Ukraine).

The UNFC is not intended to replace national mineral classification systems or reporting using the CRIRSCO Template. Its main purpose is the ability to summarize and compare resources within the European Union to enable a coordinated management approach in this field of industry (UNECE 2022). The UNFC provides for a greater level of detail (granularity) when classifying projects than the CRIRSCO Template due to the sub-category system and allows for the specification of mineral resources that are not established or permitted within the CRIRSCO Template (e.g. prospective projects) (UNECE 2024a).

In 1999 a Bridging Document between UNFC and CRIRSCO was adopted and it was last updated in May 2024. The Bridging Document can serve as a supporting document for the evaluation of projects in the UNFC system and the development of bridging methodologies to UNFC from other, national, classifications (UNECE 2024a).

The UNFC is a resource project-based and principle-based classification system for defining the environmental-socio-economic viability and technical feasibility of projects to develop resources. Exploration and mining projects are classified in a three-dimensional matrix according to the three primary criteria: environmental, social and economic feasibility (E axis), technical feasibility (F axis) and the degree of confidence in geological data (G axis). The primary level of resource classification is the result of a combination of categories from each of these axes into a three digit code (e.g. E1F1G2 or 112). The combination of categories and sub-categories constitute classes and sub-classes of a project according to its feasibility or the readiness of the project for development in current time (Feasible Projects, Potentially Feasible Projects, etc.) (UNECE 2019, UNECE 2022).

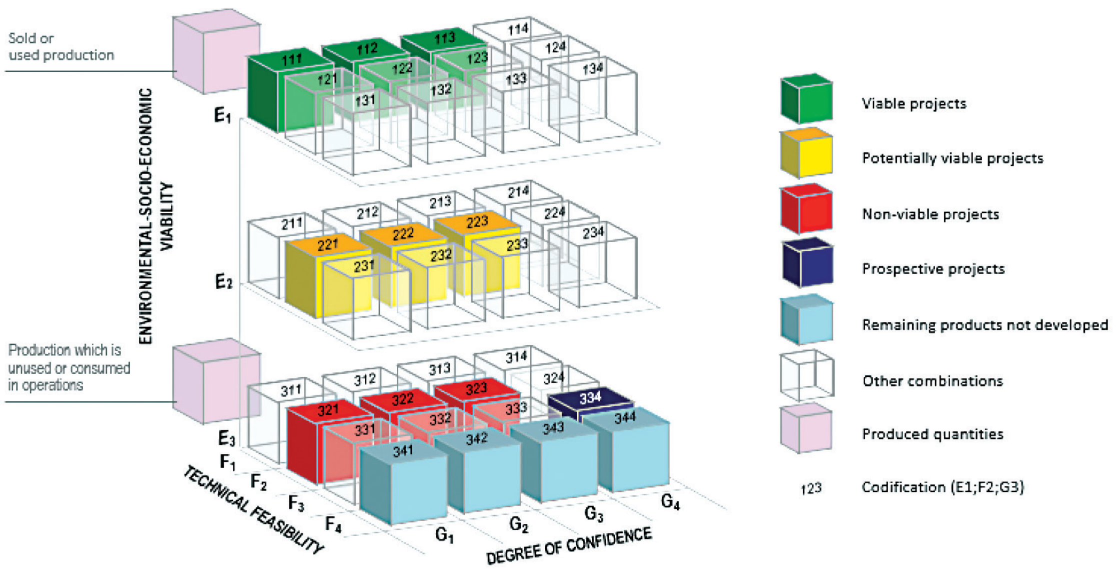

Figure 3. The three-dimensional UNFC classification matrix (UNECE 2019)

The colour-coded fields in the 3D matrix are typical categories, but individual situations on individual deposits or projects may also require the use of other fields.

UNFC categories are only established for those projects (deposits) that have quantified mineral reserves or resources.

Comparison of the Czech and international classification systems

The main difference between the Czech classification according to the Mining Act and the international CRIRSCO Template is the fact that the MA refers to "reserves" as the quantities that are currently sub-economic, which is terminologically inconsistent with the CRIRSCO concept of reserves. In the international system only those parts of the Measured or Indicated Resources that are currently economically recoverable, net of mining losses and contamination, are designated as reserves. The closest to the international standard for reserves are the Czech Mineable Reserves. However, even in this case there is not a complete agreement, because according to the MA these reserves reflect mining losses but not dilution. In addition, the Czech classification introduces a category of Geological Reserves which is close to the 'Total Inventory' category in some Anglo-Saxon systems, but those are also not supported by the CRIRSCO Template. The comparison between the Czech MA and CRIRSCO categories can now be partly made indirectly through the UNFC categorisation of Gabriel et al. (2023) (see Table 1).

Table 1. Comparison of the categories as defined in the CRIRSCO Template, UNFC categories and the Czech Mining Law. Adapted after UNECE (2024) and Gabriel et al. (2023).

CRIRSCO Template			*Corresponding UNFC Category*			*UNFC Class*	*Categories as set in the Czech Mining Act*
Public Report and Study Types	*Standard Definitions*						
Feasibility Study or Life of Mine Plan (for an operating mine)	Mineral Reserves	Proved	E1	F1	G1	Viable Projects	Mineable Reserves with "POPD"
		Probable			G2		
Pre-feasibility Study	Mineral Reserves	Proved	E2	F2	G1	Potentially Viable Projects	Mineable Reserves without approved "POPD"/Mining Licence
		Probable			G2		
Feasibility Study, Life of Mine Plan (for an operating mine) or Pre-feasibility Study	Mineral Resources (exclusive of Mineral Reserves)	Measured	E2	F2	G1		
		Indicated			G2		
		Inferred			G3		
Scoping Study report or other Public Report on a Mineral Resource estimate	Mineral Resources	Measured	E2	F2	G1		Economic Explored Free Reserves
		Indicated			G2		
		Inferred			G3		Economic Prospected Free Reserves
Public Report on exploration stage projects	Exploration Target		E3	F3	G4	Prospective Projects	Prognosticated Resources P
	Exploration Results		Estimates not published				Prognosticated Resources Q
Not applicable	Estimates obtained from historical reports					Non-viable Projects	E.g. Resources and Reserves in the ABC$_1$C$_2$ system.

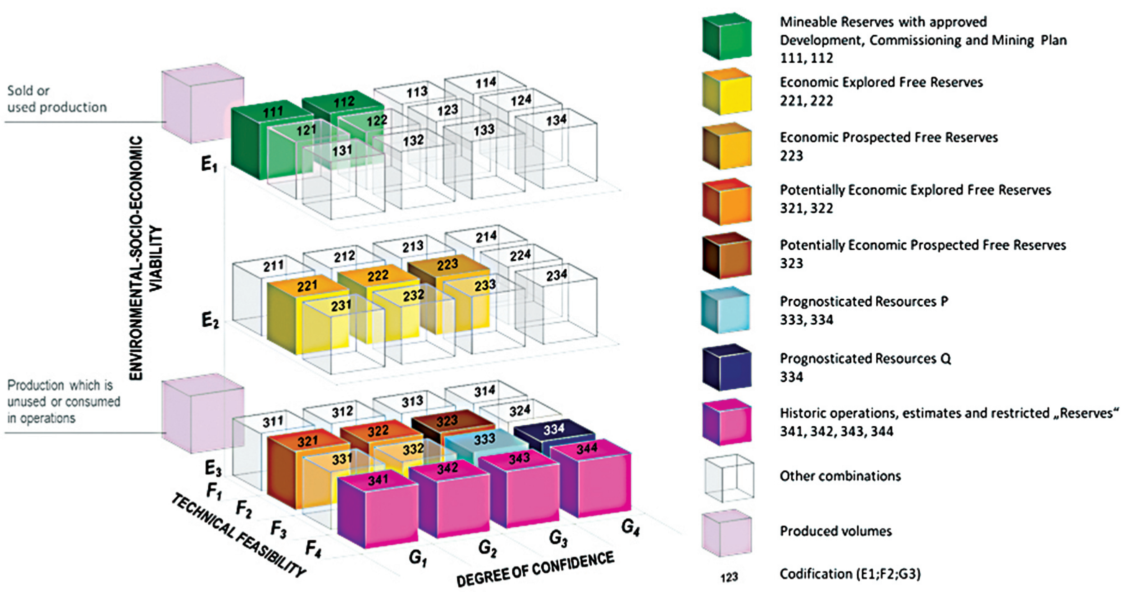

Figure 4. Mapping the classification categories according to the Czech Mining Act into the UNFC three-dimensional matrix (Gabriel et al. 2023)

The ABC1C2 system used in the past was largely compatible with the CRIRSCO principles. A tabular comparison of past and current reserve and resource classifications with the CRIRSCO Template categories is provided in earlier editions of this annual publication, Mineral Commodity Summaries of the Czech Republic, e.g. Starý et al. (2022).

In 2023, a mapping document enabling the conversion of the categories of the Czech national system according to the Mining Act to the UNFC categories was developed (Gabriel et al. 2023). However, implementing regulations for the use of the UNFC within the Czech legal framework had not been issued by the relevant state administration authorities by the date of publication of this overview.

Conversion between the Czech national classification categories and the UNFC is based on a comparison of the definitions of the individual categories of reserves and resources as defined in the Mining Act and the Ministry of Environment Decree No. 369/2004 Coll. with the definitions of the categories in the UNFC core documents (UNECE 2019, UNECE 2022). Some principles from the Bridging Document between CRIRSCO and the UNFC (UNECE 2024a,b) were also used as auxiliary criteria. The methodology was developed only for Reserved Mineral Deposits under the Mining Law. For Non-reserved Deposits the methodology needs to be adapted in the future.

In addition to the main categories, the sub-categories were also used for the conversion purposes, since their more detailed definitions allow for a more precise classification of the resource in the classification system.

The mapping of each category of the Czech system to the UNFC categories with the rationale for each is presented in the report by Gabriel et al. (2023).

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MINERAL BASE OF THE CZECH REPUBLIC AND ITS DEVELOPMENT IN 2023

Petr Uldrych et al.
Ministry of the Environment of the Czech Republic

1. Legal framework for mineral resource use

1.1. Reserved and non-reserved minerals and their deposits

The minerals defined in Act No. 44/1988 Coll., on the Protection and Use of Mineral Resources (the Mining Act) as amended, are classified as being reserved and non-reserved. Natural accumulations of reserved minerals form reserved mineral deposits which constitute the mineral wealth of the country and are owned by the Czech Republic. Deposits of non-reserved minerals (especially sand and gravel, crushed stone and brick clay) are a constituent part of the land as stipulated in paragraph 7 of the Mining Act. The possibility to declare significant non-reserved mineral deposits as reserved deposits, was cancelled by the amendment of the Mining Act in 1991. Decisions of administrative agencies in this matter, which had been issued before the amendment went into effect, remain valid based on transitional provisions (paragraph 43 and 43a of the Mining Act). The deposits specified by these decisions are still reserved deposits, i.e. owned by the state, separated from the land itself.

1.2. Planning, approval and carrying out of mineral prospecting and exploration

1.2.1. Reserved minerals

Prospecting and exploration for reserved mineral deposits, by virtue of the ČNR Act No. 62/1988 Coll., on Geological Work (the Geological Act) as amended, may be conducted by an individual or organisation, providing that the work is managed and guaranteed by a qualified and certified person (certified responsible manager for the geological work). An organisation seeking to prospect for and explore these mineral deposits, to verify their reserves, and to process geological documents for their exploitation and protection, must make a request to the Ministry of the Environment to establish an exploration area. The proceedings, subject to administrative rules, are concluded by the establishment or non-establishment of an 'exploration area' (exploration permit). In the former case, the following must be determined: the survey area, the mineral to be prospected and explored for which the exploration area is being established, the conditions for the execution of the work, and the period of validity of the exploration area. The exploration area is not a territorial decision, but provides the entrepreneur or organisation (hereinafter "entrepreneur") with the exclusive privilege to prospect for the mineral in a given exploration area. In the first year, the entrepreneur is obliged by law to pay a tax of CZK 2,000 per km^2 or km^2 piece of exploration area, which increases annually by CZK 1,000 per km^2 and its piece (to CZK 3,000 in the second year, to CZK 4,000 in the third year, etc.). These taxes represent an income for the municipalities, in whose cadastral areas the exploration area is established. If an exploration area lies on cadastral areas of more municipalities the income is divided after ratio of exploration areas on cadastral areas of individual municipalities.

Within the scope of planning and conducting the prospecting for and exploration of reserved mineral deposits, the organisation must consider the conditions and interests protected by special regulations (section 22 of the Act on Geological Work). These primarily refer to the laws for the protection of landscape and nature, agricultural and forest land; to the Water and Mining Acts etc. The Ministry of the Environment can cancel the established exploration area, if the organisation repeatedly or severely violates the obligations set by the Geological Act.

1.2.2. Non-reserved minerals (and their mining)

The above-mentioned enactments apply to prospecting and exploration for non-reserved mineral deposits, only, if they were previously declared as reserved deposits according to the transitional provisions of the Mining Act. In other cases, an organisation can prospect and explore for non-reserved minerals only upon agreement with the landowner. The provision under section 22 of the Act on Geological Work is also valid in these cases. The mining of non-reserved deposits, which constitutes a part of the land, an operation conducted according to the mining methods set by Act No. 61/1988 Coll., on Mining Operations, Explosives and the State Mining Administration, as amended.

1.3. Permit to mine a prospected and explored deposit

If, during prospecting and exploration, a reserved mineral is found to be of quality and quantity indicative of its accumulation (supported by a partial deposit reserve estimate given in the category of prospected reserves), the organisation must report it to the Ministry of the Environment, which issues a certificate for the reserved deposit owned by the state. At the same time, this certificate ensures the deposit against actions rendering its mining difficult or impossible by the establishment of a protected deposit area (CHLÚ) according to section 17 of the Mining Act.

The entrepreneur's right to mine the reserved deposit is provided by the grant of a mining lease. The submittal of a proposal for the grant of a mining lease must be preceded by an approval from the Ministry of the Environment, which may depend on the fulfilment of limiting conditions accounting for the interests of the state mineral policy, and on covering expenses of geological work already funded by the state. The organisation, on whose behalf the exploration was carried out, has priority in receiving the approval for the grant of the mining lease. If it fails to assert its mining lease, precedence is then given to the organisation which participated financially in the exploration. Somewhat different rules apply to cases concerning crude oil and natural gas based on a transposed EU directive.

The mining lease is only granted to an entrepreneur possessing a Certificate of Mining Operations issued by an authorised Regional Mining Office. This grant procedure takes place in cooperation with relevant administrative agencies, mainly in agreement with environmental, land use planning and building authorities. The entrepreneur‘s proposal for the grant of a mining lease must be furnished with documentation as stipulated by law. The procedure deals with landowner relations and settlement of conflicts of interests, which are protected by special regulations. The environmental impact assessment (EIA) represents a part of the documentation, too. The grant of a mining lease represents a mining as well as land use authorisation.

The entrepreneur, who has been granted a mining lease, may start mining operations only after obtaining a mining permit from the authorised Regional Mining Office. The issue of this permit is subject to an administrative procedure assessing the plans of the opening, the preparation and the mining of the deposit, and the plans for rehabilitation and reclamation after termination of the mining. In justified cases, the Regional Mining Authority may combine the grant of a mining lease and of a mining permit into one administrative procedure.

1.4. Royalties on reserved minerals mined

The entrepreneur is obliged to pay royalties on the mining lease and the extracted reserved minerals. An annual lease payment of CZK 300 is assessed on every hectare opened within

Royalty tariffs on extracted minerals for individual royalty bases

Mineral, group of minerals	Unit	Tariff for unit in CZK
Crude oil	m^3	558.00
Combustible natural gas	m^3	0.27
Uranium	t	5,834.13
Cesium	kg	160,782.00
Tin	t	22,726.00
Lithium	t	10,692.00
Manganese	t	2,308.00
Copper	t	7,115.00
Rubidium	kg	114,103.00
Tungsten	t	46,625.00
Golg	kg	40,919.00
Gemstones – moldavites	kg	1,939.59
Gemstones – garnets	kg	1,500.00
Gemstones – mass SiO_2	kg	10.00
Diatomite	t	4.95
Glass and foundry sand	t	8.24
Bentonite	t	3.32
Minerals used to stonework inclusive of fissile slates	m^3	17.55
Gypsum	t	21.84
Graphite	t	30.00
Technically utilisable mineral crystals	t	15.00
Ceramic and refraktory clays and claystones	t	34.74
Kaolin	t	30.00
Quartz, quartzite, dolomite, marl, basalt, phonolite, trachyte if the minerals are suited for technochemical or melting processing.	t	4.36
Feldspar	t	13.73
Wollastonite	t	5.00
High-purity limestone	t	10.55
Other limestones and corrective additives for cement production	t	3.25
Bituminous coal	t	9.90
Brown coal – opencast mining	GJ	1.18
Brown coal – underground mining	t	3.88
Crushed stone	m^3	2.91
Sand and gavel	m^3	3.39
Brick clays and related minerals	m^3	1.40
Other minerals	t	50.37

the mining lease area, which is marked off on the surface. If there is permitted a mining activity in the mining lease consisting in the opening, the preparation and the mining of the reserved deposit this annual payment amounts CZK 1,500. The Regional Mining Authority fully transfers this payment to the municipalities, in whose territories the mining lease is located, according to the lease proportions in each municipal territory.

An annual royalties on minerals extracted in mining leases are given by the Government Provision no. 98/2016 Coll. from 16.3.2016, paragraph 33k, article 2 of the Mining Act in the wording of the Act 89/2016 Coll. amending the Mining Act no. 44/1988 Coll. on mineral protection and use.

The royalty is calculated as the product of royalty base, given by amount of mineral mined reported as net mine production in the mining lease, and the royalty tariff defined in Annex to the Government Provision no. 98/2016 Coll. for the mineral in question.

The Regional Mining Authority transfers the yielded royalties partly to the state budget of the Czech Republic to be purposefully used in remediation of environmental damage caused by the mining of reserved and non-reserved deposits, for the provision of discharge of the state geological service connected to protection and registration of mineral wealth and partly to the budget of the relevant municipalities. Portions of the state budget and the budget of the relevant municipalities differ for different minerals and are given by the Mining Act.

1.5. Reserves for mining damages and remediation during the mining of reserved minerals

During the course of mining, the entrepreneur is required to generate sufficient financial reserves for mining damages and for reclamation of areas affected by the deposit exploitation.

2. Selected statistical data on exploration and mining on the territory of the Czech Republic

Statistical data/year		2019	2020	2021	2022	2023
registered geological works [a)]	total	6,122	6,137	5,376	5,574	5,158
	economic geological	21	28	17	19	23
protected deposit areas – number		1,154	1,161	1,156	1,157	1,154
mining leases – total number		960	959	952	954	954
number of exploited reserved deposits		497	491	487	487	486
number of exploited non-reserved deposits		170	178	179	179	166
mine production of reserved deposits, mill. t [b)]		110	100	103	106	95
mine production of non-reserved deposits, mill. t [b)]		13	14	15	15	13
organizations managing reserved deposits		304	305	302	303	297
organizations mining reserved deposits		172	171	153	145	167
organizations mining non-reserved deposits		132	132	105	104	130

Note: Numbers of data in view are given unless otherwise indicated

a) engineering-geological and hydrogeological works prevail

b) conversions: natural gas 1 mill m^3 = 1 kt, dimension and crushed stones 1,000 m^3 = 2.7 kt, sand and gravel and brick clays and related minerals 1,000 m^3 = 1.8 kt

3. Significance of mining in the Czech economy

Ratio/year	2019	2020	2021	2022	2023
Annual GDP* growth	3.0	1.4	6.99	2.4	1,1
Share of mining and quarrying in GDP, % of current prices	0.6	0.4	0.5	0.5	0,4
Share of mining and quarrying GVA in GVA of industrial production**, % of current prices	2.1	1.4	1.4	1.4	1,3

Source: Czech Statistical Office, own calculations
Notes:
* *GDP determined by production approach, volume indices, stable period of previous year = 100*
** *Industrial production = mining and quarrying + manufacturing + electricity + gas, steam and air conditioning supply*

4. Trends of reserves of minerals (economic explored disposable reserves)
Totals in mill. t (if not otherwise stated)

Statistical data/year	2019	2020	2021	2022	2023
Metallic ores [a)]	95	95	95	95	95
Energy minerals [b)]	2,763	2,735	2,686	2,653	2,088
of which: uranium (U) (kt)	1	1	1	1	1
crude oil	22	22	21	21	21
natural gas [b)]	6	5	5	5	5
Industrial minerals	2,486	2,503	2,486	2,480	2,462
Construction minerals [c)]	5,153	5,161	5,178	5,272	5,294

Note:
a) in 2018 Au ores (25,642 kt), Li ores (860 kt), Sn-W ores (42,336 kt) and Mn ores (23,372 kt), in 2020 Au ores (25,642 kt), Li ores (860 kt), Sn-W ores (42,336 kt) and Mn ores (26,495 kt), 2021 Au ores (25,642 kt), Li ores (860 kt), Sn-W ores (42,336 kt) and Mn ores (26,495 kt), in 2022 Au ores (25,642 kt), Li ores (860 kt), Sn-W ores (42,336 kt) and Mn ores (26,495 kt)
[c)] *moldavite bearing rock – conversion into kt: 1,000 m^3 = 1.8 kt*
[d)] *at reserved mineral deposits including dimension stone, conversion into kt – dimension and crushed stones 1,000 m^3 = 2.7 kt, sand and gravel and brick clays and related minerals 1,000 m^3 = 1.8 kt*

Generating of the financial reserves is approved by the Regional Mining Authority during the mining permit procedure regarding the opening and extraction of the deposit. Drawing on the reserves is permitted by the Regional Mining Authority upon agreement with the Ministry of the Environment and upon notification by the relevant municipality. In the case of (partially) state-owned enterprises, the Regional Mining Authority decides in agreement with the Ministry of Industry and Trade.

5. Summary of exploration licences valid in 2023 and newly issued in 2023 (listed according to minerals) – prospecting and exploration works financed by companies

Minerals and underground placement sites	Number of valid EA (min. 1)	Number of valid EA (min. 2)	Number of new issues in 2023	Start of validity in 2023
Bituminous coal	–	–	–	–
Crude oil and natural gas	11	–	2	2
Sn–W and Li ores	8	–	1	1
Li ore	–	8	1	1
Cu ore	–	2	–	–
Au ore	1	–	–	–
Graphite	–	–	–	–
Gemstones	2	–	–	–
Kaolin	11	–	1	1
Clays	4	–	1	1
Bentonite	5	–	1	1
Feldspar and feldspar substitutes	16	–	2	2
Silica raw materials	4	–	–	–
Corrective additives for cement production	–	–	–	–
Dimension stone	1	–	–	–
Crushed stone	1	–	–	–
Sand and gravel	10	–	1	1
Underground placement sites, underground reservoirs	5	–	–	–
Total	**79**	**10**	**9**	**9**

EA – exploration area
Mineral 1 (min. 1) – in case that the raw material is the major one
Mineral 2 (min. 2) – in case that the raw materials is a by–product

6. State-funded geological projects

6.1. Economic geology projects

The Central Geological Authority of the state administration fulfils the duty involving the state register of reserved deposits – state property (section 29 of the Mining Act). Accordingly, it issues the register as one of the main sources for

- land use planning
- the raw material policy
- the energy policy
- the environmental policy
- the structural policy
- the employment policy

The register lists the latest status of the deposits as documented in the reserves estimate. The reserves estimate is prepared with respect to the conditions of exploitability expressing

- the state of the market, prices, business economy,
- the mining and technical conditions of exploitation,
- the conflicts of interests arising from the deposit exploitation (primarily environmental protection and other conflicts)

It is altogether entirely unstable factors reflecting political, economic and social change (in the largest sense).

In the field of deposit geology, the processing of updated data bases of the publication Raw *Material Resources of the Czech Republic – Mineral Resources* 2023 was carried out.

Revision of the potential of existing Q-category forecast resources defined for mineral and ore reserves in the Karlovy Vary Region. Assessment and evaluation of the North Bohemian brown coal basin in terms of the possibility of its release for further exploitation. Methodology of implementation of the UNFC system in the conditions of the legislative framework of the Czech Republic.

Expenditures for state-funded exploration work related to economic geology (rounded values)

1993	CZK	248.7 mill	2009	CZK	10.1 mill
1994	CZK	249.8 mill	2010	CZK	4.2 mill
1995	CZK	242.3 mill	2011	CZK	4.0 mill
1996	CZK	163.0 mill	2012	CZK	1.0 mill
1997	CZK	113.2 mill	2013	CZK	1.5 mill
1998	CZK	114.2 mill	2014	CZK	0.7 mill
1999	CZK	110.8 mill	2015	CZK	0.7 mill
2000	CZK	26.3 mill	2016	CZK	1.7 mill
2001	CZK	21.5 mill	2017	CZK	0.9 mill
2002	CZK	17.0 mill	2018	CZK	1.0 mill
2003	CZK	7.0 mill	2019	CZK	1.0 mill
2004	CZK	26.2 mill	2020	CZK	0.7 mill
2005	CZK	12.0 mill	2021	CZK	1.1 mill
2006	CZK	1.7 mill	2022	CZK	1.4 mill
2007	CZK	3.0 mill	2023	CZK	2.1 mill
2008	CZK	9.9 mill			

6.2. Other geological projects

Mainly geological work of a non-economic geology character was funded by the state. Individual projects were publicly commissioned in order to implement the following partial programmes:

- geological informatics
- geological mapping
- geohazards of the environment
- hydrogeology

The following expenditures were spent on these geological projects since 1998

1998	CZK	29.6 mill	2011	CZK	22.8 mill
1999	CZK	39.2 mill	2012	CZK	12.6 mill
2000	CZK	48.5 mill	2013	CZK	8.2 mill
2001	CZK	72.8 mill	2014	CZK	7.5 mill
2002	CZK	61.0 mill	2015	CZK	9.2 mill
2003	CZK	67.0 mill	2016	CZK	9.0 mill
2004	CZK	52.1 mill	2017	CZK	8.8 mill
2005	CZK	60.3 mill	2018	CZK	8.7 mill
2006	CZK	55.4 mill	2019	CZK	8.6 mill
2007	CZK	58.1 mill	2020	CZK	8.9 mill
2008	CZK	41.0 mill	2021	CZK	8.5 mill
2009	CZK	42.2 mill	2022	CZK	6.2 mill
2010	CZK	35.0 mill	2023	CZK	6.8 mill

- engineering geology
- comprehensive geological studies

7. Summary of selected legal regulations on mineral prospecting and exploration in force as of June 30, 2023

7.1. Acts

Act No. 44/1988 Coll., on mineral protection and use (the Mining Act) – as amended by the Acts No. 541/1991 Coll., No. 10/1993 Coll., No. 168/1993 Coll., No. 132/2000 Coll., No. 258/2000 Coll., No. 366/2000 Coll., No. 315/2001 Coll., No. 61/2002 Coll., No. 320/2002 Coll., No. 150/2003 Coll., 3/2005 Coll., No. 386/2005 Coll., No. 186/2006 Coll., No. 313/2006 Coll., No. 296/2007 Coll., No. 157/2009 Coll., No. 227/2009, Coll., No. 281/2009 Coll., No. 85/2012 Coll. , No. 350/2012 Coll., No. 498/2012 Coll., 257/2013 Coll., No. 89/2016 Coll., No. 264/2016 Coll., No. 183/2017 Coll., No. 225/2017 Coll., No. 403/2020 Coll., No. 609/2020 Coll., No. 88/2021 Coll., No. 261/2021 Coll., No. 248/2021 Coll, No. 152/2023 Coll., No. 349/2023 Coll. and No. 465/2023 Coll.

Act No. 61/1988 Coll., on mining operations, explosives and the state mining administration as amended by the Acts No. 425/1990 Coll., No. 542/1991 Coll., No. 169/1993 Coll., No. 128/1999 Coll., No. 71/2000 Coll., No. 124/2000 Coll., No. 315/2001 Coll., No. 206/2002 Coll., No. 320/2002 Coll., No. 226/2004 Coll., No. 3/2005 Coll., No. 386/2005 Coll., No.186/2006 Coll., No. 313/2006 Coll., No. 342/2006 Coll., No. 296/2007 Coll., No.376/2007 Coll., No.124/2008 Coll., No.274/2008 Coll., 223/2009 Coll., No. 227/2009 Coll., No. 281/2009 Coll., No. 155/2010 Coll., No 184/2011 Coll. , No. 18/2012 Coll., 64/2014 Coll., No. 250/2014 Coll., No. 206/2015 Sb., No. 204/2015 Sb., No. 320/2015 Coll., No. 91/2016 Coll., No. 243/2016 Coll., No. 451/2016 Coll. and No. 183/2017 Coll., 91/2018 Coll., No. 403/2020 Coll., No. 609/2020 Coll., No. 261/2021 Coll., No. 284/2021 Coll., No. 225/2022 Coll., No. 152/2023 Coll. No. 179/2023 Coll. and No. 465/2023 Coll.

Act No. 62/1988 Coll., on geological work, as amended by the Acts No. 543/1991 Coll., No. 366/2000 Coll., No. 320/2002 Coll., No. 18/2004 Coll., No. 3/2005 Coll., No. 444/2005

Coll., No. 186/2006 Coll., No.124/2008 Coll., No. 223/2009 Coll., No. 227/2009 Coll., No. 281/2009 Coll., No. 85/2012 Coll., 64/2014 Coll., 183/2017 Coll., 225/2017 Coll., No. 261/2021 Coll. and No. 149/2023 Coll.

Act No. 157/2009 Coll., on mining waste treatment and amendment of some acts, as ammended by the Act No. 168/2013 Coll., No. 183/2017 Coll., No. 225/2017 Coll. and 609/2020 Coll., 284/2021 Coll.

Act No. 85/2012 Coll., on carbon dioxide capture into natural rock textures and on amendment of some acts, as amended by the Acts No. 383/2012 Coll. and No. 64/2014 Coll., 193/2016 Coll., 183/2017 Coll. And No. 609/2020 Coll. and No. 465/2023 Coll.

Act No. 158/2000 Sb., on prospecting, exploration and exploitation of sea bottom mineral resources and on safety of crude oil and natural gas operations in sea, as amended by the Act No. 296/2007 Coll., No. 124/2008 Coll., No. 227/2009 Coll., No. 281/2009 Coll., No. 201/2015 Coll and No. 183/2017 Coll.

7.2. Other legal regulations

7.2.1. Mineral deposits exploitation

Decree of the ČBÚ No. 104/1988 Coll., **on efficient use of reserved deposits, on permits and notification of mining operations and other activities employing mining methods,** as amended by the Decree No. 242/1993 Coll., No. 434/2000 Coll., and No. 299/2005 Coll.

Decree of the ČBÚ No. 415/1991 Coll., **on construction, the elaboration of documentation and the determination of safety pillars, rods and zones for the protection of underground and surface sites** in the wording of the Decree of the ČBÚ No. 340/1992 Coll., and No. 331/2002 Coll.

Decree of the ČBÚ No. 172/1992 Coll., **on mining leases** in the wording of the Decree No. 351/2000 Coll.

Decree of the ČBÚ No. 175/1992 Coll., **on the conditions of non-reserved mineral deposit exploitation** in the wording of the Decree No. 298/2005 Coll.

Decree of the MŽP ČR No. 363/1992 Coll., **on the survey and registry of old mine workings** in the wording of the Decree of the MŽP No. 368/2004 Coll.

Decree of the MŽP ČR No. 364/1992 Coll., **on protected deposit areas**

Decree of the ČBÚ No. 435/1992 Coll., **on mine surveying documentation during mining and during some operations employing mining methods** in the wording of the Decree of the ČBÚ No. 158/1997 Coll., the Decree No. 298/2005 Coll. and the Decree No. 382/2012 Coll.

Government Provision No. 98/2016 Coll.**, on the royalty tariffs** (of mined out minerals)

Decree of the MPO No. 29/2017 Coll., on mining technical records as amended by the Decree of the MPO No. 287/2021 Coll.

7.2.2. Geological work

Decree of the MŽP No. 282/2001 Coll., **on the registration of geological work**, in the wording of the Decree of the MŽP No. 368/2004 Coll.

Decree of the MŽP No. 368/2004 Coll., **on geological documentation**

Decree of the MŽP No. 369/2004 Coll., **on the planning, execution and evaluation of geological work, on announcing geohazards, and on the procedure for estimating reserves of reserved deposits** as amended by the Decree of the MŽP No. 18/2009 Coll.

7.2.3. Regulations on licensing of mining operations and verification of qualification

Decree of the ČBÚ No. 298/2005 Coll., **on the requirements for professional qualification and competence in mining or operations employing mining methods, and on some legal regulation changes,** in the wording of the Decree No. 240/2006 Coll. and the Decree No. 378/2012 Coll. and Decree No 549/2020 Coll.

Decree of the ČBÚ No. 15/1995 Coll., **on the licensing of mining operations and operations employing mining methods as well as on the development of sites and installations, which constitute these operations,** in the wording of the Decree No. 298/2005 Coll. and the Decree No. 380/2012 Coll.

Decree of the MŽP ČR No. 206/2001 Coll., **on the certificate of qualification for planning, executing and evaluating geological work**

ECONOMY AND MINERALS

Foreign direct investment in mining in the Czech economy

Foreign direct investment (FDI) is an investment of money or money assessable assets and rights made by a company or individual in one country in business interests (e.g. agreement on profit distribution, excercise of effective influence on a company business, minimum stake 10% in a company equity, in a company voting rights) in another country in order to gain share in the business.

FDI = equity (investment of foreign investor into a company equity also equity of branches, daughter and associate companies)
+ reinvested profit (= retained profit of past periods + post-tax profit – dividends)
+ other capital (given and taken credits and debt securities among direct investors and their branches, daughters and associate companies)

Compiled on the basis of the texts:
Foreign Direct Investment – FDI.-(I)INVESTOPEDIA, www.investopedia.com/terms/fdi.asp
Bolotov I. (2015): Diskuse na téma přímé zahraniční investice a a) jejich obecné dopady na Českou ekonomiku b) jejich dopady na strukturu zapojení České republiky do mezinárodního obchodu. 2M0301 „Mezinárodní obchod“, cvičení č. 9. – Katedra mezinárodního obchodu, Fakulta mezinárodních vztahů, VŠE, Praha.

Following tables are based on CNB data and own calculations.

Foreign direct investment in the Czech Republic – state on the date December 31 of the given year (ths CZK unless otherwise stated)

		FDI total	In mining and processing of bituminous and brown coal	In extraction of crude oil and natural gas	In other mining	In supporting activity in mining total	Total in mining activities	Total in mining activities as % of FDI total
2016	Equity	1,569,048,217	11,071,231	1,636,785	3,173,462	81,980	15,963,458	1.02
	Reinvested profit	1,310,028,377	–10,037,497	3,706,865	4,246,086	1,460,430	–624,116	–0.05
	Other capital	245,154,046	1,711,341	–1,594	450,777	–80,547	2,079,977	0.85
	Total	3,124,230,640	2,745,075	5,342,056	7,870,325	1,461,863	17,419,319	0.56
2017	Equity	1,658,868,518	11,065,886	2,000,260	3,166,623	49,746	16,282,515	0.98
	Reinvested profit	1,412,506,549	–13,219,180	5,203,427	3,558,423	355,695	–4,101,635	–0.29
	Other capital	249,895,999	1,617,600	–73,241	608,660	–6,314	2,146,705	0.86
	Total	3,321,271,066	–535,694	7,130,446	7,333,706	399,127	14,327,585	0.43
2018	Equity	1,777,308,973	11,067,039	1,967,942	3,120,295	19,746	16,175,022	0.91
	Reinvested profit	1,538,676,507	–11,878,808	5,350,665	3,653,677	311,780	–2,562,686	–0.17
	Other capital	373,483,090	–16,960	2,378	721,514	–3,761	703,171	0.19
	Total	3,689,468,570	–828,729	7,320,985	7,495,486	327,765	14,315,507	0.39
2019	Equity	1,895,463,899	11,079,777	1,734,419	3,053,555	19,746	115,021	0.01
	Reinvested profit	1,574,898,431	–12,661,050	5,122,983	3,821,021	313,014	309,410	0.02
	Other capital	405,378,216	–16,960	–748	675,286	–3,761	2,821	0.00
	Total	3,875,740,546	–1,598,233	6,856,654	7,549,862	328,999	427,252	0.01
2020	Equity	1,855,120,519	11,079,777	2,358,330	3,053,555	19,746	16,511,408	0.89
	Reinvested profit	1,700,690,103	–12,531,560	5,316,271	3,791,958	312,275	–3,111,056	–0.18
	Other capital	465,981,592	–16,960	–5,067	675,286	–3,761	649,498	0.14
	Total	4,021,792,214	–1,468,743	7,669,534	7,520,799	328,260	14,049,850	0.35
2021	Equity	2,339,446,353	11,127,365	2,398,620	3,907,182	27,830	17,460,997	0,75
	Reinvested profit	1,608,799,545	–11,867,331	5,071,659	4,492,336	284,555	–2,018,781	–0,13
	Other capital	454,837,437	0	498	–298,263	0	–297,765	–0,07
	Total	4,403,083,335	–740,016	7,470,777	8,101,255	312,385	15,144,401	0,34
2022	Equity	4,534,792,931	11,834,054	2,432,662	4,389,529	76,696	18,732,941	0.4
	Reinvested profit	1 894 841 440	–21,190,459	6,098,381	5,018,093	291,307	–9,782,678	–0.5
	Other capital	486,569,226	0	–113	536,983	0	536,870	0.11
	Total	6,916,203,597	–9,56,405	8,530,930	9,944,605	368,003	9,487,133	1.37
2023*	Equity	2,319,612,963	–2,778,088	4,855,391	3,308,898	26,338	5,415,139	0.23
	Reinvested profit	2,011,498,869	–10,584,612	9,116,433	4 790,143	452,530	4,961,533	0.27
	Other capital	550,091,273	0	–2,924,154	–429,373	12,628	–3,340,899	–0.61
	Total	4,881,203,105	–13,362,700	11,047,670	7,669,668	491,496	5,849,438	0.12

* *preliminary data*

Foreign direct investment of the Czech Republic origin abroad – state on the date December 31 of the given year (ths CZK unless otherwise stated)

		FDI total	In mining and processing of bituminous and brown coal	In extraction of crude oil and natural gas	In other mining	In supporting activity in mining total	Total in mining activities	Total in mining activities as % of FDI total
2016	Equity	–	0	0	182,961	0	182,961	0.06
	Reinvested profit	202,345,248	0	0	199,935	0	199,935	0.10
	Other capital	–17,541,072	0	0	–553	0	–553	0.003
	Total	498,070,982	0	0	382,343	0	382,343	0.08
2017	Equity	345,296,757	0	0	191,655	0	191,655	0.06
	Reinvested profit	334,332,372	0	0	121,519	0	121,519	0.04
	Other capital	9,433,924	0	0	0	0	0	0.00
	Total	689,063,053	0	0	313,174	0	313,174	0.05
2018	Equity	476,945,220	0	0	404,039	0	191,655	0.04
	Reinvested profit	383,617,076	0	0	322,281	0	112,480	0.03
	Other capital	60,618,976	0	0	0	0	0	0.00
	Total	921,181,272	0	0	726,320	0	726,320	0.08
2019	Equity	507,292,707	0	249,795**	0	0	249,795	0.05
	Reinvested profit	472,888,590	0	154,112**	0	0	154,112	0.03
	Other capital	40,808,577	0	104**	0	0	104	0.0003
	Total	1,020,989,874	0	404,011**	0	0	404,011	0.07
2020	Equity	516,239,684	0	249,795**	0	0	249,795	0.05
	Reinvested profit	546,529,185	0	140,511**	0	0	154,112	0.03
	Other capital	31,156,826	0	104**	0	0	104	0.00
	Total	1,093,925,695	0	390,410**	0	0	404,011	0.04
2021	Equity	605,483,460	0	0	0	0	0	0,00
	Reinvested profit	441,734,753	0	0	0	0	0	0,00
	Other capital	129,494,133	0	0	0	0	0	0,00
	Total	1,176,712,345	0	0	0	0	0	0,00
2022	Equity	568,764,616	0	0	359,217	616,859	976,076	0.17
	Reinvested profit	578,575,190	0	0	487,681	–25,664	462,017	0.08
	Other capital	124,223,561	0	0	–87,779	0	–87,779	–0.07
	Total	1,176,712,345	0	0	759,119	591,195	1,350,314	0.12
2023*	Equity	618,865,057	746	52,479	234,249	184,585	608,657	0.10
	Reinvested profit	799,862,190	–1,228	1,525,532	545,512	–53,832	2,937,518	0.37
	Other capital	118,780,526	9,713	133	4,378	360,744	374,968	0.32
	Total	1,537,507,773	9,232	1,578,145	784,139	491,497	3,921,142	0.26

** preliminary data*

*** FDI in extraction of crude oil and natural gas and in supporting activity in mining total*

Aggregate deposits in the Czech Republic

Josef Godány

Crushed stone

Crushed stone is along with sand and gravel generally referred as the aggregate. Sufficient available resources of construction raw materials, in particular CS (crushed stone, i.e. crushed aggregates) are needed to develop transport infrastructure, including modern railway corridors and a motorway network, etc. For projects to be ecologically and economically viable it is desirable that the necessary raw materials of suitable quality are as close as possible to the sites of transport structures. The environmentally viable use of local deposits is beneficial to environmental protection as it minimizes the transport of raw materials over long distances. In connection with the gradual use and extraction of existing CS deposits – i.e. for deposits already worked by mining activities (MA) as part of the developing, preparing and mining plan (DPMP) and in the zoning decision according to the activities carried out by mining method (ACMM) – usually a procedure of several years can be considered from preparing the project to mining. Although further expansion or continuation of mining is approached with a reasonable time perspective, until now the Czech Geological Survey (CGS) records projects that have long been solved/prepared for 7 to 11 years with an unclear result. In no case is it immediately possible to use other new resources or continue mining on existing deposits only after the existing deposits are exhausted. For about 30 years, no new stone quarry has been opened in the Czech Republic. Without further extending the existing mining activities or providing the authorization for opening a new aggregate deposit it is not possible to ensure sufficient production of the assortment of adequate quality covering the demand and the need for CS in individual regions, especially near already completed or planned line structures of state or regional importance.

Of the total 326 registered exclusive deposits of CS only 179 were active in 2023 in the Czech Republic, i.e. with mining authorization, and 49 of the total 219 non-reserved mineral deposits had mining authorization. In total there are 228 active stone quarries in the Czech Republic (but only 210 active and reporting production) and their total annual production of CS was 16.7 million m^3 in 2022. The Czech Republic has seemingly large amounts of geological reserves of CS but the volumes of reserves that can be mined are significantly lower (they amount to just over 29% of the total geological reserves) and the reserves with permitted mining are even lower (they amount to less than 29%). The production and consumption of CS has been growing significantly over the last ten years (in 2012 – 12.1 millions m^3, in 2023 – 15.4 millons m^3). The price of construction aggregates are thus rising significantly (on average by CZK 50-150 per ton over the last year). Moreover production fractions of 0/4, 2/4, 2/5 and 4/8 mm are insufficient for the small crushed aggregate (SCA) and production fractions 8/11, 11/16, 16/22, 8/16, 16/32 and 32/63 mm are insufficient for the coarse crushed aggregate (CCA), in particular adequate crushed-run rock for railway beds complying with B0 class. In the medium and long term, the construction and construction material industries have sufficient reserves of production capacity, but the real availability of stocks of input raw materials that are being reduced at a high pace can pose a problem.

Unlike stone quarries, where no new deposits were opened, new sand pits were launched. Most of these deposits have been exploited for a long time, and it is logical that the stocks of raw materials are gradually being mined out. These deposits were mainly developed within defined mining claims (MC) according to the possibilities of gradual expansion and deepening to the extent of the applicable decision until the maximum economical exhaustion of all stocks. Since about 1993 along with mining in reserved deposits of construction raw materials the importance of mining in non-reserved mineral deposits has been gradually increasing as part of planning permits that currently produce high amounts of prime concrete sands and ballast annually and are starting to have a significant share in the total production of construction raw materials in the Czech Republic. Unfortunately, these resources are being gradually exhausted, and new resources for planned use are encountering major issues. Overall, according to the latest statement of the Road And Motorway Directorate of the Czech Republic (RSD) there is clearly a lack of high-quality CCA for asphalt mixtures, a lack of suitable fraction 0/4, 2/4, 4/8 and 8/16 mm for concrete, a combination of many different aggregates in asphalt mix is critical, the necessary amounts of high-quality aggregate for asphalt mixing plants and concrete mixing plants are not secured. The number of complaints and the price of work is also increasing in proportion to the decrease in high-quality natural aggregates.

The 32/63 mm grain fraction BI class railway ballast aggregate has very specific requirements and not every quarry can produce it. Some quarries have a certificate for the 0/32 mm fraction, but do not have a certificate for the BI class 32/63 mm fraction. This is caused mainly because the crushed 32/63 mm fraction class BI aggregate must meet the very strict criterion in the impact crushability and crushing resistance test. Moreover, not the entire deposit but only some parts of it meet these strict criteria. Therefore, each issued certificate always states precisely specified deposit parts which meet the requirements to guarantee the maximum possible quality of the aggregate. These very strict quality conditions are laid down by the relevant regulation – the new General Technical Conditions (GTC), "Aggregates for railway ballast" which replace the GTC ref. no. 59110/2004-O13 in the wording of Amendment No. 1, ref. No. 23155/06-OP effective as of August 1st, 2006 – and these are intended to ensure the long life span of the aggregate in railway constructions. If these parameters were not observed the aggregate is at risk of degenerating and the safety of the operated tracks is compromised.

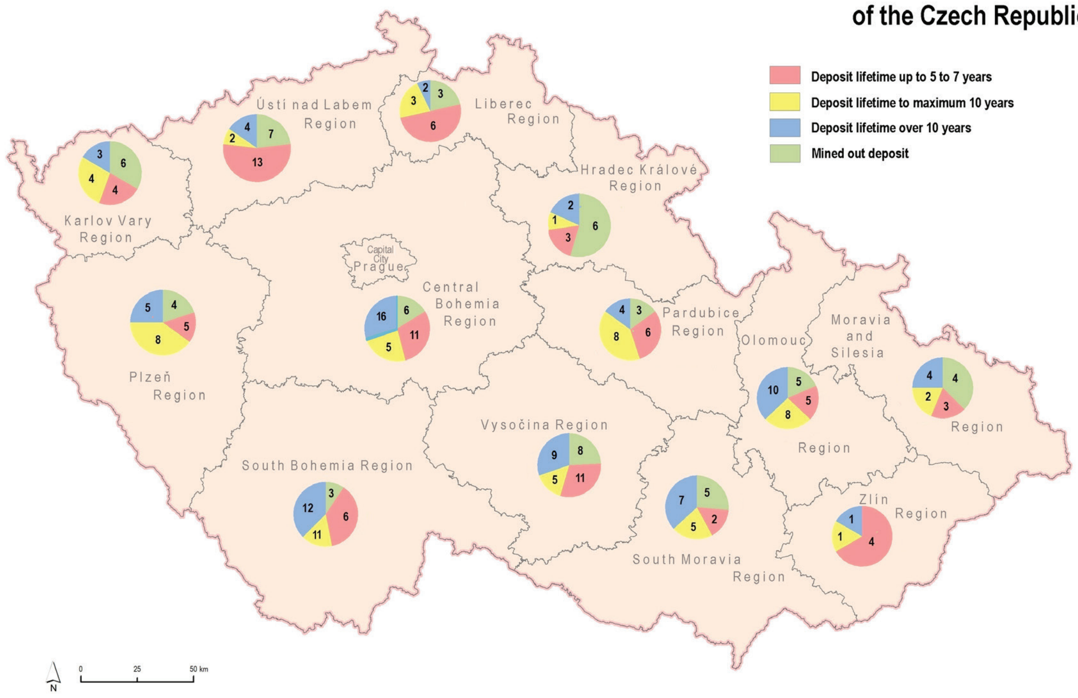
Another aggregate class that will be used in the near future for railway structures is the B0class 32/63 mm fraction. It is the aggregate used in high-speed tracks. In the Czech Republic high-speed construction railway projects with a design speed of 350 km/h are already being prepared. The B0 class 32/63 mm aggregate fraction will needed for all lines from 200 km/h to 350 km/h. The currently proposed criteria have not been approved yet, it is a draft. Also the number of quarries that meet the new requirements for class B0 is not even known. Anyway the requirements for this aggregate will be enormous since only new crushed aggregate is acceptable for safe operation at high speeds. Only 8 quarries with an annual production capacity of 110 thousand tons of high-quality BI class raw material (in the best case B0) meet the current strict criteria for the use of high-quality crushed aggregates when constructing railway corridors which will be part of the European railway network in the Czech Republic In this context, it should also be noted that this fact represents the current state of affairs given the mining progress and readiness of quarries to extract these reserves of stone. Not always when developing individual mining sites does the raw material outside the already excluded technologically unsuitable parts show the constant physical-mechanical parameters across the entire mining profile and the extraction course. In this respect the supply of aggregates for this sector can also be very problematic.

Other factors that will directly affect the actual implementation and delivery of these railway construction materials can particularly include an excessive transport load at the sites intended for supplying current and future construction projects concentrated from a small number of mining sites (sometimes even a single one) for even relatively long distances with significant loss of these natural resources. Furthermore the availability of loading sites for ballast gravel and adequate facilities, i.e. branch lines, shuttle transport to railheads, intermediate loading, bulk storage in one place, complicated operation on secondary lines due to the disconnection of complete trains, the requirements of railway construction for large amounts of materials over a short period of time (line closures, expensive handling and working machines for operations in structural layers of the track bed), the requirements for aggregates from one supplier for the entire section (variety of aggregates, i.e. basalts, greywackes, granites, etc.) and last but not least the production technology equipment allowing the production of the 32/63 mm fraction aggregates for track superstructure, and the 0/32 mm fraction for the track substructure in the required time. The accessibility of the production process breakdown using at least the required two-stage crushing is about 40% of the 32/63 mm fraction and 60% of the 0/32 mm fraction. On average one standard meter of a single-track railway body requires 4 tons of aggregate for the track superstructure and 4 tons for the track substructure.

Each quarry has a different petrographic character, quality and also technological-processing facilities, extraction conditions, geological and structural conditions as well as territorial environmental conditions. Not every quarry produces the same quality of raw material with the identical petrographic type, therefore their production is different and their use on the market as well. Each quarry has specific petrographic characteristics and the quality and technological properties of the raw material and, with respect to the technological possibilities of processing the given raw material, the resulting possible production applicable on the market. The physical-mechanical properties of rocks greatly affect the demand factor of grinding processes when treating mineral resources. The most important physical-mechanical properties include the crushability and abrasiveness of the material being processed. The Wi work index and Ai abrasion index are very important criteria in deciding and choosing the method of crushing. Inappropriate technology can significantly affect the overall processing costs, in particular energy costs and the cost of exchanging machinery action elements. The characteristics of aggregates are specified in the relevant ČSN EN standards. They involve a group of characteristics which are inherent to a rock and whose changes are beyond the real possibilities of aggregate suppliers both financially and technically. In particular they include sulphur content, frost resistance, durability, rate of absorption, strength, polished stone value, Micro-Deval abrasiveness, impact crushability, soft grains, foreign particles of mineralogical nature and partly also crushing resistance.

Not every petrochemical type of rock from crushed and extracted aggregate can be used for example in high-strength and construction concretes or in coated asphalt mixtures, etc. For example crushed limestone is therefore particularly suitable for the underlying films. Crushed stone from sedimentary limestone is not used in construction concrete in the Czech Republic. Crushed limestone is absolutely not allowed to be used as an aggregate for railway ballast, and in particular for structural concrete because of the potential content of unwanted

Number and service life of mined and mined out crushed stone deposits in the regions of the Czech Republic



rocks and minerals (hornstone and SiO_2), which are susceptible to ASR (alkali-silica reaction). Aggregates, especially those used in concrete, are monitored for their resistance to ASR.

The aggregates used in asphalt technologies are monitored for the adhesion of the bonding agent (asphalt) to the aggregate to determine if additives need to be added to the mixture. Basic rocks are considered to be the most appropriate types. The adhesion of asphalt to the aggregate decreases with decreasing alkalinity in approximately the following order: limestone → dolomites → basalts → gabbro→ greywackes → phonolites → diorites → granites → ryolites → porphyries, and porphyrites.

Currently resources of construction raw material deposits licensed for extraction are getting smaller and smaller. A large part of the reserved deposits of non-reserved raw materials are approaching their completion. While the share of recycled products is increasing these are not suitable for standard applications in the linear infrastructure. The required technological characteristics cannot be achieved with these recycled products. Recycled products can be effectively used as an auxiliary material for multiple constructions, but not as the main material. Increasing the share of recycled materials at construction sites is an important aspect due to the growing focus on the circular economy. However, the amounts of recyclates produced from construction and demolition waste are not sufficient. The gradual substitution of primary mineral raw materials by recyclates has certain limits because many applications in the construction sector require high-quality aggregate from primary sources (e.g. high-strength concrete, railway ballast superstructure, etc.). Following recycling the aggregate must meet the technical requirements for gradation, small particle content, fine particle content, grain shape, edge rounding, the content of foreign particles as well as the tests for strength, rate of absorption, resistance to freezing, the proportion of shale grains, the breakdown of basalt. This is because of the precondition of maintaining the original mechanical-physical properties which should be constant. Overall, the technological characteristics of recycled materials in some aspects also cannot meet the requirements for natural materials (e.g. compressive strength, crushing resistance, rate of absorption, resistance to freezing, etc.) and thus their use is significantly reduced. Technological treatment and hygienic analysis of construction and demolition waste (C&D) is extremely demanding and significantly increase the cost of recycled materials and, as a result, its use on the market is more limited compared to primary sources. Another problem with recycling from C&D waste and railway ballast aggregates is that they are more energy demanding than extracting and treating CS, in particular because of high water consumption. Especially at this time when water consumption is growing but its resources are declining rapidly because of the climate change. For recycled C&D waste material it is essential to check the leachability, to carry out sampling by an independent entity, and to introduce a mandatory sampling frequency. Moreover, the aggregate obtained from railway ballast can only be recycled long-term if the actual gradation and the shape index, crushing resistance, abrasion resistance and strength characteristics comply with the strict quality and technological requirements and properties of class B0 and BI, or BII. More often however is the process of crushing aggregates to a smaller fraction that can be used as a track substructure´s structural layer, as an underlying layer of road structures, or as a gravel pack for sealing landfills or for ground reclamation. In practice, the original "gravel" from the ballast bed of refurbished railway lines has been used for many years, at best only from about 60–70% and exclusively on the track substructure of the 0/32 mm fraction layer on completely new construction projects. However the 32/63mm fraction recyclate from the railway ballast superstructure is not applied retrospectively, this application requires a 100% fresh primary raw material from the quarry, just like about 30% of the whole new 0/32mm fraction for the railway ballast substructure. The rest of the 32/63mm and 0/32mm pre-crushed fractions are used for CCA in road construction or concrete, and – in particular – the waste.

Sand and gravel

In connection with the gradual use and extraction of existing sand gavel deposits – i.e. for deposits already worked by mining activities (MA) as part of the development, preparation and mining plan (DPMP) and in the panning permit according to the activities carried out by the mining method (ACMM) – a procedure of several years from the project preparation to mining must be considered. Although further expansion or continuation of mining is approached with a reasonable time perspective, until now CGS records sand and gravel extraction projects that have long been solved/prepared for 5 to 10 years with a very unclear result. In any case it is not immediately possible to use other new resources or continue mining on existing deposits until the existing deposits have been completed. Without further extending the existing mining activities or providing the authorization to open a new sand and gravel deposit sufficient production of the assortment of adequate quality covering the demand and the need for sand and gravel in individual regions cannot be guaranteed, especially near already implemented or planned line structures of state or regional importance.

Of the total 204 registered exclusive deposits of sand and gravel only 75 were active in 2023 in the Czech Republic, i.e. with mining authorization (but only 65 of them were active and reported production), and 102 of the total 324 non-reserved mineral deposits had mining authorization (but only 95 were active and reported production). In total there are 177 active stone sandpits in the Czech Republic (but only 160 active and reporting production) and their total annual production of sand and gravel was 10.3 million m^3 in 2023. In recent years the annual amounts of sand and gravel extraction in the Czech Republic have been very stable – around 6.5 million m^3 (reserved deposits) + about 5 million m^3 (non-reserved deposits). Total aggregate consumption including sand and gravel only in concrete is about 6 million m^3/year in the Czech Republic. Sandpits containing deposits of non-reserved mineral make up the largest share with low resource life. Sand and gravel is the only construction material where non-reserved extraction is not just a supplementary activity but has recently accounted for around 45% (in 2023 43%) of total production. The Czech Republic has seemingly large amounts of geological reserves of sand and gravel but the amount of reserves that can be mined in deposits of non-reserved mineral are significantly lower (555 millions m^3 – just over 26% of the total geological reserves) and the reserves with permitted mining according to DPMP are even lower (133 millions m^3 – slightly more than 6%). This situation is very worrying with regard to ensuring a continuous supply of sand and gravel.

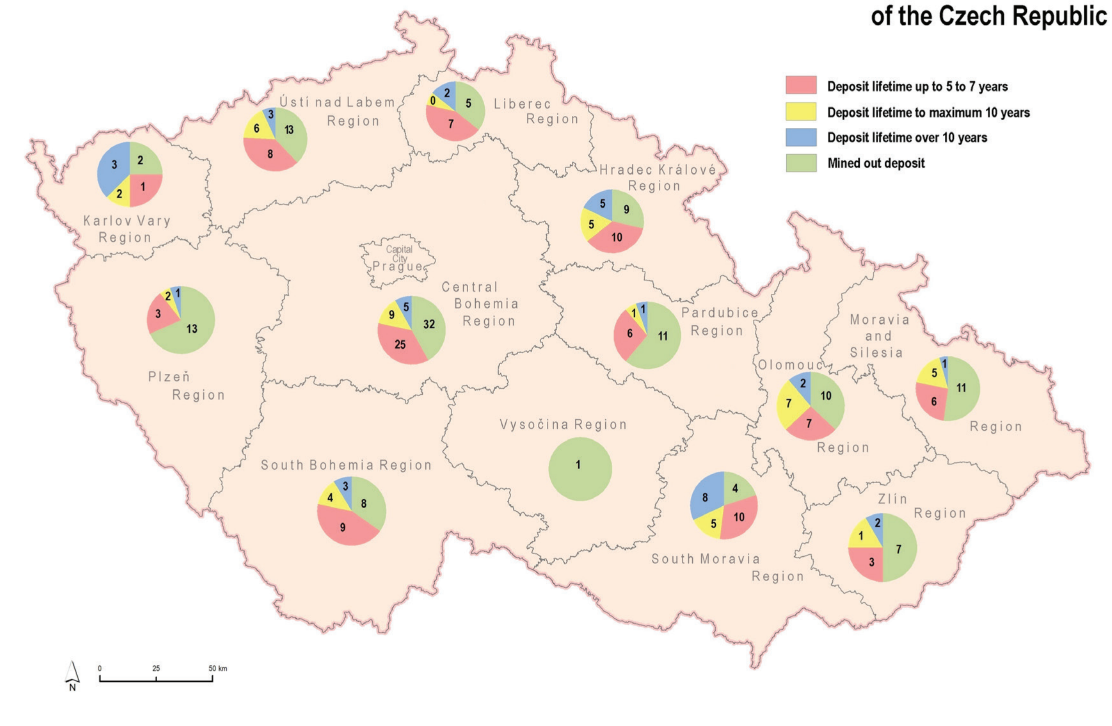
The production and consumption of sand and gravel has been growing significantly over the last 8 years. Prices of extracted construction aggregate prices are also rising significantly (by 15% to 25% per 1 ton on average over the last year). In the medium and long term, the construction and the construction material industries have sufficient reserves of production capacity, but the real availability of stocks of input raw materials that is being reduced at a high rate can pose a problem.

The requirements for the quality and amount of the produced construction materials are getting significantly stricter, and in most regions of the Czech Republic there is a significant shortage of the 4/8, 8/16, 16/32 mm crude fraction. Most of the currently operated deposits produce a predominant 0/4 mm sand fraction at the expense of the coarse fraction. Some regions are heavily deficient in the natural resources of the extracted aggregate, e.g. in the Vysočina Region sand and gravel must be transported from the remote South Bohemian and South Moravian regions. A large part of the Karlovy Vary Region, the Pilsen Region, the Moravian-Silesian Region, the Ústí nad Labem Region (with its only source in the district of Litoměřice and partly Louny), the Zlín Region and the whole southern part of the Central Bohemia Region is starting to have a deficiency of sand and gravel (this even faster deploys the available reserves from the districts of Mělník, Nymburk, Kolín, Praha-východ and Mladá Boleslav). Insufficient sand and gravel crude 4-8-16-32 mm fractions are becoming a problem throughout the country, as the sand fraction predominates over the gravel in most sandpits.

Since about 1993, along with the extraction in reserved deposits of construction minerals the importance of extraction in non-reserved deposits carried out on the basis of relevant planning permission has gradually increased. Non-reserved deposits currently produce high annual amounts of high-quality concrete sand and sand and gravel and are starting to have a significant share in the total production of construction minerals in the Czech Republic. Unfortunately, these resources are being gradually exhausted, and new resources for planned use are encountering major issues.

According to the applicable legislation a new reserved deposit of non-reserved mineral can no longer be determined although in many cases these are more important deposits in terms of use and economy than in many reserved deposits. In addition to reserved deposits non-reserved deposits have been playing an economically more important role recently. These perspective deposits, especially of construction minerals, are very difficult to implement in the territorial planning documentation (e.g. in the land development principles) especially when they are unused/ reserved. In the future, it can be assumed that this contradiction will increase due to completing almost depleted reserved deposits and shortages in raw material on

Number and service life of mined and mined out sand and gravel deposits in the regions of the Czech Republic



the market, as well as progress in the technology of mining and processing mineral resources. After 20 December 1991, i.e. when Act No. 541/1991 Coll., amending and supplementing Act No. 44/1988 Coll., on the Protection and Utilization of Mineral resources (Mining Act) came into force and stipulated that newly defined deposits of non-reserved minerals – building minerals (sand and gravel, crushed stone, stone for rough stone-cutting production, raw minerals for bricks) cannot become reserved deposits and therefore are a part of the land (section 7 of the mining act), the state authorities have withdrawn from any investment in the search for non-reserved minerals.

A major problem in the use of non-reserved mineral deposits includes disproportionate to significantly disadvantaged conditions of payments for the removal of land from the Agricultural Land Fund (ALF) – especially deposits of construction minerals (sand and gravel, etc.) compared to identical activities involving the use of reserved deposits of a non-reserved mineral in the same geological, deposit and environmental conditions. The inadequacy consists mainly in disproportionately higher one-off payments taking into account the environmental weight of effects of various environmental factors (in some cases 10 to 15 times higher). Sandpits from the deposits of non-reserved minerals where extraction is not only a supplementary activity but contribute to the total production by roughly 45–47% of all used sand and gravel deposits in the Czech Republic have the largest share of low life resources. The amount of these payments is currently devastating the vast majority of non-reserved sand and gravel deposits. These are the deposits with extraction from water where neither technology nor the legislation allows their reclamation to arable soil.

While the share of recycled products is increasing these are not suitable for standard applications in the linear infrastructure. The required technological characteristics cannot be achieved with these recycled products. Recycled aggregates are typically far worse in quality and their use in the upper and most heavily loaded layers of roads is technologically highly restricted or even excluded. Recycled products can be effectively used as an auxiliary material for multiple constructions, but not as the main material. Increasing the share of recycled materials at construction sites is an important aspect due to the growing focus on the circular economy. However, the amounts of recyclates produced from construction and demolition waste are not sufficient. According to the Association for the Development of Recycling building materials in the Czech Republic the use of recyclates in the construction industry is increasing, but its pace is relatively slow. It follows from the data of the Association that, for example, between 2007 and 2011 the ratio of recyclate production to the production of crushed stone and sand and gravel was around 4%. In 2018-2022 this was already 18%, an increase of three and a half times. The gradual substitution of primary mineral raw materials by recyclates has certain limits because many applications in the construction sector require high-quality extracted and crushed aggregate from primary sources (e.g. high-strength concrete, railway ballast superstructure, etc.). Following the recycling the aggregate must meet the technical requirements for gradation, small particle content, fine particle content, grain shape, edge rounding, the content of foreign particles as well as the tests for strength, rate of absorption, resistance to freezing, the proportion of shale grains. This is because of the precondition of maintaining the original mechanical-physical properties which should be constant. Due to reuse recycled aggregates lose the required quality parameters. Therefore many construction projects do not even permit the use of recyclates and consistently require the use of primary raw minerals.

Conclusion

Overall, most of the current resources of sand and gravel and crushed aggregate were opened before 1989, in the best case some sand and gravel deposits in the nineties of the last century. Most large gravel resources have a real life span of 7, max. 15 years. This implies that if the process of "recovery" of some substantial deposit of the extracted aggregate is now started, it can be assumed that the actual extraction commences at the earliest in 2027-2035, when many existing deposits will be inactive. Without certain substantial changes in the settings of all steps – including the legislation – that would allow the use of deposits of the extracted aggregate, this "critical" situation will undoubtedly occur. The industrial acquisition of mineral deposits is usually very costly and is associated with a high risk expressed by differences between evaluated assumptions and financial or other economic results and the consequences of their use. The results of the economic and financial evaluation must provide potential investors with evidence of the economic viability of the project, the expected profit level of investment projects that are offered. Unfortunately, the current setting of approval processes in the framework of the valid legislation of the Czech Republic does not allow potential investors to find the necessary degree of certainty and success for the economic return of significant funds put in investment projects over the long term, i.e. geological surveys, opening and exploiting new deposits of natural mineral resources for construction and other purposes. The administrative procedure for obtaining authorization for opening, preparing and exploiting mineral deposits is very complex and lengthy, and replacing the capacities of already depleted or almost depleted mineral deposits with new ones is not taking place at an adequate pace. Therefore, in some localities of the Czech Republic an imbalance arises between the demand and supply of mainly the raw minerals needed for construction sector.

The factors affecting this situation include, among other things, often hard to solve conflicts of interest between landowners and mining companies, meeting very strict conservation and environmental protection requirements and other partial environmental elements (in particular, protecting the agricultural land resources and groundwater resources), the emergence of generally negative public experience with mineral extraction. Media campaigns, which often publish any inadmissibility of mining under any conditions at a particular location during administrative proceedings without the possibility of confronting and applying compromise solutions, are also contributing to this undesirable situation.

It must be realized that the largest part of the high-quality sand and gravel and sand in the Czech Republic comes from the extraction from water and the deposits of sand and gravel in Olomouc, Zlín, South Bohemia regions are mostly situated in protected areas of natural water accumulation (CHOPAV). Under the same conditions, i.e. in the CHOPAV and in the water resources protection zone (OPVZ) classes I and II, a number of projects for extracting sand and gravel deposits were or are permitted, without significant conflict and threats to the quality and yield of groundwater.

In the medium and long term, the construction and the construction material industries have sufficient reserves of production capacity, but the real availability of reserves that is being reduced at a high pace can pose a problem. Currently resources at construction raw mineral deposits licensed for extraction are getting smaller and smaller. Although there is a large number of resources and amounts of geological reserves of crushed stone and sand and gravel recorded in the Czech Republic, the real reserves in MC and in planning permissions usable for business are very low. In the near future possible gradual outages of available resources of construction minerals can be expected and the end of the operating life of a large part of existing stone quarries and sandpits at the same time. This worrying situation will result in the available reserves in the Czech Republic being depleted in a short horizon (i.e. under 10 years) resulting in the risk of not meeting the economic needs of the state.

In connection with the gradual use and depletion of existing sand and gravel deposits a procedure lasting several years can normally be assumed – from preparing the project to mining. Although further expansion or continuation of new mining is approached with a reasonable time perspective, until now there are registered projects that have long been solved/prepared for 7 to 9 years with an unclear result. In any case, it is not immediately possible to use other new resources or continue mining on existing deposits until the existing deposits have been completed. Without the authorization to open a new sand and gravel deposit sufficient production of the assortment of adequate quality covering the demand and the need for the extracted aggregate in individual regions or the entire CR cannot be guaranteed, especially near already implemented or planned line structures of state or regional importance.

EU and other global players efforts to reduce their raw material dependence

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Pavel Kavina, Ph.D., Czech Geological Survey

Many countries in the world perceive securing sufficient mineral inputs for their economies as an absolutely crucial task with a direct impact on national security. Japan probably has the most sophisticated system that works well. As a country with limited natural resources, Japan has for many decades recognized the importance of securing a stable supply of critical minerals necessary for its high-tech industries, including electric vehicles, advanced electronics and renewable energy technologies. Japan's approach to ensuring a steady flow of these materials is multifaceted and includes international partnerships, investment in alternative technologies, and promotion of the use of scarce domestic resources. Japan currently uses the state agency Japan Organization for Metals and Energy Security (JOGMEC) in combination with the extensive activities of the Japan International Cooperation Agency (JICA) to ensure its raw material security. JOGMEC has offices in 12 countries around the world.

South Korea, where the Korea Resources Corporation (KORES) plays a key role, places a similarly high priority to Japan in ensuring a secure supply of abundant mineral resources. KORES is wholly owned by the Korean government and has a strong mandate to develop South Korea's access to strategically important mineral resources, both domestically and internationally. KORES fulfils the resource policy objectives of the Korean government in the field of mineral resources by participating directly or indirectly through joint ventures or minority investments in the exploration, development and production of strategically important mineral resources abroad and managing strategic mineral commodity reserves. At the end of 2023, the Government of Korea published a list of 33 critical mineral commodities, including ten "supercritical" mineral commodities (lithium, nickel, cobalt, manganese, graphite and five REEs: neodymium, dysprosium, terbium, cerium, lanthanum).

Over the last 15 years, China has been extremely active and very assertive in securing sufficient raw material resources abroad, both in Africa, Latin America and Asia. Among many other activities in this area, and in addition to its active raw materials diplomacy around the world, China hosts the Forum on China-Africa Cooperation every three years, which focuses primarily on mineral and energy cooperation.

Issues related to the security of supply of critical minerals have received attention in the US for about 15 years. Wider awareness of the importance of critical minerals began to spread in 2008 with the publication of the report Minerals, Critical Minerals, and the U.S. Economy (National Research Council, 2008). International news media subsequently highlighted the vulnerability of the rare earth element (REE) supply chain when China threatened to cut off supplies to Japan over a territorial dispute in the East China Sea (New York Times, 2010). This event set off a chain of responses by the US government and other market economies to address these concerns. Important steps in the United States included the development of a critical minerals screening methodology led by the US Geological Survey (USGS). The critical minerals screening methodology provided the framework for the development of the first U.S. critical minerals list (Fortier et al. 2018; Federal Register, 2018), as mandated by Executive Order (EO) 13817 (Federal Register, 2017). It was also one of the bases for the development of the Federal Strategy for Ensuring a Safe and Secure Supply of Critical Minerals, which was mandated by the same order (Federal Strategy, 2019). In 2022, a list of the 50 U.S. critical minerals was published, which includes the following commodities: aluminum, antimony, arsenic, baryte, beryllium, bismuth, cerium, cesium, chromium, cobalt, dysprosium, erbium, europium, fluorspar, gadolinium, gallium, germanium, graphite, hafnium, holmium, indium, iridium, lanthanum, lithium, lutetium, magnesium, manganese, neodymium, nickel, niobium, palladium, platinum, praseodymium, rhodium, rubidium, ruthenium, samarium, scandium, tantalum, tellurium, terbium, thulium, tin, titanium, tungsten, vanadium, ytterbium, yttrium, zinc, and zirconium.

The European Union began to look more deeply into the issue of ensuring the availability of mineral resources for the European economy sometime in 2006. The importance of this issue for the European continent was emphasized in the European Commission, in particular by Finland, Sweden, Portugal, Spain, Greece, Poland and the Czech Republic, which was at the very beginning of European measures to strengthen raw material security. The first result was the preparation and publication of an integrated Raw Materials Strategy by the Raw Materials Initiative, which was prepared by the team of European Commission Vice-President Günter Verheugen with the contribution of experts from the above-mentioned countries. The strategy was published in November 2008 under the title “The raw materials initiative – meeting our critical needs for growth and jobs in Europe” (COM (2008) 699 final). The Raw Materials Initiative was built on three main pillars: to re-examine domestic (European) raw materials potential using modern methods, to build mutually beneficial relationships with countries that have a wide range of raw materials potential and to promote the development of material-efficient technologies. Subsequently, a first list of EU critical minerals (14 commodities) was drawn up in 2011 and updated every three years. The last update of the EU›s list of critical minerals was in 2023. The fifth list of critical and strategic minerals already includes 34 mineral commodities: antimony, arsenic, baryte, bauxite, beryllium, bismuth, boron/borate, cobalt, coking coal, copper, feldspar, fluorspar, gallium, germanium, hafnium, helium, lithium, magnesium, manganese, natural graphite, nickel, niobium, platinum group metals, phosphate rock, phosphorus, REE (light & heavy), scandium, silicon, strontium, tantalum, titanium metal, tungsten and vanadium. In March 2023, the Critical Raw Materials Act, a regulation of the European Parliament and the European Council, was proposed, debated and subsequently approved as the first legislative measure to provide a framework for ensuring a secure and sustainable supply of critical raw materials to the EU.

Czech critical raw material imports dependency screening

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Methodology and data sources

Data on resources, reserves and extraction of CRM in the Czech Republic were obtained from the databases of the Czech Geological Survey, while data on imports and exports of CRM were obtained from the database of the Czech Statistical Office (CSO). Data on domestic consumption of CRM, i.e. the total volume of raw materials directly used in the economy, were calculated using the internationally respected method where domestic material consumption is defined as "the annual volume of raw materials extracted in a given territory plus all physical imports of a given raw material minus all physical exports" (OECD 2023, USGS 2023). Data on imports and exports were obtained from the CSO database "Movement of Goods across Borders"[1], which obtains data from the Customs Administration of the CZ by tracking the flow of goods according to HS codes.[2] The HS codes in this research are based on the Harmonized Commodity Description and Coding System, an international system for the identification and classification of goods. In some cases where international differences in HS codes existed for some of the commodities, the EU classification (EU Access2Markets) was used).[3] The HS codes of the specific CRMs are given for each commodity import dependency table. When analyzing the source countries, it is important to consider that tracking trade across borders does not always allow to identify the actual country of origin of the raw material, as the database does not track the entire supply chain. If the raw material is extracted in one country and processed in another, the database registers not the country of extraction as the source country, but the country of processing from where the raw material was imported into the CZ. As a result, even countries that do not obviously mine the raw material themselves (e.g. typically the Netherlands, Luxembourg or, in some cases, Germany, Austria and UK) appear among the supplier countries. In some cases, these may even be re-exports before import into the CZ.

The import and consumption of CRM is reported in accordance with the entire concept of the yearbook for the last five years, i.e. for the period January 2019 to December 2023. Data for 2019 allows tracking the evolution of consumption and supply prior to the COVID pandemic, 2020–2021 generally shows a drop-in consumption during the global pandemic,

1 https://apl.czso.cz/pll/stazo/STAZO.STAZO

2 In 2023, the CZSO launched a new database "Foreign Trade in Goods". Although the CSO announces that this database is slightly more accurate in terms of detecting actual trade between residents and non-residents of the Czech Republic, it is unusable for the purposes of our research for two reasons. First, it only provides data on the value of traded goods, not the weight, which makes it impossible to assess the evolution of trade volume and CRM consumption in an era when CRM prices change rapidly and significantly. Second, the new database only provides data from 2020 onwards, which means that it does not provide a long enough time series to assess the evolution of CRM trade. Moreover, given the COVID pandemic or its impact on extraction, production and supply chains, data for 2020 to 2021 cannot be considered sufficiently indicative.

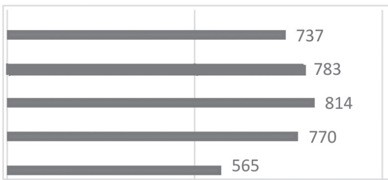
3 trade.ec.europa.eu/access-to-markets/en/content/harmonised-system-0

and data for 2022–2023 shows how CRM supply changed after the Russian invasion of Ukraine.

In the case of some commodities, e.g. phosphorus, magnesium, platinum group metals or in some years e.g. graphite, domestic material consumption is negative. This is due to the fact that there are companies operating in the Czech Republic that produce, refine or otherwise upgrade a given commodity or group of commodities from imported raw materials and subsequently the commodity is exported abroad in significant volumes, e.g. Fosfa a.s. (phosphorus) or Safina a.s. (platinum metals). In some specific cases, there may also be an impact of commodity trades on the overall balance of Czech foreign trade.

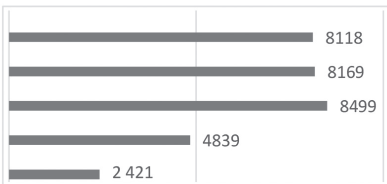
ANTIMONY (HS 261710, *HS 282580, HS 8110*)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100	737	China (37%), France (25%)
2020	100	783	USA (36%), France (35%)
2021	100	814	France (37%), USA (34%)
2022	100	770	USA (42%), France (31%)
2023	100	565	USA (36%), France (35%)



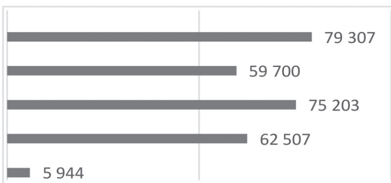
ARSENIC METAL (HS 280480)

Year	Import reliance (%)	Czech consumption (kg)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100	8118	China (99%)
2020	100	8169	China (99%)
2021	100	8499	China (87%), Luxemburg (12%)
2022	100	4839	China (99%)
2023	100	2 421	China (99%)

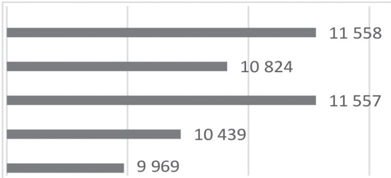


BAUXITE and ALUMINIUM UNWOUGHT (HS 2606, *HS 76011000*)

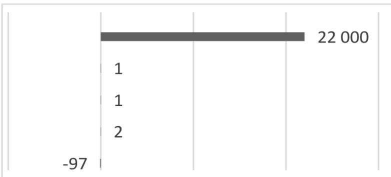
Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100	79 307	Russia (30%), Mozambique (16%)
2020	100	59 700	Russia (26%), Mozambique (22%)
2021	100	75 203	Russia (21%), Canada (18%)
2022	100	62 507	Island (14%), Venezuela (14%)
2023	100	5 944	Bosnia (44%), China (43%)



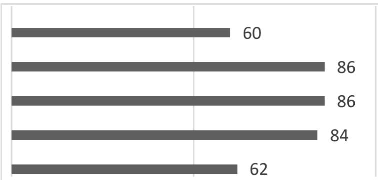
BARYTES (HS 2511, *HS 283327, HS 283660*)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100	 11 558	China (31%), Spain (21%)
2020	100	10 824	China (25%), Spain (24%)
2021	100	11 557	China (33%), Spain (20%)
2022	100	10 439	Germany (28%), Spain (21%)
2023	100	9 969	China (34%), Germany (21%)

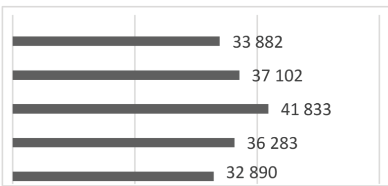
BERYLLIUM (HS 811212, HS 261790, *HS 28259020*)

Year	Import reliance (%)	Czech consumption (kg)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100	 22 000	Ukraine (100%)
2020	100	1	USA (100%)
2021	100	1	USA (100%)
2022	100	2	USA (50%), Germany (50%)
2023	100	-97	USA (100%)

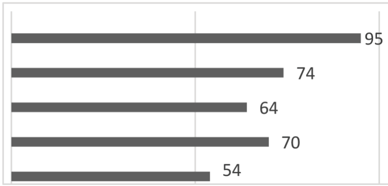
BISMUTH (HS 8106)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100	 60	Netherlands (39%), China (24%)
2020	100	86	China (63%), Korea (16%)
2021	100	86	China (91%), UK (4%), Germany (2%)
2022	100	84	Netherlands (64%), China (28%)
2023	100	62	China (88%), Slovakia (3%), UK (3%)

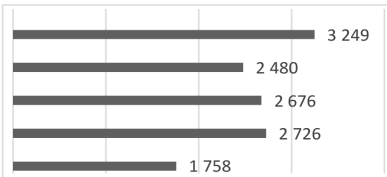
BORON/BORATE (HS 2528, *HS 2840*, *HS 281000*)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100	 33 882	Turkey (94%)
2020	100	37 102	Turkey (97%)
2021	100	41 833	Turkey (96%)
2022	100	36 283	Turkey (97%)
2023	100	32 890	Turkey (97%)

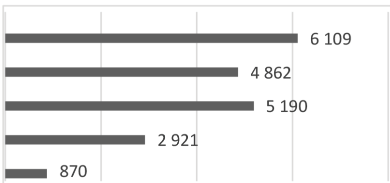
COBALT (HS 2605, HS 8105, *HS 28220000, HS 28273400, HS 29152300*)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		UK (28%), USA (16%), Canada (12%)
2020	100		UK (42%), USA (16%), Finland (13%)
2021	100		UK (32%), USA (13), Belgium (13%)
2022	100		UK (39%), USA (20%), Finland (13%)
2023	100		UK (29%), USA (20%), Finland (14%)

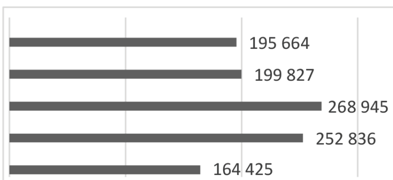
COKING COAL (HS 27011210)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	50		Poland (67%), Canada (17%)
2020	55		Poland (84%), USA (12%)
2021	60		Poland (67%), Canada (16%)
2022	65		Poland (65%), USA (13%)
2023	62		Poland (72%), USA (14%)

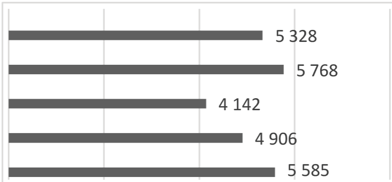
COPPER (HS 2603, *HS 7402, HS 7403*)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Germany (72%), Poland (15%)
2020	100		Germany (71%), Poland (19%)
2021	100		Germany (68%), Poland (22%)
2022	100		Germany (61%), Poland (26%)
2023	100		Germany (52%), Poland (34%)

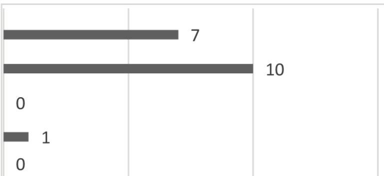
FELDSPAR (HS 252910)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	0		Germany (82%), France (9%)
2020	0		Germany (96%), Turkey (3%)
2021	0		German (96%), Turkey (2%)
2022	0		Germany (94%), Turkey (2%),
2023	0		Germany (93%), Turkey (2%)

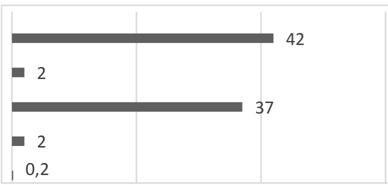
FLUORSPAR (HS 25292100, HS 25292200)[4]

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Germany (44%), Netherlands (42%)
2020	100		Germany (44%), Netherlands (34%)
2021	100		Netherlands (49%), Germany (31%)
2022	100		Netherlands (45%), Germany (37%)
2023	100		Netherlands (43%), Germany (41%)

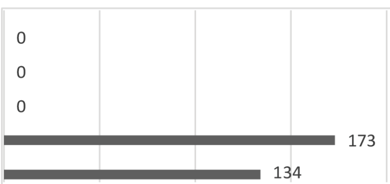
GALLIUM (HS 81129289)

Year	Import reliance (%)	Czech consumption (kg)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		China (86%), USA (14%)
2020	100		China (100%)
2021	-		—
2022	100		USA (100%)
2023	-		—

GERMANIUM (HS 811292, HS 811299)

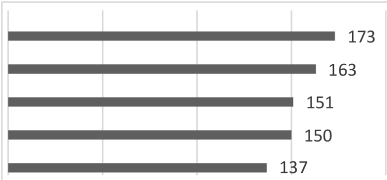
Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Brazil (93%), Austria (3%)
2020	100		Austria (60%), Poland (27%)
2021	100		Russia (80%), Austria (10%)
2022	100		Germany (44%), Poland (37%)
2023	100		Austria (56%), France (11%)

HAFNIUM (HS 81123100, HS 81123900, HS 81129210)

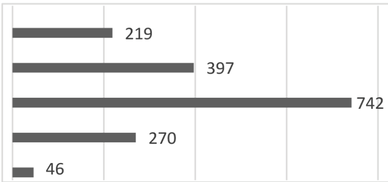
Year	Import reliance (%)	Czech consumption (kg)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	-		—
2020	-		—
2021	-		—
2022	100		USA (67%), Austria (19%)
2023	100		USA (88%), China (12%)

[4] The calculation does not include *HS 28111100, HS 28263000, HS 28261200*. The Czech consumption of HS 28111100 between 2018-2023 was 2,709 tones, of HS 2826300 in the same period it was 0 tones, of HS 28261200 it was 1,462 tones.

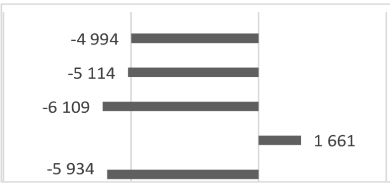
HELIUM (HS 28042910)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Germany (54%), Italy (14%)
2020	100		Germany (57%), Italy (13%)
2021	100		Germany (46%), Hungary (18%)
2022	100		Germany (38%), Hungary (17%)
2023	100		Germany (36%), Hungary (20%)

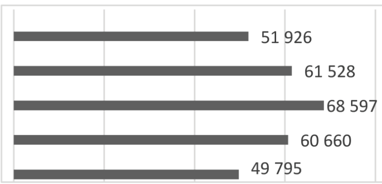
LITHIUM (HS 20121955, HS 20134350, *HS 28252000, HS 28369100*)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Zimbabwe (44%), Netherlands (11%)
2020	100		Netherlands (45%), Zimbabwe (39%)
2021	100		Netherlands (56%), Zimbabwe (21%)
2022	100		Zimbabwe (50%), Netherlands (17%)
2023	100		Chile (30%), UK (26%)

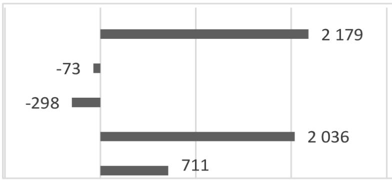
MAGNESIUM METAL (*HS 8104, HS 28273100*)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Germany (54%), China (25%)
2020	100		Germany (32%), China (27%)
2021	100		China (31%), Romania (13%)
2022	100		China (55%), Germany (15%)
2023	100		China (30%) Romania (17%)

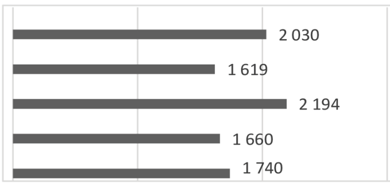
MANGANESE (HS 2602, *HS 2820, HS 720211, HS 8111*)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Ukraine (26%), France (15%)
2020	100		Ukraine (22%), Gabon (18%)
2021	100		Bulgaria (68%), Slovakia (9%)
2022	100		Bulgaria (52%), Gabon (14%)
2023	100		Gabon (44%), Bulgaria (21%)

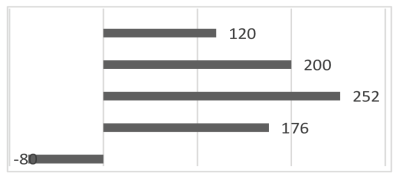
NATURAL GRAPHITE (HS 2504)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Mozambique (29%), Germany (20%)
2020	100		Germany (30%), China (22%)
2021	100		Germany (42%), China (22%)
2022	100		China (58%), Germany (15%)
2023	100		China (54%), Germany (12%)

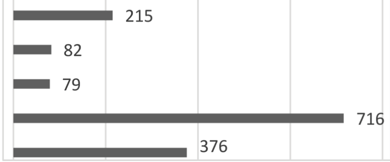
NICKEL (HS 2604, *HS 750210*, HS *7504000, HS 28254000, HS 75011000*)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Russia (44%), Australia (10%)
2020	100		Finland (28%), Russia (13%)
2021	100		Russia (21%), Finland (20%)
2022	100		Finland (28%), Russia (18%)
2023	100		Russia (54%), Madagascar (7%)

NIOBIUM (HS 26159000, HS 26159010, *HS 72029300*)

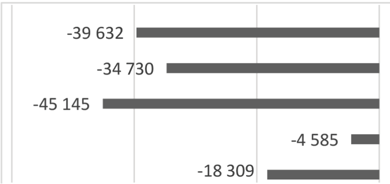
Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Brazil (93%), China (3%)
2020	100		Brazil (99%)
2021	100		Brazil (96%), Sierra Leone (3%)
2022	100		Brazil (100%)
2023	100		Brazil (94%), Canada (3%)

PHOSPHATE ROCK (HS 2510)[5]

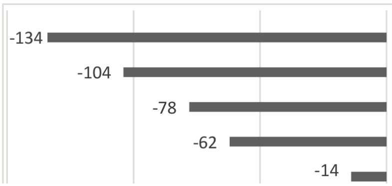
Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Austria (34%), Poland (32%)
2020	100		Austria (94%), Italy (5%)
2021	100		Poland (91%), Italy (9%)
2022	100		Austria (99%), Italy (1%)
2023	100		Austria (96%), Italy (2%)

[5] Phosphates and phosphorus are sometimes classified in one category (e.g. SCREEN3), sometimes (e.g. in the Critical Resources Act) they are classified separately. This is how we are proceeding here.

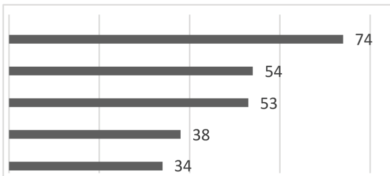
PHOSPHORUS (HS 2809, HS 28047010)[6]

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Netherlands (54%), Germany (15%)
2020	100		Netherlands (72%), Germany (12%)
2021	100		Netherlands (60%), Germany (13%)
2022	100		Belgium (19%), China (17%)
2023	100		China (35%), Serbia (29%)

PLATINUM GROUP METALS (HS 7110, HS711510)[7]

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Ireland (74%), Poland (8%)
2020	100		Germany (63%), Ireland (15%)
2021	100		Germany (50%), Austria (19%)
2022	100		Germany (75%), UK (6%)
2023	100		Germany (33%), Netherlands (19%)

RARE EARTH ELEMENTS (HS 28461000, HS 28469010, HS 28469020, HS 28053010, HS 28053020, HS 28053030)[8]

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Austria (55%), China (28%)
2020	100		Austria (44%), China (37%)
2021	100		Austria (50%), China (37%)
2022	100		Austria (58%), China (31%)
2023	100		Austria (85%), China (6%)

6 Phosphates and phosphorus are sometimes classified in one category (e.g. SCREEN3), sometimes (e.g. in the Critical Resources Act) they are classified separately. This is how we are proceeding here.

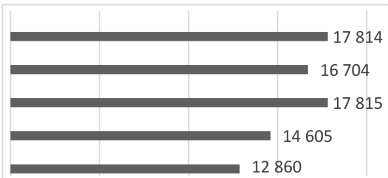
7 The group includes palladium, platinum, rhodium, iridium, osmium and ruthenium. HS 711292 (waste and scrap of platinum) is not included. Import of HS 711292 into Czech Republic between 2018 and 2023 was 1,068 tons with major importers Nigeria (796 tones and UK 141 tones), export 115 tons. The Czech Republic is a significant producer of PGMs from imported scrap. This explains the negative figure for Czech PGM consumption.

8 Cerium compounds, compounds of lanthanum, praseodymium, neodymium or samarium, inorganic or organic, compounds of europium, gadolinium, erbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium or yttrium, inorganic or organic, intermixtures or interalloys of rare-earth metals, scandium and yttrium

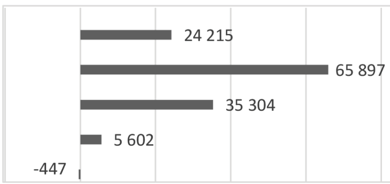
SCANDIUM (HS 28053040, HS 28469030)

Year	Import reliance (%)	Czech consumption (kg)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		USA (100%)
2020	100		China (70%), USA (30%)
2021	100		Germany (90%), China (10%)
2022	-		-
2023	100		China (99%), USA (1%)

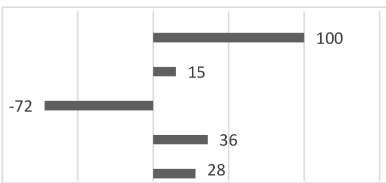
SILICON METAL (HS 720221, HS 280461)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Slovakia (36%), Ukraine (11%),
2020	100		Slovakia (41%), Kazakhstan (11%)
2021	100		Slovakia (36%), Poland (9%)
2022	100		Slovakia (34%), Malaysia (11%)
2023	100		Slovakia (31%), Kazakhstan (14%)

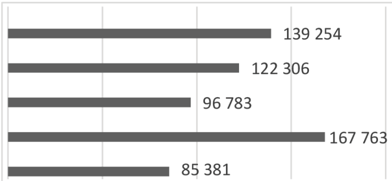
STRONTIUM METAL (HS 28051910)

Year	Import reliance (%)	Czech consumption (kg)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Poland (94%), Germany (6%)
2020	100		China (73%), Poland (26%)
2021	100		China (68%), Poland (27%)
2022	100		Poland (80%), Germany (20%)
2023	100		Poland (67%), Germany (33%)

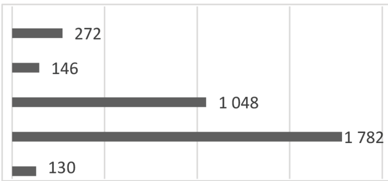
TANTALUM (HS 26159060, *HS 8103*)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Thailand (39%), China (33%)
2020	100		China (35%), Japan (27%),
2021	100		China (89%), Japan (9%)
2022	100		China (51%), Japan (23%)
2023	100		Japan (37%), Thailand (30%)

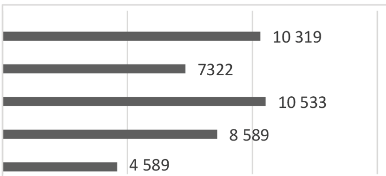
TITANUM (HS 2614, *HS 8108*, *HS 28230000, HS 26209960*)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Ukraine (97%)
2020	100		Ukraine (97%)
2021	100		Ukraine (95%)
2022	100		Ukraine (94%)
2023	100		Ukraine (96%)

TUNGSTEN (HS 8101, HS 2611, HS 28259040, *HS 28418000*, *HS 72028000, HS 28499030*)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		USA (50%), Vietnam (17%)
2020	100		USA (72%), Poland (5%)
2021	100		USA (66%), Germany (7%)
2022	100		USA (42%), Poland (11%)
2023	100		USA (56%), Poland (24%)

VANADIUM METAL (HS 26159000, HS 26159090, *HS 28253000*, *HS 81129291*)

Year	Import reliance (%)	Czech consumption (t)	Main Czech suppliers (%) (extraction and *processing* stage)
2019	100		Russia (93%), Austria (6%)
2020	100		Russia (92%), Austria (7%)
2021	100		Russia (95%), Austria (4%)
2022	100		Russia (95%), Austria (4%)
2023	100		Russia (82%), Austria (13%)

Geological survey of deep-sea polymetallic nodules in the interoceanmetal exploration area

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Introduction

The exploration rights of the Interoceanmetal Joint Organization (IOM) are granted to an area located within the Clarion-Clipperton Zone (CCZ) in the eastern central Pacific Ocean. All activities related to exploration of minerals in the Area (the seabed and ocean floor beyond the limits of national jurisdiction) come under the United Nations Convention on the Law of the Sea (1982), the Agreement relating to the implementation of Part XI of the Convention (1994) as well as Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area – regulations established by the International Seabed Authority (ISA). The ISA currently has 168 member states, including Czech Republic and the European Union as a whole.

The ISA issues legal documents regulating the conduct of research and the future use of the seabed. The IOM´s contract for exploration of polymetallic nodules was granted for 15 years and provided the contractor security of tenure and exclusive right to explore for polymetallic nodules in the exploration area, as well as to move to a contract for exploitation (regulations for exploitation of mineral resources in the Area are under the development process by the ISA). In 2016, and 2021 respectively, the contract has been extended and is valid till 2026.

In addition to geological survey, IOM is working on research into the technology of mining and processing of deep-sea polymetallic nodules (PMN), as well as on environmental research.

Brief history of the IOM license area

The Interoceanmetal Joint Organization was established on 27 April 1987, based on the Intergovernmental Agreement between seven states: Bulgaria, Cuba, Czechoslovakia, East Germany, Poland, Soviet Union and Vietnam. IOM started its business operations in December 1987. Registered in the District Court in Szczecin, Poland, as an international company, in accordance with the Polish law it obtained the legal personality on 16 December 1987. In 1989, Vietnam suspended its membership in the organization. In 1990, after the unification of Germany, GDR (East Germany) separated from IOM. In January 1992, the USSR duties and obligations were taken over by the Russian Federation. On 31 December 1992, the liabilities of the former Czechoslovakia were taken over by the Czech Republic and the Slovak Republic.

IOM did a preliminary study of a 546,000 km^2 area located in the eastern part of the CCZ, during which a perspective area of 300,000 km^2 with the highest rate of nodule abundance was selected. On 30 July 1992, the General Secretary of the United Nations awarded IOM and its member states the Certificate of Registration, whereby IOM became the pioneer investor. The registered pioneer area of IOM covered 150,000 km^2. On 29 March 2001, IOM and the International Seabed Authority signed a contract for polymetallic nodules exploration within the 75,000 km^2 area.

Location

The IOM exploration area covers app. 75,000 km2 of the eastern part of the CCZ and consists of two sectors, B1 and B2 (Fig. 1). In B2 sector there are four exploration blocks (H11, H22, H33, H44) and preliminary delineated Preservation Reference Zone (Tab. 1, Fig. 2). Within the H22 exploration block the H22_NE exploitable block was delineated. Preservation Reference Zone (PRZ) is an area in which no mining shall occur to ensure representative and stable biota of the seabed in order to assess any changes of the marine environment. The obligation of establishing the PRZ in its license area is imposed on the contractor by the ISA. Delineation of the PRZ in the IOM exploration area is preliminary and the final location is being considered.

Adjacent properties (common borders) to the IOM exploration area belong to 4 organizations – NORI (Nauru), OMS (Singapore), BGR (Germany) and BMJ (Jamaica). The BMJ exploration area was delineated in April 2021 and reflects generally increased interest in deep sea mineral exploration in the area that has emerged during the past decade. 11 out of a total 19 exploration contracts has been signed in the 2011–2021 period.

Tab.1. IOM´s Exploration area (sectors and blocks). Areas are calculated in UTM map projection coordinate system.

Exploration area	Area (km^2)
B1 sector	11 952
B2 sector	63 234
– H11 exploration block	5 390
– H22 exploration block	4 151
– - H22_NE explotable block	957
– H33 exploration block	4 008
– H44 exploration block	1 919
– PRZ (preliminary)	2 626
Total	**75 186**

Exploration methods

Before 2001, 21 research expeditions were carried out to the CCZ area, mainly focused on regional research. Since the signing of the exploration contract between ISA and IOM in 2001, 6 expeditions have been organized. The work was carried out in accordance with the program approved by the ISA. The study included a geological survey focused on determination of PMN abundance, nodule coverage, determination of metal content and chemical composition of PMNs, as well as study of seabed sediments, their geotechnical properties. During the expeditions, basic oceanographic, meteorological and environmental data were collected.

Distance methods used during expeditions include:

- multibeam bathymetry,
- geoacoustic survey (side-scan sonar and sub-bottom profiler),
- photo and video profiling.

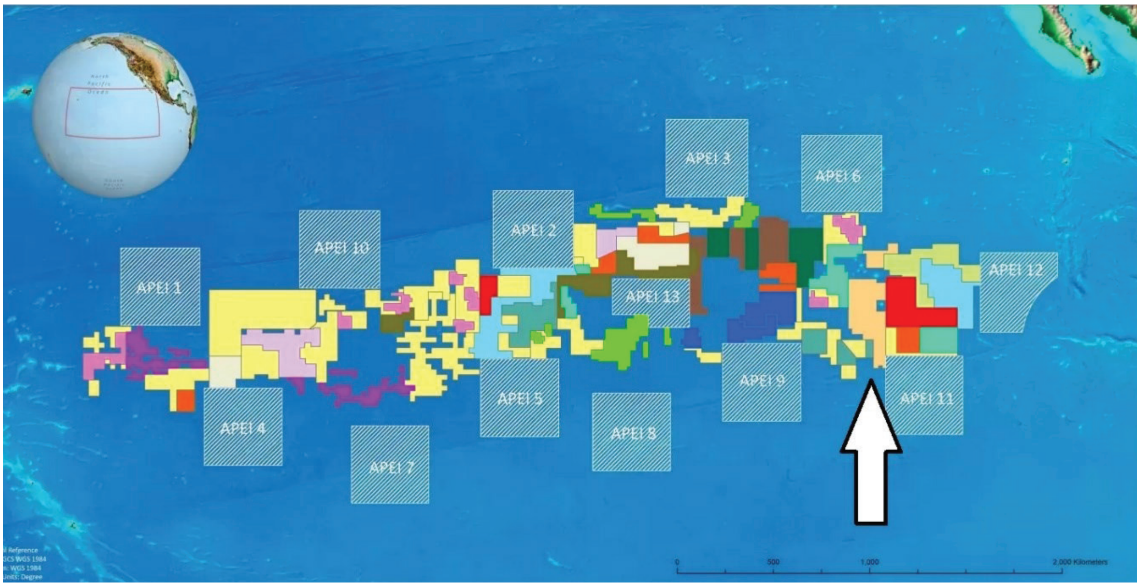

Fig. 1. The IOM exploration area (light orange colored areas) and adjacent properties in the Clarion-Clipperton Zone in the eastern central Pacific Ocean [1]

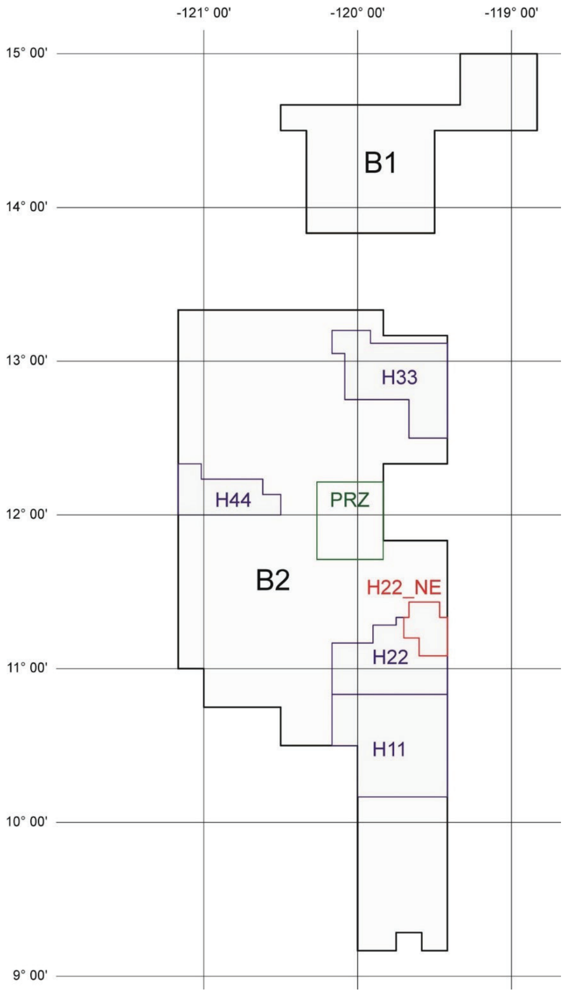

Fig. 2. IOM exploration area (B1 and B2 – sectors, H11, H22, H33, H44 – exploration blocks, H22_NE – exploitable block, PRZ – Preservation Reference Zone)

Following seabed sampling systems were applied during the exploration expeditions:

- box corer sampling,
- piston (gravity) corer sampling,
- trawling and dredging.

Multibeam bathymetry

Multibeam sonar is used to map the seafloor. The multiple physical sensors of the sonar send and receive sound pulses that map the seafloor or detect other objects. Multibeam collects two types of data: seafloor depth and backscatter. The seafloor depth (bathymetry) is computed by measuring the time it takes for the sound to leave the array, hit the seafloor, and return to the array. Backscatter is a measurement of the intensity of the sound echo that reflects back to the multibeam array. Multibeam sonar is usually mounted directly on the ship's hull [2].

Bathymetric mapping of the whole exploration area (B1 and B2 sectors) was performed during expedition in 1999. New high resolution bathymetric survey, carried out in 2018, was focused on exploration blocks H11, H22 (Fig. 3), H33 and H44. The bathymetric survey was performed according to the design profile scheme (system of parallel profiles and perpendicular control profiles).

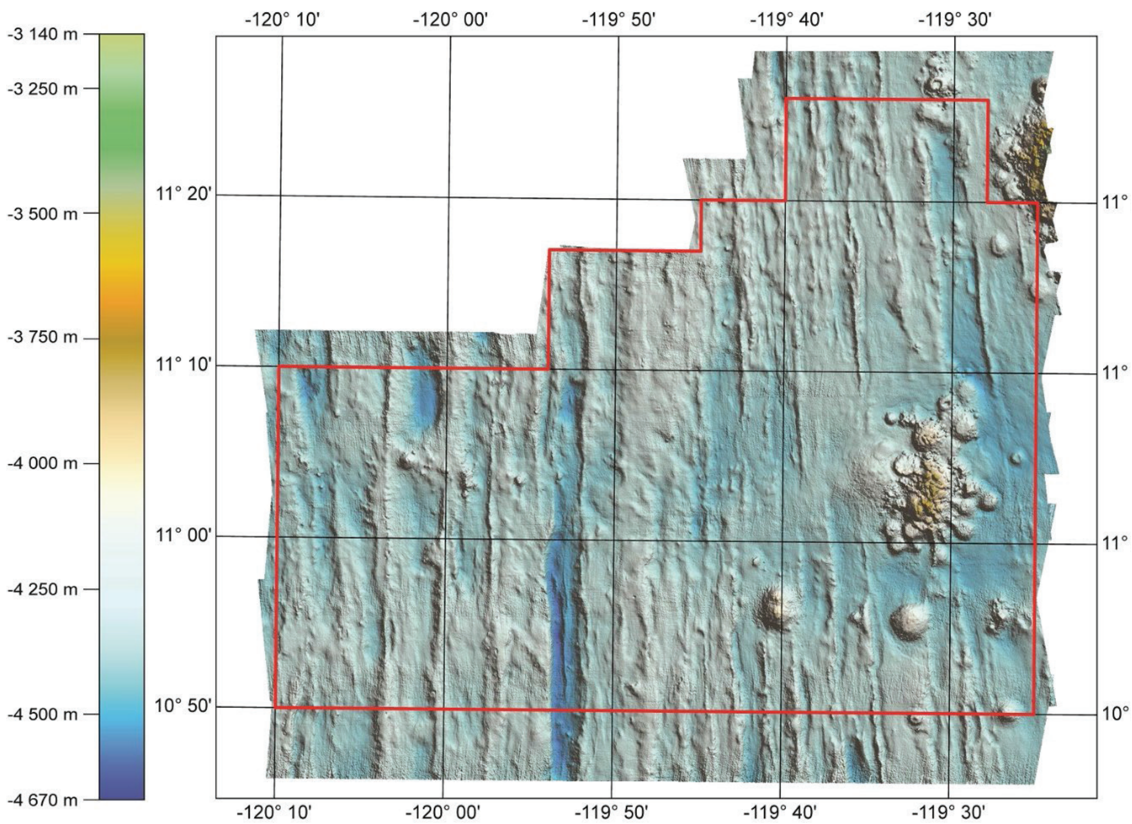

Fig. 3. Ocean depths in the H22 exploration block are in the range from –3,692 m to –4,673 m

Side-scan sonar

Side-scan sonar is an active sonar system for detecting and imaging objects on the seafloor. The multiple physical sensors of the sonar send and receive the acoustic pulses that help map the seafloor or detect other objects. Side scans search at constant speeds and in straight lines. With side scan sonars, the sea bottom is mapped from directly beneath the device to either side. This device is usually placed on a tow-fish. It is an underwater vehicle, that is towed behind a surface vessel [3].

Side-scan sonar was used to map sediment types, nodule coverage, obstacles (information for future mining operations) and detailed seabed morphology (slopes and their orientations). The sonar registration ranges are 1,000 m on each side of the survey (Fig. 4).

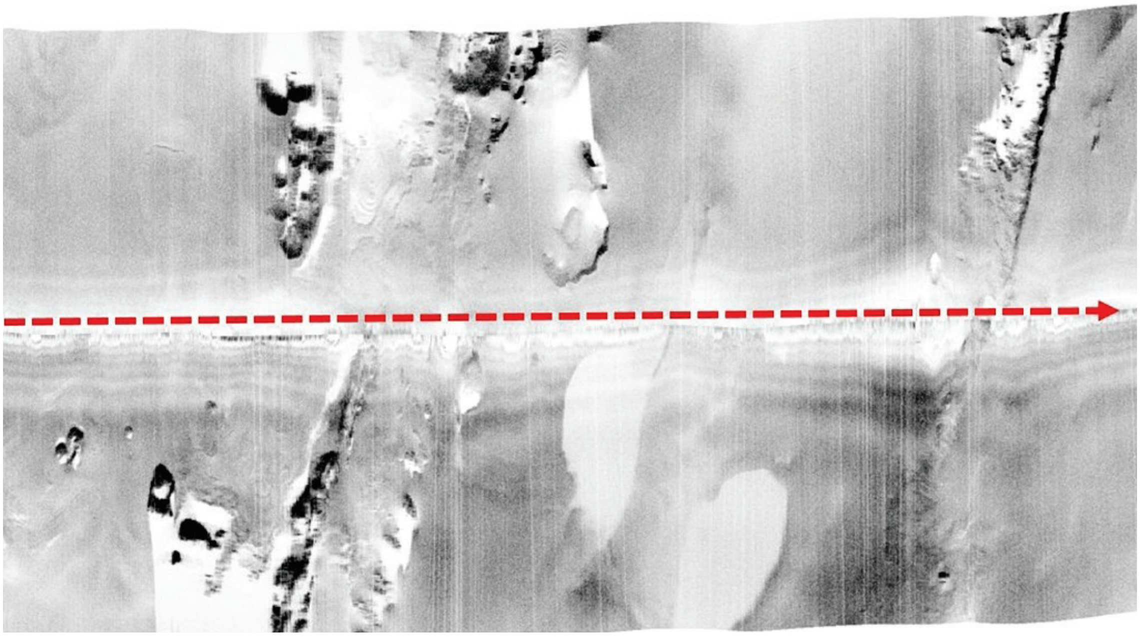

Fig. 4. An example of side-scan sonar data processed into a sonogram. The red arrow shows the direction of the vessel's movement and towing.

Sub-bottom profiler

A sub-bottom profiler is a sonar system that uses sound to map beneath the seafloor. It emits low-frequency sound pulses that are directed vertically at the seafloor. When pulses hit substrate, they may penetrate layers of seafloor and reach horizons of various sediment types. By calculating the time taken for a sound pulse to return to the device, it is possible to determine sediment and layer composition, thickness and other characteristics. This device is usually placed on a tow-fish (alongside with the side-scan sonar) and towed behind a surface vessel [4].

The distance of the towed device from the sea bottom can be 30 to 200 m, usually about 120 m. The depth range of the profiler is up to about 170 m. An example of the sediment profile under the bottom surface is shown in Fig. 5. Interpretations of geoacoustic profiling data allow us to study the internal structure of the sedimentary cover of the study area. In total, 667 km of geoacoustic profiling was completed during the contract period (from 2001).

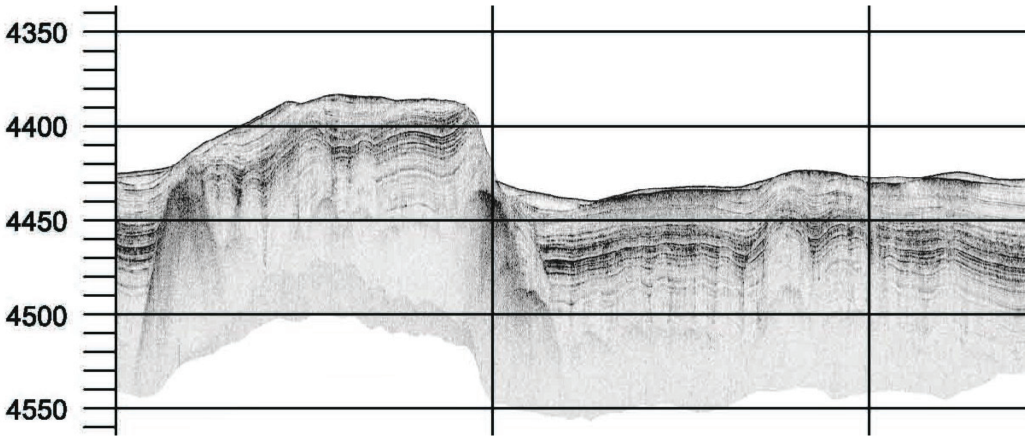

Fig. 5. An example of side-scan sonar data processed into a profilogram (depth data in meters)

Photo and video profiling

Photo and video profiling was carried out by the device placed on a tow-fish, an underwater vehicle towed behind a surface vessel. The distance of the photo-video device from the bottom was about 3.5 m, each photo of the seabed covered an area of about 4 m^2 (Fig. 6). The frequency of photography was about every 20 meters of the profile. At the same time, continuous video recording of the seabed in digital format in the colour image mode was conducted across all profiles. For each photo profile, graphs with coverage data were constructed. In total, 1,609 km of photo/video profiling (over 89,000 images) was completed during the contract period (from 2001).

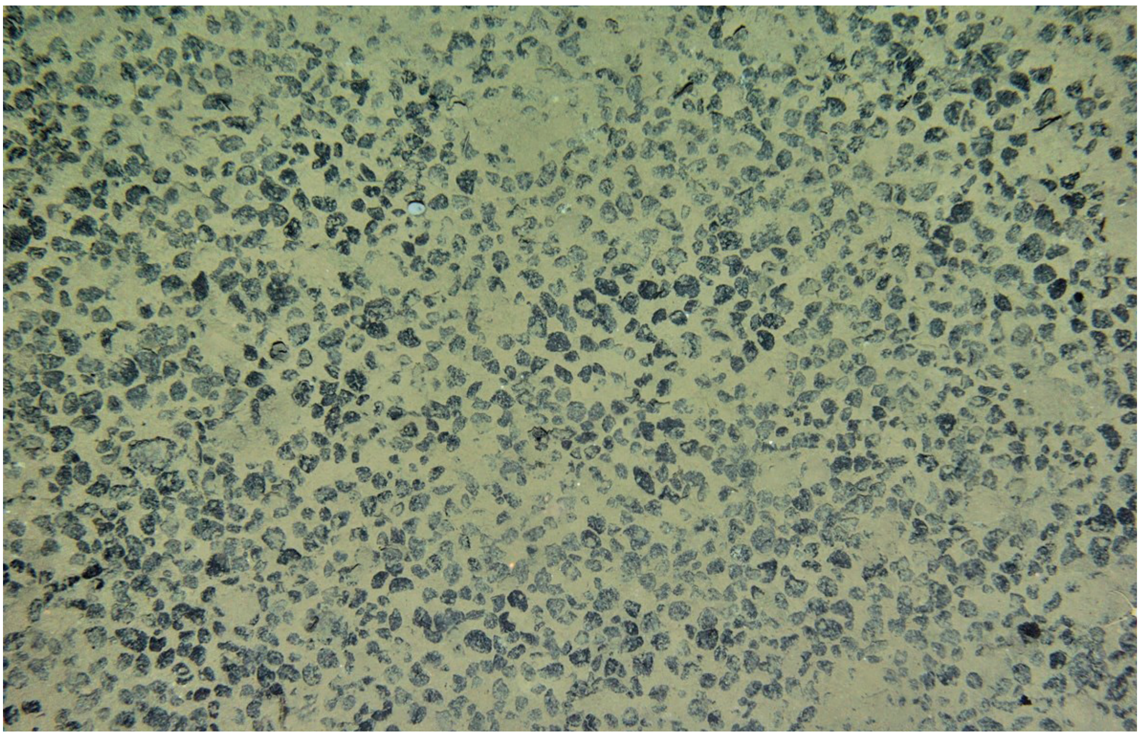

Fig. 6. Photo of the seabed taken in the H22 exploration block

Box corer sampling

Nodule and bottom sediments samples were collected using a box corer. This device has a capture area of 0.25 m^2 of the sea bottom, penetrating sediments to the depth up to 50 cm (Fig. 7). It is also equipped with a photographic system to document the sampling process. The lowering and raising operations were carried out using a winch. Box corer samples represent most important source of knowledge of the deposit, providing data on nodule and sediment characteristics, determination of nodule abundance and geotechnical measurements. In total, 396 box corer station samples were collected during the contract period (from 2001).

Fig. 7. Collected box-corer sample of sediment with polymetallic nodules after draining the water

Piston corer sampling

Sampling was carried out using gravitational tube with an internal diameter of 116 mm, a weight of 800 kg and a length of 5 m. The tube was equipped with a plastic liner with an inner diameter of 107 mm. The lowering and raising operations were carried out using a winch. The device penetrates seabed sediment to the depth up to 4 m and provides core samples (Fig. 8) for study of sediment characteristics and geotechnical measurements. In total, 11 piston corer station samples were collected during the contract period (from 2001).

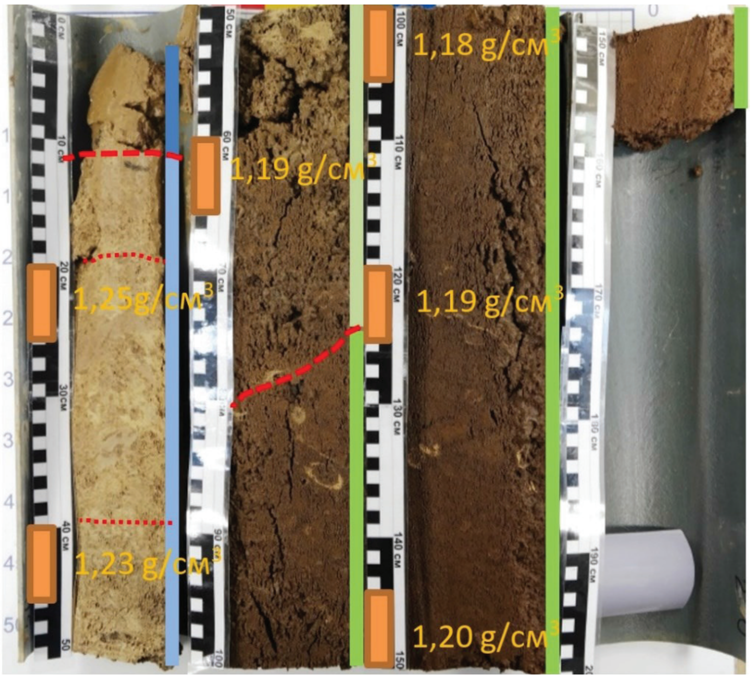

Fig. 8. An example of sections of sediments exposed by piston corer

Trawling and dredging

A large-volume nodule samples were collected using trawl, having an inlet of 40 × 140 cm dimensions. A basket of general capacity equalling 1,000 kg, made of polyamide fabric and 2 meters long, was attached to the body of the trawl, in order to collect nodules. Lifting

Fig. 9. A large-volume trawling sample collected in the H22 exploration block

operations were carried out using a transit winch. Trawling have been used regularly in almost every cruise. During the contract period (starting from 2001) total of 4,000 kg of polymetallic nodules were collected by trawling. Samples of nodules collected by trawl are used for chemical analyses, technological laboratory and benchmarking tests.

Hard rock type of the seabed (basalts) was occasionally sampled using the dredge – cylinder-like sampler 1 m long and 0.8 m in diameter. Two dredging samples were collected during the contract period.

Geological setting

The Clarion–Clipperton Zone is the world's largest (around 5.5 million km^2) and most perspective area of polymetallic nodules occurrence, with estimated resources of 21 billion tons of nodules [5]. The sedimentary cover is a mixture of carbonates (e.g. carbonate oozes), red brown clays, and siliceous sediments (siliceous oozes and siliceous-argillaceous oozes). Sediment accumulation in the area does not exceed the rate of 10 mm/1,000 years [6].

Lithology and stratigraphy

Based on the origin and composition, the bottom sediments within the IOM exploration area can be divided into four litho-stratigraphic units (Kotliński, 2010):

- F_{MI} (Oligocene-Miocene) – biogenic calcareous ooze, Marquise Formation;
- F_{MII} (Miocene) – X-ray amorphous radiolarian silty clay, Marquise Formation.
- F_{ClIII} (Miocene-Pliocene) – zeolitic clay or reddish brown clay and denser zeolitic crusts, Clipperton Formation;
- F_{ClIV} (Pleistocene-Holocene) – siliceous silty clay, ethmodiscus clay and calcareous silty clay, Clipperton Formation.

The sedimentary cover within the IOM exploration area is about 100 m thick [7]. Four seismic complexes (A, B, C and F) were identified:

- A - corresponds to the clay strata of Clipperton formation lying on the seabed surface and is called upper transparent layer by the nature of the seismoacoustic record;
- B – corresponds to the sequence of interbedded nano-fossil carbonates and radiolarian clays of the lower part of Clipperton formation;
- C – corresponds to nano-fossil marl oozes of the Marquesas formation and is called lower transparent layer;
- F – is identified with the acoustic basement represented by tholeiitic basalts of the second oceanic layer.

Polymetallic nodules

Occurrences of nodules with such high abundance as in the CCZ result from complex processes present on the regional and on local scales lasting for the past several millions of years. Polymetallic nodules are composed of both nucleus and concentric layers of iron and manganese hydroxides and oxides (Fig. 10). Nucleus can be composed of volcanoclastic debris, lithified sediment, bioclasts or fragments of older nodules. Beside Mn and Fe, also Cu, Ni, Co are the main metal elements present in nodules.

In some areas of the CCZ, nodules cover more than 70% of the bottom, whereas other areas are nodule-free. Nodules can occur on the seabed at any depth, but the highest concentrations have been found between 4,000 and 6,000 m.

According to the growth model for polymetallic nodules in the CCZ presented by ISA [6], six main factors control the process of nodule growth: metals supply (sea water and the bottom sediments); nucleus presence; Antarctic bottom water (the current is a supplier of oxygen and materials becoming nuclei; semi-liquid surface layer (providing chemical environment for the growth); bioturbation (the mechanism which prevents nodules from burial below sediment surface); and internal nodule stratigraphy (result of the changing geological history of deep-sea sedimentary basins).

The position of growing nodule is crucial in relation to the semi-liquid surface layer. The three accepted models of nodules growth are:

- in semi-liquid surface layer – diagenetic (D-type), called R (rough) type because of their complicated morphology;
- on the boundary of sea water and semi-liquid surface layer as a mixed type of hydrogenetic and diagenetic processes (HD-type), called R+S (rough-smooth) type because of their mixed morphology;
- above the sea bottom, on the surface sediments – hydrogenetic (H-type), called S (smooth) type because of their shape.

The IOM exploration area is dominated by D-type nodules in B2 sector and HD/H-types in B1 sector.

Polymetallic nodules in the CCZ generally grow very slowly, at rates of 1–10 mm/1,000,000 years [8]. Slow rate of growth indicates that for the nodules to reach the size of centimeters, stable environmental conditions are required. The accumulation rate of sediments within the area is three orders of magnitude higher and stays at a level of several millimeters per thousand years.

Fig. 10. Internal structure of polymetallic nodule

The CCZ nodules vary in size and range from tiny particles, visible only under a microscope, to large pellets of more than 20 centimeters in diameter. However, most nodules are between 5 and 10 cm in diameter. In the IOM exploration area, nodules are divided into fractions, where nodules within 0–4 cm refer to small fractions, 4–8 cm to medium fractions and 8+ cm nodules to large fractions. Size distribution partly depends on genetic types of nodules. No general rule was applied to size distribution due to high variability in nodule size within the IOM exploration area. For example, in the H22_NE exploitable block medium fractions prevail. On the contrary, small and large factions dominate the B1 sector.

Mineralogical composition of nodules is generally dominated by todorokite/buserite, with a lesser amount of birnessite and traces of vernadite. Additionally, the samples indicated the presence of Fe-rich clay minerals (nontronite and Fe-smectite) and mixtures of quartz, barite, zeolites, apatite, and barite.

Polymetallic nodules of the CCZ are characterized by high abundance and high metals content (especially Mn, Ni, Cu, Co, Mo, Zn and REE). Results from the B1 and B2 sectors are comparable with the results from other contracted areas in the CCZ. The mean grades of metals are shown in Tab. 2 [9,10,11].

Tab. 2. Mean grades of Mn, Ni, Cu, Co, Zn and REE within the IOM exploration area (variant for cut-off abundance 10 kg/m^2 of wet nodules)

Exploration area	Mn [%]	Ni [%]	Cu [%]	Co [%]	Zn [%]	REE [ppm]
B1	27.84	1.21	0.90	0.21	–	–
B2	30.90	1.32	1.21	0.18	0.15	–
H11 + H22	31.37	1.30	1.29	0.16	0.16	–
H33	32.35	1.41	1.20	0.18	0.15	–
H44	30.71	1.32	1.19	0.19	0.14	–
H22_NE	29.19	1.31	1.25	0.18	0.15	713

Mineral resources and reserves estimates

Seafloor polymetallic nodules in the CCZ occur typically on the surface of deep seabed, as a rule they are embedded in the semi-liquid surface layer and are, quite often, partly covered (blanketed) by a thin layer of unconsolidated sediments. Only those are included in current resource estimates for the IOM exploration area. Buried polymetallic nodules (more than 15 cm deep), locally reported within the IOM exploration area [12], have not been considered in the resource estimates.

Resources estimation is based on data collected during scientific expeditions carried out by IOM. Four reports using geostatistical data analysis have been prepared (2007, 2011, 2015 and 2020) and two validations performed by the Competent Person (2016 and 2020).

Methodology of estimation

Estimates of resources and abundance of nodules and metals were carried out in square elementary blocks with a side of 500 m using kriging and co-kriging. The estimates used

8 nearest sampling stations, two from each quadrant (quarters) into which the circular data search zone was divided. The center of the circular data search zone coincides with the center of the elementary block. In the calculation procedure, isotropic models of variograms, cross-variograms, covariance and cross-co-variance were used. The total resources of polymetallic nodules of the exploration blocks and ore fields (ore bodies), for different values of maximal the ocean-floor slopes, were obtained by summation of resources estimated for elementary blocks.

The accuracy of resource estimation in blocks H11 + H22 and in block H22_NE is high as evidenced by small, standard kriging errors in the range of 3–6%. The resources of nodules in blocks H33 and H44, expressed by standard errors from the 8–12% range, are estimated with much lower accuracy. The different size of errors is the result of the different density of the bottom sampling in individual blocks.

Results of estimation

The current status is shown in Tab. 3. The resource validation was carried out in accordance with the Reporting standard of the ISA for mineral exploration results assessments, mineral resources and mineral reserves [13]. The effective date for the estimate is August 2020. The dependency the tonnage of nodules and mean abundances in relation to the minimum abundance of wet nodules in B2 Sector is illustrated in Fig. 11.

Tab. 3. Mineral Resource estimate of wet polymetallic nodules in the IOM exploration area (variant for cut-off abundance 10 kg/m^2 of wet nodules)

Mineral Resource Classification	Mean Abundance (kg/m^2)	Resources Wet (million ton)
Measured (H22_NE block)	14.6	12.2
Measured Total		**12.2**
Indicated (H11 + H22 blocks)	12.4	77.0
Indicated Total		**77.0**
Inferred (B1 sector)	13.4	62.6
Inferred (H33 block)	12.0	21.8
Inferred (H44 block)	11.5	13.6
Inferred (B2 sector other)	11.59	85.3
Inferred Total		**183.3**
GRAND TOTAL		**272.5**

Mineral Resources were estimated at various nodule abundance cut-offs for the IOM Exploration Area. Selected base scenario is an abundance cut-off of 10 kg/m^2 (in wet condition). Assumptions will be revised in accordance with new knowledge, data and technological developments. No Mineral Reserves were estimated at this stage of the project development.

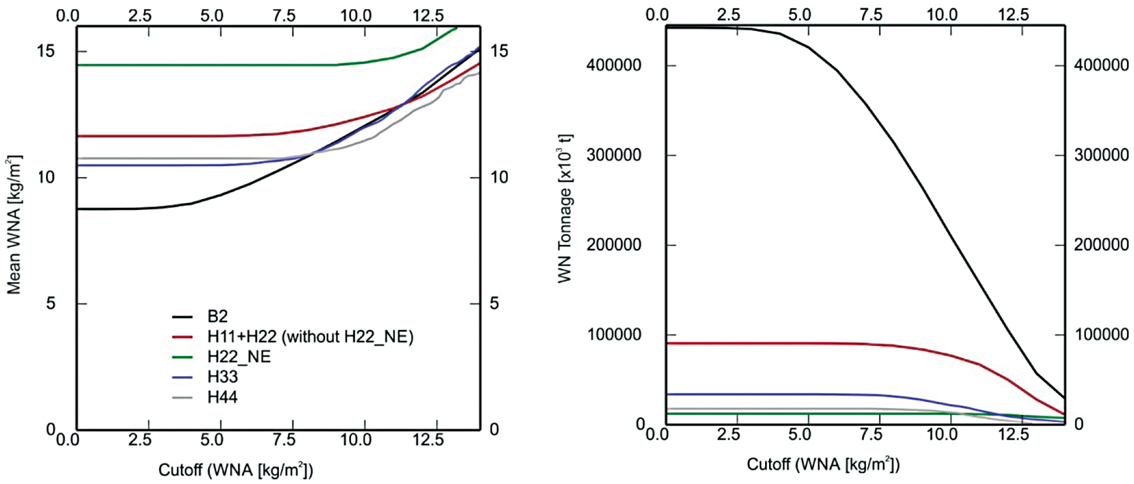

Fig. 11. Dependence of the average abundance of wet nodules (top) and the tonnage of wet nodules (bottom) on the cut-off value of the abundance of wet nodules (WNA)

Conclusions

The IOM license is under a contract for exploration of polymetallic nodules signed with the International Seabed Authority. Legal framework for mining and environmental regulations, as a fundamental condition for future deep sea mining activities, is currently under the development by the ISA.

Based on the economic evaluation, the IOM project can be described as an investment with some risk factors. It has promising economic potential due to growing market demand for battery metals which cannot be met by traditional sources (onshore, recycling, extraction from exclusive economic zones). The project possesses significant potential to contribute to the clean energy transition and expected demand of metals.

According to the European Commission´s list of critical raw materials for the EU, cobalt, manganese, and REEs are considered critical metals. From 2023, the list of critical raw materials also includes copper and nickel. These metals do not meet the supply risk threshold, but are listed as strategic raw materials, strategically important for green, digital, space and defence applications and are subject to future supply risks [14, 15]. Low supply and increasing import reliance of metals vital for European economy are a challenge for the long-term strategy of securing raw materials. This means that all major metals contained in polymetallic nodules are currently considered critically important for the EU.

Achieving of the Green Deal targets and solving the climate crisis requires extensive implementation of low-emission technologies (electro mobility, photovoltaics, wind turbines, CO_2 capture, nuclear installations, LEDs, and others). This is necessarily associated with increased consumption of specific metals. Polymetallic nodules offer a promising alternative supply of metals that can help achieve these goals.

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Outline of domestic mine production

		2019	2020	2021	2022	2023
Energy minerals						
Uranium	t U	33	29	27	21	13
	Concentrate production, t U (1)	36	28	26	22	17
Bituminous coal	kt	3,150	1,861	2,008	1,281	1 000
Brown coal	kt (2)	37,465	29,505	29,278	33,233	28 660
Crude oil	kt	81	91	83	75	67
Natural gas	mill m^3	146	138	153	165	119
Industrial minerals						
Pyrope bearing rock	kt	12	1	0	3	4
Moldavite (tectite) bearing rock	ths m^3	42	46	49	48	38
	kt (1 m^3 = 1.8 kt)	76	83	88	86	68
Kaolin	Raw, kt (3)	3,446	3,069	3,454	3,009	2 402
	Beneficiated, kt	629	626	645	558	439
Clays	kt	441	454	456	478	426
Bentonite (4)	kt	357	226	198	167	196
Diatomite	kt	43	46	18	44	38
Feldspar	kt	460	419	504	493	352
Feldspar substitutes	kt	33	29	24	21	23
Silica minerals	kt	17	11	20	10	13
Glass sand	kt	740	683	715	664	555
Foundry sand	kt	514	470	583	615	543
Limestones and corrective additives for cement production	kt	11,806	11,296	11,480	10,784	9 272
Dolomite	kt	453	398	393	429	344
Gypsum	kt	10	17	17	20	11
Construction minerals						
Dimension stone	Mine production in reserved deposits, ths m^3 (5)	117	135	125	112	118
	Mine production in reserved deposits, kt (1 m^3 = 2.7 kt) (5)	315	365	338	302	319
	Mine production in non-reserved deposits, ths m^3 (6)	16	47	62	32	35
	Mine production in non-reserved deposits, kt (1 m^3 = 2.7 kt) (6)	42	127	167	86	95
Crushed stone	Mine production in reserved deposits, ths m^3 (5)	14,057	14,247	14,883	14,883	13,773
	Mine production in reserved deposits, kt (1 m^3 = 2.7 kt) (5)	37,954	38,467	40,184	40,184	37,187
	Mine production in non-reserved deposits, ths m^3 (6)	1,449	1,465	1,703	1,805	1,632
	Mine production in non-reserved deposits, kt (1 m^3 = 2.7 kt) (6)	3,912	3,956	4,598	4,874	4,406
Sand and gravel	Mine production in reserved deposits, ths m^3 (5)	6,204	6,476	6,602	6,739	5,912
	Mine production in reserved deposits, kt (1 m^3 = 1.8 kt) (5)	11,167	11,657	11,884	12,130	10,642
	Mine production in non-reserved deposits, ths m^3 (6)	4,897	4,821	5,270	5,046	4,409
	Mine production in non-reserved deposits, kt (1 m^3 = 1.8 kt) (6)	8,775	8,815	8,678	9,486	7,936
Brick clays and related minerals	Mine production in reserved deposits, ths m^3 (5)	825	694	560	595	349
	Mine production in reserved deposits, kt (1 m^3 = 1.8 kt) (5)	1,485	1,249	1,008	1,071	628
	Mine production in non-reserved deposits, ths m^3 (6)	298	301	404	411	256
	Mine production in non-reserved deposits, kt (1 m^3 = 1.8 kt) (6)	536	542	727	740	461
Metallic ores (not mined)						

(1) corresponds to sales production (without beneficiation losses)
(2) Czech Statistical Office presents so-called sales mining production which is production of marketable brown coal and reaches on average about 95 % of given mine production
(3) raw kaolin, total production of all technological grades
(4) including mining of montmorillonite clays overburden of kaolins since 2004
(5) decrease of mineral reserves by mining production
(6) estimate

Domestic share in the world mine production

			2019	2020	2021	2022	2023
Energy minerals							
Uranium (U)		world: WNA	0.07%	0.06%	0.05%	0.04%	0,04%
Bituminous coal		world: IEA, BP	0.04%	0.03%	0.03%	0.02%	0,01%
Brown coal + Lignite		world: IEA, BP	5.07%	4.62%	4.60%	4.50%	4,35%
Crude oil		world: BP	0.002%	0.002%	0.002%	0.001%	0,001%
Natural gas		world: BP	0.004%	0.004%	0.004%	0.004%	0,004%
Industrial minerals							
Gemstones	Pyrope bearing rock		N	N	N	N	N
	Moldavite (tecti-te) bearing rock		N	N	N	N	N
Kaolin		world: MCS	8.20%	6.98%	7.04%	6.27%	6,2%
Clays			N	N	N	N	N
Bentonite		world: MCS	1.93%	1.41%	1.27%	0.88%	0,82%
Diatomite		world: MCS	1.48%	2.09%	0.78%	1.76%	1,28%
Feldspar		world: MCS	1.77%	1.82%	1.90%	1.76%	1.75%
Feldspar substitutes			N	N	N	N	N
Glass + Foundry sand		world: MCS	0.38%	0.44%	0.54%	0.34%	0,28%
Limestones		world: MCS *	0.23%	0.22%	0.26%	0.22%	0,21%
Dolomite			N	N	N	N	N
Gypsum		world: MCS	0.007%	0.01%	0,01%	0.01%	0,01%
Construction minerals							
			N	N	N	N	N
Metallic ores (not mined)							

** calculation based on lime and cement production,*
2 t of limestone = 1 t of lime or 2 t of cement

ENVIRONMENT AND MINERALS

Mining and nature protection

1,524 reserved and 810 non-reserved mineral deposits were registered in the Czech Republic as of December 31, 2023. The number of exploited deposits was markedly lower – 477 reserved and 176 non-reserved. Only 35 reserved and 8 non-reserved deposits were mined in the specially nature protected areas, which represents 7.5 % and 4.54 % of the total number, respectively.

Act No 114/1992 Sb. on nature and landscape protection in its present wording regulates activities in specially protected areas (ZCHÚ) of the Czech Republic (national parks – NP (Národní park), protected landscape areas – CHKO (Chráněná krajinná oblast), national nature reserves, nature reserves, national nature monuments and nature monuments). According to this Act, all mineral mining (section 16) in national parks (with exception of crushed stone and sand mining for construction in the territory of the national park), in the first zone of protected landscape areas (section 26) and in national nature reserves (section 29) is prohibited. Although the mining of mineral resources is not prohibited by law in other areas (2nd to 4nd zones of the CHKO, nature reserves, national nature monuments and nature monuments),

Specially protected areas (ZCHÚ) in the Czech Republic

Number/year	2019	2020	2021	2022	2023
Total number	2,663	2,694	2,698	2,708	2,690
National parks (NP)	4	4	4	4	4
Protected landscape areas (CHKO)	26	26	26	26	26
Others	2,609	2,633	2,664	2,668	2,690

Source: AOPK ČR (2024)

National parks in the Czech Republic

National park	Year of the NP declaration	National park area (km^2)	Proportion on the territory of the Czech Republic 78 864 km^2 (%)
Krkonoše Mountains National Park	1963	363	0.46 %
Podyjí National Park	1991	63	0.08 %
Šumava National Park	1991	685	0.87 %
National Park Bohemian Switzerland	2000	79	0.10 %

Source: AOPK ČR (2023)

Structure of ZCHÚ in 2023

Category of specially protected areas	Number	Area (km²)	Proportion on the territory of the Czech Republic 78 864 km² (%)
LARGE-EXTENT ZCHÚ			
National parks (NP) – mining explicitly prohibited	4	1,190	1.51
Protected landscape areas (CHKO)	26	11,382	14.43
– (in them the 1st zones of CHKO where mining is explicitly prohibited)	26	937	1.19
ZCHÚ with mining explicitly prohibited by the Act No. 114/1992 Sb.	29*	2,066*	2.62*
SMALL-EXTENT ZCHÚ			
National nature monuments (NPP)	127	82.2	0.10
National nature reserve (NPR)	116	304.4	0.39
Nature monuments (PP)	1,614	345.3	0.43
Nature reserves (PR)	833	437.1	0.55
NPP, NPR, PP, PR	2,690	1 168.9	1.48
– (from them NPP, NPR, PP, PR on the area of NP, CHKO)	753	472.1	0.59
LARGE-EXTENT AND SMALL-EXTENT ZCHÚ – total	**2,720**	**14,678**	**18.61**

** data from 2013, currently without updating*
Source: AOPK ČR (2024)

it is very difficult to obtain authorization. Legal regulations which mention prohibition of the "permanent damage of the soil surface" are the main reason – and they practically exclude mineral mining. A further reason is the civil activity in the field of environmental protection.

Mineral deposits are mined, and were in the past mined, in the CHKO in majority of cases where the mining claims were already determined before these CHKO were established. Mining in the CHKO declined after 1989 till 2002, after it rather grows till 2008 and after declines and stagnates respectively namely of registered deposits, which follows from the data in the table "Mining of reserved and non-reserved mineral deposits in CHKO" below and also from the fact that reserved deposits were mined in 19 from 25 CHKO in 2007 and 2008 (see the table "Mining of reserved and non-reserved mineral deposits in individual CHKO") compared to 17 from 25 CHKO in 2006. Deposits were mined only in 16 CHKO in 2009 and 2010, in 14 CHKO in 2011 till 2014 and in 15 CHKO in 2015 when CHKO Kokořínsko was extended about 140 km^2 and now is colled Kokořínsko-Máchův kraj. In 2016, the number of protected landscape areas in the Czech Republic increased to 26 (CHKO Brdy was established on

Mining of reserved and non-reserved mineral deposits in CHKO, kt

Mineral	Reserved deposits					Non-reserved deposits				
	2019	2020	2021	2022	2023	2019	2020	2021	2022	2023
Gemstones*	8	1	0	2	4	0	0	0	0	0
Crude oil	0	0	0	0	0	0	0	0	0	0
Natural gas**	1	1	1	1	1	0	0	0	0	0
Quartz sand***	547	494	607	574	537	0	0	0	0	0
Feldspar	360	352	432	414	213	0	0	0	0	0
Limestone	3,228	3,040	5,043	3,980	4,508	0	0	0	0	0
Dimension stone**	48	85	95	57	64	1	0,1	0	3	2
Crushed stone**	4,454	4,340	4,153	3,542	4,003	30	21	22	624	25
Sand and gravel**	1,474	1,333	1,426	1,307	945	20	18	0	40	43
Brick clay**	0	0	0	0	0	0	0	0	0	0
Total	**9,865**	**9,647**	**11,757**	**9,874**	**10,275**	**51**	**39**	**22**	**104**	**70**
Index, 1990 = 100	62	61	74	61	64	–	–	–	–	-
Index, 2000 = 100	107	108	131	108	111	17	13	7	221	22

* *pyrope bearing rocks,*

** *conversion to kt: natural gas (1,000,000 m³ = 1 kt), dimension and crushed stone (1,000 m³ = 2.7 kt), sand and gravel and brick clays (1,000 m³ = 1.8 kt),*

1. 1. 2016, raw materials mined in 17 CHKO). The CHKO mined raw materials number was 17 in 2021. In 2022 it was 18 in 2023.

As far as the impact of mining on the area is concerned, the CHKO Český kras (Bohemian Karst – limestone mining) is especially unfavourably affected. The impact on some other CHKO, especially CHKO Třeboň region, Poodří. České středohoří Mts., Blanský les is still rather high (see Tab. “Impact of mining of reserved deposits in CHKO”). The reduction in mining by 32% occurred in 2017 in the České středohoří protected landscape area. The mining activities in the area of Moravský kras (Moravian Karst) were terminated in 2014 by abandoning of mining limestone deposit Ochoz-Skalka. In 2017 two deposits are being mined here again – the limestone deposit Ochoz u Brna and the deposit of foundry sands Rudice-Seč. In 2018 were not operated the deposits in the area of Moravský kras again – neither Ochoz u Brna nor Rudice-Seč. In 2019 was the other limestones deposit Ochoz u Brna in operation again. From 2015 when CHKO Kokořínsko was extended about 140 km^2 (now is called Kokořínsko-Máchův kraj) is reported quartz sand deposit Srní – Okřešice in this CHKO. In 2016 the Brdy protected landscape area (CHKO) was established but mining there was not take place. In 2017, however, a crushed stone in the total amount of 11 kt was already mined on two localities (Záběhlá-Červený lom and Chaloupky-hlína) and this situation was the same in 2018. In 2019–2021 mining at the site did not take place. In 2022 and 2023 quarrying of building stone resumed at the Chaloupky-hlína locality (10.8 kt).

Mining of reserved and non-reserved mineral deposits in individual CHKO, kt

Name of CHKO	2019	2020	2021	2022	2023
Beskydy Mts.	18	43	52	37	32
Bílé Karpaty Mts.	177	197	242	200	220
Blaník	0	0	0	0	0
Blanský les	1,024	806	1,023	1,026	810
Brdy **	0	0	0	11	11
Broumov region	79	153	139	106	113
České středohoří Mts.	2,122	2,053	2,025	2,059	1 824
Český kras (Bohemian Karst)	3,293	3,369	3,224	3,288	3 139
Český les Mts.	0	0	0	0	0
Český ráj	0	0	0	0	0
Jeseníky Mts.	74	68	23	86	57
Jizerské hory Mts.	0	0	0	0	0
Kokořín region – Máchův kraj	547	494	388	574	537
Křivoklát region	346	301	397	214	261
Labské pískovce (Elbe sandstones)	0	0	0	0	0
Litovelské Pomoraví region	0	0	0	0	0
Lužické hory Mts.	5	0,1	0	2	5
Moravský kras (Moravian Karst)	1,997	1,822	1,933	1,491	1 007
Orlické hory Mts.	0	0	0	0	0
Pálava region	0	0	0	0	0
Poodří region	116	200	191	206	175
Slavkovský les region	279	267	302	311	213
Šumava Mts.	170	76	66	95	68
Třeboň region	1,186	1,165	1,365	1,379	785
Žďárské vrchy Mts.	165	141	157	133	125
Železné hory Mts.	174	203	161	149	131
Total mine production (rounded)	**11,772**	**11,359**	**11,688**	**11,161**	**9,513**

* *in 2014 the CHKO Kokořínsko was extended about 140 km^2, now is called Kokořínsko-Máchův kraj*
** *CHKO Brdy was established on 1. 1. 2016*

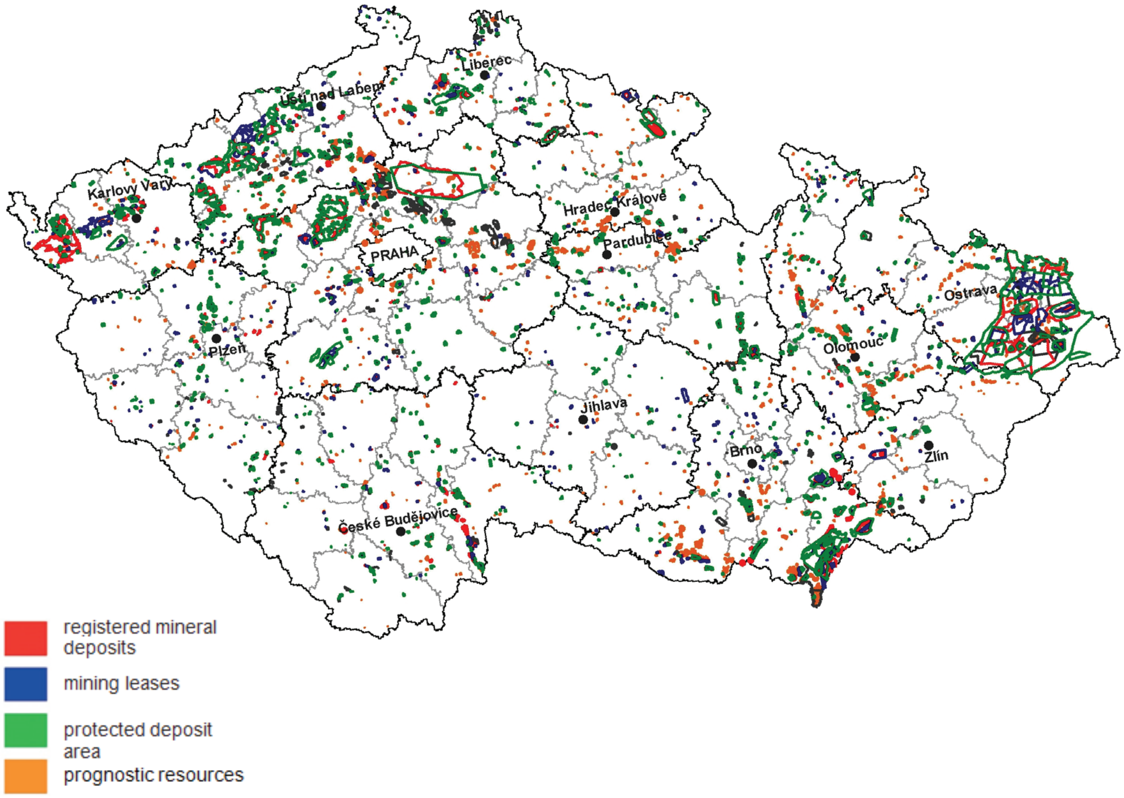
It is possible to get a clearer picture of mining activities in the Czech Republic from following map.

As well as the Act No. 114/1992 Sb. on nature and landscape protection. Act No. 100/2001 Sb. on environmental impact assessment and the Decree of the MŽP No. 17/2011 Sb. (formerly No. 395/1992 Sb.), by which some provisions of the Act No. 114/1992 Sb. are applied, have a fundamental influence on permission for exploration and mining.

Impact of mining of reserved deposits in CHKO, t/km^2 in a year
(areas of CHKO as of December 31)

Name of CHKO	area km^2 in 2022	2019	2020	2021	2022	2023
Beskydy Mts.	1,205	15	35	43	31	38
Bílé Karpaty Mts.	747	240	264	324	268	295
Blaník	40	0	0	0	0	0
Blanský les	220	4,655	3,663	4,650	4,664	3,682
Brdy*	345	0	23	0	0	32
Broumov region	432	183	404	322	245	262
České středohoří Mts.	1,069	1,985	1,921	1,894	1,926	1,706
Český kras (Bohemian Karst)	132	24,947	25,523	24,424	24,909	23,780
Český les Mts.	466	0	0	0	0	0
Český ráj	182	0	0	0	0	0
Jeseníky Mts.	744	100	91	31	116	77
Jizerské hory Mts.	374	0	0	0	0	0
Kokořín region – Máchův kraj*	410	1,334	1,205	946	1,400	1,310
Křivoklát region	625	554	482	635	342	418
Labské pískovce (Elbe sandstones)	243	0	0	0	0	0
Litovelské Pomoraví	93	0	0	0	0	0
Lužické hory Mts.	271	20	0,5	0	7	18
Moravský kras (Moravian Karst)	97	20,588	18,784	19,928	15,371	10,381
Orlické hory Mts.	233	0	0	0	0	0
Pálava region	85	0	0	0	0	0
Poodří region	82	1,415	2,439	2,329	1,403	2,134
Slavkovský les	611	457	437	494	509	349
Šumava Mts. (CHKO + NP)	1,680	101	45	39	57	41
Třeboň region	687	1,726	1,695	1,987	2,007	1,143
Žďárské vrchy Mts.	709	233	197	221	188	176
Železné hory Mts.	285	611	801	565	523	481
TOTAL (total mining/total area)	**12,065**	**976**	**942**	**969**	**925**	**819**

Note: an impact exceeding 10,000 t/km^2 in a,year is regarded as critical
** CHKO Brdy was established on 1. 1. 2016*
*** in 2014 the CHKO Kokořín region was extended about 140 km^2, now is called Kokořín region-Mácha's country (Máchův kraj)*



Mining activities charge of the Czech Republic territory

The Mining Act No. 44/1988 Sb. obliges the mining companies by its section 31 to reclaim the areas with mining impacts and to create financial means for this reclamation. These are considered as mining costs from the viewpoint of the profi tax, Table “Development of reclamations after mining” shows that the areas with mining impact decreased and those reclaimed increased in 2018–2022.

Methods of reclamation used in 2022 are shown in the table “Reclamation after mining of reserved minerals in 2022”.

Mining influences the environment. changes the character of the landscape and alters ecological conditions for flora and fauna. In some areas mining activities can last several human generations. This way the impact of mining persists and a more permanent new arrangement of natural conditions and relationships in its area is not quickly evident. The new arrangement can be equal to or even better than the original one, of course on a different level. Examples include artificial lakes formed e.g. in south Bohemia by sand and gravel mining, constructions and sport grounds in former quarries or specially protected nature areas proclaimed paradoxically in the territory of former quarries, and also 35 hectares of new vineyards planted as agricultural reclamation of a closed brown coal mine in the north of Bohemia in the Most wine region. They represent by their area almost 6.5 % of the total 550 hectares of productive vineyards of the Czech wine region.

In Bavaria. Germany. They studied the plant biodiversity in local quarries (S.Gilcher-U. Tränkle (2005): Steinbrüche und Gruben Bayerns und ihre Bedeutung für den Arten- und Biotopschutz, -Bayerischen Industrieverband Steine und Erden e.V., München). Of the 2533 known plant species (of which 701 are endangered) in Bavaria in quarries whose combined

Area affected by mining by region, 2023

Region	Area affected by mining in mining leases (km²)	Area affected by mining outside mining leases (km²)
Capital City of Prague	1.03	0.02
Central Bohemia	14.03	1.42
South Bohemia	10.95	0.84
Plzeň	75.89	0.86
Karlovy Vary	46.15	27.61
Ústí nad Labem	110.72	5.72
Liberecj	12.41	5.47
Hradec Králové	4.08	0.15
Pardubice	6.40	0.67
Vysočina	4.267	1.96
South Moravia	18.51	0.92
Olomouc	13.20	2.29
Zlín	2.60	0.15
Moravia and Silesia	215.16	7.24
Czech Republic	**468.01**	**55.30**

Development of reclamations after mining in 2023

km²		2019	2020	2021	2022	2023
Reserved deposits	Area with manifestation of mining, not yet reclaimed	426	414	336	513.4	523.3
	Reclamations in process	60	63	28	55.5	53.7
	Reclamations finished since the start of mining	255	271	273	262.4	329.8
	Reclamations finished in the given year	4	12	2.4	3.3	3.9
Non-reserved deposits	Area with manifestation of mining, not yet reclaimed	16	17	10.3	16.6	16.3
	Reclamations in process	5	4	2.3	3.3	3.9
	Reclamations finished since the start of mining	3	4	4.4	4.1	2.6
	Reclamations finished in the given year	0.2	0.9	0.3	0.3	0.3

area amounts to 0.006 % of Bavaria’s total area. they counted 1039 species (41 % of the total count), of which 87 species were endangered (12.4 % of all endangered plant species).

In Baden-Württemberg, Germany, (Schelkingen quarries – raw material for cement) an original research project was developed *(Brodkom E. – Benett P. – Jans D. (editors)(2001): Good environmental practice in the European extractive industry. A reference guide – Environnement hors-série no 1. p. 35. Société de l’industrie minérale, Paris)*. “This consisted of using cut grass to encourage vegetation growth by spreading it over the

Reclamation after mining of reserved minerals in 2023

Region	Reclamations in process								Reclamations finished							
	agricultural		forest		water		other		agricultural		forest		water		other	
	in DP	out DP	in DP	out DP	in DP	out DP	in DP	out DP	in DP	out DP	in DP	out DP	in DP	out DP	in DP	out DP
South Bohemia	7	0	33	0	51	0	14	0	48	35	90	34	113	3	32	1
South Moravia	194	0	41	0	2	0	20	0	379	32	195	20	7	0	23	10
Karlovy Vary	135	7	166	203	0	1	69	325	403	1,213	1,409	2,677	559	32	162	117
Hradec Králové	25	0	5	0	3	0	1	0	41	3	67	3	45	0	27	2
Liberec	17	0	54	7	1	0	10	0	90	48	366	32	5	0	15	2
Moravia and Silesia	11	5	289	79	12	2	480	21	875	77	887	192	329	8	530	39
Olomouc	20	0	39	15	114	0	33	16	21	98	26	51	137	4	5	5
Pardubice	4	0	2	1	2	0	3	24	16	0	17	8	78	0	10	2
Plzeň	27	11	28	1	1	0	0	1	24	16	45	30	0	0	18	0
Prague	0	0	0	0	0	0	5	351	1	3	0	0	0	0	3	1
Central Bohemia	119	0	138	3	26	0	25	1	350	75	102	11	91	0	114	16
Ústí nad Labem	472	85	136	245	28	7	496	72	2,092	10,081	2,520	2,619	255	215	1,102	1,284
Vysočina	0	0	0	0	0	0	4	8	0	0	29	5	0	0	8	16
Zlín	0	0	0	0	0	0	3	0	36	54	5	0	0	0	1	0
Czech Republic intotal	**1,031**	**108**	**795**	**554**	**240**	**10**	**1,163**	**819**	**4,376**	**11,735**	**5,758**	**5,682**	**1,619**	**262**	**2,050**	**1,495**

[ranked according to regions and way of reclamation; DP = mining lease (in = within, out = outside), areas in hectares (1 km² = 100 ha)]
** Data 2021 not available*

floor of a closed-down quarry. In order to protect germination. the grass counteracts high soil temperatures. The moisture of the soil is retained much longer, and the air humidity under the grass is higher. Corresponding tests on the following substrates were carried out at the quarry: raw soil substrate (unchanged quarry site), mixed substrate (screen residue and excavated material), excavated material. With regard to effectiveness. it can be stated that 50 to 60 % of the species established on the areas from which the cut grass was taken were introduced and naturalised in an single mowing process. The costs incurred by such the process range between a minimum of 0.43–0.61 EUR/km^2 (without site preparation) and a maximum of 1.36–1.87 EUR/km^2 (including distribution of substrate and further measures). In contrast to that. the costs occuring for recultivation for agricultural or forestry purposes, amount to between 1.02–3.07 EUR/km^2."

In 2009 participants in the workshop Obnova území narušených těžbou nerostných surovin ("Restoration of Mining-Impacted Land") organized by the citizens association Calla-Association for Preservation of the Environment and by the Department of Botany of the Faculty of Science at the University of South Bohemia set down principles of eco-friendly restoration of mining-impacted land (J. Řehounek (2010): Přírodovědci formulovali zásady ekologické obnovy po těžbě. (Naturalists formulated principles of post-mining ecological restoration – Minerální suroviny/Surowce mineralne (magazine), 1:32–33. Mining Union of the Czech Republic, Brno):

1. Prior to commencing mining – a qualified biological assessment not only of the mining area, but also of its surroundings is essential. It would be beneficial if the actual mining were to be managed, if possible, in such a way so as to preserve (possibly maintain and expand) as many (semi) natural habitats in the immediate vicinity of the mine site or dumping ground. A roughly 100-metre zone in an area that can be accessed by most of the species is key for the subsequent colonization of the mining-impacted land during spontaneous succession.
2. Environmental impact assessments. biological assessments and reclamation plans, which concern the restoration of mining-impacted land and dumping grounds, should be prepared by experts, who are not only familiar with the current state of knowledge in the field of ecological restoration. but also with realistic possibilities and limits of mining technology. These problems should henceforth be included in the examinations for persons authorized to prepare environmental impact assessments pursuant to Act No. 100/2001 Coll. (EIA) and for persons certified in preparing biological assessments pursuant to § 67 of Act No. 114/1992 Coll. and in preparing assessments evaluating impacts on bird areas and on Special Areas of Conservation (SAC) pursuant to § 45i of said Act. Ongoing training in ecological restoration should be mandatory for these persons.
3. A basic restoration plan (e.g. in the form of a remediation and reclamation summary) should already be known when a mining lease (in the case of reserved deposits) is granted, or when a planning permit that designates the area for mining (in the case of non-reserved deposits) is granted, and should take into account the potential possibilities of the area. Room must be left to make any possible changes according to current conditions during the mine planning phase (plan of mine development work /POPD/ including detailed rehabilitation and reclamation plans, mining permits, etc.) and during the actual mining and completion phases.
4. It is essential to conduct another continuous assessment of the locality (a scheduled monitoring programme) already during the course of mining and after its termination, which may discover the presence of rare and endangered species and communities, as well as important geological and geomorphological phenomena. The restoration plan will have to be modified with respect to this assessment, which should be provided by the mining company via or under supervision of a qualified person.
5. Prior to, during and after mining, it is necessary to monitor invasive species at the mine site and in its surroundings. If their presence may possibly jeopardize the intended restoration method, then they must be removed by sanitation methods.
6. The great majority of mining-impacted land can restore itself spontaneously – via spontaneous succession, which may in some cases also be guided (directed. blocked or reversed). As a rule, at least 20 % of a large mine site's total area should be left to spontaneous succession in the most bilogically valuable areas. Smaller mining sites and dumping grounds can usually be integrated into the landscape without problem, thus ecological succession may be implemented in their entire area.
7. If endangered and specially protected species and communities are highly dependent on the mine site environment, then their population and biotypes will have to be managed appropriately. This should be covered by mandatory funds generated by the mining

Share of specially Protected Areas of the Czech Republic nature (zvláště chráněná území přírody České republiky (ZCHÚs)) established in localities with former mining ("after mining") in all the ZCHÚs
(compiled after data of the Nature Conservation Agency of the Czech Republic – AOPK ČR in 2024)

Region	Number of ZCHÚs (without CHKOs)	Area of ZCHÚs (without CHKOs) (ha)	Number of ZCHÚs "after mining"	Area of ZCHÚs (without CHKOs) "after mining" (ha)	Share of ZCHÚ areas "after mining" in the all ZCHÚs (without CHKOs) area	Share of ZCHÚ number "after mining" in the all ZCHÚs (without CHKOs) number
	data 2023	data 2023	data 2013*	data 2013*	data 2013*/ data 2023	data 2013*/ data 2023
Central Bohemia	313	17,148	41	817.99	4.72 %	13.18 %
Prague	92	2,383	36	714.04	29.37 %	38.71 %
Karlovy Vary	95	6,032	6	33.03	0.55 %	6.32 %
Olomouc	165	7,636	20	195.88	2.57 %	1.21 %
South Moravia	351	11,565	23	343.00	2.99 %	0.67 %
Pardubice	110	6,223	5	116.84	1.88 %	0.45 %
Plzeň	196	6,808	17	148.09	2.17 %	0.87 %
Zlín	215	2,582	6	23.72	0.92 %	2.79 %
Moravia and Silesia	167	8,727	17	264.81	3.03 %	10.18 %
Liberec	126	5,928	6	244.38	4.12 %	0.48 %
Vysočina	204	5,936	4	29.25	0.49 %	1.97 %
Ústí nad Labem	182	9,951	12	327.79	3.29 %	0.66 %
Hradec Králové	135	8,830	6	17.10	0.19 %	0.44 %
South Bohemia	339	17,146	18	247.24	1.49 %	0.53 %
Czech Republic total	**2,690**	**116,885**	**217**	**3,523.16**	**3.01 %**	**8.15 %**

** data from 2013 onwards are not available* company for reclamation, after its completion by public funds designated for landscape programmes.

8. The most valuable mine sites and dumping grounds should be declared specially protected areas (most often classified specifically as a nature monument) and managed accordingly, or declared temporary protected areas if only temporary protection is needed. Less valuable mine sites and dumping grounds left to eco-friendly restoration should almost always at least be registered as important landscape elements. Special attention should be paid to mine sites that may be incorporated into the territorial system of ecological stability.
9. Restoration of a mine site or dumping ground should primarily increase the observable landscape diversity. It is necessary to break up straight lines and surfaces (peripheries, shore lines, etc.) with uneven areas, at the very latest after termination of (or preferably during the course of) mining. Shallow shore areas are necessary at flooded mine sites.
10. Unsuitable pieces of equipment and waste should removed after mining is terminated, if the aim is to integrate a mine site or dumping ground into the environment.
11. The nutrient-rich top soil sections must be permanently removed from those parts of the mine site that are designated for eco-friendly restoration in the least amount of time. This already needs to be taken into account during the reclamation planning phase. As overburden is returned, so are excess nutrients, which mostly support the evolution of a few less abundant, agressive species, including invasive ones. Once mining commences it is therefore necessary to verify. in collaboration with protection of agricultural land resources authorities (hereinafter OZPF), if the overburden is being carefully and completely removed from areas designated for eco-friendly restoration. Otherwise it is necessary to modify the implementation of the reclamation plan, again however in collaboration with OZPF and mining authorities.
12. From an environmental protection perspective, phased mining and restoration works best at larger mine sites, specifically when spread out over a longer period so that abandoned areas of the mining area are gradually left to restoration. This procedure helps create more varied and higher-quality communities with regard to age and extent in restored areas.
13. It is beneficial to place permanent study areas designated for scientific research, testing of eco-friendly interventions and monitoring in all types of mining areas. These areas should be respected by the mining companies.

Conclusion of the workshop: Eco-friendly restoration of mining-impacted land is certainly not the only option of how to deal with the integration of these areas into the landscape. Our laws should however allow for this restoration method which is common in many countries to become an equivalent alternative to the thus far predominant forest and agricultural reclamations.

In 2011 a final report on project VaV SP/2d1/141/07 “Rekultivace a management nepřírodních biotopů v České republice” (“Reclamation and Management of Non-Natural Biotypes in the Czech Republic”) was published for the entire duration of the project in 2007–2011 carried out by the Institute for Environmental Policy. Public Benefit Corporation by the Institute of Geology of the Academy of Sciences of the Czech Republic. Public Research Institution. and by the Czech University of Life Sciences Prague. Its fi and recommendations state among other things:

“Areas impacted by mining and by some other human activities such as quarries, sand pits, mining sites of kaolin and brick clays, waste piles/dumps and large waste depots are by far not really devastated. dead “lunar landscapes”. On the contrary, it is being demonstrated that, in terms of the protection of diverse biotypes, they are a very important refuge. where mushrooms and wild plants and animals are finding optimum living conditions which they entirely lack in urbanized and industrial areas, and on land used intensively by agriculture...”

GEOLOGY AND MINERALS

Geological evolution of the area of the Czech Republic

Arnošt Dudek

The Czech Republic is located in the very centre of Europe at the limit between the Hercynian Meso-Europe and the Neo-Europe (Fig. 1). There is hardly any country with such a variegated geological structure in such a small area and with such a complex geological evolution. Practically all known rocks and the majority of geological formations and known types of ores and industrial minerals occur on the state territory. Even though most ore deposits are interesting mainly from a scientific and mineral collectors' point of view, a number were of European importance during the Middle Ages and the beginning of modern time. The interesting and complex history of this area attracted attention of researchers already in early times and it strongly influenced the evolution of the mining and geological sciences. It was on this territory where one of the oldest mining laws, the Jihlava Mining Law (1260), and slightly later the mining law of the King Wenceslas II "Ius regale montanorum" (1300), which became basis of many mining laws in other states of the world especially in South America, came into being. The origin of the world-known works of Georgius Agricola, especially his book "Bermannus sive de re metallica dialogus" (1530), is also linked to the territory of the Bohemian Massif.

Three main structural complexes form the geological structure of Czech territory. The oldest one, consolidated already during the Precambrian orogenies, is **Brunia (Brunovistulicum)**, taking basically the area of Moravia. This segment of the Earth's crust probably represents an extremity of the East European platform, even though some researchers consider it as a part of the African plate. The influence of the younger – Paleozoic and Alpine – orogenies was only minor and it served as a foreland of the nappe structures which were thrust over it. The **Hercynian-consolidated Bohemian Massif**, overlapping to the area of the neighbouring Austria, Germany and Poland in the south, west and north, forms the major part of the state territory. Bohemian Massif belongs to the Paleo-Europe. The Hercynian orogeny in the end of the Carboniferous put the finishing touches on it, even though it also contains older building elements. It already behaved as a consolidated block after the Hercynian orogeny, only sometimes flooded by epi-continental sea and affected only by fault tectonics. As a crustal block rising from young sedimentary formations, it broke up only during the younger mountain-building processes, morphologically only in the end of the Neogene and in the Quaternary. Geological continuation of the Hercynides towards the west is indicated by other crustal blocks which were created later – Schwarzwald, Vosges Mountains, the French Massif Central and Iberian Meseta, in the northern branch then the Armorican Massif and massifs in southern England and Ireland. The eastern margin of the Bohemian Massif was thrust over the Cadomian unit of the Brunovistulicum during the Hercynian orogeny. The boundary between the hercynian Mesoeurope and alpine Neoeurope crosses the eastern part of the Czech Republic. The Alpides are represented there by the **West Carpathians**. They are

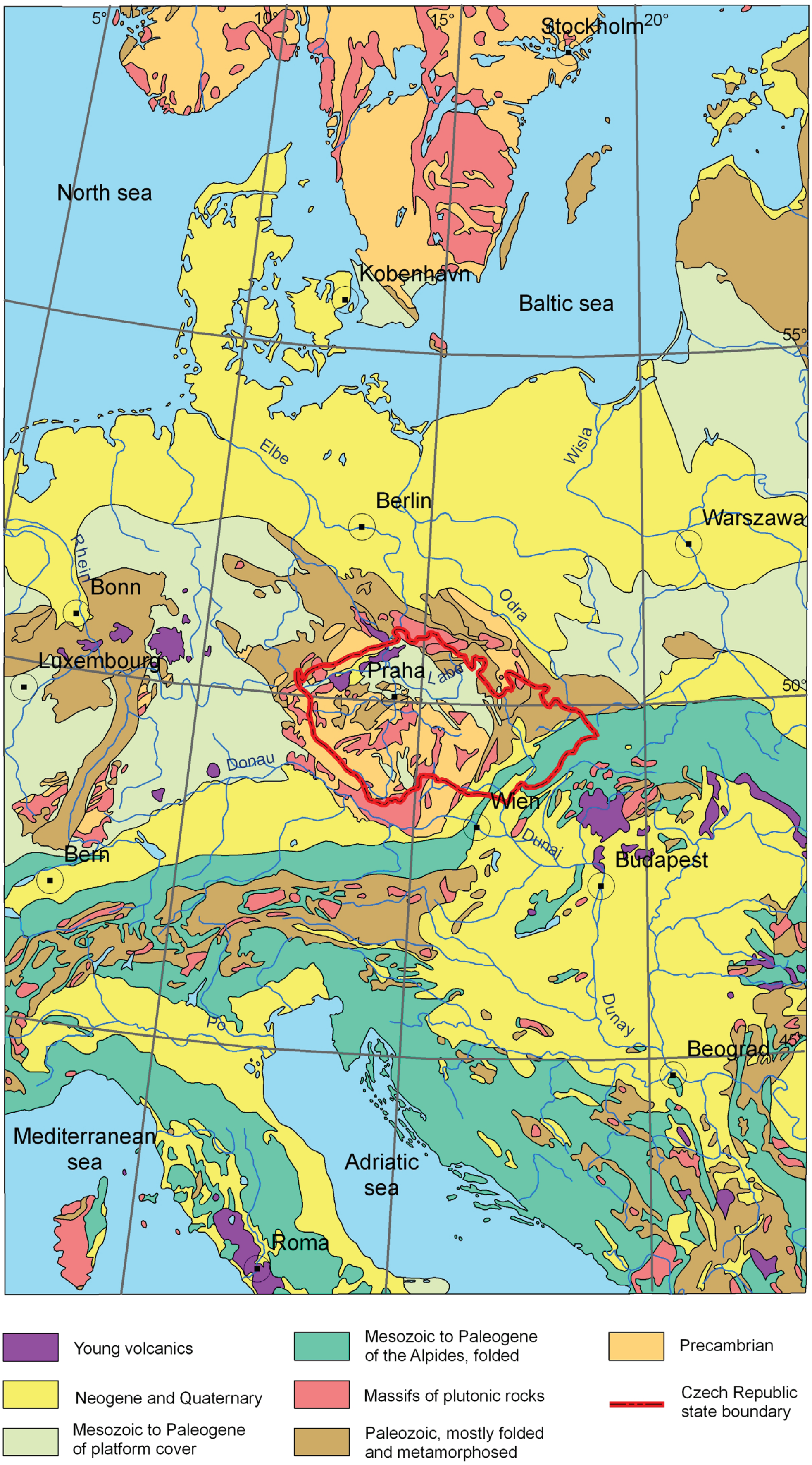


Fig. 1. Geological position of the Czech Republic in Europe

built by an inner unit – Central West Carpathians, Outer Flysh Carpathians and the Carpathian Foredeep. The ***Central West Carpathians*** are formed by pre-Mesozoic volcanosedimentary complexes, mostly metamorphosed and penetrated by late-Hercynian granitoid plutons, and their sedimentary cover (Trias to Lower Cretaceous). At the beginning of Upper Cretaceous the Central Carpathians were intensively folded and in places also metamorphosed. A tectonic zone of first order – the ***Klippen Belt,*** built mostly by Mesozoic sedimentary rocks separates the Central Carpathians from the external Flysh Carpathians. The ***Outer Flysh Carpathians*** are formed (besides rare uppermost Jurassic sediments and local Cretaceous volcanics) predominantly by sedimentary complexes of Cretaceous and Paleogene age. These complexes were as horizontal nappes thrust over the Brunovistulian basement and its sedimentary cover over a distance of tens of kilometres partly even over the Neogene Carpathian Foredeep.

As in the study of the history of mankind, there is little information on the oldest periods of the evolution of the Earth we live on, and our findings are accompanied by a large number of uncertainties. This of course applies also for the Czech territory, even though it belongs to the areas where systematic geological research was in progress since the beginning of the 19^{th} century.

Complexes of the **Brunia (Brunovistulicum)** crop out on the surface only in the western Moravia, but they reach far to the east below the overthrust nappes of the Outer Flysh Carpathians. They are formed by metamorphic rocks – mainly monotonous biotite paragneisses – which were altered during the Proterozoic orogenies, and intruded by huge massifs of abyssal magmatic rocks of about 550 Ma age at the boundary between the Proterozoic and Paleozoic. The Brno and Dyje Massifs represent the exposures of these rocks. Granitoid plutons covering large areas as well as smaller basic massifs of gabbros and norites compacted this unit and prevented its later reworking by younger mountain-building processes, which formed the Bohemian Massif. Western parts of the Brunovistulicum are built by variegated volcano-sedimentary complexes (involving limestones, graphitic rocks, quartzites, amphibolites and orthogneisses). These parts were strongly affected by the Hercynian tectonometamorphic processes. They crop out from beneath of the overthrust Hercynian complexes of the Moldanubicum and Lugicum in tectonic windows of the Dyje and Svratka Domes of the **Moravicum** and Desná Dome of the **Silesicum**. Their appurtenance to the Brunia (Brunovistulicum) has not been commonly accepted yet and these units are by some authors ranked to the Lower Paleozoic and to the Hercynian Bohemian Massif. Platform sediments – the Cambrian conglomerates and sandstones in limited areas, marine Silurian shales sporadically and extensive and important sediments of the Devonian, Mississippian (Lower Carboniferous) and continental sediments of the coal-bearing Pennsylvanian (Upper Carboniferous) – are deposited on the Cadomian basement. The younger platform cover is represented by sediments of the Jurassic, Cretaceous, Paleogene and the Neogene of the Carpathian Foredeep. This consolidated basement was overthrust by nappes of the Outer Flysh Carpathians from the east (Fig. 2).

The lower level (basement) of the **Bohemian Massif** – the epi-Variscan platform – is built by metamorphic rocks intruded by numerous and very large granitoids massifs, and by only weakly metamorphosed or unmetamorphosed but Hercynian-folded Lower Paleozoic. Regionally it is divided (Fig. 3) into the core, formed by the highly metamorphosed **Moldanubicum** and mostly only weakly metamorphosed **Bohemicum (Teplá-Barrandian domain)**. This core is rimmed by the **Saxothuringicum** (Krušné hory Mts.) on the NW, **Lugicum** (Krkonoše Mts., Orlické hory Mts., Králický Sněžník) on the north and **Moravo-Silesicum** (Jeseníky Mts., eastern part of the Českomoravská vrchovina Highlands) on the east (see Fig. 3). These marginal complexes are metamorphosed mostly less intensively than the central Moldanubicum.

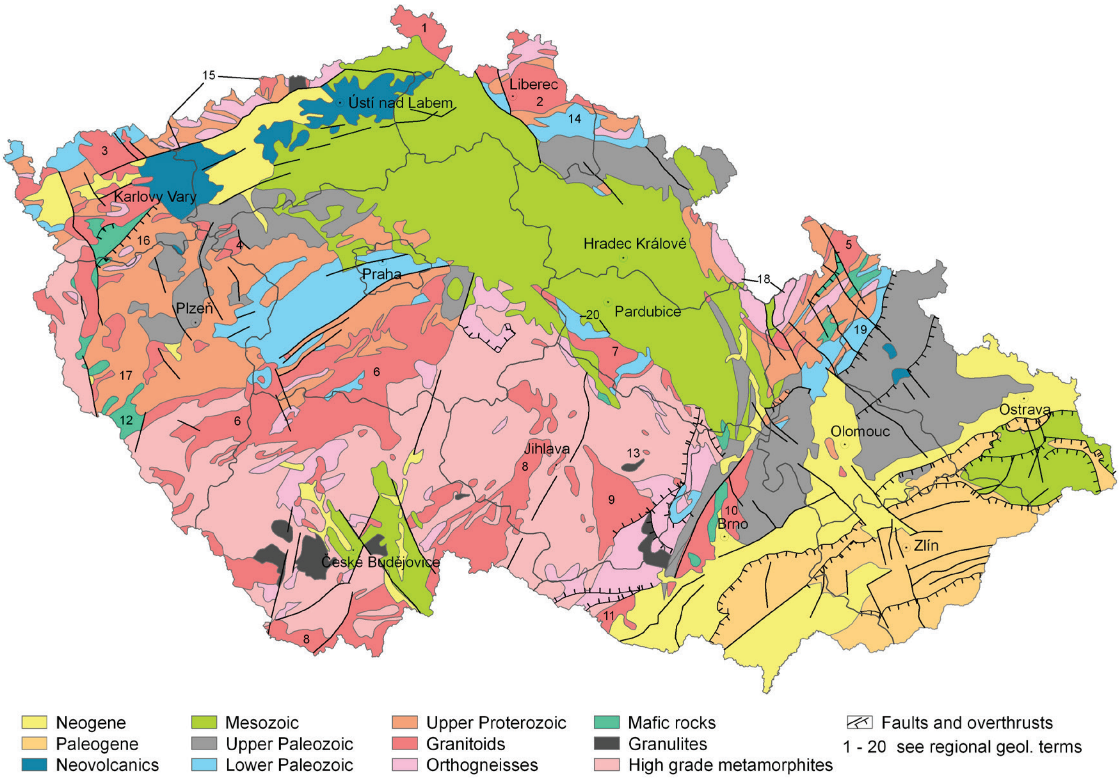


Fig. 2. Geology of the Czech Republic

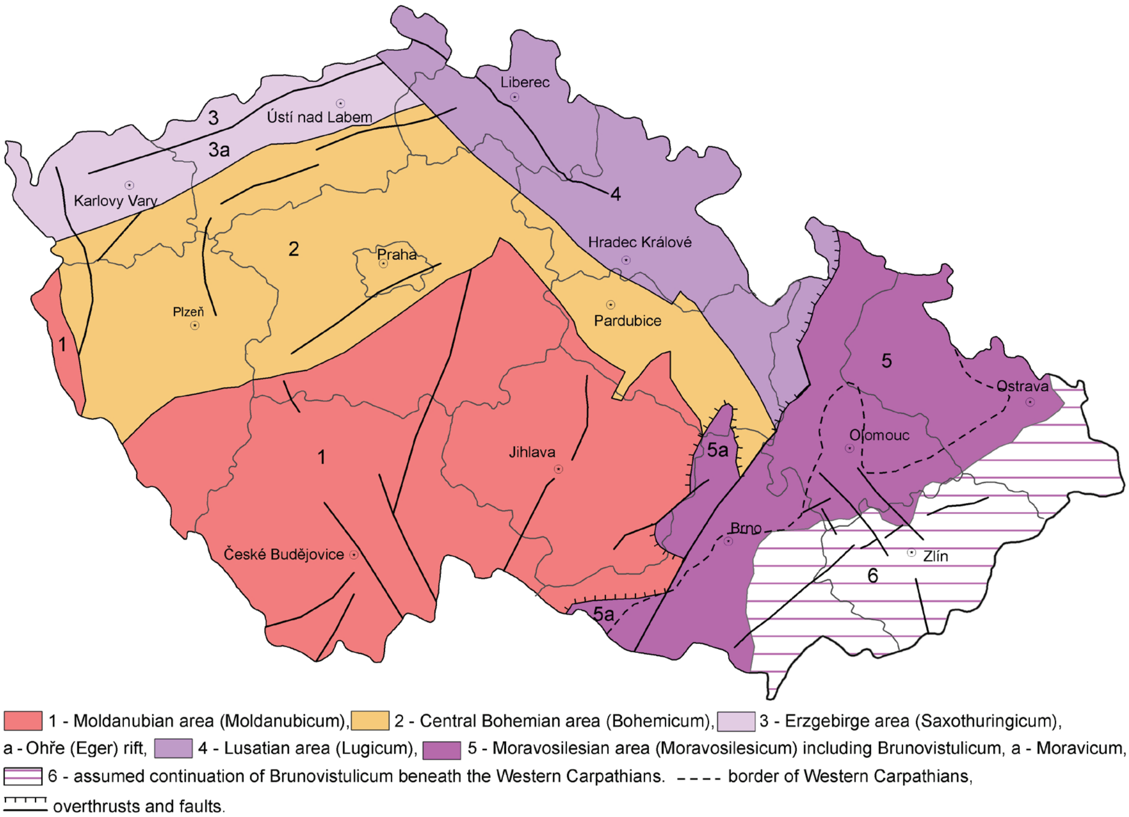


Fig. 3. Regional basement division of the Bohemian Massif on the territory of the Czech Republic

The ***Moldanubicum*** is formed by rocks metamorphosed mainly in the amphibolite facies – sillimanite and cordierite gneisses and migmatites with intercalations of orthogneisses, marbles, quartzites, graphitic rocks and amphibolites. Bodies of high-temperature and high-pressure metamorphic rocks – granulites and garnet peridotites with eclogites – are numerous, too. Their occurrences mark the course of old tectonic zones, along which these rocks were exhumed from depth. They are exposed mainly in southern Bohemia (Blanský les, Prachatice, Křišťanov and Lišov granulite massifs) and western Moravia (Bory and Náměšť granulite massifs). The age of the protolith of Moldanubian complexes is probably Upper Proterozoic; their metamorphism under the amphibolite, granulite and eclogite facies conditions is linked to the Hercynian orogeny. Pre-Paleozoic, Cadomian metamorphism of regional extent, mostly overprinted by the Hercynian processes, is nevertheless documented. Minor bodies of old orthogneisses exhumed along deep-reaching faults in the southern Bohemia, the radiometric age of which is even 2.1 Ga, represent a single exception. They document the existence of the Lower Proterozoic in the deeper crustal structure of the Bohemian Massif. Some Moldanubian rocks, especially gneisses, granulites and amphibolites, represent common resources of building stone.

The metamorphic rock complexes of the central Bohemian ***Bohemicum (Teplá-Barrandian domain)*** as well as the marginal complexes of the Saxothuringicum, Lugicum and Moravo-Silesicum developed by regional metamorphism of mainly Upper Proterozoic protoliths (1,000–545 Ma). During this period, the area of today’s Bohemian Massif was covered by a deep sea, in which sandy and clayey rocks were deposited. Surrounding continents, probably rather distant in the mainland formed by very old rocks, represented the source area of the deposited material. Some clastic minerals from metamorphic rocks of the southern Bohemia (up to 2.7 Ga old, in the neighbouring Bavaria even 3.8 Ga) were at least in part derived from the Archaic of the African shield. They were of course deposited much later. The sedimentation was accompanied by submarine volcanism of tholeiitic basalts, which formed linear structures tens of kilometres long, maybe in some cases standing out above the sea level (*island arcs*) as well as much less extensive acid volcanism. The volcanic activity was accompanied by deposition of black shales with abundant pyrite and of siliceous sediments – lydites. Finely banded structures resembling organogenic stromatolites, which would belong to the oldest organic remnants on the Czech territory, were found rarely in the latter. A set of these sediments and volcanic rocks was intensively folded and mostly also metamorphosed in the end of the Proterozoic. Very weakly metamorphosed Proterozoic rocks are nowadays exposed only in central Bohemia between Prague and Plzeň (in the so-called *Barrandian*). The intensity of their alteration increases towards the marginal mountains. A continuous succession of thin metamorphic zones of Barrovian type up to gneisses with kyanite and sillimanite developed especially towards the W and SW. Proterozoic rocks are altered into gneisses and amphibolites also in the Krušné hory Mts., Krkonoše Mts., Orlické hory Mts. and Hrubý Jeseník Mts. These complexes were intruded by numerous massifs of granites (especially Stod, Čistá-Jesenice and Lužice massifs) and gabbros (Kdyně and Poběžovice massifs) in the end of the tectonometamorphic processes especially in the western and northern Bohemia. The Pre-Paleozoic ***Cadomian orogeny*** represents one of the most important magmatogennic and tectonometamorphic processes in the evolution of the Bohemian Massif.

The Earth’s crust in Czech territory was not completely solid after the Cadomian orogeny and it gradually broke into a number of smaller blocks, which moved away from each other and were partly flooded by sea again during the ***Lower Paleozoic*** [Cambrian, Ordovician, Silurian, Devonian to Mississippian (Lower Carboniferous)]. Unaltered sediments were preserved especially in central Bohemia, in the area between Prague and Plzeň (Pilsen), named Barrandian, to a lesser extent also in other parts of the Bohemian Massif. In its marginal parts (excluding Brunovistulicum), Paleozoic complexes experienced strong metamorphism and therefore their identification and dating is commonly very difficult. In the Barrandian, sedimentation started already in the ***Lower Cambrian***, represented by a formation of conglomerates and sandstones up to several hundred to thousand meters thick. Sporadic occurrences of shales of fresh-water or brackish origin, in which the oldest fossils of arthropods in Bohemia were found, are known here. Sea penetrated to central Bohemia in the Middle Cambrian and deposited sandstones and especially shales, which are world-known for their occurrences of trilobite fauna. The evolution of the Cambrian was terminated by extensive rhyolites and andesite terrestrial volcanism.

The ***Ordovician*** started by the sea again transgressing in central Bohemia and by the formation of the so-called ***Prague Basin***, the evolution of which continued until the Middle Devonian. The Ordovician rocks are represented mainly by clastic sediments, mostly various types of shales with thick quartzite intercalations), the deposition of which was accompanied by intensive basaltic volcanism. Deposits of sedimentary iron ores (e.g. Nučice, Ejpovice etc.) which were of a high importance in the 19th and beginning of the 20th century originated in relation to the volcanic activity. The Bohemian Massif was located close to the southern polar circle in the Ordovician and sedimentation of rocks as well as volcanic activity proceeded in the sub-polar climate. This crustal segment moved rather rapidly to the north, into warmer waters of the tropic of Capricorn in the end of the Ordovician.

The change of the climate and by this also conditions of development of organisms and sedimentation during the ***Silurian*** resulted in formation of fine-grained black shales with abundant graptolite fauna, accompanied also by intensive volcanic activity and intrusions of numerous diabase sills. Mass development of organisms with carbonate shells occurred in its upper parts with regard to the increasing temperature and massive limestone formations were formed.

Continuous carbonate sedimentation in the Prague Basin lasted until the ***Devonian***, whereas in the surrounding parts of Europe as well as more distant areas the rock deposition was interrupted by the ***Caledonian orogeny***. Gradual unaffected evolution of both the sediments and organisms and their long-lasting detailed study by several generations of Czech paleontologists was a prerequisite for the determination of the first, globally valid ***stratotype*** between two systems (Silurian and Devonian) in Klonk u Suchomast SW of Prague. The limestone sedimentation in the Prague Basin terminated in the Middle Devonian and sandstones with terrestrial flora ended the Devonian sedimentation in this area.

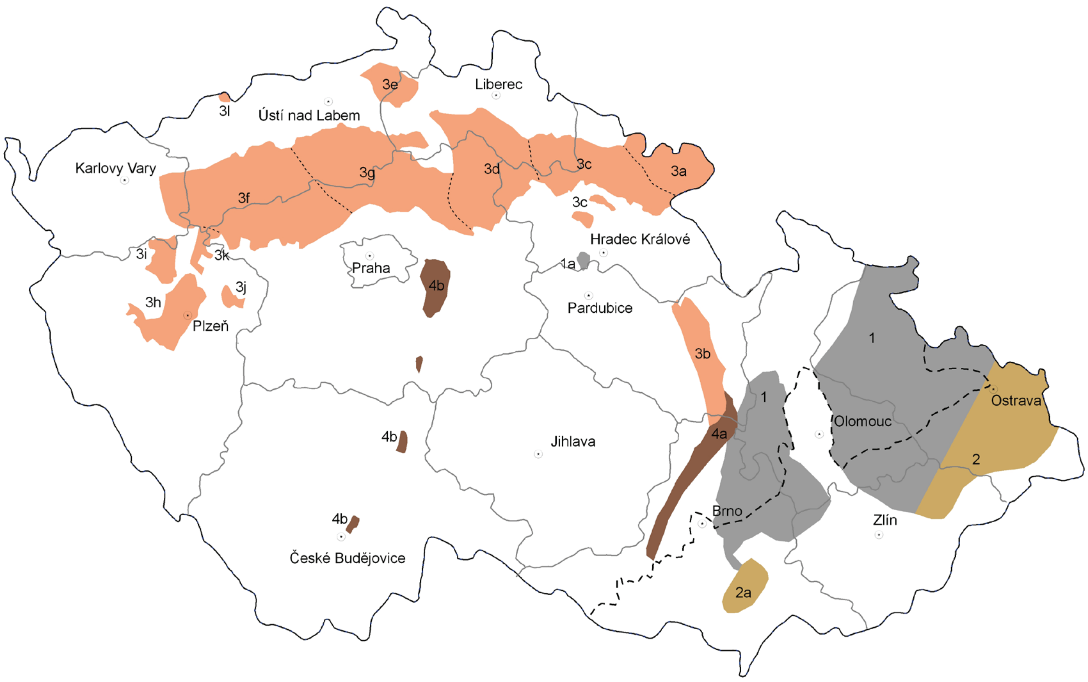
Sedimentation of the Devonian rocks continued in the Upper Devonian only in the area of the Krkonoše Mts. (on Ještěd Mt.) and especially in Moravia in the Jeseníky Mts. and in the Moravian Karst. Evolution of the Devonian in Moravia differed from that on the Bohemian territory. Transgressive complex of the siliciclastic and volcanic rocks with stratiform deposits of Fe, Cu, Au, Zn and Pb overlie the old Brunovistulian basement in its western, more mobile part. This clastic sedimentation continues also in the Mississippian (Lower Carboniferous). The Devonian rocks on the more stable Brunovistulian basement in the south and east begin by clastic rocks, which in places reach over 1,000 m in thickness. Limestones appear only in the Upper Devonian and their evolution continues until the Mississippian (Lower Carboniferous). There is therefore no manifestation that the sedimentation was interrupted by the Hercynian orogeny in Moravia. Sedimentation spaces just moved to the east to Ostrava region and to today's Carpathian basement. Limestones of the Upper Devonian form important deposits especially in central Moravia (e.g. Mokrá, Líšeň, Hranice etc.).

A change in the character of the sedimentation in the end of the Devonian is an expression of the ***Hercynian orogeny***, which affected (about 340–310 Ma ago) the majority of the Czech lands with a high intensity and expressed itself by the development of the nappe structure and a very strong metamorphism of large areas. Even the crystalline complexes formed during the Cadomian orogeny were metamorphosed again. Vast massifs of granitoid magmatic rocks of several thousand km^2 extent, not yet completely uncovered by denudation, formed practically simultaneously. Their intrusions were accompanied also by extensive surface volcanic activity and the development of very numerous deposits of variable genetic types (e.g. Krušné Hory Mts. massifs and Sn, W, Li, Ag, U, Co, Ni mineralization in the Saxothuringicum or Central Bohemian and Moldanubian Plutons in the Moldanubicum and Au, Sb, Ag, Pb, Zn, U mineralization). Granitoid massifs represent an important resource of building and dimension stone as well as feldspar raw materials. Weathered crusts of granitoids (e.g. Krušné hory Mts. massifs, Dyje Massif) are an important source of kaolin, too.

There are two different types of the ***Carboniferous*** and its rocks in the Bohemian Massif as a result of the Hercynian orogeny. The Mississippian (Lower Carboniferous) is represented in Bohemia only by restricted relics of marine sediments found by drillings under the Bohemian Cretaceous Basin E of Hradec Králové, and by weakly metamorphosed slates in the Ještěd Ridge SW of Liberec. The sedimentation of the continental type begins in the intra-mountain basins only in the Pennsylvanian (Upper Carboniferous, Westphalian) and continues in the Permian. Basins with partly individual evolution extend in the Plzeň (Pilsen) surroundings towards the North and Northeast as far as the Broumov area in the NE tip of the Bohemian part of the Czech Republic (Fig. 4), where their stratigraphic extent is the largest and the sedimentation finishes as late as the Lower Triasic. They are to a large extent overlain by sediments of the Bohemian Cretaceous Basin. River and lake deposits – conglomerates, arkoses and shales with layers of tuffs, tuffites and lavas – are in many places accompanied also by formation of coal seams, which were and still are of a high economic importance. Some seams show an elevated U content making them even potential deposits. The Carboniferous arkoses in the Plzeň (Pilsen) and Podbořany regions gave rise to important deposits of kaolin. Carboniferous mainly refractory clay and claystone are important, too. The Bohemian Massif reached the equator on its way to the north and coal formation reflects the dominating tropical climate.

In Moravosilesian area, which was just weakly influenced by the Hercynian orogeny thanks to the solid Brunovistulian basement, the Devonian sedimentation was continuous until the Mississippian (Lower Carboniferous), when the formation of limestones terminated. It was followed by flyshoid sedimentation of conglomerates, greywackes and shales in multiple alternation of individual layers (Culm development). The greywackes represent a resource of a high-quality building stone. The depositional environment gradually changed from marine to fresh-water during the latest Mississippian and the Pennsylvanian (Upper Carboniferous) and important deposits of bituminous coal (paralic basins of the Ostrava, and limnic basins of the Karviná region) formed in the coastal marshes. The Czech part of the Upper Silesian Basin represents the most important bituminous coal mining district in the Czech Republic. The Carboniferous system in the Czech Republic was, and remains, not only an important energy base of the state but also a world-known classical area of Carboniferous flora and fauna.

The Hercynian mountains were rapidly lowered by erosion and denudation in the ***Permian***, and thick formations of red-brown conglomerates, sandstones, arkoses and shales formed.

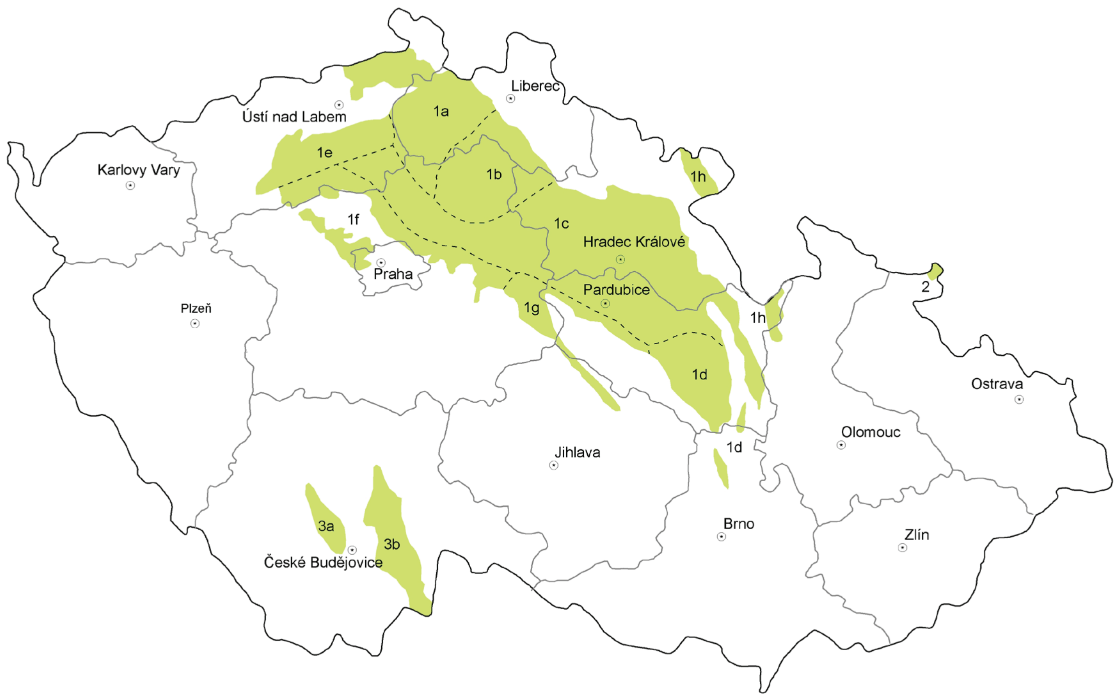


1 - Marine Mississippian (Lower Carboniferous - Culm); a - occurrence near Hradec Králové, 2 - Pennsylvanian (Upper Carboniferous) of the Upper Silesian Basin; a - occurrence in South Moravia, 3 - Limnic Permo - Carboniferous; partial basins: a - Intrasudetic B.; b - Orlice B.; c - Krkonoše Piedmont B.; d - Mnichovo Hradiště B..; e - Česká Kamenice B.; f - Kladno-Rakovník B.; g - Mšeno-Roudnice B. (Mělník B.); h - Plzeň B.; i - Manětín B.; j - Radnice B.; k - Žihle B; l - Brandov occurrence 4 - Permo - Carboniferous of the grabens: a - Boskovice G., b - Blanice G.
--- border of the Western Carpathians, ······· boundary of basins.

Fig. 4. Carboniferous and Permian in the Bohemian Massif and in the basement of the Western Carpathians on the territory of the Czech Republic

Sedimentation was accompanied also by basaltoid, andesitoid up to rhyolitic volcanism of the intra-plate type and sedimentation of clastic rocks with elevated Cu content. A substantial change of climate, caused by the shift of the lithospheric plate with the Bohemian Massif further north, into the belt between the equator and tropic of Cancer, resulted in the formation of deserts, which covered most of Europe. These sediments are today preserved in the Bohemian Massif only in relics. They reach the highest thickness – up to 3 km – in tectonic troughs of roughly N-S direction, so-called grabens (Boskovice and Blanice grabens). Coal seams (today already mined out) of Upper Stephanian age occur locally on the basis of the Permian in these grabens, and higher horizons contain restricted lake and river calcareous sediments. These are commonly overfilled by relics of Stegocephalians and especially of the Permian insects, which made the Boskovice Graben famous.

The Bohemian Massif was slowly uplifted as a compact block after the Hercynian consolidation and it remained mainly land almost until the end of Mesozoic. White lake sandstones of the ***Triassic*** are represented only to minor extent in NE Bohemia in the Krkonoše Mts. Piedmont and Intra-Sudetic Basins. Sea penetrated from the Carpathian area to northern Germany by a narrow channel across northern Bohemia (roughly between Brno and Dresden) in the ***uppermost Jurassic***. This channel linked the deep Tethys on the SE with the shallow shelf sea to the north from the Bohemian Massif. Limestones (Oxfordian–Kimmeridgian) are exposed only in small islands along the Lužice Fault. In the consolidated Bohemian Massif was the ***Alpine orogeny*** represented mainly by origin of faults or rejuvenation of older fault



1. Bohemian Cretaceous Basin and its facies areas (developments): a - Lužice a., b - Jizera a., c - Labe (Elbe) a., d - Orlice-Žďár a., e - Ohře (Eger) a., f - Vltava-Beroun a., g - Kolín a., h - Hejšovina and Bystřice a. 2. Cretaceous in environs of Osoblaha.
3. South Bohemian basins: a - České Budějovice b., b - Třeboň b. ---- boundary of facies areas (developments)

Fig. 5. Upper Cretaceous in the Bohemian Massif on the territory of the Czech Republic

systems. ***Transgression of the Upper Cretaceous sea***, which flooded all the northern and partly also the central part of the Bohemian Massif, was of much higher importance. Several hundreds meters thick strata of the Upper Cretaceous claystones, marlites, sandy marlites and sandstones (the Bohemian Cretaceous Basin – Fig. 5) developed there. The Bohemian Cretaceous Basin is divided into facies areas (developments) shown in Fig. 5 based on character of sedimentation in particular parts of the Basin. Rock complexes of the Basin represent the most important underground water reservoir in the Czech Republic and also an important raw material resource (ceramic and refractory clay, glass, foundry and mortar sand, cement raw materials, building and sculpture stone but also uranium). A small occurrence of Upper Cretaceous sediments near Osoblaha is an extremity of the Polish Opole Cretaceous Basin. Smaller, but fresh-water Upper Cretaceous basins formed also in southern Bohemia. It is the České Budějovice Basin localized more westward and the Třeboň Basin localized more eastward.

The evolution in Moravia was different. The Triassic is not represented at all, whereas in the ***Jurassic*** the sea penetrated from the Mediterranean area far to the NW and flooded the eastern margin of the Bohemian Massif. Jurassic sediments are nowadays to a large extent covered by rocks of the Neogene or the Outer Flysh Carpathian nappes. Tectonic blocks of the Jurassic limestones, exhumed from depth in front of the Carpathian nappes and forming isolated klippen by Štramberk and in the Pavlovské vrchy Hills, represent an important land-forming element and also an important resource of very pure carbonate raw material.

The character of the sedimentation in the Outer Carpathians markedly changed in the ***Cretaceous***. Sediments formed in deeper sea from submarine slides and turbidite currents,

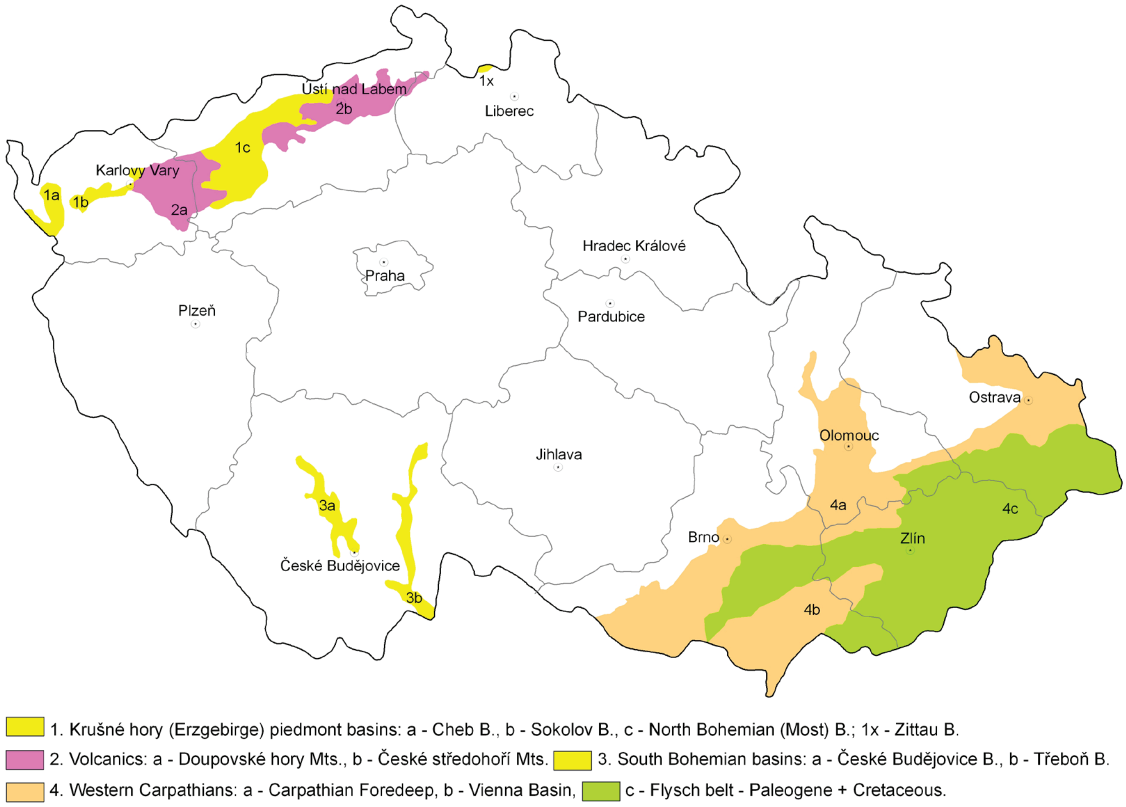


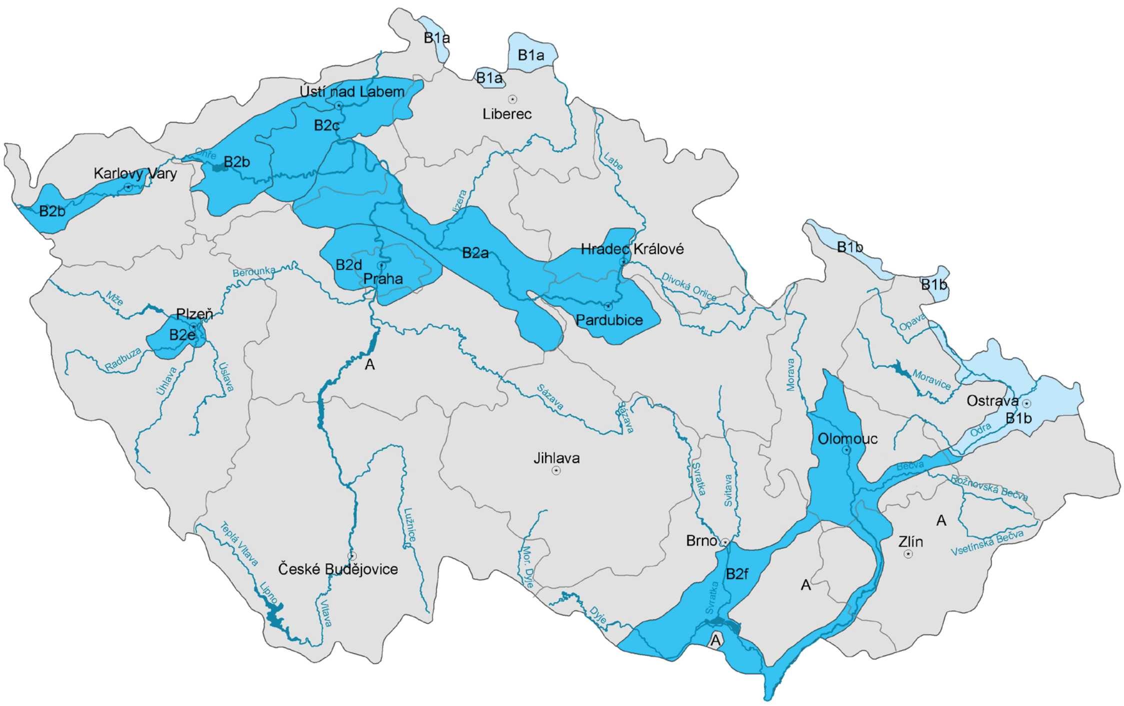
Fig. 6. Tertiary in the Bohemian Massif and Western Carpathians on the territory of the Czech Republic

transporting clastic material far from the land. They are characterized by multiple alternations of sandy and clayey layers of a low thickness (dm to m) and infrequently also sandstone benches, which are collectively called **flysh**. The sediments reach even many thousand meters in thickness. The flysh sedimentation continued in this area also in the Paleogene (Fig. 6).

The Bohemian Massif remained land which was only occasionally flooded in the east by shallow epicontinental sea from the Carpathian area. Nevertheless, several depressions with intensive freshwater sedimentation were formed as a result of strong tectonic movements in the Alpine and Carpathian space in the end of the ***Paleogene and in the Neogene***. This is the area of the South Bohemian basins (the České Budějovice Basin and the Třeboň Basin) with lignite, clay and diatomite deposits and also a marked tectonic trough of the SSW-NNE direction (Ohře Rift) in north-western Bohemia, where the Krušné Hory Piedmont basins (Cheb, Sokolov, North Bohemian and Zittau) formed – see Fig. 6. Sandstones and especially clays and claystones with thick (exceptionally and locally up to 60 m) brown coal seams sedimented in these basins. Brown coal deposits in the North Bohemian and Sokolov basins represent the most important brown coal deposits in the Czech Republic. Important deposits of Neogene clays then occur in the Cheb Basin. Formation of basins was accompanied by very intensive **volcanic activity** and a large accumulation of lavas and pyroclastics (the Doupovské hory Mts. Volcanic Complex, České středohoří). The rocks are mainly various types of olivine basalts and alkaline basaltic rocks, to lesser extent also more acid phonolites. Volcanic conduits and necks give today's landscape a beautiful character. The main volcanic activity took place 35–17 Ma ago, a younger phase 8 Ma ago and the last minor volcanoes are just several thousand years old (Komorní and Železná hůrka). The area represents a classical example of alkaline volcanism and it played an important role in the evolution of geosciences. The rocks are important not only as a building stone but also as a raw material for manufacture of molten basalt products. Deposits of the Bohemian garnets at the southern margin of České středohoří are related to the volcanic activity, too (pyropes were carried up by volcanic necks from the ultrabasic rocks in the crystalline basement). Weathering and decomposition of tuffs of the Doupovské hory and České středohoří Mts. resulted in the formation of important bentonite deposits.

The flysh complexes of the Carpathian area were folded and thrust in the form of nappes (verified by exploration) over a distance of several tens of kilometres towards the west and southwest over the Bohemian Massif in the end of the ***Paleogene***. The Carpathian Foredeep, partly still covered by the arriving nappes, formed in front of the thrust nappes in the ***Neogene*** (Miocene). The sediments of the Vienna Basin (of up to 5 km in thickness) were subsequently hardly folded. These are represented mainly by marine clay, marl and sand, just partially diagenetically consolidated, which contain smaller deposits of oil and gas. The depositional setting of the younger formations became progressively fresh-water. The youngest ones contain deposits of lignite.

Important tectonic processes expressing themselves by marked vertical movements of individual crustal segments operated in the Bohemian Massif in the end of the Tertiary and beginning of the Quaternary. In this way, the marginal mountains – Šumava Mts., Český les Mts., Krušné hory Mts., Krkonoše Mts., Orlické hory Mts. as well as Hrubý Jeseník Mts. – were uplifted by up to 1,000 m and the Bohemian basin was formed. This is sometimes considered



A - Quaternary of the denudation areas, B1 - Quaternary areas of the continental glaciation: a - North Bohemian Area, b - North Moravian Area, B2 - Quaternary of the extra glacial areas: a - Labe (Elbe) a., b - Krušné hory (Erzgebirge) piedmont basins, c - České středohoří Mts., d - Praha Plain, e - Plzeň Basin, f - Moravian dales.

Fig. 7. Quaternary division on the territory of the Czech Republic

as being formed by the impact of a large meteorite, but this is a nonsense resulting from the interpretation of satellite images without knowledge of the real structure of the massif. The Bohemian Massif was influenced by several phases of continental and mountain **glaciations** during the ***Quaternary***. A periglacial climate dominated here, which resulted in the formation of massive stony debris and block-seas, terrace system of the rivers (Fig. 7) as well as really extensive loesses. Terrace sediments of rivers especially form important deposits of sand and gravel and feldspar raw materials, and loesses of brick clays. The continental ice sheet reached as far as the northern margin of the massif and left sediments of frontal moraines in the Ostrava region, on the northern piedmont of the Hrubý Jeseník Mts. and in the Šluknov and Frýdlant extremities. Mountain glaciers modified morphology of the marginal mountains, especially the Krkonoše Mts., to a lesser extent also the Jeseníky Mts. and Šumava Mts., where even minor glacier lakes formed.

Figures in this chapter were adapted by the author from

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Regional geological units and minerals associated with them

(that minerals are indicated whose deposits belong to the units; digits of figures and units are related to the previous chapter "Geological evolution of the area of the Czech Republic")

Arnošt Dudek

Bíteš orthogneiss – mostly muscovite orthogneiss of the Cadomian age, characteristic of the Moravicum of the Dyje and Svratka domes between Krems in Austria and Svojanov in the Czech Republic (opal, kaolin, crushed stone) – Fig. 3 – unit 5a

Blanice Graben – fault system of the NNE-SSW direction in central and southern Bohemia, marked also by downthrown islands of the uppermost Carboniferous and Permian with hard coal and anthracite seams. It continues as Rodel line in Austria (Au-Ag-ores) – Fig. 4 – unit 4b

Bohemian Cretaceous Basin **–** sediments of the Upper Cretaceous (Cenomanian to Santonian), overlying mainly crystalline complexes and Upper Paleozoic rocks in the northern part of the Bohemian Massif. Based on the lithological character, it has been regionally classified into facial developments as follows:

- *Lužice* (U-Zr-ores, glass and foundry sand) – Fig. 5 – unit 1a
- *Jizera* (glass and foundry sand, dimension stone) – Fig. 5 – unit 1b
- *Orlice-Žďár* (foundry sand) and its *east Bohemian* (clays) and *Moravian parts* (clay) Fig. 5 – unit 1d
- *Ohře (Eger)* – the Most, Teplice (quartzite, corrective additives for cement production) and Louny part (clay) Fig. 5 – unit 1e
- *Vltava-Beroun* including Prague surroundings (clay, dimension stone) Fig. 5 – unit 1f

Boskovice Graben – tectonic trench of the NNE-SSW direction in western Moravia filled with sediments of the uppermost Carboniferous and Permian (hard coal) Fig. 4 – unit 4a

Bory granulite massif – a small granulite body in the Moldanubicum N of Velké Meziříčí in western Moravia (feldspar, crushed stone) – Fig. 4 – unit 4a

Brno Massif **–** a large massif in western Moravia built by a variable series of both acid and basic plutonic rocks of the Cadomian age (feldspar, crushed stone) – Fig. 2 – unit 10

Carpathian Flysh – a part of the Outer Carpathians in eastern Moravia built by clayey and sandy Cretaceous and Paleogene sediments, with a marked nappe structure of the pre-Miocene age. It composes the Chřiby Mts. and the Ždánice Forest and mountain ranges on the border with Slovakia – the Beskydy, Javorníky and Bílé Karpaty Mts. (natural gas) – Fig. 6 – unit 4c

Carpathian Foredeep **–** the external part of the Carpathian mountain chain in eastern Moravia, which was formed in front of the Outer Carpathian nappes and overlies the south-eastern slope of the Bohemian Massif. It is filled with the Miocene sediments of the Egerian to Badenian (oil, natural gas, clay, bentonite, gypsum in the Opava Basin) – Fig. 6 – unit 4a

Central Bohemian Pluton – an extensive Hercynian granitoids pluton on the border between Bohemicum and Moldanubicum, more basic than the massifs of the Krušné hory Mts. and in Českomoravská vrchovina Highlands (granodiorites, tonalite, diorite). Important deposits in the exocontact (U, Au, Ag-Pb-Zn-ores, feldspar, quartz, dimension and building stone) – Fig. 2 – unit 6

Cheb Basin – the westernmost of the Tertiary basins, at the crossing of the Ohře rift and the Tachov Graben. Sedimentation continued from Eocene until Pliocene (brown coal, kaolin, clay, diatomite, glass and foundry sand – numerous conflicts of interest) – Fig. 6 – unit 1a

České Budějovice Basin **–** a smaller, western basin of South Bohemian basins, filled with fresh-water sediments of the Upper Cretaceous and to a minor extent Neogene and Quaternary. Episodic ingressions of the sea from the Alpine foredeep (lignite, tectites, diatomite, sand and gravel) – Fig. 6 – unit 3a

České středohoří Mts. **–** a classical area of the Tertiary alkaline volcanic rocks (olivine basalts to phonolites) exposed in the Ohře (Eger) rift between Chomutov and Nový Bor, with the main volcanic centre in Roztoky nad Labem (pyrope, diatomite, feldspar substitutes, crushed stone) – Fig. 6 – unit 2b

Čistá-Jesenice Massif – a minor granitoid massif in western Bohemia composed of both Cadomian and Hercynian bodies. It is covered from a large part by Carboniferous and Permian sediments (feldspar, dimension and building stone) – Fig. 2 – unit 4

Domažlice Crystalline Complex – south-western part of the upper Proterozoic of the Bohemicum in the Šumava piedmont, metamorphosed during both Cadomian and Hercynian orogeny, with minor massifs of granitoids and gabbroic rocks and abundant pegmatites (feldspar) – Fig. 2 – unit 17

Doupovské Hory Mts. – a volcanic complex of the Tertiary age at the crossing of the Ohře rift with the Jáchymov fault, between Karlovy Vary and Kadaň. Alkaline volcanic rocks are represented mainly by olivine basalt, "leucitic" tephrite and abundant tuffs. Phonolites are missing (bentonite, crushed stone) – Fig. 6 – unit 2a

Dyje Massif – a massif of the Cadomian granitoids in the Dyje Dome of the Moravicum in SW Moravia, extending from the northern vicinity of Znojmo almost to Danube. It was affected by a strong tropical weathering in the Jurassic and Neogene and from a large part covered by sediments of the Carpathian foredeep (kaolin, feldspar, building stone) – Fig. 2 – unit 11

Hroznětín Basin – the northern extremity of the Sokolov Basin N of Karlovy Vary (bentonite) – Fig. 6 – unit 1b

Intra-Sudetic Basin – southern extremity of the Lower Silesian Basin in the NE tip of Bohemia, with sedimentary fill from the Mississippian (Lower Carboniferous) to Upper Cretaceous about 3,000 meters in thicknes, and Pennsylvanian and Permian volcanites. (hard coal) – Fig. 4 – unit 3a

Islet zone of the Central Bohemian Pluton – a number of both large and minor blocks of the contact metamorphosed Proterozoic and Lower Paleozoic rocks from the mantle of the pluton, downthrown into granitoids (Au, building stone, barite, limestone) – Fig. 2 – unit 6

Jílové Belt – a belt of the Upper Proterozoic volcanic (basalt, andesite, boninite and rhyolites), subvolcanic and acid plutonic rocks extending over 120 km in NNE-SSW direction south of Prague, from a major part enclosed in granitoids of the Central Bohemian Pluton (Au-ores, building stone) – Fig. 2 – unit 6

Kdyně Massif – a complex of metabasic, gabbroic and dioritic rocks in the Domažlice Crystalline Complex on the border of Šumava and Bohemian Forest (dimension and building stone) – Fig. 2 – unit 12

Kladno-Rakovník Basin – one of the basins of the Central Bohemian limnic Carboniferous, partly covered by Cretaceous sediments (hard coal, kaolin, claystone) – Fig. 2 – unit 12

Krkonoše-Jizera Crystalline Complex – western part of the Lužice area built by metamorphic rocks of the Proterozoic and Lower Paleozoic age (limestone, dolomite) and intruded by plutons of the Cadomian (Lužice) and Hercynian (Krkonoše-Jizera) age (feldspar, dimension and building stone). Fe-bearing skarns, Sn and W-ores, fluorite and barite occur in the exocontact of the plutons – Fig. 2 – unit 14

Krkonoše-Jizera Massif – Hercynian granitoid massif building the border range with Poland (excellent dimension stone, feldspar) – Fig. 2 – unit 2

Krkonoše Mts. piedmont basin – one of the Sudetic (Lugian) Upper Paleozoic basins partially covered with Cretaceous sediments. Formations encompass Westphalian C, Stephanian, whole Permian and extend up to the lowermost Triasic (Cu-ores, Au paleoplacers, bituminous coal, pyrope) – Fig. 4 – unit 3c

Krušné hory Mts. Piedmont basins – a group of limnic Tertiary basins associated with the Ohře Rift SE of the Krušné hory Mts. From WSW to ESE, these are: Cheb, Sokolov and North Bohemian basins. – Fig. 6 – unit 1

Krušné hory Mts. Pluton – a large Hercynian granitoid pluton underlying metamorphic rocks of the Krušné Hory and Smrčiny Mts., exposed by erosion only in numerous partial massifs (Sn-W-ores, Li-Rb-Cs ores, kaolin, feldspar, quartz, building stone) – Fig. 2 – unit 3

Krušné hory Mts. Crystalline Complex – a part of the Saxothuringicum built by metamorphic complexes mostly of the Proterozoic, subordinately also of the Lower Paleozoic age (U, Ag, Bi, Co, As-ores, Cu-ores, Sn-skarns, fluorite, barite, kaolin) and intruded by Hercynian granitoids. – Fig. 3 – unit 3 (Fig. 2 – unit 15)

Lužice Massif – an extensive Cadomian granitoids massif predominantly on the German territory, extending into the Jizera Mts. (quartz, dimension and building stone) – Fig. 2 – unit 1

Moldanubian Pluton – the largest Hercynian granitoids complex in the Bohemian Massif in Českomoravská vrchovina Highlands, Šumava and Waldviertel (dimension and building stone; Au-W and U-ores and Ag-Pb-Zn-ores in the exocontact) – Fig. 2 – unit 8

Moldanubicum – basement of the southern part of the Bohemian Massif built by high-grade metamorphic complexes of Proterozoic and probably also Lower Paleozoic age. The cadomian tectonometamorphic processes were followed by hercynian high temperature and low pressure metamorphism and the whole complex was penetrated by numerous late-Hercynian granitoid plutons. – Fig. 3 – unit 1

Moravian-Silesian Devonian – weakly metamorphosed volcano-sedimentary unites in the Jeseníky Mts. – *Vrbno Strata, Šternberk-Benešov Belt* (Fe-ores, Cu-ores, Pb-Zn-ores, barite, quartzite, dolomite) – Fig. 2 – unit 19

Moravian-Silesian Carboniferous – marine flyshoid Mississippian (Lower Carboniferous) of the Nízký Jeseník Mts. and Drahany Highlands (slate, quartz) and productive paralic Mississippian to limnic Pennsylvanian (Upper Carboniferous) of the Ostrava region (Upper Silesian Basin – hard coal, natural gas) – Fig. 4 – unit 1, 2

Mšeno-Roudnice Basin – one of the Central Bohemian Carboniferous to Permian basins, completely overlain by the Bohemian Cretaceous Basin (hard coal) – Fig. 4 – unit 3g

Nasavrky Massif – a minor however very complex Hercynian granitoid body exposed in the Železné hory Mts. (pyrite, dimension and building stone; fluorite and barite in the exocontact) – Fig. 2 – unit 7

North Bohemian Basin – the largest Tertiary basin of the Ohře Rift between the Doupov Mts. and České středohoří Mts. (brown coal, clay, bentonite, diatomite, quartzite) – Fig. 6 – unit 1c

Ohře rift – a prominent fault structure in the south-eastern piedmont of the Krušné hory Mts. delimited by the Krušné hory and Litoměřice faults and their directional continuations. Tertiary alkaline volcanites, coal-bearing basins and mineral as well as thermal waters are associated with the rift – Fig. 3 – unit 3a

Orlické hory Mts.-Kłodzko Crystalline Complex – metamorphic complexes of probably Proterozoic age in the eastern part of the Lužice area in the Orlické hory and Rychleby Mts. and in Kłodzko – Fig. 2 – unit 18

Outer klippen zone of the Western Carpathians – extensive fragments of Jurassic and Cretaceous sediments brought up from depth in front of the flysh nappes – Štramberk, Pavlovské vrchy (limestone) – Fig. 2 and 6 – unit 4c

Plzeň Basin – an independent basin at the SW margin of the West Bohemian Carboniferous (hard coal, kaolin, clay) – Fig. 4 – unit 3a

Quaternary alluvia – alluvia and terraces of majority of larger water courses (feldspar, sand and gravel, in south Bohemia and SW Moravia also tectites) – Fig. 7 – units B2a, B2b, B2f

Quaternary placers – in piedmont of the Šumava and Jeseníky Mts. (Au), Krušné Hory Mts. (Sn), southern piedmont of the České středohoří Mts. (pyrope)

Sokolov Basin – the smallest Tertiary basin of the Ohře Rift WSW of the Doupovské hory Mts. with important deposits of energy minerals (brown coal, U, clay, bentonite) – Fig. 6 – unit 1b

South Bohemian Basins – freshwater sedimentation space of the Upper Cretaceous and Tertiary age, where the Rudolfov horst separates the smaller České Budějovice Basin in the west from the larger Třeboň Basin in the east – Fig. 6 – unit 3

Svratka Dome of the Moravicum – the northern of the domes built by metamorphic rocks of the Moravicum W of Brno (graphite, feldspar, limestone, building stone) – Fig. 3 – unit 5a

Syrovice-Ivaň terrace – a higher located Quaternary terrace between the Jihlava and Svratka rivers S of Brno (feldspar) – Fig. 7 – unit B2f

Teplá Crystalline Complex – the NW part of the Proterozoic of the Central Bohemian area (Bohemicum) with a rapid succession of metamorphic zones from SE to NW into the Slavkov Forest (feldspar) – Fig. 2 – unit 16

Tertiary relics of the Plzeň region – relics of the formerly more extensive Tertiary sediments on the site of a river paleostream discharging into the North Bohemian Basin (clay, bentonite) – not shown on scale of the maps

Třebíč Massif – an extensive massif of the Hercynian melanocratic granitoids and syenitoids (durbachites) in the Českomoravská vrchovina Highlands (amethyst, morion, feldspar, dimension stone) – Fig. 2 – unit 9

Třeboň Basin – a larger, eastern basin of South Bohemian basins with continental Cretaceous and Tertiary sediments (kaolin, clay, bentonite, diatomite) – Fig. 6 – unit 3b

Upper Silesian Basin – a Carboniferous basin formed by sediments of Upper Mississippian and Pennsylvanian situated predominantly in Poland and extending to the Czech Republic only by its SW part. It is formed by volcanoclastic sediments with numerous hard coal seams. On the Czech territory, it is further subdivided into i) western, more mobile paralic Ostrava part, ii) eastern, platform limnic Karviná part and iii) southern Beskydy part (hard coal, natural gas) – Fig. 4 – unit 2

Variegated Group of the Moldanubicum – metamorphic complexes of paragneisses and migmatites with numerous intercalations of amphibolites, marbles, quartzites, graphitic rocks and skarns (Fe-skarns, graphite, feldspar, limestone, dolomite, fluorite, building stone) – part of the Modanubian unit 1, in Fig. 3

Vienna Basin – an extensive Tertiary Neogene basin with marine sedimentary fill gradually becoming freshwater of more than 5,000 m in thickness (lignite, oil, natural gas) – Fig. 6 – unit 4b

Železné hory Mts. area – part of Bohemicum built by weakly metamorphosed volcano-sedimentary series of the Upper Proterozoic and sediments of the Lower Paleozoic (Mn-Fe-carbonates, pyrite, fluorite, barite, limestone) and the Hercynian granitoid Nasavrky Massif – Fig. 2 – unit 20

Zittau Basin – a Tertiary basin in the continuation of the Ohře Rift, extending only by a negligible south-eastern extremity into the Czech territory (brown coal, lignite, clay) – Fig. 6 – unit 1d

Žulová Massif – a minor Hercynian granitoid massif in the northern tip of the Moravian-Silesian area (kaolin, quartz, dimension and building stone) – Fig. 2 – unit 5

Geodynamics of the origin of the Bohemian Massif covering the territory of the Czech Republic

Karel Schulmann, Vojtěch Janoušek, Ondrej Lexa

The Bohemian Massif represents one of the largest exposure of the European Variscan belt located at its eastern extremity (Figure 1). The Variscan architecture of the Bohemian Massif can be defined by four major tectonic units: 1) The Saxothuringian Neoproterozoic continental basement with its Palaeozoic cover, 2) The Teplá-Barrandian (Bohemicum) Neoproterozoic basement and its Early Palaeozoic cover of the Prague Basin (the Bohemia Terrane of South Armorica), 3) The Moldanubian high- to medium-grade metamorphic unit intruded by numerous Carboniferous granitic plutons, altogether forming the high-grade core of the orogen, 4) The easterly Brunia Neo-Proterozoic basement with Early to Late Palaeozoic cover.

The Gondwana faunas of Lower Palaeozoic (Cambrian and Ordovician) sediments of the Saxothuringian and Teplá-Barrandian domains and numerous isotopic and U-Pb zircon data imply affinity to northern Gondwana margin. Schulmann et al. (2009) suggested that the Variscan structure of the Bohemian Massif resulted from Andean type convergence and formed as a typical upper plate orogen located above a long lasting Devonian-Carboniferous subduction system. These authors shown that all the current criteria defining an Andean type of convergent margin are present and surprisingly well preserved. In particular it is: 1) the development of blueschist facies metamorphism along the Saxothuringian margin, 2) calc-alkaline to potassium rich (shoshonitic) arc type magmatism in distance 150–200 km from the suture zone (Žák et al., 2005), 3) back-arc basin developed on continental upper plate crust later replaced by thick continental root (Schulmann et al., 2005), 4) deep granulite facies metamorphism associated with supposed underplating of the crust by mafic magmas at the bottom of the root and 5) continental lithosphere underthrust underneath the thickened root system. Based on these criteria, the architecture of the eastern Variscan belt is interpreted as the result of a large-scale and long-lasting subduction process associated with crustal tectonics, metamorphism, magmatic and sedimentary additions that developed over the width of at least 500 km, in present coordinates, and time scale of ~80 Ma.

Present day architecture of the Bohemian Massif and location of Palaeozoic sutures

Saxothuringian is represented by Neoproterozoic par-autochthon represented by migmatites and paragneisses dated at ~580–550 Ma. These rocks are intruded by Cambro-Ordovician calc-alkaline porphyritic granodiorites converted to augen orthogneiss during the Variscan orogeny. The basement is unconformably covered by Cambrian and Ordovician sequences overlain by Late Ordovician to Famennian pelagic sediments and Famennian to Visean flysh. The par-autochthon is thrust by allochthonous units containing deep water equivalents of the Ordovician to Devonian rocks of the para-autochthon and proximal flysh sediments.

The allochthonous are represented by pile of thrust sheets marked by decreasing pressure and metamorphic age from the top to the bottom (Franke, 2000; Konopásek and Schulmann, 2005). In the highest structural position occur thrust sheets with metabasites of Ordovician protolith

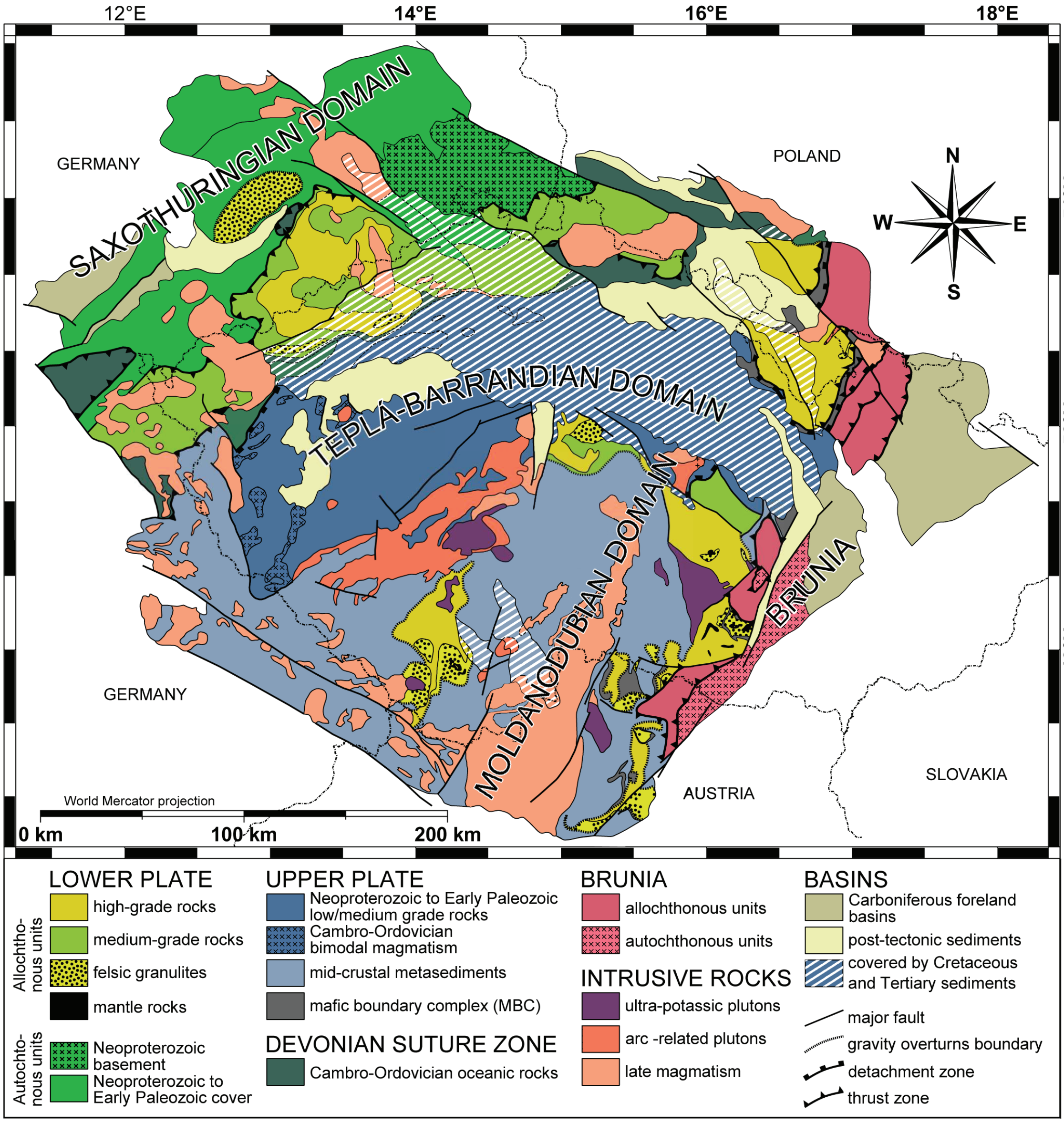


Figure 1. Plate tectonic map of the Bohemian Massif

age eclogitized during Devonian (~395 Ma). Structurally deeper occur sheets associated with middle pressure assemblages and Late Devonian zircon and Hbl cooling ages (~365 Ma). This rock pile represents Late Ordovician to Devonian passive margin imbricated during Devonian convergence. In the Sudetic part (Figure 1, Figure 2a-c) of the Bohemian Massif, the Ordovician rift sequences are characterized by the presence of deep marine sediments and MORB type volcanics followed by Silurian and Devonian sedimentary sequences. The Ordovician oceanic rocks are metamorphosed at blueschist-facies conditions probably at Late Devonian.

The oceanic subduction stage was followed by Carboniferous continental subduction of the Saxothuringian continental rocks underneath easterly Teplá-Barrandian block which was responsible for the eclogitization of continental crust at ~350–340 Ma (Schmädicke et al., 1995). This event is responsible for the global reworking of the Saxothuringian at high pressure conditions, thrusting of subducted continental crust and exhumation of deep rocks.

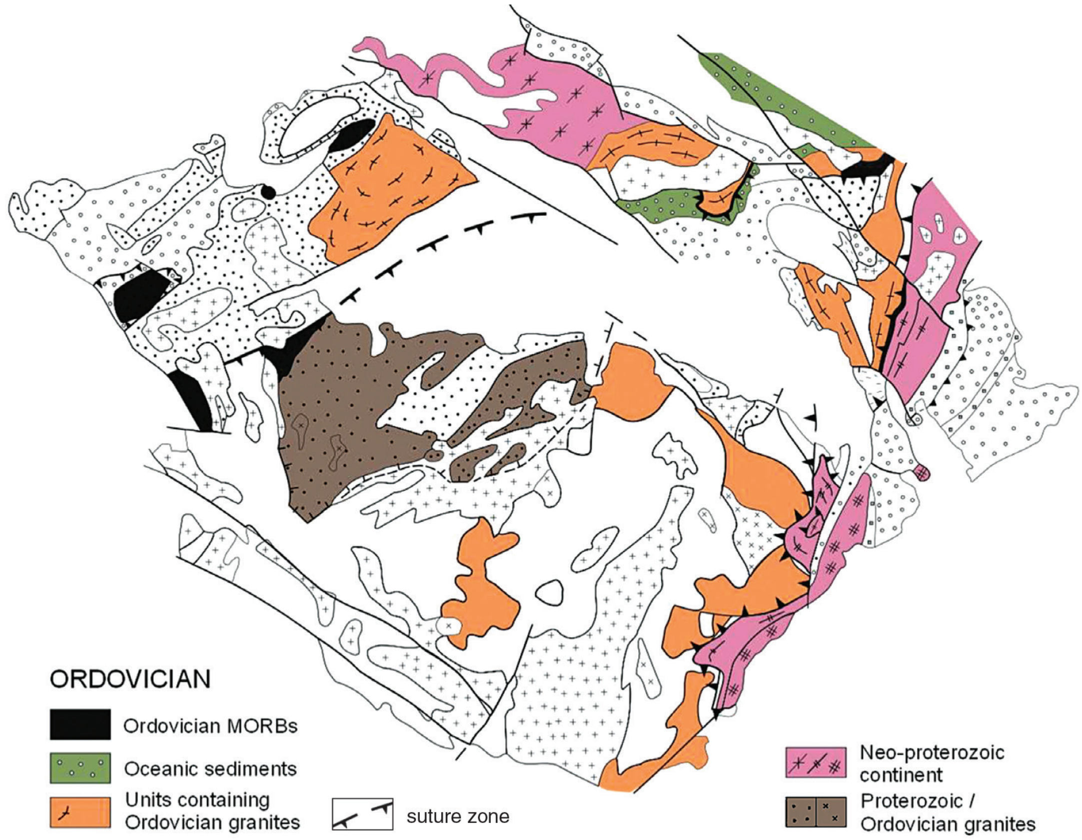


Figure 2a. Architectural evolution of the Bohemian Massif – Ordovician stage

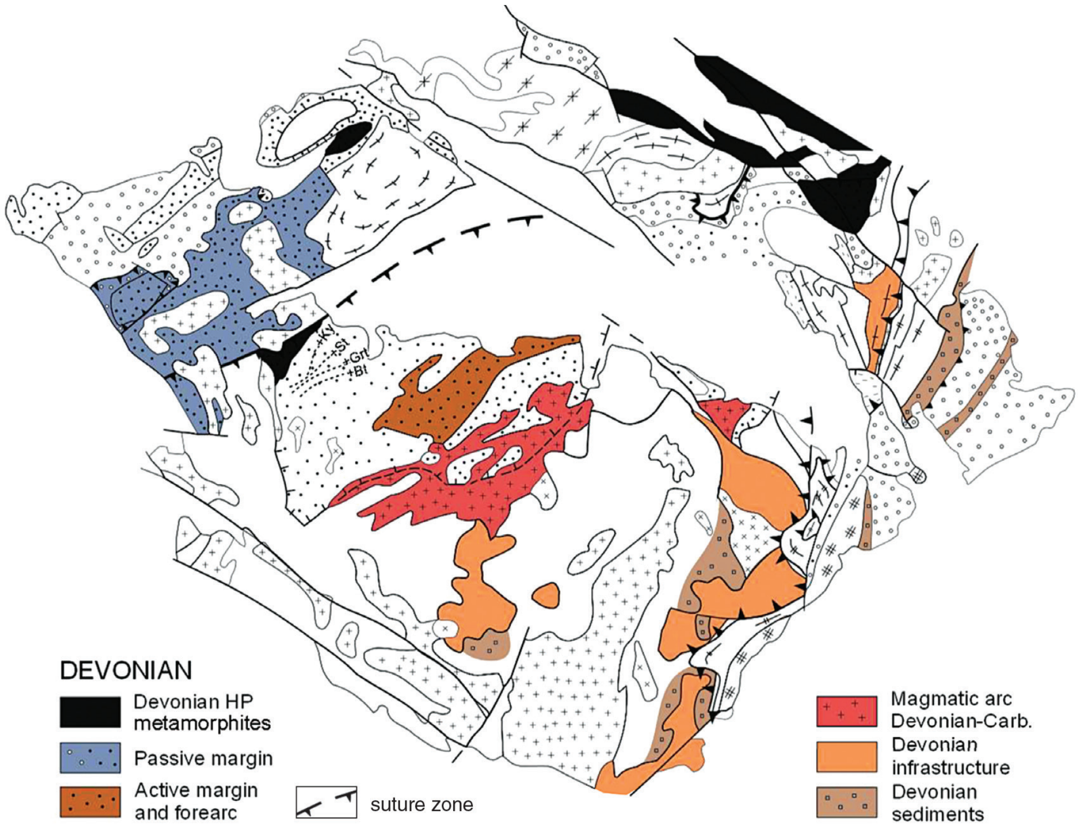
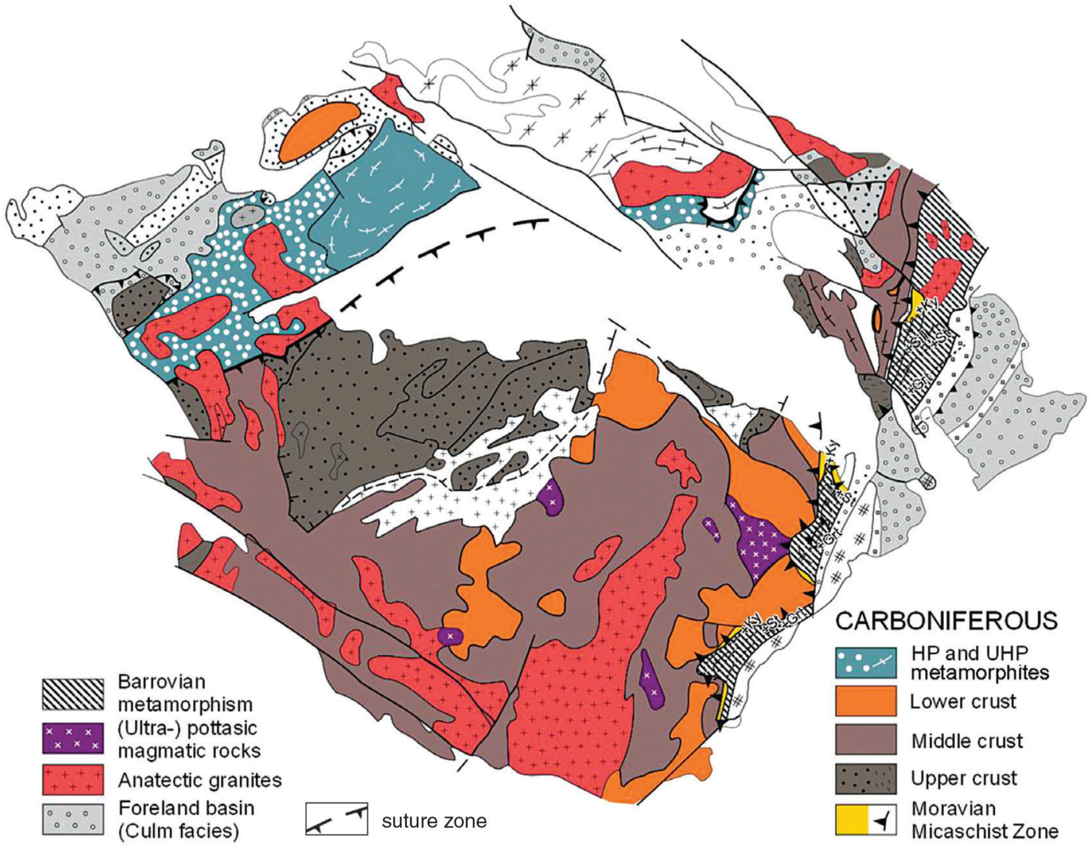


Figure 2b. Architectural evolution of the Bohemian Massif – Devonian stage



Metamorphic zones and facies: Ky – kyanite zone, St – staurolite zone, amphibolite facies, Grt – granulite facies, Bt – blueschist facies

Figure 2c. Architectural evolution of the Bohemian Massif – Carboniferous stage

The Saxothuringian – Teplá-Barrandian boundary is characterized by presence of units with high proportions of ultramafic and mafic high pressure rocks (Figure 1). Represented by serpentinites at the bottom and thick body of amphibolites, eclogites and metagabbros (Medaris et al., 1995). The protolith of gabbros and eclogites was dated as Cambrian and Ordovician while the Devonian metamorphic and cooling ages range between 410 and 370 Ma. The metamorphic evolution started with eclogite-facies metamorphism and terminated by granulite and amphibolite-facies retrogression. These rocks are interpreted as the oceanic fragment at suture position.

Teplá-Barrandian (the Bohemicum) consists of Neoproterozoic basement with the lower arc-related volcano-sedimentary sequence, followed by siliceous black shales and a flyshoid sequence (shales, greywackes and conglomerates. The Neoproterozoic basement is unconformably overlain by a thick sequence (1500–2000 m) of Lower Cambrian conglomerates, graywackes, and sandstones and Upper Cambrian volcanics. The Lower Palaeozoic Prague Basin is characterized by Early Ordovician (Tremadocian) transgression followed by mid-Ordovician rift related volcanics. Sedimentation of Silurian graptolite shales was associated with important volcanic activity accompanied by basaltic and ultramafic intrusions. The sedimentation continued from Upper Silurian to Devonian by carbonate dominated sequence and terminated at mid-Devonian with Givetian calc turbidites.

The whole sedimentary package is folded by steep folds presumably of Late Devonian age as indicated by Culm facies sediments unconformably deposited on folded Early Paleozoic strata. The deformation affected also the underlying Neoproterozoic basement, with the intensity and age increasing progressively to the west (Zulauf, 2001). In the same direction rises also the metamorphic degree, reaching amphibolite-facies conditions close to the Teplá-Barrandian/Saxothuringian boundary. In this area is developed a typical Barrovian metamorphic zonation ranging from biotite zone in the east up to kyanite zone in the west dated at middle Devonian by $^{40}Ar/^{39}Ar$ method (Dallmeyer and Urban, 1988).

The Teplá-Barrandian and Moldanubian domain boundary is masked by the Central Bohemian Plutonic Complex. Its activity started with intrusions of calc-alkaline Devonian (~370 Ma) tonalites to granodiorites transformed into orthogneisses. The first unmetamorphosed plutonic rocks were Late Devonian (~354 Ma) calc-alkaline tonalites, granodiorites, trondhjemites, quartz diorites and gabbros. The source of the basic magmas was a slightly depleted mantle above a subduction zone. Further south/southeast occur Early Carboniferous (~349–346 Ma) high-K calc-alkaline plutonic bodies (mainly granodiorites with minor quartz monzonite and monzogabbro bodies). The intermediate rock types resulted from mixing of slightly enriched mantle-derived and crustal magmas. Finally, further east occur syn-deformational bodies or post-tectonic elliptical intrusions of magnesio-potassic rocks of mid-Carboniferous (~343–337 Ma) ages. The plutonic bodies contain numerous xenoliths, screens of the Barrandian-like Palaeozoic and Neo-Proterozoic rocks.The Central Bohemian Plutonic Complex is interpreted as a relatively shallow section (< 10 km) through the Devonian-Carboniferous magmatic arc, which widened and expanded to the east with time.

The Moldanubian is subdivided into two tectonic units: The Drosendorf Unit composed of the “Monotonous Group” represented by Proterozoic metasediments, with numerous Late Proterozoic to Early Palaeozoic orthogneisses, quartzites and amphibolites and the “Varied Group” composed of plagioclase-bearing paragneiss quartzites and marbles intercalated with amphibolites and leptynites (Tollmann et al., 1982). The protoliths of varied metasediments are supposed to be at least partly Early Palaeozoic in age with predominance of Ordovician zircons. Structurally highest is the “Gföhl Unit” composed of orthogneiss with Ordovician protolith ages, amphibolitized eclogites, granulites, garnet- and spinel-bearing peridotites surrounded by felsic migmatites.

Two NW-SE trending belts of high-pressure rocks (granulites, eclogites and peridotites) are distinguished: the western belt located close to the Barrandian–Moldanubian boundary, and the eastern belt rimming the eastern margin of the Bohemian Massif (Medaris et al., 1995). These two belts alternate with NW-SE trending wide belts represented by the Varied and Monotonous groups.

The amphibolite-facies metamorphism developed on the regional scale in the Drosenforf Unit and reflects maximal pressures of 10 kbar at temperatures of 650–700 °C. However, higher grade (eclogitic) boudins have been identified, generally at the boundary between both groups. Metamorphism of the Gföhl unit is characterized by early eclogite facies followed with granulite-facies and amphibolite-facies retrogression (O’Brien and Rötzler, 2003). The age of early high-pressure metamorphism was probably Late Devonian and the granulite-facies overprint is of Viséan age as shown by a number of zircon ages.

The deformation history in the Moldanubian Zone reveals early vertical NNE-SSW trending fabrics, associated with crystallization of high-pressure mineral assemblages. These steep foliations are reworked by flat deformation fabrics that are associated with medium- to low-pressure and high-temperature mineral assemblages. The sub horizontal foliations bear intense NE-SW trending mineral lineation that is commonly associated with generalized ductile flow towards NE. The early sub-vertical fabrics is dated at 350 to 340 Ma, while the ages for the sub-horizontal vary around 335 Ma. In the SW part of the Moldanubian domain, younger set of steep NW-SE metamorphic fabrics reworks the flat foliation, having been associated with low-pressure metamorphic conditions at around 325–315 Ma (Schulmann et al., 2005).

The Moldanubian metamorphic units are commonly intruded by numerous Variscan plutons including magnesio-potassic syenites to melagranites (durbachites), and S-type granitoids. The magnesio-potassic syenites to melagranites are spatially, structurally and temporally associated with high-pressure granulites (Janoušek and Holub, 2007). These rocks have isotopic signatures indicating a metasomatized lithospheric mantle source, presumably contaminated by subducted mature crustal material.

The Moldanubian – Brunia continental transition zone was defined as a zone of medium grade metamorphism called the Moravo-Silesian Zone (Suess, 1926). This zone of intense deformation resulted from thrusting of the Moldanubian over Brunia continent to the east. The contact between these units is marked by a particular unit, the Moravian "micaschist zone", which is composed of kyanite-bearing micaschists. This first order tectonic boundary contains boudins of eclogites, high-pressure granulites and peridotites embedded in the metapelites of both Moravian and Moldanubian parentage order tectonic boundary.

The underlying Moravo-Silesian Zone is characterized by two nappes composed of orthogneiss at the bottom and metapelite sequence at the top. This nappe sequence is overlying Neoproterozoic basement which is often imbricated with Pragian to Givetian cover. The orthogneisses of the Moravian Zone are derived from the underlying Brunia continent. This zone of intense deformation, 50 km wide and 300 km long, is marked by a tectonically inverted metamorphic sequence ranging from chlorite to kyanite-sillimanite zones. The metamorphism is interpreted as a result of continental underthrusting associated with intense top to the NNE oriented shearing. The subsequent deformation is connected with recumbent folding and imbrication of Neoproterozoic gneisses with Devonian cover. The age of this later phase is constrained at 340–325 Ma $^{40}Ar/^{39}Ar$ ages (Fritz et al., 1996).

The Brunia continent originally called the Brunovistulicum by Dudek (1980) consists of Neoproterozoic migmatites and schists dated at ~680 Ma and intruded by 550 Ma old granites. This basement is unconformably overlain by Cambrian and Ordovician strata followed by Lower Devonian quartzites and conglomerates and Givetian carbonate platform sedimentation. Since Early to Late Carboniferous (~350–300 Ma), foreland sedimentary environment developed resulting in deposition of 7.5 km thick Variscan flysch (Culm facies). Low-grade source rocks gradually pass to high-grade metamorphic source material marked by pyrope-rich mineral fraction and granulite pebbles dated at 340–330 Ma (Hartley and Otava, 2001, Kotková et al., 2007). Since 310 Ma deformation started of the flysch basin characterized by metamorphism and intense deformation in the west. The deformation terminated by folding of molasse sediments at ~300 Ma.

Geodynamic evolution of the Bohemian Massif

The succession of tectonic events (Figure 3) can be interpreted in terms of south-eastward (in the present-day coordinates) oceanic subduction of large Saxohuringian ocean underneath an active continental margin, obduction of the passive margin units, formation of a fore-arc

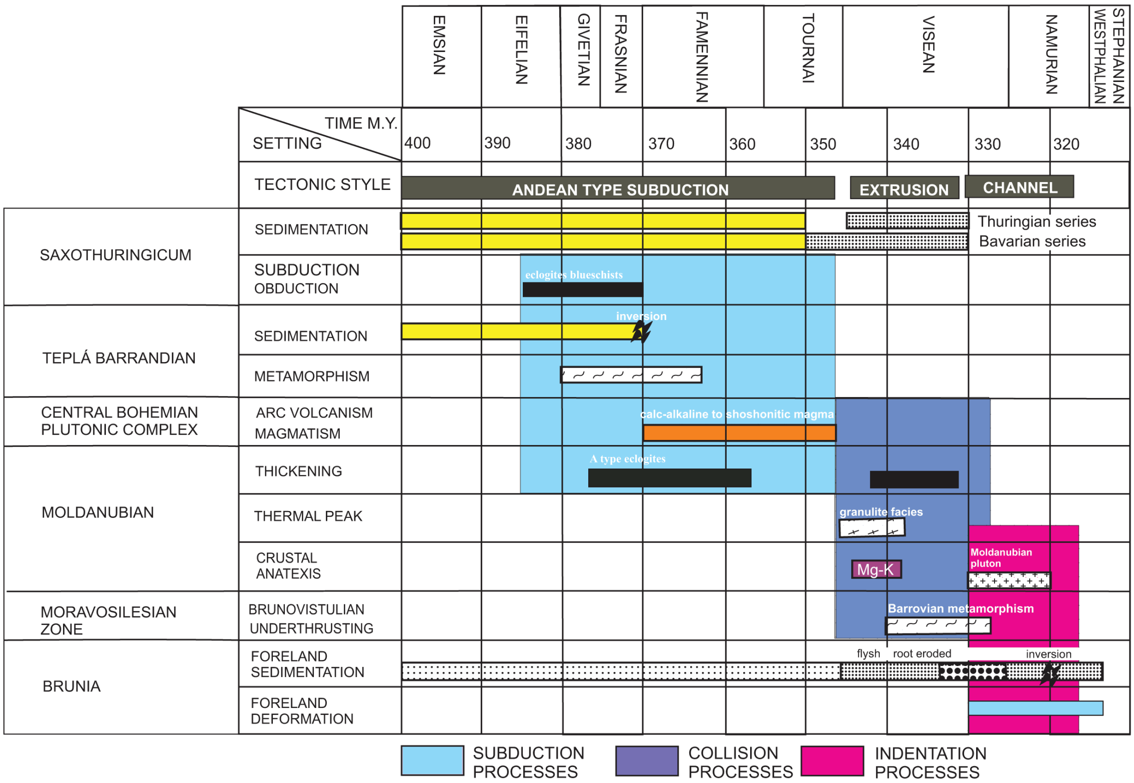


Figure 3. Chronological chart of tectonic events forming Bohemian Massif

region, growth of a magmatic arc and development of a large-scale back-arc system on the continental lithosphere. The early Saxothuringian oceanic subduction event was followed by a continental underthrusting of Saxothuringian continent leading to gradual flattening of the subduction zone marked by eastward migration of arc depocenters and subsequent crustal thickening. The latter event was responsible for the development of a thick continental root at the expense of the upper plate composed of the Teplá-Barrandian and Moldanubian units. The final evolution is marked by the continental indentation of easterly Brunia continent, exhumation of the Moldanubian lower crust, collapse of the Teplá-Barrandian and Moldanubian thrusting over Brunia platform.

Early Devonian oceanic subduction underneath the continental margin (Figure 4) is marked by relics of Ordovician to Lower Devonian passive margin metamorphosed under blueschist–eclogite facies conditions indicating a Mid-Devonian oceanic subduction. These units are obducted above a continuously underthrust continental Saxothuringian plate. The Barrovian metamorphic zonation and related deformation in the overriding Teplá-Barrandian continental margin are interpreted as ductile part of the Barrandian crust extruded during early stage of upper plate Late Devonian shortening. The steep folding of central part of anchimetamorphic Barrandian Neoproterozoic sequences is interpreted as a same deformation event but occurring in more shallow crustal levels. The subduction of a Saxothuringian oceanic crust underneath the Tepla-Barrandian crust is responsible for the origin of a magmatic arc represented by Devonian calc-alkaline orthogneisses and tonalities of the Central Bohemian Magmatic Complex and by isolated granodiorite stocks intruding Neoproterozoic sediments. At this stage the Barrandian basin operated as fore-arc domain as it is indicated by Devonian zircons in the sediments of the same age in the Prague basin. It is difficult to evaluate the original depositional origin of Moldanubian metasediments, metabasites and other high grade rocks due to severe and polyphase reworking.

Amphibolites derived from Siluro-Devonian tholeiitic basalts associated with carbonates, widespread in Lower Austria and south Bohemia, are interpreted as volcanic products of a large-scale back-arc system. In addition, the felsic metavolcanics and amphibolite layers in the Varied Group are regarded as continuity of back-arc bimodal volcanism till Givetian. The back-arc hypothesis corroborates with impressive amount of marbles with high Sr isotopic ratios that indicate shallow marine environment during Palaeozoic. A back-arc environment is further supported by bimodal volcanic activity in narrow Devonian basins developed on the north-eastern margin of the Brunia continent suggesting only minor thinning of continental crust at the easternmost termination of the back-arc system. In this concept the rest of Brunia represents a stable continental domain not affected by the back-arc spreading.

The Barrandian became a for-arc region, while the future Moldanubian continued to evolve as a crustal back-arc system. The position of high-pressure rocks, existence of the Mariánské Lázně Complex at suture position and location of calc-alkaline magmatic rocks confirm a polarity of the oceanic subduction underneath the easterly fore-arc and magmatic arc system during Late Devonian. The distance of the arc from the trench area represented by the suture indicates that the dip of subduction zone was probably moderate (30–40 degrees). The migration of magmatic centres to the east associated with temporal evolution of magma geochemistry from calc-alkaline to more potassic/shoshonitic affinities (from 370 to 336 Ma) are compatible with flattening of the subduction zone during Early Carboniferous.

The Carboniferous crustal thickening is recognized in all units except the Teplá-Barrandian. The Saxothuringian domain is characterized by the arrival of the continental crust and its subduction underneath the easterly Teplá-Barrandian–Moldanubian. The main thrust boundary migrated further west, so that the continent was thrust underneath the fossil Devonian suture and former fore-arc region. At the same time the deformation regime changed in the far field back-arc region, which recorded progressive thickening of the whole previously thinned and thermally softened domain. Recent structural studies have shown that the earliest preserved fabrics have been sub-horizontal, which may indicate that the lower crustal material was flowing horizontally from the area of subduction channel towards region of easterly back stop.

Indeed, the influx of lower crustal material transported by east dipping Saxothuringian continental subduction zone underneath the fore arc (Teplá-Barrandian) and subsequently towards the former back-arc domain is regarded to be at the origin of the future "Gföhl Unit". This hypothesis is in line with the whole-rock geochemical and Sr-Nd isotopic composition as well as the zircon inheritance patterns in the Moldanubian HP-HT granulites. Importantly, the crustal material involved in the subduction and extruded over the sub-arc and sub-back arc mantle lithosphere may have developed voluminous high-pressure granulites known from many regions of the Bohemian Massif. Alternatively, the back-arc domain with inherited high thermal budget from Devonian stretching may have been thickened and the partially molten lower crust may have been transported downwards and transformed to high-pressure granulites.

The onset of thickening of the root is not recorded in the Teplá domain, which behaved as a supra-structural domain at this time, but it is shown by deformation in the Barrandian domain. Here, the steep fabric is well dated by adjacent syntectonic calc-alkaline plutons at about 355–345 Ma. In contrast to the west, the eastern sector records onset of loading of the Brunia

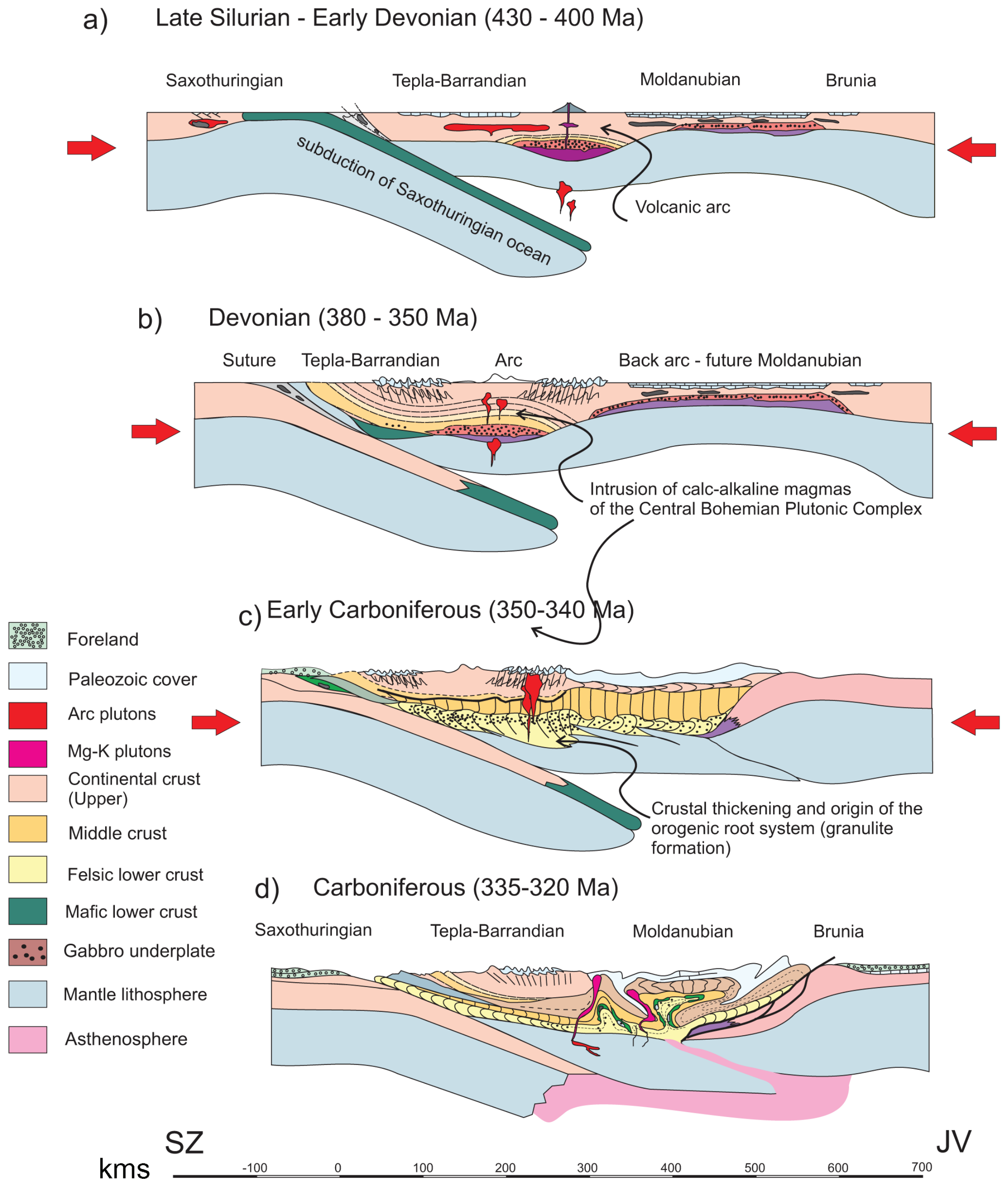


Figure 4. Geodynamics of the Bohemian Massif

platform at Tournaisian manifested by sedimentation of coarse basal clastics and destruction of the Givetian carbonate platform.

Late Visean exhumation of orogenic lower crust of the upper plate during Early Carboniferous is exemplified by the two NE–SW trending belts of granulites, eclogites and peridotites intimately associated with the magnesio-potassic plutons. The first belt, recognized west of the magmatic arc, was exhumed along huge west dipping detachment zone, which was also responsible for collapse of the upper part of the magmatic arc system and downthrow of the whole Barrandian section. Such a huge vertical material transfer could have been responsible for vertical exchange of lower crustal and upper crustal material in a range of 50 km with final throw of 15 km. The cooling ages from the lower crustal domain show that the granulites passed the 300 °C isotherm during Carboniferous, suggesting that the lower crustal bulge reached very shallow position in the upper plate.

The second lower crustal belt rims the eastern margin of the Bohemian Massif, i.e. the boundary with the Brunia continent. Here the fabric of granulites is also vertical and is interpreted in terms of massive vertical exchanges with orogenic middle crust. The zone of lower crustal bulge is interpreted as enormous anticline extrusion surrounded by middle crust coevally transported downwards in form of huge crustal scale synforms. The model of vertical extrusion is based on the concept of buckling of lower and mid-crustal interface followed by growth of crustal scale antiforms. This process is thought to be triggered by rheological and thermal instabilities in the arc region, while to the east it is forced by rigid back-stop, preserved only locally.

However, the most important feature of the eastern Variscan front is the development of horizontal fabrics in the Moldanubian root zone, parallel to the Brunia continental margin. The intense deformation of the Brunia leading to the formation of Moravo-Silesian imbricated nappe system, the origin of crustal mélange forming the Moravian micaschist zone and mixed high-pressure rocks and migmatites in the overlying Moldanubian nappe have been recently interpreted in terms of indentation of the Brunia continent into the hot and thick continental root. This lower crustal indentation and flow of hot lower crustal rocks in supracrustal levels are consistent with the model of continental channel flow driven by arrival of crustal plunger, a model which is advocated for two decades for the deformation of the Eastern Cordillera in the Andes. Finally, the load of Brunia platform related to deep indentation process, leads to the development and easterly propagation of the foreland basin associated with progressive involvement of the early clastic basin infill into the channel flow process. In our model (Schulmann et al., 2008) as the hot Moldanubian rocks advances over the Brunia platform, the imbricate footwall nappe system of the Moravian zone is generated and thrust over the foreland basin rocks.

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Paleogeographic evolution of the Bohemian Massif

Over the last 25 years of the 20th century, geology has collected and continues to collect so much information from global tectonics, paleontology, geophysics and geochemistry that it is possible to synthesise the paleogeographic evolution of our planet for over 1 billion years.

Paleogeographic reconstructions in the form of paleocontinent and paleoocean maps are usually available only from the Upper Proterozoic, or Neoproterozoic, namely the Ediacaran (= Vendian), i.e. from around 600 Ma. Their detail varies. They differ in the contours of the continents, the enumeration of the mentioned micro-continents, oceans and seas, rifts, subduction zones. By default, island arcs are not mentioned. But these played an important role in orogenesis and sometimes in the migration of organisms, so they are important for paleogeography. Reconstructions also partially differ in dates of certain configurations of the paleogeographic situation.

These facts create conditions and circumstances of the paleogeographic reconstruction of the Bohemian Massif.

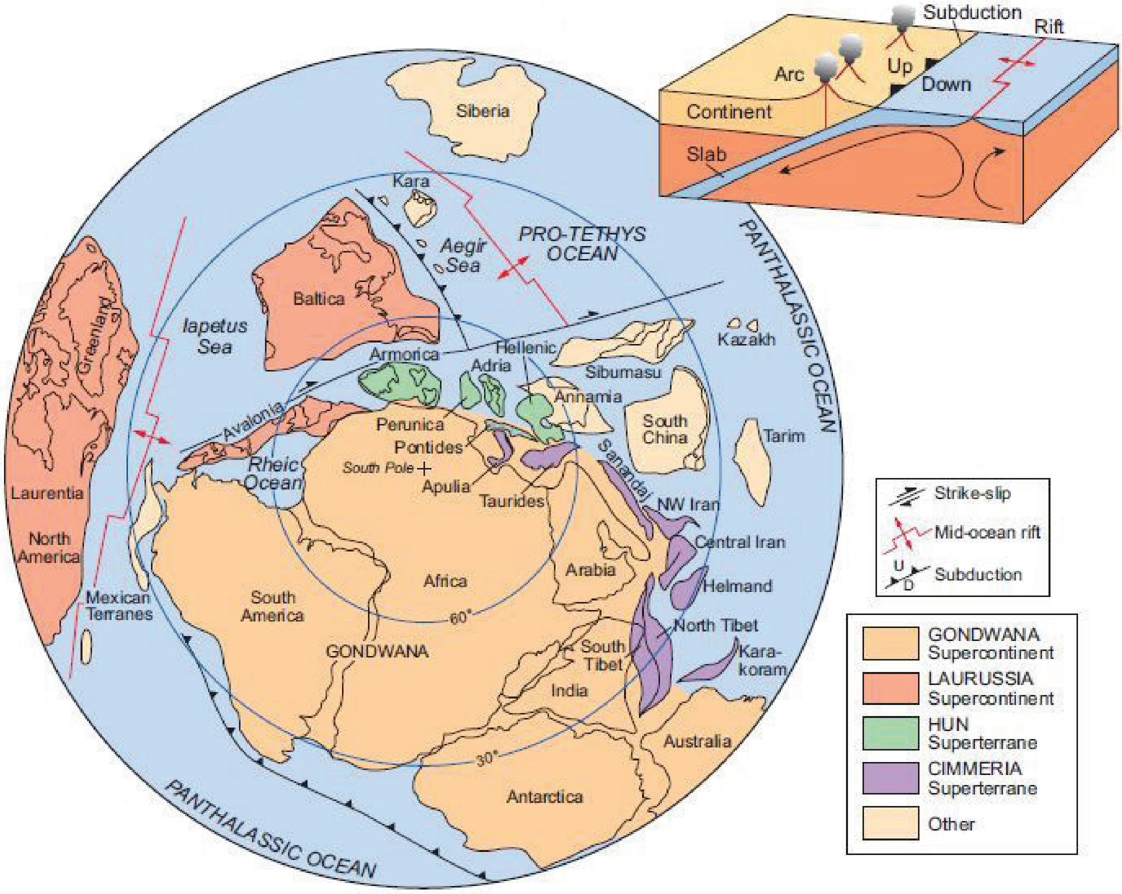

Fig. 1. Paleogeography of Upper Cambrian (before 500 Ma).
Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

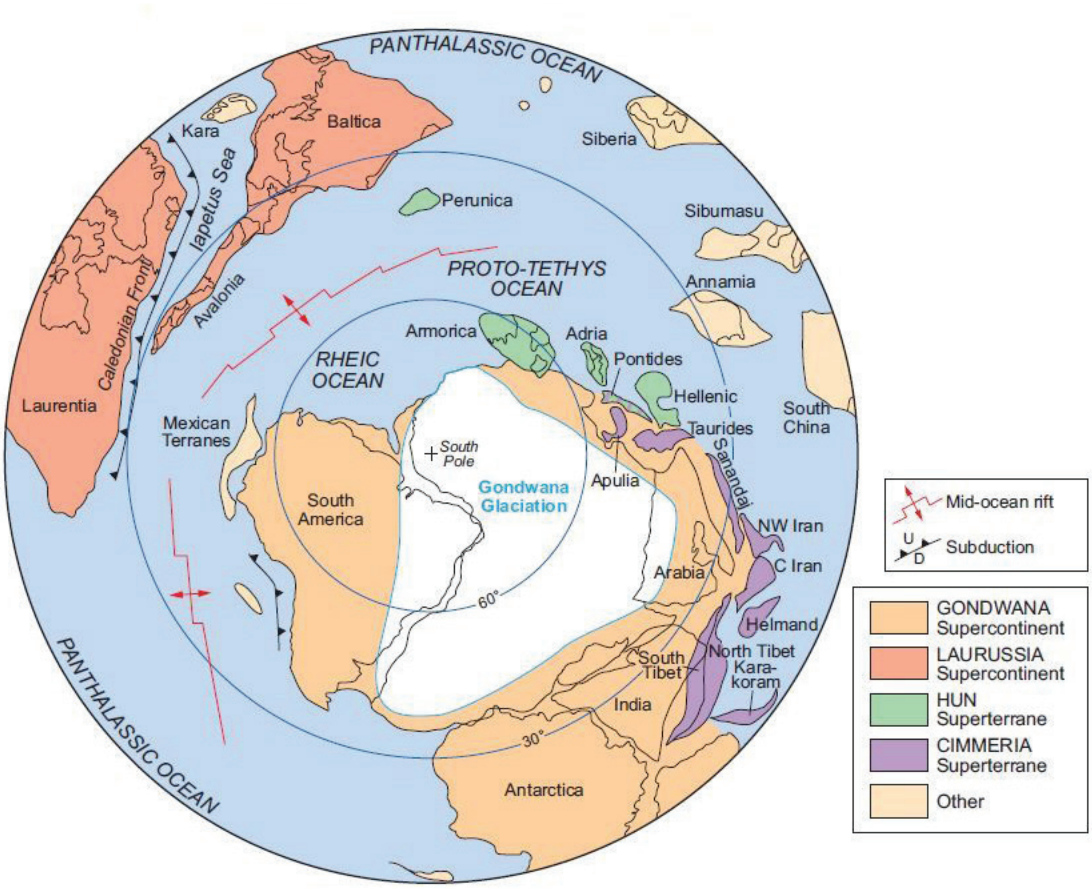

Fig. 2. Paleogeography of the boundary of the Uppermost Ordovician and Lowermost Silurian (before 440 Ma). Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

The oldest rocks of today‘s Bohemian Massif originated in the range of 1000–545 Ma in the Neoproterozoic (see the previous chapter “Geological evolution of the area of the Czech Republic” in this publication). At that time (Scotese Ch. R. (2001, 2014)), they were part of the supercontinent Rodinia at first. Its disintegration into two halves – continents – separated by the Panthalassic and Pan-African Oceans before 750 Ma was followed by the separation of the Congo Craton – the third continent – from the northern one of the two. It probably included rocks of the Bohemian Massif (Brunia) and was located in the equatorial zone. The oceans between the three continents were completely subduced and formed the Pannotia supercontinent (650–500 Ma) in the southern hemisphere (a collision known as Cadomian and Pan-African orogenesis). But Pannotia began to disintegrate soon after its formation and disintegrated (before 560 Ma) to form the Iapetus Ocean and the Tornquist Sea into the continents of Laurentia, Siberia, Baltica and Gondwana. The rocks of the Bohemian Massif together with other African rocks were part of Gondwana near the South Pole. Under unknown circumstances, some of them were separated from Gondwana and, in a form of a larger island (microcontinent), moved northward in the upper Cambrian from the area between the South Pole and the South Polar Circle. It was accompanied and followed by a set of similar separated islands – microcontinents – collectively called the Hun Superterrane (Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007)). From this peri-Gondwanan position, the larger

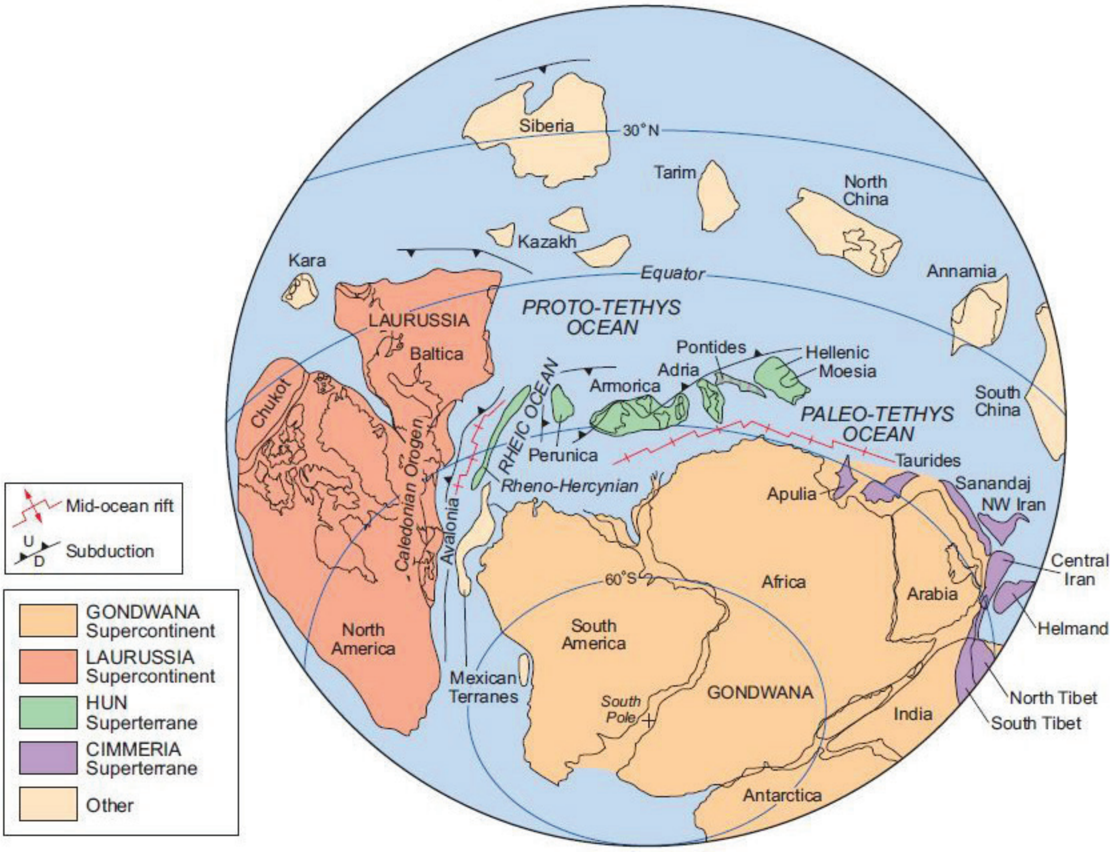

Fig. 3. Paleogeography of the Early Devonian (before 400 Ma).
Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

(but westward) neighbouring Avalonia followed them in the Lower Ordovician. Avalonia was separated from Gondwana by the emerging rift of the future Rheic Ocean and from the Baltica by the rift of the Tornquist Sea (or Ocean). (Cocks, L.R.M. – Torsvik, T.H. (2006), Fatka, O. – Mergl, M. (2009)).

Wandering island – the seed of today‘s Bohemian Massif – was called the microcontinent Perunica by Havlíček V. et al. (Havlíček, V. – Vaněk, J. – Fatka, O. (1994)). During its pilgrimage to the north, it was part of a long-term subduction process of considerable magnitude (see the previous chapter “Geodynamics of the origin of the Bohemian Massif covering the territory of the Czech Republic” in this publication), that developed over at least 500 km in current coordinates in the time period from Silurian to Carboniferous.

About 450 Ma, at the turn of Ordovician and Silurian, Avalonia reached Baltica by the Tropic of Capricorn and collided with Laurentia. The collision created a Caledonian Orogeny on the continent called Laurussia and also Euramerica. At the same time, the Iapetus Ocean between Laurentia and Avalonia and the Tornquist Sea between Laurentia and the Baltica enclosed, and the opening of the Rheic, Ran and Themis Oceans continued.

Perunica crossed the south polar circle at the turn of the Upper Cambrian and Lower Ordovician (about 490 Ma). In the Lower Devonian (400 Ma), it was located by the Tropic of Capricorn. In the Upper Devonian to the Lower Carboniferous (370–340 Ma), it moved in

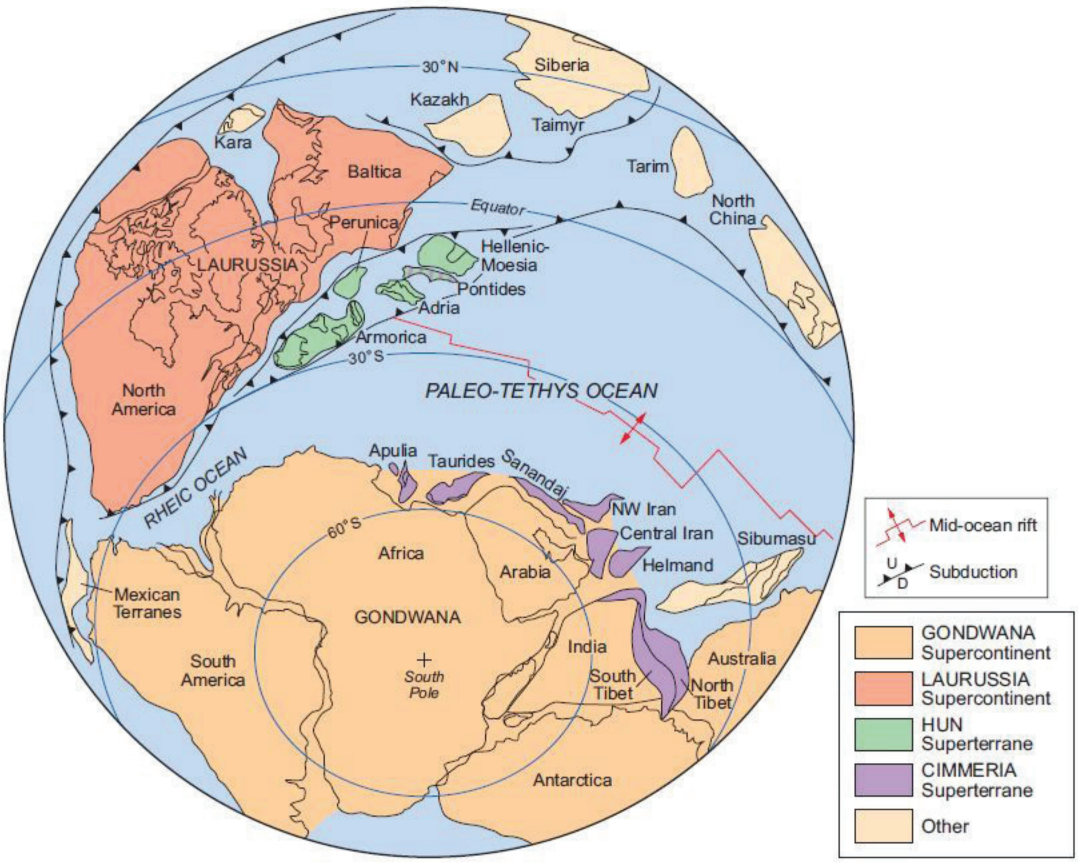

Fig. 4. Paleogeography of the Early Carboniferous (Mississippian before 340 Ma).
Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

the tropical zone south of the equator. A collision with Laurussia happened to it in this zone at the end of the Carboniferous. The collision was part of the formation of the Variscan Orogen. The Variscan Orogen results from numerous other collisions of the microcontinent of the Hun superterrane with Laurussia, including Armorica (a set of Armorican lithological units – Armorican Terrane Assemblage), Adria and Hellenic lithological unit (Hellenic Terrane), and from Laurussia‘s direct collision with Gondwana. In European Variscides emerging from Middle Devonian to Upper Carboniferous (390–310 Ma), Armorica is the basis of their western part, Perunica of their eastern part.

After the incorporation of Perunica into the variscides of Laurussia, Perunica shared the fate of Laurussia. That included: the closure of the Rheic Ocean and opening of the Paleo-Tethys Ocean and the Panthalassic Ocean, and the collision of Laurussia with Gondwana that formed the Pangea supercontinent in the Upper Carboniferous (before 330 Ma), the disintegration of Pangea in the Jurassic (before 150 Ma) that formed Laurasia and the division of Laurasia by the Atlantic Ocean into North America and Eurasia in Cretaceous (before 90 Ma). Eurasia represents the last anchorage of the Bohemian Massif within its paleogeographic evolution.

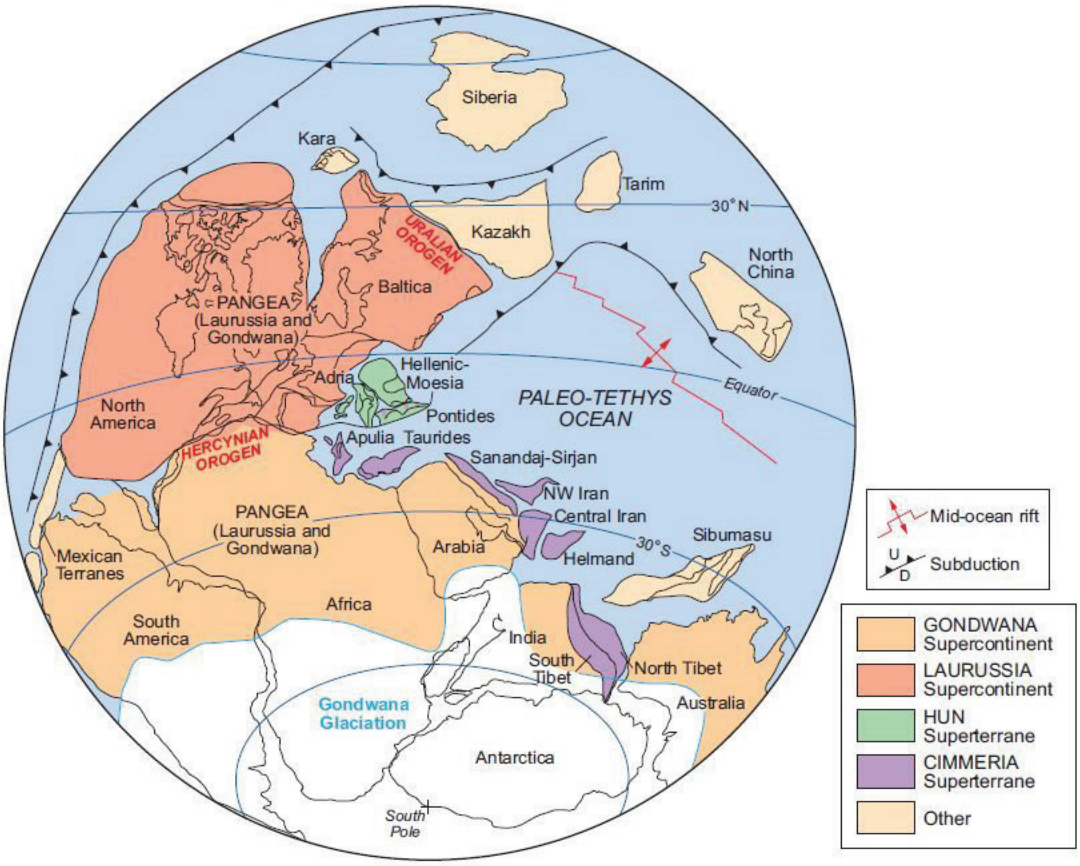

Fig. 5. Paleogeography of the Late Carboniferous (Pennsylvanian before 310 Ma).
Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

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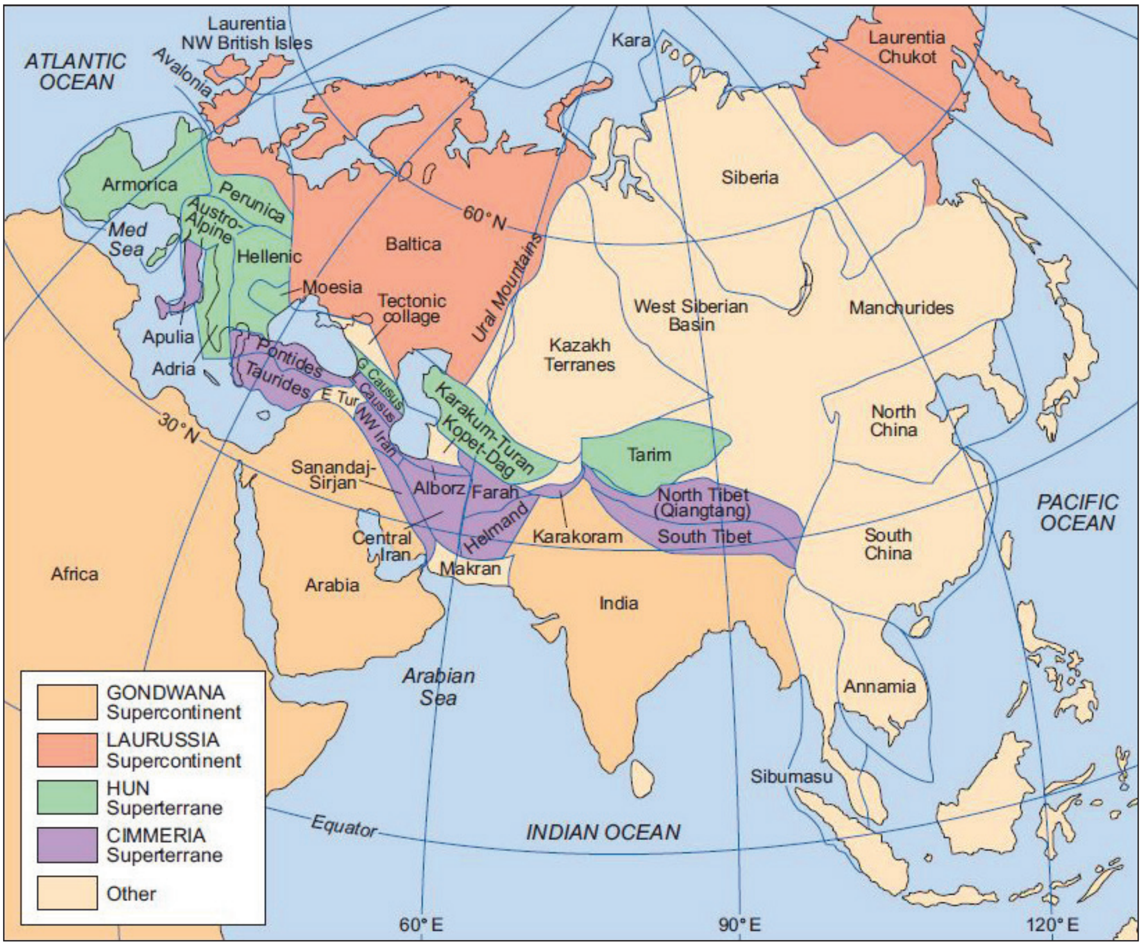

Fig. 6. Current position of Palaeozoic supercontinents, continents and lithological units. Ruban, D. A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

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MINERALS CURRENTLY MINED IN THE CZECH REPUBLIC

ENERGY MINERALS

Significant geological reserves of energy minerals on the territory of the Czech Republic can be found only in uranium ores, bituminous coal and brown coal. Geological reserves of these raw materials take a share of rounded 1 per cent in the world reserves. Brown coal deposits are concentrated in the Krušné Hory Mts. Piedmont Basins. About over one third of domestic electric energy and abot 40% of heat (heating plant) production is covered by coal from these basins. All the bituminous coal mining is at present concentrated in the Czech part of the Upper Silesian Basin. Uranium mining has been abandoned. Coal production started to thrive on the Czech territory in the 19th century in the beginning of the industrial revolution. After the World War II, uranium ore mining developed. Production of energy minerals as a whole reached its peak in the second half of the 1980' and after that a recession came connected with the decline of U-ore and all kinds of coal mining.

Uranium is an important Czech energy mineral with more than a third share in total domestic production of electricity. The Czech Republic was one of the world's most important uranium producers and historically with a total production of over 113 kt of uranium in the years 1946 to 2018 in the form of sorted ores (from the beginning of mining until 1975) and chemical concentrate (since 1953) is on 12th rank in the world. The closure of the last mined deposit for economic reasons in 2016 probably ended (if not definitively) uranium mining in the Czech Republic for a long time. The total amount of mine output in the Czech Republic and its share in world mining has been constantly declining. While in 1990 it reached more than 4%, between 1994 and 2003 it was around 2%, after 2005 it has already fallen below 1% and currently our republic with uranium production – in 2023 reached 13 t – below 20 t per year is far behind 10th rank in the world with less than 0.1% share in the world mining. At present, uranium is obtained as a side effect of groundwater treatment as part of disposal operations after in situ leaching of uranium ores.

Crude oil was one of the few minerals in the Czech Republic, the extraction of which was constantly growing until 2003. After that, it remained stable for two years and has been declining since 2006. The main reason for the decline in the last three years, there has been a decline in world prices, but also high royalty tariff on extracted mineral. Exports are negligible and are around 0.4% relative to domestic mining. However, the total share of extracted oil in the Czech Republic in domestic consumption has long been only between 1and 1.5%. In 2023, 67 kt were extracted, this corresponds to the share of about 1% of the Czech Republic consumption. The deposits are located in the Carpathian foredeep and the Vienna Basin.

The share of domestic natural gas production in recent years covers domestic annual consumption of about 2%. The average annual production volume has long been maintained at the level of 120–150 million m^3, from 2010 to 2015 it stabilized at values of around 200 million m^3 per year. After that, it ranged from less than 170–180 million m^3 and in 2019 it fell to

146 million m^3. The reason for the decline in extraction was mainly the worldwide decline in prices. In 2021, however, natural gas extraction in the Czech Republic increased to 153 million m^3 and in 2022 extraction reached 165 million m^3 and in 2023 declined to 119 million m^3. The most significant accumulations of natural gas in South Moravia are tied to the Carpathian foredeep region and South-East slopes of the Bohemian Massif. These deposits are often associated with crude oil. In northern Moravia, Carboniferous natural gas deposits (coal mine methane – CMM) mined from closed underground bituminous coal mines in the Czech part of the Upper Silesian Basin (so-called degassing of coal seams) are of the greatest importance.

Bituminous coal is an important Czech energy and metallurgical raw material. Although its share is constantly declining slightly, it still produces around 6% of domestic electricity and 13.5% of heat. Gross annual bituminous coal mining in the Czech Republic has been a long time (from 1973 to 1990) relatively stable and ranged between 33 and 38 million tons, with a record in 1975, when 38.6 million tons of bituminous coal were mined. In this period, disposable (and similarly saleable) mine production was around 28 million tons per year, and in the case of the Upper Silesian Basin it accounted for between 75 and 80% of gross extraction. Bituminous coal mining in the Czech Republic has had a declining trend since 1990. From 2013, the consequences of the decline in world prices of steam coal began to manifest themselves, and mining gradually fell to 1.861 million tonnes in 2020. In the year, coal mining increased to 2,008 million tonnes. In 2022 production fell to 1,281 kt. Production in 2023 declined to 1,000 kt. Saleable output is always somewhat different from the decline in coal reserves. Higher saleable output is related to the processing and sale of coal from dumping grounds, washery plants, etc., on the contrary, lower sales production reflected a decrease in interest in bituminous coal on the market and thus a part of mined raw material was deposited in dumping grounds. Roughly half (over 46%) of the coal mined in the Czech part of the Upper Silesian Basin is coking coal, and slightly less is steam coal. The remaining 7% is PCI (pulverized coal injection) coal, which is mainly used in iron processing. Btuminous coal is currently mined only in the Czech part of the Upper Silesian Basin.

Brown coal is the most important Czech energy mineral. It produces about 43% of domestic electricity and 44% of heat. Mining takes place only in the North Bohemian and Sokolov basins. The peak of lignite mining in the Czech Republic was in the 1980s, when gross annual mine output ranged from 91 to almost 97 million tons per year (the highest 96.9 million tons in 1984). Both disposable and saleable extraction almost copied gross output and differed minimally in individual years. Since 1988, when mining last exceeded 91 million tons, it has been gradually declining. In 2019, mining decreased slightly to 37.5 million tonnes and the decline continued in 2020 to 29.5 million tonnes. In absolute numbers both basins contributed roughly equally. Brown coal is currently mined only in the North Bohemian Basin and the eastern part of the Sokolov Basin. The share of deposits in the North Bohemian Basin was about 80% of the total brown coal production in the Czech Republic in the whole monitored period, the highest (84%) was in 2011, 2019 and 2020. In 2019 the share of total brown coal mining in the Sokolovská Basin decreased to about 16%, otherwise was mostly less than 20%. In 2020, brown coal mining in the Czech Republic reached 29.505 million tonnes, and practically the same value was reached in 2021 – 29.278 million tonnes. In 2022, the Czech brown coal production increased to 33.390 million tonnes and in 2023 declined to 28,660 million tonnes.

Relatively large reserves of brown coal in northern Bohemia (North Bohemian coal basins) are blocked on the basis of the announcement of the so-called territorial limits of lignite mining in northern Bohemia. These were determined by Resolutions of the Government of the Czech Republic No. 444 of 1991, 1176/2008 and 827/2015. The government resolution defines mining areas and areas that should remain unmined. The main reason for their determination was the protection of the environment and the landscape in the area of northern Bohemia.

Lignite is mostly classified as brown coal in the world, but in the Czech Republic it is reported separately. While in 1988 the annual production was 2.2 million tons, over the next five years it gradually decreased by almost 1 million tons. At that time, lignite was still mined in three deposits in the Vienna Basin. In 1992, the mining of the Kyjov seam in Šardice ended. Less than two years later, mining at the Dubňany deposit was terminated, and from the second half of 1994, lignite in the Czech Republic was mined in only one Hodonín deposit until mining was terminated (0.5 million tons per year, 0.3 million tons 2009) in 2009.

Bituminous coal

1. Characteristics and use

Coal is a flammable sedimentary rock (coal caustobiolite) formed by coalified organic matter (originating from peat) and mineral admixtures originating from plant bodies or from sediments coming into the coal-forming environment or from the coalification process. Coalification determines the gross combustion value, the reflectivity of vitrinite, the hydrogen content in the H combustible. Mineral admixtures (carbominerites in bituminous coal and minerites in brown coal) form the M ashes.

The internationally recognised boundary between bituminous and brown coal is not clearly defined, but it is accepted that bituminous coal has the Qsm,af (combustion heat on the anhydrous ash-free basis) equal to or greater than 24 MJ/kg at a light reflectance of vitrinite Rr $\geq$ 0,6 %. Anthracites include all coals with a vitrinite reflectance Rr $\geq$ 2 %. The limit value between meta-anthracite (most coalified anthracite) and semi-graphite is the hydrogen content in the combustible (Hh) 0.8%.

Reserves

2023		
Country	**mill. t**	**%**
USA	218,938	29.1%
China	135,069	17.9%
India	105,979	14.1%
Australia	73,719	9.8%
Russia	71,719	9.5%
Ukraine	32,039	4.3%
Kazakhstan	25,605	3.4%
Indonesia	23,141	3.1%
Poland	22,530	3.0%
Columbia	4,554	0.6%
World	**753,639**	**100.0%**

2023			
Country	**mill. t**	**% World**	**% EU**
EU	25,539	3.4%	100.0%
Poland	22,530	3.0%	88.2%
Czechia	1,081	0.1%	4.23%
Spain	868	0.12%	3.40%
Hungary	276	0.04%	1.08%
Bulgaria	192	0.03%	0.8%
Romania	11	0.001%	0.04%

Source: BP Statistical Review of World Energy 2022 (No reserves update in the 2023 issue).

Uses

Production of electricity and heat, metallurgy, chemistry. Coking coal is defined as bituminous coal with a quality that enables the production of coke for blast furnace production of pig iron or for heating purposes. Other types of bituminous coal are referred to as steam coal, which are used mainly to generate electricity.

Classification as critical raw materials for the European Union

Coking coal 2011 – no, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes
Steam coal 2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

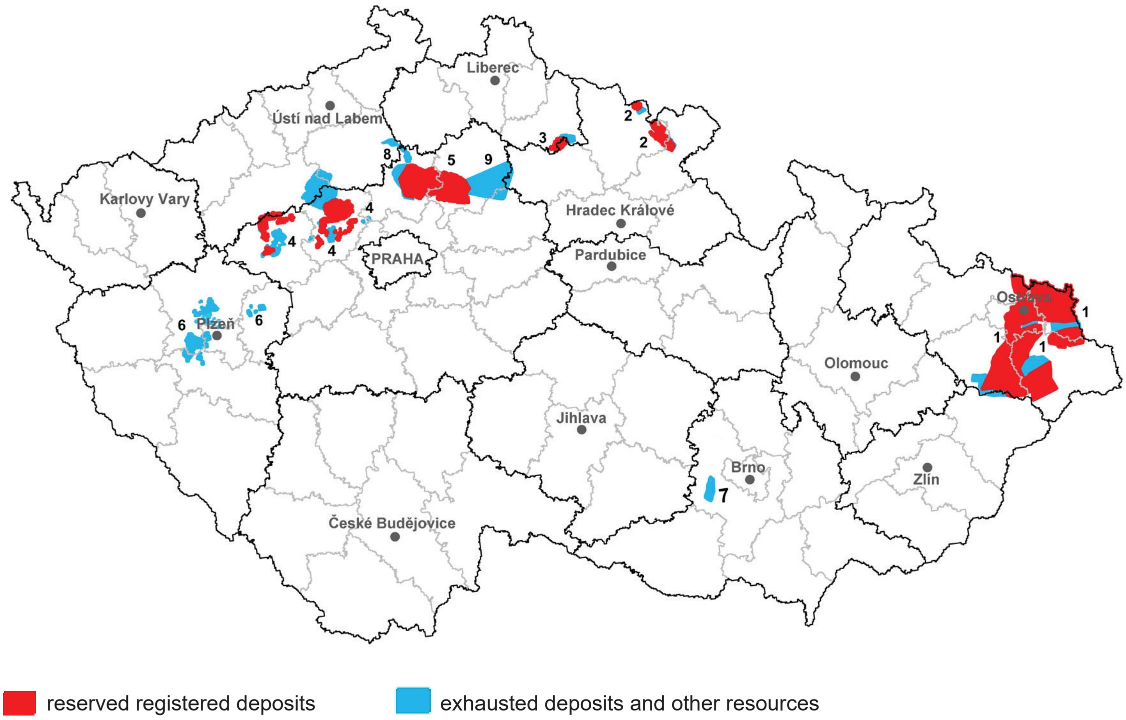
There are deposits of coking and steam bituminous coal in the Czech Republic. The Czech part of the Upper Silesian Basin with an area of approximately 1,550 km2 (approximately 30% of coal reserves are in the Czech Republic and 70% in Poland), operationally called the Ostrava-Karviná coalfield (OKR), is decisive, and there is also a significant share of coking coal. At present, this is the only area of bituminous coal mining in the Czech Republic and the company OKD, a.s., Ostrava mines here.

- The Bludovice fault divides the basin into two parts: the northern Ostrava-Karviná and the southern Podbes-kydy. The significant tectonic fault (the Orlová Fault) divides the Ostrava-Karviná part of the basin into a wes-tern, geologically older and tectonically intensively affected Ostrava part of the basin with a paralic develop-ment of sediments , and the eastern, less complex Karviná part with not only paralic but also limnic sediment development. The western part contains several dozen relatively low-thickness (on average approx. 0.7 m) layers of high-quality coking coal, while in the eastern part there are medium-thickness layers (on average approx. 1.8 m) with mixed coking or steam coal predominant in the recoverable depths. Since 2002, hard coal has been mined only in the Karvina part, and from 2021 the entire production of the basin is ensured by the last used deposit of the ČSM Mine with the Louka mining area. At the end of 2020, mining at the Darkov Mine with the Darkov and Karviná-Doly II mining areas was completed, and at the beginning of 2021 at the ČSA Mine with the Doubrava u Orlová and Karviná-Doly I mining areas. Already in 2016, mining at the Stonava mining area was completed and at the end 2019 in the mining area of Lazy. The calorific value Qir of the mi-ned coal is usually between 23–30 MJ/kg, the ash content Ad between 10 and 30%. Due to long-term intensi-ve mining, mining in the Ostrava part of the basin was getting deeper and deeper (even over 1,000 m), which, together with difficult mining and geological conditions, enormously increased the mining costs. Therefore, the mines in Ostrava became unprofitable and were gradually closed and liquidated. Most of the mines in the eastern part had sufficient reserves with a simpler geological structure, which can be mined at significantly lower costs. However, the value of this coal is reduced by its lower quality due to its coking properties.
- In the northern area of the Podbeskydy part of the basin, 1 deposit (mining lease Staříč) of predominantly coking coal in the Ostrava Formation was mined by one mine until 31 March 2017. The calorific value Qir of the mined coal ranged on average between 28–29 MJ/kg, the ash content Ad between 11–19%. Relatively lar-ge coal reserves have been evaluated further south, especially in the vicinity of Frenštát pod Radhoštěm, where the coal-bearing carbon is covered with Miocene and the Beskydy nappes. Coal would be mined here under difficult geological conditions from depths of 800–1,300 metres. In addition, the deposit partially ex-tends into the Beskydy Protected Landscape Area, and therefore its use is not yet planned.
- Until the final cessation of mining in the last 3 mining areas (Kačice, Srby, Tuchlovice) in mid-2002, the second most important area with bituminous coal reserves was the Kladno-Rakovník Basin located in Central Bohemia west of Prague. However, most of the reserves of the original Kladno-Rakovník Basin with steam coal have already been mined and the remaining ones have lost their economic significance. The calorific value Qir of the mined coal ranged on average between 18–20 MJ/kg, the ash content Ad between 20–35%. In the north-eastern continuation of the Kladno part of the basin, a deposit of relatively high-quality

and partially coking coal near Slaný was identified and examined in the 1950s and 1960s, with geological (potentially economic) reserves of approximately 364 million tonnes, but lying at depths of 700–1,300 m and with complex hydroge-ological and gas conditions. The average calorific value Qir is between 18–22 MJ/kg, the ash content Ad between 20–40%. The opening of this deposit was stopped after the excavation of two main pits in the early 1990s, and the two pits excavated so far have been backfilled.

- Northeast of Prague, the Mšeno part of the Mšeno-Roudnice Basin with geological reserves of steam coal of over 1.1 billion tonnes was identified and preliminarily explored. The average calorific value Qir is between 16–20 MJ/kg, the ash content Ad between 24–40%. However, the use of these reserves is currently unrealis-tic (economic aspects and conflict of interest – drinking water for the Central Bohemian region in the overly-ing Cretaceous sandstones). At present, the Roudnice part of this basin and the Mnichovo Hradiště Basin lying east of the Mšeno-Roudnice Basin appear to be completely unpromising.
- A low-perspective deposit of low-quality steam bituminous coal is evaluated in the Krkonoše Piedmont Basin.
- Deep mining of mainly steam coal in the Czech part of the Intra-Sudetian Basin definitively ended in the early 1990s. From 1998 to 2007, very little surface mining took place at the Žacléř deposit.
- Mining of bituminous coal in the Pilsen region (Pilsen and Radnice Basins) was also definitively terminated in the first half of the 1990s, and the remaining reserves were removed from the Register in 2002. Slight mining efforts in the adjacent Manětín and Žihel Basins and in isolated carbon relics near Mirošov, Merklín, Tlustická, Malé Přílepy, etc. were of a rather local significance.
- The mining of steam bituminous coal in the Boskovice furrow (Rosice-Oslavany mining district) west of Brno definitively ended at the beginning of 1992.
- Small isolated relics of bituminous coal to anthracite in the Blanice furrow were mined locally in the past, for example near Lhotice northeast of České Budějovice, west of Vlašim and in the Český Brod region.
- The slight mining of anthracite in the carbon relic near Brandov in the Ore Mountains has never been of signi-ficant important.

3. Registered deposits and other resources of the Czech Republic



Coal basins

*(Names of basins with mined deposits are indicated in **bold type**)*

1 **Czech part of the Upper-Silesian Basin**
2 Czech part of the Intra-Sudetic Basin
3 Krkonoše Mts. Piedmont Basin
4 Central Bohemian Basins (namely Kladno-Rakovník Basin)
5 Mšeno Part of Mšeno-Roudnice Basin
6 Plzeň Basin and Radnice Basin
7 Boskovice Graben
8 Roudnice Part of Mšeno-Roudnice Basin
9 Mnichovo Hradiště Basin

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	62	62	62	62	62
exploited	6	5	1	1	1
Total mineral *reserves, kt	16,275,710	16,272,828	16,269,450	16,268,216	16,322,035
economic explored reserves	1,441,494	1,439,817	1,400,735	1,400,481	1,261,763
economic prospected reserves	5,989,227	5,989,111	5,907,419	5,906,193	5,755,398
potentially economic reserves	8,844,989	8,843,900	8,961,296	8,961,542	9,304,874
exploitable (recoverable) reserves	15,970	3,243	1,360	3,600	2,856
Mine production, kt	3,150	1,861	2,008	1,281	1,000

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	kt	590,300	590,300	590,300	590,300	590,300
P_2		–	–	–	–	–
P_3		–	–	–	–	–

5. Foreign trade

2701 – Bituminous coal, briquettes and similar solid fuels made of bituminous coal

		2019	2020	2021	2022	2023
Import	kt	3,577	3,426	4,573	4,402	214
Export	kt	1,414	767	1,395	883	140

2701 – Bituminous coal, briquettes and similar solid fuels made of bituminous coal

		2019	2020	2021	2022	2023
Average import prices	CZK/t	3,409	2,417	3,158	7,209	5,339
Average export prices	CZK/t	3,333	2,608	3,933	7,776	6,091

2704 – Coke and semi-coke from bituminous coal, brown coal or peat, agglomerated retort coal

		2019	2020	2021	2022	2023
Import	kt	221	220	241	237	14,3
Export	kt	589	536	652	592	65

2704 – Coke and semi-coke from bituminous coal, brown coal or peat, agglomerated retort coal

		2019	2020	2021	2022	2023
Average import prices	CZK/t	5,376	4,712	6,218	11,411	8,170
Average export prices	CZK/t	7,888	6,260	8,488	14,943	10,594

6. Prices of domestic market

OKD, a.s. bituminous coal sales

Coal type/year			2019	2020	2021	2022	2023
Coking coal	sales*	tonnes	1,892,812	1,059,838	1,560,270	870,235	504,697
	revenue	ths CZK	6,953,000	3,458,019	6,691, 000	7,769,000	3,298,000
	average price	CZK/ tonne	3,673	3,263	4,288	8,927	6,535
Steam coal	sales*	tonnes	1,396,572	841,188	875,992	1,316,400	1,316,400
	revenue	ths CZK	3,104,000	2,453,174	1,583,000	5,719,000	7,789,000
	average price	CZK/ tonne	2,223	2,916	1,807	4,344	6,129

** saleable output*
Sources: (OKD Annual Reports)
For 2019 – OKD výroční zpráva 2019, OKD, a.s., pp. 5, 9.
For 2020 – OKD výroční zpráva 2020, OKD, a.s., pp. 11, 12.
For 2021 – OKD výroční zpráva 2021, OKD, a.s., pp. 9, 10.
For 2022 – OKD výroční zpráva 2022, OKD, a.s., pp. 10, 11.
For 2023 – OKD výroční zpráva 2023, OKD, a.s., pp. 9, 10.

7. Mining companies in the Czech Republic as of December 31, 2023

OKD, a.s., Ostrava

8. World production and world market prices

World mine production

During 2019 and 2023, world production of bituminous coal developed as follows:

	2019	2020	2021	2022	2023
Steam coal (WBD), mill. t	5 959.1	5 729.0	6 070.5	6 620.4	N
Coking coal (WBD), mill. t	1 057.0	1 034.4	1 035.1	1 041.8	N
Bituminous coal total (WBD), mill. t	7 016.2	6 763.5	7 105.7	7 662.3	N

After Coal Information IEA 2023 production of bituminous coal reached these numbers (mill. t):

	2019	2020	2021	2022	2023[e]
Steam coal	6,025.0	6,175.0	5,707.0	7,221.0	7,628.0
Coking coal	978.0	1,007.0	1,015.9	1,096.0	1,113.0
Bituminous coal total	7,003.0	7,182.0	6,722.9	8,318.0	8,394.0

e – preliminary values

Main producers according to WBD

2022		
Steam coal		
Country	mill. t	%
China	3,590	54.2
India	832	12.6
Indonesia	680	10.3
USA	440	6.6
Australia	247	3.7
Russia	242	3.4
South Africa	228	3.7
Kazakhstan	105	1.6
Columbia	58	0.9
Poland	40	0.6
World	**6,620**	**100.0**

2022		
Coking coal		
Country	mill. t	%
China	572	54.9
Australia	169	16.2
Russia	100	9.6
USA	56	5.4
India	52	4.5
Mongolia	27	2.6
Canada	20	1.9
Poland	13	1.2
Kazakhstan	9	0.9
Ukraine	7	0.7
World	**1 042**	**100.0**

Main producers according to Coal Information IAE 2023

2022		
Steam coal		
Country	mill. t	%
China	3,780	49.6
India	1,020	13.4
Indonesia	719	9.4
USA	428	7.1
Australia	282	6.3
Russia	336	5.2
EU	263	0.9
World	**7,628**	**100.0**

EURACOAL regularly publishes data on the extent of maritime trade in bituminous coal. broken down into steam and coking coal in its Market Report:

Steam coal (mill. tonnes)

Exporter	2019	2020	2021	2022	2023
Indonesia	375	342	346	360	380
Australia	212	199	200	178	180
Russia	179	169	178	N	171
Colombia	76	52	56	54	56
South Africa	78	75	66	72	74
USA	36	24	35	34	34
Others	20	15	16	174	174
Total world	**976**	**876**	**897**	**877**	**955**

Coking coal (mill. tonnes)

Exporter	2019	2020	2021	2022	2023
Austrálie	183	172	167	160	151
Kanada	34	27	26	28	31
USA	44	35	38	36	47
Rusko	25	29	32	N	37
Total	**290**	**266**	**266**	**267**	**270**

The world's largest importers of bituminous coal according to IEA (for 2019 to 2023)

Bituminous coal total (million tonnes)					
Country	**2019**	**2020**	**2021**	**2022**	**2023**
China	298	317	338	301	451
India	247	220	207	228	241
Japan	185	174	173	184	171
South Korea	130	123	126	125	120
Europe	N	137	154	176	139
ASEAN	N	N	N	137	150
Eurasia	N	N	N	34	32
Central and South America	N	N	N	30	28
North America	N	N	N	21	21
Africa	N	N	N	17	20
World	**N**	**N**	**N**	**1 367**	**1 468**

World market prices

World prices of bituminous coal both contractual and spot. are traditionally determined mainly by prices of American and Australian coal.

EURACOAL (Market Report 2019 to 2023) provided an overview of the development of monthly prices of steam coal in USD/tce and EUR/tce CIF South-West Europe in terms of 7,000 kcal/kg:

Month/year		01	02	03	04	05	06	07	08	09	10	11	12
2018	USD	112.23	105.54	94.21	93.45	99.75	110.58	116.55	110.28	117.41	118.35	113.97	100.42
2018	EUR	92.01	85.47	76.37	76.13	84.45	94.69	99.80	95.50	100.71	103.06	100.27	88.20
2019	USD	98.40	92.17	87.38	63.71	67.78	59.05	62.43	68.50	66.22	69.81	65.52	64.86
2019	EUR	86.19	81.20	77.32	56.69	60.61	52.28	55.65	61.56	60.18	63.17	59.29	58.36
2020	USD	60.76	56.91	55.14	56.14	44.64	53.63	59.16	60.06	60.40	66.90	59.97	72.35
2020	EUR	54.74	52.19	49.85	51.69	40.95	47.65	51.62	50.78	51.22	56.81	50.66	59.45
2021	USD	80.47	75.69	77.42	81.61	94.43	115.47	142.16	166.76	189.12	250.29	174.74	141.54
2021	EUR	66.12	62.57	65.07	68.12	77.72	95.81	120.22	141.67	160.67	215.75	153.11	125.22
2022	USD	163.33	207.74	379.31	325.20	381.49	393.75	441.15	415.40	426.62	318.48	260.75	307.29
2022	EUR	144.37	183.15	344.26	300.64	360.66	372.72	433.43	410.21	430.75	324.12	255.61	290.20
2023	USD	211.33	161.57	171.29	170.99	153.9	114.87	141.00	126.81	141.02	143.45	149.36	139.94
2023	EUR	196.24	150.79	160.94	155.89	141.60	10.97	127.51	116.24	131.99	135.81	138.18	128.35

BP Statistical Review of World Energy (BP) and the World Bank – The Pink Sheet (WB) report average prices of some types of coal (USD/t – BP, resp. USD/mt – WB):

Year	2019	2020	2021	2022	2023
Market price in NW Europe (BP)	60.86	50.16	121.70	N	N
Spot prices of the US Central Appalachian coal	57.16	42.77	68.54	N	N
The spot price of Japanese import coking coal CIF (BP)	108.58	80.50	130.37	N	N
Spot price of coal. China. Qinhangdao (BP)	85.89	83.10	153.55	N	N
Australian steam coal. 6.300kcal CIF Neawcastle (WB)	77.89	60.8	138.1	344.9	172.8
South African coal (WB)	71.94	65.7	119.8	240.6	119.1

Brown coal

1. Characteristics and use

Brown coal (lignite, subbituminous coal) is a phytogenic kaustobiolite coalified less than bituminous coal. The boundary between brown and bituminous coal is not internationally exactly defined, but its definition given by the value of combustion heat on an anhydrous ashless basis (Q_sm,af) < 24 MJ/kg and light reflectance of vitrinite R_r < 0.6% is generally accepted. The most coalified brown coal (in Czech terminology brown coal metatype) is called subbituminous coal in foreign literature.

The international boundary between brown coal and lignite has not been established, but lignite is usually considered to be a raw material with a carbon content in combustibles below about 65% and a calorific value <17 MJ/kg. The terminology of coal is not uniform around the world, often the English term "lignite" is used to denote both the quality of our (Central European) brown coal and of lignite (brown coal hemitype), which is reported separately in the Czech Republic.

Reserves

2023		
Country	**mill. t**	**% world**
Russia	90,447	28.2
Australia	76,508	23.9
Germany	35,900	11.2
USA	30,003	9.4
Indonesia	11,728	3.7
Turkey	10,975	3.4
China	8,128	2.5
Serbia	7,112	2.2
New Zealand	6,750	2.1
Poland	5,865	1.8
World	**320,469**	**100.0**

2023			
Country	**mill. t**	**% world**	**% EU**
EU	53,051	16.6	100.0
Germany	35,900	11.2	67.7
Poland	5,865	1.8	11.1
Greece	2,876	0.9	5.4
Hungary	2,633	0.8	5.0
Bulgaria	2,174	0.7	4.1
Czechia	1,081	0.3	2.0
Spain	319	0.1	0.6
Romania	280	0.09	0.5

Source: BP Statistical Review of World Energy 2024.

Uses

The use of brown coal is mainly in the energy industry (electricity and heat production), to a lesser extent in the chemical industry.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

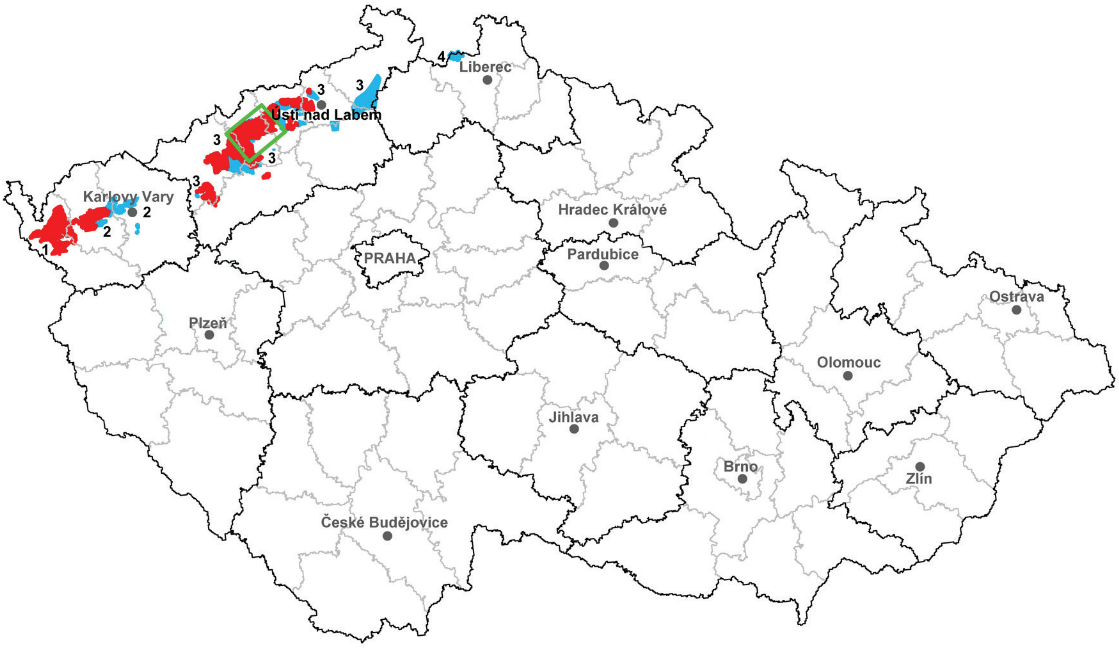
Brown coal is still the main source of energy in the Czech Republic and thus provides state energy security. The largest Czech brown coal basins originated in a tectonic trough and follow the direction parallel to the Ore Mountains and the northwestern border of the Czech Republic. The total area of coal-bearing sedimentation is 1,900 km^2. The underlying sediments are classified into the Eocene, the seams and overlying sediments (up to 400 m thick) belong to the Lower Miocene, and in the Cheb Basin, the sedimentation ends as far as in the Pliocene. In the area of the basins at the foothills of the Ore Mountains (Podkrušnohorská basins), the following main separate basins are mostly defined (from NE to SW): North Bohemian, Sokolov and Cheb. The largest North Bohemian Basin is further divided into 3 parts. The North Bohemian Basin accounts for about 89% of the total brown coal production in the Czech Republic, the remaining 11% comes from the Sokolov Basin. Mining is practically exclusively surface. In the past, underground mining was carried out to a lesser extent in various places, mainly in the North Bohemian Basin.

- ICurrently, there are 5 exploited lignite deposits in the North Bohemian Basin (Bílina-Lom Bílina, Ervěnice-Lom ČSA, Holešice, Komořany, Tušimice-Lom Libouš) and another 37 unmined lignite deposits are registered.
- In the Chomutov part of the North Bohemian Basin, the brown coal seam is divided into 3 benches. Towards the NW of the basin, these layers are connected or converged and are surface mined together. This coal has less calorific energy and lower to medium degree of coalification. It is used mainly for combustion in power plants, the desulphurisation of which has eliminated the problem of increased sulphur content (Sd around 2.8%) in this coal. The ash content generally rises from NW to SE, where it can reach up to 50% (on average it is around 35–40%). The average thickness of the mined seam is about 23 m and the calorific value of coal Q_ir is about 10 MJ/kg. Coal from this part of the basin is mined by one large quarry Tušimice-Libouš (mining lease Tušimice).
- Coal with a lower ash content (15–40%) and a higher degree of coalification is mined in the Most part of the North Bohemian Basin. Coal is used in the energy sector, and sorted types are also produced for small consumers. It has locally significantly increased contents of sulphur (Sd usually between 1 and 1.5%) and arsenic. The average thickness of the mined seam is between 20–30 m, the calorific value between Qir 10–17 MJ/kg. The depth of surface mining is gradually increasing, currently reaching up to 150 m in some places. Mining in this part of the basin is provided by 4 large quarries: Bílina-Velkolom Bílina, Ervěnice-Velkolom ČSA, Holešice and Komořany (mining areas Bílina, Ervěnice, Holešice, Komořany u Mostu). The quarries with the highest lifetime period are Holešice, Bílina-Velkolom Bílina. The Vršany and Slatinice quarries, which are connected to the Holešice quarry, are set aside for reserve and the planned continuation of mining. In the last deep mine Dolní Jiřetín-Centrum (mining area Dolní Jiřetín u Mostu), mining was finished in the first quarter of 2016. Experimental underground mining was started, so called corridor mining, when small amounts of coal were extracted from the closing slopes of the quarry (deposits Komořany, Ervěnice).
- In the Teplice part of the North Bohemian Basin, mining ended in 1997 with the closure of the Chabařovice quarry. The remaining reserves of medium-coalified, high-quality coal with a low sulphur content below the municipality of Chabařovice will not be possible to extract due to conflicts of interest and complex hydrogeological conditions. Similar conflicts will

probably prevent the extraction of other reserves of quality coal in other sections of this part of the basin. Small isolated occurrences of brown coal seams in the Central Bohemian Uplands were largely mined in the past. In this sub-basin, lignite reserves are gradually being reassessed and written off – e.g. at the Proboštov, Modlany-hlubina deposits, etc.

- The Sokolov Basin west of Karlovy Vary has two main seam formations (Antonín and Josef). The largest reserves are contained in the thickets and highest seam Antonín, in the western part divided into 2 to 3 benches. It is a weakly to moderately coalified boiler coal with a lower sulphur content (Sd around 1%) and a higher water content compared to the coal of the North Bohemian Basin. In the western part of the basin, the formerly important Bukovany mining area has been shut down, and the Svatava and Habartov mining area are close to shutting down, following the end of mining at the Svatava-Medard deposit. Since 2001, mining has been carried out only in the eastern part of the central basin in the Alberov, Lomnice and Královské Poříčí mining areas. Mining in the Sokolov Basin is expected to continue until 2030. A seam with an average mined thickness of 26–38 m is surface mined in the Alberov-Velkolom Jiří large quarry (Alberov mining area). Since 2015, only overburden works have been carried out in the Nové Sedlo-Družba quarry (Nové Sedlo mining area) and no coal has been mined. Smaller coal mining operations were carried out until 2017 in the Královské Poříčí-Marie quarry (Královské Poříčí mining area). Since 2012, the out-of-balance coal reserves have been mined and recovered to a small extent during remediation work in the western part of the basin in the northern part of the Svatava-Medard quarry (Svatava mining area). The calorific value Qir is between 12 and 14 MJ/kg and the ash content Ad is between 20 and 24%. Coal is used mainly in the energy industry (sorted fuels, combustion in power plants and production of energy gas and briquettes), but also in the production of some carbo-chemical products. The coal of the lower Josef seam, which had a higher degree of coalification, but also increased contents of ash, Ge, sulphur and other pollutants (As, Be), is no longer used. A very promising source of Ge and other trace elements bound to the Josef, Anežka and intermediate seams is the already closed Vítkov u Sokolova – Michal deposit with mining terminated in part of the area in 1988. In the past, it was mined in smaller quantities in isolated relics south of Karlovy Vary.
- The Cheb Basin has over 1.7 billion tonnes of geological reserves of weakly coalified brown coal (calorific value Q_ir around 10 MJ/kg). The coal has an increased content of water, ash (20–40%), sulphur (2–4%) and other pollutants. Due to the locally high content of liptodetrites, it could also be suitable for chemical processing. In the past, it was mined for a short time, especially in the Pochlovice part of the basin to the East. However, re-mining of coal in this basin is still impossible, the vast majority of reserves are tied to the protection of mineral water resources Františkovy Lázně.
- From Germany and especially Poland, a small part of the Zittau Basin extends into the Czech Republic. The upper seam has already been mined on the surface, the deep mining of the remaining two seam horizons is hindered not only by economic but also technical problems with the amount of waterlogged sands in the overburden.
- In the past, small occurrences of low-quality brown coal in the Czech Cretaceous basin were occasionally mined in small quantities as an accompanying raw material in the mining of refractory clays, e.g. near Moravská Třebová or Svitavy.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits

exhausted deposits and other resources

area of ecological territorial limits for mining (Government Resolution no. 444/1991)

Coal basin

(Names of basins with mined deposits are indicated in ***bold type****)*

1 Cheb Basin

2 **Sokolov Basin**

3 **North–Bohemian Basin**

4 Czech part of the Zittau (Žitava) Basin

Territorial ecological mining limits

Josef Godány

The relatively large reserves of brown coal in Northern Bohemia (North Bohemian coal basin) are blocked by “Regional environmental limits” for brown coal mining in Northern Bohemia (today this relates only to the North Bohemian coal basin). The limits were set by Czech Government Resolutions Nos. 166, 443, and 490 of 1991 (for the Sokolov coal basin) and Resolution No. 444 of the same year (for the North Bohemian coal basin). The Government Resolutions define mining areas which should remain unexcavated. The main reason for setting the limits was environmental and landscape protection of Northern Bohemia. However, territorial limits for the Sokolov coal basin were removed relatively soon – by Government Decree No. 511 of 1993.

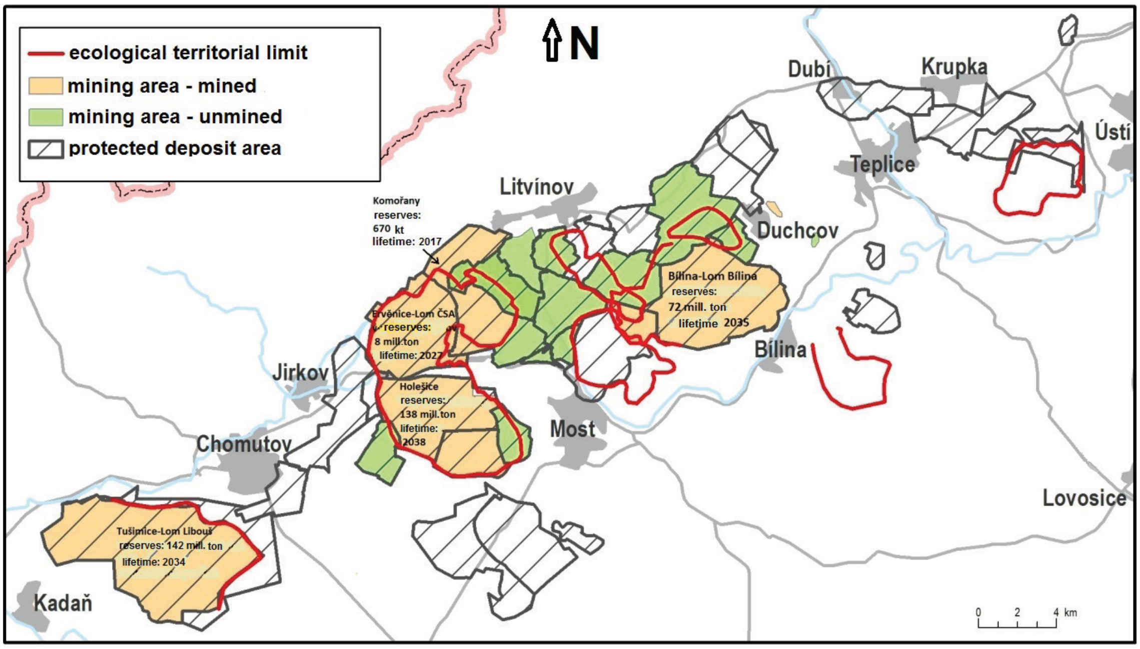
With diminishing reserves of brown coal in mined areas there is an escalating pressure to reconsider or amend the original decision of 1991, i.e. the preserved Government Resolution No. 444/1991. There was a minor change to the territorial environmental limits in the foreground of the large opencast mine Bílina (deposit in Bílina) by Government Resolution No. 1176/2008 and the subsequent Government Resolution No. 827/2015 which repealed Government Resolution No. 1176/2008 and significantly moved the environmental limit boundary – to the distance of 500 m from the urban area of Mariánské Radčice. This shifted the anticipated end of mining in the mine from 2038 to 2055. The mining company has been ordered to primarily use the mined coal to meet the needs of the heating industry. Government Resolution No. 444/1991 still applies to the remaining deposit area, including the large opencast mine ČSA (deposit in Ervěnice – ČSA mine). The question of breaking the territorial environmental limits in the ČSA opencast mine will remain conditionally open until 2020 (if the current territorial environmental limits are preserved, the mining is expected to end in 2024). The coal reserves behind the territorial environmental limits in the ČSA opencast mine are of the highest quality (the calorific value of coal from this deposit area is at least 17 MJ/kg).

Overall, the environmental territorial limits block about 954 million tonnes of coal reserves. The truth is that brown coal and nuclear power are still the only relevant sources for our energy sector. Brown coal is also the most important raw material for the Czech heating industry. The main product of the brown coal industry is a dusty brown coal for power stations and heating plants. In the long term, approximately 93 % of brown coal produced is consumed by these facilities. Graded coal production for households accounts for the remaining 7 %.

The National Energy and Climate Plan envisages an increase in the share of renewable energy sources in final consumption to around 30 percent by 2030 in a number of areas. The gradual decarbonisation of the economy is likely to be associated with increased electrification of individual sectors, which will place greater demands on electricity generation. With regard to renewable energy sources, their development is expected to be mainly linked to a continued emphasis on the use of low-carbon energy sources. The development of renewables is very likely to take place mainly in the electricity sector, but also in the transport and heating and cooling sectors. The strategic plan of the Czech Republic is then not only to maintain but to increase the use of nuclear energy, even taking into account the phasing out of existing nuclear units. Nuclear power will play a primary role in electricity generation, but will also potentially play a role in, for example, heat or hydrogen production. The share of nuclear power sources should therefore increase from the current level of around 18 % to between 32 % and 42 %, even taking into account the development of small modular and advanced reactors.

The expected in electricity generation in the period around 2030 will be primarily due to the gradual decline of coal-fired sources. Coal is still a relatively important pillar in terms of electricity generation, accounting for a share of around 40 %. However, coal-fired generation is expected to cease between 2030 and 2040. Natural gas will play a role as a transitional fuel, mainly replacing coal, but mainly at the level of lower utilisation generation capacity, which also corresponds to a decline in its share from today's level of around 9% to 7% in 2030, then to between 1% and 5% by 2040. Natural gas is then no longer expected to be used in 2050, mainly due to its gradual replacement by low-emission alternatives. Renewables are expected to take over the role of the main pillar of electricity generation by 2050, together with nuclear power.

Ecological mining limits



Source: CGS

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	52	52	52	52	52
exploited	7	8	7	6	6
Total mineral* reserves, kt	8,595,438	8,565,403	8,538,637	8,505,781	8,474,594
economic explored reserves	2,138,948	2,111,604	2,086,805	2,055,968	2,026,949
economic prospected reserves	2,059,859	2,059,854	2,059,854	2,059,854	2,059,854
potentially economic reserves	4,396,631	4,393,945	4,391,978	4,389,959	4,387,791
exploitable (recoverable) reserves	612,729	586,457	562,735	531,481	507,301
Mine production, kt	37,465	29,505	29,278	33,398	28,660

Notes:

** See NOTE in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

5. Foreign trade

2702 – Brown coal, also agglomerated, except jet

		2019	2020	2021	2022	2023
Import	kt	246	183	185	213	306
Export	kt	728	549	437	1,046	35

2702 – Brown coal, also agglomerated, except jet

		2019	2020	2021	2022	2023
Average import prices	CZK/t	2,170	2,346	2,473	3,326	2,860
Average export prices	CZK/t	1,764	1,864	1,846	2,593	2,801

Note: Jet is a compact black variety of brown coal used in (mourning) jewelry

6. Prices of domestic market

Domestic brown coal prices*

Product specification	2019	2020	2021	2022	2023
graded; cube coal II; 17.6 MJ/kg; Severočeské doly	2,475	2,475	2,575	3,200	4,000
graded; nut coal I; 17.6 MJ/kg; Severočeské doly	2,340	2,360	2,485	3,150	3,938
graded; nut coal II; 17.6 MJ/kg; Severočeské doly	2,290	2,340	2,555	3,100	3,875
coarse coal dust I, II; Severočeské doly; 16.9 MJ/kg	N	N	N	N	N
industrial mixture; 10.5–15.6 MJ/kg; Severočeské doly	N	N	N	N	N

** Prices given without taxes on solid fuels.*

Sokolovská uhelná Company has not been producing graded coal since 2009. Mostecká uhelná Company has been selling the coal in auctions, price lists will no longer be issued.

7. Mining companies in the Czech Republic as of December 31, 2023

Severočeské doly, a.s., Chomutov
Vršanská uhelná a.s., Most
Sokolovská uhelná, právní nástupce, a.s., Sokolov
Severní energetická a.s., Most

8. World production and world market prices

World mine production

In the five-year period 2018–2022, world production of brown coal developed as follows:

	2019	2020	2021	2022	2023
Brown coal and lignite (WBD), mill. t	734,5	637,3	684,8	716,4	N
Brown coal and lignite (IEA), mill. t	739,0	638,5	700,0	720,0	N

Main producers according to Welt Bergbau Daten (2024)

2023		
Country	**mill. t**	**%**
Germany	130.8	18.3
Russia	89.4	12.5
Turkey	80.9	11.3
Poland	54.6	7.6
India	45.0	6.3
USA	43.1	6.0
Australia	41.6	6.1
Bulgaria	35.5	5.0
Serbia	35.1	5.8
Czech Republic	33.4	4.7
World	**716.4**	**100.0**

Market and prices

Brown coal is subject to world trade to a limited extent only. Compared to the trade with bituminous coal, brown coal does not pay off when being transported over long distances. Therefore, trade mainly takes place between neighbouring countries on the basis of contract prices that are not available in the published statistics.

Crude oil

1. Characteristics and use

Crude oil is a natural mixture of liquid, solid and gaseous compounds, mainly hydrocarbons. Its specific gravity varies be-tween 0.75 and 1 t/m^3, the average carbon content between 80 and 87.5%, the hydrogen content between 10 and 15% and the calorific value between 38 and 42 MJ/kg. The source of hydrocarbons is organic matter formed by subaquatic biochem-ical decomposition of dead biomass. Oil formation occurs at temperatures of 60–140 °C, at depths of 1,300–5,000 m in pe-litic oil-bearing sediments. From there it migrates and accumulates in permeable, porous or cracked collector rocks. Ex-tracted oil is referred to as crude oil and has highly variable properties such as colour, viscosity, molecular weight and spe-cific gravity. Crude oil is classified as light, medium or heavy according to its specific gravity measured on the API gravity scale. At 60° F (15.6 °C), light oil has a specific gravity below 31.1 °API, medium-heavy oil has a specific gravity between 22.3–31.1 °API, heavy below 22.3 °API.

According to the chemical composition, there are 4 basic types – paraffinic, naphthenic, aromatic and asphaltic oil.

Crude oil is also referred to as sweet or sour according to the sulphur content (sweet below 0.5 wt.% S, acidic above this limit).

Industrially important deposit types

Until the 1990s, oil extraction, with one exception, was carried out by drilling from deposits of its secondary accumulation. The exception were tar or bituminous sands which were mined. Since the 1990s, the USA has developed the extraction of shale oil (and shale gas) from primary deposits by drilling using hydraulic fracturing – fracking of oil-bearing parent rocks.

Bituminous sands are a promising source. The world's largest deposits and resources are located in Venezuela (Orinoco slate sands) and Canada (Athabasca slate sands). Due to the economic and technical complexity of extraction, they are currently mined in large quantities only in Canada by surface mining. The bitumen content (8–14 °API) in sands is usually between 10–12%. The extracted bitumen is processed into synthetic crude oil or directly into petroleum products in specialised refineries

Uses

Crude oil is usually treated by distillation (refining) to separate its individual fractions: gasoline, petrol, kerosene, diesel, lubricating oil, asphalt. Higher hydrocarbons (long hydro-carbon chains) are treated (shortened) in the cracking process. The use of oil is versatile, new possibilities are constantly emerging. The largest volume of consumption is used for energy in transport systems, the energy industry in general, and in the petrochemical (supplying transport) and chemical industries.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

Reserves

2023		
Country	**Bn t**	**% World**
Venezuela	48.0	19.6
Saudi Arabia	40.9	16.7
Canada	27.1	11.1
Iran	21.7	8.9
Iraq	19.6	8.0
Russia	14.8	6.1
Kuwait	14.0	5.7
United Arab Emirates	13.0	5.3
World	**244.4**	**100.0**

2023			
Country	**Bn t**	**% World**	**% EU**
EU	0.3	0.12	100.0
Romania	0.1	0.04	33.3
Denmark	0.1	0.04	33.3
Italy	0.1	0.04	33.3

Source: BP Statistical Reviewof World Energy 2023 (no reserves update in the 2023 issue)

2. Mineral resources of the Czech Republic

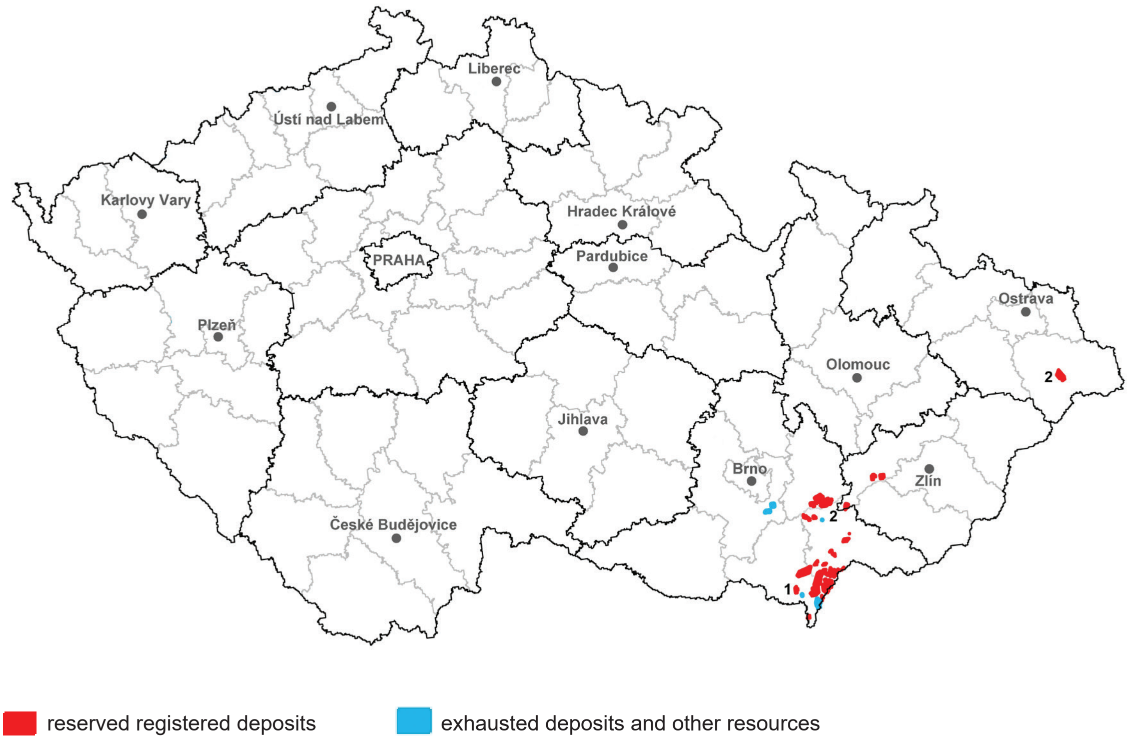
Unlike coal, the Czech Republic does not have sufficient resources for oil or natural gas. Industrially significant oil accumulations occur mainly in southern Moravia and are linked to the geological units of the Western Carpathians and the SE slopes of the Bohemian Massif. Although domestic oil production grew until 2003 and has been relatively stable in recent years, it covers only about 2–3% of domestic needs.

- In the area of the Vienna Basin (Moravian part), the deposits are scattered into many sub-structures and productive horizons, lying mainly at depths from 450 to 2,000 metres. The most productive are the sandstones of the middle and upper Baden. The largest in this area is the Hrušky deposit, most of which has already been extracted. However, research in the area is still ongoing. New oil fields with a gas cap have been discovered and are being extracted in the Poštorná, Poddvorov and Prušánky areas.
- The area of the Carpathian foredeep and SE slopes of the Bohemian Massif. The deposits found so far are among the largest oil deposits in the Czech Republic. The most significant accumulations are mainly related to collectors in the Miocene, Jurassic and to cracked and weathered parts of the crystalline complex. Dambořice currently remain the largest and most important oil deposit. Other important deposits Borkovany, Žarošice, Uhřice and Ždánice were discovered in the vicinity of this deposit by a systematic survey conducted on the basis of interpretation of 3D seismic data. Oil is accumulated here in Jurassic sediments – at the Žarošice deposit in the Vranovice carbonates and at the Uhřice-jih deposit in the sandstones of the Gresten Formation. At present, these deposits are intensively extracted – they account for about 70% of the total oil production in the Czech Republic and almost 80% of the re-coverable reserves. In order to achieve the highest possible yield, the technology of horizontal wells is also used in extraction. In the case of the Uhřice-jih and Dambořice deposits, gas is additionally injected into the top parts of the deposits in order to maintain the deposit pressure. At the Žarošice deposit, a significant source of pressure is pre-sent in

the form of the gas cap and the active bedding water, and therefore the use of this method is not yet nec-essary.

Oil and gas deposits are genetically linked. In the Vienna Basin, oil deposits occur in Baden and Lower Miocene sediments, while in the Sarmatian, only gas deposits are found. Crude oil in the Czech Republic is mostly light, sulphur-free, paraffinic to paraffinic-naphthenic. In 2009, 3 types of crude oil were mined in the Czech Republic – light, medium and heavy, with specific weights from 812 to 930 kg/m^3 at 20 °C, which corresponds to 20 to 43°API, sulphur contents in the crude oil ranged from 0.08 to 0.32% of weight.

3. Registered deposits and other resources of the Czech Republic



Principal areas of deposits presence

*(names of areas with exploited deposits are indicated in **bold type**)*

1 **Vienna Basin**	2 **West–Carpathian Foredeep**

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	39	39	39	39	40
exploited	33	34	32	31	32
Total mineral *reserves, kt	31,482	31,391	31,308	31,233	31,558
economic explored reserves	21,648	21,565	21,491	21,422	21,422
economic prospected reserves	4,020	3,963	4,004	3,990	4,323
potentially economic reserves	5,814	5,863	5,813	5,813	5,813
exploitable (recoverable) reserves	1,439	1,361	1,359	1,330	1,365
Mine production, kt	81	91	83	75	67

** See NOTE in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

5. Foreign trade

2709 – Petroleum oils and oils obtained from bituminous minerals, crude

		2019	2020	2021	2022	2023
Import	kt	7,738	6,174	6,841	7,425	7,406
Export	kt	0.2	0.4	0.001	0.001	0.001

2709 – Petroleum oils and oils obtained from bituminous minerals, crude

		2019	2020	2021	2022	2023
Average import prices	CZK/t	11,094	7,970	11,404	15,535	12,715
Average export prices	CZK/t	9,833	468,835	235,562	175,544	134,153

271011 – Petrol (Gasoline)

		2019	2020	2021	2022	2023
Import	kt	N	N	N	N	N
Export	kt	N	N	N	N	N

271011 – Petrol (Gasoline)

		2019	2020	2021	2022	2023
Average import prices	CZK/t	N	N	N	N	N
Average export prices	CZK/t	N	N	N	N	N

Czech Republic crude oil import by country and import costs

	2019		2020		2021		2022		2023	
Country	**kt**	**CZK/t**	**kt**	**CZK/t**	**kt**	**CZK/t**	**kt**	**CZK/t**	**kt**	**CZK/t**
Russia	3, 821	10,585	3,013	7,337	3,417	11,089	4,162	12,937	4,306	10,988
Azerbaijan	2,194	11,662	1,426	8,968	1,096	11,958	1,726	19,291	1,965	15,091
USA	277	11,395	728	7,990	804	11,422	468	20,566	181	14,085
Kazakhstan	990	11,827	567	10,041	1,239	11,676	726	16,009	756	15,305
United Kingdom	–	–	128	7,811	1	N	1	N	–	–
Saudi Arabia	104	10,612	104	3,515	1	N	204	19,340	—	–
Norway	–	–	89	7,034	81	14,390	1	N	–	–
Nigeria	178	11,228	59	6,424	45	6,512	–	–	–	–
Niger	–	–	35	6,622	N	N	–	–	–	–
Algeria	82	10,773	82	9,816	26	7,967	–	–	–	–
Total	**7,439**	**11,644**	**7,738**	**11,093**	**6,175**	**11,940**	**7,425**	**15,535**	**7,208**	**13,867**

Note: Only countries with imports exceeding 10 tonnes of crude oil in a given year are included
Source: ČSÚ

6. Prices of domestic market

Prices of domestic producers are not open to public.

7. Mining companies in the Czech Republic as of December 31, 2023

MND a.s., Hodonín
LAMA GAS & OIL s.r.o., Hodonín

8. World production and world market prices

World production

World crude oil production reached these amounts in recent years:

	2019	2020	2021	2022	2023
World crude oil production (WBD), mill. t	4,466	4,471	4,246	4,430	N
World crude oil production (BP), mill. t	4,486	4,477	4,238	4,424	4,514

Note: BP – BP Statistical Review of World Energy 2023

Main producers according to BP

2023		
Country	**mill.t**	**%**
USA	827	18.3
Russia	542	12.0
Saudi Arabia	532	12.5
Canada	278	11.8
Iran	214	6.2
Iraq	209	4.6
China	205	4.5
Brazil	184	4.1
United Arab Emirates	176	3.9
Kuwait	140	3.1
World	**4,514**	**100.0**

World market prices

The price development of the OPEC basket oil according to EURACOAL (Market Report):

Month/ year	01	02	03	04	05	06	07	08	09	10	11	12
2016	26.50	28.72	34.65	37.86	43.21	45.84	42.68	43.10	42.89	47.87	43.22	51.67
2017	52.40	53.37	50.32	51.37	49.20	45.21	46.93	49.60	53.44	54.90	60.74	62.06
2018	66.85	63.48	63.76	68.43	74.11	73.22	73.27	72.26	77.18	79.39	65.33	56.94
2019	58.74	63.83	66.37	70.78	69.97	62.92	64.71	59.62	62.36	59.91	62.94	66.48
2020	65.10	55.53	33.92	17.66	25.17	37.05	43.42	45.19	41.54	40.08	42.61	49.17
2021	54.38	61.05	64.56	63.24	66.91	71.89	73.53	70.33	73.88	82.11	80.37	74.38
2022	85.24	93.95	113.48	105.64	113.87	117.72	108.55	101.90	95.32	93.62	89.73	79.68
2023	81.62	81.88	78.45	84.13	75.82	75.19	81.06	87.33	94.60	91.34	N	N

TThe average price quotations of crude oil purchases according to the IEA and BP (USD/bbl)

Commodity/year	Units	Conversion factor	2019	2020	2021	2022	2023
Brent Crude, CIF Rotterdam	USD/bbl	1 t = 7.560 bbl	64.21	41.84	70.91	101.32	82.60
	USD/t		485.43	316.31	53.08	765.98	624.76
Dubai Crude, CIF Rotterdam	USD/bbl	1 t = 7.596 bbl	63.71	42.41	68.91	96.38	82.09
	USD/t		483.94	322.15	523.44		
West Texas Intermediate (WTI), CIF Rotterdam	USD/bbl	1 t = 7.400 bbl	57.03	39.25	68.10	94.58	83.60
	USD/t		422.02	290.45	503.94	699.89	583.71
Nigerian Forcados Crude, CIF Rotterdam	USD/bbl	1 t = 7.500 bbl	64.95	42.31	69.76	101.40	78.88
	USD/t		487.13	317.33	523.20	760.50	627.00

Note: bbl = abbreviation of term barrel

Natural gas

1. Characteristics and use

Natural gas is a mixture of gaseous hydrocarbons, especially methane (CH_4), and other gases (hydrogen, nitrogen, carbon dioxide, hydrogen sulphide and inert gases). Methane predominates – more than 50% of the mixture. Raw gas has a certain admixture of oil, water and sand. In the Czech Republic, there are 3 basic types of natural gas: dry gas (with CH_4 content 98–99%), moist gas (85–95% CH_4 and hydrocarbon admixture) and gas with an increased proportion of inert components (50–65% CH_4, over 10% N_2 and over 20% CO_2).

There are two types of natural gas: conventional, more or less oil related, and unconventional. Unconventional types of natural gas differ by their sources and they include tight gas. i.e. gas retained in impermeable or only partially permeable sandstones (tight gas, tight sandstones), shale gas, i.e. gas retained in shale, gas hydrate in sediments of seabeds or permanently frozen polar soil (permafrost), coal bed methane (CBM). Coal bed methane is unconventional only where it is extracted from seams by drilling and artificial cracking of coal. Methane obtained from degassing wells or shafts in connection with coal mining is referred to as coal mine methane (CMM) and it is not considered an unconventional type of natural gas.

Industrially important deposit types

Until the 1990s, natural gas was extracted from conventional deposits. Since the 1990s, the USA has developed the extraction from unconventional deposits – deposits of shale oil (and shale gas) – by drilling using hydraulic fracturing – fracking of oil-bearing and gas-bearing parent rocks.

Reserves

2023		
Country	**Trillion m^3**	**% World**
Russia	37.4	19.9
Iran	32.1	17.1
Quatar	24.7	13.1
Turkmenistán	13.6	7.2
USA	12.6	6.7
China	8.4	4.5
Venezuela	6.3	3.3
Saudi Arabia	6.0	3.2
United Arab Emirates	5.9	3.1
World	**188.1**	**100.0**

2023			
Country	**Trillion m^3**	**% World**	**% EU**
EU	0.3	0.16	100.0
Netherlands	0.1	0.05	33.3
Poland	0.1	0.05	33.3
Romania	0.1	0.05	33.3

Source: BP Statistical Review of World Energy 2024

Uses

Natural gas, along with oil and coal, is one of the world's major natural fuels. It is a versatile source of energy – it is most often used for heating and electricity generation.

Classification as critical raw materials for the European Union:

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

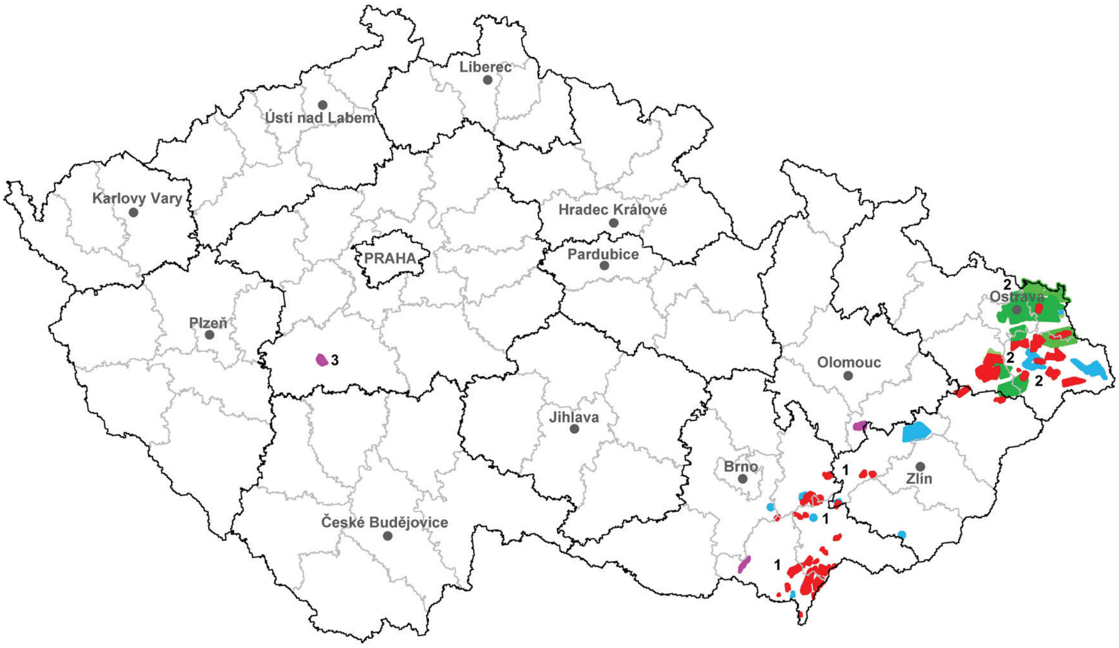
As in the case of oil, the Czech Republic does not have sufficient sources of natural gas. Deposits and resources are concentrated in southern and northern Moravia. They are connected to the geological units of the Western Carpathians and the south-eastern slopes of the Bohemian Massif, where they are mostly connected with oil. In northern Moravia, they are also bound to the coal seams of the Upper Silesian Basin. Natural gas production in the Czech Republic has been relatively stable for a long time and covers about 1 to 2% of domestic consumption.

- Natural gas deposits, genetically linked to the formation of oil, are found in the Moravian part of the Vienna Basin. Oil deposits are concentrated mainly in the central part of the basin, gas deposits predominate in the peripheral areas. They are deposited in Baden sediments together with oil deposits either as separate natural gas deposits or as gas caps of oil deposits or as gas dissolved in oil. The overlying Sarmatian sediments contain almost exclusively natural gas deposits. The extracted gas contains from 87.2 to 98.8% of CH_4 by volume, it has a calorific value of 35.6 to 37.7 MJ/m^3 (dry gas at 0°C), specific gravity 0.72 to 0.85 kg/m^3 (at 0°C) and H_2S content below 1 mg/m^3. New sources of natural gas were prospected especially in the area of Břeclav, Poštorná, Charvátská Nová Ves, Prušánky, Josefov, Lednice, Poddvorov, Dolní Bojanovice and Podivín, mostly using 3D seismic technology. Further research after these positive results will focus on analogous types of deposit structures. The largest exhausted natural gas deposits from the Hrušky and Poddvorov mining fields were used as underground gas storage facilities in Tvrdonice and Dolní Bojanovice.
- The area of the Carpathian foredeep and SE slopes of the Bohemian Massif is considered to be a promising area, where the most significant accumulations of natural gas are currently available. The largest deposits found so far include Dambořice, Ždánice, Dolní Dunajovice, Uhřice and Horní Žukov (gas deposits after extraction mostly converged to underground reservoirs) and Lubná-Kostelany (almost exhausted today). The most important accumulations are mainly related to trap rocks in the Miocene, Jurassic and in cracked and weathered parts of the crystalline complex. Natural gas (and gas condensate) was extracted from a depth of over 3,900 m from the deepest used Karlín deposit. These gas deposits have a very variable composition. Methane represents 98% of the Dolní Dunajovice deposit, while in the Kostelany-západ deposit, it is only 70% methane with industrially usable concentrations of He and Ar. Significant reserves are tied up in the gas caps of the Ždánice-miocén and Kloboučky heavy oil deposits. An intensive search for a new extraction technology is currently underway, which would make it possible to economically extract not only part of the reserves of heavy oil, but also natural gas bound in gas caps. A survey (especially using 3D seismic technology) discovered new resources of natural gas, especially in the Poštorná area. Based on these positive results, further

research will focus on analogous types of deposit structures. The Dolní Dunajovice and Uhřice natural gas deposits are secondarily used as underground gas storage facilities. In northern Moravia, between Příbor and Český Těšín, there are gas deposits bound mostly to weathered and tectonically disturbed carbon relief, or to directly adjacent Miocene clasts. The origin of the gas of these deposits, formed at the peaks of morphological elevations of carbon, has not yet been clearly clarified (whether it is gas formed during coalification of coal seams or gas associated with the formation of oil). These are especially the Bruzovice and Příbor deposits. Part of the Příbor deposit or the already mined-out Žukov deposit serve as an underground gas storage.

- Demonstrably Carboniferous gas is obtained by degasification (mining from already closed deep mines) of coal seams of the Czech part of the Upper Silesian coal basin. During this process, the mine gases are diluted by air suction and the resulting concentration of the gases thus obtained is around 50–55% $CH_{4;}$ O_2, N_2, CO and CO_2 are also present. Its quality depends on the methods and technical possibilities of this degasification and it is therefore very volatile. CH4 content of the undiluted carbon dioxide is 94 to 95%. Gas from individual locations is supplied for consumption to local customers (e.g. Mittal Steel) through a network of more than 100 km long pipelines. Natural gas sorbed on coal seams accounts for about 22–25% of the current total production and recoverable reserves in the Czech Republic. Natural gas from the Rychvald deposit is transported by a 22 km long gas pipeline to the Nová Huť steelworks in Ostrava.
- Numerous occurrences of natural hydrocarbons both on the surface and in the boreholes were found in the area of the Carpathian flysch mantles. In the past, there was limited mining from several deposits (e.g. Hluk).

3. Registered deposits and other resources of the Czech Republic



- reserved registered deposits of natural gas
- exhausted deposits and other resources of natural gas
- reserved registered deposits of natural gas adsorbed on coal seams
- other resources of natural gas adsorbed on coal seams
- underground gas reservoirs

Principal areas of deposits and underground gas reservoirs

*(Names of regions with mined deposits are indicated in **bold type**)*

1 **South-Moravian region**	2 **North-Moravian region**	3 underground gas reservoir Háje

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	97	97	98	98	99
exploited	64	67	66	64	64
Total mineral *reserves, mill m^3	30,339	30,203	30,071	29,904	29,859
economic explored reserves	6,994	6,799	6,757	6,633	6,571
economic prospected reserves	2,807	2,725	2,776	2,735	2,752
potentially economic reserves	20,538	20,679	20,538	20,536	20,536
exploitable (recoverable) reserves	9,829	10,105	4,098	4,819	4,776
Mine production, mill m^3	146	138	153	165	119

** See NOTE in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	mill. m^3	16,767	16,767	16,767	16,767	16,767
P_2		–	–	–	–	–
P_3		–	–	–	–	–

5. Foreign trade

271121 – Natural gas

		2019	2020	2021	2022	2023
Import	ths m^3	7,481,881	6,210,123	6,383,792	6,584,327	4,896,671
Export	ths m^3	645,242	782,138	1,008,928	454,108	11,927

271121 – Natural gas

		2019	2020	2021	2022	2023
Average import prices	CZK/ths m^3	5,906	3,962	11,941	34,760	17,873
Average export prices	CZK/ths m^3	6,132	4,381	4,370	29,510	13,615

Natural gas import to the Czech Republic 2019–2023

Country	2019			2020			2021			2022			2023		
	ths m³	ths CZK	CZK/ths m³	ths m³	ths CZK	CZK/ths m³	ths m³	ths CZK	CZK/ths m³	ths m³	ths CZK	CZK/ths m³	ths m³	ths CZK	CZK/ths m³
Austria	5	172	N	1	433	N	2	707	361822	2	549	297722	1	326	326 000
Germany	746 572	4 519 729	6 054	1 696 475	5 982 503	3 526	0	-		-	-	-	-	-	-
Denmark	3 694	6 322	1 711	-	-	-	553	2788	5042	-	-	-			
France	295	1 998	6 782	-	-	-	-	-	-	-	-	-			
Switzerland	1 808	3 937	2 178	-	-	-	-	-	-	-	-	-			
Luxemburg	-	-	-	-	-	-	-	-	-	-	-	-			
Norway	W	W	-	-	-	-	-		-	1129340	39286111	34787	4 256 025	75 672 495	1 778
Poland	-	-	-	-	-	-	-	-	-	-	-	-			
Countries and territories not mentioned	-	-	-	-	-	-	-	-	-	-	-	-	151 770	2 567 185	16 915
Countries and territories not covered by intra EU trade	-	-	-	-	3 746	4 631	37 664	421086	11180	1825	40749	22328	74 735	1 806 121	
Russia	6 174 659	37 127 850	6 013	4 512 596			6 343 113	75793796	11949	5234628	18701643	34903	402 644	7 340 143	18 229
Slovakia	14 835	57 856	3 900	<1	21	N	1	4	N						
USA	<1	117	N	-						218531	6822123	31218			
Italy	250	1 729	6 904	242			242	1649	6813						
Ukraine							246	8116	3299						
Great Britain	-	-	-	-	-	-	-	-	-	-	-	-	11 480	131 166	11 425
Holland	-	-	-	-	-	-	-	-	-				16	21 000	1 313

Source: ČSÚ (CZSO)

6. Prices of domestic market

Prices of domestic producers are open to public incompletely.

Unigeo a.s. shows data in its Annual Reports for 2018–2022 which allow to deduct approximate average prices of natural gas supply to local gas distribution system (GasNet s.r.o.):

	2019	2020	2021	2022	2023
Unigeo a.s. price – CZK/m³	6	4	14	37	11

Trading on the Energy Exchange of the Czech Moravian Commodity Exchange Kladno (CMKBK) with the SSDP (composite natural gas supply services of gas products (commodity)) – price quotation*) averages weighted by realized quantity

		2019	2020	2021	2022	2023
To 630 MWh/delivery point (630 MWh = 59,684 m³)	CZK/MWh **)	533	406	1,619	3,733	1,483
	CZK /ths m³ ***)	5,629	4,291	17,028	39,402	15,752
Over 630 MWh/delivery point (630 MWh = 59,684 m³)	CZK /MWh **)	526	382	1,583	3,677	1,452
	CZK /ths m³ ***)	5,557	4,037	16,622	38, 605	15,301

Source: Czech Moravian Commodity Exchange Kladno

*Explanations: SSDP (**sdružené služby dodávky zemního plynu**) = composite natural gas supply services of gas products (commodity) = natural gas physically delivered into the customers offtake point on the territory of the Czech Republic with obligation of the customer to take delivery of the gas from the distribution network (gas grid) and responsibility of the holder of the natural gas trading licence (supplier) for any deviations in line with relevant legal regulations according to the Energy Act and the relevant implementing and related regulations in force including distribution of natural gas and the system services.*

**) Prices are quoted in CZK without VAT, gas tax or any other indirect tax or similar payment and do not include distribution of natural gas and related services*

***) Original format of quoted prices*

****) Recalculated quoted prices with using of calorific value 1 MWh = 94.74 m³ of natural gas*

7. Mining companies in the Czech Republic as of December 31, 2023

MND a.s., Hodonín
Green Gas DPB, a.s., Paskov
LAMA GAS & OIL s.r.o., Hodonín
Unigeo a.s., Ostrava – Hrabová
UNIMASTER spol. s r.o., Praha

8. World production and world market prices

World mine production

The volumes of world natural gas production in recent years were as follows:

	2019	2020	2021	2022	2023
World natural gas production (WBD), mill m³	3,252	3,168	3,301	3,327	N
World natural gas production (BP), mill m³	3,968	3,861	4,053	4,049	4,059

Note: BP – BP Statistical Review of World Energy 2024.

Main producers according to BP

2023		
Country	**mild. m^3**	**%**
USA	1,035	25,5
Russia	586	14,4
Iran	252	6,2
China	234	5,8
Canada	190	4,7
Qatar	181	4,5
Australia	152	3,8
Norway	117	2,9
Saudi Arabia	114	2,8
Algeria	102	2,5
World	**4,059**	**100.0**

Natural gas prices in various countries according to the BP Statistical Review of World Energy 2024 (USD/mill Btu converted to USD/m^3 and USD/MWh)

Country/year		2019	2020	2021	2022	2023
Germany, average import price	USD/mil. Btu	5.03	4.06	8.94	24.17	12.69
	USD/MWh	17.16	1384	30.51	81.93	43.02
	USD/m^3	0.19	0.15	0.33	0.91	0.48
United Kingdom, Heren NBP Index	USD/mil. Btu	4.47	3.42	15.80	25.10	12.3
	USD/MWh	15.24	1166	53.92	85.56	41.93
	USD/m^3	0.17	0.12	0.59	0.95	0.47
USA, Henry Hub, spot price	USD/mil. Btu	2.51	1.99	3.84	6.45	2.53
	USD/MWh	8.56	6.79	13.11	22.24	8.72
	USD/m^3	0.09	0.08	0.14	0.23	0.09
Canada (Alberta)	USD/mil. Btu	1.27	1.58	2.75	N	N
	USD/MWh	4.33	5.39	9.39	N	N
	USD/m^3	0.05	0.06	0.10	N	N

Note:
1) The price conversion from USD/mill Btu to USD/m^3 was performed by the use of the following ratios:
1 ft^3 (cubic foot) of natural gas = 1,050 Btu (British thermal unit); 1 m^3 = 35.31 ft^3; 1 m^3 = 37,075.5 Btu
2) 3,412,969 Btu = 1 MWh

Uranium

1. Characteristics and use

Average U content (and its extent) in the earth's crust (ppm)

2.5 (0,003–4.8) U

Industrially important minerals

Uraninite K(Th,TR,UO_2).mPbO (up to 92% U), nasturane KUO_2.mPbO (up to 90% U), uranium black $UO_{2.70–2.93}$ (up to 60% U), coffinite $U[SiO_4(OH_4)_4]$ (up to 67% U), carnotite $(K_2(UO_2)_2(V_2U_8).3H_2O$ (up to 64% U), autunite $Ca(UO_2)(PO_4)_2.6H_20$

Industrially important deposit types

1. Infiltration in sandstones: basin Chu-Sarysu and Syr Darya (Kazakhstan), Kyzylkum (Uzbekistan), Wyoming (USA), Tim Mersoi (Niger), Königstein (Germany), Hamr, Stráž (Czech Republic)
2. Discordant – „unconformity": Athabasca District (Canada), Ranger (Australia)
3. Felsic intrusions: Rössing, Husab (Namibia), Dalongshan (China)
4. Magmatic-hydrothermal: Olympic Dam (Australia)
5. Fossil river placers: Witwatersrand (South Africa), Elliot Lake (Canada)
6. Volcanic: Streltsovsk (Russia), Fushou, Benxi (China), Dornod (Mongolia), Kurišková-Jahodná (Slovakia)
7. Metasomatic: Ingulskoye, Smolinskoye (Ukraine), Caetité/Lagoa Real (Brazil)
8. Vein: Beaverlodge (Canada), Jaduguda, Turamdih (India), Chongyi, Lantian (China), Aue-Schlema (Germany), Příbram, Rožná (Czech Republic)

Reserves

2023		
Country	**t**	**% World**
Australia	1,692,700	27.9
Kazakhstan	815,200	13.4
Canada	588,500	9.2
Russia	480,900	7.9
Namibia	470,100	7.7
S. Africa	320,900	5.3
Niger	311,100	5.1
Brazil	276,800	4.6
China	223,900	3.7

2023		
Country	**t**	**%**
Mongolia	144,600	2.4
Uzbekistan	131,300	2.2
Ukraine	107,200	1.8
Botswana	87,200	1.4
Tanzania	58,200	1.0
Jordan	52,500	0.9
USA	59,400	1.0
World	**6,078,500**	**100.0**

Source: Uranium 2023: Resources, Production and Demand („Red Book").
Resources evaluated at the level of recoverable identified resources (reasonably assured resources plus inferred resources) at a uranium price lower than USD 130 / kg.
In addition to the above classification (condition of resource evaluation) and the inventory of resources of the EU, reserves of 17,956 tonnes of uranium in Hungary are reported in the EU.

2023			
Country	**t**	**% World**	**% EU**
EU	81,300	1.2	100.0
Spain	28,500	0.5	35.1
Slovak Rep.	15,500	0.3	19.0
Turecko	11,700	0.2	14.4
Sweden	9,600	0.2	11.8
Portugal	5,600	0.1	6.9
Finland	1,200	0.0	1.5
Czech Rep.	800	0.0	1.1

Uses

Energy industry, military (nuclear ammunition, anti-tank ammunition from depleted uranium), radioisotopes (medicine, defectoscopy), glassmaking, ceramics.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

The Czech Republic was one of the world's most important uranium producers. Historically, with a total production of about 112 thousand t of uranium in the years 1946 to 2019 in the form of sorted ores (from the beginning of mining until 1975) and chemical concentrate (since 1953) the Czech Republic ranks 12th in the world. The peak of uranium ore mining in the Czech Republic took place from the end of the 1940s to the beginning of the 1990s, when it was terminated due to high production losses in all vein deposits mined until then (except Rožná). In 1995, mining at the Hamr deposit ended for the same reason, and a year later, for mainly ecological reasons, at the Stráž deposit, mining at the sandstone-type deposits was terminated. From then until the end of 2016 (in 2017, the mined ore was obtained as part of the processing of residual structures in uranium ores during the clearing of stopes before their abandonment and the implementation of preparatory liquidation work) in the Czech Republic only the Rožná vein deposit. The closure of the Rožná deposit probably ended the uranium mining in the Czech Republic for a long time (if not definitively). During the peak of mining (1955–1990), the annual production of uranium ranged between 2,000 and 2,900 tonnes (max. slightly over 3,000 t in the years 1959 to 1960 and 1962 to 1964). Then, within three years, it dropped to about 600 and remained around this value until 1999. Since 2000, the mined amount has been declining slowly but steadily to 128 t in 2016, when the mining of U ores was terminated. Since then, uranium has been obtained from the remediation of closed mines in the amount of 30–40 t U per year. While in 1990 share in world mining reached more than 4%, between 1994 and 2003 it was around 2%, after 2005 it has already fallen below 1% and currently (2018) our republic with a production of around 35 tonnes per year ranks 14th in the world with less than 0.1% share in worldwide mined amount.

Usable uranium accumulations were found both in the crystalline complex bedrock and in the overlying formations of the Bohemian Massif. There are two main stages in the formation of uranium ores – late Variscan and Alpine.

Depending on the geological environment, according to the IAEA classification, there were practically only two types of deposits in the Czech Republic – vein and sandstone. From the point of view of metal production, hydrothermal vein deposits (veins in metamorphites. zone deposits in metamorphites and along large faults in granitoids) were of the greatest importance. The total production of U metal from these types of deposits was almost 84 kt. The second place in terms of production (a total of 29.5 kt U) is occupied by deposits of uranium–bearing sandstones of the Czech Cretaceous basin. The remaining less than 0.9 kt U is then accounted for by deposits in permocarbon and tertiary sediments (according to the IAEA classification, mainly of the coal or lignite type). The vast majority of the uranium mined – almost 86% – was mined by traditional underground mining. About 400 t of uranium were mined by surface quarries, which represents about 0.3% of the total amount. The remaining part of uranium (about 14%) was obtained mainly by underground leaching from wells (in situ leaching).

Vein deposits in the Czech Republic were divided into 3 subtypes:

- Veins and venous systems of hydrothermal origin in metamorphic rocks. The ore mineralisation with the predominant uraninite is very uneven, contrasting and it is spatially and genetically related to the massifs of the Variscan granitoids. Mostly steeply inclined ore bodies (veins) have a thickness of a few cm to 1 m. rarely more. The U contents in these deposits mostly ranged from 0.1 to several tenths of a percent, exceptionally up to about 1%. This type included the largest Czech and one of the world's largest hydrothermal vein deposits Příbram, formerly important deposits Jáchymov, Horní Slavkov, and some smaller deposits, such as Licoměřice-Březinka, Zálesí u Javorníka, Předbořice, Chotěboř, Slavkovice, Lázně Kynžvart-Kladská, Planá u Mariánských Lázní-Svatá Anna. etc.
- Blurred graphitised and chloritized or only chloritized ore-bearing crushed zones in metamorphic rocks, mostly with steep dip. The ore mineralisation is uneven, mostly disseminated with the main minerals uraninite, coffinite and brannerite. The ore bodies have a plate-like shape with thicknesses of several meters to 10 m and the U contents in the deposits ranged from around 0.09 to 0.3%. This includes, for example, the last mined Rožná deposit, Zadní Chodov, Olší, Okrouhlá Radouň, Dyleň, Jasenice-Pucov, etc.
- Ore mineralisation bound to chloritized tectonic zones in Variscan granitoids mainly with uraninite-coffinite-brannerite mineralisation. The ore mineralisation is relatively uniform and forms columnar or lenticular bodies, mostly steeply inclined. The U contents in the deposits mostly ranged between 0.07 and 0.13%. The most important deposit of this type was Vítkov 2, other examples are Nahošín and Lhota u Tachova.

Deposits in uranium-bearing sandstones:

- Predominantly stratiform ore mineralisation in waterbearing Cenomanian silty sandstones of the Lusatian development of the Czech Cretaceous basin, formed mainly by uraninite and U-blacks, in some places also by hydrozirconium. The ore bodies are placed horizontally or sub-horizontally and have a layered, plate-shaped and less lenticular shape with thicknesses between a few decimetres and a few metres. The ore mineralisation is part of the matrix and is relatively evenly distributed. The U grades in deposits range on average from 0.03 to 0.14%. The deposits in the vicinity of Stráž pod Ralskem were of decisive importance, where both traditional deep mining (Hamr, Břevniště, Křižany) and leaching of ore from boreholes (Stráž) took place. Other proven deposits (Osečná-Kotel) and prognostic resources (Hvězdov, Mimoň, Heřmánky, etc.) have not yet been mined. More than 98% of registered reserves in the Czech Republic (mostly potentially economic = irrecoverable resources) are tied to this type of deposits. Uranium reserves would be economically recoverable mainly by in situ leaching (ISL) (= in situ recovery (ISR)), which is currently not ecologically acceptable.

Other deposits:

- Stratiform mineralisation in the sediments of the Late Paleozoic, formed by uranium-bearing coal seams and surrounding rocks in the Pennsylvanian (= Upper Carboniferous) and Lower Permian in the Intra Sudetic Basin (e.g. Radvanice, Rybníček, Svatoňovice) and in the Kladno-Rakovník Basin (Jedomělice, Rynholec). The ore mineralisation, consisting mainly of uraninite, had the shape of small slightly inclined irregular lenses, or plates at most several decimetres thick. The average U content in the deposits ranged from 0.1 to 0.3%.
- Stratiform ore mineralisation in the eastern part of the Sokolov Basin (e.g. Mezirolí. Podlesí) and its Hroznětín part (e.g. Hájek, Ruprechtov, Hroznětín). Irregular ore mineralisation in sediments enriched with organic material (including coal), consisting mainly of uranium blacks. was mostly in the form of smaller plates and lenses with thicknesses from decimetres to at most several metres. U grades averaged between 0.1 and 0.2%.

Economically important and especially intensively used deposits in the past were concentrated in five areas. In the following overview, the areas with the type of ore and the most important deposits are listed according to the importance given by the amount of uranium mined. The percentage share of the area in the total extraction is added in brackets.

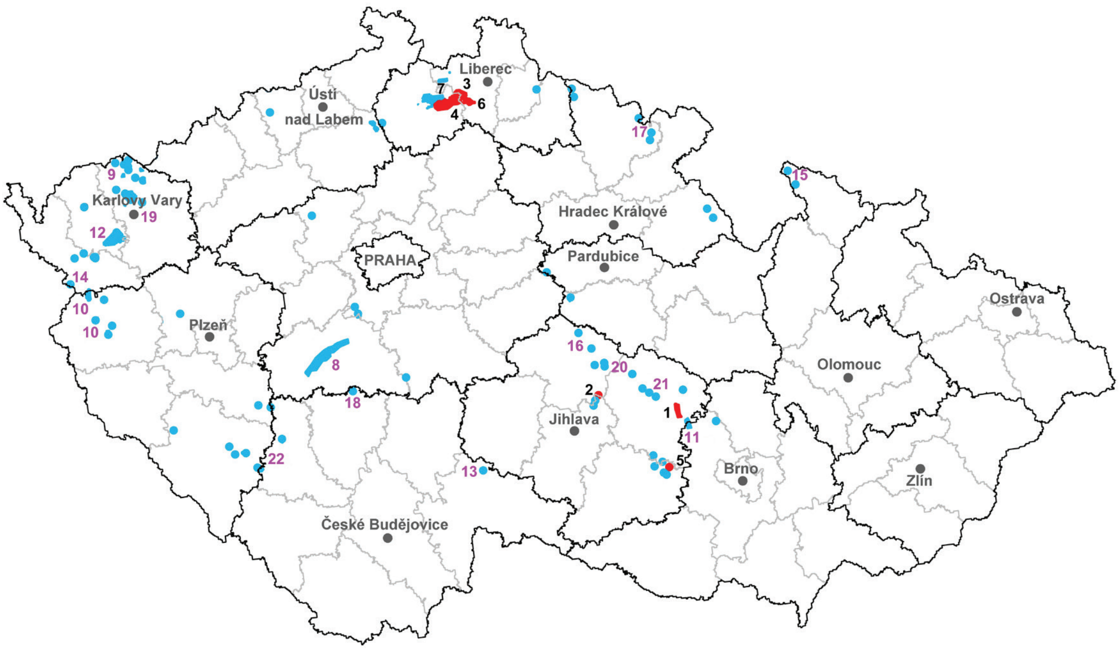
- Central Bohemian – vein ore mineralisation: e.g. Příbram, Předbořice (almost 40% of total metal mined)
- North Bohemian – ore mineralisation in Cretaceous sediments: e.g. Stráž pod Ralskem, Hamr pod Ralskem, Břevniště pod Ralskem (around 24%)
- Moravian – zone and vein ore mineralisation: Rožná Olší (about 21%)
- West Bohemian – zone and vein ore mineralisation: e.g. Zadní Chodov, Vítkov 2, Horní Slavkov, Dyleň (less than 10%)
- Krušné hory – vein deposits and ore mineralisation in Tertiary sediments: e.g. Jáchymov, Hájek (less than 7%)

Other small deposits and occurrences scattered over the remaining territory of the Bohemian Massif e.g. in Železné Hory, Rychlebské Hory, Krkonoše and at the Okrouhlá Radouň deposit contributed the remaining 2% to the total amount of approx. 112 thousand tonnes U mined after World War II.

All extracted raw material was chemically treated and the final product was a chemical uranium concentrate sold abroad (in 2015 to Canada. France and Russia). In the last 25 years. The energy company ČEZ a.s. (ČEZ) has been the almost exclusive customer of uranium concentrate. Uranium consumption purchased fuel elements at the Dukovany and Temelín nuclear power plants has ranged from 650 to 700 tonnes per year in recent years.

The setting pit in Stráž pod Ralskem where leachate waste from the deposit containing 0.030 to 0.063% of rare earths (lanthanum to gadolinium) has accumulated for 30 years, but also scandium, yttria, niobium, zirconium and hafnium is a potential resource of these metals. Apart from Zr the reserves of these metals have not yet been evaluated.Apart from Zr the reserves of these metals have not yet been evaluated.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits exhausted deposits and other resources

Reserved registered deposits

1 Rožná	3 Břevniště pod Ralskem	5 Jasenice-Pucov	7 Stráž pod Ralskem*
2 Brzkov	4 Hamr pod Ralskem	6 Osečná-Kotel	

* *uranium is recovered only as a byproduct from the treatment of groundwater and technological solutions during mine liquidation and reclamation work upon termination of in-situ leaching (ISL), otherwise in situ recovery (ISR), of uranium ores*

Exhausted deposits and other resources

8 Příbram	13 Okrouhlá Radouň	18 Předbořice
9 Jáchymov	14 Dyleň	19 Hájek + Ruprechtov
10 Zadní Chodov + Vítkov 2	15 Javorník	20 Chotěboř
11 Olší	16 Licoměřice-Březinka	21 Slavkovice
12 Horní Slavkov	17 Radvanice + Rybníček + Svatoňovice	22 Mečichov-Nahošín

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	7	7	7	7	7
exploited	0	0	0	0	0
Total mineral * reserves, t U	134,862	134,833	134,825	134,803	134,803
economic explored reserves	1,300	1,300	1,300	1,300	1,300
economic prospected reserves	19,448	19,448	19,448	19,448	19,448
potentially economic reserves	114,114	114,085	114,077	114,055	114,043
exploitable (recoverable) reserves	276	276	276	267	267
Mine production, t U	33	29	27	21	13
Production of concentrate, t U **	33	28	26	22	17

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

** *sales production (without ore milling losses)*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	t U	214,253	214,253	233,769	233,769	233,769
P_2,	t U	12,319	12,319	17,736	17,736	17,736
P_3		–	–	–	–	–

Other* prognostic resources P_1, P_2, P_3

Year	2019	2020	2021	2022	2023
P_1	–	–	–	–	–
P_2	–	–	–	–	–
P_3	–	–	–	–	–

* *Prognostic resources of uranium-bearing sandstones type in the Bohemian Cretaceous Basin, unexploitable at the present time.*

5. Foreign trade

28441030 – Natural uranium – wrought

		2019	2020	2021	2022	2023
Import	t U	0	0	0	0	0
Export	t U	0	0	0	0	0

28441030 – Natural uranium – wrought

		2019	2020	2021	2022	2023
Average import prices	CZK/kg U	–	–	–	–	–
Average export prices	CZK/kg U	–	–	–	–	–

6. Prices of domestic market

Mined uranium is exported.

7. Mining companies in the Czech Republic as of December 31, 2023

DIAMO, s.p., Stráž pod Ralskem

8. World production and world market prices

World mine production

In recent years the volume of world production of uranium in a concentrate expressed in terms of the U_3O_8 and U content of concentrates was as follows:

	2019	2020	2021	2022	2023
Uranium production, U_3O_8 (according to WBD)	64,278	55,718	55,981	55,972	N
Uranium production, t U (according to WNA*)	64,554	56,287	56,377	58,201	N

Note:
*1) *Uranium mining production. World Nuclear Association. September 2023.*
2) 1 t U = 1.179 t U_3O_8

According to the Uranium Investing News.com (INN), primary U production has been in recent years identical to World Nuclear Association (WNA) data:

Year	2019	2020	2021	2022	2023
Tonnes U	54,742	47,731	47,808	49,355	N

Main producers according to WNA

2023		
Country	**t U**	**%**
Kazakhstan	21,227	43.4
Canada	7,351	15.0
Namibia	5,613	11.5
Australia	4,087	8.4
Uzbekistane	3,300	6.8
Russia	2,508	5.1
Niger	2,020	4.1
China[e]	1,700	3.5
India[e]	600	1.2
South Africa[e]	200	0.4
Ukraine	100	0.2
World	**48,888**	**100.0**

e – estimate

According to the WNA in 2022 about 57% of world production was obtained from the following 10 largest deposits which are located in 5 countries:

Deposit	Country	Mining company	Mine type	tonnes U
Cigar Lake	Kanada	Cameco / Orano	underground	6,928
Husab	Namibie	Swakop Uranium	open pit	3,358
Inkai (sites 1–3)	Kazachstán	Kazatomprom / Cameco	ISL	3,201
Olympic Dam	Austrálie	BHP Billiton	underground	2,813
Karatau (Buděnskoje 2)	Kazachstán	Uranium One / Kazatomprom	ISL	2,560
Rössing	Namibie	Rio Tinto	open pit	2,255
Somair	Niger	Orano	open pit	2,020
Central Mynkuduk	Kazachstán	Uranium One / Kazatomprom	ISL	1,740
Kharasan 1	Kazachstán	Kazatomprom / Uranium One	ISL	1,650
South Inkai	Kazachstán	Uranium One / Kazatomprom	ISL	1,600
Kharasan 1	Kazakhstan	Kazatomprom / Uranium One	ISL	1,455
TOP 10 total				**28,125**

ISL = in situ leaching (more than half of uranium is extracted worldwide with this technology, in 2022 66%)

ESA average annual prices of natural uranium
(EUR/kg U) according to EU Nuclear Observatory

	2019	2020	2021	2022	2023
Long-term price	79.43	71.37	89.00	101.28	115.79
Spot price	55.61	N*	N*	137.26	149.28

** In 2021 and 2022 there were not enough trades (less than 3) to represent the average price of European trades.*
Note: ESA – Euratom Supply Agency. the European Agency for the common supply policy based on the principle of fair and equitable supplies of nuclear fuels to European users.

INDUSTRIAL MINERALS

Industrial minerals are mineral raw materials that are used in industry both treated and un-treated; non-metals or their compounds are also obtained from them. After construction and energy minerals, they repre-sent another main group of minerals in the Czech Republic. Ceramic and glass raw materials are traditionally important both in terms of geological reserves and mining. The most important are kaolins from the Pilsen and Karlovy Vary areas, but also from the areas around Kadaň and Podbořany. Furthermore, glass sands from Střeleč and the surroundings of Provodín, feldspars from Halámky, Krásno and Luženičky, clays from the Cheb Basin and Central Bohemia and bentonites from areas around Most, Kadaň and in the last 20 years also Karlovy Vary. De-posits of limestone and cement raw materials also hold considerable geological reserves, and their mining also reaches high volumes.

Kaolin, quartz sands, feldspar, clays, bentonites and limestones are also important export commodities in the minerals sector.

On the contrary, the once important era of mining of graphite, pyrite, fluorite, barite, but also some other in-dustrial minerals has probably definitely ended.

Bentonite

1. Characteristics and use

Bentonite is a soft, very fine-grained, inhomogeneous, differently coloured rock composed essentially of the clay mineral montmorillonite ($xM+(Al_{2-x}Mg_x)Si_4O_{10}(OH)_2$), which was formed mostly by subaquatic or subaerial weathering of volcanic products (especially glassy felsic ashes). Montmorillonite is a carrier of characteristic properties of bentonite – considerable sorption capacity characterised by high value of base exchange (ability to accept certain cations from solutions and release Mg from its molecule instead them, sometimes Ca and alkalis), internal swelling in contact with water (some bentonites do not swell, but they have high absorbency like bleaching clays (especially when activated), high plasticity and cohesion. Bentonite also contains other clay minerals (kaolinite, illite, beidellite), Fe compounds, quartz, feldspar, volcanic glass, etc., which are pollutants and are removed by treatment if possible.

Reserves

They are extensive worldwide.

Uses

It is versatile and depends on its mineralogical composition and technological properties. It is mostly used as a binder in foundry, in the pelletisation of iron ores (4-10 kg per a tonne of pellets), it is also used as a sorbent (decolourisation, catalysts, refining, filtration, desiccants, wastewater treatment, pesticide carriers), in drilling fluids, as fillers (paints, varnishes, pharmaceuticals, cosmetics) and suspensions (lubricating oils), in construction (sealing material), agriculture, etc. Recently, the consumption of bentonite as a sorbent of domestic animal excrements (cat litter) and as a binder in granulated feed has increased significantly.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

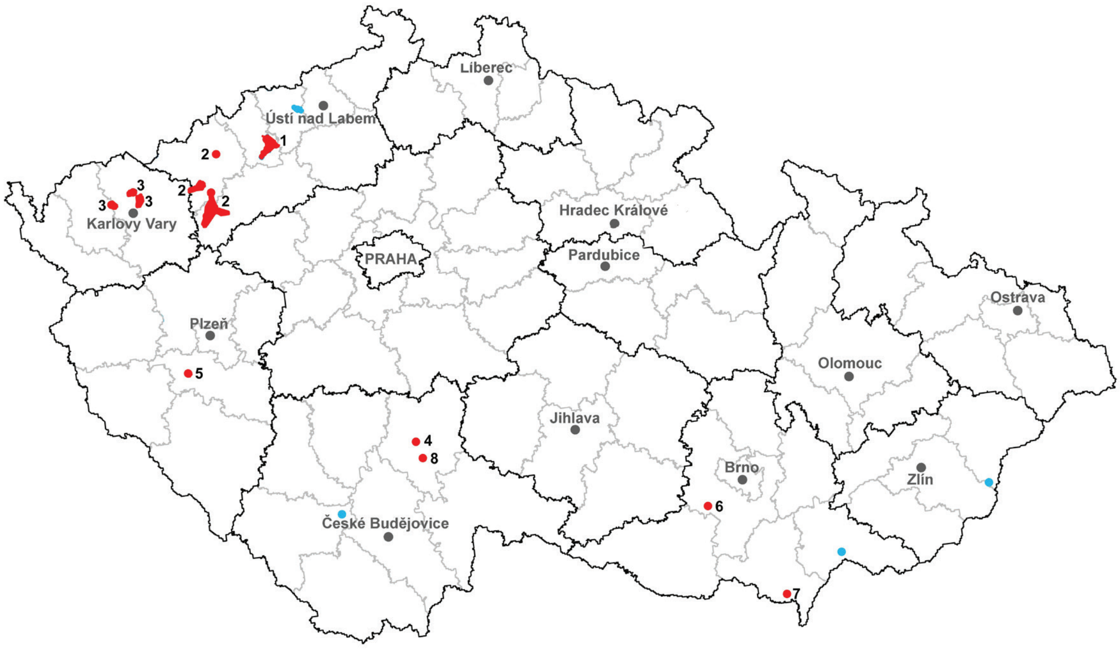
2. Mineral resources of the Czech Republic

All bentonite deposits in the Czech Republic were formed by argillization of volcanic rocks. The vast majority of bentonite deposits and reserves in the Czech Republic are concentrated in the area of the Doupov Mountains and the Central Bohemian Uplands. A significant part of the raw material from bentonite deposits in these areas consists of the highest quality raw material suitable primarily for foundry purposes (binder of foundry sands in moulding) – both activated (replacement of Ca^{2+} a Mg^{2+} ions by Na+ ions) and non-activated bentonite. The development of mining, processing and use of bentonites in the Czech Republic occurred at end of the 1950s, especially in connection with its use in foundry. Mining culminated first in the early and late 1980s (207 kt in 1987); there was a decline in mining in the first half of the 1990s in connection with the decline in demand from the foundry industry (54 kt in 1995). In 1996–2000, mining increased significantly once again, mainly due to increased demand for differently applied raw materials (litter, feed, sealing materials, etc.), then it stabilised for several years and culminated in 2007 after another increase.

- The most important deposit area is the eastern edge of the Doupov Mountains at the junction with the North Bohemian Basin. Most of the reserves and the largest bentonite deposits in the Czech Republic are concentrated in the vicinity of Kadaň and Podbořany. The most important currently mined deposit in this area is the Rokle u Kadaně. Bentonites from the Nepomyšl deposit near Podbořany are occasionally used, but still to only a small extent.
- In the area of the western edge of the Doupov Mountains, in contact with the Hroznětín Basin, bentonite deposits are concentrated mainly in the vicinity of Hroznětín. Due to economic reasons, mining and processing activities were terminated in 1993 at the Hroznětín-Velký Rybník deposit. Relatively large reserves in several deposits were verified in the late 1990s. However, most of these deposits (except for the Všeborovice deposit) have unfavourable overburden conditions, are less explored and sometimes have a worse quality composition of the raw material than deposits in the Podbořany, Kadaň and Most regions. Bentonites in the Sokolov Basin are of growing importance, where a suitable raw material (montmorillonite clay) from kaolin overburden has been processed for litter production since 2004, first mainly from the Božičany-Osmosa-jih deposit and gradually also from some other deposits in the area (Mírová, Podlesí, Ruprechtov, Otovice).
- Deposits in the Most region at the junction of the south-eastern edge of the North Bohemian Basin and the Central Bohemian Uplands were in the past the most important bentonite areas in the Czech Republic. The most important deposits in the area include Braňany-Černý vrch deposit that is currently at the end of its capacity and its northern surroundings (Braňany 1); the Stránce and Střimice deposits, for example, are already abandoned today.
- Until recently, the Tertiary basins of the Plzeň region (Dnešice) and the South Bohemian Basin (Maršov, Rybova Lhota) were of minor importance. The raw material (mostly montmorillonite clays) is usually of poorer quality and can be used mainly in agriculture or as a sealing material, but currently mainly for the production of litters – this is the case of the Maršov deposit, the production of which has increased significantly in recent years.
- In 2014, overlying suitable montmorillonite clays, mined as part of opening works at the Plesná-Velký Luh kaolin deposit in the Cheb Basin, also began to be used for the production of litters.
- Montmorillonite clays predominate in the Miocene sediments of the Carpathian Neogene in southern Moravia. With a few exceptions (Ivančice-Réna), this is a lower quality raw material, suitable primarily for agriculture or as a sealing material. Two small, now unused deposits (Ivančice-Réna, Poštorná) are evaluated here.

Since 2006, bentonite has been kept in the Register as one raw material type – foundry bentonite and its other types have been merged.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits   exhausted deposits and other resources

Principal areas of deposits and deposits outside them

*(Names of areas and the mined deposit outside are indicated in **bold type**)*

1 České středohoří Mts.

2 Doupovské hory Mts.

3 Sokolov Basin

4 Maršov u Tábora

5 Dněšice – Plzeňsko jih

6 Ivančice – Réna

7 Poštorná

8 Rybova Lhota

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	39	38	39	39	40
exploited	10	9	9	10	10
Total mineral *reserves, kt	309,801	309,599	323,772	323,604	323,185
economic explored reserves	77,571	77,369	82,614	82,446	82,250
economic prospected reserves	126,877	126,877	134,488	134,488	134,265
potentially economic reserves	105,353	105,353	106,670	106,670	106,670
exploitable (recoverable) reserves	31,994	32,182	32,182	23,369	23,369
Mine production, kt**	357	226	198	167	196

* *See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

** *Including montmorillonite clays from kaolin deposits overburden*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	kt	27,017	27,017	27,017	27,017	27,017
P_2,	kt	36,361	36,361	36,361	36,361	36,361
P_3		–	–	–	–	–

5. Foreign trade

250810 – Bentonite

		2019	2020	2021	2022	2023
Import	kt	75	62	71	54	55
Export	kt	166	170	180	183	145

250810 – Bentonite

		2019	2020	2021	2022	2023
Average import prices	CZK/t	2,453	3,007	3,125	5,077	4,626
Average export prices	CZK/t	3,251	3,530	3,501	4,529	5,360

250820 – Decolourizing earths and fuller's earth

		2019	2020	2021	2022	2023
Import	kt	0	0	0	0	0
Export	kt	0	0	0	0	0

250820 – Decolourizing earths and fuller's earth

		2019	2020	2021	2022	2023
Average import prices	CZK/t	–	–	–	–	–
Average export prices	CZK/t	–	–	–	–	–

6. Prices of domestic market

Bentonite prices are not quoted.

7. Mining companies in the Czech Republic as of December 31, 2023

KERAMOST, a.s., Most
Sedlecký kaolin a.s., Božičany

8. World production and world market prices

World mine production

	2019	2020	2021	2022	2023^{e}
World mine production (according to MCS), kt	16,300	18,200	19,000	20,400	20,000
World mine production (according to WBD), kt	21,809	18,925	18,832	18,643	N

e – preliminary values

Main producers according to MCS

2023^e		
Country	**kt**	**%**
USA	4,700	23.5
India	3,700	18.5
Turkey	2,400	12.0
China	2,100	10.5
Greece	1,400	7.0
Danmark	900	4.5
Iran	850	4.3
Czech Republic	230	1.2
Brazil	220	1.1
Spain	170	0.9
Mexico	80	0.4
Uzbekistan	50	0.3
World	**20,000**	**100.0**

e – preliminary values

Main producers according to WBD

2022		
Country	**kt**	**%**
USA	4,580	24.6
India	2,100	11.3
China	2,018	10.1
Turkey	1,341	7.2
Greece	1,106	5.9
Iran	535	2.9
Russia	316	1.7
Germany	302	1.6
Slovakia	220	1.2
Brazil	186	1.0
Czech Republic	135	0.7
World	**18,643**	**100.0**

Prices of traded commodities

Commodity/year		2019	2020	2021	2022	2023
Bentonite, U.S. market price, ex works, average (MCS)	USD/st	98	97	100	101	99
Slovakian bentonite, yearly average price of exports to the Czech Republic (CZSO)	EUR/t	49.71	53.64	66.78	119.15	107.8

Clays

1. Characteristics and use

Clays are sedimentary or residual unconsolidated rocks composed of more than 50% clay in the sense of grain size fraction (grain size below 0.002 mm) and containing as an essential component clay minerals, especially kaolinite groups, as well as hydro-micas (illite) and montmorillonite (see bentonite). According to the composition of clay minerals, clays are divided into monomineral (e.g. kaolinite, illite, etc.) and polymineral (composed of several clay minerals). The clays also contain various impurities, such as quartz, micas, carbonates, organic matter, oxides and hydroxides of Fe and others. The colours vary based on the admixtures – white, grey, yellow, brown, purple and usually green and more. Secondary, they can be consolidated – claystones, or in addition non-metamorphically recrystallized – clay shales.

In terms of deposits and technology, this category includes a wide range of rocks with a high content of clay minerals. In the world, clays often include bentonites and brick raw materials, but also kaolins. Clays occur in virtually all sedimentary formations around the world.

Reserves

They are extremely large worldwide.

Uses

They are mostly used in ceramic production, as refractory materials, fillers, sealants, in the paper industry, for oil filtration, etc.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

According to technological properties and usability, clays are divided in the Czech Republic as follows:

- Porous – raw material for ceramic production with white or light baking paint, sintering at temperatures above 1,200 °C. Kaolinite predominates among clay minerals, the contents of clastic particles are low.
- Refractory for grog – the raw material after burning out provides a material suitable as grog for the production of fireclay products. The highest possible content of Al_2O_3, the lowest possible content of Fe_2O_3, high heat resistance and the lowest possible absorbency after burning out are required for the raw material. The main clay mineral is again kaolinite (or dickite).
- Refractory others – raw material usable as a binding (plastic) component in the production of mainly refractory products. In addition to high bond strength, the lowest possible content of Fe_2O_3 and clasts is required.
- Non-refractory ceramic – a raw material with wide technological properties and uses (e.g. stoneware, tiles, additives, etc.).
- Aluminium subsoil – kaolinitic clays in the subsoil of coal seams of the Most part of the North Bohemian Basin, containing about 40% Al_2O_3, in some places 3–7% TiO_2 and mostly

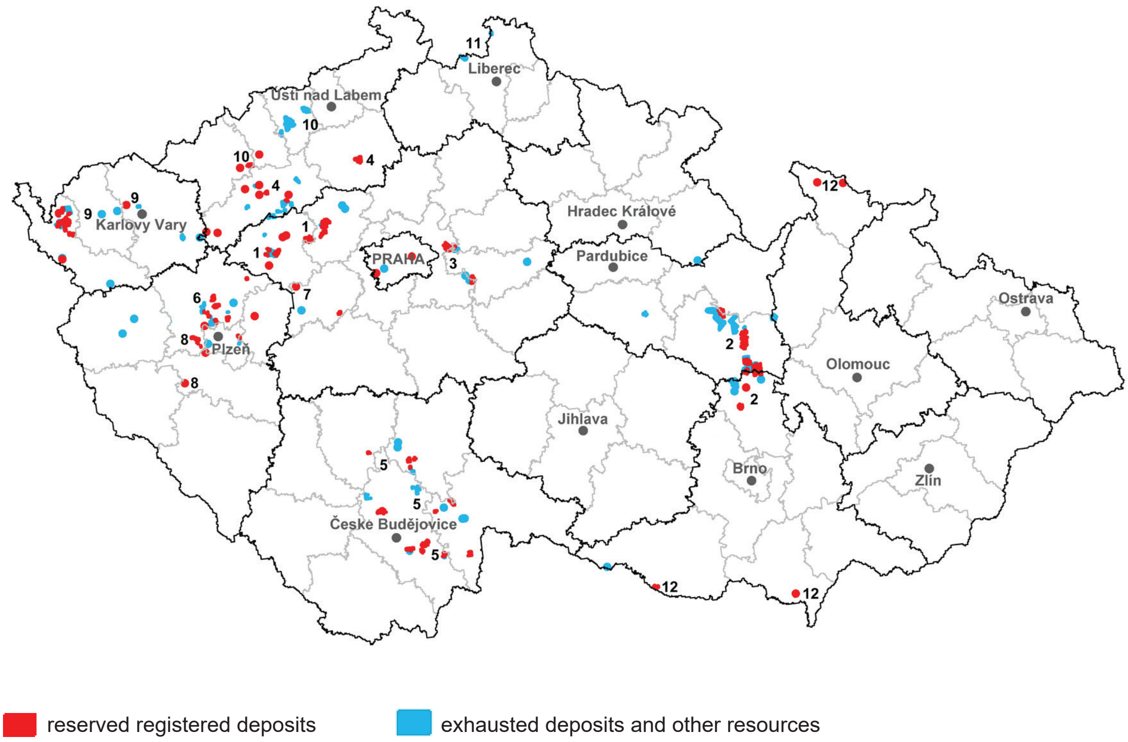
a considerable amount of siderite. In the past, they were considered as a possible source of Al. Today, they are no longer important due to the energy intensity of production and, in addition, they are mostly covered with coal mine dumps.

Deposits and clay resources in the Czech Republic are concentrated in the following main deposit areas:

- Kladno-Rakovník Permocarbon – mainly highly refractory claystones (schistous clays), which are used for the production of refractory grogs. Red-burning tile clays and grey non-refractory claystones are also less represented. The most important deposit of highly refractory claystones is the mined large deposit Rynholec-Hořkovec 2. Until recently, a smaller deposit Lubná-Marta was mined both in the depths (until 2017) and on the surface (until 2018).
- Moravian and East Bohemian Cretaceous – this is the area with the largest reserves of refractory raw material with the same use as in the previous area (with a slightly worse quality of composition). At present, only one deposit is surface mined – Březinka.
- Louny Cretaceous – clays are suitable for similar uses like the porous and refractory others, but mainly like ceramic. At present, only the medium-sized Líšťany deposit of non-refractory clays is used.
- Cretaceous around Prague – clays are suitable as highly refractory clays for grog, refractory binding and as porous. The most important are the used deposits of refractory clays for grog at Vyšehořovice and Brník.
- South Bohemian basins – clays are highly to moderately refractory, especially suitable as binding (other refractory), as well as porous and non-refractory. The main deposits of binding clays are Borovany-Ledenice (where diatomite is also mined), mining also takes place to a lesser extent at the Zahájí-Blana and Jehnědno deposits.
- Pilsen Basin and Tertiary relics of Central and Western Bohemia – moderately refractory clays predominate, which are evaluated as binding and ceramic for the production of tiles, as well as stoneware. The most important is the long-mined large deposit Kyšice-Ejpovice. Smaller mining also takes place at the Vižina deposit of binding clays.
- Cheb and Sokolov Basin – the Cheb Basin is much more important, where there are significant binding clays, porous and refractory ones, stoneware, etc. The critical mined deposit of binding clays not only in the area, but the whole Czech Republic today is Nová Ves u Křižovatky 2. Smaller mining also takes place at other deposits Vackov (binding clays) and Nová Ves and Suchá (porous and binding clays).
- North Bohemian and Zittau basins – in addition to the above-mentioned aluminium base clays, there are also overlying ceramic (stoneware) clays. At present, only the medium-sized deposit of ceramic clays Tvršice in the North Bohemian Basin is mined to a small extent.
- Tertiary and Quaternary in Moravia – there are ceramic (especially stoneware and tile) clays. Smaller mining was renewed here for a short time in 2008–2016 (Poštorná).

The most important areas today are the Cheb and South Bohemian basins, the Cretaceous in the vicinity of Prague, the Rakovník Permocarbon and less and less the Moravian and East Bohemian Cretaceous. Clays and claystones are now only surface mined in the Czech Republic.

3. Registered deposits and other resources of the Czech Republic



Major deposit areas

*(Names of areas with exploited deposits are in **bold**)*

1 **Kladno-Rakovník Carboniferous**
2 **Moravian and East Bohemian Cretaceous**
3 **Cretaceous around Prague**
4 **Louny Cretaceous**
5 **South Bohemian Basins**
6 **Plzeň Basin**
7 **Tertiary relicts of Central Bohemia**
8 **Tertiary relicts of West Bohemia**
9 **Cheb Basin and Sokolov Basin**
10 **North Bohemian Basin**
11 Zittau Basin
12 Tertiary and Quaternary in Moravia

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	108	108	108	108	108
exploited	13	13	13	13	13
Total mineral *reserves, kt	911,289	910,937	910,235	909,917	909 064
economic explored reserves	161,859	160,363	160,165	159,914	159 239
economic prospected reserves	390,864	390,826	390,616	390,616	396 594
potentially economic reserves	358,566	359,748	359,454	359,387	353 231
exploitable (recoverable) reserves	39,997	38,747	33,998	33,793	23 026
Mine production, kt	441	454	456	478	426

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	kt	331,988	331,988	331,988	331,988	331,988
P_2,	kt	38,196	38,196	38,196	38,196	38,196
P_3		–	–	–	–	–

5. Foreign trade

2508 – Other clays (not including expanded clays of heading 6806), andalusite, kyanite and sillimanite, whether or not calcined; mullite; chamotte or dinas earth

		2019	2020	2021	2022	2023
Import	t	103,748	93,676	109,227	85,575	5,057
Export	t	304,803	299,105	322,088	365,232	22,183

2508 – Other clays (not including expanded clays of heading 6806), andalusite, kyanite and sillimanite, whether or not calcined; mullite; chamotte or dinas earth

		2019	2020	2021	2022	2023
Average import prices	CZK/t	3,389	4,382	4,533	6,156	8,650
Average export prices	CZK/t	2,883	3,153	3,047	3,631	4,287

250830 – Refractory (fire) clay

		2019	2020	2021	2022	2023
Import	t	8,111	7,439	8,901	7,832	191
Export	t	18,243	6,173	7,464	12,836	778

250830 – Refractory (fire) clay

		2019	2020	2021	2022	2023
Average import prices	CZK/t	3,139	3,168	3,002	3,790	10,812
Average export prices	CZK/t	1,714	3,555	3,335	4,654	4,148

250840 – Other clays

		2019	2020	2021	2022	2023
Import	t	11,590	7,439	9,286	9,216	5,332
Export	t	61,052	64,147	76,621	112,481	6,929

250840 – Other clays

		2019	2020	2021	2022	2023
Average import prices	CZK/t	3,476	3,168	4,519	5,755	6,318
Average export prices	CZK/t	905	932	945	1,122	1,358

250870 – Chamotte or dinas earth

		2019	2020	2021	2022	2023
Import	t	2,138	8,046	9,075	6,541	334
Export	t	59,555	58,600	58,239	56,644	4,251

250870 – Chamotte or dinas earth

		2019	2020	2021	2022	2023
Average import prices	CZK/t	7,148	7,527	7,161	8,636	6,485
Average export prices	CZK/t	4, 236	4,443	4,359	5,463	6,211

6. Prices of domestic market

Various qualities of clay have different market prices. Prices are made public in the limited extent only (some producers do not publish them at all). In 2023 they fluctuated generally between CZK 400 – 8,000 per tonne.

7. Mining companies in the Czech Republic as of December 31, 2023

Whiteware clays
KERACLAY, a.s., Brník

Refractory clays for grog
KERACLAY, a.s., Brník
České lupkové závody, a.s., Nové Strašecí
P-D Refractories CZ a.s, Velké Opatovice

Other refractory clays (ball clays)
LB MINERALS, s.r.o., Horní Bříza

Non-refractory ceramic clays
LB MINERALS, s.r.o., Horní Bříza
Sedlecký kaolin a.s.

8. World production and world market prices

World mine production

There are no recognised figures of world production and world trade with clays (referred to as other refractory clays in our terminology) because of difficulties in classifying these clays on a uniform basis and the questionability of their direct comparability based on quality and use.

World fuller's earth production (MCS)

MCS statistics contains worldwide values of fuller‘s earth production:

	2019	2020	2021	2022	2023^e
World production, kt	3,180	3,930	4,040	4,000	4,300

e – preliminary values

World production of fuller's earth (MCS)

2022^e		
Country	**kt**	**%**
USA	2,300	53.5
India	730	17.0
Spain	570	13.3
Senegal	120	2.8
Mexico	120	2.8
Turkey	60	1.4
Greece	30	0.7
World	**4,300**	**100.0**

e – preliminary values

In statistics, the group of clays also includes raw materials consisting of minerals and rocks serving for non-clay refractory material production: kyanite, sillimanite, shales, siliceous sandstone (quartzite) – dinas.

World clay resources are extremely extensive.

World market prices

Clay prices are generally not provided. In the reporting period of 2018–2022, Industrial Minerals quoted indicative prices of minerals belonging to the sillimanite group, until 2018 in a wider range:

Commodity/year	2019	2020	2021	2022	2023
Ball clay, USA market (MCS), USD/t	55	46	46	47	47
Common clay, USA market (MCS), USD/t	18	17	17	18	17
Fire clay, USA market (MCS), USD/t	14	12	12	12	12
Fuller's earth, USA market (MCS), USD/t	88	89	88	97	95
Fire clay, chamotte, Polish, average import price into the Czech Republic (CZSO), EUR/t	50	40	38	35	51

Diatomite

1. Characteristics and use

Diatomite is a sedimentary rock composed mainly of microscopic shells of freshwater or marine diatoms. This rock appears in varying degrees of consolidation – it is either loose (diatomaceous earth, infusorial earth) or consolidated (diatomaceous schist, or even hornstone). The loose rock has the form of a very fine-grained sediment. During diagenesis, the shells are partially dissolved and the sediment is impregnated with loose opal, solidified and it undergoes a schist-forming process. According to the degree of porosity, polishing and absorbent schists are distinguished, sometimes even opal hornstone. The chemical composition is completely dominated by SiO_2, the content of which should be as high as possible. From the technological point of view, the porosity, resistance to acids and temperatures, thermal and electrical conductivity, bulk density of the raw material, humidity, chemical composition, etc. are monitored. Pollutant appear in the form of an admixture of clasts, clayey and organic parts (sponges) and increased contents of Al_2O_3, Fe_2O_3 and CaO. Deposits are formed in water basins with a low $CaCO_3$ content with suspended aluminosilicate substances. The most favourable conditions are in cold waters near volcanic areas.

Reserves

They are extensive worldwide.

Uses

The raw material is used for filtration purposes (purest types), for the production of fillers (rubber, paper, cosmetics), for abrasive purposes, in the production of catalyst carriers and in the construction industry for the production of thermal and sound insulation materials.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

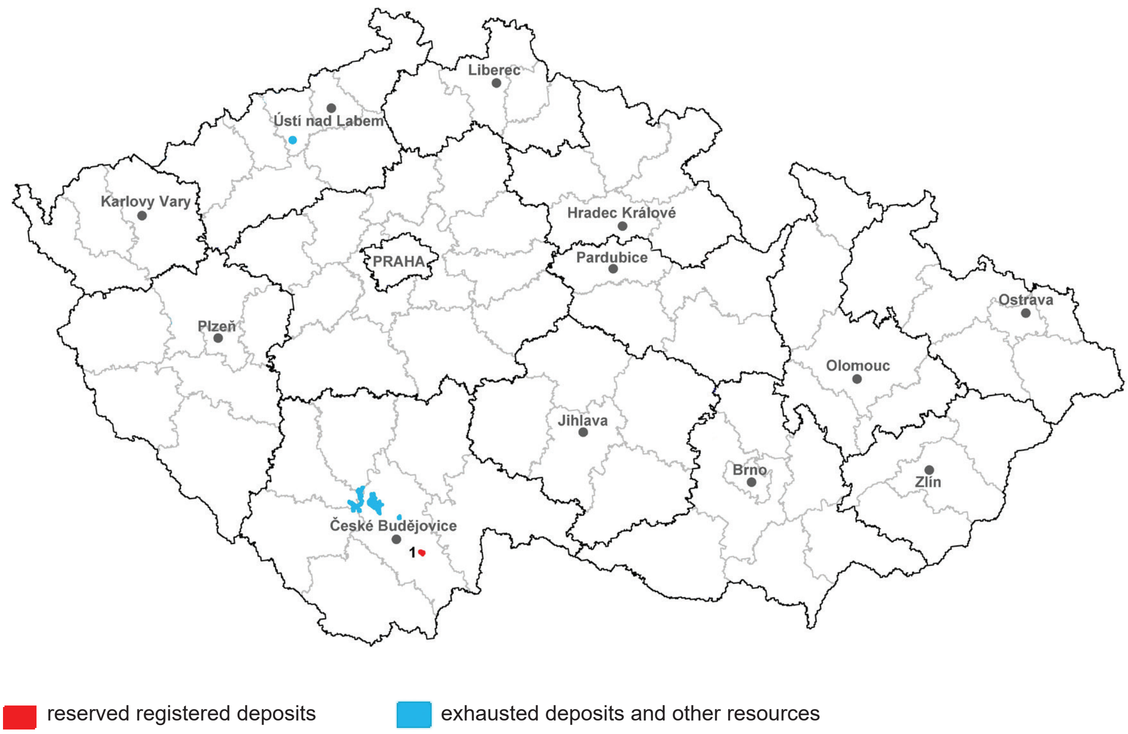
2. Mineral resources of the Czech Republic

Accumulations of diatomite (diatomaceous earth) in the Czech Republic are related to the areas of occurrence of Tertiary and Quaternary lake sediments, especially to Tertiary sediments of the South Bohemian basins, where our only diatomite deposit is located today. Other occurrences are related to occurrence of volcanites in the České středohoří Mts. and there are also smaller occurrences in other places of the Bohemian Massif and in the Neogene of the Carpathian foredeep and flysch.

- The largest accumulations of diatomite in Bohemia are found in the South Bohemian basins. Spongodiatomites and diatomite clays (low-quality building diatomites) occur together with lignites in the Budějovice Basin. The Borovany-Ledenice deposit, located in the Třeboň Basin, is the only registered and at the same time used deposit in the Czech Republic. Tertiary sediments were deposited in a tectonic confined space on the Moldanubian bedrock. The deposit position of diatomites, diatomaceous clays and spongodiatomites is classified as the upper part of the Mydlovary Formation. The diatomites are whitish grey to ochre, unconsolidated and are positioned almost horizontally. The average thickness of the raw material is about 8.5 metres (maximum 15 m). In addition to diatomites, overlying stiffs are also mined at the deposit. Especially pure diatomites are used after treatment for filtration purposes or as fillers in the food, chemical, pharmaceutical and other industries. Diatomites of the highest quality are used in the filtration of wines, liqueurs, beer, edible oils or fats. The others are mostly suitable only for the production of building and insulating materials, or a litter for pets. Other sources and occurrences (e.g. Malovice, Dobřejovice, Zliv, Záboří) in the Budějovice Basin contain diatomite of lower quality with transitions to clays.

- Many outcrops of diatomite are known in the České středohoří Mts., which were occasionally mined in the first half of the 19th century as a raw material for the production of abrasives and polishing materials. The most important former Kučlín deposit was exhausted in 1966. At present, they are no longer important in terms of deposits.
- Lenticular occurrences of diatomites were examined in the Carpathian flysch south of Brno (Pouzdřany), but they were negative in terms of deposits.
- Quaternary diatomites are known from the vicinity of Most (together with organogenic lake mud) and Františkovy Lázně (former Hájek deposit – formerly mined together with peat, now it is the Soos nature reserve), today they are no longer significant as deposits.

3. Registered deposits and other resources of the Czech Republic



Exploited deposit:

1 **Borovany-Ledenice**

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	1	1	1	1	1
exploited	1	1	1	1	1
Total mineral *reserves, kt	2,316	2,266	2,246	2,197	2,156
economic explored reserves	1,616	1,568	1,550	1,503	1,462
economic prospected reserves	0	0	0	0	0
potentially economic reserves	700	698	696	694	694
exploitable (recoverable) reserves	1,441	1,395	1,377	1,333	1,296
Mine production, kt	43	46	18	44	38

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

5. Foreign trade

2512 – Siliceous fossil meal*, siliceous earth

		2019	2020	2021	2022	2023
Import	t	14,148	12,711	9,700	9,672	10,809
Export	t	9,403	4,847	3,941	3,889	7,750

2512 – Siliceous fossil meal*, siliceous earth

		2019	2020	2021	2022	2023
Average import prices	CZK/t	5,371	5,605	7,014	8,483	7,842
Average export prices	CZK/t	4,681	6,930	7,644	8,940	13,406

*Note: * diatomite*

6901 – Bricks, blocks, tiles and other ceramic goods of siliceous fossil meals

		2019	2020	2021	2022	2023
Import	t	29,534	43,053	56,958	71, 219	49,027
Export	t	589	742	856	11	14

6901 – Bricks, blocks, tiles and other ceramic goods of siliceous fossil meals

		2019	2020	2021	2022	2023
Average import prices	CZK/t	1,406	1,279	1,405	1,597	2,174
Average export prices	CZK/t	2,415	2,357	2,274	69,352	31,972

6. Prices of domestic market

Diatomite was sold domestically in 2022 for CZK 18,000 – 30,000 per tonne.

7. Mining companies in the Czech Republic as of December 31, 2023

LB MINERALS, s.r.o., Horní Bříza

8. World production and world market prices

World mine production

World production of diatomite in the past five years was as follows:

	2019	2020	2021	2022	2023^{e}
World mine production (according to MCS), kt	2,190	2,320	2,450	2,600	2,600
World mine production (according to WBD), kt	2,299	2,199	2,496	2,496	N
World mine production (according to World Mineral Statistics), kt	2,100	2,200	2,500	2,600	N

e – preliminary values

Main producers according to MCS

2023^e		
Country	**kt**	**%**
USA	830	31.9
Denmark (processed)	440	16.9
China	270	10.4
Turkey	210	8.1
Argentina	100	3.8
Mexico	100	3.8
Peru	100	3.8
France	80	3.1
South Korea	65	2.5
Spain	55	2.1
Czech Republic	50	1.9
South Korea	50	1.9
Germany	50	1.9
Russia	50	1.9
World	**2,600**	**100.0**

e – preliminary values

Prices of traded commodities (USD/t)

Commodity/year	2019	2020	2021	2022	2023
US diatomite, prices average, FOB works, according to MCS	338	326	410	416	410
Czech diatomite, average export price to Austria, EUR/t, CSO	104	127	132	154	231

Dolomite

1. Characteristics and use

Carbonate rocks with $MgCO_3$ contents above 27.5% and $MgCO_3$ + $CaCO_3$ above 80% are classified as dolomites in the Czech Republic.

Dolomites can be formed directly by precipitation from seawater, but more often they are the result of alteration of limestones by Mg – metasomatosis (dolomitisation) during their diagenesis or by Mg-brines after it. The transformation is often incomplete and subsequent recalcification also occurs, so that sufficiently Mg-rich and homogeneous large bodies of dolomite occur less often compared to Mg-limestone.

Reserves

They are extensive worldwide.

Uses

Pure dolomite is an important raw material for the glass, ceramic and chemical industries. Dolomite rocks are also used for the production of dolomitic limes and hydrates, magnesium cements, refractories in metallurgy, for the desulphurisation of thermal power plant flue gases, for decorative purposes, for the production of fertilizers and fillers, as correctives for acid soils and as industrial fillers. They are also often used for the production of crushed aggregates and for other construction purposes.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Raw material resources of the Czech Republic

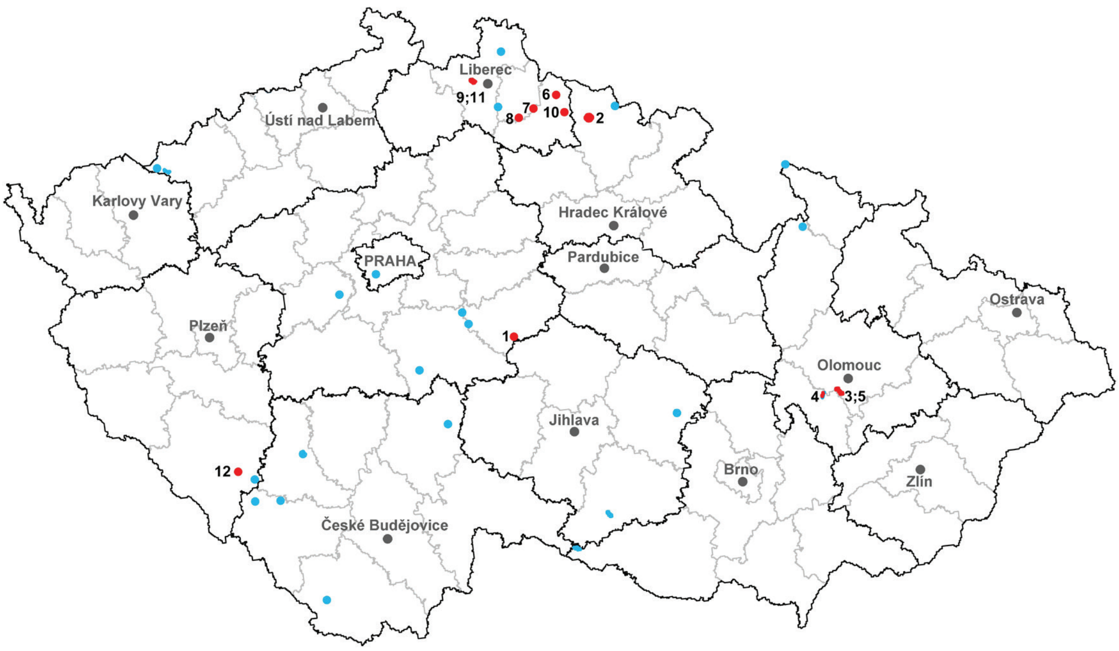
Deposits, resources and occurrences of dolomites and calcareous dolomites in the Czech Republic are concentrated in the following main areas:

- Krkonoše-Jizera crystalline complex with deposits of crystalline calcareous dolomites to dolomites, forming lenses in the surrounding rocks. This area is the most important in the Czech Republic in terms of the number of deposits and the volume of reserves. In Lánov, the largest and most important deposit of dolomites in the Czech Republic, raw material is mined with average contents of MgO almost 19% and CaO around 32%.
- Šumava Mts. and Bohemian Moldanubian with several smaller deposits of pure dolomites (mined Bohdaneč deposit, abandoned Jaroškov deposit) and calcareous dolomites (e.g. Podmokly, Krty).
- The Ore Mountains crystalline complex with several small deposits in the vicinity of Kovářská and Přísečnice (e.g. the exhausted deposit of pure dolomite Vykmanov).
- The Moravian branch of the Moldanubicum with small occurrences of often high-quality dolomite (the exhausted Dolní Rožínka deposit) and little-explored projected reserves (Lukov u Moravských Budějovic, Číchov, etc.).
- Devonian of Barrandien, with the already exhausted classical deposit of pure dolomites Velká Chuchle.

- Orlicko-Kladsko crystalline complex and the Silesian Block (Velké Vrbno dome) with several smaller deposits of dolomites (Bílá Voda).
- Moravian (Čelechovice-Přerov) Devonian SW from Olomouc with two larger deposits (Hněvotín, Bystročice) of Lažánek limestone dolomites, which appear here together with Vilémovice limestones. The average Mg contents in both deposits are around 17%. Further SW there is a medium-sized deposit of Lažánek limestone dolomites Čelechovice of similar composition (reserves bound by the protective zone of the spa).

The most important are the areas of the Krkonoše-Jizera crystalline complex and the Moravian Devonian, where dolomites (Lánov, Hněvotín) partially occur in some deposits, but they are mostly calcareous dolomites. The Šumava Moldanubian deposits are mostly smaller or are formed by low-purity calcareous dolomites. In other areas, dolomites form only smaller lenses and are often insufficiently explored (especially in western Moravia).

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits   exhausted deposits and other resources

Principal areas of deposits presence

*(Names of exploited deposits are in **bold type**)*

1 **Bohdaneč**	5 Hněvotín	9 Kryštofovo Údolí
2 **Lánov**	6 Horní Rokytnice	10 Křížlice
3 Bystročice	7 Jesenný-Skalka	11 Machnín-Karlov pod Ještědem
4 Čelechovice na Hané	8 Koberovy	12 Podmokly

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	12	12	11	11	11
exploited	2	2	1	1	1
Total mineral *reserves, kt	524,142	522,028	522,635	521,206	520,862
economic explored reserves	82,643	80,529	80,136	79,707	79,363
economic prospected reserves	337,297	337,297	337,297	337,297	337,297
potentially economic reserves	104,202	104,202	104,202	104,202	104,202
exploitable (recoverable) reserves	9,526	7,526	7,132	6,703	6,659
Mine production, kt	453	398	393	429	344

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	kt	23 946	23 946	23 946	23 946	23 946
P_2		–	–	–	–	–
P_3		–	–	–	–	–

5. Foreign trade

2518 – Dolomite calcined, roughly trimmed or cut; agglomerated

		2019	2020	2021	2022	2023
Import	t	443,075	485,996	476,715	434,566	295,782
Export	t	58	73	105	64	90

2518 – Dolomite calcined, roughly trimmed or cut; agglomerated

		2019	2020	2021	2022	2023
Average import prices	CZK/t	227	235	233	278	324
Average export prices	CZK/t	5,472	9,651	6,352	7,875	7,756

6. Prices of domestic market

Average domestic prices of traded commodities

Product specification	2019	2020	2021	2022	2023
Dolomite aggregates, CZK/t	318–376	325–387	320–430	350–480	380–520
Ground calcitic dolomite, bulk, CZK/t	770–830	780–850	840	1,170–1,250	1,230–1,320
Ground calcitic dolomite, bagged, CZK/t	1,900–2,060	1,950–2,100	2,200	2,875–3,150	2,920–3,300

7. Mining companies in the Czech Republic as of December 31, 2023

Krkonošské vápenky Kunčice, a.s.

8. World production and world market prices

World mine production

World dolomite production is not listed in the statistics. Even though dolomite is considered to be a main potential source of magnesium in the lithosphere, it is currently not used for the production of magnesium. Otherwise, calcined dolomite with a minimum magnesium content of 8% is suitable for this purpose.

World dolomite prices are not included in international overviews.

Feldspar

1. Characteristics and use

Feldspar raw materials are rocks whose characteristic component is one of the minerals from the feldspar group or a mixture thereof in such a form, quantity and quality that it can be extracted industrially. Feldspars are a group of monoclinic (orthoclase $KAlSi_3O_8$, sanidine) and triclinic (microcline KAlSi3O8 and plagioclase) potassium and sodium-calcium aluminosilicates. Together with quartz, they are the most widespread rock-forming minerals, which together make up 60% of the earth's crust. Potassium (K) feldspars are of industrial importance – orthoclase, microcline and acidic (with a predominance of Na over Ca) members of the plagioclase family (albite $NaAlSi_3O_8$, oligoclase, andesine). Alkaline (with a predominance of Ca over Na) members of the plagioclase series (labradorite, bytownite, anorthite $CaAl_2Si_2O_8$) are of marginal importance. Vein rocks (pegmatites, aplites), igneous rocks (leucocratic granitoids) and sediments (feldspar sands and gravels) are mainly used as feldspar raw materials, as well as residues of incompletely kaolinised rocks and metamorphites. The main pollutants are a high proportion of iron in the feldspar lattice (untreatable) and impurities (treatable).

Reserves

2023		
Country	**kt**	**% svět****
China	730,000	N
Turkey	720,000	N
India	320,000	N
South Korea	180,000	N
Brazil	150,000	N
Iran	95,000	N
Czech Republic*	54,000	N
Thailand	45,000	N
World	N	N

Source: MCS 2023
** Bilance zásob k 1. 1. 2024 (national Register of Reserves as of 1. 1. 2024, rounded)*
*** Total world reserves are large but not quantified*

2023			
Country	**mill. t**	**% svět**	**% EU**
EU	154,000	5.40	100.0
Czech Republic*	54,000	1.90	56.5
Romania	22,000	0.80	14.3
Slovakia	22,000	0.80	14.3
Spain	17,000	0.60	11.0
Poland	5,000	0.20	3.2
Italy	1,000	0.04	0.6

Source: European Minerals Yearbook – version 2022
** Bilance zásob k 1.1.2023 (national Register of Reserves as of 1.1.2024)*

Uses

Due to their low melting point, feldspars are used as a flux in ceramic mixtures, glass stem, glazes, enamels and in recent years also as casting powders in metallurgy. Almost 90% of feldspars are consumed by the glass and ceramic industries. A small amount is also used as a filler, especially in paints and plastics. Feldspar substitutes are also used in glassmaking. In addition to feldspar raw materials, rocks that have an alkali content bound to another mineral (mostly nepheline $Na_3K(Al_4Si_4O_{16}$ – anhydrous sodium-potassium aluminosilicate) are used as their substitutes. In the world, nepheline syenites are mainly used, and to a lesser extent also nepheline phonolites.

Classification as critical raw materials for the European Union
2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023– yes

2. Mineral resources of the Czech Republic

In the Czech Republic, deposits of feldspar raw materials are connected to primary sources, consisting mainly of leucocratic granitoids and pegmatite bodies. Secondary sources are represented by feldspar gravels and sands.

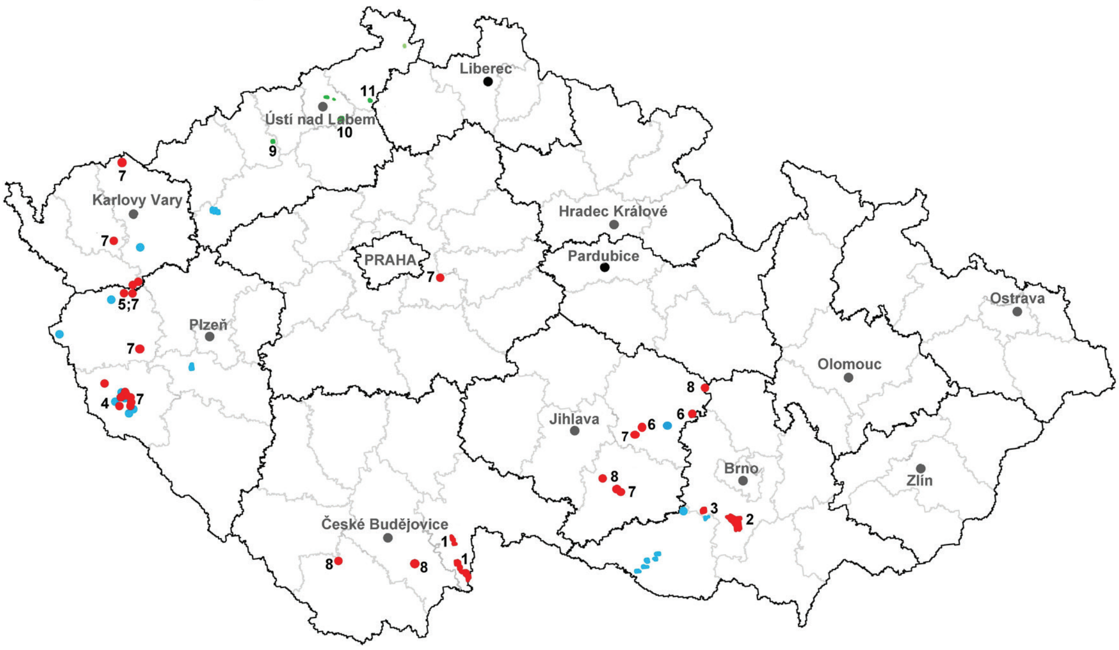
- An important source of feldspar raw materials are currently the deposits of fluvial Quaternary feldspar placers, which make up 36% of geological reserves. They were formed by the deposition of desintegrated granite rocks with mostly high content of porphyric phenocrysts, mostly potassium feldspars. The following two areas are the most important:
  1. the upper course of the Lužnice River with deposits Halámky, Krabonoš, Tušť, Dvory nad Lužnicí, Majdalena, among which the mined deposit Halámky is decisive, the remaining deposits are not mined. The Halámky deposit mined from water is one of the most important sources of quality feldspars in the Czech Republic and the most important representative of the secondary type of deposits – feldspar gravel sands. A large part of the reserves of these deposits is linked to conflicts of interest with nature protection, especially with the Třeboňsko Protected Landscape Area. The Lužnice gravel sands account for less than 19% of the total geological reserves of feldspar raw materials.
  2. the area south of Brno with deposits of the Jihlava River – the Syrovice-Ivaň terrace with deposits Bratčice, Žabčice-Smolín, Hrušovany, Ledce, etc. has a slightly worse feldspar quality – higher Fe contents. However, the vast majority of the local raw material is currently used only as construction gravel, only a part has been deposited in dumpings since 2000 for later use as feldspar raw material. Similar deposits of feldspar accumulations of the Jihlava River are in the vicinity of Ivančice southwest of Brno. Together, they make up about 17% of the geological reserves of feldspar raw materials.

The raw material of fluvial deposits are feldspar gravels with a predominance of potassium feldspars over plagioclase, suitable for the production of utility porcelain, medical ceramics, glass, etc. and, to a limited extent, for the production of glazes.

- The importance of fine to medium-grained leucocratic granitoids (granites and granite aplites, quartz diorites) is constantly growing, currently accounting for almost 50% of all domestic geological reserves of feldspar raw materials. Due to the dimensions of the granitoid bodies, the deposits are often medium to larger in size and the raw material is usually of relatively high quality. They are developed, for example, in the Krušné hory pluton in western Bohemia, where the most important and largest domestic deposit Krásno is quarried (albitic aplitic granite), the Mračnice massif (Mračnice: quartz diorite-trondhjemite), the Třebíč massif (Velké Meziříčí-Lavičky: aplitic granite, Mikulovice and Výčapy: tourmaline granite). They were also explored in other massifs, such as Brno (Moravský Krumlov), Dyje (Přímětice), Chvaletice, Blanice, Babylon, Kladruby (Benešovice), partial massifs of the Central Bohemian pluton, etc. The raw material consists mostly of sodium-potassium feldspars and is used in the production of sanitary ceramics, stained glass, porcelain, grinding wheels, etc.

- Coarse-grained to porphyric leucocratic granitoids could represent a significant source of feldspar raw material in the future, currently accounting for about 6.5% of total reserves. Deposits and sources form relatively large bodies, but often with a lower quality of raw material (increased Fe contents). They are known in the massifs of Říčany (Štíhlice), Čistec-Jesenice, Bor, Krkonoše-Jizera pluton (Liberec granite), Lestkov (Hanov), etc. The raw material consists mostly of sodium-potassium feldspars and to reduce the Fe content it is usually necessary to treat it with high-intensity magnetic separation.
- In the past, the pegmatite deposits known from several areas were the only source of raw material used mainly for ceramics. The deposits are mostly smaller, which is caused by the limited range of pegmatite bodies and they account for only 8% of the total reserves. The most important is the Poběžovice-Domažlice area with the mined Luženičky deposit and other, currently unmined deposits and resources (e.g. Meclov, Mutěnín, Ohnišťovice, Otov, Bozdíš) with pegmatites of medium to worse quality with an admixture of dark minerals, which have a balanced ratio of sodium and potassium. feldspars. However, there are also deposits of quality sodium and sodium-calcium feldspars for glazes and clear glass (Ždánov). In other areas, potassium feldspars predominate in pegmatites. In the Teplá region in western Bohemia, there are relatively abundant occurrences of relatively high-quality feldspars with low contents of pollutants (Beroun, Křepkovice, Zhořec). Recently, the relatively little explored area of Písek is perhaps promising. Some smaller occurrences and deposits are known from the vicinity of Humpolec, Tábor, Rozvadov (Česká Ves), from western Moravia (Smrček), etc. Due to the irregularity of the deposit bodies, small and largely extracted reserves, but also conflicts of interest, feldspars from pegmatites are no longer a very promising source. A large part of the highest quality raw material of pegmatite deposits (mainly in the Poběžovice-Domažlice and Písek areas) is considerably depleted by mining, especially in the more easily accessible subsurface areas. This also applies to the area of the Bory granulite massif with a small Bory-Olší deposit, following the classic exhausted Dolní Bory deposit.
- Recently, deposits of feldspar raw materials forming lenses in metamorphic rocks have been newly investigated. The orthoclasite to microclinite deposit Markvartice near Třebíč is situated in the western branch of the variegated group of the Moravian Moldanubicum. The Malá Tresná albitite deposit lies on the NW edge of the Svratka dome of the Moravicum at the junction of the micaschist zone and the Olešnice group. The Chvalšina deposit of anorthosite to gabbro is deposited in the amphibolites of the Český Krumlov variegated group of the Šumava Moldanubicum.
- Another potentially promising source of feldspar raw material may be the kaolinised feldspar rocks with undecomposed or imperfectly decomposed feldspars. These are mainly arkoses in the Plzeň and Podbořany areas, gneisses and granitoids in the Znojmo area (see the chapter Kaolin – feldspar kaolin).
- Tertiary volcanics – nepheline phonolites – of the České středohoří Mts. are used as feldspar substitutes in the Czech Republic (Želenice deposit). Due to the high contents of colouring oxides, they can be used in the glass and ceramic industry only as a flux for coloured materials. The high alkali content (10–10.5% Na_2O and 3.5–5% K_2O) makes it possible to reduce melting temperatures and shorten the burning time.

3. Registered deposits and other resources of the Czech Republic



- reserved registered deposits
- exhausted deposits and other resources
- feldspar mineral substitutes (reserved registered exploited deposit and and other resources)

The main deposit areas of feldspar raw material

*(Names of exploited deposits are in **bold type**)*

1 **Sediments of the Lužnice River region**

2 **Sediments of the Jihlava River (the Syrovice-Ivaň Terrace)**

3 Sediments of the Jihlava River (the Ivančice region)

4 **Pegmatites (the Poběžovice-Domažlice region)**

5 Pegmatites (the Teplá region)

6 Pegmatites (the western Moravia region)

7 **Granitoids**

8 Others

Feldspar mineral substitutes (nepheline phonolites):

9 **Železnice**

10 Tašov-Rovný

11 Valkeřice-Zaječí vrch

4. Basic statistical data of the Czech Republic as of December 31

Feldspar
Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	41	42	42	42	42
exploited	10	10	10	9	9
Total mineral *reserves, kt	101,487	102,853	102,324	101,802	113,794
economic explored reserves	29,742	29,334	28,846	28,369	30,702
economic prospected reserves	55,889	57,663	57,622	57,577	62,069
potentially economic reserves	15,856	15,856	15,856	15,856	21,023
exploitable (recoverable) reserves	22,126	21,599	29,709	29,288	25,419
Mine production, kt	460	419	504	493	352

* *See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	kt	48,530	48,530	48,530	48,530	48,530
P_2		–	–	–	–	–
P_3		–	–	–	–	–

Number of deposits; reserves; mine production
Feldspar substitutes (nepheline phonolites)

Year	2019	2020	2021	2022	2023
Deposits – total number	3	3	3	3	3
exploited	1	1	1	1	1
Total mineral *reserves, kt	199,709	199,709	199,107	199,635	199,612
economic explored reserves	0	0	0	0	0
economic prospected reserves	199,709	199,680	199,656	199,635	199,612
potentially economic reserves	0	0	0	0	0
exploitable (recoverable) reserves	24,140	24,111	24,086	24,065	24,042
Mine production, kt	33	29	24	21	23

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1		–	–	–	–	–
P_2,	kt	30 ,300	30,300	30,300	30,300	30,300
P_3		–	–	–	–	–

5. Foreign trade

252910 – Feldspar

		2019	2020	2021	2022	2023
Import	t	7,225	5,607	6,634	4,325	3,487
Export	t	271,561	224,780	244,689	257,161	179,817

252910 – Feldspar

		2019	2020	2021	2022	2023
Average import prices	CZK/t	3,632	3,619	3,354	3,754	5,301
Average export prices	CZK/t	834	859	894	1,066	1,096

252930 – Leucite, nepheline and nepheline syenite

		2019	2020	2021	2022	2023
Import	t	4,524	4,207	4,552	4,150	2,648
Export	t	482	543	759	244	441

252930 – Leucite, nepheline and nepheline syenite

		2019	2020	2021	2022	2023
Average import prices	CZK/t	6,488	6,680	6,562	7,561	8,750
Average export prices	CZK/t	10,866	11,071	10,345	12,092	13,351

6. Prices of domestic market

Feldspars were sold domestically for CZK 2,300–7,500 per tonne in 2023 depending on their chemism and usage.

7. Mining companies in the Czech Republic as of December 31, 2023

Feldspar
KMK GRANIT, a.s., Krásno
LB MINERALS, s.r.o., Horní Bříza
Družstvo DRUMAPO, Němčičky
Moravia Tech, a.s., Brno

Feldspar substitutes
KERAMOST, a.s., Most

8. World production and world market prices

World mine production

The data on world feldspar production and on the production of countries from various sources differ considerably. Estimates of Chinese feldspar production differ the most. The lowest total data are given in the Mineral Commodity Summary (MCS), which, for example, does not mention Germany at all among the world's leading feldspar producers. MCS provides data for feldspar and nepheline syenite. Higher global mining is reported by the yearbook World Mineral Production (WMP), published by the British Geological Survey. Probably the most accurate figures are given in the Austrian yearbook Welt Bergbau Daten (WBD).

Year	2019	2020	2021	2022	2023^e
World mine production of feldspar (according to MCS), kt	23,000	24,400	27,600	26,600	27,000
World mine production of feldspar (according to WBD), kt	31,001	29,786	36,029	39,520	N
World mine production of feldspar (according to WMP), kt	30,400	30,200	34,800	347,300	N

e – preliminary values

Main producers according to MCS

2023^e		
Country	**kt**	**%**
Turkey	6,200	23.0
India	5,000	18.5
China	2,500	9.3
Italy	2,200	8.1
Iran	2,000	7.4
Thailand	1,300	4.8
South Korea	900	3.3
Spain	800	3.0
Brazil	760	2.8
USA	590	2.2
Saudi Arabia	550	2.0
Mexico	460	1.7
Czech Republic	450	1.7
Pakistan	400	1.5
World	**27,000**	**100.0**

e – preliminary values

Prices of traded commodities (according to IM)

Commodity/year		2019	2020	2021	2022	2023
Feldspar, marketable production, US market, average price, according to MCS	USD/t	107	108	110	104	102
Nepheline syenite, average US import price, according to MCS	USD/t	156	163	164	183	200
Feldspar for the ceramic and glass industry, average export price from the Czech Republic to Poland (CZSO)	EUR/t	38.24	27.99	26.77	36.62	45,5

Gemstones

1. Characteristics and use

Gemstones (gems) are natural materials that are suitable for use in jewellery. They can be minerals, rocks, natural glass and organic materials (e.g. pearls, amber, jet (a compact black variety of brown coal used to make (mourning) jewellery) or ivory). Their main properties are beauty (mainly interesting colour, type of cutting, etc.), durability (hardness, toughness) and rarity. Gems used to be sorted by hardness (diamond, corundum, chrysoberyl, beryl, spinel, topaz…), because the hardness of 7 or more is ideal for use in jewellery. Today, a mineralogical system is used according to its chemical composition – the most important gems are elements (diamond), oxides (corundum, spinel, chrysoberyl, quartz, etc.) and silicates (beryl, tourmaline, topaz, etc.). In terms of origin and geological environment, gems are found in volcanites (diamond, corundum, olivine, amethyst in geodes), pegmatites (beryl, tourmaline, topaz, chrysoberyl, rose quartz), hydrothermal veins (emerald, quartz), metamorphites (corundum, spinel, emerald) and sediments (almost all the listed ones after erosion of the original parent rocks).

Gemstones are a raw material that is completely different from the others listed in this yearbook. This is due to the extreme range of their price depending on the quality. The old division into precious and semi-precious stones is also no longer used in modern literature, because, for example, high-quality amethyst can be more expensive than low-quality ruby or emerald. Rather, the division into gemstones (used cut in jewellery) and decorative stones (e.g. agate, malachite, etc., usually used only polished). Waste after gem processing can in some cases (mainly garnets and corundum) be used as an abrasive.

Technically, it is necessary to divide the stones in the jewellery into the following four categories:

1. natural stones, completely untreated
2. natural stones modified by men (e.g. high-temperature firing, radioactive irradiation, filling of cracks with a foreign substance, artificial colouring and many others are used)
3. synthetic stones (same properties as natural stones)
4. imitations (e.g. glass, different properties than natural stones)

The problem is that only an experienced expert with very good instrumentation can correctly identify a gemstone and place it in these categories, and new treatment procedures appear every year. The differences in price are huge.

There are treatments that significantly improve the appearance of the stone, and which logically must have a lower price than the same natural stones. Synthetic cut diamonds are also common on the market today (so far mainly coloured, colourless are much harder to produce) and their share will increase rapidly in the future. It is necessary to emphasise that these are stones that may seem very similar to a layman.

Reserves

There are not listed.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

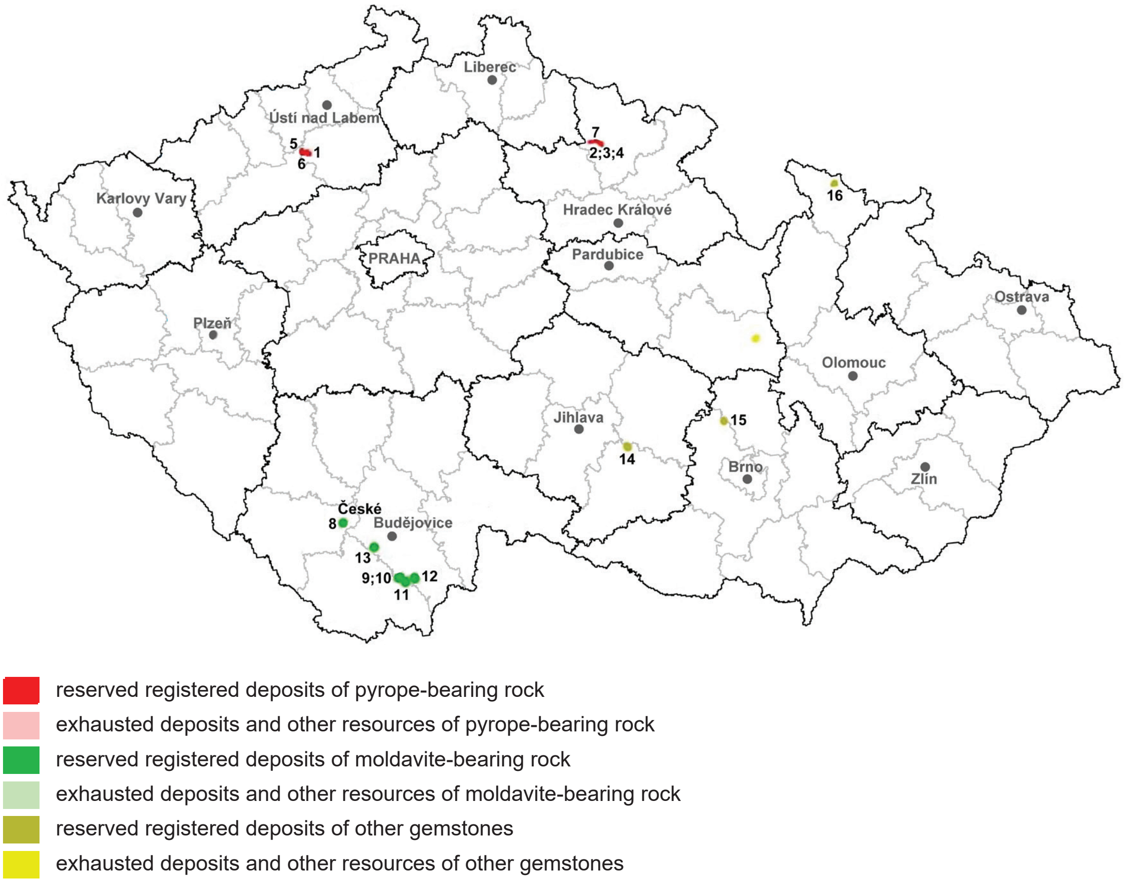
2. Mineral resources of the Czech Republic

Although the Czech Republic is very geologically complex and therefore rich in various types of deposits, it is very poor in gemstones. Only deposits of pyrope (Czech garnet) and moldavites are of international importance; the occurrences of some decorative quartz (crystals and smoky quartz in pegmatites around Velké Meziříčí and Liberec), agates in the foothills of Krkonoše Mts., amethyst and jasper in the Ore Mountains, porcelainite (originally clay minerals burned in contact with basalt) in southern Moravia, opals in the vicinity of Křemže in southern Bohemia, etc. are economically insignificant.

Pyrope is a mineral from the group of garnet with a composition of $Mg_3Al_2[SiO_4]O_3$, but always with an admixture of Fe and dyed with Cr. The world's most famous blood-red pyrope gemstone is the Czech garnet, mined for several centuries in Quaternary gravels at the foot of the České středohoří Mts. Their parent rock are the ultrabasic xenoliths (enclosures) in Tertiary volcanites. At present, the Podsedice deposit is being mined and the small Vestřev deposit in Podkrkonoší is already exhausted. The content of pyropes over 2 mm in the raw material is fluctuating and usually ranges between 20 and 100 g per 1 ton of rock. Real Czech garnets are always small; raw stones with a diameter of over 5 mm are infrequent and those over 7 mm are rare. Therefore, in jewellery, much larger and more abundant almandine garnets imported from abroad are used as central stones, but they have a brownish or purple hue.

A completely unique Czech gem is the moldavite, which belongs to the tektites. Tektites are natural glasses that occur in several places around the world. Their formation has always been a mystery, but at present the prevailing opinion is that they are terrestrial rocks that were remelted during the fall of a large meteorite and the melt sprayed over a long distance. For most of the world's tektites, we have also been able to identify the crater where the meteorite landed. The moldavites originate from the Ries crater near the German city of Nördlingen in Bavaria and were formed about 15 million years ago. They are located in southern Bohemia in Tertiary and Quaternary alluviums, mainly south of České Budějovice. They are characterised by a green colour and an uneven surface with many grooves, which were created by natural etching. Moldavites are usually 1 to 3 cm in size, larger ones are rare. They are used in jewellery either in their natural state or cut. There are smaller occurrences of moldavites in southern Moravia around Třebíč, but there they have an unattractive brown-green colour and are unusable as gems. Several small deposits were and are mined in southern Bohemia. The content of moldavites in deposits is very variable and usually ranges between 8 to 15 g per 1 m^3 (5 to 8 g per 1 ton) of rock.

3. Registered deposits and other resources of the Czech Republic



Pyrope-bearing rock:	Moldavite-bearing rock:	Other gemstones:
1 **Podsedice-Dřemčice**	8 **Hrbov u Lhenic**	14 Bochovice *
2 Vestřev	9 **Chlum nad Malší-východ**	15 Rašov **
3 Dolní Olešnice	10 **Ločenice-Chlum**	16 Velká Kraš ***
4 Horní Olešnice 1	11 Besednice	
5 Horní Olešnice 2	12 Slavče-sever	
6 Linhorka-Staré	13 Vrábče-Nová Hospoda	
7 Třebívlice		

(Names of exploited deposits are in ***bold type****)*

* *amethyst,*
** *opal,*
*** *gem varieties of quartz*

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number [a)]	15	15	15	15	14
exploited [b)]	4	4	2	5	5
Total mineral *reserves, kt [a)]	19,359	19,357	19,357	19,354	20,443
economic explored reserves	3,162	3,161	3,161	3,159	3,157
economic prospected reserves	13,016	13,016	13,016	13,015	13,013
potentially economic reserves	3,181	3,180	3,180	3,180	3,180
exploitable (recoverable) reserves	29,551	29 549	1,099	1,096	1,093
Total mineral *reserves, m^3 [c)]	1,466,041	1,415 330	1,372,017	1,324,198	1,353,273
economic explored reserves	26,352	21,352	9,352	4,452	79,221
economic prospected reserves	1,434,478	1,393 978	1,357,454	1,314,535	1,268,841
potentially economic reserves	5,211	5,211	5,211	5,211	5,211
exploitable (recoverable) reserves	281,317	235,817	187,293	140,924	184,000
Total mineral *reserves, kt (1 m^3 = 1.8 t) [c)]	1,465	2,556	1,371	2,384	2,434
economic explored reserves	47	38	9	8	9
economic prospected reserves	1,434	2,509	1,357	2,366	2,282
potentially economic reserves	9	9	5	9	9
exploitable (recoverable) reserves	506	236	187	253	331
Mine production, kt [a)]	12	1	0	3	4
Mine production, ths m^3 [c)]	42	46	49	48	38
Mine production, kt [c)] (1 m^3 = 1.8 t)	76	83	88	86	68

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

a) pyrope-bearing rock

b) in 2016–2017 one deposit of pyrope and three deposits of moldavite, in 2018 one deposit of pyrope and two deposits of moldavite, in 2019–2020 two deposits of pyrope and two deposits of moldavite

c) moldavite-bearing rock

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P1,	[b] kt	749	749	749	749	795
P1,	[c] ths m^3	66	66	66	66	66
P1,	[c] kt	118	118	118	118	118
P2,	[a] t	100	100	100	100	100
P3		–	–	–	–	–

Notes: [a] jasper, [b] pyrope-bearing rock, [c] moldavite-bearing rock

5. Foreign trade

7102 – Diamonds, whether or not worked, but not mounted or set

		2019	2020	2021	2022	2023
Import	kg	30,097	18	1,011	73,401	31,065
Export	kg	5	39	34	56	0

7102 – Diamonds, whether or not worked, but not mounted or set

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	7,393	16,246,944	309,815	6,203	9,404
Average export prices	CZK/kg	3,003,200	2,570,462	1, 231,765	767,727	–

7103 – Precious (other than diamond) and semi-precious stones, whether or not worked or graded but not strung, mounted or set

		2019	2020	2021	2022	2023
Import	kg	374,073	115,537	422,193	589,089	470,165
Export	kg	45,644	78,985	176,699	178,772	116,490

7103 – Precious (other than diamond) and semi-precious stones, whether or not worked or graded but not strung, mounted or set

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	928	266	310	391	306
Average export prices	CZK/kg	1,575	1,021	591	679	843

251320 – Emery, natural corundum, natural garnet and other natural abrasives

		2019	2020	2021	2022	2023
Import	t	4,017	12,711	1,669	3,266	2,917
Export	t	276	147	139	91	145

251320 – Emery, natural corundum, natural garnet and other natural abrasives

		2019	2020	2021	2022	2023
Average import prices	CZK/t	7,810	8,367	8,813	9,665	9,140
Average export prices	CZK/t	10,350	2,860	23,950	19,037	15,338

6. Prices of domestic market

The international gemstone trade is currently so globalized that no substantial price differences exist anywhere in the world including the Czech Republic. The only difference is that rather lower-quality gemstones are imported due to lower purchasing power as well as to less experienced jewellers and customers; high-quality gemstones in the Czech market are rare.

Company Granát, cooperative of art manufacturing in Turnov, purchased Czech garnets (pyropes) under following conditions in 2023:

Purchase prices of raw Czech garnets by size classes

Class	Screen size (mm)	Minimum thickness (mm)	Price CZK/g
IV.	2.6–2.9 mm	2.6 mm	10 CZK /g
III.	3.0–3.9 mm	2.6 mm	20 CZK /g
II.	4.0–4.9 mm	3.0 mm	50 CZK /g
I.	5.0–5.9 mm	3.5 mm	120 CZK /g
E0 and bigger	from 6.0 mm and more	4.5 mm	from 250 CZK /g

In the year 2023 Company Granát bought for the jewelery processing also moldavites (solid, intact stones) weighing from 1g to 10g and bought also the moldavite raw material (broken stones and fragments) for the cutting in a weight of 1g above and a minimum material thickness of 5 mm.

The actual purchase price of moldavites, depending on the size and quality of the stones, ranges from 100 to 300 CZK per gram.

Internet wholesale NATURSHOP.cz offered moldavites in the following size–shape-number-price relations (each moldavite was packaged separately in a plastic box with its description):

Mine locality	Weight (g)	Number of pieces	Price (CZK)
Besednice *	1.62–2.04	1	1,050 – 1,690
	2.15–2.82	1	1,840 – 2,380
	2.95–3.05	1	2,220 – 2,670
	3.10–3.20	1	2,740 – 2,780
	3.30–3.52	1	2,760 – 2,970
	3.55–3.62	1	2,880 – 3,000
	4.50	1	4,690
Chlum	3.65–3.75	1	2,150 – 2,210
	3.80–3.95	1	2,230 – 2,250
	4.04–4.85	1	2,290 – 2,750
	5.35–5.42	1	3,260 – 3,280
	5.50–5.45	1	3,350 – 3,420
	5.64–6.20	1	3,630 – 3,850
	7.05	1	5,100

*Note: * moldavites from this locality are visually regarded as the best*

7. Mining companies in the Czech Republic as of December 31, 2023

Pyrope-bearing rock
Granát, družstvo umělecké výroby, Turnov

Moldavite-bearing rock
MAWE CK s.r.o., Český Krumlov
Muzeum vltavínů Český Krumlov s.r.o.

8. World production and world market prices

World production

Statistical data on gem-quality garnet production are not available. MCS overviews provide the following data on global production of industrial garnets whose world's largest producers include Australia, China, South Africa, India and the USA in recent years

	2019	2020	2021	2022	2023e
World production, t	1,110,000	1,100,000	925,000	971,000	970,000

e – preliminary value

World statistics include principally diamond mining, both gem-grade and industrial ones.

World gem-grade diamond production was as follows
in ths ct (ct = carat; 1 ct = 0.2 g):

	2019	2020	2021	2022	2023e
World mine production (according to MCS)	82,400	62,300	73,900	75,200	74,000
World mine production (according to WBD)	83,460	79,230	74,591	79,407	N

e – preliminary values

Main producers according to MCS

2023e		
Gem-quality diamonds		
Country	**ths carats**	**%**
Russia	24,000	31.6
Botswana	17,000	22.4
Canada	15,000	19.7
Angola	7,900	10.4
South Africa	3,800	5.0
Congo (Kinshasa)	2,000	2.6
Namibia	2,000	2.6
Lesotho	730	1.0
Sierra Leone	550	0.7
Zimbabwe	440	0.6
Tanzania	320	0.4
Brazil	160	0.2
Guinea	103	0.1
World	**76,000**	**100.0**

2022e		
Industrial diamonds		
Country	**ths carats**	**%**
Russia	18,000	40.0
Congo (Kinshasa)	8,000	17.8
Botswana	7,000	15.6
South Africa	6,000	13.3
Zimbabwe	4,000	8.9
Angola	1,000	2.2
Others	1,000	2.2
World	**45,000**	**100.0**

e – preliminary values

World production of industrial diamonds was as follows:

	2019	2020	2021	2022	2023^e
World production (according to WBD), ths ct	55,000	45,000	46,000	45,000	45,000
World production (according to MCS), ths ct	57,116	45,275	43,170	43,545	N

e – preliminary values

World market prices

Gemstone prices depend on the type, size, and quality of the stones while the price ranges are considerable.

Approximate price of diamonds: Global average price in USD per carat (plus five-year forecast).

Does not include synthetic diamonds.

According to https://www.creditdonkey.com/diamond-prices.html, the following price points indicate the current prices of gem-quality diamonds and the recommended values for the best price-quality/beauty ratios of gem-quality diamonds in 2023. The prices quoted are for round diamonds. Other diamond shapes cost up to 20–40 % less than round diamonds.

Carat Weight	Diamond Price USD/ct	Total Price USD/ct	Recommended Price USD/ct
0.25	800–4,000	200–1,000	300–450
0.50	1,000–8,000	500–4,000	1,000–1,500
0.75	1,300–9,000	1,000–6,800	2,000–3,000
1.00	2,000–16,000	2,000–20,000	4,500–6,000
1.50	2,670–20,000	4,000–30,000	8,000–10,000
2.00	4,000–35,000	8,000–70,000	18,000–21,000
3.00	7,000–66,700	20,000–200,000	40,000–50,000

Commodity/year	2019	2020	2021	2022	2023^e
Industrial diamonds, US import, USD/ct (according to MCS)	5.82	8.41	13.0	8.4	14.0
Industrial garnets, US import, USD/t (according to MCS)	214	250	280	194	190

e – preliminary values

Gypsum

1. Characteristics and use

Gypsum is a sedimentary rock composed mainly or completely of the gypsum mineral ($CaSO_4.2H_2O$), which is usually colourless to white. The rock is often contaminated with impurities (clayey, sandy, ferrous, limestone, dolomite, anhydrite, etc.). The vast majority of gypsum deposits were formed by evaporation of sea or lake water and subsequent crystallisation of gypsum (often with anhydrite) in arid areas. Deposits formed by other means (e.g. hydration of anhydrite, decomposition of sulphides, metasomatic, etc.) are of little importance. Anhydrite (anhydrous $CaSO_4$) is often classified as gypsum. It is usually converted into gypsum by wet grinding

Reserves

They are extensive worldwide.

Uses

Gypsum is most often used in the manufacture of building materials – the production of gypsum, cement, plasters and prefabricated parts – and in small quantities for other purposes (in agriculture, in the production of glass, paper, in pharmacy and also as a filler). At present, energy gypsum is used rather than natural gypsum, which is a product of desulphurisation, especially of coal flue gases.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023– no

2. Mineral resources of the Czech Republic

Gypsum deposits in the Czech Republic are bound to Miocene (Baden-Wieliczkien) sediments of the Opava Basin (marginal part of the Carpathian foredeep) – most of the productive Baden lies on the Polish side. The average gypsum content in the raw material is 70–80%. Clays and sands are the main pollutants. The surface parts of the deposits are often affected by karsting. Mining (in the past also deep) of gypsum in the Opava region was taking place almost continuously in various localities since the middle of the 19th century. At present, only one deposit is surface mined (pit quarry) – Kobeřice in southern Silesia. After 1994, mining began to decline sharply, and after 2000, it stabilised at around 5 to 10% of the mining volume in the 1980s and 1990s. The main reason is the high production of energy gypsum, arising from the desulphurisation of power plants and heating plants.

3. Registered deposits and other resources of the Czech Republic

reserved registered deposits   exhausted deposits and other resources

1 **Kobeřice ve Slezsku-jih**	3 Rohov-Strahovice	5 Třebom
2 Kobeřice ve Slezsku-sever	4 Sudice	

*(Names of mined deposits are indicated in **bold type**)*

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	5	5	5	5	5
exploited	1	1	1	1	1
Total mineral *reserves, kt	504,159	504,133	504,116	504,096	504,085
economic explored reserves	119,022	119,006	118,989	118,969	118,958
economic prospected reserves	302,990	302,990	302,990	302,990	302,990
potentially economic reserves	82,137	82,137	82,137	82,137	82,137
exploitable (recoverable) reserves	2,181	2,172	2,156	2,128	2,117
Mine production, kt	10	17	17	17	11

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

5. Foreign trade

252010 – Gypsum, anhydrite

		2019	2020	2021	2022	2023
Import	t	79,423	95,403	163,223	176,849	167,604
Export	t	105,680	209,012	174,689	121,438	136,635

252010 – Gypsum, anhydrite

		2019	2020	2021	2022	2023
Average import prices	CZK/t	2,167	1,853	1,137	1,338	1,643
Average export prices	CZK/t	131	372	293	272	490

6. Prices of domestic market

Average prices of traded commodities on the domestic market

	2019	2020	2021	2022	2023
mined gypsum, CZK/t	N	N	N	N	N
grey gypsum binder, bagged in 30 kgs, pallets, CZK/t	4,507	4,625–4,820	4,660–4,860	4,800–5,000	5,000–5,300
white gypsum binder, bagged in 30 kgs, paliets, CZK/t	7,627	6,100–8,425	7,540–10,690	7,800–11,000	8,100–11,500

7. Mining companies in the Czech Republic as of December 31, 2023

GYPSTREND s.r.o., Kobeřice

8. World production and world market prices

World mine production

Data on world production of primary gypsum in recent years:

	2019	2020	2021	2022	2023[e]
World mine production of gypsum (according to MCS), kt	148,000	144,000	153,000	155,000	160,000
World mine production of gypsum (according to WBD), kt	160,426	166,593	175,566	176,988	N

e – preliminary values

Main producers according to MCS

2023e		
Country	**kt**	**%**
USA	22,000	13.8
Iran	16,000	10.0
China	12,000	8.5
Oman	12,000	7.5
Spain	11,000	6.9
Thailand	10,000	6.3
Turkey	10,000	6.3
Mexico	5,400	3.4
Germany	5,200	3.3
Japan	4,300	2.7
India	4,300	2.7
Russia	4,100	2.6
Saudi Arabia	4,000	2.5
Brazil	2,900	1.8
Algeria	2,500	1.6
Canada	2,400	1.5
World	**160,000**	**100.0**

e – preliminary values

World market prices

There are no global indicative prices of gypsum. The Mineral Commodity Summaries (MCS) publishes US market prices, which have long ranged from $ 7 to $ 9 / t for raw gypsum with FOB delivery and to $ 35 to $ 40 / tonne for calcined gypsum with FOB delivery.

Industrial sands

1. Characteristics and use

Industrial sands is a common term for glass and foundry sands. These are quartz sands, which often occur in their deposits together.

Glass sands are granular light to white sedimentary rocks (quartz sands or sandstones), which are used after treatment as a raw material for glass production. Requirements for their quality (grain size, mineral and chemical composition) vary according to the type of glass produced. Sands of the required quality do not usually occur in nature, so it is necessary to modify them by crushing, washing (removal of washable particles) and sorting (achieving the required grain size). In the production of higher quality raw materials, it is necessary to reduce the contents of colouring oxides (Fe_2O_3, TiO_2, Al_2O_3) by more demanding methods of treatment (electromagnetic separation, flotation, etc.); the maximum SiO_2 content is also required. Melting glass sands are used for the production of glass bath for the production of flat, packaging and some technical glasses (max. contents of Fe_2O_3 0.023 to 0.040%), utility glass (up to 0.021% Fe_2O_3); higher quality types of glass sands are used for the production of opaque quartz glass (max. 0.020% Fe_2O_3) and the best ones (max. 0.012 to 0.015% Fe_2O_3) are used for crystal, semi-optical and some technical glasses.

Foundry sands are granular light-coloured rocks that are suitable for the production of foundry moulds and cores either directly or after treatment. The main requirements for foundry sands are sufficient heat resistance, strength (depending on the quality and quantity of the binder component) and suitable grain size (medium grain size and regularity of grain size). Due to their variability, natural foundry sands are increasingly being replaced by synthetic sands, i.e. quartz sands, into which a specified amount of binder (usually bentonite) is mixed.

Reserves

They are not listed worldwide.

Uses

Natural quartz sands, after wet sorting and drying, are often dyed with inorganic pigments and used for plasters, roofing and other decorative purposes.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

The largest and most important deposits of glass sands in the Czech Republic are concentrated in the Czech Cretaceous basin, the smaller ones are in the Cheb basin. Some potentially interesting areas of the Czech Cretaceous Basin are mainly unpromising for reasons of nature protection (e.g. Lusatian Mountains, Bohemian Paradise, Adršpachy-Teplice Rocks, etc.).

- The most important deposit in the Czech Republic is Střeleč in the Jizera facial area of the Czech Cretaceous basin. The mined raw material consists of weakly consolidated quartz sandstones of Coniacian age and its quality reaches world parameters. The Mladějov reserve deposit in Bohemia is assessed in its southern forecourt.

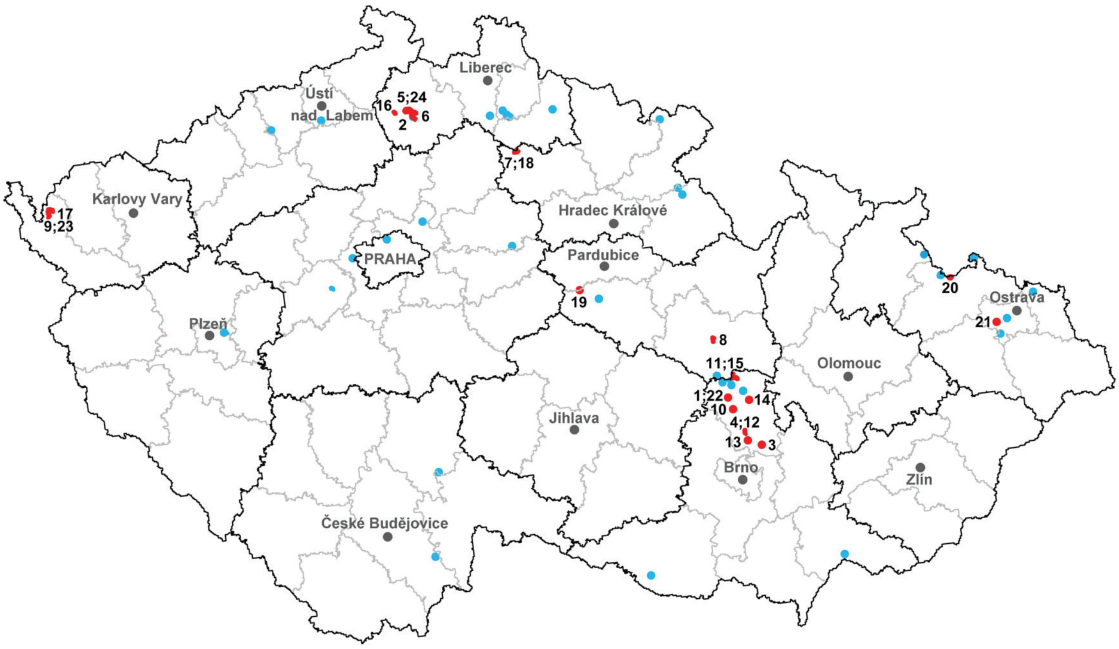
- The second most important area is the southern surroundings of Česká Lípa in the Lusatian facial area of the Czech Cretaceous basin. The raw material consists of weakly consolidated quartz sandstones of mid-Turonian age. The Provodín and Srní 2-Veselí deposits used until recently were exhausted in 2010 and 2015 respectively, and they were being gradually replaced by the Srní-Okřešice deposit since 2004, which has been the only mined deposit in the area since 2016.
- The non-traditional Velký Luh deposit is formed by the Pliocene gravels of the Cheb Basin (flooded material from kaolinically weathered Smrčina granite). The raw material is used for the production of technical, ceramic and water sands, most of the potentially economic raw material can be used as construction sand. The production of glass sands is not present here, because it would require a demanding treatment (abrasion, electromagnetic separation, grinding).

Foundry sand deposits accompany glass sands (lower quality raw material) on all deposits and they also occur separately. As in the case of glass sands, the deposits around Provodín and Střeleč are of the greatest importance.

- The third most important area is the Orlice-Žďár facial area of the Czech Cretaceous basin. The raw material consists of weakly consolidated Cenomanian quartz or glauconitic sandstones (natural sands). Mining is concentrated in the vicinity of Blansko, Voděrad and Svitavy.
- Glacigenic sands of northern Moravia (Palhanec-Vávrovice, Polanka nad Odrou), aeolian sands in the Elbe (Zvěřínek, Kluk) and southern Moravia (Bzenec, Strážnice, Břeclav), fluvial terrace sands of central (Tetín, Serbia, exhausted Kobylisy-Dolní Chabry), southern (Lžín) and western Bohemia (Kyšice) and others, are currently of no interest due to low quality, demanding processing of raw materials and sufficient availability of better quality raw materials from other sources. The same applies to the sands of the Carpathian Neogene basins (Nový Šaldorf), etc.
- The sands of the Pliocene sediments of the Cheb Basin (Velký Luh) are of local importance.
- In addition, foundries sometimes use sands which are generated as waste during the floating of kaolins (e.g. Krásný Dvůr).

Deposits of glass and foundry sands in the Czech Republic are surface mined. Raw material of lower quality is used in construction.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits   exhausted deposits and other resources

1 **Nýrov****	9 **Velký Luh***	17 Lomnička u Plesné**
2 Provodín*	10 **Voděrady****	18 Mladějov v Čechách*
3 **Rudice-Seč****	11 Babolky**	19 Načešice**
4 **Spešov-Dolní Lhota****	12 Blansko 1-Jezírka**	20 Palhanec-Vávrovice**
5 **Srní-Okřešice***	13 **Blansko 2-Mošna****	21 Polanka nad Odrou**
6 **Srní 2-Veselí***	14 Boskovice-Chrudichromy**	22 Rudka-Kunštát**
7 **Střeleč***	15 Deštná-Dolní Smržov**	23 Velký Luh 1**
8 **Svitavy-Vendolí****	16 Holany**	24 Zahrádky-Srní**

* *deposits of glass and foundry sands*
** *deposits of foundry sands*

*(Names of exploited deposits are in **bold type**)*

4. Basic statistical data of the Czech Republic as of December 31

Glass sand
Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	6	7	7	7	7
exploited	4	3	3	3	3
Total mineral *reserves, kt	249,379	255,849	255,088	254,378	267,526
economic explored reserves	78,644	77,914	77,153	76,443	86,498
economic prospected reserves	29,970	29,970	29,970	29,970	28,769
potentially economic reserves	147,965	147,965	147,965	147,965	152,259
exploitable (recoverable) reserves	72,337	71,609	36,781	70,139	27,879
Mine production, kt	740	683	715	664	555

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	kt	0	0	0	0	0
P_2,	kt	14,927	14,927	14,927	14,927	14,927
P_3		–	–	–	–	–

Foundry sand
Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	25	26	26	26	26
exploited	8	6	6	6	6
Total mineral *reserves, kt	409,489	405,761	405,160	404,524	415,718
economic explored reserves	125,227	124,748	124,162	123,538	130,409
economic prospected reserves	133,423	133,412	133,397	133,385	139,259
potentially economic reserves	147,601	147,601	147,601	147,601	146,050
exploitable (recoverable) reserves	73,378	72,891	4,374	71,117	34,180
Mine production, kt	514	470	583	615	543

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	kt	15,157	15,157	15,157	15,157	15,157
P_2,	kt	14,723	14,723	14,723	29,650	29,650
P_3		–	–	–	–	–

5. Foreign trade

250510 – Silica sands and quartz sands

		2019	2020	2021	2022	2023
Import	t	268,793	257,395	299,888	331,924	266,959
Export	t	500,007	497,653	563,458	518,411	439,370

250510 – Silica sands and quartz sands

		2019	2020	2021	2022	2023
Average import prices	CZK/t	1,073	994	1,082	1,117	1,159
Average export prices	CZK/t	478	503	520	510	606

7001 – Cullet and other waste and scrap of glass; glass in the mass

		2019	2020	2021	2022	2023
Import	t	206,349	209,208	230,866	227,244	222,238
Export	t	21,517	15,357	27,188	16,147	30,913

7001 – Cullet and other waste and scrap of glass; glass in the mass

		2019	2020	2021	2022	2023
Average import prices	CZK/t	1,564	1,533	1,628	1,731	2,381
Average export prices	CZK/t	850	1,277	1,776	1,513	2,685

6. Prices of domestic market

Prices of foundry sands are not open to public, prices of glass sands are given in the range of CZK/t 500–5,400 in 2023.

7. Mining companies in the Czech Republic as of December 31, 2023

Glass sand
Sklopísek Střeleč, a.s., Mladějov
Provodínské písky a.s., Provodín
LB MINERALS, s.r.o., Horní Bříza

Foundry sand
Provodínské písky a.s., Provodín
Sklopísek Střeleč, a.s., Mladějov
Pískovna ŠAMŠULA a.s.
LB MINERALS, s.r.o., Horní Bříza
PEDOP s.r.o., Lipovec

8. World production and world market prices

World mine production

The published statistics on the production of industrial sand do not distinguish between glass and foundry sands. The large increase in the total volume of production by the MCS was due to the inclusion of the Netherlands mining, which has only occurred since 2017. Total production has developed as follows in recent years:

	2019	2020	2021	2022	2023^{e}
Industrial sands (according to MCS), kt	325,000	235,000	353,000	380,000	400,000

e – preliminary values

Main producers according to MCS

2023e		
Country	**kt**	**%**
USA	130,000	32.5
China	88,000	22.0
Italy	33,000	8.3
Turkey	15,000	3.8
France	14,000	3.5
Nederland	12,000	3.0
India	12,000	3.0
Germany	11,000	2.8
Bulgaria	8,500	2.1
Russia	7,300	1.8
Mexico	7,000	1.8
Spain	6 600	1.7
Poland	5,800	1.5
Canada	5,500	1.4
Australia	5,500	1.4
United Kingdom	4,200	1.1
Malaysia	4,000	1.0
World	**400,000**	**100.0**

e – preliminary values

Prices of traded commodities – silica sand

Commodity/year		2019	2020	2021	2022	2023e
Silica sand for industrial use, average price, MCS	USD/t	46.10	29.5	42.4	45.3	54.0

e – preliminary values

Kaolin

1. Characteristics and use

Kaolin is most often a residual (primary), less often redeposited (secondary) white or light-coloured rock that contains a substantial amount of clay minerals from the kaolinite group. It always contains quartz, it can also contain other clay minerals, micas, feldspars and others depending on the nature of the parent rock.

Kaolin was most often formed by weathering or hydrothermal processes from various feldspar-rich rocks, most often granitoids, rhyolites, arkoses, gneisses, etc. These primary kaolins can be relocated, then they are secondary kaolins. The deposits are concentrated in the areas of occurrence of feldspar rocks, in which kaolinisation took place.

Reserves

They are extensive worldwide.

Uses

Most of the raw kaolin is treated in a dry or wet way to increase the content of the useful component (kaolinite). Treated kaolin is used for different purposes and different demands are placed on the raw material accordingly. Most kaolin is consumed in coatings and as a filler in the paper industry (around 45%) and also in the ceramics industry in the production of porcelain and other ceramics (around 20%). It is also used as a filler in rubber, plastics and paints, as optical fibre reinforcement, in the production of refractory materials, in the cosmetic, pharmaceutical and food industries. Kaolin is also the base material for the production of artificial zeolite. In the world, kaolin production is often ranked among clays.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

The technological suitability of kaolin is assessed according to the properties of the obtained floated kaolin. In the Czech Republic, kaolins are divided according to their usability:

- Kaolin for the production of porcelain and fine ceramics – this is the highest quality kaolin with high requirements for purity, rheological properties, strength after drying, pure white baking colour ($Fe_2O_3 + TiO_2$ contents without treatment by high-intensity electromagnetic separation up to 1.2%), Al_2O_3 at least 33%.
- Kaolin for the ceramic industry – does not have precisely defined properties, it is used in various ceramic recipes. White and whitish baking colour, low contents of colouring oxides, etc. are appreciated.
- Kaolin for the paper industry – used as a filler in paper and as a coating – high whiteness in raw state and low abrasives content are required here. Furthermore, as a filler in rubber (low contents of "rubber poisons" are required here – Mn up to 0.002%; Cu up to 0.001%; and Fe up to 0.15%), plastics, glass fibres, etc.
- Titanium kaolin – has a TiO_2 content above 0.5% and occurs only in the Karlovy Vary region, where it originated from granites with a high content of Ti-minerals. Tests and

practices have shown in some cases the possibility of reducing the TiO_2 content by high-intensity electromagnetic separation, then part of these kaolins can be used as kaolin for the production of porcelain and fine ceramics, or as kaolin for the ceramic and paper industries.
- Feldspar kaolin – contains higher proportions of non-kaolinised feldspars, it is mainly used for the ceramic industry, especially for the production of sanitary and utility ceramics.

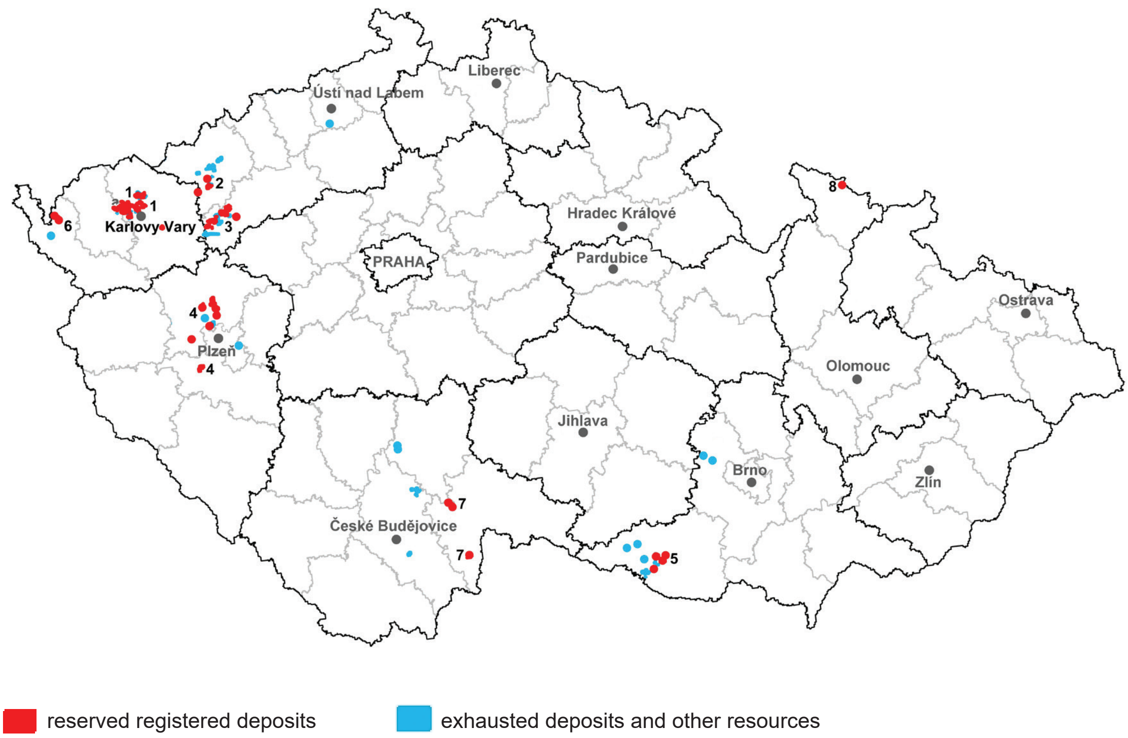
In the Czech Republic, all deposits were formed by kaolinic weathering of feldspar rocks. They are characterised by a decrease in kaolinisation with depth and a transition to unweathered parent rock. The absolutely predominant clay mineral is kaolinite. The main areas with kaolin deposits are:
- Karlovy Vary area – the parent rocks were the autometamorphic and mountain granites of the Karlovy Vary massif. It is the most important area of occurrence of the highest quality kaolins for the production of porcelain and their potential substitutes – titanium kaolins. There are also kaolins for the ceramics industry, and to a lesser extent also kaolins for the paper industry. The most important deposits are Božičany, Jimlíkov, Mírová and the Ruprechtov deposit opened in 2005, where kaolins for the production of porcelain and fine ceramics are mined together with titanium and ceramic kaolins. Kaolin for the paper industry is mined at the Otovice-Katzenholz deposit.
- Kadaň are – kaolins originated from granulite gneiss of the Ore Mountains crystalline complex. Kaolin can be used for the paper or ceramic industries. In 2003, the deposit Kralupy near Chomutov-Merkur (paper kaolin) was exhausted, other deposits were exhausted even earlier (e.g. Kadaň, Prahly). Since 2003, kaolin has been used for the paper industry in the large Rokle deposit, where overlying bentonite has also been mined for a long time.
- Podbořany are – the parent rock is the arkose sandstone of the Líně Formation of Central Bohemian Permocarbon. All the above-mentioned types of kaolins occur here. However, some kaolins evaluated as kaolins for the production of porcelain and fine ceramics are of lower quality (rather they should be ceramic to feldspar) and are used to a very limited extent as additives for the Karlovy Vary kaolins in the production of porcelain due to their rheological properties. The most important deposit is the large mined kaolin deposit for the production of porcelain and fine ceramics Krásný Dvůr-Podbořany.
- Pilsen area – the parent rock of kaolins are the carbonic arkoses of the Pilsen basin. Kaolins from this area are mainly usable as paper (the largest reserves of the highest quality raw material) and ceramic kaolins, slightly as feldspar kaolins and kaolins for the production of porcelain and fine ceramics. In 2005, in connection with the revaluation of reserves, most of the paper kaolins were transferred to the ceramic category. The most important large mined deposits of paper and ceramic kaolins are Horní Bříza, Kaznějov-jih and Lomnička-Kaznějov north and Chlumčany-Dnešice south of Pilsen.
- Znojmo area – kaolins originated mainly from the granitoids of the Dyje massif, and to a lesser extent from the Bíteš orthorhombic of the Dyje dome of the Moravicum. Kaolins are evaluated here mainly as feldspar and to a lesser extent paper kaolins. A small deposit of paper kaolin Únanov-sever was exhausted in 2007.
- Cheb Basin – kaolins were formed by kaolinisation of granites of the Smrčina massif. Only one deposit of Plesná-Velký Luh (ceramic and paper kaolins) is evaluated here, which has been used since 2018.
- Třeboň Basin – a small area where kaolins originated from granites and biotite paragneisses of the Moldanubian. Only ceramic kaolins on two small deposits are evaluated here:

Kolence and Klikov. Raw material is not mined, nor is its mining expected in the future due to its low quality.

- Vidnava – kaolins originated from granites of the Žulová massif. The raw material of the only one and no longer mined Vidnava deposit is alternatively evaluated as paper and ceramic kaolin, but for reasons of the best use of the raw material, it is registered among the clays for the production of refractory grogs.
- Other smaller occurrences of kaolins are either exhausted (Lažánky) or they were not yet explored (Žluticko, Toužimsko, Javornicko).

Czech kaolin deposits are also important from a global point of view, the most important being the Pilsen and Karlovy Vary areas, as well as the areas around Podbořany and Kadaň. All kaolin deposits in the Czech Republic are currently surface mined.

3. Registered deposits and other resources of the Czech Republic



Major deposit areas

*(Names of areas with exploited deposits are in **bold**)*

1 **Karlovy Vary Region**	4 **Plzeň Region**	7 Třeboň Basin
2 **Kadaň Region**	5 Znojmo Region	8 Vidnava
3 **Podbořany Region**	6 Cheb Basin	

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	77	77	77	77	77
exploited	18	18	18	18	18
Total mineral *reserves, kt	1,147,845	1,148,248	1,162,974	1,158,543	1,143,995
economic explored reserves	244,432	240,196	247,199	246,781	262,393
economic prospected reserves	461,095	465,952	481,923	481,901	472,871
potentially economic reserves	442,318	442,100	433,852	429,861	408,731
exploitable (recoverable) reserves	106,311	104,278	101,371	108,636	110,061
Mine production, kt [a)]	3,446	3,069	3,454	3,009	2,402
Beneficiated (water-washed) kaolin production, kt	629	626	645	558	449

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

[a)] Raw kaolin, total production of all technological grades

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	kt	17,197*	17,197*	17,197*	17,197*	17,197*
P_2		–	–	–	–	–
P_3		–	–	–	–	–

** Kaolin for ceramics manufacturing*

The data of kaolin for production of porcelain and fine ceramics and kaolin used as fillers in paper industry have been stated separately due to great varieties of end use and prices of the individual kaolin types:

Number of deposits; reserves; mine production

Kaolin for production of porcelain and fine ceramics	2019	2020	2021	2022	2023
Deposits – total number	34	34	34	34	34
exploited	8	8	8	8	8
Total mineral *reserves, kt	244,590	244,294	244,044	243,863	236,404
economic explored reserves	47,483	47,187	46,937	46,756	64,868
economic prospected reserves	107,617	107,617	107,617	107,617	99,835
potentially economic reserves	89,490	89,490	89,490	89,490	71,701
exploitable (recoverable) reserves	23,245	23,079	15,270	22,499	26,637
Mine production, kt [a)]	239	266	226	227	172

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

a) Exploited deposits: Božičany-Osmosa-jih, Jimlíkov, Krásný Dvůr-Podbořany, Mírová, Podlesí 2, Podlesí-Čapí hnízdo, Ruprechtov

Number of deposits; reserves; mine production

Kaolin for paper industry	2019	2020	2021	2022	2023
Deposits – total number	31	31	31	31	31
exploited	9	9	9	9	9
Total mineral *reserves, kt	285,410	283,549	277,701	276,807	275,724
economic explored reserves	58,732	56,904	57,886	57,563	56,548
economic prospected reserves	172,154	172,131	167,801	167,779	167,752
potentially economic reserves	54,524	54,514	52,014	51,465	51,424
exploitable (recoverable) reserves	31,324	30,441	31,260	30,911	30,087
Mine production, kt [a)]	1,256	1,234	1,322	1,189	861

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

a) Exploited deposits: Horní Bříza-Trnová, Chlumčany-Dnešice, Kaznějov-jih, Lomnička-Kaznějov, Otovice-Katzenholz, Rokle

5. Foreign trade

2507 – Kaolin and other kaolinic clays, whether or not calcined

		2019	2020	2021	2022	2023
Import	t	38,914	43,231	37,553	27,276	2,213
Export	t	537,827	471,566	505,634	460,466	30,552

2507 – Kaolin and other kaolinic clays, whether or not calcined

		2019	2020	2021	2022	2023
Average import prices	CZK/t	3,557	3,511	4,249	4,867	5,433
Average export prices	CZK/t	2,945	3,134	3,146	3,591	4,547

25070020 – Kaolin

		2019	2020	2021	2022	2023
Import	t	17,818	20,582	21,586	20,394	1,540
Export	t	537,578	471,370	505,461	460,406	30,552

25070020 – Kaolin

		2019	2020	2021	2022	2023
Average import prices	CZK/t	3,557	4,135	4,258	4,864	4,920
Average export prices	CZK/t	2,942	3,130	3,142	3 590	4,546

25070080 – Kaolinic clay (other than kaolin)

		2019	2020	2021	2022	2023
Import	t	21,097	22,650	15,967	6,882	6,724
Export	t	249	197	173	59	0

25070080 – Kaolinic clay (other than kaolin)

		2019	2020	2021	2022	2023
Average import prices	CZK/t	2,571	2,944	4,236	4,873	4 384
Average export prices	CZK/t	9,598	12,667	13,446	7,427	–

6. Prices of domestic market

Average prices of traded kaolin on the domestic market

In 2023, production prices of kaolins were in the following ranges:

Kaolin for ceramics manufacturing CZK/t 2,500 – 4,000
Kaolin for paper industry CZK/t 2,800 – 5,200
Kaolin other CZK/t 3,700 – 6,600

7. Mining companies in the Czech Republic as of December 31, 2023

Kaolin for manufacture of porcelain and fine ceramics
Sedlecký kaolin a.s., Božičany
Kaolin Hlubany, a.s.

Kaolin for ceramics manufacturing
LB MINERALS, s.r.o., Horní Bříza
Sedlecký kaolin a.s., Božičany

Kaolin for paper industry
LB MINERALS, s.r.o., Horní Bříza
KERAMOST, a.s., Most
Sedlecký kaolin a.s., Božičany

Titanium-bearing kaolin
Sedlecký kaolin a.s., Božičany

Feldspar-bearing kaolin
In 2023 there were no companies mining feldspar-bearing kaolin on the territory of the Czech Republic

8. World production and world market prices

World mine production

World kaolin production in recent years was as follows:

	2019	2020	2021	2022	2023[e]
World mine production (according to MCS), kt	44,300	46,400	49,300	51,900	51,000
World mine production (according to WBD), kt	44,272	42,703	44,395	45,102	N

e – preliminary values

Main producers according to MCS

2023e		
Country	**kt**	**%**
Uzbekistan	8,500	16.7
China	8,400	16.5
India	8,400	16.5
USA	4,400	8.6
Czech Republic	3,100	6.1
Rossia	2,500	4.9
Turkey	2,300	4.5
Iran	2,100	4.1
Brasil	1,200	2.9
Spain	270	0.5
Mexico	240	0.5
World	**51,000**	**100.0**

e – preliminary values

Prices of traded commodities

Commodity/year		2019	2020	2021	2022	2023e
Kaolin, average US market price, ex works, according to MCS	USD/st	161	159	152	157	160
Kaolin Czech, average export price into Germany (CZSO)	EUR/t	96.92	99.06	107.23	134.5	175.1

e – preliminary values

Limestone and cement raw materials

1. Characteristics and use

Limestones as minerals are sedimentary (limestones in the narrow sense) and metamorphic (crystalline limestones or marbles) rocks formed by $CaCO_3$ (calcite or aragonite). Limestones were formed by chemical, biogenic and mechanical processes or combinations thereof. Dolomite and other components (silicate, phosphatic, etc.) form primary and secondary admixtures. Depending on their origin, limestones show different physical characteristics, structure, hardness, colour, weight and porosity, from low consolidated marls through chalk to compact limestones. The colour depends on the type of admixture (pyrite and organic matter – black, without admixture – light to white). Thermal and pressure transformation of limestones created crystalline limestones (calcitic marbles). Limestones are present in virtually all sedimentary geological formations and their metamorphic equivalents worldwide.

This raw material group also includes cement-corrective sialitic raw materials, e.g. shales, clays, loesses, loams, sands, etc., which correct the contents of SiO_2, Al_2O_3 and Fe_2O_3 in the clinker firing mixture and thus make it possible to adjust the chemical composition of the basic raw material. Most of them are rocks occurring directly on deposits of cement limestones or separately in the vicinity.

Reserves

They are extensive worldwide.

Uses

Limestones are used in the production of building materials (lime, cement, mortar, crushed stone, dimension and crushed stone, etc.), in metallurgy, in the chemical and food industries, newly in the desulphurisation of thermal power plants, in agriculture and in other fields (glass and ceramics industries, etc.). Cement corrective sialitic raw materials are used in the production of cement.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

According to their usability, limestones in the Czech Republic are divided into:

- High-percentage – with at least 96% of carbonate component (of which max. 2% $MgCO_3$). They are mainly used in the chemical, glass, food, rubber and ceramic industries, in metallurgy, for desulphurisation and for the production of lime of the highest quality (non-hydraulic lime).
- Others – with a carbonate content of at least 80%, used primarily for cement production, lime production, desulphurisation, etc. In the Czech Republic until 1997, dolomites and dolomitic limestones were included in this group.
- Clay – with $CaCO_3$ content around 70% and higher contents of SiO_2 and Al_2O_3. They are used for the production of cement and various types of lime.

- Carbonates for agricultural purposes – with a carbonate content of at least 70–75%. They are used in the treatment of agricultural and forest lands.
  The above limestones are suitable as dimension and crushed stone (see next chapters).

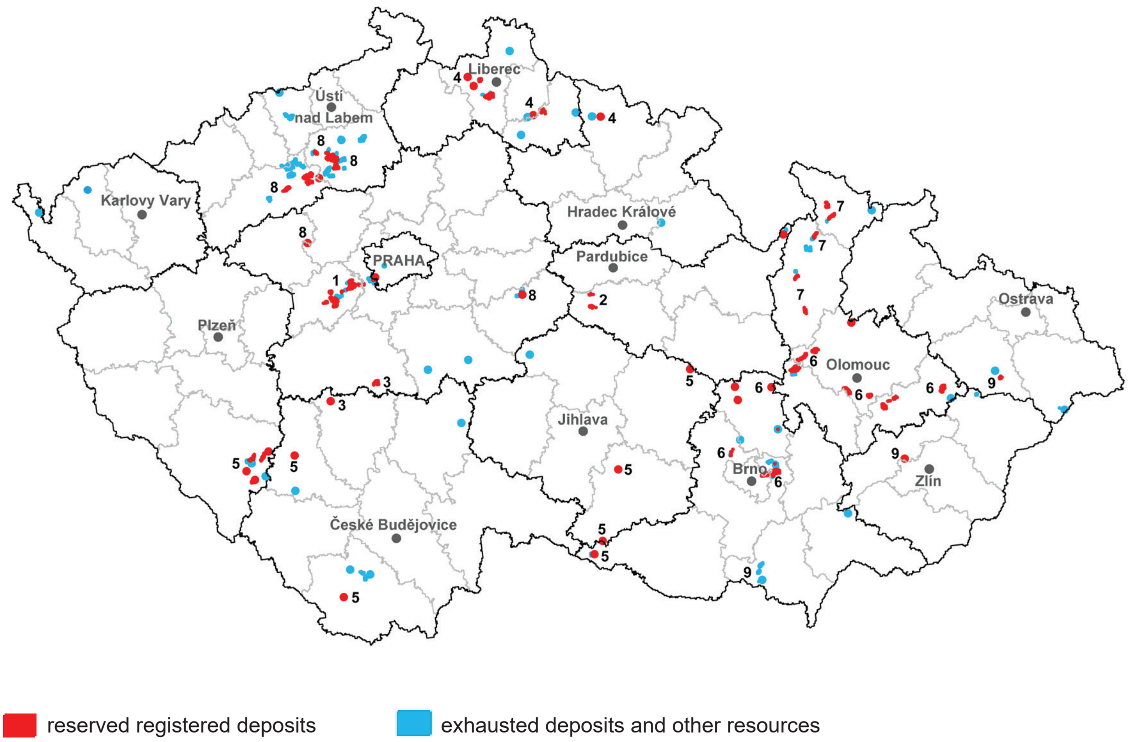
Deposits and the main sources of limestones in the Czech Republic are concentrated in the following main areas:

- Devonian rocks of the Barrandian – the most important and largest deposit area in the Czech part of the Czech Republic. Almost all types of raw materials are present, especially high-percentage limestones and other limestones, but also limestones for agricultural purposes and cement and correction raw materials. Deposits bound to sediments, mainly of Lower Devonian age, are usually formed by several lithological species. The purest of them are Upper Koněprusy limestones (average $CaCO_3$ contents approx. 98%). However, a significant part of the reserves and projected sources are linked to conflicts of interest with nature protection in the Bohemian Karst Protected Landscape Area. The most important used deposits are Koněprusy (high-percentage limestones), Kozolupy-Čeřinka (high-percentage and other limestones), Kosoř-Hvížďalka (other limestones), Loděnice (other limestones), Radotín-Špička (other limestones), Tetín (high-percentage limestones and others).
- Paleozoic of Železné Hory – a small area, but significant in terms of deposits. The raw material consists of crystalline Podolí limestones (high-percentage, 95% $CaCO_3$) and less pure darker crystalline limestones (other limestones, 90% $CaCO_3$). Prachovice deposit (high-percentage + others) is the only mined and decisive deposit.
- Central Bohemian Pluton islet zone – small isolated areas often with relatively pure, metamorphic limestones (mostly high-percentage and other limestones). The most important is the mined Skoupý deposit (high-percentage limestones).
- Krkonoše-Jizera crystalline complex – deposits of medium and smaller dimensions usually form lenses, deposited in phyllite and mica schist rocks. Limestones are crystalline, often with variable $MgCO_3$ contents (dolomitic limestones to calcareous dolomites – see chapter Dolomite) and SiO_2 (mainly other and agricultural limestones). Apart from the Lánov dolomite deposit, the only deposit used is Černý Důl (other limestones).
- Moldanubicum – deposits of smaller dimensions are represented by crystalline limestones, forming streaks or lenses in metamorphic rocks. Dolomitic limestones to dolomites commonly occur here together with limestones. Most deposits are evaluated as limestones for agricultural purposes and other limestones. Most deposits and reserves are concentrated in the Šumava Mts. Moldanubicum with the important used deposit Velké Hydčice-Hejná (other limestones).
- Moravian Devonian – the most important and very large deposit area of Moravia with deposits of various sizes. The main raw material in most deposits is the Vilémovice limestone (high-percentage; 96–97% $CaCO_3$). Furthermore, Křtice, Hády and Lažánky limestones (other limestones) are represented, evaluated mostly as cement raw material. The largest and most important deposits are concentrated in the sub-areas of the Moravian Karst with a large mined deposit Mokrá u Brna (high-percentage and other limestones and cement and correction raw materials) and the Hranice Devonian with a large mined deposit Hranice-Černotín (other limestones and cement and correction raw materials). Other, mostly unused deposits are found in the Konice-Mladeč Devonian, Čelechovice-Přerov Devonian and in the Devonian of the Boskovice Graben.

- The Silesian Bock (Branná group), Zábřeh group and Orlice-Kladsko crystalline complex – smaller deposits of crystalline limestones, which form stripes in metamorphic rocks. They are often very pure (high-percentage limestones with up to 98% $CaCO_3$, less other limestones) and in the northern part of the territory also usable for stonemasonry. The most important mined deposits are Horní and Dolní Lipová (high-percentage and other limestones) in the Silesian Block and Vitošov (high-percentage limestones), which lie on the border of the Desná dome and the Zábřeh crystalline complex.
- Czech Cretaceous Basin (Ohře and Kolín area) – large to medium deposits. The raw materials are clayey limestones and marlstones with $CaCO_3$ contents between 80–60% (the most important area of clayey limestones). The used Úpohlavy-Chotěšov deposit (clayey limestones) is of key importance.
- The outer klippen zone of the Western Carpathians – limestones are formed by tectonically isolated blocks in the surrounding rocks (so called ridges). The raw materials are Štramberk limestones on the NE and Ernstbrunn limestones on the SW. They are very pure with average $CaCO_3$ contents of 95–98%, $MgCO_3$ around 1% (high-percentage limestones). The most important deposit is the Štramberk deposit (high-percentage and other limestones), which has since 2005 been the only mined deposit after mining was terminated at the Mikulov deposit.

Other areas of occurrence of carbonate rocks, such as the Krušné hory crystalline complex, the Nízký Jeseník Mts. culm, the Moravicum, the Tertiary of South and Central Moravia, etc., are mostly of only local significance. Deposits of limestones, cement raw materials and dolomites are surface mined in the Czech Republic.

3. Registered deposits and other resources of the Czech Republic



Major deposit areas

(Names of areas with exploited deposits are in ***bold****)*

1 **Devonian of the Barrandian**

2 **Paleozoic of the Železné hory Mts.**

3 **Central Bohemian Islet Zone**

4 **Krkonoše Mts.-Jizerské hory Mts. Crystalline Complex**

5 **South-Bohemian and Moravian Moldanubicum**

6 **Moravian Devonian**

7 **Silesicum (Branná Group), Orlické hory Mts.-Kladsko Crystalline Complex and Zábřeh Group**

8 **Bohemian Cretaceous Basin**

9 **Outer Klippen Belt of the Western Carpathians**

4. Basic statistical data of the Czech Republic as of December 31

Limestones – total number
Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	85	85	85	85	85
exploited	22	22	22	22	22
Total mineral *reserves, kt	4,724,605	4,712,955	4,178,073	4,163,329	4,699,478
economic explored reserves	2,020,399	2,009,011	1,761,116	1,755,163	1,993,388
economic prospected reserves	1,819,749	1,819,539	1,658,910	1,658,803	1,822,357
potentially economic reserves	884,457	884,405	758,047	749,363	883,733
exploitable (recoverable) reserves	1,131,050	1,257,354	1,196,691	1,182,737	848,538
Mine production, kt	11,357	11,296	11,007	10,319	9,272

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Limestones – total number
Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	kt	82,489	82,489	82,489	82,489	82,489
P_2,	kt	350,957	350,957	350,957	350,957	350,957
P_3		–	–	–	–	–

Owing to the importance and considerable differences in technological use and prices, high-percentage limestones, corrective additives for cement production and other limestones are monitored separately.

High-percentage limestones containing 96 % or more of $CaCO_3$
Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	27	27	28	28	28
exploited	10	10	8	10	10
Total mineral *reserves, kt	1,288,592	1,284,292	1,275,664	1,269,274	1,268,039
economic explored reserves	685,552	681,209	672,717	672,663	668,600
economic prospected reserves	417,911	417,911	417,775	417,775	420,603
potentially economic reserves	185,129	185,172	185,172	178,836	178,836
exploitable (recoverable) reserves	497,389	529,9943	514,572	510,328	165,031
Mine production, kt	4,709	4,186	4,450	4,158	3,857

* See ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

High-percentage limestones containing 96 % or more of $CaCO_3$
Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	kt	5,400	5,400	5,400	5,400	5,400
P_2,	kt	26,345	26,345	26,345	26,345	26,345
P_3		–	–	–	–	–

Other limestones
Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	48	48	49	50	50
exploited	17	17	17	16	16
Total mineral *reserves, kt	2,311,976	2,305,870	2,303,207	2,299,070	2,294,279
economic explored reserves	968,552	962,716	963,761	959,636	954,910
economic prospected reserves	811,694	811,694	807,986	807,879	807,814
potentially economic reserves	531,460	531,460	531,460	531,555	531, 555
exploitable (recoverable) reserves	593,759	568,906	644,359	639,391	518,287
Mine production, kt	5,601	5,523	5,451	5,122	4,348

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

Other limestones
Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	kt	71,267	71,267	71,267	71,267	71,267
P_2		–	–	–	–	–
P_3		–	–	–	–	–

Corrective additives for cement production
Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	13	13	13	14	14
exploited	2	2	2	2	2
Total mineral *reserves, kt	522,971	522,419	521,882	533,332	533,022
economic explored reserves	239,828	239,276	238,739	238,171	237,861
economic prospected reserves	156,785	156,785	156,785	160,791	160,791
potentially economic reserves	126,358	126,358	126,358	134,370	134,370
exploitable (recoverable) reserves	151,506	150,955	150,328	153,664	77,309
Mine production, kt	449	551	473	465	266

** See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

Corrective additives for cement production
Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	kt	84,493	84,493	84,493	84,493	84,493
P_2		–	–	–	–	–
P_3		–	–	–	–	–

In many limestone deposits, high-percentage limestones and other limestones are extracted together. Five out of fourteen corrective additives for cement production deposits make part of other limestones deposits.

5. Foreign trade

2521 – Limestone flux; limestone and other calcareous stone, of kind used for the manufacture of lime or cement

		2019	2020	2021	2022	2023
Import	t	294,296	343,891	421,109	476,629	49,836
Export	t	225,111	166,275	177,504	186,282	145,975

2521 – Limestone flux; limestone and other calcareous stone, of kind used for the manufacture of lime or cement

		2019	2020	2021	2022	2023
Average import prices	CZK/t	166	192	214	248	317
Average export prices	CZK/t	473	506	522	617	711

2522 – Quicklime, slaked lime and hydraulic lime

		2019	2020	2021	2022	2023
Import	t	91,140	78,831	102,793	136,237	118,293
Export	t	235,827	214,435	173,518	84,036	81,093

2522 – Quicklime, slaked lime and hydraulic lime

		2019	2020	2021	2022	2023
Average import prices	CZK/t	1,711	1,737	2,300	2,985	3,491
Average export prices	CZK/t	2,096	2,220	2,140	2,792	5,726

2523 – Portland cement, aluminous cement, slag cement, supersulphate cement and similar hydraulic cements, whether or not coloured or in the form of clinkers

		2019	2020	2021	2022	2023
Import	t	583,569	617,179	688,642	634,710	500,134
Export	t	785,000	568,895	621,962	448,994	291,322

2523 – Portland cement, aluminous cement, slag cement, supersulphate cement and similar hydraulic cements, whether or not coloured or in the form of clinkers

		2019	2020	2021	2022	2023
Average import prices	CZK/t	1,766	1,921	1,965	2,371	3,084
Average export prices	CZK/t	1,621	1,832	1,789	2,127	2,834

6. Prices of domestic market

Average prices of traded commodities on the domestic market

Product specification	2019	2020	2021	2022	2023
Cement CEM I, 42,5 R, on pallets, CZK/t	2,840	2,840	2,920	3,700	4 450
Cement CEM I, 42,5 R, on pallets, covered with foil, CZK/t	2,900	2,900	3,000	3,750	4 600
Cement CEM III A, 32,5 R, on pallets, CZK/t	2,600	2,660	2,720	3,350	3 850
Cement CEM III A, 32,5 R, on pallets, covered with foil, CZK/t	2,660	2,660	2,720	3,350	3 900
Dolomitic hydrated lime, bulk, CZK/t	5,840	4,100	4,500	5,600	6 200
Quicklime, ground, bulk, CZK/t	1,981–2,880	3,650–4,020	3,400–4,100	4,100–5,000	4 500–5 600
Limestone, ground, bulk, CZK/t	425–690	430–710	440–750	550–930	600–300
Limestone, crushed, CZK/t	253–450	190–550	200–550	250–650	300–720

7. Mining companies in the Czech Republic as of December 31, 2023

High-percentage limestones
Velkolom Čertovy schody, a.s.
LB Cemix, s.r.o.
Vápenka Vitošov s.r.o
LOMY MOŘINA spol. s r.o.
CEMEX Czech Republic, s.r.o
Českomoravský cement, a.s.
Vápenka Vitoul s.r.o.
Omya CZ s.r.o.
Agir spol. s r.o.

Other limestones
Českomoravský cement, a.s.
Cement Hranice, a.s.
CEMEX Czech Republic, s.r.o.
Omya CZ s.r.o.
LB Cemix, s.r.o.
HASIT Šumav. vápenice a omítkárny, s.r.o.
LOMY MOŘINA spol. s r.o.
Kalcit s.r.o., Brno
KLCT s.r.o.
Krkonošské vápenky Kunčice, a.s.

Clayey limestones
Holcim (Česko), a.s.

Carbonates for agricultural use
PRACTIC 99, s.r.o.

Corrective additives for cement production
Českomoravský cement, a.s.
Cement Hranice, a.s.

8. World production and world market prices

World mine production

World limestone production is estimated at billions of tonnes. Its amount may be inferred from data on lime and cement manufacture. According to MCS data, world production of these two commodities in recent years was as follows:

Commodity/year	2019	2020	2021	2022	2023[e]
World cement production, mill. t	4,100	4,200	4,400	4,100	4,100
World lime production, mill. t	432	427	430	430	430

e – preliminary values

The same table as the previous one, but including limestone; calculations are based on the relationship: 2 tonnes of limestone = 1 tonne of lime or 2 tonnes of cement (limestone production for construction purposes is not taken into account)

Commodity/year	2019	2020	2021	2022	2023e
World limestone production derived from the global cement production, mill. t	4,100	4,200	4,400	4,100	4,100
World limestone production derived from the global lime production, mill. t	862	854	860	860	860
World limestone production derived from the global lime production and cement production, mill. t	4,962	5,054	5,260	4,960	4,960

e – preliminary values

Main producers according to MCS

2023e		
Cement		
Country	**kt**	**%**
China	2,100,000	56.8
India	370,000	7.5
Vietnam	120,000	2.3
USA	95,000	2.1
Turkey	85,000	1.7
Indonesia	64,000	1.5
Brazil	65,000	1.5
Iran	62,000	1.4
Russia	61,000	1.3
Saudi Arabia	54,000	1.3
World	**4,100,000**	**100.0**

2023e		
Lime		
Country	**kt**	**%**
China	310,000	72.1
USA	17,000	4.0
India	16,000	3.7
Russia	11,000	2.6
Brazil	8,400	2.0
Germany	5,600	1.3
Japan	7,000	1.6
South Korea	5,200	1.2
Turkey	4,800	1.1
Iran	3,900	0.9
World	**430,000**	**100.0**

e – preliminary values

Prices of traded commodities – calcium carbonat

Commodity/year		2019	2020	2021	2022	2023
Cement, at plant USA (MCS)	USD/t	124.0	125.0	127.00	140.0	150.0
Quick lime, at plant USA (MCS)	USD/t	128,3	131,4	133,4	151,3	155,0^{e}
Hydrated lime, at plant USA (MCS)	USD/t	154,6	156,0	159,6	183,1	185,0^{e}
Limestone, Slovakian, yearly average price of import into the Czech Republic (CZSO)	EUR/t	6.11	6.19	6.56	8.30	9,3

Silica minerals

1. Characteristics and use

Various types of rocks with a high content of SiO_2 are used as silica raw materials (usually at least 96% but over 99% for high quality glass and silicon production). These are various quartzites (sedimentary or metamorphic rocks, composed mainly of quartz and formed by silicification of sandstones or cementation of silica sands with silica binding agent), silicified sandstones, silicites, silica sands and boulders and vein and pegmatite quartz. Raw material quality requirements are set by standards. SiO_2 contents and heat resistance are monitored. The pollutants are high contents of especially Al_2O_3 and Fe_2O_3, or other oxides.

Reserves

They are extensive worldwide.

Uses

Silica materials are used to produce ferrosilicon for the steel industry, metallic silicon (semi-conductors and solar photovoltaic panels), refractory building materials (dinas – bricks, mortars, ramming mass). They are also used for the production of porcelain and ceramics. Clear quartz, ultraviolet and optical glass (fibre) is produced from vein quartz, crystal and quartz boulders.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

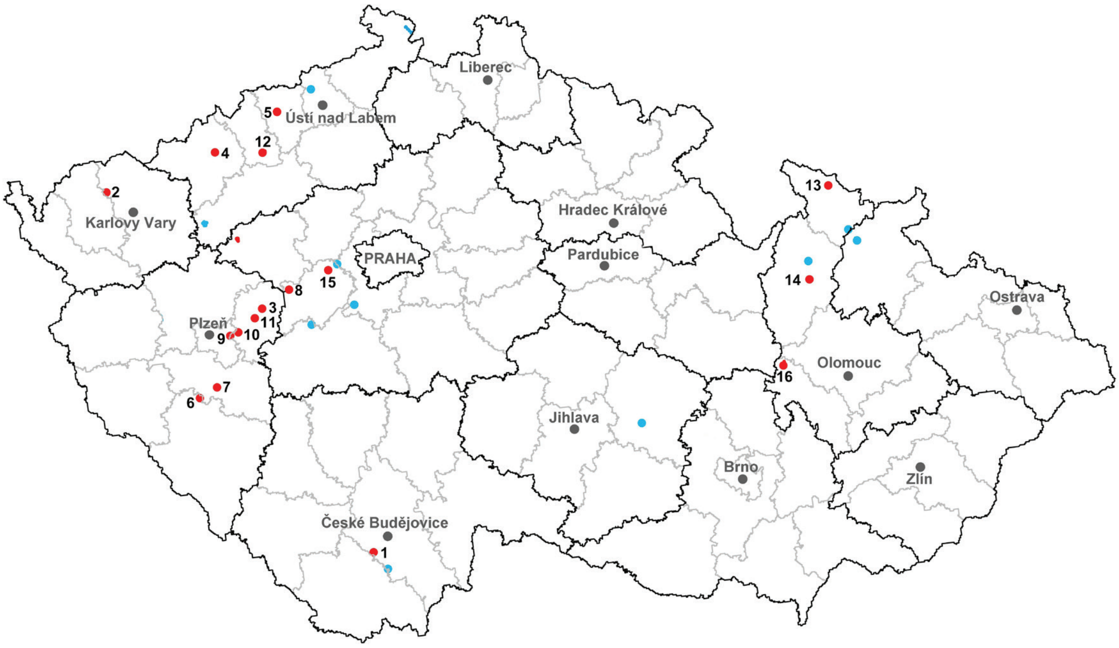
In the Czech Republic, silica materials are divided into silica materials and silica materials for special glasses. Deposits of silica materials are mainly related to the occurrences of "amorphous" Tertiary quartzite, Cretaceous "crystalline" quartzie and Ordovician quartzite, and to a lesser extent to deposits of vein quartz and silicites (lydites) of the Upper Proterozoic. At present, in the Czech Republic, with one exception, these raw materials are practically not mined and are mostly replaced by silica sands (entirely in the ceramic and glass industries), of which there is a sufficient amount on the market and which are also less variable and cheaper.

- Venous quartz deposits occur practically throughout the Czech Republic. The raw material can be used for the production of ferrosilicon, silicon and for ceramic and glass purposes. Accumulations of vein quartz are today unpromising due to low and fluctuating quality and they are gradually removed from the Register. Deposits and occurrences can be divided into several genetic groups:
- now insignificant deposits and occurrences of very pure quartz in pegmatites (Dolní Bory)
- silica veins of the rampart type (silicificated dislocation zones) in the Tachov region (Tachov-Světecká hora), in northern (Rumburk) and southern (Římov-Velešín) Bohemia and in the Jeseníky Mountains (Bílý Potok-Vrbno, Žárová)
- quartz veins bound to granitoid plutons (Žulová pluton: Velká Kraš, Karlovy Vary pluton: Černava-Tatrovice, Lusatian pluton: Rumburk, etc.)
- Deposits of "amorphous" quartz (quartz grains are bonded with very fine quartz bonding agent) were formed by silicification of Tertiary and Upper Cretaceous deposits in Most

area (Lužice u Mostu-Dobrčice, Stránce, Skršín) and Chomutov area (Chomutov-Horní Ves). In the Podbořany area (Skytaly, Vroutek) and Žlutice area they occur only in the form of relict boulders. Quartzite was a classic raw material for the production of dinas and the purest raw material can also be used for the production of metallic silicon. In the Podbořany area, quartzite was also used in ceramic production.

- Neoid silicification of Cretaceous sandstones created deposits of "crystalline" quartzites (isometric quartz grains) in Teplice area (Jeníkov-Lahošť, Střelná) and Most area (Bečov). Quartzites are usable mainly for metallurgical processing (mainly ferrosilicon), partly also for the production of dinas and metallic silicon.
- Of the Paleozoic quartzites, the Barrandian Ordovician quartzites (Kublov, Mníšek pod Brdy, Drahoňův Újezd-Bechlov, Sklená Huť, Železná) were of the greatest importance. They are usually rated as poorer in quality for the production of ferrosilicon and to a lesser extent dinas. Other larger accumulations of quartzites and quartz rocks are in the Devonian rocks of the Silesian Bock (Vikýřovice), etc. These quartzites are of low quality and are suitable after treatment for the production of lower quality dinas.
- In the future, perhaps the deposits of Upper Proterozoic silicites (cobblestones) could prove useable for the industries for the amount of their reserves and their quality, especially in the Rokycany area (Litohlavy, Kyšice-Pohodnice) and Přeštice area (Kaliště, Kbelnice). According to tests, the raw material could be suitable for the production of silicon alloys and perhaps even partially for the production of dinas.
- Once, cobble quartz from the extraction of sand and gravel in the Elbe, Dyje, Cheb region, etc was also considered a possible raw material for the production of silicon and special types of glass. At present, the 16–50 mm fraction is used in this way at the Vrábče-Boršov deposit in the Budějovice basin, which consists practically only of quartz boulders (other rocks, limonitised boulders and other impurities are picked out by hand). Gravel is exported to Germany (around 20 kt per year) as a silica material for the production of ferrosilicon.
- Only milky white vein quartz is suitable after treatment as a silica material for special glasses. In the Příbram area (Krašovice) it is bound to the Central Bohemian pluton (zone of metamorphic islets) and in the Prostějov area (Dětkovice) to hydrothermal veins, which have undergone metamorphosis together with the surrounding rocks (phyllites).

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits   exhausted deposits and other resources

Quartz – quartzites

1 **Vrábče-Boršov**	6 Kaliště	11 Sklená Huť
2 Černava-Tatrovice	7 Kbelnice	12 Stránce
3 Drahoňův Újezd-Bechlov	8 Kublov-Dlouhá Skála	13 Velká Kraš
4 Chomutov-Horní Ves	9 Kyšice-Pohodnice	14 Vikýřovice
5 Jeníkov-Lahošť	10 Litohlavy-Smrkový vrch	15 Železná

Quartz for special glass

16 Dětkovice	17 Krašovice

*(Names of exploited deposits are in **bold type**)*

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	17	15	15	15	15
exploited	1	1	1	1	1
Total mineral *reserves, kt	26,679	26,668	26,526	26,519	26,490
economic explored reserves	763	763	924	914	885
economic prospected reserves	21,727	21,716	21,416	21,416	21,416
potentially economic reserves	4,189	4,189	4,189	4,189	4,189
exploitable (recoverable) reserves	428	417	188	178	164
Mine production, kt	17	11	20	10	13

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	kt	4,533	4,533	4,533	4,533	4,533
P_2		–	–	–	–	–
P_3		–	–	–	–	–

5. Foreign trade

2506 – Quartz (other than natural sands); quartzite, whether or not roughly trimmed or merely cut

		2019	2020	2021	2022	2023
Import	t	15,128	11,971	43,350	67,198	43,349
Export	t	8	1	69	29	73

2506 – Quartz (other than natural sands); quartzite, whether or not roughly trimmed or merely cut

		2019	2020	2021	2022	2023
Average import prices	CZK/t	2,210	2,223	689	720	809
Average export prices	CZK/t	1,166	68,571	63,611	51,787	59,588

720221 – Ferrosilicon

		2019	2020	2021	2022	2023
Import	t	25,397	23,659	26,843	23,220	20,166
Export	t	11,997	10,598	12,576	12,897	9,792

720221 – Ferrosilicon

		2019	2020	2021	2022	2023
Average import prices	CZK/t	26,785	25,930	38,498	62,955	39,560
Average export prices	CZK/t	23,458	21,849	34,262	54,388	36,118

6. Prices of domestic market

Prices of silica minerals are not open to public.

7. Mining companies in the Czech Republic as of December 31, 2023

Budějovické štěrkopísky, spol. s r.o., Vrábče

8. World production and world market prices

World mine production

World production of silicon in recent years:

	2019	2020	2021	2022	2023[e]
Silicon production (according to MCS), kt	8,410	8,120	9,150	9,110	9,000

e – preliminary values

Main producers according to MCS – Si metal and Si in ferrosilicon

Country	2023e	
	kt	%
China	6,600	73.3
Russia	620	6.9
Brazil	390	4.3
Norway	340	4.1
USA	310	3.8
Island	130	1.4
Kazachstan	125	1.4
France	110	1.2
Malaysia	80	0.9
Bhutan	80	0.9
India	60	0.7
World	**9,000**	**100.0**

e – preliminary values

Prices of traded commodities:
– silicon (USc/lb), US market, according to MCS

Commodity/year	2019	2020	2021	2022	2023e
Silicon metal, metallurgical grade	106	97	220	362	190

– ferrosilicon (EUR/t), according to MCS

Komodita/rok	2019	2020	2021	2022	2023e
Ferosilicon, 50% Si, price average, USc/lb (MCS)	102	103	134	N	N
Ferosilicon, 75% Si, price average, USc/lb (MCS)	89	87	192	312	150

e – preliminary values

CONSTRUCTION MINERALS

The term construction minerals is employed for all minerals used in the construction industry, such as transport, construction, water, industrial, residential and other buildings, the production of concrete, mortar and bituminous mixtures, bricks and blocks. Minerals for the production of building materials, especially carbonates, are classified industrial minerals in the Czech Republic.

The Czech Republic has extremely large geological reserves of construction minerals. The total verified sources of construction minerals in the Czech Republic are around 20 billion tonnes and a total of around 65 million tonnes are mined annually (in 2023 their mining reached 61,6 million tonnes), their share in the total extraction of raw materials is gradually increasing and currently is about 60%. In 2023 79% of the production of construction minerals comes from reserved deposits, which account 40 million tonnes. The decisive importance have crushed stone and sand and gravel, which together make up 90% of the volume (over 61 million tonnes) of all extracted construction minerals. The share of production from reserved deposits in crushed stone and sand and gravel together is 70% (in 2023 43 million tonnes). It is higher for crushed stone, where extraction from reserved deposits represents 89% of the total extraction of crushed stone. For sand and gravel, the production from reserved deposits accounts for only 43% of the total production. In the Czech Republic, we divide construction minerals into the following basic groups:

- **Crushed stone**, which is used either untreated (quarry stone) or it mainly used to produce crushed aggregate, which is also its technical name
- **Sand and gravel**, which are technically called mined aggregates
- **Brick clays and related minerals**, suitable alone or in a mixture for brick production
- **Dimension stone**, stone for rough and noble stonemasonry

Brick clays and related minerals

1. Characteristics and use

Brick clay includes all types of raw materials suitable alone or in a mixture for brick production. The following types of rocks are most often used for this purpose: loess, loess and slope loams, clays and claystones, marls, slate wastes and others. The production material itself has two main components – plastic and opening material (grog), which are proportionally represented either directly in the raw material or the optimal ratio of both can be obtained by mixing them. The component (base) that predominates in the production mixture is essential; the additional component, which modifies the properties of the raw material, is corrective (depending on the nature, it has a plasticising or non-plasticising function), or ingredient. The pollutants in the brick clay are mainly carbonates, gypsum, siderite, organic substances, larger rock fragments, etc.

Reserves

They are extensive worldwide. Deposits of brick clay in the world are located practically everywhere and are not generally registered.

Uses

Brick production (bricks, brick blocks, roofing tiles, clay).

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

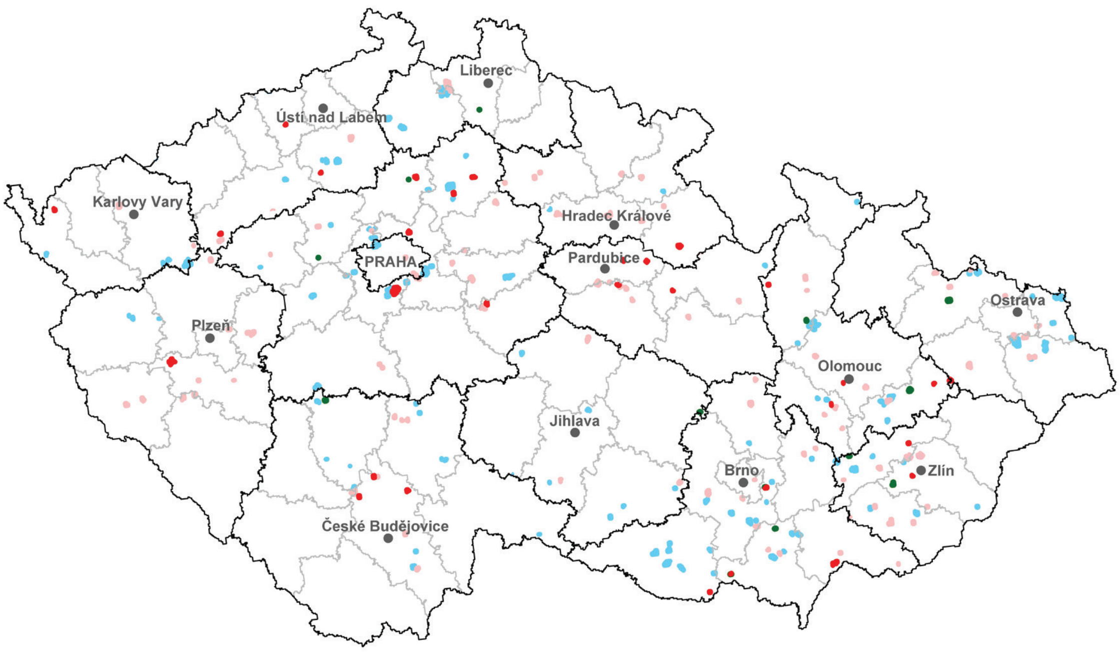
Among the brick clays in the Czech Republic, Quaternary loams of various genesis predominate as the basic component. The source of natural corrective raw materials are mostly deposits of pre-Quaternary age.

- Deposits of Quaternary raw materials (loess and loess loams, clays, sands and sandy-clay rock residues) are widespread throughout the country and are the most abundantly mined. The most important of them are tied to aeolian and deluvial-aeolian, or glacial (northern Bohemia and Silesia) sediments. In aeolian sediments, buried soil horizons, clasts and calcareous concretions are pollutants; the deluvial ones contain hard clasts. Aeolian raw materials are suitable (usually in a mixture) for the production of demanding thin-walled elements. Deluvial raw materials can be used as corrective components for more plastic soils or for the production of thick-walled masonry shards.
- Neogene pelites are a more widespread pre-Quaternary raw material of the limnic basins of Bohemia and the Vienna Basin. They are characterised by a sandy admixture and locally also by the increased presence of montmorillonite or clasts, in the area of the Vienna Basin and the Carpathian foredeep also by an increased content of soluble salts. They are one of the long-used raw materials. They are also suitable for the production of demanding thin-walled load-bearing and shaped products.
- Paleogene claystones (also calcareous) are used in eastern and southeastern Moravia. These are weathered parts of the flysch layers of the outer Western Carpathians nappes. Flowering

substances and sandstone benches are serious pollutants. The product range is limited to solid bricks or perforated products.

- Upper Cretaceous clays and claystones (often calcareous) are used as the basic raw material in the area of the Czech Cretaceous Basin and South Bohemian basins. Marls, marlstones and sand as a correction. The raw material is suitable for the production of even the most demanding perforated masonry and ceiling materials; in southern Bohemia due to the occurrence of limonitised sandstone for the production of undemanding masonry products.
- Permocarbon pelites and aleuropelites serve as a raw material in the areas of the Permocarbon basins and trenches of Bohemia and Moravia. The presence of sandstones in the formation and the complex structure of deposits are characteristic. They give the possibility of production of fired roofing and thin-walled products.
- Early Proterozoic and Old Paleozoic weathered shales and their residues are used in the vicinity of Prague, Pilsen, Rokycany, etc. The usual pollutants are solid clasts and pyrite. They are not suitable for the production of more demanding brick products.

3. Registered deposits and other resources of the Czech Republic



- reserved deposits – exploited (13)
- reserved deposits – unexploited (117)
- non-reserved deposits – exploited (8)
- non-reserved deposits – unexploited (118)

There are large numbers of brick mineral deposits registered in the Czech Republic and thus they are not listed in this overview. Their distribution over the Czech territory is rather uneven and consequently in some regions there is a shortage of these minerals (e.g. Českomoravská vrchovina Highlands covering most of the Vysočina Region area with capital Jihlava).

4. Basic statistical data of the Czech Republic as of December 31

Reserved deposits: Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	129	129	126	130	130
exploited	15	15	16	16	13
Total mineral *reserves, ths m^3	527,679	526,197	525,687	524,943	524,508
economic explored reserves	194,738	193,821	193,458	193,311	193,060
economic prospected reserves	227,968	227,884	227,971	227,376	227,192
potentially economic reserves	104,973	104,492	104,258	104,256	104,256
exploitable reserves	56,505	59,553	65,882	67,472	67,516
Mine production in reserved deposits, ths m^3	694	560	595	578	349

** See <u>NOTE</u> in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	ths m^3	25,691	25,691	25,691	25,691	25,691
P_2,	ths m^3	245,459	224,159	224,159	224,159	224,159
P_3		–	–	–	–	–

Non-reserved deposits: Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	125	123	126	126	125
exploited	6	7	8	8	8
Total mineral *reserves, ths m^3	693,532	692,192	692,731	699,271	702,492
economic explored reserves	63,622	63,609	65,612	59,718	60,097
economic prospected reserves	523,057	521,313	519,845	517,213	516,945
potentially economic reserves	106,853	107,270	107,274	122,340	125,450
exploitable reserves	10,514	10,697	10,654	11,026	12,554
Mine production in non-reserved deposits, ths m^3 [a)]	301	404	411	448	256

** See <u>NOTE</u> in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

[a)] estimate

5. Foreign trade

690410 – Building bricks

		2019	2020	2021	2022	2023
Import	ths pcs	17,304	14,568	22,592	20,835	12,352
Export	ths pcs	15,399	15,606	18,637	16,204	5,551

690410 – Building bricks

		2019	2020	2021	2022	2023
Average import prices	CZK/piece	22.0	21.4	22.2	29.9	29,0
Average export prices	CZK/piece	32.5	35.1	34.8	47.01	52,9

690510 – Roof tiles

		2019	2020	2021	2022	2023
Import	ths pcs	9,395	8,697	13,855	19,314	12,100
Export	ths pcs	9,608	9,979	10,924	17,739	5,849

690510 – Roof tiles

		2019	2020	2021	2022	2023
Average import prices	CZK/piece	18.7	21.2	18.7	16.6	16,3
Average export prices	CZK/piece	18.4	18.8	20.6	22.7	28,9

6. Prices of domestic market

Domestic prices of brick clay and brick products

Product specification	2019	2020	2021	2022	2023
Brick clay; CZK/t	95	95	95	105	110
Full brick; CZK/piece	5.0–9.4	6.5–10	8.9	6.5–11	6.5–15
Honeycomb brick; CZK/piece	10.5–13.0	14	17	12,5–18	12.5–20
Facing bricks; CZK/piece	20–55	22–50	23–53	24–56	26–62
Brick blocks Porotherm; CZK/piece	62–180	71–210	80–250	90–320	90–350
Clay (ground clay bricks for tennis courts); CZK/t	1,550–3,190	1,550–2,950	1,750–2,950	2,300–2,950	2,300–3,50
Roof tiles; CZK/t	25–51	29–55	28–62	35–86	35–95
Ventilating, boundary tile; CZK/t	68–246	269	275	284–312	295–320
Classical shingle tile; CZK/t	9–32	14–35	17–43	19–47	19–50

7. Mining companies in the Czech Republic as of December 31, 2023

Brick clays and related minerals – reserved deposits
Wienerberger Cihlářský průmysl, a.s., Č. Budějovice
HELUZ cihlářský průmysl v.o.s., Dolní Bukovsko
Cihelna Hodonín, s.r.o.
Cihelna Kinský s.r.o., Kostelec n.Orl.
Zlínské cihelny s.r.o.

Brick clays and related minerals – non-reserved deposits
HELUZ cihlářský průmysl v.o.s., Dolní Bukovsko
Wienerberger Cihlářský průmysl, a.s., Č. Budějovice
Ing. Jiří Hercl, cihelna Bratronice, Kyšice

8. World production and world market prices

Global mining of brick clays is not statistically recorded and many states do not monitor it at all. Brick clays are not subject to global trade.

Crushed stone

1. Characteristics and use

The term building stone includes all solid igneous, sedimentary and metamorphic rocks, if their technological properties correspond to the conditions determined according to the purpose of their use. It must have certain physical-mechanical properties which result from its genesis, mineralogical composition, structure, texture, secondary transformations and other characteristics. The rocks are used in the mined state (quarry stone) or mainly in the dressed state (aggregate). The pollutants are faulty, crushed, weathered or altered zones, locations of technologically unsuitable rocks, higher contents of sulphur compounds and amorphous SiO_2 and others.

Reserves

They are extensive and inexhaustible worldwide.

Uses

Building industry.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

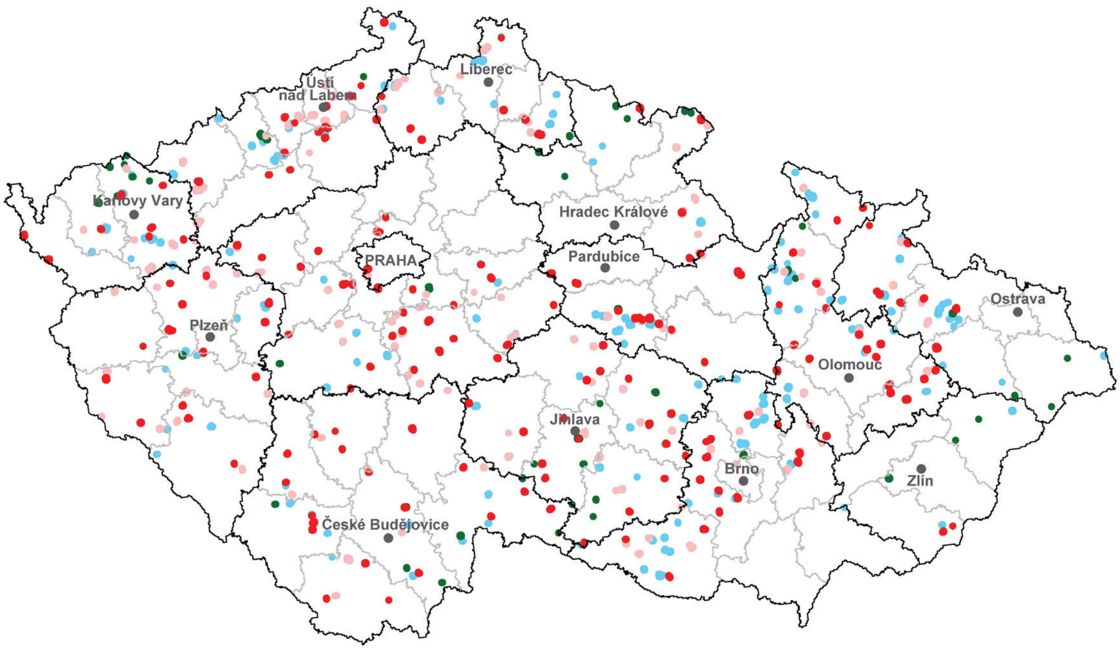
Industrially usable deposits of building stone are widespread throughout the Bohemian Massif, significantly less in its basin areas. In the Western Carpathians, deposits are present only rarely.

- Currently, the most important positions are regionally metamorphosed deposits – they are generally crystalline shales, which are bound exclusively to crystalline complexes of the Bohemian Massif – Moldanubicum, Moravicum, Silesicum, crystalline complex of the Slavkov Forest, West Sudeten, Kutná Hora and Domažlice crystalline complex, South Bohemian and Bory granulite massif, etc. In addition to technologically very suitable rocks (orthogneiss, granulites, amphibolites, serpentines, crystalline limestones, etc.), there are also less suitable rocks (micashists, paragneisses, quartzites). Deposits of contact metamorphosed rocks (hornstones, shales) at the contact of the Central Bohemian and Nasavrky plutons with Algonquian and Paleozoic sediments are of minor importance. Metamorphic (regional and contact) rocks account for about 30% of the total production of crushed stone in the Czech Republic.
- Sedimentary rocks are of constant importance, among which deposits of consolidated clastic sediments (siltstones, greywackes, sandstone, etc.) predominate. The foremost place is occupied by the Kulm greywackes of Nízký Jeseník and Drahanská vrchovina. They also occur in the Proterozoic Barrandian, the Moravian Devonian and the flysch zone of the Carpathians. The share of sedimentary rocks in the total production of crushed rocks in the Czech Republic has recently decreased slightly and currently clastic sedimentary rocks (mainly greywackes) make up around 24–25% of the total production.
- In the recent past, the main source of raw material for the production of crushed stone in the Czech Republic were deposits of flowing rocks. Deposits of paleovolcanics (effusive rocks

of pre-Tertiary age) occur practically only in the Barrandian (consolidated pyroclastics are also suitable here), in the Krkonoše Mts. piedmont basin and the Intra-Sudetic Basin. Sometimes they contain layers of pyroclastics or secondary metamorphosed rocks. Deposits of basic rocks – spilites, diabases, etc. are especially important. The deposits of basic (especially basaltic) rocks are also of the greatest importance within deposits of neovolcanics (effusive rocks of post-Cretaceous age). They are concentrated mainly in the České středohoří Mts. and the Doupov Mountains, less so in the neovolcanic area of the Czech Cretaceous Basin and the Nízký Jeseník Mts. and in the area around Železný Brod. Their share in the total production of crushed aggregate in the Czech Republic has been slightly decreasing in recent years and basic volcanics currently make up about 23–24%.

- Deep igneous deposits are also an important source of crushed stone (especially granite and quartz diorites). Various types of rocks (including vein accompaniment) with suitable technological parameters are mined in many places of the Central Bohemian pluton, the central Moldanubian pluton, the Železné Hory pluton (Nasavrky massif), the Brno massif and other plutonic bodies. Separate deposits of vein rocks are of little importance. Deep igneous rocks account for about 20% of the total production of crushed stone in the Czech Republic.
- Chemogenic and organogenic deposits are represented by carbonates (Barrandian older Paleozoic, Moravian-Silesian Devonian) and silicites (lydites in the Algonquian in the Pilsen area). They account for about 2% of the total production of crushed stone in the Czech Republic.
- A small amount of suitable clays from the overlying Cypris formation in the Sokolov Basin is used for the production of lightweight aggregate (LIAPOR).

3. Registered deposits and other resources of the Czech Republic



reserved deposits – exploited (179)
reserved deposits – unexploited (147)
non-reserved deposits – exploited (49)
non-reserved deposits – unexploited (169)

Because of the large number of crushed stone deposits in the Czech Republic, they are not listed.

4. Basic statistical data of the Czech Republic as of December 31

Reserved deposits: Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	319	320	322	325	326
exploited	176	175	177	178	179
Total mineral *reserves, ths m^3	2,457,253	2,478, 611	2,491,395	2,512,650	2,561,417
economic explored reserves	1,173,441	1,183, 964	1,181,819	1,220,713	1,259,193
economic prospected reserves	1,133, 231	1,142,587	1,157,520	1,142,092	1,152,912
potentially economic reserves	150,581	152,060	152,056	149,845	149,322
exploitable reserves	693,865	703,856	739,016	726,590	760,298
Mine production in reserved deposits, ths m^3	14,057	14,247	14,883	14,883	13,773

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	ths m^3	3,040	3,040	3,040	3,040	3,040
P_2,	ths m^3	–	–	–	–	–
P_3		–	–	–	–	–

Non-reserved deposits: Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	222	215	216	220	218
exploited	47	48	49	48	49
Total mineral *reserves, ths m^3	1,030,196	1,030,658	1,090,666	1,081,742	1,084,167
economic explored reserves	40,544	40,480	41,801	42,592	42,477
economic prospected reserves	911,345	912,416	918,307	908,272	910,812
potentially economic reserves	78,307	77,762	130,558	130,878	130,878
exploitable reserves	52,878	48,268	55,069	57,702	65,456
Mine production in non-reserved deposits, ths m^3 a)	1,449	1,465	1,703	1,805	1,632

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

a) *estimate*

5. Foreign trade

251710 – Pebbles, gravel, broken or crushed stone

		2019	2020	2021	2022	2023
Import	t	1,147,319	1,177,472	1,161,633	1,500,310	1,460,959
Export	t	723,318	355,755	504,742	408,077	314,863

251710 – Pebbles, gravel, broken or crushed stone

		2019	2020	2021	2022	2023
Average import prices	CZK/t	188	205	173	256	277
Average export prices	CZK/t	200	202	180	208	263

6. Prices of domestic market

Domestic prices of crushed stone 2019–2023 – nationwide

Product specification	2019	2020	2021	2022	2023
crushed stone, spilite, fraction 4–8mm, CZK/t	308	334	369	405	534
crushed stone, amphibolite, fraction 4–8 mm, CZK/t	378	386	384	420	548
crushed stone, granite, fraction 4–8 mm, CZK/t	355	353	368	394	515
crushed stone, gneiss, fraction 4–8 mm, CZK/t	341	342	345	418	532
crushed stone, porphyry, fraction 4–8 mm, CZK/t	329	318	355	394	475
crushed stone, granodiorite, fraction 4–8 mm, CZK/t	351	349	376	401	574
crushed stone, greywacke, fraction 4–8 mm, CZK/t	343	376	343	407	563
crushed stone, basalt, fraction 4–8 mm, CZK/t	315	338	365	373	554
crushed stone, hornfels, fraction 4–8 mm, CZK/t	283	307	292	341	558
crushed stone, limestones, fraction 4–8 mm, CZK/t	333	329	375	377	432
crushed stone, spilite, fraction 8–16 mm, CZK/t	285	295	326	342	415
crushed stone, amphibolite, fraction 8–16 mm, CZK/t	298	301	307	343	443
crushed stone, granite, fraction 8–16 mm, CZK/t	266	282	288	318	380
crushed stone, gneiss, fraction 8–16 mm, CZK /t	270	287	276	335	425
crushed stone, porphyry, fraction 8-16 mm, CZK/t	273	264	295	296	358
crushed stone, granodiorites, fraction 8–16 mm, CZK /t	276	293	316	332	425
crushed stone, greywacke, fraction 8–16 mm, CZK /t	288	334	288	312	430
crushed stone, basalt, fraction 8–16 mm, CZK /t	283	310	316	323	422
crushed stone, hornfels, fraction 8–16 mm, CZK /t	268	282	268	300	434
crushed stone, limestones, fraction 8–16 mm, CZK /t	282	289	315	313	415

gneiss: orthogneiss + paragneiss

Average domestic prices of crushed stone in 2023 – by regional units

2023	Průměrné ceny (uvedených) frakcí (Kč/t)																		V územních celcích
Územní celek - kraj	0-4 mm	0-8 mm	0-16 mm	0-32 mm	0-63 mm	0-125 mm	4-8 mm	8-16 mm	8-32 mm	11-22 mm	16-22 mm	16-32 mm	32-63 mm	63-125 mm	netříděný materiál	tříděný materiál	skrývka	na zásypy	
Královéhradecký kraj	335	FN	FN	340	325	250	565	495	FN	470	FN	390	395	325	325	510	FN	100	**371**
Plzeňský kraj	261	FN	FN	275	257	240	446	410	FN	365	387	405	295	265	240	38	100	120	**274**
Středočeský kraj	225	230	FN	268	262	235	590	462	FN	480	FN	430	345	310	300	410	105	100	**317**
Liberecký kraj	220	250	FN	275	298	220	530	440	450	345	420	285	330	315	318	420	100	90	**312**
Pardubický kraj	245	2	FN	283	262	244	535	420	385	410	416	358	294	318	320	400	100	110	**300**
Ústecký kraj	265	185	FN	325	305	280	465	390	285	400	410	380	335	340	335	380	FN	110	**324**
Jihomoravský kraj	235	FN	FN	274	315	238	560	490	FN	395	384	376	345	328	320	440	90	130	**328**
Karlovarský kraj	260	230	242	289	305	264	380	325	375	340	328	289	301	257	235	460	120	130	**285**
Jihočeský kraj	260	242	236	295	310	262	518	420	FN	375	405	387	320	315	280	380	100	120	**307**
Olomoucký kraj	236	263	306	272	270	225	572	441	380	459	FN	415	332	324	318	466	90	130	**323**
Zlínský kraj	FN	220	FN	295	300	290	510	FN	FN	FN	FN	380	358	405	FN	490	FN	100	**335**
Moravskoslezský kraj	352	384	FN	337	326	275	610	485	FN	440	432	463	404	408	320	450	100	140	**370**
Kraj Vysočina	225	275	226	310	284	260	510	421	290	405	390	384	348	332	297	710	90	120	**327**
Kraj hlavní město Praha	265	FN	315	310	295	FN	510	438	FN	FN	430	384	352	380	430	FN	FN	FN	**374**
ČR - celkově	**260**	**228**	**265**	**296**	**294**	**253**	**522**	**434**	**361**	**407**	**400**	**380**	**340**	**330**	**311**	**427**	**100**	**115**	**213**

Explanation: FN – fraction is not produced

7. Mining companies in the Czech Republic as of December 31, 2023

Crushed stone – registered deposits

EUROVIA Kamenolomy a.s.
Českomoravský štěrk a.s.
KAMENOLOMY ČR s.r.o.
KÁMEN Zbraslav a.s.
Kámen a písek s.r.o.
COLAS CZ a.s.
M - SILNICE a.s.
GRANITA s.r.o.
Basalt CZ s.r.o.
Basalt s.r.o.
Kámen Brno s.r.o.
Lom Klecany s.r.o.
BERGER SUROVINY s.r.o.
CEMEX Sand k.s.
RENO Šumava a.s.
BES s.r.o.
ZAPA beton a.s.
Rosa s.r.o.
CEMEX Sand k.s.
Silnice Čáslav - Holding a.s
C4SC78 s.r.o.
SHB s.r.o.
Žula Rácov s.r.o.
LOMY MOŘINA s.r.o.
Ludvík Novák
Českomoravský cement a.s.
Skanska a.s.
BISA s.r.o.
LOM DEŠTNO a.s.
Kalivoda DC s.r.o.
Hutira – Omice s.r.o.
Kamenolom Číměř s.r.o.
ERB invest s.r.o.
Froněk s.r.o.
LOM HAMR s.r.o.
Moravské kamenolomy s.r.o. Froněk s.r.o.
ZD Šonov u Broumova
PEDOP s.r.o.
František Matlák
FORTEX STAVBY s.r.o.
EKOZIS s.r.o.
KARETA s.r.o.
DOLESA s. r. o.
Kozákov – družstvo
Madest s.r.o.
LB s.r.o.
HERLIN s.r.o
RESTA DAKON s.r.o.
Stavební recyklace s.r.o
GRANITES s.r.o.
GRANIO s.r.o.
Kamenolom KUBO s.r.o.
Lom Drahenický Málkov s.r.o.
SATES ČECHY s.r.o.
Quarzit Quarry a.s.

UNIKOM a.s.
Daosz s.r.o.
NATRIX a.s.
Pavel Dragoun

Crushed stone – non–registered deposits
COLAS CZ a.s.
Silnice Morava s.r.o.
Českomoravský štěrk a.s.
EUROVIA Kamenolomy a.s.
Kámen a písek s.r.o.
KAMENOLOMY ČR s.r.o.
Sokolovská uhelná p.n. a.s.
SP Bohemia k.s.
GRANITA Lomy s.r.o.
Žula s.r.o.
Basalt s.r.o.
KÁMEN Zbraslav a.s.
Moravské kamenolomy s.r.o.
RENO Šumava a.s.
ZETKA Strážník a.s.
ZAPA beton a.s.
KÁMEN Zbraslav a.s.
TS služby s.r.o.
LOM DEŠTNO a.s.
ZUD a.s.
Ligranit a.s.
Stavoka Kosice a.s.
Stavební recyklace s.r.o.
SENECO s.r.o.
Kalcit s.r.o.
Obec Hošťálková
Vojenské lesy a statky ČR s.p.
Lom Kozárovice a.s.
LB s.r.o.
Lesostavby Frýdek-Místek a.s.
UNI-STONE JÁCHYMOV s.r.o.
Kamenolom Žlutava s.r.o.
EKOZIS s.r.o.
Lesy České republiky s.p.
Jihočeské katolické lesy s.r.o.
Lesní družstvo obcí
Silnice Čáslav-Holding a.s.

8. World production and world market prices

Mine production of the crushed stone is frequently reported together with sand and gravel under the term aggregates.

Crushed stone prices are not formed on the international market. Neither indicative regional prices are quoted.

European production of building stone + gravel sands

	2019	2020	2021	2022	2023
European production of building stone + gravel (WMP), mill. tonnes	2,444	2,446	2,520	2,437	N

Dimension stone

1. Characteristics and use

The raw materials are all types of solid rocks of magmatic, sedimentary and metamorphic origin, which are block workable and their properties are suitable either for rough stone production (curbs, paving blocks, building blocks, etc.) or for noble production (stonework, stone sculptures and special works). The decisive factors for rough production include the mineralogical-petrographic composition, physical-mechanical properties, structure, texture, blockiness, secondary transformations and more. In the case of raw materials for noble production, the appearance, colour, polishability and durability of the rock are evaluated. Negative properties include weathering and secondary transformations, crushed zones, intercalations of unsuitable rocks, etc.

Reserves

They are extensive worldwide.

Uses

In construction, stonework and sculpture.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

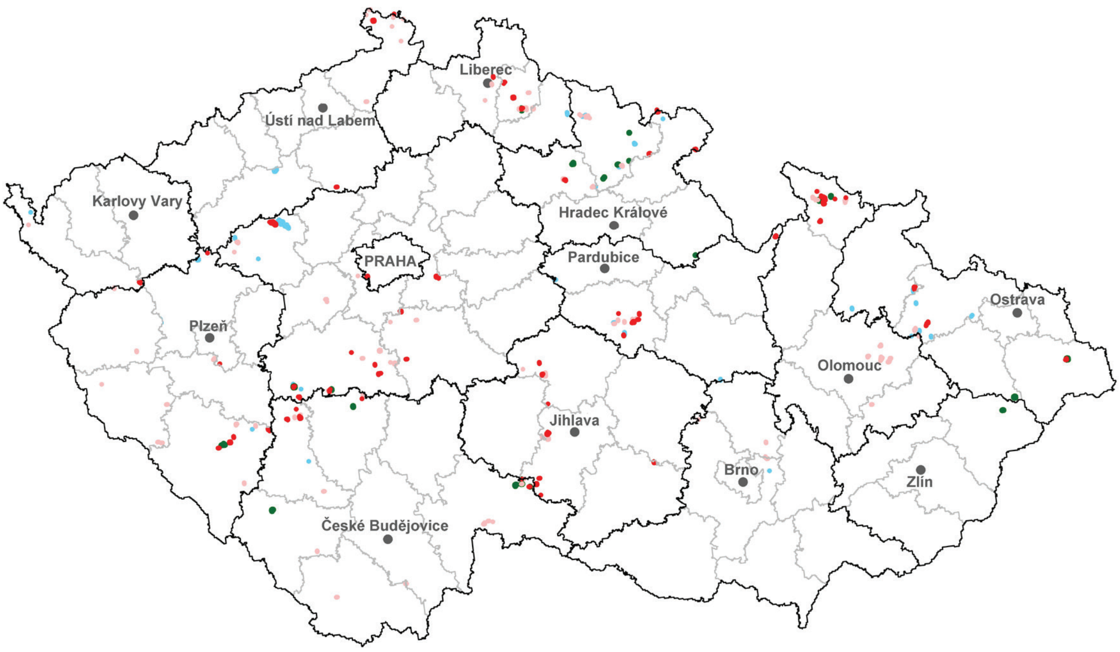
2. Mineral resources of the Czech Republic

At present, deep igneous rocks (especially granitoid rocks) are the most widely used in the Czech Republic as a stone for rough and noble stonemasonry production, which have long accounted for approximately 85–90% of the volume of mined reserved deposits. They have a more than 50% share in the total geological reserves. These rocks account for about 85% of total mining at reserved deposits and for about 60–70% of total mining at non-reserved deposits. Roughly 10% of the extraction from reserved deposits is occupied by sandstones, in the case of non-reserved deposits it is around 30% of the extraction volume. The proportion of marbles is low – around 1 to 2%.

- For rough stone production (cubes, curbs, bollards, stairs, plinths, etc.) mainly deep igneous rocks were and are used; other rocks (columnar basalts, vein rocks) were and are used much less. The deposits are, similarly to the building stone, bound to the Central Bohemian and Moldanubian pluton, the Nasavrky massif, or other plutonic bodies of the Bohemian massif (Štěnovice massif, Žulová pluton, Čistá-Jesenice massif, etc.).
- Deep igneous rocks and marble are the most used for noble production. The most used are the light rocks – granites and granite-diorites, which occur in Bohemia in the Central Bohemian and Central Moldanubian pluton, in the Štěnovice, Krkonoše-Jizera, Čistá-Jesenice and Nasavky massifs and in Moravia in the Třebíč and Žulová massifs. Dark igneous rocks are of minor importance – diabases, diorites and gabbro, which are bound to the basic bodies of the Central Bohemian pluton, the Kdyně and Lusatian massifs, etc. These rocks are used for tiling (including polished tiling), paving, monuments and in stone sculpture.
- Neovolcanics are not very suitable, with the exception of some trachytes of the Central Bohemian Uplands and the Doupov Mountains, which are used in sculpture and for cut tiles.

- Of the sedimentary rocks, sandstone and arkose are of great importance. In Bohemia, these are the Cenomanian sandstones from the eastern surroundings of Prague, Hořice and Broumov. Less significant are the Triassic and red Permian sandstones from the foothills of the Giant Mountains. In Moravia, these are Cretaceous Těšín sandstones, or also the red Perm sandstones of the Tišnov region. Sandstones are used for the production of cut and ground tiles. The Devonian limestones of the Barrandien and the Moravian Karst are equally popular raw materials for their versatile range of uses (cladding material, conglomerates, terrazzo, etc.). Pleistocene travertines were mined in the Přerov region for internal cladding, terraces and conglomerates. The shales of the Moravian-Silesian Paleozoic are used as cladding, covering and paving material, expandites and fillers. Kulm greywackes were often used for rough stonemasonry (cubes, curbs).
- Of the metamorphic rocks, crystalline limestones and dolomites (marbles) are the most used – for polished tiles, paving, terrazzo, conglomerates and in sculpture. They occur abundantly in the Bohemian Forest and Czech branches of the Moldanubian, Krkonoše-Jizera and Orlicko-Kladsko crystalline complex, Svratka anticline, Silesicum, in the Branná formation (Silesia). The phyllites of the Proterozoic of Western Bohemia (the Střela Valley) and the Železný Brod crystalline complex, as well as the slate curling iron in northern Moravia and Silesia, are used as roofing and cladding (the waste is used as a filler). Serpentines mined in Moravia and western Bohemia were and are still used.

3. Registered deposits and other resources of the Czech Republic



- reserved deposits – exploited (52)
- reserved deposits – unexploited (106)
- non-reserved deposits – exploited (19)
- non-reserved deposits – unexploited (48)

There are many registered dimension stone deposits in the Czech Republic and therefore they are not listed.

4. Basic statistical data of the Czech Republic as of December 31

Reserved deposits: Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	158	158	158	157	158
exploited	63	64	54	55	52
Total mineral *reserves, ths m^3	181,383	184,236	182,835	183,139	182,786
economic explored reserves	77,511	78,320	78,031	77,729	77,678
economic prospected reserves	64,380	66,427	65,753	66,300	65, 998
potentially economic reserves	39,492	39,489	39,051	39,110	39,110
exploitable reserves	77,407	108,505	79,798	85,108	82,771
Mine production in reserved deposits, ths m^3	117	135	125	112	118

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	ths m^3	3 026	3 026	3 026	3 026	3 026
P_2,	ths m^3	–	–	–	–	–
P_3		–	–	–	–	–

Non-reserved deposits: Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	69	69	70	69	67
exploited	21	21	21	19	19
Total mineral *reserves, ths m^3	33,250	26,096	26,520	26 285	26,251
economic explored reserves	2,152	2,132	2,101	2 039	2,039
economic prospected reserves	28,124	21,008	21,463	21 290	21,256
potentially economic reserves	2,956	2,956	2,956	2 956	2,956
exploitable reserves	1,192	1,875	1,931	4 585	6,401
Mine production in non-reserved deposits, ths m^3 [a)]	16	47	62	32	35

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

[a)] *estimate*

5. Foreign trade

2514 – Slate, also rougly worked or cut

		2019	2020	2021	2022	2023
Import	t	12,328	10,311	12,215	8,903	10,950
Export	t	7,476	7,066	9,477	4,372	4,688

2514 – Slate, also rougly worked or cut

		2019	2020	2021	2022	2023
Average import prices	CZK/t	1,391	1,260	1,354	1,499	1,519
Average export prices	CZK/t	1,118	1,088	1,329	1,348	1,023

2515 – Marble, travertine, ecaussine and other calcareous stone

		2019	2020	2021	2022	2023
Import	t	4,509	5,198	5,513	4,770	4,607
Export	t	23	39	24	1	1

2515 – Marble, travertine, ecaussine and other calcareous stone

		2019	2020	2021	2022	2023
Average import prices	CZK/t	8,956	8,989	8,384	8,007	10,809
Average export prices	CZK/t	37,815	48,627	76,749	62,308	67,524

2516 – Granite, porphyry, basalt, sandstone and other stone

		2019	2020	2021	2022	2023
Import	t	10,163	5,344	5,019	9,692	11,013
Export	t	3,498	2,880	3,339	1,654	1,627

2516 – Granite, porphyry, basalt, sandstone and other stone

		2019	2020	2021	2022	2023
Average import prices	CZK/t	7,267	8,563	11,020	6,503	5,671
Average export prices	CZK/t	4,070	4,245	5,365	3,581	1,877

6801 – Setts, curbstones and flagstones of natural stone (except slate)

		2019	2020	2021	2022	2023
Import	t	22,079	20,859	29,325	37,981	37,337
Export	t	31,731	33,823	34,981	23,156	16,316

6801 – Setts, curbstones and flagstones of natural stone (except slate)

		2019	2020	2021	2022	2023
Average import prices	CZK/t	2,189	2,479	2,533	2,648	2,395
Average export prices	CZK/t	2,367	2,554	2,455	2,930	2,866

6802 – Worked monumental and crushed stone (except slate) and stonework

		2019	2020	2021	2022	2023
Import	t	27,301	25,392	26,962	33,015	30,091
Export	t	29,279	51,707	71,629	59,709	47,791

6802 – Worked monumental and crushed stone (except slate) and stonework

		2019	2020	2021	2022	2023
Average import prices	CZK/t	14,530	14,783	16,983	18,092	16,845
Average export prices	CZK/t	6,253	4,727	4,088	5,456	5,165

6803 – Worked slate and articles of slate or of agglomerated slate

		2019	2020	2021	2022	2023
Import	t	1,976	1,817	1,482	1,870	975
Export	t	79	90	133	79	41

6803 – Worked slate and articles of slate or of agglomerated slate

		2019	2020	2021	2022	2023
Average import prices	CZK/t	21,318	19,505	34,521	28,407	29,535
Average export prices	CZK/t	150,651	135,629	147,490	211,015	181,073

6. Prices of domestic market

Product specification			Unit	2019	2020	2021	2022	2023
greyish blue Hlinec granite	cobblestones		CZK/t	2,150–2,600	2,250–2,800	2,250–2,800	2,680–4,200	2 800–4 400
	margin stones		CZK/bm	320–450	340–450	340–450	450–550	520–620
	cleaved prisms		CZK/m^2	2,100	2,100	2,100	2,500	2 500
	curbstones		CZK/bm	1,000–1,200	1,000–1,200	1,000–1,200	1,000–1,300	1 000–1 300
	slabs	polished, thickness 2–8 cm	CZK /m^2	1,800–3,800	1,800–3,800	1,800–3,800	2,000–4,200	2 150–4300
		emery grounded, thickness 2–8 cm	CZK /m^2	1,600–3,600	1,600–3,600	1,600–3,600	1,800–4,000	1 850–4 200
		sand blasted finish, thickness 2–8 cm	CZK /m^2	1,400–1,200	1,400–1,200	1,400–1,200	1,500–1,800	1 600–1 900
		formatted suitable as pavement, thickness 3 cm	CZK /m^2	1,560–2,260	1,560–2,260	1,560–2,260	1,650–2,500	1 700–2 650
Granite Kozárvice Chlum Řečice		cobblestones 18/18–4/6	CZK/t	2,000–2,500	2,600	2,800	3,200	3 350
		curbstones 10/20/40–20/10/40	CZK/t	2,500	2,500–2,800	3,000	3,500	3 600
		margin stones	CZK/t	350	350	350	400	460
		blocks 0.5–0.99 to 2.0–2.49 m^3	CZK /m^3	5,500–7,600	5,500–7,600	5,500–7,600	6,000–8,500	6 200–8 700
		blocks 2.5–2.99 to 4.0–5.0 m^3	CZK /m^3	8,500–9,500	8,500–9,500	8,500–9,500	8,700–10,000	8 750–10 500
light Silesian granite	cobblestones		CZK/t	1,900–3,000	2,400–3,000	2,450–2,750	1,800–3,100	3 200–3400
	margin stones		CZK/bm	300–369	400–450	500–520	2,000–3,500	700–800
	cleaved prisms		CZK/m^2	1,650	2,000	2,200	2,400–4,000	2 550
Mrákotín type granite – pavement slabs		sand blasted finish, thickness 2–8 cm	CZK/m^2	1,320–2,500	1,500–2,600	1,600–2,750	1,800–3,100	1 900–3 300
		emery grounded, thickness 2–8 cm	CZK/m^2	1,600–2,500	1,700–2,850	1,750–3,000	2,000–3,500	2 200–3 700
		polished, thickness 2–8 cm	CZK/m^2	2,000– 3,200	2,100–3,200	2,200–3,350	2,400–4,000	2 500–4 200
granite blocks			Kč/m^3	<1,5 m^3 = 8,000 >1,5 m^3 = 10,000	<1,5 m^3 = 8 500 >1,5 m^3 = 11,000	<1,5 m^3 = 8,700 >1,5 m^3 = 11,500	<1,5 m^3 = 9,000 >1,5 m^3 = 12,000	<1,5 m^3 = 9 500 >1,5 m^3 =12 500
sandstone – cut slabs	thickness 5 cm		CZK/m^2	1,000–1,930	1,000–1,930	1,000–1,930	1,200– 2,200	1 300–2 350
	thickness 10 cm		CZK/m^2	2,770–3,410	2,770–3,410	2,770–3,410	3,000–3,600	3 200–3 800
	thickness 15 cm		CZK/m^2	4,190–5,180	4,190–5,180	4,190–5,180	4,300–5,400	4 500–5 450
marble – pavement	cut	Supíkovice marble	CZK/m^2	280–1,100	320–1,200	350–1,300	450–1,500	500–1 600
		Lipová marble	CZK/m^2	280–1,190	340–1,250	360–1,300	450–1,500	500–1 600
	smoothed	Supíkovice marble	CZK/m^2	360–1,240	380–1,300	380–1,300	450–1,500	500–1 600
		Lipová marble	CZK/m^2	360–1,350	380–1,400	380–1,400	450–1,500	500–1 600
	polished	Supíkovice marble	CZK/m^2	390–1,280	420–1,300	420–1,300	550–1,600	600–1 700
		Lipová marble	CZK/m^2	390–1,390	420–1,450	420–1,450	550–1,600	600–1 700
basalt	column 131–160 cm	quarry Soutěsky	Kč/t	5,000	–	–	–	–
	paving thick 2 cm	quarry Soutěsky	Kč/m^2	650	–	–	–	–
	paving thick 10 cm	quarry Soutěsky	Kč/m^2	750	–	–	–	–

Notice: bm (běžný metr) – running metre

7. Mining companies in the Czech Republic as of December 31, 2023

Dimension stone – reserved deposits
Slezské kamenolomy a.s.
MEDIGRAN s.r.o.
Granit Lipnice s.r.o.
Průmysl kamene a.s.
Plzeňská žula a.s.
HERLIN s.r.o.
Josef Máca
SATES ČECHY s.r.o.
RESTA DAKON s.r.o.
ČESKÁ ŽULA s.r.o.
Ligranit a.s.
GRANIT-ZACH s.r.o.
ABAKRON s.r.o.
GRANITES s.r.o.
LOM DEŠTNO a.s.
Třebocký lom CZ s.r.o.
Těžba nerostů a.s.
KÁMEN OSTROMĚŘ s.r.o.
KAVEX - Granit Holding a.s.
Lom Matula Hlinsko a.s.
Granit Zedníček s.r.o.
NATRIX a.s.
Kámen Hudčice s.r.o
Důl Svatoňovice a.s.
GRANIO s.r.o.
Lom Drahenický Málkov s.r.o.
Kamenoprůmysl. závody s.r.o.
Lom Žernovka s.r.o.
Krákorka a.s.
M. & H. Granit s.r.o.
Veristulos s.r.o.

Dimension stone – non-reserved deposits
RSATES ČECHY s.r.o.
Cernin s.r.o.
PROFISTAV Litomyšl a.s.
Žula s.r.o.
Josef Máca
Lom Horní Dvorce s.r.o.
WÜHNANOFF s.r.o.
Jiří Sršeň
Dubenecký pískovec s.r.o.
SPONGILIT PP s.r.o.
Kamenolom Javorka s.r.o.
KOKAM s.r.o.

8. World production and world market prices

GGlobal mining of decorative stone is not statistically recorded and many states do not monitor it at all. The most important producer of dimension stone in Europe is Italy, in the world it is the US, Brazil, and China.

Decorative stone is traded worldwide at prices according to company price lists. The prices of decorative stone depend on the quality and colour of the rock and the degree of processing. Some idea can be gained from the price level in the US market (Source USGS, 2024):

Dimension stone sold or used in the US in 2022, classification by types

	Amount, t	Value, ths USD	Average price, USD/t
Granite	491,000	102,000	208
Limestone	1,170,000	197,000	168
Marble	57,900	23,000	397
Sandstone	385,000	39,900	104
Slate	25,500	14,000	549
Other types of stone	250,000	46,000	184

Dimension stone export from the US in 2022, classification by types

	Amount, ths t	Value, ths USD	Average value, USD/t	Main destination, by value
Marble, travertine, alabaster worked (further worked than simply cut with a flat surface)	78	10,200	131	Canada, 44%
Marble, travertine, crude or roughly trimmed	5	4,590	918	Italy, 74%
Marble, travertine, merely cut, by sawing or otherwise (blocks or slabs)	5	3,440	688	Canada, 72%
Granite, crude or roughly trimmed	17	5,880	346	China, 42%
Granite, merely cut, by sawing or otherwise (blocks or slabs)	18	6,610	367	Canada, 81%
Slate, worked and articles of slate	3	4,200	1,400	Canada, 44%
Slate, whether or not roughly trimmed or merely cut (blocks or slabs)	6	288	48	Canada, 76%
Other calcareous, memorial, or building stone; alabaster (other than marble and travertine; crude, roughly cut or simply cut into blocks or slabs)	11	6,250	568	Canada, 96%
Other monumental or building stone (other than calcareous stone and alabaster, granite, sandstone, slate, dolomite, quartzite, and steatite; crude, roughly trimmed or merely cut into blocks or slabs)	18	6,960	387	Canada, 78%

Dimension stone import in the US in 2022, classification by types

		Amount, ths t	Value, ths USD	Average value, USD/t or USD/mill.ft^2	Main source by value
Marble and alabaster (simply cut with a flat surface)	tonnes	62 700	56 500	901	Italy, 23%
Roofing slate	mill ft^2	1 170 000	16 800	14	Spain, 59%
Roughly trimmed or simply cut slate (rectangular blocks or slabs)	mill ft^2	4 280	2 530	591	India, 58%
Worked slate and articles of slate products and other products (other than roofing products, including agglomerated slate)	mill ft^2	73 400	41 600	567	China, 34%
Travertine, monumental or building stone and products thereof (simply cut with a flat surface, other than tiles and granules)	mill ft^2	22 500	12 400	551	Italy, 42%
Travertine, worked monumental or building stone (dressed or polished but not further worked)	mill ft^2	15 100	11 500	762	Turkey, 45%

Note: ft^2 – square foot; 1 ft^2 = 0.092903 m^2

Salient statistics USA – dimension stone sold or used by producers

Year	2019	2020	2021	2022	2023^e
Tonnage (kt)	2,520	2,130	2,330	2,500	2 380
Value (mill USD)	415	414	466	520	421
Imports for consumption (mill USD)	1,890	1,750	2,200	2,400	2 320
Exports (mill USD)	59	47	47	49	48
Price	**Variable, depending on type or product**				
Granite only, sold or used by producers					
Tonnage (kt)	430	436	464	470	491
Value (mill USD)	105	110	128	130	102
Imports for consumption (mill USD)	913	859	900	902	880
Exports (mill USD)	17	13	12	13	13
Price	**Variable, depending on type or product**				

e – preliminary values
Source: MCS

Sand and gravel

1. Characteristics and use

Sand and gravel (sometimes called gravel sand) is a mixture of gravel and sand and it is one of the most important raw materials in the building materials industry. It consists of unconsolidated sediments, formed by drift and sedimentation of more or less processed fragments (sand e.g. 0.063 to 2 mm, gravel e.g. 2 to 128 mm) originating from rocks disintegrated by weathering. In their composition, boulders of resistant rocks and minerals (quartz, feldspar, quartzite, lydite, granite, etc.) predominate over the less resistant ones (most crystalline and sedimentary rocks). A mixture of silt and clay is added to them. The main pollutants include humus, clay layers, higher contents of washable particles and sulphur, high contents of unsuitable or weathered grains. Furthermore, opal, chalcedony, hornstone and diatomite – aqueous silicon compounds react with feldspar alkalis to form a silica gel, which absorbs water and causes concrete to crack.

Reserves

They are extensive and inexhaustible worldwide.

Uses

The main use of gravel and sand is given by the size and shape of the grains, the type and structure of the rocks and minerals that make it up. Gravel and sand and gravel are most often used as natural aggregates in construction – for concrete mixtures, drainage and filtration layers, backfills and road stabilisation. Sand is mainly used in construction in mortar and concrete mixtures, as grog in the production of bricks, for plasters, as a filler for excavated spaces, etc.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023– no

2. Mineral resources of the Czech Republic

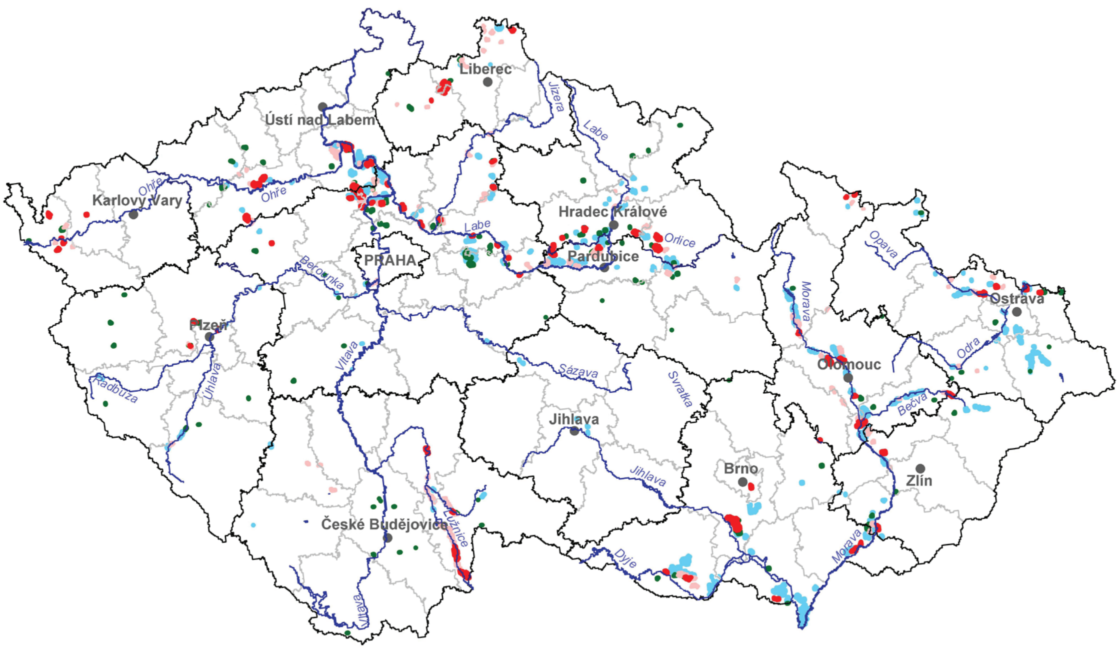
In the Czech Republic, the vast majority of deposits are of Quaternary origin, namely of fluvial origin, much less represented are the deposits of fluviolacustrinal, glacifluvial, glacilacustrinal and aeolian origin. Industrially usable deposits are concentrated mainly in the catchment area of larger rivers.

- The Elbe River Basin – deposits mainly in the right-bank part of the middle course (significant area for Central and Eastern Bohemia) and in the lower course of the Elbe are characterised by well-worked boulders, fluctuations in the ratio of gravel and sand and suitability for concrete-making purposes. There are also significant accumulations in the Orlice and Ohře river basins, the lower reaches of the Cidlina and Jizera rivers and the middle course of the Ploučnice. For concrete-making purposes, the raw material generally requires treatment (washing, sorting).
- The Vltava River Basin – the lower courses of the Vltava and Berounka rivers are important in terms of deposits, but conflicts of interest are frequent. The main deposit area of southern Bohemia are the upper and middle courses of the Lužnice River. The right bank of the Nežárka river is also a promising area.

- The Morava River Basin – on the upper and middle courses of the Morava River, there are accumulations of gravel and sand with a predominance of the coarse fraction; they are suitable to be used in concretes after treatment. Smaller-grained fractions are increasing in the Upper Moravian gorge. The reserves are tied to the valley floodplain, the raw material is suitable for road construction and as mortar sands. An important area for gravel and sand in South Moravia are the middle and lower courses of the river Dyje and its tributaries, especially in the Dyje-Svratka valley basing and in the vicinity of Brno (Svitava, Svratka).
- The Odra River Basin – gravel and sand of the middle reache of the Opava and its confluence with the Odra are important. In terms of quality, the raw material is suitable for road shoulder reinforcement and stabilisation.

Glacigenic deposits in northern Bohemia (Frýdlant area), and the areas around Ostrava and Opava are of minor importance. The aeolian sands of the Elbe and southern Moravia are mainly used for mortar purposes. The proluvial sediments of northern Bohemia, Ostrava, Olomouc, etc are only of local significance. Facially variable Tertiary sands are used somewhat more frequently, e.g. in the Cheb region, in the area of the North Bohemian and South Bohemian basins, or in the area around Pilsen (mortar sands) and especially in Moravia (e.g. Prostějov area, Opava area). Weathered Czech and Moravian Cretaceous sandstones and sands from kaolin floating plants are used for construction purposes.

3. Registered deposits and other resources of the Czech Republic



reserved deposits – exploited (65)
reserved deposits – unexploited (139)
non-reserved deposits – exploited (95)
non-reserved deposits – unexploited (229)

Because of their large number, deposits of sand and gravel are not listed.

4. Basic statistical data of the Czech Republic as of December 31

Reserved deposits: Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	205	204	203	203	204
exploited	65	63	64	63	65
Total mineral *reserves, ths m^3	2,118,240	2,109,426	2,100,932	2,093,692	2,139,265
economic explored reserves	1,073,155	1,066,585	1,076,839	1,072,133	1,085,562
economic prospected reserves	803,566	801,125	782,356	778,692	814,009
potentially economic reserves	241,519	241,716	241,737	242,867	239,694
exploitable reserves	397,770	400,093	555,455	567,049	547,606
Mine production in reserved deposits, ths m^3	6,204	6,476	6,602	6,739	5,912

* *See NOTE in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	ths m^3	149,027	149,027	149,027	149,027	149,027
P_2,	ths m^3	946,239	946,239	946,239	946,239	946,239
P_3		–	–	–	–	–

Non-reserved deposits: Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	343	339	332	328	324
exploited	92	93	94	93	95
Total mineral *reserves, ths m^3	2,071,278	2,080,395	2,076,102	2,077,863	2,078,067
economic explored reserves	104,040	104,479	104,150	104,067	103,784
economic prospected reserves	1,731,561	1,740,272	1,736,587	1,737,672	1,740,286
potentially economic reserves	235,677	235,644	235,365	236,124	233,997
exploitable reserves	55,169	59,751	60,123	71,638	100,756
Mine production in non-reserved deposits, ths m^3 [a)]	4,897	4,821	5,270	5,046	4,409

* *See NOTE in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

a) estimate

5. Foreign trade

250590 – Other sand (natural sand of all kinds, also coloured, except sand containing metals and except silica sand and quartz sand)

		2019	2020	2021	2022	2023
Import	kt	131,022	159,963	153,723	104,900	57,266
Export	kt	6,227	9,011	1,534	1,246	1,270

250590 – Other sand (natural sand of all kinds, also coloured, except sand containing metals and except silica sand and quartz sand)

		2019	2020	2021	2022	2023
Average import prices	CZK/t	491	352	382	565	1,032
Average export prices	CZK/t	387	1,557	10,785	9,313	1,171

6. Prices of domestic market

We present the average prices of gravel sands according to the price lists of mining organizations, without taking into account qualitative parameters.

Average domestic prices of sand and gravel in 2023 – by regional units

2023	Average prices of (listed) fractions (CZK/t)																		in regions
REGION	0-1 mm	0-2 mm	0-4 mm	0-8 mm	0-16 mm	0-32 mm	0-63 mm	4-8 mm	8-16 mm	8-32 mm	11-22 mm	16-32 mm	22-63 mm	32-63 mm	unsorted material	pit material	over - burden	for backfill	
Hradec Králové	FN	190	182	FN	110	394	417	385	377	FN	434	453	FN	402	148	153	110	115	**276**
Plzeň	150	180	223	135	FN	245	FN	345	390	294	FN	490	345	370	105	FN	80	105	**247**
Central Bohemia	220	254	201	143	FN	307	382	323	342	FN	284	381	FN	375	160	160	90	190	**254**
Liberec	FN	325	242	209	208	180	180	670	641	288	FN	420	FN	300	137	140	90	130	**277**
Pardubice	FN	266	235	260	FN	370	378	430	420	FN	595	470	FN	395	160	130	FN	120	**325**
Ústí nad Labem	160	245	263	215	232	281	268	332	320	FN	405	375	FN	410	175	160	80	100	**251**
South Moravia	FN	224	210	155	180	296	370	363	401	FN	389	428	228	423	232	130	90	130	**266**
Karlovy Vary	FN	228	216	210	213	298	279	324	322	FN	335	438	FN	325	165	130	100	90	**245**
South Bohemia	255	270	330	408	320	310	250	421	445	FN	FN	459	FN	505	140	FN	100	95	**308**
Olomouc	FN	399	310	400	315	290	285	521	468	380	436	495	335	434	155	140	90	140	**329**
Zlín	490	430	440	FN	FN	345	335	568	435	FN	435	530	FN	450	380	FN	FN	FN	**440**
Moravia and Silezia	250	240	346	FN	354	335	325	534	520	FN	432	410	FN	FN	FN	195	95	125	**320**
Vysočina	In this region is not the sand-gravel material produced																		
Prague	In this region is not the sand-gravel material produced																		
Czech Republic - total	**254**	**271**	**267**	**237**	**242**	**304**	**315**	**435**	**423**	**321**	**416**	**446**	**303**	**399**	**178**	**149**	**93**	**122**	**295**

Explanation: FN - fraction is not produced

Average domestic prices of sand and gravel in 2019–2023 (CZK/t)

Region/year	2019	2020	2021	2022	2023
Hradec Králové	162	180	202	251	276
Plzeň	203	217	220	240	247
Central Bohemia	153	184	187	236	254
Liberec	208	202	235	248	277
Pardubice	183	289	269	296	325
Ústí nad Labem	190	220	230	233	251
South Moravia	169	202	204	248	266
Karlovy Vary	180	194	213	234	245
South Bohemia	198	191	216	250	308
Olomouc	233	265	277	319	329
Zlín	273	293	338	406	440
Moravia and Silesia	272	267	263	317	320
Vysočina	Sand and gravel are not mined in this region				
Prague	Sand and gravel are not mined in this region				
Czech Republic total	**202**	**225**	**238**	**273**	**295**

7. Mining companies in the Czech Republic as of December 31, 2023

Sand and gravel – registered deposits
České štěrkopísky s.r.o.
Českomoravský štěrk a.s.
KÁMEN Zbraslav a.s.
LB MINERALS s.r.o.
CEMEX Czech Republic s.r.o.
CEMEX Sand k.s.
Družstvo DRUMAPO
Písky – J. Elsnic s.r.o.
TVARBET Moravia a.s.
Václav Maurer
Městské lesy Hradec Králové a.s
Písek – Beton a.s.
ZAPA beton a.s.
EUROVIA Kamenolomy a.s.
Kinský dal Borgo a.s.
realma-pískovna dolany s.r.o.
Budějovické štěrkopísky s.r.o.
KAMENOLOMY ČR s.r.o.
TAPAS Borek s.r.o.
Pískovna Sojovice s.r.o.
DOBET s.r.o.
Pískovna Černovice s.r.o.
MIROS Pardubice a.s.
NZPK s.r.o.
BS Cost s.r.o
Lubomír Kruncl
Těžba štěrkopísku s.r.o.
ZECHMEISTER s.r.o.
KM Beta Moravia s.r.o.
Ladislav Šeda
Obec Kostomlátky
CEMEX Czech Republic s.r.o .
Oldřich Psotka

Sand and gravel – non-registered deposits
České štěrkopísky s.r.o.
SLOVÁCKÁ TĚŽEBNÍ s.r.o.

CEMEX Sand k.s.
Vltavské štěrkopísky s.r.o.
ZEPIKO s.r.o.
Písek Žabčice s.r.o.
Písník Kinský s.r.o
LIKOD s.r.o.
Severočeské pískovny a štěrkovny s.r.o.
Moravia Tech a.s.
DRACAR OLOMOUC s.r.o.
REALMA-PÍSKOVNA DOLANY s.r.o.
Hradecký písek a.s.
Pískovna Mistřín s.r.o.
Rovina Písek a.s.
ZS Kratonohy a.s.
Sušárna a.s. Kratonohy
SPONGILIT PP s.r.o.
Farma U Jezera s.r.o.
KAMENOLOMY ČR s.r.o.
Pískovna Pohořelice s.r.o.
Technické služby CZ s.r.o.
ZAPA beton a.s.
Písky – Skviřín s.r.o.
STAVOKA Hradec Králové a.s.
M&M Dresler s.r.o.
Vodhosp. stavby Javorník – CZ s.r.o.
ZOD Brniště a.s.
Václav Maurer
MORAS a.s.
realma-pískovna dolany s.r.o.
INTERAGENCIE Business Services s.r.o.
VRAMAT CZ s.r.o.
Ing. Václav Luka
SABIA s.r.o.
Pískovna Klíčany HBH s.r.o.
INGEA realizace s.r.o.
Marie Beranová
Impectus s.r.o.
KORA – VODOSTAVING s.r.o.
BEST a.s.
Obecní lesy Bludov s.r.o.
Oldřich Psotka
Jan Holub
Obec Osek nad Bečvou
Očenášek – Mikulkam s.r.o.
Ilona Seidlová
Kateřina Honsová
Obec Rabštejnská Lhota
Václav Merhulík
Vladimír Vilímek
AZS RECYKLACE ODPADU s.r.o.
Technické služby Strakonice s.r.o.
Zemědělské družstvo Kokory

8. World production and world market prices

Sand and gravel extraction is often statistically recorded together with crushed stone extraction under the common term “aggregates”.

Sand and gravel prices are not created in the international market. Indicative and regional prices are also not quoted.

MINERALS CURRENTLY UNMINED IN THE CZECH REPUBLIC

MINERALS MINED IN THE PAST WITH RESOURCES AND RESERVES

ENERGY MINERALS

Lignite

1. Characteristics and use

In Czech terminology, lignite is the least coalified type of brown coal (brown coal hemitype), often with larger or smaller fragments of woods and trunks with distinct annual rings. Its combustion heat ($Q_s^{m,af}$) on an anhydrous ashless basis is less than 17 MJ/kg. The internationally recognised boundary between lignite and brown coal has not been established. Around the world, lignite is mostly included in brown coal, but in the Czech Republic it is reported separately.

Reserves

Worldwide 319,879 million tonnes (BP SRWE 2019 – brown coal and lignite combined), of which 28% Russia, 24% Australia, 11% Germany, 9% USA, 3% Indonesia and 3% Turkey. The EU with its 53,356 million tonnes has a share of 17%, and the largest reserves are found in Germany (68% of the EU and 11% of the world), Poland (11% of the EU and 2% of the world), the Czechia, Greece and Hungary (each of these countries having approximately 5% of EU and 1% of world reserves).

Uses

Lignite is used mainly in the energy industry (electricity and heat production).

Classification as critical raw materials for the European Union

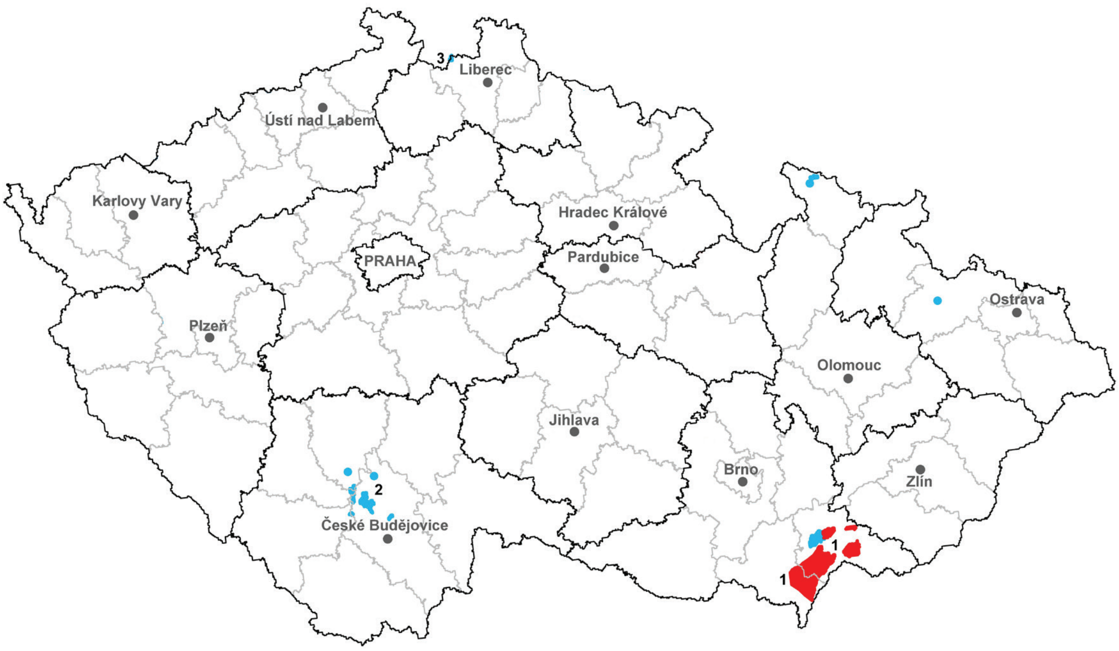
2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

- Significant lignite deposits in the Czech Republic are only at the northern edge of the Vienna Basin, which extends from Austria to southern Moravia. There are two seams in the youngest sediments of Pannonian age. The reserves of the northern Kyjov seam are practically exhausted (the last mine in Šardice was closed at the end of 1992). Since 1994, when mining at the Dubňany deposit was terminated, the reserves of the southern Dubňany seam was mined only in one deep mine – Hodonín-Mikulčice. Its termination was originally expected in 2004, but based on an agreement to extend the contract with ČEZ, mining continued until 2008. Virtually the entire production of this mine was burned at the Hodonín power plant. Economic reserves are reported in four other deposit areas, but their use is not currently being considered. South Moravian lignite is xylodetritic, in places with abundant trunks. It has a high water content from 45 to 49%, ash content A^d varies between 23–26%, the average content of S^d from 1.5 to 2.2% and the calorific value Q_i^r 8 to 10 MJ/kg. In addition, just recently before its mining was terminated, lignite was used for more than just fuel, unfortunately only in small quantities. After crushing and grinding, it was used to produce "teraclean" for soil fertilisation.

- Less significant occurrences of lignite are in the narrow lobular outcrops of the České Budějovice basin. Most of the reserves have been exhausted and the rest are of no economic significance.
- Smaller isolated occurrences of lignite (Miocene) in the Zittau Basin were also largely mined out in the past and the residual reserves are of no economic significance.
- A small occurrence near Uhelná ve Slezsku east of Javorník and in Dolní Životice SW from Opava were also largely mined out in the past.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits exhausted deposits and other resources

Principal areas of deposits presence:

1 Vienna Basin	2 České Budějovice Basin	3 Czech part of the Zittau (Žitava) Basin

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	5	5	5	5	5
exploited	0	0	0	0	0
Total mineral reserves*, kt	997,229	997,229	997,229	997,229	997,229
economic explored reserves	619,652	619,652	619,652	619,652	619,652
economic prospected reserves	229,932	229,932	229,932	229,932	229,932
potentially economic reserves	147,645	147,645	147,645	147,645	147,645
exploitable (recoverable)	1,903	1,903	1,903	1,903	1,903
Mine production, kt	0	0	0	0	0

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

Lignite mining ended in 2009.

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	kt	177,351	177,351	177,351	177,351	177,351
P_2,	kt	37,531	37,531	37,531	37,531	37,531
P_3		–	–	–	–	–

5. Foreign trade

No separate tariff item exists for lignite.

6. Prices of domestic market

There are none

7. Mining companies in the Czech Republic as of December 31, 2023

There are none

8. World production and world market prices

World mine production
Worldwide, lignite production is included in brown coal (lignite) production.

Prices of traded commodities
There are no international market for lignite commodities as lignite is generally not traded outside a producing country.

INDUSTRIAL MINERALS

Barite

1. Characteristics and use

Average Ba content (and its extent) in the earth's crust (ppm)
425 (250–600) Ba

Industrially important minerals
Baryte $BaSO_4$. Barium, which is a crucial component of barite, is primarily bound in igneous rocks, which release it during their weathering and it enters sediments and residues.

Industrially important deposit types
1. Submarine hydrothermal-exhalative: Brooks Range Basin, (Alaska – USA), Mangampeta (India), Gongxi (Hunan – China).
2. Hydrothermal veiny and metasomatic: Silvermines (Ireland), Appalachian Quarter (Canada).

Reserves

2023		
Country	**kt**	**% World**
China	92,000	N
Kazakhstan	85,000	N
India	51,000	N
Iran	38,000	N
Russia	12,000	N
World*	**N**	**N**

** Estimate of the total identified reserves*
Source: MCS 2024

Barite reserves in the EU are known from Spain and Slovakia. Spanish reserves are not published. With their 9.182 kt, Slovakia represents 2.4% of world reserves

Uses
Barite has a wide range of applications due to its properties such as whiteness, high density, chemical resistance, X-ray and gamma ray absorption. It is used in the production of glazes, enamels, paints, special types of glass, plastics, pyrotechnics (signal rockets, detonators, etc.). It also forms part of protective coatings and plasters against X-rays and radioactive radiation, poisons for rodents and insects. The largest amount of barite is used for heavy flushing in exploration and extraction boring, especially for oil and natural gas.

Classification as critical raw materials for the European Union
2011 – no, 2014 – no, 2017 – yes, 2020 – yes, 2023 – yes

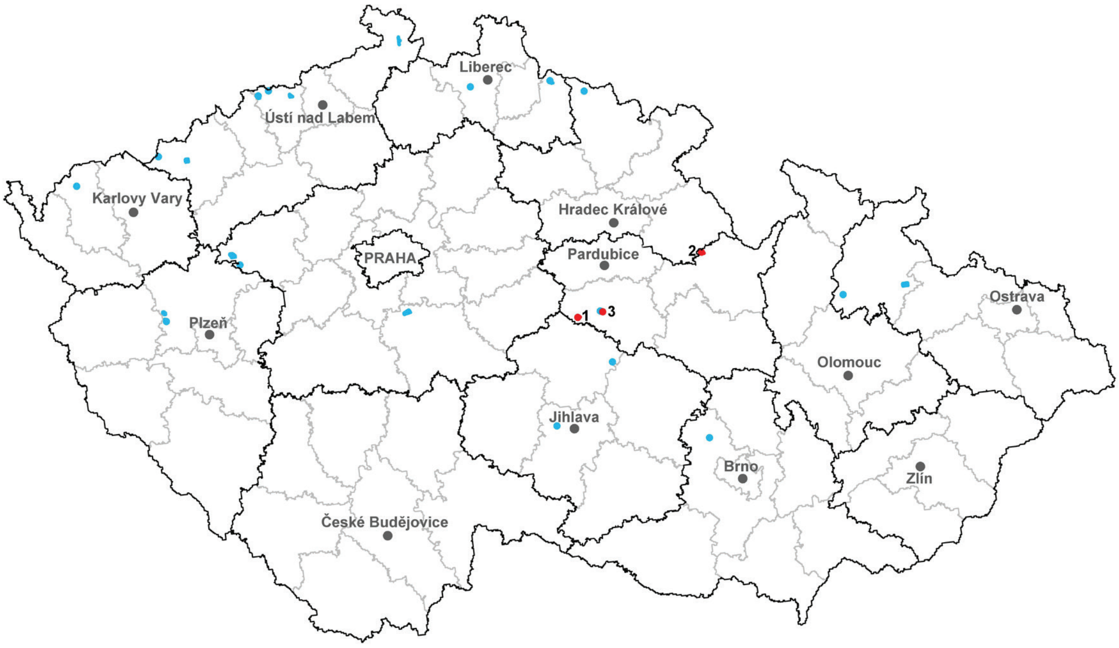
2. Mineral resources of the Czech Republic

The Czech Republic has only smaller deposits and sources of barite. Also, the quality of the raw material is not the highest and ranges on average between 25 and 60% of barite content ($BaSO_4$) as a useful component in individual deposits and resources. Barite deposits in the Czech Republic are of hydrothermal origin, mostly of the veiny or stockwork type, and to a much lesser extent of the metasomatic or stratiform type. They are distributed unevenly in several places in the Bohemian Massif, which is due to the larger number of barite formations of different ages and different deposit types. The most important deposits and sources were in Krušné Hory (the Ore Mountains) (e.g. Kovářská, Mackov, Nakléřov, Moldava-Vápenice), Železné Hory (the Iron Mountains) (e.g. Běstvina, Křižanovice), Krkonoše (the Giant Mountains) (e.g. Harrachov); smaller deposits, resources and occurrences are known from the Jeseníky Mountains (e.g. Horní Benešov), from the Proterozoic of the West (e.g. Pernárec) and Central Bohemia (e.g. Krhanice), Orlické Hory (e.g. Bohousová), the Čistec-Jesenice massif (e.g. Otěvěky), etc.

- Hydrothermal veins in places with polymetallic admixture have a length along the strike varying from tens to hundreds of metres, exceptionally up to 1 km, and thickness from decimetres to several metres, they are characterised by a lenticular and paragraph-like character of the barite filling. They are mostly tied to regional faults, sometimes to lower order faults, mainly in the NW-SE and NNW-SSE direction. The younger polymetallic and the youngest quartz contribution is significant, and it devalues the raw material in the deeper parts (e.g. Mackov, Bohousová). This type includes, for example, the exhausted former Pernarec deposit mined in 1924–1960, as well as deposits, sources and occurrences in Mackov, Bohousová, Nakléřov, etc., where only barite is present or where it strongly predominates. Fluorite is also substantially present in the Běstvina, Moldava, Kovářská, Harrachov, etc. deposits, along with barite. In the Moravicum, the accumulation of barite is known from Květnice near Tišnov, where barite was mined in 1905–1908 and during World War II.
- The stratiform barite type of deposits originated from submarine hydrotherms springing along seabed faults. In the Bohemian Massif, they form layers and lenses in Proterozoic sediments of the islet zone (Krhanice nad Sázavou), the Čistá-Jesenice massif (Čistá, Otěvěky), the Iron Mountains (Křižanovice, Liboměřice) and the Jeseníky Mountains Devonian (Horní Město-Skály, Horní Benešov, where barite was as an accompanying raw material mined 1902–1914 and 1955–1960).

Barite was obtained in the Czech Republic from domestic deposits until 1990 from the Běstvina deposit and until 1991 from the Harrachov deposit. The underground mining significantly prevailed. Resumption of mining is not considered in the near future. The deposits lost their industrial significance, their reserves were gradually re-evaluated and in most cases removed from the Register. Here, as in the case of fluorite, there is plenty of better quality and cheaper raw materials, especially from China.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits   exhausted deposits and other resources

Registered deposits and other resources are not mined

1 Běstvina	2 Bohousová	3 Křižanovice	4 Kovářská

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number [a)]	3	3	3	4	4
exploited	0	0	0	0	0
Total mineral *reserves, kt	1,015	1,015	1,015	1,557	1,557
economic explored reserves	0	0	0	268	268
economic prospected reserves	0	0	0	121	121
potentially economic reserves	1,015	1,015	1,015	1,168	1,168
Mine production, kt	0	0	0	0	0

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

a) Deposits with registered barite reserves

5. Foreign trade

251110 – Natural barium sulphate (barite)

		2019	2020	2021	2022	2023
Import	t	7,972	7,674	7,401	7,047	6,963
Export	t	146	205	272	258	181

251110 – Natural barium sulphate (barite)

		2019	2020	2021	2022	2023
Average import prices	CZK/t	9,953	10,115	10,873	12,177	11,918
Average export prices	CZK/t	15,530	18,017	15,121	16,363	19,204

251120 – Natural barium carbonate (witherite)

		2019	2020	2021	2022	2023
Import	t	0	0	0	0	0
Export	t	0	0	0	0	0

251120 – Natural barium carbonate (witherite)

		2019	2020	2021	2022	2023
Average import prices	CZK/t	–	–	–	–	–
Average export prices	CZK/t	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

World barite production was as follows in recent years:

	2019	2020	2021	2022	2023^e
World mine production of barite (according to MCS), kt	8,870	6,840	6,730	8,260	8,500
World mine production of barite (according to WBD), kt	9,510	7,841	8,358	8,278	N

e – preliminary values

Main producers according to MCS

Country	2023^e	
	kt	%
India	2,700	31.8
China	1,900	22.3
Morocco	1,200	14.1
Kazakhstan	600	7.1
Laos	600	7.1
Iran	300	3.5
Mexico	260	3.1
Turkey	250	2.9
Russia	250	2.9
World	**8,500**	**100.0**

e – preliminary values

Price of traded commodity

Barite is traded in three different quality grades: as a weighting agent in drilling muds and as white paint-grade and chemical-grade barite.

Commodity/Year		2019	2020	2021	2022	2023
Drilling-grade, ground Ex-works US, MCS	USD/t	179	183	167	145	150
Spanish barite, annual average price of imports into the Czech Republic (CZSO)	EUR/t	508	488	546	631	652

Fluorspar

1. Characteristics and use

Average F content (and its extent) in the earth's crust (ppm)

500 (270–800) F

Industrially important minerals

Fluorspar CaF_2 (se 48.9% F), fluorapatite $Ca_5(PO_4)_3F$ (with 3.8% F)

Industrially important deposit types

1. Vein-hydrothermal of various origins: La Cuevas (Mexico), Vergenieg, Buffalo (South Africa), Illinois-Kentucky (USA), Shizhuynan, Shuangijangkou (China).
2. Metasomatic: Amba Dongar (India), Kerio Valley (Kenya), Rio Verde, Potosi (Mexico).
3. Sedimentary phosphates: Baja California (Mexico), Bone Valley (USA), Oulad Abdoun (Morocco).

Reserves

2023		
Country	**kt**	**% World**
Mexico	68,000	24,3
China	67,000	23,9
South Africa	41,000	14,6
Mongolia	34,000	12,1
Spain	15,000	5,4
Iran	4,500	1,6
Vietnam	3,400	1,2
World	**280,000**	**100,0**

Source: MCS 2024

In the EU, fluorite reserves are known from Spain and the United Kingdom. They are not published in the United Kingdom.

Uses

In terms of use and quality requirements, we distinguish three basic types of fluorspar:
(a) metallurgical (min. 85% CaF_2, max. 15% SiO_2)
(b) chemical for the production of hydrofluoric acid (min. 97% CaF_2, up to 1.5% SiO_2, 0.1–0.3% S)
(c) ceramic in the production of glass, enamels, etc. (80–96% CaF_2, up to 3% SiO_2).

More than half of the extracted fluorspar is consumed by the chemical industry for the production of F, HF, NaF and cryolite. It is also widely consumed (approx. 1/3 of its production) in metallurgy of aluminium and steel as a flux reducing the melting temperature. It is further used, for example, in the production of cement, in glassmaking (glass with an admixture of 10–30% CaF_2 is opaque, white and opalescent), in the production of enamels and enamels. Polyfluoropolyhalogenalkanes containing bromine, which are used for the production of special extinguishing agents and anaesthetics, have a special status.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes

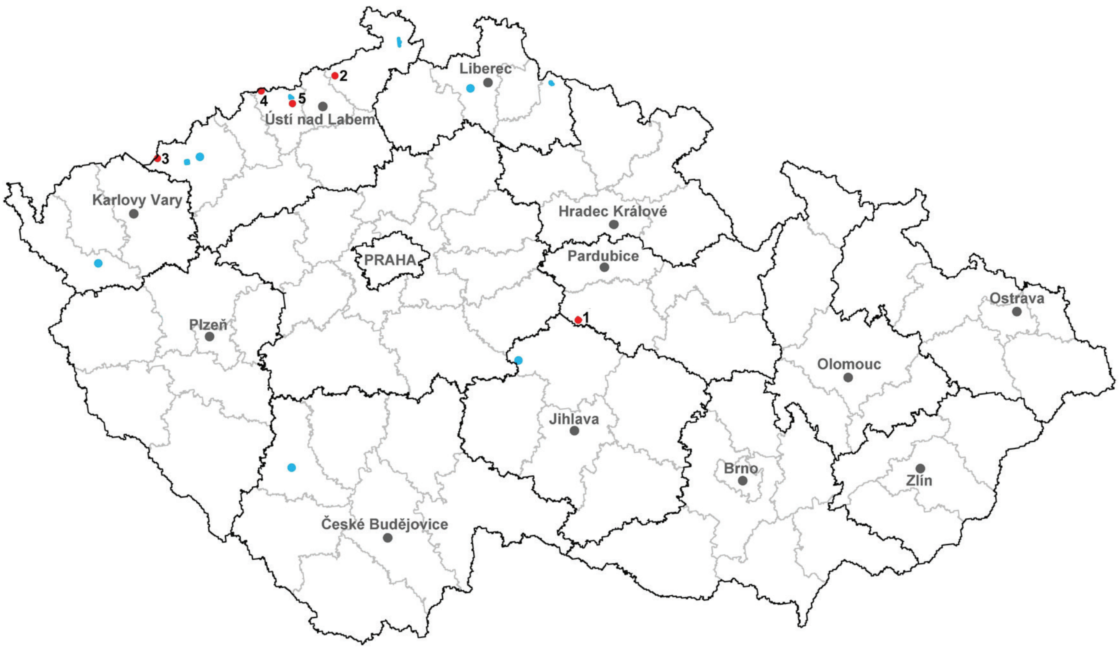
2. Mineral resources of the Czech Republic

The Czech Republic has only smaller deposits and resources of fluorspar. Also, the quality of the raw material is not the highest and ranges on average between 45 and 57% of fluorspar (CaF_2) content as a useful component in individual deposits. All fluorite deposits in the Czech Republic are of hydrothermal origin, venous, stockwork and occasionally also of the impregnation or metasomatic type. They are mostly situated in the peripheral areas of the Bohemian Massif, where they are connected to the deep fault lines of the Ore Mountains (SW – NE) and Elbe-Lusatian direction (NW – SE). The most important deposits and sources are in the Ore Mountains (e.g. Moldava, Kovářská, Krásný Les), and in the Lusatian area of the Czech Cretaceous Basin (Jílové u Děčína-Sněžník) and the Iron Mountains (Běstvina). Smaller sources and occurrences are also found in other places of the Bohemian Massif, e.g. in the Giant Mountains (Harrachov), Ještěd-Kozákov Ridge (Křižany), Slavkovský les (Novina), etc. The only exception among primary hydrothermal deposits is the secondary anthropogenic deposit Proboštov-tailing pond Přítkov, formed by flotation sands after treatment of fluorite ores and concentrates in Sobědruhy.

- Accumulations of fluorspar most often occur together with a substantial proportion of barite (e.g. registered deposits Běstvina, Kovářská and exhausted depossits and resources Krásná Lípa, Hradiště u Vernéřova, Harrachov, Křižany u Liberce, etc.).
- A smaller part of fluorspar accumulations do not contain barites practically at all (e.g. registered deposit Jílové u Děčína and exhausted deposits and resources Blahuňov u Chomutova, Kožlí u Ledče, etc.) or they contain it only in minor amounts (e.g. registered deposit Moldava, exhausted deposit Vrchoslav, etc.).

Industrial fluorspar mining in the Czech Republic began in the early 1950s (except for minor mining in Kožlí near Ledeč nad Sázavou during the two world wars) and lasted until the first quarter of 1994, when the exploitation of the last used Jílové, Běstvina and Moldava deposits was finished. The deep mining method completely prevailed and the fluorspar raw material was processed in the treatment plant in Sobědruhy near Teplice, where two main products were produced from it – floated and lump fluorspar. The renewal of mining in the Czech Republic is not expected in the near future, because there is plenty of higher quality and cheaper raw material on the market, especially from China. The remaining reserves in Czech deposits are mostly not currently economically viable.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits   exhausted deposits and other resources

Registered deposits and other resources are not mined

1 Běstvina	3 Kovářská	5 Proboštov – tailing pond Přítkov
2 Jílové u Děčína	4 Moldava	

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number [a)]	5	5	5	5	5
exploited	0	0	0	0	0
Total mineral *reserves, kt	2,210	2,210	2,726	2,726	2,726
economic explored reserves	0	0	678	678	678
economic prospected reserves	32	32	459	459	459
potentially economic reserves	2,178	2,178	1,589	1,589	1,589
Mine production, kt	0	0	0	0	0

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

[a)] *Deposits with registered fluorspar reserves*

5. Foreign trade

252921 – Fluorspar, containing 97 wt % or less of calcium fluoride

		2019	2020	2021	2022	2023
Import	t	2,495	2,688	2,387	2,703	2,479
Export	t	62	137	159	459	157

252921 – Fluorspar, containing 97 wt % or less of calcium fluoride

		2019	2020	2021	2022	2023
Average import prices	CZK/t	6,729	8,021	8,805	13,907	10,756
Average export prices	CZK/t	14,000	14,777	12,628	14,101	17,177

252922 – Fluorspar, containing more than 97 wt % of calcium fluoride

		2019	2020	2021	2022	2023
Import	t	12,403	9,519	9,130	8,319	N
Export	t	9,562	6,279	6,916	6,009	N

252922 – Fluorspar, containing more than 97 wt % of calcium fluoride

		2019	2020	2021	2022	2023
Average import prices	CZK/t	10,064	9,955	8,902	10,201	N
Average export prices	CZK/t	12,754	13,377	12,377	13,672	N

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

World fluorspar production in recent years was as follows:

	2019	2020	2021	2022	2023^e
World mine production of fluorspar (according to MCS), kt	6,720	8,240	8,680	8,300	8,800
World mine production of fluorspar (according to WBD), kt	7,662	7,742	8,392	8,236	N

e – preliminary values

Main producers according to MCS

Country	2023e	
	kt	%
China	5,700	64.8
Mexico	1,000	11.4
South Africa	930	10.6
Mongolia	410	4.7
Vietnam	170	1.9
Spain	150	1.7
Iran	120	1.4
Kazakhstan	67	0.8
Germany	60	0.7
Pakistan	52	0.6
World	**8,000**	**100.0**

e – preliminary values

Important producers also include the United States, which does not publish its statistics on fluorspar production. Most American production is a by-product of limestone mining or is produced as a synthetic product of oil refining.

Prices of traded fluorspar commodities

Two grades of fluorspar are listed in market quotations: filtercake for the production of hydrofluoric acid and metallurgical fluorspar.

Commodity/year	2019	2020	2021	2022	2023
Average price USA market, CIF – acid grade (MCS), USD/t	304	309	322	360	430
Average price USA market, CIF – metallurgical grade (MCS), USD/t	292	149	151	140	360
Yearly average import price into the Czech Republic (CSO) from Germany, both qualities total, CZK/t	6,521	9,916	10,438	9,667	9,357
Yearly average import price into the Czech Republic (CSO) from Germany, both qualities total, EUR/t	6,521	9,916	10,438	9,667	388

Graphite

1. Characteristics and use

Average C content (and its extent) in the earth's crust (ppm)

(200–800) C

Industrially important minerals

Graphite is one of the naturally occurring forms of carbon (C). It is an important technical mineral. According to the size of the flakes, a distinction is made between "flake" graphite, macrocrystalline with a flake size above 0.1 mm and "amorphous" – crypto to microcrystalline below 0.1 mm, which appears as a solid. The division of crystalline graphite into large, medium and small flakes is a commercial division which has no general rules and varies according to the producer.

Industrially important deposit types

1. Orogenically metamorphic: Kaiserberg (Austria), Graphite Lake (Canada), Moldanubian and Moravian-Silesian deposits of the Bohemian Massif
2. Contact metamorphic: La Colorada (Mexico)
3. Epigenetic: Kahatagaha, Bogala (Sri Lanka)

All rocks whose essential part is graphite and from which it can be obtained by their treatment are considered raw graphite materials.

Reserves

2023		
Country	**kt**	**% World**
China	78,000	27.9
Brazil	74,000	26.4
Madagascar	25,000	8.9
Mozambique	24,000	8.6
Tanzania	18,000	6.4
Russia	14 000	5.0
India	8,600	3.1
Czech Republic	7,900	2.3
Canada	5,700	2.0
Mexico	3,100	1.1
North Korea	2,000	0.7
South Korea	1,800	0.6
Sri Lanka	1,500	0.5
Norway	600	0.2
World	**280,000**	**100,0**

Source: MCS 2024

2023			
Country	**Mill. t**	**% World**	**% EU**
EU	8,500	2.43	100.0
Czech Republic*	7,900	2.26	92.9
Norway	600	0.17	7.1
Austria	–	–	–
Germany	–	–	–

** Bilance zásob (national Register of Reserves as of 1. 1. 2024)*
*** own estimate*
European Minerals Yearbook – version 2023

Uses

Foundry and metallurgy, electrical engineering, electrochemistry, chemical, missile and armaments industries, nuclear energy, production of refractory materials, lubricants and protective coatings, pencils, fibres, synthetic diamonds.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes

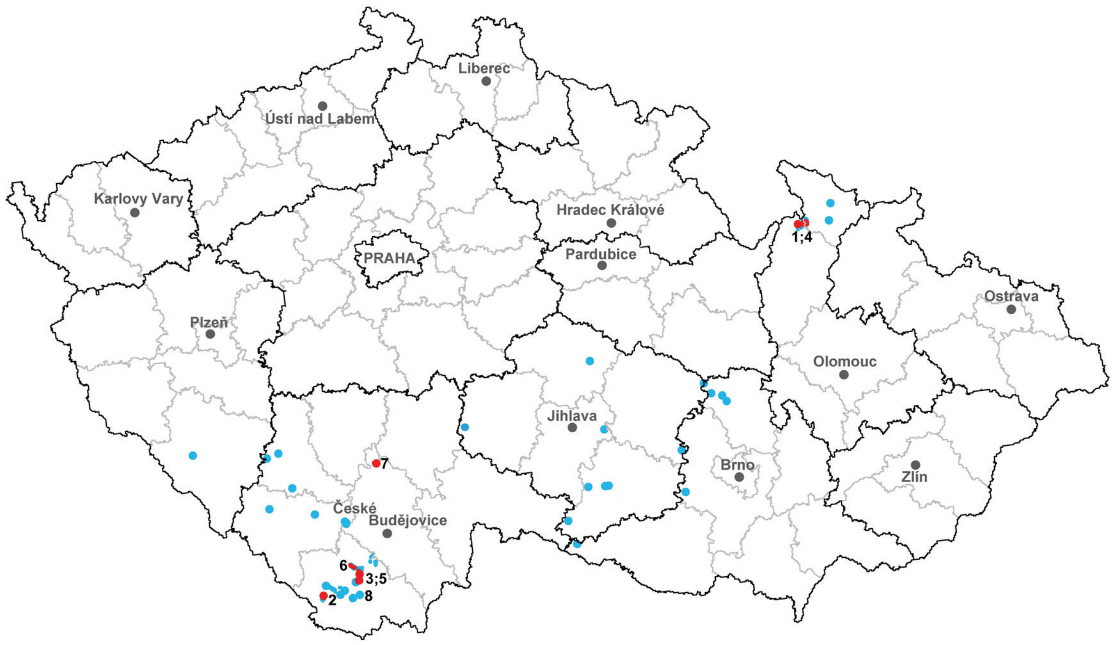
2. Raw material resources of the Czech Republic

In the Czech Republic, there are only smaller deposits and sources of graphite. The quality of the raw material also fluctuates and the graphite contents (C_{graph}) mostly range between 20–40% in deposits and sources of amorphous graphite and between 10–20% in deposits and sources of crystalline graphite. All graphite deposits in the Czech Republic are of the metamorphogenic genetic type. It was formed during the regional metamorphosis of clay-sand sediments with a higher content of biogenic material, which is evident from the increased content of S, P, V and the frequent presence of limestones. Deposits occur in the Bohemian Massif, namely in the Moldanubicum, Moravicum and the Silesian Block.

- The most important deposits and sources are found in the Moldanubicum, especially in the variegated group of Český Krumlov, with crystalline, amorphous and mixed graphite. The most important deposits of crystalline raw material were Český Krumlov-Městský vrch and Lazec, where mining was terminated in the second half of 2003. Amorphous or mixed raw material prevailed in the deposits and sources of Bližná, Český Krumlov-Rybářská ulice, Spolí, Mokrá, etc. The diverse Sušice-Votic group is less significant with the occurrence of the only deposit of crystalline graphite in Koloděje nad Lužnicí-Hosty, which was mined until 1967 (and there is currently a plan to use it again for surface mining). In the past, the occurrence near Černovice was mined in the variegated zone of the Chýnov micaschists, which is no longer of importance as a deposit. South Bohemian raw graphite materials have the nature of graphite-rich gneisses, quartzites or carbonates. Smaller occurrences, nowadays without industrial significance, are also known from the Moravian Moldanubicum (e.g. Lesná, Lubnice, Louka, Římov, etc.).
- The deposits of the Moravian-Silesian region occur in the area affected by a lower degree of metamorphosis. Graphite has a lower degree of crystallinity (amorphous graphite predominates) and contains significantly more sulphur, which is bound to pyrite or pyrrhotite. It is characteristic of the whole area that the positions of graphite in limestones contain more combustible substances and less sulphur than the positions in graphitic schists and phyllites. The largest deposit in Moravia was considered to be Velké Tresné deposit, which is practically exhausted today. It is located in the Olešnice group of the Svratka dome. In the Silesian Block, the most important deposit was Velké Vrbno-Konstantin, which forms part of the graphite zone on the western perimeter of the Velké Vrbno dome, and from the second half of 2003 to 2008 it remained the only mined deposit in the Czech Republic. In the vicinity of Branná and Velké Vrbno, several other small deposits and sources of mostly amorphous graphite are registered.

In most cases, the same applies to graphite deposits in the Czech Republic as to fluorspar and barite: underground mining is economically unprofitable and has gradually declined. For a long time, the Czech Republic had been one of the world's leading producers of graphite, but mainly due to the growing pressure of cheaper and better quality, especially Chinese graphite, mining was ended. In southern Bohemia, the majority of the raw material is recoverable by deep mining and a smaller part also by surface mining. The last deposits of crystalline graphite in southern Bohemia that were mined underground were closed in the second half of 2003. In northern Moravia, underground mining also originally predominated, but part of the raw material can also be recovered on the surface, and the last quarry of amorphous graphite Velké Vrbno – Konstantin ended its mining activities in 2008. The raw graphite material was flotation-processed in treatment plants in Netolice, where flotation concentrates with a content of 75 to 90% of graphite were produced, and also in Malé Vrbno, where concentrates with a content of 50 to 70% of graphite were produced. Some flotation concentrates were chemically refined in Týn nad Vltavou up to 99.9%.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits   exhausted deposits and other resources

Registered deposits and other resources are not mined

Amorphous graphite:	**Crystalline graphite:**	**Mixed (from amorphous to crystalline) graphite:**
1 Velké Vrbno-Konstantin	5 Český Krumlov-Městský vrch	8 Spolí
2 Bližná-Černá v Pošumaví	6 Lazec-Křenov	
3 Český Krumlov-Rybářská ulice	7 Koloděje nad Lužnicí-Hosty	
4 Velké Vrbno-Luční hora 2		

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	8	8	8	8	8
exploited	0	0	0	0	0
Total mineral *reserves, kt [a)]	13,701	13,701	13,701	13,112	13,112
economic explored reserves	2,981	2,981	2,981	2,981	2,981
economic prospected reserves	4,935	4,935	4,935	4,935	4,935
potentially economic reserves	5,785	5,785	5,785	5,785	5,785
Mine production, kt [a)]	0	0	0	0	0

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

[a)] *Reserves and mine production are given for crude graphite (graphite "ore"); average graphite contents in the raw material range between 15 and 20 % (crystalline grade) and 25–35 % (amorphous grade), respectively*

Approved prognostic resources P_1, P_2, P_3

Year		2019	2020	2021	2022	2023
P_1,	kt	3,280	3,280	3,280	3,280	3,280
P_2,	kt	8,895	8,895	8,895	8,895	8,895
P_3,	kt	2,627	2,627	2,627	2,627	2,627

5. Foreign trade

2504 – Natural graphite

		2019	2020	2021	2022	2023
Import	t	4,182	2,509	2,142	4,174	3,008
Export	t	2,004	2,582	2,450	2,138	2,275

2504 – Natural graphite

		2019	2020	2021	2022	2023
Average import prices	CZK/t	22,985	24,642	30,558	27,511	29,751
Average export prices	CZK/t	28,710	28,404	27,286	32,356	37,511

3801 – Artificial graphite; colloidal or semi-colloidal graphite; preparations based on graphite

		2019	2020	2021	2022	2023
Import	t	2,780	2,302	3 ,99	7,075	10,699
Export	t	4,961	1,113	2,968	4,502	7,726

3801 – Artificial graphite; colloidal or semi-colloidal graphite; preparations based on graphite

		2019	2020	2021	2022	2023
Average import prices	CZK/t	57,246	59,594	57,840	49 629	35,064
Average export prices	CZK/t	37,506	46,496	34,269	41 058	35,196

6903 – Other refractory ceramic goods (for example, retorts, crucibles, muffles, nozzles, plugs, supports, cupels, tubes, pipes, sheaths and rods)

		2019	2020	2021	2022	2023
Import	t	6,714	4,068	6,181	5,553	4,736
Export	t	25,193	21,258	27,142	25,809	21,952

6903 – Other refractory ceramic goods (for example, retorts, crucibles, muffles, nozzles, plugs, supports, cupels, tubes, pipes, sheaths and rods)

		2019	2020	2021	2022	2023
Average import prices	CZK/t	80,763	114,159	100,402	158,617	132,992
Average export prices	CZK/t	114,246	127,488	119,886	144,804	156,606

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

World graphite production has been gradually increasing again since 2009, when it reached its last low. Between 2013 and 2016, world production was very stable and ranged between 1,100 and 1,200 kt, with world graphite mining falling to around 900 kt in 2017, in 2018–2019 world mining increased again to between 950 and 1,150 kt and in 2020 it decreased to 950 kt.

	2019	2020	2021	2022	2023^e
World mine production of graphite (according to MCS), kt	1,100	966	1,130	1,680	1,600
World mine production of graphite (according to WBD), kt	1,605	1,128	1,663	1,727	N

e – preliminary values

Main producers according to MCS

Country	2023^e	
	kt	%
China	1,230.0	76.9
Madagascar	100.0	6.3
Mozambique	96.0	6.0
Brazil	73.0	4.6
South Korea	27.0	1.7
Russia	16.0	1.0
India	11.5	0.7
North Korea	8.1	0.5
Norway	7.2	0.5
Tanzania	6.0	0.4
Canada	3.5	0.2
Sri Lanka	2.2	0.1
Mexico	2.0	0.1
Turkey	2.0	0.1
Ukraine	2.0	0.1
World	**1,600**	**100**

e – preliminary values

Prices of traded commodities (USD/t)

Commodity/year	2019	2020	2021	2022	2023^e
Prices of imports to the USA in foreign ports – flake, USD/t, according to MCS	1,340	1,340	1,330	1,200	1,200
Prices of imports to the USA in foreign ports – lump and chip (Sri Lanka), USD/t, according to MCS	2,380	2,940	2,010	2,590	2,500
Prices of imports to the USA in foreign ports – amorphous, USD/t, according to MCS	511	567	629	563	565

e – preliminary values

METALLIC ORES

Ores are, in the Czech terminology exclusively, metallic mineral raw materials from which metals can be industrially produced. Deposits of Mn, Cu, polymetallic (Pb, Zn, Ag), Sn, W, Li, Au and Ge ores were registered in the Register as at the 1st January 2024 in the Czech Republic. Geological reserves of ores were, with a few exceptions, potentially economic; more significant amounts of economic reserves were reported only for gold-bearing ores.

Ore mining in the Czech Republic has a very old tradition. The oldest archaeological evidence of panning for gold dates from the 9th century BC. In the Middle Ages, Bohemia was a centre of European gold, silver and tin mining, the resources of which were almost exhausted by long-term mining activities. With a few exceptions (e.g. the Au-W ore deposit in Kašperské Hory), there are only poor ores in the Czech Republic. Mining experienced its last great boom during the Cold War after 1948, when ore deposits were mined with significant economic losses in order to ensure independence from the import of raw materials from Western countries. The level of ore mining and its development has long been influenced by the "limit costs of metals" declared by the central authorities, through which ore mining was subsidised from 1965 to 1988. The amount of reserves, both geological and, above all, industrial, corresponded to this. In connection with the changes that took place in the Czech Republic in 1989, the government adopted in 1990 the concept of a phase-out in ore mining and processing. The basis of this concept was a gradual but radical reduction of subsidies for mining and processing of ores so that since 1993 the subsidies have not been provided at all. As a result of the termination of subsidies, the mining of ore deposits was gradually phased out before 1993. First, in 1990, mining ended on Cu ore deposits in Zlaté Hory (Zlaté Hory-Hornické skály and Zlaté Hory-jih deposits in mining lease Zlaté hory – východ). Cu metal was then obtained until 1993 from deposits of polymetallic ores. At the beginning of 1991, the mining of Sn-W ores at the Krásno deposit (mining lease Krásno) ended. In 1991, a miniature deposit of Scheelite W ores was mined as part of experimental mining in Nekvasovy-Chlumy. Mining at the Sn-W-Li ore deposit Cínovec-jih (mining lease Cínovec) ended a year earlier. Mining of Fe ores in the Czech Republic ended in 1992, when the Přísečnice magnetite deposit was closed. The mining of Au ores and Sb also ended in 1992 with the closure of the Krásná Hora deposit. In the first quarter of 1994, the mining of polymetallic and Au ores in Zlaté Hory (Zlaté Hory-západ deposit, mining lease Zlaté Hory I – západ) was definitively terminated, and this was the last ore deposit in the Czech Republic (if we do not consider U ores, which are classified as energy minerals). The reserves of ore deposits were subsequently gradually reassessed according to new conditions of usability and, the formerly economic ores, were, with some exceptions (e.g. some Au ore deposits), reclassified as potentially economic and in some cases even removed from the Register completely (all Fe, Ni, Sb ores, most polymetallic ores, Cu, Sn, W and Ge ores).

Cobalt

1. Characteristics and use

Average Co content (and its extent) in the earth's crust (ppm)

25 (8–237) Co

Industrially important minerals

Cobaltite CoAsS (35% Co), smaltite $CoAs_3$ (24% Co), carrollite $Cu(Co,Ni)_2S_4$ (29% Co), asbolane $Mn(O,OH)_2.(Co,Ni,Ca)_x(OH)_2.nH_2O$ (32% Co)

Industrially important deposit types

Cobalt ores are generally found as an accompanying raw material in copper and nickel deposits. Especially in the copper deposits of the Copper Belt area (Democratic Republic of the Congo, i.e. Congo (Kinshasa) and Zambia).

Reserves

2023		
Country	t	% World
Congo (Kinshasa)	6,000,000	72.3
Australia	1,700,000	20.5
Indonesia	500,000	6.0
Cuba	500,000	6.0
Philippines	260,000	3.1
Russia	250,000	3.0
Canada	230,000	2.8
Madagascar	100,000	1.2
Turkey	91,000	1.1
USA	69,000	0.8
Papua New Guinea	49,000	0.6
World	**8,300,000**	**100.0**

Source: MCS 2024

2023			
Country	t	% World	% EU
EU	192,056	100.0	2.7
Poland	157,000	81.7	2.2
Finland	35,056	18.3	0.5

Source: European Minerals Yearbook – version 2023

Uses

Rechargeable battery electrodes, superalloys for the production of parts for gas turbine engines, car airbags, catalysts for the oil and chemical industry, sintered carbides (hard metals) and diamond tools, corrosion and wear resistant alloys, desiccants for paints, coats and inks, dyes and pigments, ground coatings for enamelled porcelain paints, high speed steels, magnetic recording media, magnets, and steel radial tires.

Classification as critical raw materials for the European Union
2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved sources of cobalt in the total amount of 8,035 t Co, mainly in the Staré Ransko locality.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2605 – Cobalt ores and concentrates

		2019	2020	2021	2022	2023
Import	kg	476	1,348	2,300	3,200	533
Export	kg	0	0	0	10	4

2605 – Cobalt ores and concentrates

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	1,637	492	250	233	248
Average export prices	CZK/kg	–	–	–	900	750

8105 – Cobalt mattes and other intermediate products of cobalt metallurgy; cobalt and articles thereof, including waste and scrap

		2019	2020	2021	2022	2023
Import	t	117	80	95	91	84
Export	t	53	33	71	48	52

8105 – Cobalt mattes and other intermediate products of cobalt metallurgy; cobalt and articles thereof, including waste and scrap

		2019	2020	2021	2022	2023
Average import prices	CZK/t	1,406 ,61	1,500,534	1,482,289	1,702,747	1,844,940
Average export prices	CZK/t	1,317,312	1,151,138	1,077,027	1,353,907	1,119,173

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

Statistical data on world cobalt production:

	2019	2020	2021	2022	2023[e]
Mine production of cobalt (according to CI), t	153,700	145,000	163,514	198,600	231,600
Mine production of cobalt (according to MCS), t	144,000	142,000	165,000	197,000	230,000
Mine production of cobalt (according to WBD), t	124,518	130,056	134,476	166,030	N

e – preliminary values, (CI – Cobalt Institute)

Main producers according to MCS

Country	2023^e	
	t	%
Congo (Kinshasa)	170,000	73.9
Indonesia	17,000	7.4
Russia	8,800	3.8
Australia	4,600	2.0
Madagascar	4,000	1.7
Philippines	3,800	1.7
Cuba	3,200	1.4
Papua New Guinea	2,900	1.3
Turkey	2,800	1.2
Canada	2,100	0.9
USA	500	0.2
World	**230,000**	**100.00**

e – preliminary values

The world's largest cobalt miners / producers according to INN.com

1. Glencore
2. China Molybdenum
3. Vale
4. Gecamines
5. Euroasian Resources Group

Prices of traded commodities

Annual prices according to yearbooks DERA, MCS

Commodity/year	2019	2020	2021	2022	2023^e
99,8 % Co, volný trh, sklad, Rotterdam (USD/kg) (DERA)	81.16	39.52	38.08	63.55	30.16
Min. 99,8 %, elektrolytický, (USD/t), (DERA – průměr za posl. 5 let)	N	N	N	64,508	47,682
Co cathodes, US spot market, annual average, USD/lb (MCS)	16.95	15.70	24.21	30.78	17.00
99,8 % Co, LME sklad, cash (USD/t) (DERA 5 year average)	72,621	32,796	31,331	65,554	42,589

e – preliminary values

Copper

1. Characteristics and use

Average Cu content (and its extent) in the earth's crust (ppm)

68 (10–100) Cu

Industrially important minerals

Chalcopyrite $CuFeS_2$ (34% Cu), covellite CuS (66% Cu), chalcocite Cu_2S (80% Cu), bornite Cu_5FeS_4 (63% Cu), enargite Cu_3AsS_4 (47% Cu), tetrahedrite $Cu_{12}Sb_4S_{13}$ (max. 45% Cu)

Industrially important deposit types

1. Porphyry (with Mo): Chuquicamata (Chile), Bingham (USA), Recsk (Hungary), Dexing (China)
2. Pyrite polymetallic: Iberian pyrite belt (Spain – Portugal), Outokumpu district (Finland), Baiyinchang district (China)
3. Stratiform: Jezkazgan (Kazakhstan), White Pine District (USA), Copper Belt Region (Democratic Republic of the Congo – Zambia), Polkowice-Sieroszowice district (Poland), Liwu (China)
4. Magmatogenic: Norilsk (Russia), Sudbury (Canada), Jinchuan (China)
5. Magmatic-hydrothermal: Olympic Dam (Australia)

Reserves

2023		
Country	**mill. t**	**% World**
Chile	190	21.3
Peru	120	9.1
australia	100	10.9
Congo (Kinshasa)	80	3.5
Russia	80	7.0
Mexico	53	6.6
USA	50	4.9
China	41	3.0
Poland	34	3.4
Indonesia	24	2.7
Kazakhstan	20	2.3
Zambia	21	2.1
Canada	7.6	0.9
World	**1,000**	**100.0**

Source: MCS 2024

2023			
Country	**mill. t**	**% World**	**% EU**
EU	125	14.35	100.00
Romania	98	11.26	78.50
Poland*	22	2.53	17.62
Sweden	2	0.19	1.32
Spain	1	0.13	0.89
Finland	1	0.11	0.79
Portugal	1	0.10	0.71
Makedonie	0.2	0.02	0.17

** Bilans zasobów złoż kopalin w Polsce 2023*

Source: European Minerals Yearbook – version 2023

Uses

Transmission and production of electricity, building wiring, telecommunications and the manufacture of electrical and electronic products account for about three quarters of total copper use. The construction industry is a massive market, followed by electronics and electronic products, transport, industrial machinery, consumer and general products.

Classification as critical raw materials for the European Union:

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023– no

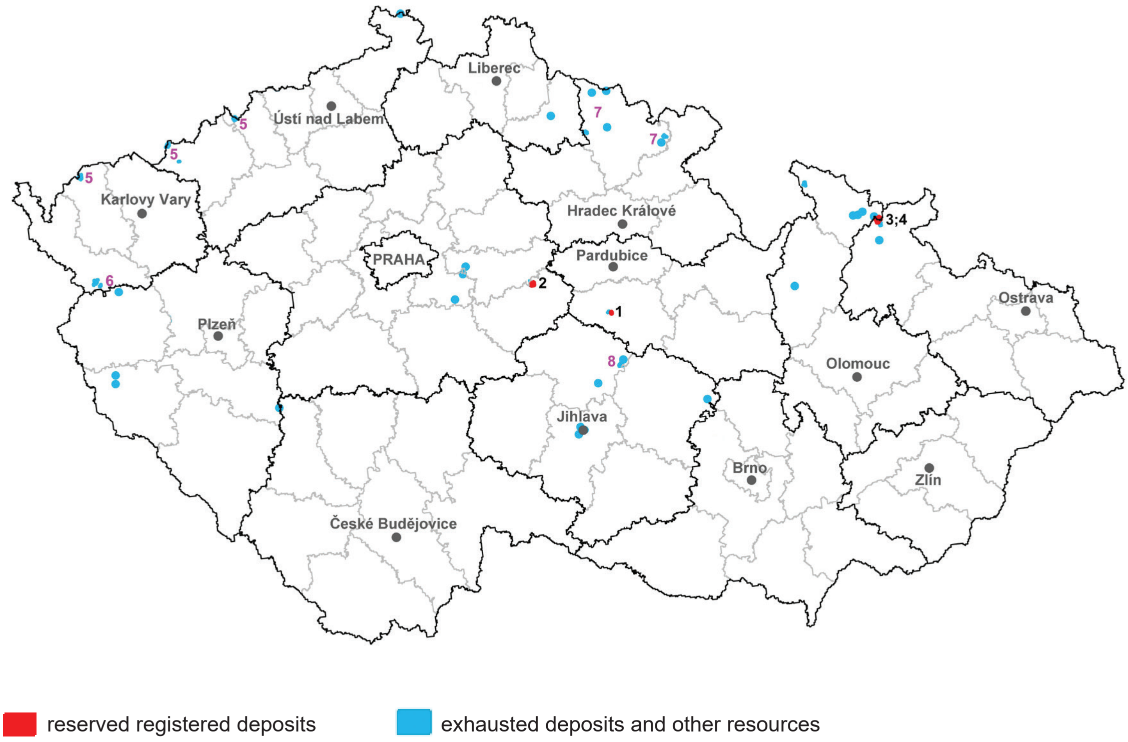
2. Mineral resources of the Czech Republic

There are no economically usable deposits of Cu ores in the Czech Republic. Cu ores of various genetic types have been present and used in the past.

- Volcanogenic-sedimentary deposits of the pyrite formation with the most significant occurrence in the Zlaté hory ore district were mined the most. The ore mineralisation, paragenetically associated with the initial spilite-keratophyre volcanism, is located in the volcanic-sedimentary complex of the Vrbno layers of Devonian age. Individual types of ores, monometallic Cu, complex Cu-Pb-Zn with Au and polymetallic Pb-Zn, are spatially separated and create a certain zonality. Monometallic ores consisted of chalcopyrite, with a variable admixture of pyrite or pyrrhotite with a metal content of 0.4–0.7% Cu. They were mined in the Zlaté Hory-jih and Zlaté Hory-Hornické skály deposits. The mining of these ores was terminated at the Zlaté Hory deposit in 1990. A total of 5,808 kt of ore containing 34,741 t of copper was mined in 1965–1990.
- The stratiform layers of monometallic Cu ores (chalcopyrite) in the epizonally metamorphosed volcanogenic-sedimentary complex are explored at the former deposit Tisová u Kraslic. Mining of ores with a content of up to about 1% Cu was stopped in 1973 and in the 1980s a preliminary exploration was carried out on the deposit, the results of which, however, were no longer used and the deposit (mine) was transferred to wet conservation.
- Less significant occurrences of Cu or Cu-Zn-Pb ores of the stratiform type of pyrite formation are known from many localities in the Bohemian Massif (Staré Ransko, Křižanovice, Svržno).
- Hydrothermal (vein) deposits of Cu ores (Rybnice, Rožany) and sedimentary Cu ores (Giant Mts. Foothils (Podkrkonoší)) were of only historical significance. A very poor former Horní Vernéřovice-Jívka deposit was mined here in 1958–1965.

Mining of Cu ores in the Czech Republic was stopped in 1990. In connection with the ongoing reassessment (rebalancing) of polymetallic and copper ores, a large part of Cu deposits and reserves was gradually removed from the Balance in 1990–2004.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined

Reserved registered deposits:

1	Křižanovice	3	Zlaté Hory-Hornické Skály
2	Kutná Hora	4	Zlaté Hory-východ

Exhausted deposits and other resources:

5	in Krušné hory Mts. (Erzgebirge Mts.) and Tisová	7	in Krkonoše Mts. Piedmont Basin and Intrasudetic Basin
6	Tři Sekery and surroundings	8	Staré Ransko

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number [a)]	4	4	4	4	4
exploited	0	0	0	0	0
Total mineral *reserves, kt Cu	51	51	51	51	51
economic explored reserves	0	0	0	0	0
economic prospected reserves	0	0	0	0	0
potentially economic reserves	51	51	51	51	51
Mine production, kt Cu	0	0	0	0	0

** See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

[a)] *deposits with registered Cu content*

5. Foreign trade

2603 – Copper ores and concentrates

		2019	2020	2021	2022	2023
Import	t	0.013	0	1	0	5
Export	t	0	0	0	0	0

2603 – Copper ores and concentrates

		2019	2020	2021	2022	2023
Average import prices	CZK/t	384,615	–	76,000	–	38,000
Average export prices	CZK/t	–	–	–	–	–

7402 – Unrefined copper

		2019	2020	2021	2022	2023
Import	t	181	114	168	0	12
Export	t	0.006	242	112	0	36

7402 – Unrefined copper

		2019	2020	2021	2022	2023
Average import prices	CZK/t	94,232	131,927	149,047	–	146,833
Average export prices	CZK/t	333,333	110,809	80,814	–	198,778

7403 – Refined copper and copper alloys

		2019	2020	2021	2022	2023
Import	t	7,350	6,541	7,133	493	5,765
Export	t	1,447	1,550	2,005	275	4,951

7403 – Refined copper and copper alloys

		2019	2020	2021	2022	2023
Average import prices	CZK/t	92,006	84,585	102,693	118,185	118,255
Average export prices	CZK/t	133,823	138,954	139,621	126,723	125,875

7404 – Copper waste and scrap

		2019	2020	2021	2022	2023
Import	t	5,844	7,499	7,134	7,434	8,249
Export	t	57,088	57,719	66,761	4,139	54,224

7404 – Copper waste and scrap

		2019	2020	2021	2022	2023
Average import prices	CZK/t	82,131	85,355	102,694	124,687	120,189
Average export prices	CZK/t	97,739	97,979	136,214	140,805	130,348

740311 – Copper cathodes and sections of cathodes unwrought

		2019	2020	2021	2022	2023
Import	t	1,474	1,429	1,853	2,392	2,369
Export	t	19	3	7	31	19

740311 – Copper cathodes and sections of cathodes unwrought

		2019	2020	2021	2022	2023
Average import prices	CZK/t	138,457	140,871	200,613	207,812	130,347
Average export prices	CZK/t	156,819	156,471	225,445	235,049	222,211

740321 – Copper-zinc base alloys, unwrought

		2019	2020	2021	2022	2023
Import	t	5,204	4,528	4,599	3,962	2,627
Export	t	1,260	1,396	1,748	3,992	4,663

740321 – Copper-zinc base alloys, unwrought

		2019	2020	2021	2022	2023
Average import prices	CZK/t	64,822	53,147	45,224	32,062	23, 870
Average export prices	CZK/t	141,36	144,216	144,026	140,339	124, 882

740322 – Copper-tin base alloys, unwrought

		2019	2020	2021	2022	2023
Import	t	126	81	84	22	237
Export	t	129	147	245	178	162

740322 – Copper-tin base alloys, unwrought

		2019	2020	2021	2022	2023
Average import prices	CZK/t	243,627	240,841	359,526	300,449	262,549
Average export prices	CZK/t	76,484	88,881	104,318	88,229	123,462

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

World production of primary copper has been rising in recent years:

	2019	2020	2021	2022	2023e
World mine production of copper (according to COCHILCO), kt	20,668	20,559	21,345	21,548	22,413
World mine production of copper (according to MCS), kt	20,400	20,600	201,200	21,900	22,000
World mine production of copper (according to WBD), kt	20,633	21,074	21,447	22,225	N

e – preliminary values
COCHILCO (Comisión Chilena del Cobre)

Main producers according to MCS

Country	2023e	
	kt	%
Chile	5 000	22.7
Peru	2 600	11.8
Congo (Kinshasa)	2 500	11.4
China	1 700	7.7
USA	1 100	5.0
Russia	910	4.1
Indonesia	840	3.8
Australia	810	3.7
Mexico	760	3.4
Kazakhstan	750	3.3
Canada	600	2.7
Poland	480	2.2
Other	400	1.8
World	**3,100**	**14.1**

e – preliminary values

Main producers to COCHILCO*

Country	2023	
	kt	%
Chile	5,250	23.4
Kongo (Kinshasa)	2,842	12.7
Peru	2,755	12.3
China	1,685	7.5
USA	1,118	5.0
Rossia	1,000	4.5
Indonésia	895	4.0
Kazakstan	868	3.9
Australia	797	3.6
Mexico	727	3.2
World	**22,413**	**100.0**

** COCHILCO (Comisión Chilena del Cobre, Chilean state agency for copper)*

Prices of traded commodities

According to the German yearbooks DERA, the Mineral Commodity Summaries (MCS), World Bank (WB), world copper prices (USD/t, if not defined otherwise) developed as follows:

Commodity/year	2019	2020	2021	2022	2023
Electrolytic Cu, grade A, min. 99.9 %, LME, in warehouse, cash (according to DERA)	6,004.40	6,167.90	9,311.89	8,813.00	8,393.00
Electrolytic Cu, grade A, min. 99.9935%, contractual price (according to WB)	6,010.00	6,174.00	9,317.00	8,822.00	8,490.00
Copper, grade A, LME, annual average, USc/lb (according to MCS)	272.40	279.80	422.50	400.00	390.00

The price range according to MB includes the lowest and highest monthly price quotes for a given year.

Germanium

1. Characteristics and use

Average Ge content (and its extent) in the earth's crust (ppm)

1.5 Ge

Industrially important minerals

Separate Ge minerals are very rare (e.g. germanite $Cu_{13}Fe_2Ge_2S_{16}$), there are about 15 of them. Ge usually forms an isomorphic admixture of more than 70 minerals. Germanium-bearing minerals are mainly minerals Si, Sn, Pb, Zn, Cu, As, Ga, half silicates and especially sulphides. During weathering, sedimentation and sorption, there is a relatively large concentration of Ge in brown and bituminous coal.

Industrially important deposit types

1. Coal: coking coal of the Donbass and Lviv-Volyn basins (Ukraine)
2. Pb-Zn-Cu sulphide ores: Red Dog (Canada), Middle Tennessee Zinc Mining Complex (USA), Tsumeb (Namibia)
3. Oxide ores of Fe: Kremenchug Iron Ore District (Ukraine)

Reserves

Data on the recoverable Ge content in Zn ores are not available. Source: MCS 2023.
The EU does not have Ge reserves. Source: European Minerals Yearbook – version 2023.

Uses

Electronics, solar panels, optical fibres, infrared optics, polymerisation catalysts, chemotherapy, metallurgy.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes

2. Mineral resources of the Czech Republic

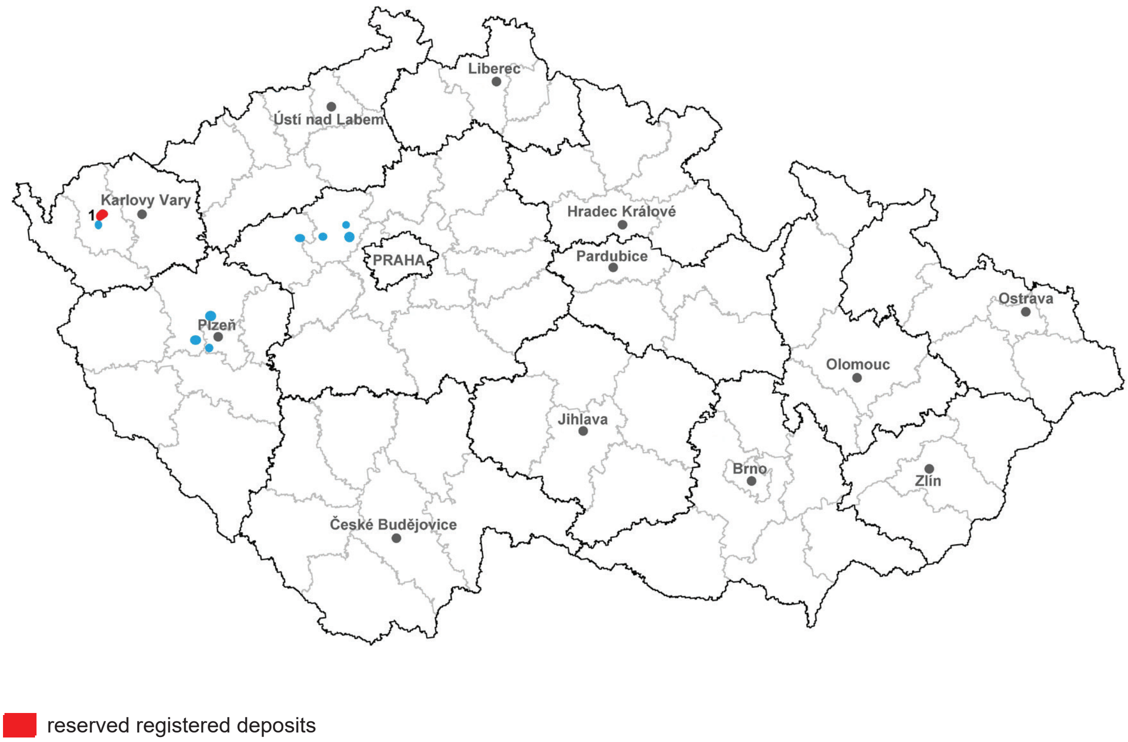
The Czech Republic has 1,248 t of unapproved Ge resources bound to brown and bituminous coal deposits.

Germanium and GeO_2 were produced in the Czech Republic at the Lachema chemical plant, J. Fučík's plant, in Kaznějov in 1955–1980. Industrial production from domestic sources was based (according to data from the former Institute for Mineral Resources (ÚNS – Ústav pro nerostné suroviny) in Kutná Hora) on the combustion of germanium-bearing coal in suitable boilers of power plants with subsequent separation of germanium-bearing fly ash (usually containing 0.1–0.3% Ge) and flue gases in dry electrostatic precipitators. In the years 1955–1971 by burning bituminous coal from the Pilsen and Radnice and Kladno-Rakovník basins (with contents of 14–38 ppm Ge). With the closure of mines mining these coals, bituminous coal ash in the production of Ge was replaced after 1966 by brown coal from the combustion of coal mined at the Jiří quarry in the Sokolov Basin (which contained

40–150 ppm Ge). However, in 1972, the production of Ge from fly ash was completely stopped; it reached its peak in 1966 with a quantity of 773 kg.

In the years 1960–1980, a total of 54 t Ge and 4 t GeO_2 were produced in Lachema Kaznějov. Most of this production came from imported GeO_2 (44.7% of total production) and Ge (25.8% of total production) and returnable waste (22.7% of total production). Domestic fly ash accounted for only 3.7 tonnes produced in 1961–1971 (6.8% of total production). The production capacity of Kaznějov's Lachema never reached the planned 10 t of Ge per year, however, in the years 1965–1975 the territory of the Czech Republic (within Czechoslovakia) produced about 5–10% of world's Ge per year.

3. Registered deposits and other resources of the Czech Republic



The registered deposit is not exploited.

1 Lomnice u Sokolova

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	1	1	1	1	1
exploited	0	0	0	0	0
Total * reserves, t Ge	473	473	473	473	473
economic explored reserves	0	0	0	0	0
economic prospected reserves	0	0	0	0	0
potentially economic reserves	473	473	473	473	473
Mine production, t Ge	0	0	0	0	0

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic and its evolutional comparison with international classifications** of this yearbook*

5. Foreign trade

81129295 – Unwrought germanium, germanium powders; excluding waste and scrap

		2019	2020	2021	2022	2023
Import	kg	4	2	5	1	2
Export	kg	0	0	0	0	0

81129295 – Unwrought germanium, germanium powders; excluding waste and scrap

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	73,500	51,000	34,800	N	38,000
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

World germanium production was as follows in recent years:

	2019	2020	2021	2022	2023^e
World germanium production (according to MCS), t	131	140	140	N	N
World germanium production (according to WBD), t	95	96	142	139	N

e – preliminary values

Main producers according to MCS

Country	2023*	
	t	%
China	132	93.0
Russia	5	3.5
Japan	2	1.4
USA	2	1.4
Ukraine	1	0.7
World	**142**	**100.0**

** – dada 2023 not available*

Prices of traded commodities

Price data are based on the US Mineral Commodity Summary (MCS)

	2019	2020	2021	2022	2023^e
GeO_2, yearly average, European market, USD/kg, MCS	913	724	770	840	880
Ge metal, annual average, European market, MCS	1,236	1,046	1,187	1,300	1,400

e – preliminary values

Gold

1. Characteristics and use

Average Au content (and its extent) in the earth's crust (ppm)

0.004 (0.001–0.005) Au

Industrially important minerals

Native gold Au (70–100% Au, usually with Ag, Cu, Hg, Pd), sylvanite (Au, Ag)Te_4 (25% Au), calaverite $AuTe_2$ (42% Au). Gold occurs as a pure metal, a natural alloy with silver (electrum) or with other metals, possibly in the form of tellurides and also selenides. It is commonly found in sulphides of antimony, arsenic, copper, iron and silver; during their processing, gold is obtained as a by-product.

Reserves

2023		
Country	**t**	**% World**
Australia	12,000	20.3
Russia	11,100	18.8
South Africa	5,000	8.5
China	3,000	5.1
USA	3,000	5.1
Indonesia	2,600	4.4
Brazil	2,400	4.1
Canada	2,300	3.9
Peru	2,300	3.9
Uzbekistan	1,800	3.1
Mexico	1,400	2.4
Papua New Guinea	1,100	1.9
Ghana	1,000	1.7
Kazakhstan	1,000	1.7
Mali	800	1.4
Tanzania	420	0.7
Others	9,200	15.6
World	**59,000**	**100.0**

Source: MCS 2024.

2023			
Country	**t**	**% World**	**% EU**
EU	1,064	2.0	100.0
Greece	527	1.0	49.5
Finland	222	0.4	20.9
Sweden	136	0.3	12.8
Czech Republic	78	0.15	7.3
Slovakia	64	0.12	6.0
Spain	37	0.07	3.5

Source: European Minerals Yearbook – version 2023

Industrially important deposit types

1. Plutogenic (including Cu-Mo deposits with Au in porphyries, skarn, Carlin type): Panguna (Papua New Guinea), Ok Tedi (Papua New Guinea), Bigham (USA), Hemlo (Canada), Southern Cross (Australia) area, Southern Cross (Australia), Muruntau (Uzbekistan), Carlin (USA), Nickel Plate (Canada), Choldon (China), Darasunskoye (Russia), Talatuyskoye (Russia), Kolar (India)
2. Volcanic: Lihir (Papua New Guinea), the Golden Quadrangle (Golden Quadrilateral; Apuseni District) area in the Apuseni Mountains – including the Roşia Montană deposit (Romania), the Silverton-Telluride ore field (USA), the Balayskoye-Tasseyevkoje ore field (Russia), the Baymak district (Russia)
3. Metamorphogenic: Sukhoi Log (Russia), Soviet Union (Russia), Duet-Brindakitsky Ore Knot (Russia), Bou Azzer (Morocco), Bendigo (Australia), Ballarat (Australia), Homestake (USA), Juno (USA), Morro Velho (Brazil)
4. Alluvial: Witwatersrand (South Africa), Yeniseiy Kriyaz (Russia), Lensky and Aldansky (Russia), Nom (USA)

Uses

Gold is used worldwide for the production of jewellery and as a thesauration metal, then in the electrical industry, for the mintage of medals and coins, for the production of dental protheses, special alloys for the aerospace (especially military) industry, for the production of infrared reflectors and more. The quality (purity) of gold is given in carats or parts of 1,000 (pure gold 24 k = 1 000, 10 k = 10/24 = 41.7 % = 417/1 000).

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

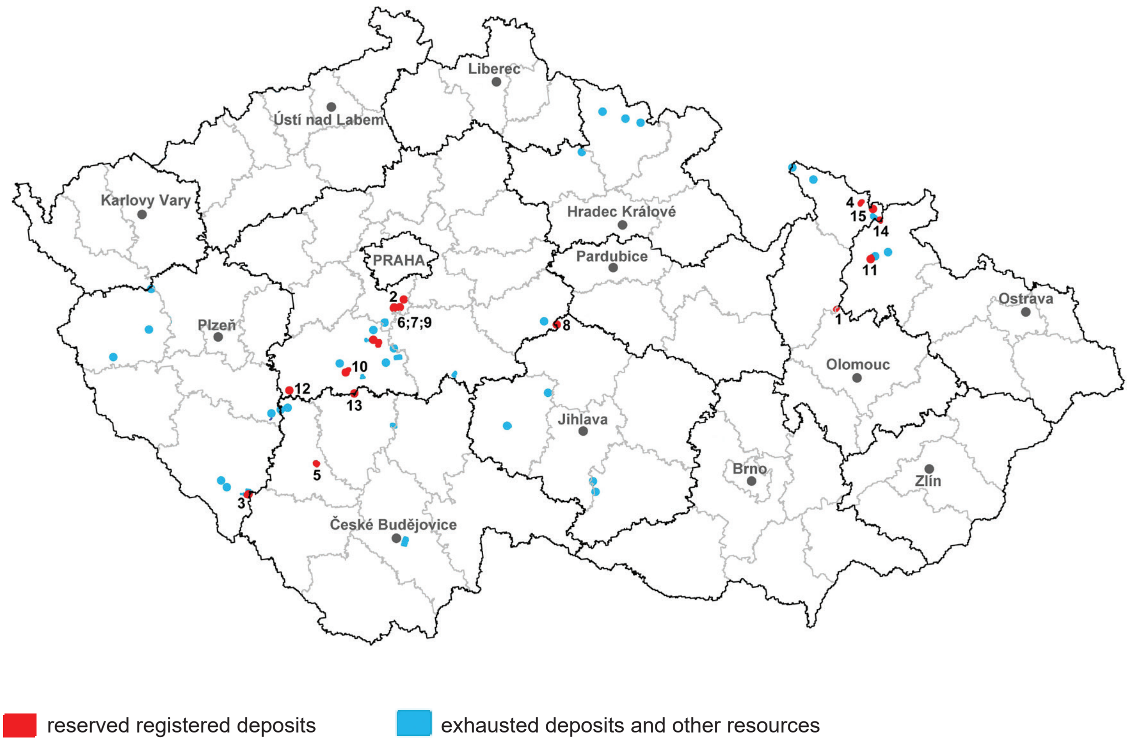
Gold deposits are currently, together with lithium ores, the only ore deposits in the Czech Republic on which significant amounts of economic reserves are reported. The tradition of using primary and secondary gold deposits in the Bohemian Massif dates back almost three millennia. In the Middle Ages, the Czech lands were ranked among the most important gold producers in Europe.

- A substantial part of Au ore mineralisation is bound to regionally metamorphosed volcanic-sedimentary complexes, in places penetrated by Variscan granitoids. In the Central Bohemian region the Jílové zone with a predominance of Au-quartz mineralisation (deposits Jílové, Mokrsko, Čelina, etc.) represents such a complex of Proterozoic age. In the area of the Jeseníky Mountains, this is a Devonian volcanism with Au ore mineralisation associated with pyrite polymetallic deposits of the stratiform type (Zlaté Hory-západ). Gold ore mining was terminated in 1994 with the closure of the Zlaté Hory-západ deposit. A total of 1,524 kg of Au was mined at this deposit in 1990–1994. Of the explored deposits, the Mokrsko deposit shows substantial reserves of Au ores, namely 98 t of Au in ores minable by quarrying with an average content of free balance reserves of 1.9 g/t Au and another more than 20 t of deep-extractable Au. Another 12.5 t of deeply recoverable Au reserves with contents of 1.6 g Au/t in ore are registered at the nearby Prostřední Lhota-Čelina deposit. Thus, there is more than 131 t Au in the entire Psí hory district (Čelina, Mokrsko).

The Vacíkov deposit SW of Příbram is similar; there is over 33 t Au in ores with Au contents of 1.1 g/t, also minable by quarrying.
- Occurrences of Au-quartz vein and stratiform ore mineralisation often with scheelite (Kašperské Hory) and Au-quartz veins and veins with increased Ag content (Roudný) are known in the Moldanubian crystalline complex. The partly unexplored Kašperské Hory deposit records 55 t of Au with an average content of 4.7 g Au/t of gold in off-balance reserves. Together with the adjacent prognostic resources, a total of 115 t Au with an average content of 5.5 g Au/t is reported on the deposit.
- Alluvial gold accumulations are spatially and genetically associated with the areas of primary deposits. Paleo-placers of Permocarbon age are found in western Bohemia (Křivce) as well as in the Krkonoše Mountains and Intra-Sudetic basins. The most extensive in terms of area are the Quaternary placers, known mainly from the foothills of the Šumava Mountains, northern Moravia and Silesia. Remains of panning that are visible to this day testify to the intensive use of placers from the Celtic times.

Since the end of mining at the Sb-Au deposit Krásná Hora in 1992 and the polymetallic deposit Zlaté Hory-západ in 1994, gold has not been mined in the Czech Republic. The use of Au ores in deposits is hindered by unresolved conflicts of interest with environmental protection and, from a global perspective unique ban on cyanidation in mining in the Czech Republic. In addition, a government resolution from 1999 stated that gold mining is undesirable in the Czech Republic. Subsequent governments extended the ban to include also the exploration of Au ores.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined.

1 Břevenec	6 Mokrsko	11 Suchá Rudná-střed
2 Jílové u Prahy	7 Mokrsko-východ	12 Vacíkov
3 Kašperské Hory	8 Podmoky	13 Voltýřov
4 Mikulovice u Jeseníka	9 Prostřední Lhota-Čelina	14 Zlaté Hory-východ
5 Modlešovice	10 Smolotely-Horní Líšnice	15 Zlaté Hory-Zlatý potok

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	15	15	15	15	15
exploited	0	0	0	0	0
Total mineral *reserves, kg Au	238,900	238,900	238,900	238,900	238,900
economic explored reserves	48,740	48,740	48,740	48,740	48,740
economic prospected reserves	28,644	28,644	28,644	28,644	28,644
potentially economic reserves	161,516	161,516	161,516	161,516	161,516
Mine production, kg Au	0	0	0	0	0

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

Approved prognostic resources P_1, P_2, P_3

Au metal in ores

Year		2019	2020	2021	2022	2023
P_1,	kg	60,221	60,221	60,221	60,221	60,221
P_2,	kg	65,846	65,846	65,846	65,846	65,846
P_3		–	–	–	–	–

Au ore

Year		2019	2020	2021	2022	2023
P_1,	kt	16,726	16,726	16,726	16,726	16,726
P_2,	kt	27,331	27,331	27,331	27,331	27,331
P_3		–	–	–	–	–

5. Foreign trade

7108 – Gold in unwrought or semi-manufactured form, gold powder

		2019	2020	2021	2022	2023
Import	kg	4,790	6,348	9,011	9,206	4,032
Export	kg	6,766	5,417	3,418	3,434	3,079

7108 – Gold in unwrought or semi-manufactured form, gold powder

		2019	2020	2021	2022	2023
Average import prices	CZK/g	952.5	1,189.3	1,175.2	1,326.8	1,309.1
Average export prices	CZK/g	344.4	380.1	335.3	599.4	713.9

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

Trend in the world's primary gold production

	2019	2020	2021	2022	2023^{e}
Mine production of gold, t (according to COCHILCO)	3,108	2,979	2,983	3,062	3,136
Mine production of gold, t (according to MCS)	3,300	3,030	3,090	3,060	3,000^{e}
Mine production of gold, t (according to WBD)	3,313	3,202	3,215	3,323	N

e – preliminary values
COCHILCO – Comisión Chilena del Cobre (Chilean state agency for copper)

Main producers according to MCS

Country	2023^{e}	
	t	%
China	370	12.3
Australia	310	10.3
Russia	310	10.3
Canada	200	6.7
USA	170	5.7
Kazakhstan	130	4.3
Mexico	120	4.0
Peru	110	3.7
Ghana	100	3.3
Indonesia	100	3.3
Others	610	15.6
World	**3,100**	**100.0**

e – preliminary values

Main producers according to COCHILCO

Country	2023	
	t	%
China	375	12.0
Russia	309	9.8
Austrália	394	9,4
Canada	189	6.0
USA	170	5.4
Mexico	135	4.3
Kazakhstan	133	4.2
Ghana	132	4.2
Indonesia	122	3.9
Uzbekistan	100	3.9
Peru	90	3.1
World	**3,136**	**100.0**

Prices of traded commodities

Average annual gold prices in USD/tr oz (1 tr oz (troy ounce) = 31.1035 g) according to the German yearbook DERA, American yearbook MCS and the World Bank's "Pink Sheet" (WB)

Commodity/year	2019	2020	2021	2022	2023
Gold 99.9 %. LME, in warehouse (according to DERA)	1,392	1,767	1,800	1,803	2,033
Au 99.5% (UK), LME average daily quotation (WB)	1,392	1,770	1,800	1,801	1,943
Au metal, annual price average (MCS)	1,395	1,774	1,801	1,800[e]	1,900

Iron

1. Characteristics and use

Average Fe content (and its extent) in the earth's crust (%)

5 (3–6.5) Fe

Industrially important minerals

Magnetite $FeO.Fe_2O_3$ (72% Fe), hematite Fe_2O_3 (70% Fe), siderite $FeCO_3$ (48% Fe)

Industrially important deposit types

1. Magmatic-hydrothermal: Kiruna (Sweden), Malmberget (Sweden), El Romeral (Chile)
2. Hydrothermally-metasomatic, with massive siderite: Bakal (Russia), Bilbao (Spain), Erzberg (Austria), Jerissa (Tunisia)
3. Banded iron formation (BIF): Hamersley region (Australia), Minas Gerais (Brazil), Lake Superior region (USA), Krivy Rih (Ukraine), Kursk Magnetic Anomaly region (Russia)

Reserves

Worldwide 81 billion t Fe (MCS 2020), of which Australia 28%, Brazil 19%, Russia 14%, China 9%, India 4%. The EU has reserves of 636 million tonnes of Fe, i.e. 0.8% of world reserves. Most of them in Sweden (83% European = 7% world) and Italy (26% European =

2023		
Country	**kt**	**%**
Australia	27,000	31.0
Brazil	15,000	17.2
Russia	14,000	16.1
China	6,900	7.9
India	3,400	3.9
Ukraine	2,300	2.6
Canada	2,300	2.6
Iran	1,500	1.7
USA	1,300	1.5
Peru	1,200	1.5
Kazakhstan	900	1.0
South Africa	620	0.7
Sweden	600	0.7
Turkey	99	0.1
Others	9,500	11.2
World	**87,000**	**100.0**

Source: MCS 2024

** metal conten*

2023			
Country	**kt**	**% World**	**% EU**
EU	635,755	100.0	0.6
Sweden	528,485	83.1	0.5
Romania	57,000	9.0	0.1
Norway	40,530	6.4	0.04
Slovakia	5,740	0.9	0.01
Italy	4,000	0.6	0.004

Source: European Minerals Yearbook – version 2023

4% world stock). Reserves are also available in Norway, Romania and Slovakia (European Minerals Yearbook – version 2019).

Uses

Iron ores are mainly used for the production of pig iron, either directly in untreated form as lump ores or as powdered ores and concentrates lumped by agglomeration or pelletisation. Some modern iron production technologies such as DRI (Direct Reduction of Iron) or COREX® also allow the processing of dust ores and concentrates without prior lumping.

Very small amounts of iron ore are used for non-metallurgical purposes – as weights, in the production of special cement (e.g. for underwater work), ferrites, animal feed, dyes, etc.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

There are no economically usable deposits of Fe ores in the Czech Republic. The ores occurring on the territory of the republic are poor, they generally have Fe contents below 40% and in most cases, they are recoverable by underground mining. At present, deposits of much richer ores with Fe contents of around 50% or more are mostly mined in the world. The average Fe contents in iron ores traded on the world market are 60% and more. The availability of higher quality and relatively cheaper iron ore from imports has led to a gradual cessation of iron ore mining in the Czech Republic. Mining of Fe ores in the Czech Republic definitely ended in 1992, when the Přísečnice magnetite deposit was closed. At the same time, the reserves of these ores were gradually removed from the Register as completely uneconomical, and since 2004 no exclusive deposits of Fe ores have been registered in the Czech Republic.

- Sedimentary iron ores are found in the Barrandian. They are Paleozoic ores of marine origin in sediments of Ordovician age. They are mostly in the shape of relatively large lenses. The ores are mainly represented by hematite, siderite and Fe-silicates (leptochlorites). The Fe content reaches an average of 25 to 30%; it is characterised by the oolithic structure of ores and a high content of SiO_2. It was intensively mined in many places (e.g. Nučice, Ejpovice, Mníšek pod Brdy, Zdice, etc.) mainly in the 19th and first half of the 20th century. The final termination of mining of these ores occurred in 1967, when the Ejpovice and Krušná Hora deposits were closed, and during 1997–1999 the remaining reserves of all sedimentary Fe deposits in the Czech Republic were written off and removed from the records of reserved mineral deposits.
- In the Moravian-Silesian Devonian there is a volcanic-sedimentary ore mineralisation of the Lahn-Dill type. Ores containing mainly hematite, magnetite and less Fe-silicates form smaller lenticular bodies, often intensely folded. Magnetite ores had average Fe contents of about 35 to 40% Fe, ores with a predominance of hematite slightly lower (about 30%). Ores were mined in many places (Medlov, Benkov, Králová, Horní Město, etc.). The main development of mining activity was in the 19th century; its final termination came in the mid-1960s. Also, all remaining reserves of Lahn-Dill deposits were written off and removed from the Register in 1997–1999.
- Small magnetite lenses are typical for skarns of the Moldanubicum (Vlastějovice, Županovice, Malešov, Budeč), the Krušné hory formation (Měděněc, Přísečnice, Kovářská),

the Krkonoše-Jizera crystalline complex, etc. Fe contents in ores were mostly around 33 to 38%. Mining mostly ended in the 1960s, and in the Přísečnice and Měděnec deposits in 1992. Residual reserves of these deposits were also removed from the Register by the end of the 1990s.

- Other genetic types of Fe ore mineralisation were mostly of only marginal importance. These were, for example, banded ores of the Sydvaranger type (Sobotín, etc.), hydrothermal ores (Krušné Hory, etc.), stratiform ores (Hraničná, etc.), sedimentary (except Ordovician), weathering, metasomatic, etc.

In the past (peak in the 19th and early 20th centuries), Fe deposits were extensively mined and relatively expensively processed, mainly as a charge for the production of pig iron. This is especially true for the poor and acidic sedimentary ores of the Barrandian, which have been subjected to Krupp-Ren process treatment. Magnetite was used to a large extent (almost exclusively in the 1970s and 1990s) for non-metallurgical purposes such as the production of cement and heavy concrete, as a heavy medium in jigs of coal treatment plants, etc.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2601 – Iron ores and concentrates

		2019	2020	2021	2022	2023
Import	t	5,335,440	4,915,243	6,035,837	4,897,574	4,101,494
Export	t	3,343	26	1	6	24

2601 – Iron ores and concentrates

		2019	2020	2021	2022	2023
Average import prices	CZK/t	2,590	2,694	3,882	N	3,211
Average export prices	CZK/t	3,742	5,405	–	13,500	34,250

7201 – Crude iron

		2019	2020	2021	2022	2023
Import	t	54,504	47,175	56,918	48,080	24,040
Export	t	45,748	51,827	85,714	39,099	22,301

7201 – Crude iron

		2019	2020	2021	2022	2023
Average import prices	CZK/t	9,545	9,090	13,556	17,709	12,636
Average export prices	CZK/t	8,563	8,535	11,542	18,264	13,398

7204 – Ferrous waste and scrap, remelted scrap ingots or iron or steel

		2019	2020	2021	2022	2023
Import	t	443,433	441,663	509,861	460,103	408,345
Export	t	2,263,155	2,188,727	2,388,140	2,120,044	2,408,995

7204 – Ferrous waste and scrap, remelted scrap ingots or iron or steel

		2019	2020	2021	2022	2023
Average import prices	CZK/t	6,085	5,854	9,338	9,891	8,634
Average export prices	CZK/t	6,600	6,216	10,009	11,143	8,742

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

World production of iron ore in recent years according to published statistics:

	2019	2020	2021	2022	2023[e]
World mine production of iron ore (according to MCS), mill. t	2,450	2,470	2,680	2,500	2,500
World mine production of iron ore (according to WBD), mill. t	1,552	1,524	1,592	1,548	N

e – preliminary values

Main producers according to MCS

Country	2023^{e}	
	mill. t	%
Australia	960	36.9
Brazil	440	16.9
China	280	10.8
India	270	10.4
Russia	88	3.4
Iran	77	3.0
South Africa	61	2.3
Canada	58	2.2
Kazakhstan	53	2.0
USA	44	1.7
Sweden	38	1.5
Ukraine	36	1.4
Peru	19	0.7
Chille	18	0.7
Turkey	17	0.7
Mauretania	13	0.5
Mexico	12	0.4
Others	48	1.8
World	**2,600**	**100.0**

e – preliminary values

Prices of traded commodities

Average annual prices of iron ore according to MCS yearbooks and World Bank data

Commodity/year		2019	2020	2021	2022	2023
Iron ore, any origin, spot price, (according to the World Bank)	USD/dmt	93.8	108.9	161.7	121.3	152.3
Iron ore, US market, annual average (according to MCS)	USD/t	92.4	91.3	141.8	114.0	138.4
Ukrainian iron ore, yearly average of import prices (according to CZSO)	USD/t	90.84	114.26	114.38	178.84	182.6

Note: dmt – dry metric ton = one tonne of dry ore

Lead

1. Characteristics and use

Average Pb content (and its extent) in the earth's crust (ppm)

16 (1–20) Pb

Industrially important minerals

Galena PbS (87% Pb), boulangerite ($Pb_5Sb_4S_{11}$ (55% Pb), bournonite $CuPbSbS_3$ (43% Pb).

Lead ores are most often part of polymetallic ores formed mainly by sulphides of lead and zinc, sometimes copper, and are accompanied by obtainable contents of silver and gold and a number of trace elements (e.g. In, Cd, Bi, etc.). The main minerals of these ores are galena and sphalerite, usually with pyrite and often with chalcopyrite. There are various, sometimes conflicting views on the genesis of a number of polymetallic ore deposits, as several genetic processes have often been applied to their origin and final form.

Industrially important deposit types

1. Sedimentary exhalative (sediment-bound, submarine-exhalative – "sedex"): Mt.Isa (Australia), Broken Hill (Australia), Gorevskoye (Russia), Xiaotieshan (China), Maqiongxia (China)
2. Stratiform: Olkusz (Poland), Mississippi Valley (USA), Silvermines (Ireland), Mirgalimsay (Kazakhstan), Frankou (China), Siding (China)

Reserves

2023		
Country	**mill. t**	**% World**
Australia	35,000	36.8
China	20,000	21.1
Russia	8,700	9.1
Mexico	5,600	5.9
Peru	5,000	5.3
USA	4,600	4.8
Iran	2,000	2.1
India	1,900	2.0
Sweden	1,700	1.8
Bolivia	1,600	1.7
Turkey	1,600	1.7
Other countries	5,900	6.2
World	**95,000**	**100.0**

Source: MCS 2024

2023			
Country	**mill. t**	**% World**	**% EU**
EU	15,160	17.20	100.00
Poland	9,000	10.20	59.40
Italy	4,000	4.50	26.40
Sweden	1,191	1.40	7.90
Portugal	479	0.50	3.20
Ireland	238	0.30	1.60
Spain	222	0.30	1.50
Slovakia	19	0.02	0.10
Finland	11	0.01	0.07

Source: European Minerals Yearbook – version 2023

Uses

Batteries (85%), chemicals (6%), metallurgical products (4%), electrical engineering, electronics

Classification as critical raw materials for the European Union:

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

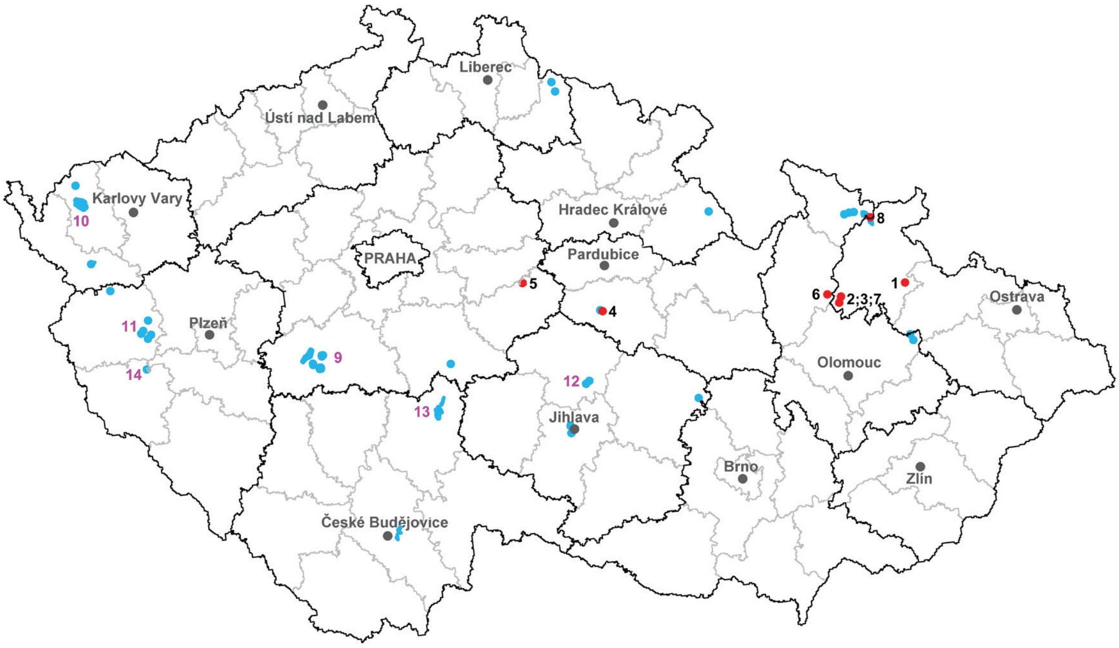
2. Mineral resources of the Czech Republic

The fame of medieval Czech ore mining was largely based on the use of vein hydrothermal deposits of polymetallic ores. Originally it was due to the content of Ag in the ores of these deposits, since the 16th century the mining and processing of lead and later also zinc ores joined in. After the Second World War, in connection with newly carried out exploratory works, volcanic-sedimentary deposits of pyrite formation became important.

- Hydrothermal polymetallic vein ore mineralisation is very abundant in the Bohemian Massif. Alongside the purely historical districts of Oloví, Jihlava, Havlíčkův Brod, the area of the Blanice Graben and others, the Příbram, Stříbro and Kutná Hora districts retained their importance until the 20th century. The main carrier of Pb ore mineralisation was galena (more or less silver-bearing), which could have been as abundant as sphalerite on most Pb-Zn deposits. Most veins had a significantly lower galena content compared to sphalerite only in the Kutná Hora district.
- A slightly different type of hydrothermal ore mineralisation was represented by the former Harrachov deposit with a vein filling consisting of barite, fluorite and galena.
- Stratiform polymetallic ores of the volcanic-sedimentary type, linked to Devonian volcanism, were verified in the 1950s and 1980s in northern Moravia. The subject of mining západ the Horní Město, Horní Benešov deposits and the Zlaté Hory-východ and Zlaté Hory-west deposits in the Zlaté Hory district. Lead contents ranging up to 0.5% were bound to galena, accompanied by sphalerite in the ore strips. The exploitation of a number of other ore objects of similar genesis has not yet begun due to the phase out of ore mining.

The extraction of Pb from polymetallic deposits was terminated in the Czech Republic in 1993 at the last deposit Zlaté Hory-západ. The final product of mining was a complex Pb-Zn concentrate, which was exported because there were no domestic capacities to smelt it. In connection with the ongoing reassessment (rebalancing) of polymetallic ores, a large part of lead deposits and reserves was gradually removed from the Register in 1990–2004.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits   exhausted deposits and other resources

Registered deposits and other resources are not mined

Reserved registered deposits:

1 Horní Benešov
2 Horní Město
3 Horní Město-Šibenice
4 Křižanovice
5 Kutná Hora
6 Oskava
7 Ruda u Rýmařova-sever
8 Zlaté Hory-východ

Exhausted deposits and other resources:

9 Březové Hory + Příbram-Bohutín
10 Oloví
11 Stříbro
12 Havlíčkův Brod (Dlouhá Ves + Bartoušov + Stříbrné Hory)
13 Ratibořské Hory + Stará Vožice
14 Černovice

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number [a)]	8	8	8	8	8
exploited	0	0	0	0	0
Total mineral *reserves, kt Pb	161	161	161	161	161
economic explored reserves	0	0	0	0	0
economic prospected reserves	0	0	0	0	0
potentially economic reserves	161	161	161	161	161
Mine production, kt Pb	0	0	0	0	0

* *See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

[a)] *Deposits with registered Pb content*

Approved prognostic resources P_1, P_2, P_3
Polymetallic (Pb – Zn ± Cu) ores

Year		2019	2020	2021	2022	2023
P_1,	kt	786	786	786	786	786
P_2,	kt	5,340	5,340	5,340	5,340	5,340
P_3		–	–	–	–	–

5. Foreign trade

2607 – Lead ores and concentrates

		2019	2020	2021	2022	2023
Import	t	0	0	0	0	0
Export	t	0	0	0	0	0

2607 – Lead ores and concentrates

		2019	2020	2021	2022	2023
Average import prices	CZK/t	–	–	–	–	–
Average export prices	CZK/t	–	–	–	–	–

7801 – Unwrought lead

		2019	2020	2021	2022	2023
Import	t	422,312	164,067	179,418	163,975	142,482
Export	t	40,600	38,209	38,650	30,313	28,857

7801 – Unwrought lead

		2019	2020	2021	2022	2023
Average import prices	CZK/t	17,841	38,113	49,391	52,995	56,498
Average export prices	CZK/t	37,688	46,383	50,378	56,119	54,634

7802 – Lead waste and scrap

		2019	2020	2021	2022	2023
Import	t	10,435	6,946	8,746	8,694	6,997
Export	t	894	3,522	4,771	836	335

7802 – Lead waste and scrap

		2019	2020	2021	2022	2023
Average import prices	CZK/t	39,088	36,284	39,461	40,211	36,562
Average export prices	CZK/t	37,688	19,376	24,259	34,261	33,173

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

World lead production has been slowly declining in recent years. The table shows data from the prestigious International Lead and Zinc Study Group (ILZSG) and data from the Mineral Commodity Summary (MCS) and Welt Bergbau Daten (WBD) yearbooks:

	2019	2020	2021	2022	2023[e]
World mine production of lead (according to ILZSG*), kt	4,695	4,445	4,546	4,436	4,447
World mine production of lead (according to MCS), kt	4,720	4,380	4,550	4,460	4,500
World mine production of lead (according to WBD), kt	4,906	4,729	4,600	4,694	N

e – preliminary values

** ILZSG – International Lead and Zinc Study Group: An intergovernmental organisation founded in 1959 by the United Nations*

Main producers according to MCS

Country	2023[e]	
	kt	%
China	1 900	42.2
Australia	440	9.8
USA	270	6.0
Mexico	270	6.0
Peru	250	5.6
India	220	4.9
Russia	200	4.4
Bolivia	90	2.0
Turkey	75	1.7
Sweden	70	1.6
Tajikistan	50	1.1
Iran	50	1.1
Other countries	610	16.6
World	**4 500**	**100.0**

e – preliminary values

Prices of traded commodities

World lead prices (USD/t, if not otherwise stated) according to the German yearbooks DERA, World Bank (WB), and Metal Bulletin (MB)

Commodity/year	2019	2020	2021	2022	2023[e]
99.97% Pb, LME (according to DERA)	1,996.90	1,823.70	2,203.83	2,152.08	2,035.00**
Refined 99.97 %, contractual price (according to WB)	2,240.00	1,997.00	2,240.00	1,997.00	2,136.00
Lead, LME, annual average, spot market, USc/lb (according to MCS)	99.90	91.30	113.00	116.50	115.00

e – preliminary values
*** Průměr za prosinec 2023*

Manganese

1. Characteristics and use

Average Mn content (and its extent) in the earth's crust (ppm)

1,000 (400–1,600) Mn

Industrially important minerals

Pyrolusite MnO_3 (55–63% Mn), psilomelane $BaMn_3O_{16}$ (45–60% Mn), manganite MnOOH (50–62% Mn), braunite $Mn^{2+}Mn^{3+}{}_6SiO_{12}$ (60–69% Mn), hausmannite $MnMn_2O_4$ (65–72% Mn), rhodochrosite $MnCO_3$ (40–45% Mn)

Industrially important deposit types

1. Hydrothermally-exhalative (volcanic-sedimentary): Molango District (Mexico), deposits of the Transvaal section of western Griqualand (South Africa)
2. Marine-sedimentary: Nikopol (Ukraine), Chiatura (Georgia), Groote Eylandt (Australia), Xiangtan (China), Wafangzi (China)

Huge amounts of Mn are bound to industrially unused deep-sea concretions lying on the ocean floor. It is estimated that these concretions weigh about $2.5.10^{12}$ t. The projected reserves of Mn in concretions (average content of 25% Mn) deposited on the seabed are about 358 million tonnes of metal.

Reserves

2023		
Country	**kt**	**% World**
South Africa	600,000	37.6
Australia	500,000	15.9
Brazil	280,000	16.5
Ukraine, concentrate	270,000	15.9
Gabon	140,000	8.2
India	61,000	3.6
Ghana	34,000	2.0
Kazakhstan, concentrate	13,000	0.8
Mexico	5,000	0.3
World	**5,000**	**0.3**

Source: MCS 2024

EU Mn reserves are known in Romania. With a tonnage of 18 million tons of Mn, they represent 1.4% of the world's reserves. Source: European Minerals Yearbook – version 2022.

Uses

More than 90% of Mn is used for the production of manganese ferroalloys used in the field of iron metallurgy, both for the production of pig iron and especially for the production of steel as a deoxidising and desulphurising additive and an important alloying metal. The average world consumption of manganese per 1 ton of crude steel is 10 kg, in modern steel mills it is at least 6 kg. Mn is also used in alloys with non-ferrous metals (Al, Cu, Ti, Ag, Au, Bi). Other uses of Mn are mainly in the production of dry batteries, dyes, soft ferrites, fertilisers, animal feed, fuel additives, welding electrodes, water treatment, etc. In terms of use and quality requirements of ores or concentrates, Mn raw materials are divided into metallurgical, chemical and those for the production of batteries.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – yes

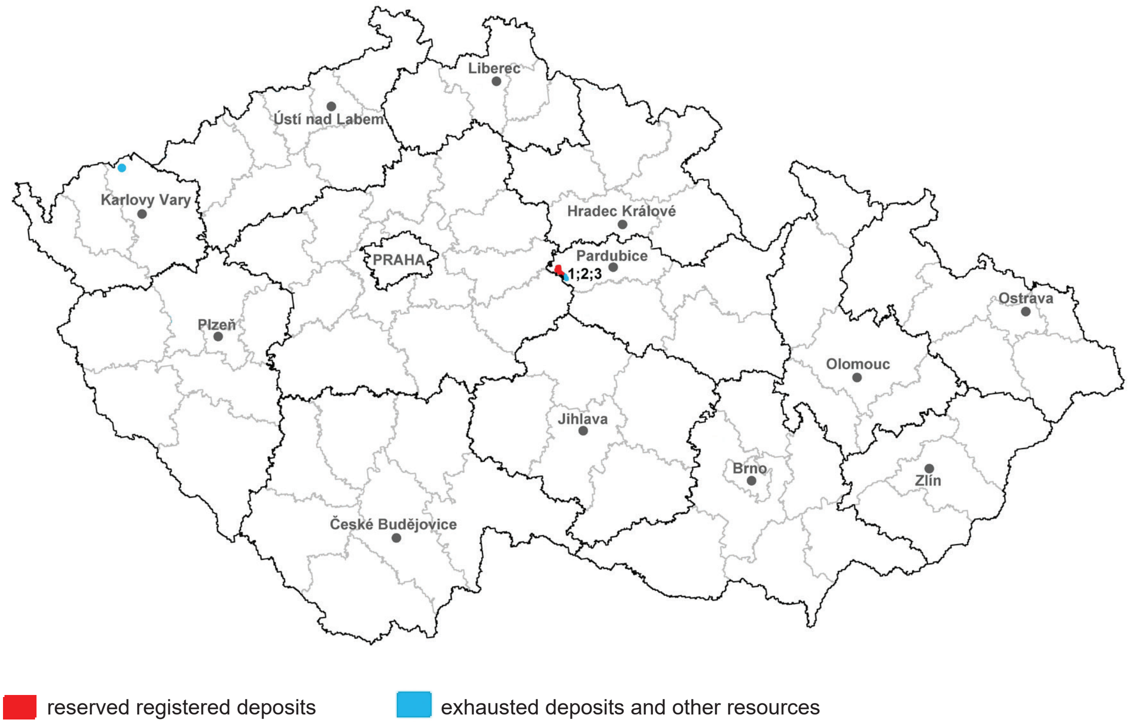
2. Mineral resources of the Czech Republic

Since 1988, the manganese ore reserves in the Register have consisted of one problematic primary deposit of poor carbonate-silicate ores and two dumps (more precisely tailing ponds) in Chvaletice and Řečany. In 2017, the reserves at the tailing ponds were reevaluated, as a result of which the total reserves of Mn ores were reduced to 135.7 million tonnes, but part of the reserves was evaluated as economic. Mn contents in ores mined in the world are around 30–50% in primary ores (mostly metamorphic) and significantly over 10% in sedimentary ores.

- The most significant accumulations of Mn-ores are known in the Iron Mountains area in the form of volcanic-sedimentary deposits in the Proterozoic. The ore mineralisation is connected with the position of graphitic pyrite shales and, together with the surrounding rocks, it is regionally metamorphosed. The ore layer, traceable from Chvaletice to Sovolusky, consists of a mixture of Mn and Fe carbonates (especially Fe-rhodochrosite), quartz, graphite and Fe sulphides. Due to metamorphosis, part of Mn is bound in silicates. The primary ore contains 12 to 13% Mn. The most extensive mining took place at the Chvaletice deposit. In the initial parts of the deposit, Fe ore of the gosan type was initially mined (from the 17th century). Since the First World War, Mn ores were also mined experimentally. From the early 1950s until the end of mining in 1975, pyrite was mined here as a raw material for the chemical industry. Simultaneously mined manganese ores were not processed due to unresolved technology and were deposited in the tailing ponds of the former treatment plant. The average total Mn content at tailing pond 3 is between 9 and 11% and at tailing ponds 1 and 2 it is between 5 and 8%. Leachable Mn accounts for about 6% in all tailing ponds. One of the possible uses of these ores could be flue gas desulphurisation; use in the production of batteries is also being considered at the moment.
- Other occurrences of Mn-ores in the Czech Republic (e.g. Horní Blatná, Arnoštov, Maršov u Veverské Bítýšky, etc.) have no economic significance and they never had any.

Manganese ore mining ended in 1962, when the Chvaletice deposit was last mined. Between 1969 and 1975, there was also a decrease in reserves at the Chvaletice deposit but as a result of pyrite mining, which definitively ended in 1975.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined

1 Chvaletice	2 Chvaletice – tailing ponds No 1 & No 2	3 Řečany – tailing pond No 3

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	3	3	3	3	3
exploited	0	0	0	0	0
Total mineral *reserves, kt ores	135,685	135,685	135,764	135,764	135,764
economic explored reserves	23,372	23,372	26,495	26,495	26,495
economic prospected reserves	3,508	3,508	464	464	464
potentially economic reserves	108,805	108,805	108,805	108,805	108,805
Mine production, kt Mn	0	0	0	0	0

** See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

5. Foreign trade

2602 – Manganese ores and concentrates

		2019	2020	2021	2022	2023
Import	t	38,875	38,875	49,576	46,251	40,095
Export	t	61	61	71	36	79

2602 – Manganese ores and concentrates

		2019	2020	2021	2022	2023
Average import prices	CZK/t	3,987	4,156	2,479	4,216	5,182
Average export prices	CZK/t	17,799	19,046	17,930	15,352	21,937

720221; 720229 – Ferromanganese

		2019	2020	2021	2022	2023
Import	t	25,089	21,816	27,968	15,642,1	9,837
Export	t	869	1,263	2,902	2,021	1,064

720221; 720229 – Ferromanganese

		2019	2020	2021	2022	2023
Average import prices	CZK/t	28,490	24,893	27,968	70,349	26,083
Average export prices	CZK/t	28,221	25,368	20,717	44,452	23,846

720230 – Ferrosilicomanganese

		2019	2020	2021	2022	2023
Import	t	36,389	37,321	37,321	33,227	23,846
Export	t	839	1,762	1,762	1,318	3,025

720230 – Ferrosilicomanganese

		2019	2020	2021	2022	2023
Average import prices	CZK/t	17,496	24,232	33,216	37,75	24,921
Average export prices	CZK/t	24,309	20,818	26,868	37,586	23,647

8111 – Manganese and articles thereof, including waste and scrap

		2019	2020	2021	2022	2023
Import	t	960	1,028	1,387	920	648
Export	t	63	77	90	155	78

8111 – Manganese and articles thereof, including waste and scrap

		2019	2020	2021	2022	2023
Average import prices	CZK/t	60,361	51,336	67,931	106,620	74,988
Average export prices	CZK/t	48,325	42,084	76,625	35,665	30,179

2820 – Manganese oxides

		2019	2020	2021	2022	2023
Import	t	740	1,093	840	577	448
Export	t	19	8	8	12	12

2820 – Manganese oxides

		2019	2020	2021	2022	2023
Average import prices	CZK/t	17,901	17,651	17,040	29,448	19,701
Average export prices	CZK/t	36,230	47,663	414,549	319,750	381,750

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World production

The world´s primary production of manganese in mined ores was as follows in recent years:

	2019	2020	2021	2022	2023^{e}
World mine production of manganese (according to MCS), kt	19,600	18,900	20,100	19,800	20,000
World mine production of manganese (according to WBD), kt	21,164	19,618	20,513	20,284	N

e – preliminary values

Main producers according to MCS

Country	2023^{e}	
	kt	%
South Africa	7,200	36.0
Gabun	4,600	23.0
Australia	3 000	15.0
Ghana	840	4.2
China	740	3.7
India	720	3.6
Brazil	620	3.1
Ivory Coast	390	2.0
Ukraine, concentrate	320	1.6
Malaysia	250	1.3
Mexico	220	1.1
Burma	210	1.1
Georgia	160	0.8
Vietnam	160	0.8
Kazakhstan, concentrate	130	0.7
World	**200,000**	**100.0**

e – preliminary values

Prices of traded commodities

According to MCS the average world prices of manganese commodities developed as follows in recent years:

Komodita/rok		2019	2020	2021	2022	2023^{e}
Mn ore, metallurgical, 46-48% Mn, CIF USA ports, (MCS)	USD/t	7.17	6.60	N	N	N
Mn ore, metallurgical, 44% Mn, CIF Chinese spot market, (MCS)	USD/t	5.63	4.59	5.27	5.97	5.00
Bulgarian manganese ore, annual average price of imports into the Czech Republic (CZSO)	EUR/t	N	N	104	87	129
Ferro-manganese, 78% Mn, US free market, in warehouse Pittsburgh, (MCS)	USD/lt	1,458	1,064	1,075-1,360	N	N
Ferro-managnese, 75%, FOB India (DERA)	USD/t	N	N	1,387	1,412	1,266
Electrolytic (EMM), min. 99.7%, export (FOB), domestic (DERA)	USD/t	N	N	3,929	3,167	2,494

Nickel

1. Characteristics and use

Average Ni content (and its extent) in the earth's crust (ppm)

99 Ni

Industrially important minerals

Pentlandite $(Ni,Fe)_9S_8$ (35% Ni), nickeline NiAs (44% Ni), garnierite $(Ni,Mg)_6(OH)_8Si_4O_{10}$ (30% Ni)

Industrially important deposit types

1. Sulphide deposits – deposits of disseminated to massive sulphide ores in basic and ultrabasic magmatites: Sudbury, Voisey's Bay (Canada), Norilsk (Russia), Monchegorsk (Russia), Emily Ann (Australia), Flying Fox (Australia), Outokumpu (Finland), Aguablanca (Spain).
2. Silicate – deposits of lateritic ores in basic and ultrabasic massifs, mainly with Co contents: Moa (Cuba), Falcondo (Dominican Republic), Goro (New Caledonia), Petea (Indonesia), Murrin Murrin, Ravensthorpe, (Australia), Shevchenko (Kazakhstan).

Reserve

2023		
Country	**kt**	**% World**
Indonesia	55,000	55.0
Australia	24,000	24.0
Brazil	16,000	16.0
Russia	8,300	8.3
New Caledonia	7,100	7.5
Philippines	4,800	4.8
China	4,200	4.2
Canada	2,200	2.2
USA	340	0.4
Others	9,100	9.1
World	**>100,000**	**100.0**

Source: MCS 2024

2023			
Country	**kt**	**% World**	**% EU**
EU	608	0.6	100.0
Finland	479	0.5	78.8
Poland	125	0.1	20.6
Spain	4	0.0	0.7

Source: European Minerals Yearbook – version 2023

Uses

Nickel excels in high chemical, thermal and mechanical stability, which is the reason it is used as an alloying additive in the production of stainless steels. Their production accounts for most of the world's primary nickel consumption. Furthermore, nickel is used in the automotive industry (NiMH batteries), in aviation, in the nuclear industry, in the energy industry, in the chemical industry, etc.

Classification as critical raw materials for the European Union
2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – yes

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved resources of nickel in the total amount of 114,891 t Ni, mainly in the Staré Ransko locality.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2604 – Nickel ores and concentrates

		2019	2020	2021	2022	2023
Import	t	0.004	9	37	11	9
Export	t	0	0	0	0	0

2604 – Nickel ores and concentrates

		2019	2020	2021	2022	2023
Average import prices	CZK/t	475,000	67,699	55,241	862,455	469,362
Average export prices	CZK/t	–	–	–	–	–

7502 – Unwrought nickel

		2019	2020	2021	2022	2023
Import	t	3,111	2,683	2,851	2,540	3,026
Export	t	198	175	124	91	89

7502 – Unwrought nickel

		2019	2020	2021	2022	2023
Average import prices	CZK/t	338,675	352,008	412,361	556,377	537,550
Average export prices	CZK/t	297,879	298,750	356,520	583,491	468,090

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of nickel

Commodity/year	2019	2020	2021	2022	2023^{e}
World mine production of nickel (according to MCS), kt*	2,610	2,510	2,730	3,270	3,600
World mine production of nickel (according to WBD), kt	2,707	2,477	2,812	3,249	N

e – estimate
** Nickel content*

Main producers of nickel according to MCS

Country	2023^{e}	
	kt*	%
Indonesia	1,800	50.0
Philippines	400	11.1
Russia	200	5.6
New Caledonia	190	5.3
Canada	180	5.0
Australia	160	5.0
China	110	3.1
Brazil	89	2.5
USA	17	0.5
Other countries	380	10.1
World (rounded)	**3,600**	**100.0**

e – estimate
** Nickel content*

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023[e]
Nickel, annual average, cash, LME, USD/t (MCS)	13,772	13,903	18,476	25,815	22,000
Nickel, annual average, cash, LME, USD/lb (MCS)	22,000	6.250	8.380	11.710	9,80
Nickel, LME, primary, min. 99.8%, cash in LME warehouse, USD/t (DERA)*	13,902.9	13,772.0	18,475.8	25,814.8	16,831**

e – estimate
* *Average annual price*
** *Průměrná cena za prosinec 2023*

Silver

1. Characteristics and use

Average Ag content (and its extent) in the earth's crust (ppm)

(0.02–0.1) Ag

Industrially important minerals

Silver is found in polymetallic (Pb-Zn and Cu) and copper deposits of various types. The main ore mineral in polymetallic deposits is Ag-galenite PbS (0,01 – >1% Ag), the others are mostly Ag sulphides and sulphosalts, such as akantite Ag_2S (87% Ag), polybasite $(Ag,Cu)_{16}Sb_2S_{11}$ (74% Ag), proustite Ag_3AsS_3 (65% Ag), pyrargyrite Ag_3SbS_3 (60% Ag), chlorargyrite AgCl (75% Ag), tetrahedrite (freibergite) $Cu_6(Ag,Fe)_6Sb_4S_{13}$ (18% Ag), native silver (100% Ag).

Industrially important deposit types

Silver production is mainly a by-product of the mining of industrially important deposits of Pb-Zn, Cu.

Reserves

2023		
Country	**t**	**% World**
Peru	110,000	18.0
Australia	94,000	15.4
Russia	92,000	15.1
China	72,000	11.8
Poland	63,000	10.3
Mexico	37,000	6.1
Chile	26,000	4.3
USA	23,000	3.8
Bolivia	22,000	3.6
India	8,000	1.3
Argentina	6,500	1.1
Other countries	57,000	9.3
World	**610,000**	**100.0**

Source: MCS 2024

2023			
Country	**t**	**% World**	**% EU**
EU	83,683	16.74	100.0
Poland	70,740	14.10	84.5
Sweden	7,852	1.60	9.4
Portugal	2,619	0.50	3.1
Spain	1,026	0.20	1.2
Slovakia	1,006	0.20	1.2
Finland	439	0.10	0.5

Source: European Minerals Yearbook – version 2023

Uses

Despite the significant decline in silver consumption in the photographic industry in connection with the development of digital photography, its consumption is not significantly decreasing, as this metal finds new applications in many industrial and consumer areas, such as electrical engineering and electronics, colour printing, deodorant production, healthcare etc. The traditional use of silver in jewellery retains its significance (approximately 1/3 of its consumption). Silver is also used in water purification, battery production, production of mirrors and special reflective surfaces (solar energy generation), catalyst production and in nuclear energy for the production of control rods for water reactors (alloy 80% Ag, 15% In and 5% Cd) .

Classification as critical raw materials for the European Union
2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

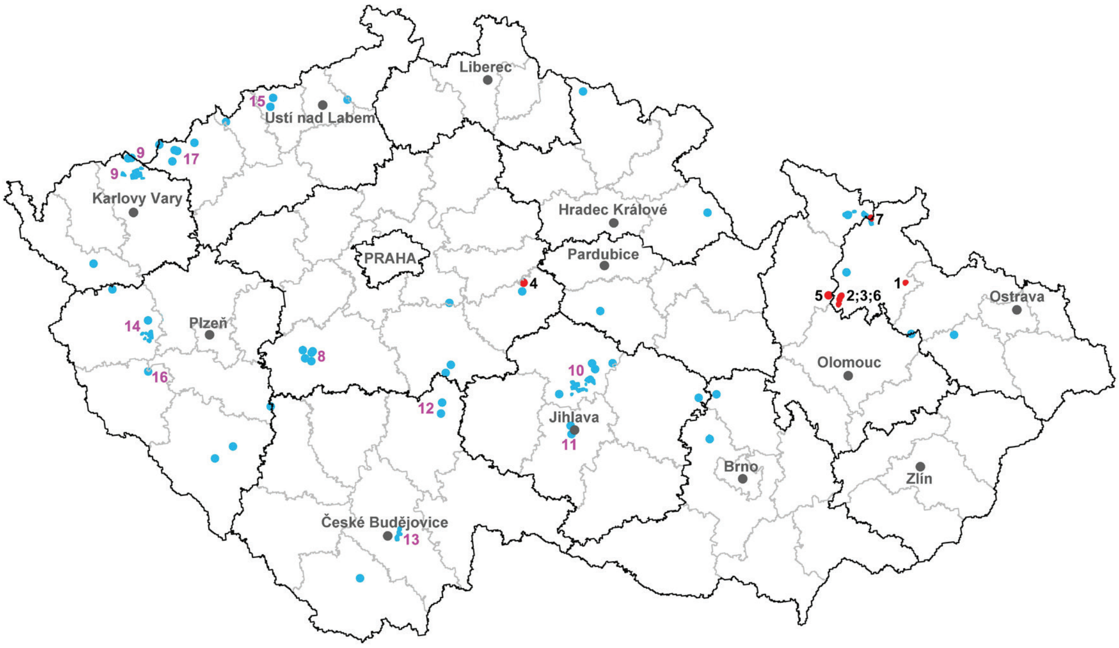
2. Mineral resources of the Czech Republic

Silver mining to a decisive extent established the tradition of medieval ore mining in Bohemia and the expansions of mining towns.

- A substantial share of Ag reserves in the Czech Republic was bound as an isomorphic impurity in sulphides of polymetallic ores, especially in galena. Part of the silver was previously obtained by mining rich polymetallic Pb-Zn ores (58–70 ppm Ag) and U-Ag ores (noble ores including native Ag with contents of about 480 ppm Ag) in the Příbram uranium-polymetallic deposit until the phase out of mining in the early nineties. The obtainable amounts of silver also contained polymetallic ores from the Horní Benešov and Horní Město deposits. The 50% lead concentrate from these deposits showed an average content of 846 g/t Ag in the years 1963–1992, the 49% zinc concentrate had an average content of 86.6 g/t. In the Zlaté Hory district, silver was contained in polymetallic ores of the Zlaté Hory-východ deposit. The average silver content of Pb-Zn concentrate produced from ores of this deposit was 0.19 g/t in the years 1988–1992.
- Many abandoned deposits of Pb-Zn-Ag ores and deposits of five-element formation (U-Bi-Co-Ni-Ag) in historical districts (Kutná Hora, Příbram, Jáchymov, Jihlava, Havlíčkův Brod, Stříbro, Stará Vožice, Ratibořské Hory, Rudolfov, Vejprty, Hrob etc.) was in the past an important source of European silver and represents classical deposit types.

The extraction of Ag from polymetallic deposits was terminated in the Czech Republic in 1993 at the last deposit Zlaté Hory-západ. In connection with the ongoing reassessment of polymetallic ores, a large part of silver deposits and reserves was gradually removed from the Register in 1990–2004.

3. Registered deposits and other resources of the Czech Republic



reserved registered deposits   exhausted deposits and other resources

Registered deposits and other resources are not mined

Reserved registered deposits:

1 Horní Benešov
2 Horní Město
3 Horní Město-Šibenice
4 Kutná Hora
5 Oskava
6 Ruda u Rýmařova-sever
7 Zlaté Hory-východ

Exhausted deposits and other resources:

8 Příbram surroundings
9 Jáchymov surroundings
10 Havlíčkův Brod surroundings
11 Jihlava surroundings
12 Ratibořské hory + Stará Vožice
13 Rudolfov
14 Stříbro
15 Hrob + Mikulov
16 Nalžovské hory
17 Vejprty + Hora sv. Kateřiny

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number [a)]	7	7	7	7	7
exploited	0	0	0	0	0
Total mineral *reserves, t Ag	532	532	532	532	532
economic explored reserves	0	0	0	0	0
economic prospected reserves	0	0	0	0	0
potentially economic reserves	532	532	532	532	532
Mine production, t Ag	0	0	0	0	0

* *See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

[a)] *Deposits with registered Ag content*

Approved prognostic resources P_1, P_2, P_3
Ag metal in ores

Year		2019	2020	2021	2022	2023
P_1,	t	33	33	33	33	33
P_2,	t	4	4	4	4	4
P_3		–	–	–	–	–

5. Foreign trade

261610 – Silver ores and concentrates

		2019	2020	2021	2022	2023
Import	kg	0	1,906	0	0	0
Export	kg	26	0	0	0	0

261610 – Silver ores and concentrates

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	–	12	–	–	–
Average export prices	CZK/kg	2,962	–	–	–	–

7106 – Silver, unwrought or in semi-manufactured or powder form

		2019	2020	2021	2022	2023
Import	kg	229,138	482,481	569,818	511,643	39,954
Export	kg	36,244	35,995	51,812	53,649	5,998

7106 – Silver, unwrought or in semi-manufactured or powder form

		2019	2020	2021	2022	2023
Average import prices	CZK/g	5.2	4.1	4.9	5.4	4,4
Average export prices	CZK/g	11.3	15.6	16.2	16.4	15,9

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

According to statistics, world production of primary silver was as follows in recent years:

	2019	2020	2021	2022	2023
World mine production of silver (according to COCHILCO), t	26,090	24,195	25,506	24,962	25,197
World mine production of silver (according to MCS), t	26,500	23,500	23,000	25,600	26,000^{e}
World mine production of silver (according to WBD), t	28,101	26,517	26,609	26,584	N

e – preliminary values
COCHILCO (Comisión Chilena del Cobre, Chilean state agency for copper)

Main producers according to MCS

Country	2023	
	t	%
Mexico	6,400	24.6
China	3,400	16.0
Peru	3,100	11.9
Chile	1,400	5.4
Poland	1,300	5.0
Australia	1,200	4.6
Bolivia	1,200	4.6
Russia	1,200	4.6
USA	1 100	4.2
Kazakhstan	990	3.8
Argentina	910	3.5
India	690	2.7
Other countries	3,000	11.5
World	**26,000**	**100.0**

Hlavní producenti dle MCS

Země	2023	
	t	%
Mexiko	6,263	24,9
China	3,505	13,9
Peru	3,043	12,1
Poand	1,428	5,7
Chile	1,378	5,5
Bolívia	1,350	5,4
Russia	1,280	5,1
Austrália	1,013	4,0
USA	998	4,0
Kazakchstan	895	3,6
World	**25,197**	**100,0**

Prices of traded commodities

According to DERA, MCS and the World Bank (WB), the world silver price in USD/tr oz (1 tr oz (troy ounce) = 31.1035 g) developed as follows in recent years:

Commodity/year	2019	2020	2021	2022	2023
Silver 99.5 %, LME, in warehouse, cash (according to DERA)	15.71	16.19	20.50	25.16	21.75
Refined. 99.9 %, Handy&Harman, New York (according to WB)	15.7	16.2	25.2	21.8	23.4
Silver metal, Platts Metal Week quotations (according to MCS)	16.24	20.58	25.23	21.88	23.4

Tin

1. Characteristics and use

Average Sn content (and its extent) in the earth's crust (ppm)

2 (0.5–3) Sn

Industrially important minerals

Cassiterite SnO_2, which can contain up to 78% Sn, less often stannite Cu_2FeSnS_4 (28% Sn)

Industrially important deposit types

Tin minerals have been concentrated during magma differentiation, and tin deposits are bound to granitic rocks and their vein and effluent equivalents. Tin ore mineralisation is also known from skarns, which form close to contacts with granitoids. Tin minerals often occur on tin-tungsten, tin-silver and tin-polymetallic deposits.

1. Granites with apical parts enriched with rare earths: Shuiximiao (CHN)
2. Pegmatites with cassiterite and rare earths accompanied by Ta, Be, Li: Greenbushes (Australia)
3. Magmatic-hydrothermal greisens: Cínovec (Czech Republic) – Zinnwald (Germany), Cornwall (United Kingdom)
4. Magmatic-hydrothermal quartz veins, skarns and contact metasomatities: San Rafael (Peru), Dachang (Čína)
5. Alluvial deposits: in Malaysia, Nigeria, Central Africa, Niushipo (China), Dachang District (China)

Reserves

2023		
Country	**kt**	**% World**
China	1,100,000	25.6
Burma	700,000	16.3
Australia	620,000	14.4
Russia	460,000	10.7
Brazil	420,000	9.8
Bolivia	400,000	9.3
Peru	130,000	3.2
Congo (Kinshasa)	120,000	2.8
Vietnam	11,000	0.3
Other countries	310,000	6.7
World	**4,300,000**	**100.0**

Source: MCS 2024

The EU has no registered Sn reserves. Zdroj: European Minerals Yearbook – version 2023.

Uses

The main uses of tin in the EU are for the production of tins and cans (28%), for the production of solders (20%) and chemicals (18%), sheet metal tinning (25%) and for the production of chemicals (20–25%). In the USA, tin is used for tinning and the production of cans (21%), solders (14%), alloys (10%), bearing metal, bronze and brass (11%), others (27%).

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

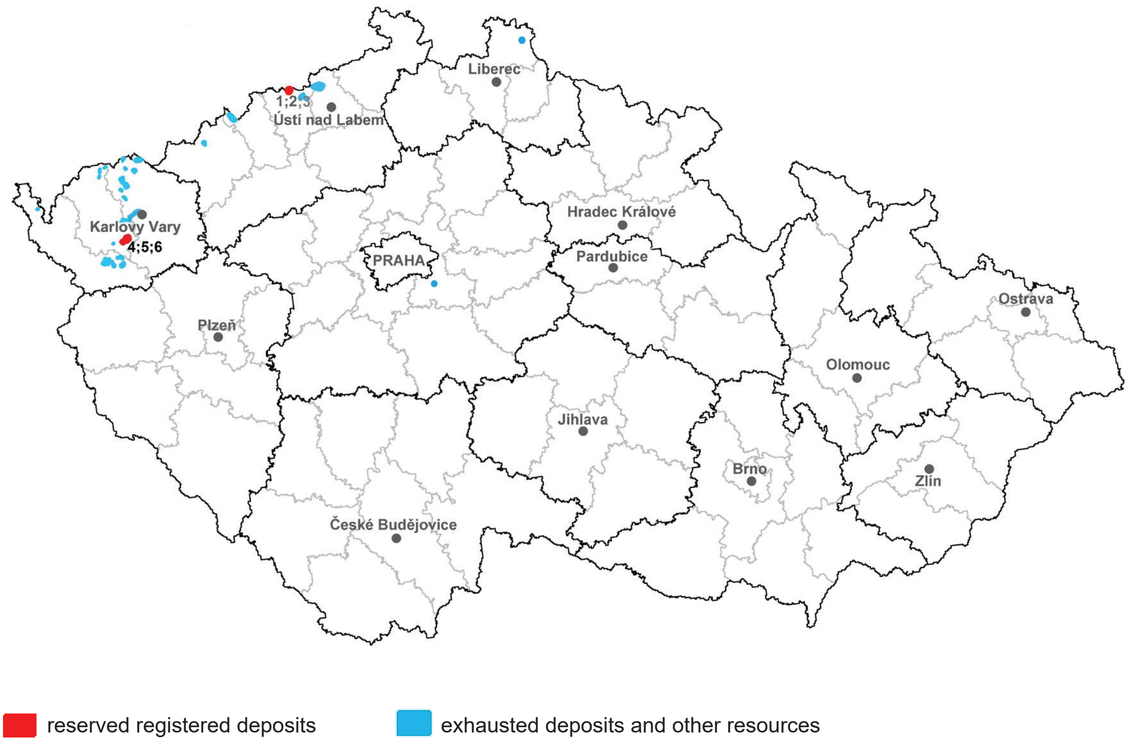
2. Mineral resources of the Czech Republic

With a few exceptions, tin deposits are concentrated almost exclusively in the Ore Mountains, the Slavkov Forest and their foothills, where they have been used since the beginning of the Middle Ages.

- The most important deposit type are the Sn-W (Li) greisen deposits. They occur both in the eastern (Cínovec, Krupka) and in the western part of the Ore Mountains (Rolava, Přebuz) and in the Slavkov Forest (Krásno, Horní Slavkov). The formation of deposits is connected with greisenisation and silicification of elevations of upper Variscan lithium-topaz granites. The main carrier of Sn ore mineralisation is cassiterite, embedded in greisen, accompanied by wolframite and zinwaldite. There is a significant proportion of hydrothermal quartz veins with cassiterite, wolframite, or Bi and Mo minerals in the Krupka and Cínovec districts. Sn-W ores with contents of approx. 0.2–0.5% Sn were mined on greisen and vein deposits.
- An interesting occurrence of tin ores is represented by polymetallic tin-bearing skarns at the former Zlatý Kopec deposit near Boží Dar. Apparently polygenic ores, consisting of magnetite with an admixture of cassiterite (with hulsite and schoenfliesite), sphalerite and chalcopyrite, contain about 0.95% of Sn.
- Basically, the only deposit accumulation of primary ores outside the Ore Mountains area are the stratiform cassiterite-sulphidic ores near Nové Město pod Smrkem. After the Second World War, only a geological survey was carried out on this former deposit, which assessed the average content of 0.23% Sn in the ore here.
- Rather, from the general metallogenetic and mineralogical point of view, the occurrence of Sn-mineralisation deserves attention, formed by stannite in the deeper zones of the "staročeské pásmo" lode in the Kutná Hora mining district, which has a complex character and is not economically significant.

Initially, mining focused on secondary (alluvial) deposits, gradually moving to the primary ones. The tin-bearing alluvial deposits in all areas of the Sn-W ores of the Ore Mountains area and its foothills have been basically completely mined out. Only in the Slavkov Forest and its foothills, small secondary accumulations of cassiterite and wolframite were preserved. Most of the reserves of primary deposits have also been mined out and the rest are currently of no economic significance. Mining of Sn (Sn-W) ores in the Czech Republic ended in 1991 with the closure of the Krásno deposit, and the Cínovec-jih deposit a year earlier. Larger residual reserves of poor-content ores remained only in the deposits in the Krásno – Horní Slavkov and Cínovec districts. In the future, they could also represent a possible source of trace and rare elements, especially of Li, Rb, Cs, or Nb, Ta, Sc, etc.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined.

1 Cínovec-jih	3 Cínovec-severozápad	5 Krásno-Horní Slavkov
2 Cínovec-východ	4 Krásno	6 Krásno-Koník

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number [a)]	6	6	6	6	6
exploited	0	0	0	0	0
Total mineral *reserves, t Sn	386,644	386,644	386,644	386,644	386,644
economic explored reserves	64,099	64,099	64,099	64,099	64,099
economic prospected reserves	66,737	66,737	66,737	66,737	66,737
potentially economic reserves	255,808	255,808	255,808	255,808	255,808
Mine production, t Sn	0	0	0	0	0

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

a) Sn-W ore deposits

Approved prognostic resources P_1, P_2, P_3
Sn metal in ores

Year		2019	2020	2021	2022	2023
P_1,	t	2,960	2,960	2,960	2,960	2,960
P_2		–	–	–	–	–
P_3		–	–	–	–	–

5. Foreign trade

2609 – Tin ores and concretates

		2019	2020	2021	2022	2023
Import	t	1	2	4	2	1
Export	t	0	0	0	0.04	–

2609 – Tin ores and concretates

		2019	2020	2021	2022	2023
Average import prices	CZK/t	465,921	467,139	596,439	985,067	777,000
Average export prices	CZK/t	–	–	–	900,000	–

8001 – Unwrought tin

		2019	2020	2021	2022	2023
Import	t	928	460	167	443	525
Export	t	62	31	27	21	31

8001 – Unwrought tin

		2019	2020	2021	2022	2023
Average import prices	CZK/t	300,536	368,573	269,401	662,844	595,067
Average export prices	CZK/t	166,640	178,356	496,823	580,328	671,968

8002 – Tin waste and scrap

		2019	2020	2021	2022	2023
Import	t	19	15	7	11	8
Export	t	83	65	98	80	85

8002 – Tin waste and scrap

		2019	2020	2021	2022	2023
Average import prices	CZK/t	275,104	465,113	569,069	758,818	620,125
Average export prices	CZK/t	456,855	421,390	469,208	685,328	539,588

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

World production of primary tin was as follows in recent years:

World mine production/Year	2019	2020	2021	2022	2023[e]
Světová těžba cínu (dle MCS), kt	296,000	264,000	305,000	307,000	290,000
Světová těžba cínu (dle WBD), kt	294,333	277,997	263,576	292,351	N
Světová těžba cínu (dle WMS), kt	320,000	292,000	272,000	273,000	N

e – preliminary values

Main producers according to MCS

Country	2023^e	
	t	%
China	68,000	21.9
Burma	54,000	17.4
Indonesia	52,000	16.8
Peru	23,000	7.4
Congo (Kinshasa)	19,000	6.1
Bolivia	18,000	5.8
Brazil	18,000	5.8
Australia	9,100	2.9
Nigeria	8,100	2.6
Malaysia	6,100	2.0
Vietnam	5,300	1.7
Rwanda	3,800	1.2
Russia	2,700	0.9
Laos	2,300	0.7
World	**310,000**	**100.0**

e – preliminary values

The world's largest producers of refined tin in 2022 (according to the International Tin Association)

1. Yunnan Tin (China)
2. Minsur (Peru)
3. PT Timah (Indonesia)
4. Yunnan Chengfeng (China)
5. MSC (Malaysia)
6. Thaisarco (Thailand)
7. EM Vinto (Bolivia)
8. Jiangxi New Nanshan (China)
9. Aubris Beerse (Belgium)
10. Guangxi China Tin (China)

Prices of traded commodities

According to 2019–2023 (DERA) yearbooks and the World Bank (WB), the world's tin prices in USD/t developed as follows:

Commodity/year	2019	2020	2021	2022	2023^e
Tin, min. 99.85%, LME, in warehouse, cash (according to DERA)	18, 660	17,323	32,587	31,354	25,138
High grade min. 99,85%, LME contractual (WB)	18,661	17,125	32, 384	31,335	25,938

**) Engineering&Mining Journal: 12 monthly quotations average*

Tungsten

1. Characteristics and use

Average W content (and its extent) in the earth's crust (ppm)

1 (0.4–70) W

Industrially important minerals

Wolframite $(Mn,Fe)WO_4$ (with 76.5% WO_3), scheelite $CaWO_4$ (with 80.6% WO_3)

Industrially important deposit types

1. Skarns: King Island (Australia), Baoshan (China), Footweg (Canada), Pine Creek (USA)
2. Greisens: Cínovec-Zinnwald (Czechia – Germany, Panasqueira (Portugal), Hongshuizhai (China)
3. Magmatic-hydrothermal: Climax (USA), Lianhuashan (China), Jeddah (Russia), Endako (Canada), Mittersill (Austria)

Reserves

2023		
Country	**Mill. t**	**%**
China	2,300,000	52.3
Australia	570,000	13.0
Russia	400,000	9.1
Vietnam	74,000	1.9
Spain	66,000	1.5
Korea North	29,000	0.7
Austria	10,000	0.2
Portugal	4,000	0.1
Others	950,000	21.6
World	**4,400,000**	**100.0**

Source: MCS 2024

2023			
Country	**Mill. t**	**% World**	**% EU**
EU	69,100	2.0	100.0
Spain	56,000	1.7	85.4
Austria	10,000	0.3	14.5
Portugal	3,100	0.1	4.5

Source: MCS 2023

Uses

Cutting tools (cemented carbides), tungsten steels, high-speed cutting steels, special stainless steels, metallic tungsten (lighting, heating resistors, ammunition), superalloys (aviation, gas turbines), chemicals.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes

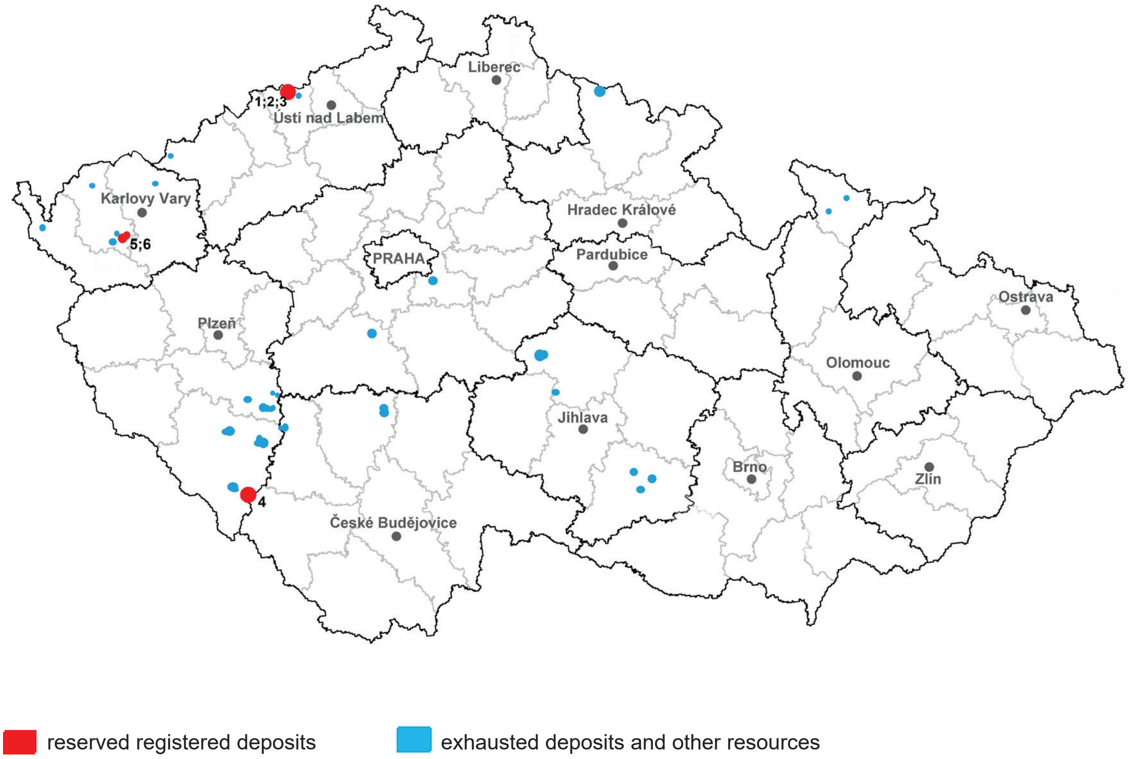
2. Mineral resources of the Czech Republic

In the Czech Republic, tungsten concentrate was obtained as a by-product in the mining and processing of vein and greisen Sn-W ores in the Cínovec (where Li (+ Rb) ore mineralisation associated with cinvaldite and other lithium micas is particularly important) and Krásno districts. In addition, especially in recent years, a number of occurrences of W-mineralisation in the form of scheelite or wolframite ores have been verified in various parts of the Bohemian Massif. Mining of W ores in the Czech Republic ended together with Sn ores in 1990 at the Cínovec deposit and a year later at the Krásno deposit. Some small occurrences of scheelites in the Moldanubicum were mined during the survey in the late 1980s and early 1990s (Malý Bor-Vrbík, Nekvasovy-Chlumy).

- In the Krušné hory Mts. (Ore Mountains) area, quartz veins and greisens occur mainly with a predominance of Sn (Cínovec, Krásno, Horní Slavkov), less with a predominance of W (Krupka 4). Greisen ores usually have a content of 0.02–0.07% W, only in the former Krupka 4 deposit it was 0.1–0.2% W. Total registered reserves of almost 100 kt W of metal in the deposits of the Cínovec district (92 kt W) and Krásno – Horní Slavkov (7 kt W) are seemingly high, but tungsten forms only an accompanying and independently unminable and unrecoverable component of complex Li-Sn-W ores. Furthermore, wolframite ore mineralisation in quartz veins and stockworks (Rotava) and scheelite inclusions in erlanes (= Ca-pyroxenic gneisses) are known here (Vykmanov at Perštejn).
- A number of, mostly small, new resources of W ores have been verified in the Moldanubicum. They are represented by quartz veins with tungsten or scheelite mainly in exocontacts of Variscan granitoids and scheelite disseminations and veinlets bound to the layers of erlane rocks. Some objects have the character of larger stratiform deposits of the type of scheelite-bearing crystalline shales, eventually skarns. Scheelite W ores often occur together with vein Au ores, which are genetically and mostly spatially separated. So far, the most significant occurrence of the stratiform type of ore mineralisation is the Au, W ore deposit of Kašperské Hory. Scheelite here forms disseminations and ore strips in silicified layers in the footwall of gold-bearing quartz veins. The average content of W in the ore is high – 0.55% (minimum metal content of the ore – cutoff grade = 0.1% W) to 1.32% (cutoff grade = 0.3% W). This corresponds to the variant reserves of W ores in the amount of 10 million t with 54.9 kt W, respectively 3.1 mil. t with 41.6 kt W. Prognostic resources of W ores with a lower average metal content of 0.24% (cutoff grade = 0.1% W) to 0.48% (cutoff grade = 0.2%) are also calculated on the deposit in the amount of 2.1 million tonnes of ore with 5.0 kt W, respectively 0.7 million tonnes of ore with 3.3 kt W. Although all reserves are potentially economic due to conflicts of interest with nature protection, the Kašperské Hory probably represent the only currently economically usable deposit of W and Au ores in the Czech Republic. It is a complex deposit of Au and W ores, and thus large and important from a European point of view. Other smaller prognostic resources of W ores, often together with Au, are in the closer (Hartmanice, Horažďovice area) and more distant surroundings (Sepekov, Mokrsko, Čelina, etc.).
- Typical contact metasomatic scheelite ore mineralisation is developed in the exocontacts of the Krkonoše-Jizera and Žulová plutons, but the known localities (Obří důl, Vápenná) have no practical significance.
- In connection with the development of survey methods, a number of genetically not yet fully clarified occurrences of W-ores have been found in the Czech Republic. Contrary

to previous notions, it has been shown that wolframite or scheelite ores occur mainly independently and only to a limited extent belong to the mixed type of Sn-W ores.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined

1 Cínovec-jih
2 Cínovec-severozápad
3 Cínovec-východ
4 Kašperské Hory
5 Krásno
6 Krásno-Horní Slavkov

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number [a)]	6	6	6	6	6
exploited	0	0	0	0	0
Total mineral *reserves, t W	140,799	140,799	140,799	140,799	140,799
economic explored reserves	21,508	21,508	21,508	21,508	21,508
economic prospected reserves	19,131	19,131	19,131	19,131	19,131
potentially economic reserves	100,160	100,160	100,160	100,160	100,160
Mine production, t W	0	0	0	0	0

** See* ***NOTE*** *in the chapter* ***Introduction*** *above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter* ***Mineral reserve and resource classification in the Czech Republic*** *of this yearbook*

[a)] *Sn-W and W ore deposits*

Approved prognostic resources P_1, P_2, P_3
W metal in ores

Year		2019	2020	2021	2022	2023
P_1,	t	–	–	–	–	–
P_2,	t	19,791	19,791	19,791	19,791	19,791
P_3		–	–	–	–	–

5. Foreign trade

2611 – Tungsten ores and concentrates

		2019	2020	2021	2022	2023
Import	kg	0	0	0	0	0
Export	kg	0	0	0	0	0

2611 – Tungsten ores and concentrates

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	–	–	–	–	–
Average export prices	CZK/kg	–	–	–	–	–

8101 – Tungsten and its products, including waste and scrap

		2019	2020	2021	2022	2023
Import	kg	240,849	378,244	738,967	808,257	574,180
Export	kg	1,060,611	1,152,964	1 436,063	986,578	794,983

8101 – Tungsten and its products, including waste and scrap

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	588	884	635	649	813
Average export prices	CZK/kg	676	805	899	920	951

720280 – Ferro-tungsten and ferrosilicotungsten

		2019	2020	2021	2022	2023
Import	kg	16,863	34,518	71,567	80,580	8,441
Export	kg	10,969	25,462	33,413	34,350	25,136

720280 – Ferro-tungsten and ferrosilicotungsten

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	569	467	541	694	624
Average export prices	CZK/kg	591	475	556	735	684

810196 – Tungsten wires

		2019	2020	2021	2022	2023
Import	kg	61,342	42,080	37,965	36,634	33,777
Export	kg	24,959	20,082	23,281	16,602	12,952

810196 – Tungsten wires

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	1,935	2,661	3,143	3,311	3,252
Average export prices	CZK/kg	5,506	5,125	5,083	6,972	6,716

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

World production of primary tungsten

	2019	2020	2021	2022	2023e
Mine production, kt (according to MCS)	83,8	78,4	83,8	79,8	78,0
Mine production, kt (according to WBD)	84,1	88,9	88,8	85,9	N

e – preliminary values

Main producers according to MCS

Country	2023e	
	t	%
China	63,000	80.8
Vietnam	3,500	4.5
Russia	2,000	2.6
Korea North	1,700	2.2
Bolivia	1,500	1.9
Spain	1,500	1.9
Rwanda	1,400	1.8
Austria	910	1.2
Australia	800	1.0
Portugal	500	0.6
Others	1,100	1.4
world	**78,000**	**100.0**

e – preliminary values

Prices of traded commodities

World price data for tungsten concentrate, ATP, tungsten metal powder and ferrotungsten are taken from the German DERA yearbook and the Mineral Commodity Summary (MCS) yearbook:

Commodity/year	2019	2020	2021	2022	2023
Wolframite concentrate. min. 65% WO_3, USD/mtu WO_3, American spot market (MCS)	195	172	225	275	260
Ferro-Tungsten. basis min. 75% W, USD/kg W, in warehouse Rotterdam	37.25	30.99	28.90	38.85	37.52
APT. European free market, USD/mtu WO_3	299.29	271.37	219.50	N	305.00*

Note: mtu – metric ton unit; 1 mtu = 1% = 10 kg WO_3 in 1 t of concentrate

** December 2023 average*

According to Metalary (http://www.metalary.com//tungsten.price/), annual tungsten prices were as follows (USD/t):

Commodity/Year	2019	2020	2021	2022	2023
Tungsten metal	35 200	30 300	31 000	N	N

Zinc

1. Characteristics and use

Average Zn content (and its extent) in the earth's crust (ppm)

70 (40–200) Zn

Industrially important minerals

The main ore mineral is ZnS sphalerite (38–67% Zn), which usually accompanies galena, pyrite and chalcopyrite in polymetallic deposits. An ore is considered a zinc ore if its content ratio is Zn: Pb > 4. Sphalerite in most cases contains cadmium from trace contents up to 2%, germanium, gallium, indium and thallium. Zinc ores occur most often in polymetallic deposits of various genetic types, similar to lead ores.

Industrially important deposit types

1. Sedimentary exhalative (sediment-bound, submarine-exhalative – "sedex"): Mt.Isa (Australia), Broken Hill (Australia), Gorevskoye (Russia), Xiaotieshan (China), Maqiongxia (China)
2. Stratiform: Olkusz (Poland), Mississippi Valley (USA), Silvermines (Ireland), Mirgalimsay (Kazakhstan), Frankou (China), Siding (China)

Reserves

2023		
Country	**kt**	**% World**
Australia	64,000	29.1
China	44,000	20.0
Russia	25,000	11.4
Peru	21,000	9.5
Mexico	14,000	6.4
India	7,400	3.4
Kazakhstan	6,700	3.0
USA	6,600	3.0
South Afrika	6,200	2.8
Sweden	4,100	1.9
Canada	1,800	0.8
Others	25,000	11.4
World	**220,000**	**100.0**

Source: MCS 2024

2023			
Country	**kt**	**% World**	**% EU**
EU	10,440	4.20	100.0
Sweden	3,493	1.40	33.5
Italy	3,400	1.40	32.6
Portugal	1,927	0.80	18.5
Ireland	1,092	0.40	10.5
Poland	340	0.10	3.3
Finland	189	0.08	1.8
Slovakia	45	0.02	0.4

Source: European Minerals Yearbook – version 2023

Uses

About 51% of zinc is consumed in galvanisation, about 34% goes to the production of alloys. About 13% is used for the production of brass and bronze and about 15% is consumed for other purposes (electrical equipment 10%).

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

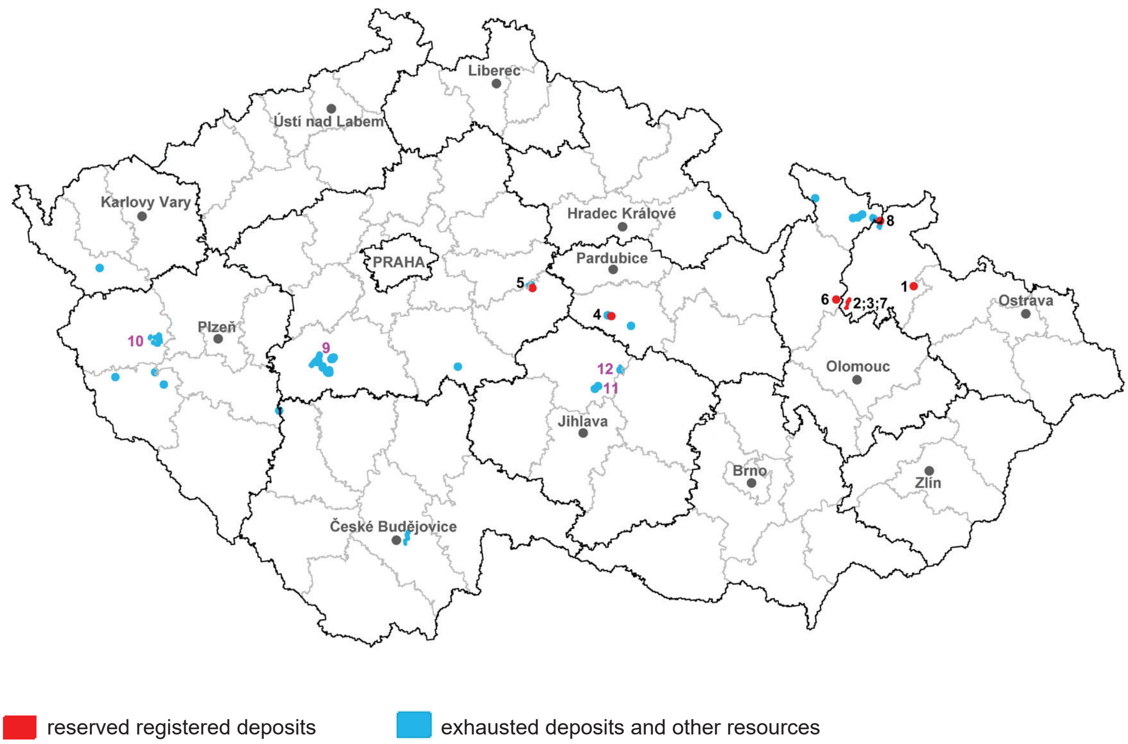
2. Mineral resources of the Czech Republic

Zinc ores occur in the Bohemian Massif almost exclusively as part of polymetallic Pb-Zn±Ag(±Cu) ores of hydrothermal or volcanic-sedimentary type.

- A significant proportion of Zn ores, represented mainly by sphalerite, was previously obtained in the former deposits of the Březové Hory, Bohutín and Vrančice districts in the vicinity of Příbram (until 1962). The Zn content of ores in these deposits ranged from 1.0 to 2.9%. Deposits in the northern part of the Kutná Hora district (Rejské, Turkaňské and Staročeské lodes), in the Havlíčkův Brod district (Stříbrné Hory, Dlouhá Ves, Bartoušov) and in western Bohemia (Stříbro, Kšice) were explored and partially mined from other venous deposits of polymetallic ores.
- The most important polymetallic deposits of volcanic-sedimentary origin were located in the Jeseníky Mountains. Disseminated sulphide ores with a content of 1.1–1.8% Zn were mined in Horní Město (1967–1970) and Horní Benešov (1963–1992) deposits. Between 1963 and 1992, a total of 6,561 kt of ore containing 39,210 t of lead and 90,711 t of zinc was extracted from both deposits. In the Zlaté Hory district, the extraction of Au Zn ores was terminated at the Zlaté Hory-západ deposit in 1994. In the years 1988–1994, a total of 771.6 kt of polymetallic ores containing 9,111 t Zn, 395 t Pb and 1,559 kg Au were mined in the Zlaté Hory-východ and Zlaté Hory-západ deposits.
- The former Staré Ransko-Obrázek deposit is probably polygenetic – sphalerite-barite ore with a content of up to 1.8% Zn was mined there until 1990. Genetically unclear types also include the Pb-Zn-Cu ore deposit with barite in Křižanovice, with contents of about 4–6% Zn, verified by exploration in the 1980s.

Mining of Zn ores in accordance with the concept of phase-out of ore mining in the Czech Republic ended at the beginning of 1994 at the last deposit Zlaté Hory-západ. The final product of polymetallic ore mining was a complex Pb-Zn concentrate, which was exported because there were no domestic capacities to smelt it. In connection with the ongoing reassessment (reregistration) of polymetallic ores, a large part of zinc deposits and reserves was gradually removed from the Register in 1990–2004.

3. Registered deposits and other resources of the Czech Republic



Registered deposits and other resources are not mined

Reserved registered deposits:

1 Horní Benešov	4 Křižanovice	7 Ruda u Rýmařova-sever
2 Horní Město	5 Kutná Hora	8 Zlaté Hory-východ
3 Horní Město-Šibenice	6 Oskava	

Exhausted deposits and other resources:

9 Březové Hory + Příbram + Bohutín	11 Havlíčkův Brod (Dlouhá Ves + Bartoušov + Stříbrné Hory)
10 Stříbro	12 Staré Ransko

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number [a)]	8	8	8	8	8
exploited	0	0	0	0	0
Total mineral *reserves, kt Zn	559	559	559	559	559
economic explored reserves	0	0	0	0	0
economic prospected reserves	0	0	0	0	0
potentially economic reserves	559	559	559	559	559
Mine production, t Zn	0	0	0	0	0

** See __NOTE__ in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic** of this yearbook*

[a)] *Deposits with registered Zn content*

5. Foreign trade

2608 – Zinc ores and concentrates

		2019	2020	2021	2022	2023
Import	t	11	17	12	10	11
Export	t	1	0	0	0	0

2608 – Zinc ores and concentrates

		2019	2020	2021	2022	2023
Average import prices	CZK/t	82,818	58,567	84,416	82,115	85,727
Average export prices	CZK/t	58,000	–	–	–	–

7901 – Unwrought zinc

		2019	2020	2021	2022	2023
Import	t	33,964	33,369	37,187	34,190	27,008
Export	t	1 498	1,299	925	1,122	905

7901 – Unwrought zinc

		2019	2020	2021	2022	2023
Average import prices	CZK/t	63,741	55,858	67,835	88,173	73,317
Average export prices	CZK/t	57,327	51,425	55,666	81,842	61,880

7902 – Zinc waste and scrap

		2019	2020	2021	2022	2023
Import	t	350	467	693	1,181	819
Export	t	3,168	2,767	3,260	2,646	2,479

7902 – Zinc waste and scrap

		2019	2020	2021	2022	2023
Average import prices	CZK/t	44,356	67,835	67,835	22,434	20,305
Average export prices	CZK/t	35,575	43,695	43,695	50,812	40,085

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

World production of primary zinc has basically stagnated over the last four years. The table shows data from the prestigious International Lead and Zinc Study Group (ILZSG) and data from the Mineral Commodity Summary (MCS) and Welt Bergbau Daten (WBD) yearbooks:

	2019	2020	2021	2022	2023^e
Mine production of zinc, kt (according to ILZSG)	12,799	12,223	12,775	12,486	12,244
Mine production of zinc, kt (according to MCS)	12,700	12,000	12,700	12,500	12,000
Mine production of zinc, kt (according to WBD)	13,082	12,668	12,929	12,732	N

e – preliminary values

Main producers according to MCS

Country	2023[e]	
	kt	%
China	4,000	33.3
Peru	1,400	11.7
Australia	1,100	9.2
India	860	7.2
USA	750	6.2
Mexico	690	5.8
Bolivia	490	4.1
Kazakhstan	330	2.8
Russia	310	2.6
Canada	240	2.0
South Africa	230	1.9
Sweden	220	1.8
Others	2,000	16.7
World	**12,000**	**100.0**

e – preliminary values

Prices of traded commodities

According to DERA, World Bank (WB), and U.S. Mineral Commodity Summaries (MCS), world zinc prices in USD/t developed as follows:

Commodity/year	2019	2020	2021	2022	2023
Special high grade, min. 99.995% cash, LME, in warehouse (according to DERA)	2,548.34	2,263.90	3,003.92	3,481.67	2,844.48*
High quality min. 99.95 %, LME contractual price (according to WB)	2,922	2,550	3,003	3,481	2,653
Zinc, annual average, American market, USc/lb (according to MCS)	124.1	110.8	145.8	190.2	152.0

** December 2023 average*

MINERALS MINED IN THE PAST WITHOUT RESOURCES AND RESERVES

Antimony

1. Characteristics and use

Average Sb content (and its extent) in the earth's crust (ppm)

0.2 (0.15–1) Sb

Industrially important minerals

Stibnite (antimonite) Sb_2S_3 (71% Sb), tetrahedrite $Cu(Ag,Fe,Zn)_3Sb(As,Bi)S_{3.25}$ (very approximately 29% Sb)

Industrially important deposit types

1. Stratiform sedimentary exhalative deposits ("sedex"): Gravelotte, United Jack (South Africa), Xikuangshan (China), Sarylach (Russia), Kadamjay (Kyrgyzstan), Costerfield (Australia)
2. Deposits of vein, stockwork and disseminated polymetallic ores mainly with antimonite, also Hg, Au, Sn and W ores with antimonite in carbonate rocks: Xian (China), Sunshine (USA), Bohutín (Czech Republic), Dúbrava, Rudňany (Slovakia), Baia Mare (Romania).

Reserves

Uses

2023		
Country	**t**	**% World**
China	350,000	19.4
Russia	350,000	19.4
Bolivia	310,000	17.2
Kyrgyzstan	260,000	14.4
Burma	140,000	7.8
Australia	120,000	6.7
Turkey	100,000	5.6
Canada	78,000	4.3
USA	60,000	3.3
Tajikistan	50,000	2.8
Pakistan	26,000	1.4
Mexico	18,000	1.0
World	**>1,800,000**	**100.0**

Source: MCS 2024

Sb reserves in the EU are known in Slovakia. With their tonnage of 2.5 kt Sb, they represent 0.1% of the world reserves (European Minerals Yearbook – version 2023).

Antimony is most often used in alloys with lead, copper and zinc, which it provides with strength, hardness and anti-corrosion properties. The majority of Sb consumption is due to its non-flammable compounds, which are used for the production of fire extinguishing mixtures. Significant amounts (around 10–15%) are used for the production of batteries, as well as in the chemical, ceramic and glass industries.

Classification as critical raw materials for the European Union
2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of antimony.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

261710 – Antimony ores and concentrates

		2019	2020	2021	2022	2023
Import	kg	12,521	14,019	8,179	8,097	9,444
Export	kg	0	0	0	0	0

261710 – Antimony ores and concentrates

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	249	208	364	314	361
Average export prices	CZK/kg	–	–	–	–	–

8110 – Antimony and articles thereof, including waste and scrap

		2019	2020	2021	2022	2023
Import	t	101	49	52	24	25
Export	t	0.3	0.4	2	1	0,5

8110 – Antimony and articles thereof, including waste and scrap

		2019	2020	2021	2022	2023
Average import prices	CZK/t	184,581	159,638	264,878	352,327	267,680
Average export prices	CZK/t	128,280	1 302,500	455,392	1,185,455	1,159,259

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

Trend in the world´s primary antimony production in 2019–2023

Mine production of Sb/Year	2019	2020	2021	2022	2023[e]
Mine production of antimony, kt (according to MCS)	162	111	112	83	83
Mine production of antimony, kt (according to WBD)	135	120	92	83	N

e – preliminary values

Main producers according to MCS

Country	2023[e]	
	t	%
China	40,000	48.2
Tajikistan Russia	21,000	25.3
Turkey	6,000	7.2
Myanmar	4,600	5.5
Rossia	4,300	5.2
Bolivia	3,000	3.6
Australia	2,300	2.8
World	**83,000**	**100.0**

e – preliminary values

Prices of traded commodities according to IM (USD/t) and MCS (USD/lb)

Commodity/year	2019	2020	2021	2022	2023[e]
Antimony, purity 99.65%, CIF US ports (according to MCS), USD/lb	3.90	2.67	5.31	6.18	5.60

e – preliminary values

Arsenic

1. Characteristics and use

Average As content (and its extent) in the earth's crust (ppm)

2 (1.7–5) As

Industrially important minerals

Arsenopyrite FeAsS (46% As), löllingite $FeAs_2$ (73% As)

Industrially important deposit types

Arsenic is a minor component of polymetallic, copper, gold-bearing, tin and cobalt-nickel ores.

Reserves

Data on global reserves of As are not published, but it is assumed that they correspond to twenty times the global extraction, i.e. about 650 kt of As_2O_3 (MCS 2021). Reserves of As in the EU are not known (European Minerals Yearbook – version 2021), but Poland reports 20 kt of As reserves in its territory (Bilans zasobów złoż kopalin w Polsce 2021).

Uses

In the production of chemical wood preservatives, lead-acid batteries, bearing lubricants, herbicides and insecticides. High-purity arsenic (99.9999%) is used to produce gallium arsenide (GaAs) semiconductors. As is used in solar cells, space research and telecommunications. Arsenic is also used for germanium-arsenide-selenide special optical materials. Indium-gallium-arsenide (InGaAs) is used for shortwave infrared technology.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – yes

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of arsenic.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

280480 – Arsenic

		2019	2020	2021	2022	2023
Import	kg	8,118	8,169	8,499	4,839	2,421
Export	kg	0	0	0	0	0

280480 – Arsenic

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	117	174	193	160	165
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World production

The volume of world production reported by WBD has been significantly higher since 2016, as it also includes the relatively high production of Peru (20 to 25 kt/y), which MCS does not take into account. World production of primary arsenic was as follows in recent years:

	2019	2020	2021	2022	2023^{e}
World production of arsenic, kt (according to MCS)	32.3	32.0	60.0	60.1	60.0
World production of arsenic, kt (according to WBD)	55.2	52.3	54.9	56.4	N

e – preliminary values

Main producers according to WBD

Country	2023e	
	kt	%
Peru	27,000	40.0
China	24,000	45.0
Morocco	8,000	13.3
Belgium	1,000	1.7
Russia	1,000	1.7
Bolivia	N	N
World	**60,000**	**100.0**

e – preliminary values

Prices of traded commodities

According to the Mineral Commodity Summaries (MCS), prices ranged as follows:

Arsenic metal /Year	2019	2020	2021	2022	2023e
Arsenic metal, China, USD/kg (MCS)	1.01	1.08	1.11	1.80	1.85
Arsenic metal, Rotterdam, USD/lb (MCS)	1.10	1.08	1.11	1.67	2.0

e – preliminary values

Mercury

1. Characteristics and use

Average Hg content (and its extent) in the earth's crust (ppm)

0.08 (0.03–0.5) Hg

Industrially important minerals

Cinnabar HgS (86% Hg), schwazite (Hg rich tetrahedrite) $(Cu,Hg)_3SbS_{3-4}$ and many sulphides and sulphosalts of other metals (e.g. Sb, As, Cu, Fe)

Industrially important deposit types

1. Volcanogenic-hydrothermal: Almadén (Spain), Red Level (USA), Nikitovka (Ukraine), Idrija (Slovenia), Sulphur Bank (USA)
2. Plutogenic-hydrothermal: Chajdarkan (Russia), Jijikrut (Russia), Tamvatnyj (Russia)

Reserves

A quantitative estimate of world Hg reserves is not available, China, Kyrgyzstan and Peru are expected to have the largest reserves (MCS 2021). The EU has known reserves only in Croatia, namely 3.8 kt Hg (European Minerals Yearbook – version 2021).

Uses

Globally, mercury mining has almost stopped due to the health risks of its use. It is still used in the field of chemistry and in electrical and electronic applications.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of mercury.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

280540 – Mercury

		2019	2020	2021	2022	2023
Import	kg	6,751	20,225	704	614	180
Export	kg	4,211	89,069	59,792	3	4

280540 – Mercury

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	317	233	439	410	1,133
Average export prices	CZK/kg	1,159	1	2	3,667	6,250

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

World mine production of mercury (t)

	2019	2020	2021	2022	2023^{e}
World mine production of mercury (according to MCS)	3,900	2,490	2,200	1,160	1,200
World mine production of mercury (according to WBD)	2,324	2,308	1,810	1,015	N

e – preliminary values

Main producers according to MCS

Country	2023^{e}	
	t	%
China	1,000	83.3
Tajikistan	100	8.3
Peru	30	2.5
Norway	20	1.7
Kyrgyzstan	6	0.5
World	**1,200**	**100.0**

e – preliminary values

Prices of traded commodities

Annual prices according to MCS yearbook

Commodity/Year		2019	2020	2021	2022	2023
Mercury, average import price to the USA (according to MCS)	USD/kg	23	26	29	33	N

** 1 flask (láhev) rtuti je ekvivalent 34,473 kg*

Sulphur

1. Characteristics and use

Average S content (and its extent) in the earth's crust (ppm)

500 (260–1 200) S

Industrially important minerals

Pure sulphur, sulphides and sulphosalts

Industrially important deposit types

Sulphur is in some cases a by-product of smelting, especially of polymetallic and copper ores. But it is mainly a product of petrochemistry, desulphurisation of oil and natural gas.

The mined sulphur deposits are either volcanic (Volcano, Italy) or mainly bound to evaporites (Calcanisetta Basin, Italy, Gulf of Mexico, USA, Osiek, Poland).

Reserves

World reserves of sulphur in oil, natural gas and sulphide ores are extensive. Most of the sulphur produced comes from oil and gas processing. In the EU, only Poland has sulphur reserves in the form of rocks, namely 494 million tonnes (Bilans zasobów złoż kopalin w Polsce 2021).

Uses

Production of sulphuric acid, essential raw material for industrial production, especially fertiliser production. Consumption of sulphuric acid was considered as one of the best indicators of the country's degree of industrial development.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any resources of sulphur.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2503 – Sulphur of all kinds, other than sublimed, precipitated and colloidal

		2019	2020	2021	2022	2023
Import	t	65,190	71,918	74,497	72,319	69,584
Export	t	8,193	5,954	9,262	18,242	14,192

2503 – Sulphur of all kinds, other than sublimed, precipitated and colloidal

		2019	2020	2021	2022	2023
Average import prices	CZK/t	2,735	2,650	3,082	5,385	3,334
Average export prices	CZK/t	2,535	2,707	3,182	5,520	2,216

2802 – Sulphur, sublimed or precipitated; colloidal sulphur

		2019	2020	2021	2022	2023
Import	t	40,745	43,006	45,596	42,373	18,573
Export	t	0.4	0.1	0.1	0.2	0

2802 – Sulphur, sublimed or precipitated; colloidal sulphur

		2019	2020	2021	2022	2023
Average import prices	CZK/t	1,843	1,802	1,950	5,385	3,723
Average export prices	CZK/t	217,742	291,667	400,000	242,424	–

2807 – Sulphuric acid

		2019	2020	2021	2022	2023
Import	t	55,506	28,307	49,283	47,006	37,276
Export	t	81,669	66,358	64,732	64,353	61,106

2807 – Sulphuric acid

		2019	2020	2021	2022	2023
Average import prices	CZK/t	2,246	2,509	2,286	3,778	3,534
Average export prices	CZK/t	1,562	1,755	2,175	4,193	2,424

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

World sulfur production, which comes mainly from the processing of liquid and gaseous hydrocarbons, has had a slightly upward trend for many years, is rather stagnating in recent years:

	2019	2020	2021	2022	2023e
World sulphur production (according to MCS), kt	80,000	79,800	81,400	82,000	82,000
World sulphur production (according to WBD), kt	81,485	78,799	77,998	82,769	N

e – preliminary values

Main producers according to MCS

Country	2023e	
	kt	%
China	19,000	23.2
USA	8,600	10.5
Saudi Arabia	8,000	9.8
Russia	7,000	8.5
United Arab Emirates	5,400	6.6
Canada	4,900	6.0
Kazakhstan	4,300	5.2
India	3,500	4.3
Japan	3,100	3.8
South Korea	3,100	3.8
World	**82,000**	**100.0**

e – preliminary values

Prices of sulphur according to Industrial Minerals (IM) and MCS in USD/t

Commodity/year		2019	2020	2021	2022	2023
Canadian, solid, spot price, FOB, Vancouver	AgM	40–130	40–80	90–140	120–170	110–160
Middle East, FOB	AgM	40–130	40–80	80–120	110–150	100–140
Reported US average price, FOB, mine and/or plant, elemental sulphur	MCS	51,10	24,60	90,90	178,50	100,00

MINERALS UNMINED IN THE PAST WITH RESOURCES AND RESERVES

Lithium, rubidium and cesium

1. Characteristics and use

Lithium, rubidium and cesium have close chemical properties and to a large extent, they occur together.

Lithium

Average content (and its extent) in the earth's crust (ppm)

30 (18–65) Li

Industrially important minerals

Spodumen $LiALSi_2O_6$ (contains 5.8–7.6% Li_2O), lepidolite $K_2Li_4Al_2[(F,OH)_2Si_4O_{10}]_2$ (contains 3.2–4.4% Li_2O), petalite $LiAlSi_4O_{10}$ (contains 3.4–4.1% Li_2O)

Reserves

2023		
Country	**t Li**	**% World**
Chile	9,300,000	34.6
Australia	6,200,000	23.0
Argentina	2,700,000	10.0
China	2,000,000	7.4
Czech Republic*	1,138,330	4.2
Canada	930,000	3.5
Zimbabwe	310,000	1.2
Brasil	250,000	0.9
Portugal	60,000	0.2
World	**26,914,000**	**100.0**

Source: MCS 2023 and own calculations

* *Bilance zásob k 1. 1. 2024 (national Register of Reserves as of 1. 1. 2024)*

No reliable data are available to determine Rb and Cs reserves for specific countries. It is assumed that Australia, Canada, China, Namibia and Zimbabwe together have less than 200 kt Rb and 200 kt Cs (MCS 2022).

Li resources

2023			
Country	**t Li**	**% World**	**% EU**
EU	5,476,000	4.6	100.0
Germany	3,038,000	2.5	55.5
Czech Rep.	1,138,330	1.0	20.8
Finland	391,000	0.3	7.1
Spain	315,000	0.3	5.8
Portugal	223,000	0.2	4.1
France	142,000	0.1	2.6
Austria	60,000	0.1	1.1
World	**120,100,000**	**100.0**	**–**

Source: MCS 2023, ČGS

Industrially important deposit types

1. Pegmatites and granites: Greenbushes (Australia), Manono (Congo, DR), Pilgangoora (Australia), Bikita (Zimbabwe)
2. Li – brines (Salars): Salar de Atacama (Chile), Salar de Uyuni (Bolivia), Quaidam Basin (China), Silver Peak (USA)
3. Li – brines (Geothermal and Oilfield Brines): Ortenau (Germany), Alberta (Canada)
4. Sedimentary: Sonora (Mexico), Jadar (Serbia), Thacker Pass (USA)

Uses

Production of electric batteries, cement, lubricants, pharmaceuticals, use in metallurgy (alloys), nuclear industry, glassmaking and ceramics.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – yes, 2023 – yes

Rubidium

Average Rb content (and its extent) in the earth's crust (ppm)

82 Rb

Industrially important minerals

Rubidium does not form its own minerals. It is contained in potassium feldspars (containing 3.3% of Rb_2O in some microclines), lepidolites (1–3.5% Rb_2O) and zinwaldites $K(Li,Fe,Al)_3\ (AlSi_3O_{10})\ (OH,F)_2$ (content = 1.5% Rb_2O)

Industrially important deposit types

1. Pegmatites and granites: Greenbushes (Australia), Tanco, Bernic Lake (Canada), Bikita (Zimbabwe)
2. Li – brines: Salar de Atacama (Chile), Salar de Uyuni (Bolivia), Quaidam Basin (China), Silver Peak (USA)
3. Magmatogenic phosphate deposits: Kola Peninsula (Russia)
4. Salt carnalite deposits: Kłodawa (Poland), Stassfurt (Germany), Ust-Vajviskoye, Verkhnekamskoye (Russia), Suria, Salena (Spain)

Reserves

No reliable data are available to determine Rb and Cs reserves for specific countries. It is assumed that Australia, Canada, China, Namibia and Zimbabwe together have less than 200 kt Rb and 200 kt Cs (MCS 2021).

The EU does not have Rb reserves.

Uses

Electronics, special glass, pharmacy, pyrotechnics

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

Cesium

Average Cs content (and its extent) in the earth's crust (ppm)

5 Cs

Industrially important minerals

It is part of several minerals with 5–32% of Cs_2O (e.g. lepidolite has 0.2–0.8% Cs_2O), only pollucite $Cs(AlSi_2O_6).H_2O$ (with up to 30% Cs_2O) is significant.

Industrially important deposit types

1. Pegmatites and granites: Greenbushes (Australia), Tanco, Bernic Lake (Canada), Bikita (Zimbabwe)
2. Li – brines: Salar de Atacama (Chile), Salar de Uyuni (Bolivia), Quaidam Basin (China), Silver Peak (USA)
3. Magmatogenic phosphate deposits: Kola Peninsula (Russia)

Reserves

No reliable data are available to determine Rb and Cs reserves for specific countries. It is assumed that Australia, Canada, China, Namibia and Zimbabwe together have less than 200 kt Rb and 200 kt Cs (MCS 2021).

The EU does not have Cs reserves.

Uses
Infrared detectors, photovoltaic cells, scintillation detectors, chemistry, radioisotopes, rocket fuels, insecticides, alkaline batteries, pyrotechnics, very dense flushing of subsea wells for oil and natural gas.

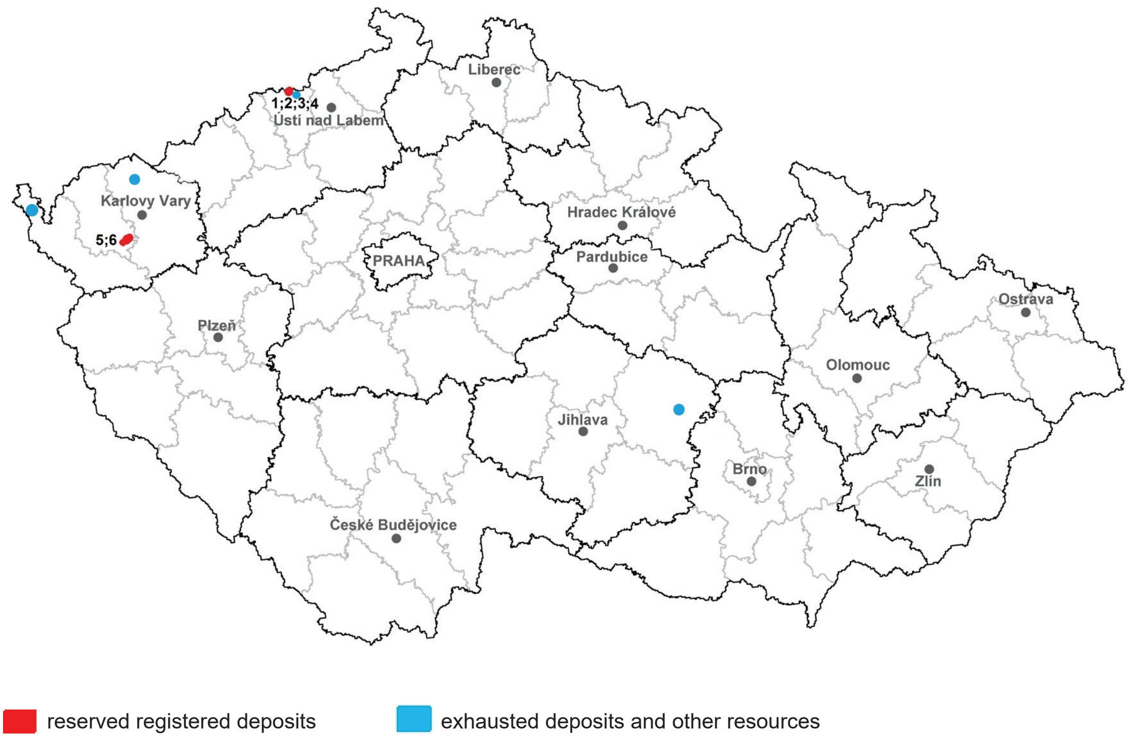
Classification as critical raw materials for the European Union
2011 – no, 2014 – no, 2017 – no, 2020 – yes, 2023 – yes

2. Mineral resources of the Czech Republic

In the Czech Republic, the entire Ore Mountains and the Slavkov Forest can be considered a lithium and rubidium province. Li raw materials are bound mainly to Li-mica, mainly zinnwaldite with a theoretical content of 1.4 to 1.6% Li, in bodies of greisen and greisenised granite associated with granitoid magmatism. With the exception of an unknown amount of mined lithium pegmatite in Rožná during World War II, Li ores were not mined separately in the Czech Republic. However, this changed in 2021, when open-pit mining of the Cínovec-odkaliště deposit began.

- Around 600–700 million tonnes of ores with increased Li contents were identified in the area of the Cínovec district in the eastern part of the Ore Mountains and its surroundings. At the three primary deposits of Li-Sn-W ores Cínovec-J, Cínovec-Z and Cínovec-V, the Register records 1,128 kt of lithium in 564 million tonnes of ore with an average content of 0.200% Li. In addition, the accompanying quantities of 806 kt Rb and 32 kt Cs were evaluated in the projected reserves at this deposit. Another 2.3 kt of Li are registered at the secondary deposit Cínovec-tailing pond, formed by waste material after treatment of Sn-W ores. Another similar deposit Horní Slavkov-tailing pond with 6.2 kt Li is registered in the Slavkov Forest. In addition, 2 kt of Li reserves and another 33–35 kt of Li are recorded in reserves in the Sn-W ore deposits in the primary deposits around Krásno and Horní Slavkov. However, the average Li contents in ores are lower (around 0.15% Li) than in the Cínovec district. In the western part of the Ore Mountains, the greisen zones are significantly smaller than the stocks and domes on the deposits and resources of the Cínovec and Krásno – Horní Slavkov districts, and there are no reserves or potentially promising Li resources.
- Smaller and insignificant resources are in pegmatites. The isolated former small deposit of Li-Sn ores Vernéřov near Aš is situated in the mica schist gneisses of the Ore Mountains crystalline complex in the western part of the Ore Mountains. 91 kt of ore resources with an average metal content of 0.56% Sn and 0.27% Li were evaluated, which corresponds to 530 t Sn and 249 t Li. Occurrences in the vicinity of Rožná are no longer of practical significance.
- Reources of brine with anomalous contents of bromine and lithium in the amount of 453.6 million m³ were evaluated in the mining lease of the Slaný bituminous coal deposit. These resources of ground mineralised water contain 123 kt Br, 15 kt Li and more than 18 million t NaCl.

3. Registered deposits and other resources of the Czech Republic



The registered deposit are not exploited

(Name of area with exploited deposit is in ***bold****)*

1 Cínovec-jih*	3 Cínovec-východ	5 Horní Slavkov-odkaliště
2 **Cínovec odkaliště**	4 Cínovec-severozápad	6 Krásno-Koník

Note:

** Deposit of also potentially economic reserves of Sn-W ores and contents of Ta and Nb in experimental concentrates*

4. Basic statistical data of the Czech Republic as of December 31

Number of deposits; reserves; mine production

Year	2019	2020	2021	2022	2023
Deposits – total number	6	6	6	6	6
Exploited	0	0	0	1	0
Total *reserves, t Li	1,138 331	1,138,331	1,138,331	1,138,331	1,138,331
economic explored reserves	156,239	156,239	156,239	156,239	156,239
economic prospected reserves	118,542	118,542	118,542	118,542	118,542
potentially economic reserves	863 550	863,550	863,550	863,550	863,550
Mine production, t Li	0	0	0	0.7	0

** See **NOTE** in the chapter **Introduction** above on a terminological difference between Czech official application of the term reserves and standard international application of the term. The relationship of domestic and foreign classifications of mineral reserves and resources is described in the separate chapter **Mineral reserve and resource classification in the Czech Republic and its evolutional comparison with international classifications** of this yearbook*

In the Czech Republic, it is possible to consider the entire Krušné hory Mts. as a lithium province. Around 300 million tonnes of ore with elevated lithium contents were identified in Cínovec and its surroundings alone. As for the potentially economic deposit of tin-tungsten ores of Cínovec-jih, 159,993 tonnes of lithium in 53.4 million tonnes of ore with an average lithium content of 0.117% are recorded in the Register of reserved mineral deposits of the Czech Republic. In addition, byproduct amounts of 56 kt of rubidium and 1.8 kt of cesium were also evaluated in this deposit. Beside the Register of reserved mineral deposits of the Czech Republic Li reserves are estimated also at former deposits Cínovec-sever-lomová těžba (79 kt), Cínovec-starý závod (3.8 kt), Vernéřov u Aše (15.2 kt) and Krásno-Koník (2 kt).

Brine reserves with anomalous bromine and lithium contents were calculated at 453.6 million m^3 in the mining lease of the Slaný deposit of bituminous coal. These groundwater reserves contain 123 kt of bromine, 15 kt of lithium and more than 18 million tonnes of NaCl.

Approved prognostic resources P_1, P_2, P_3
Li in ore

Year		2019	2020	2021	2022	2023
P_1,	t	2,142	2,142	2,142	2,142	2,142
P_2		–	–	–	–	–
P_3		–	–	–	–	–

5. Foreign trade

280519 – Lithium, potassium, rubidium, cesium

		2019	2020	2021	2022	2023
Import	kg	29,124	71,432	41,283	15,782	6,479
Export	kg	87	28	109	66	3,363

280519 – Lithium, potassium, rubidium, cesium

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	757	294	524	1,226	3,065
Average export prices	CZK/kg	184	179	8 303	76	171

28369100 – Lithium carbonates

		2019	2020	2021	2022	2023
Import	kg	76,403	46,981	101,644	74,747	32,429
Export	kg	3,402	2,886	5,537	8,779	5,955

28369100 – Lithium carbonates

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	313	191	265	250	1,115
Average export prices	CZK/kg	266	139	32	44	67

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World production

World lithium production has been growing for a long time in connection with the increase in the use of lithium in the battery industry. The largest increase occurred between 2016 and 2018, when world production doubled. There is no reliable information on world rubidium production, the raw material is probably obtained in Namibia, Zimbabwe and China, but the total production volume is unknown. Small quantities of cesium are also obtained in Namibia and Zimbabwe as a by-product of lithium mining.

Commodity/year	2019	2020	2021	2022	2023e
World mine production of lithium (according to MCS), t	86,000	82,500	107,000	146,000	180,000
World mine production of Li_2O (according to WBD), t	192,065	186,955	232,530	345,829	N

e – preliminary value

Data on rubidium and cesium mining are not provided.

Main producers according to MCS

Country	2023e	
	t	%
Australia	86,000	47.8
Chile	44,000	24.4
China	33,000	18.3
Argentina	9,600	5.3
Brazil	4,900	2.7
Zimbabwe	3,400	1.9
Canada	3,400	1.9
Portugal	380	0.2
World	**180,000**	**100.0**

e – preliminary values

The world's largest lithium miners / producers

1. Albemarle
2. Sociedad Química y Minera de Chile (SQM)
3. Livent
4. Sichuan Tianqi Lithium
5. Jiangxi Ganfeng Lithium
6. Lithium Americas
7. MGX Minerals
8. Nemaska Lithium
9. Galaxy Resources Limited
10. Wealth Minerals

Prices of traded commodities containing lithium according to IM

Commodity/year		2019	2020	2021	2022	2023[e]
Lithium carbonate, battery quality, annual average (according to MCS)	USD/t	12,100	8,600	12,600	68,100	46,000

e – předběžné údaje

Prices of sold commodities containing rubidium and cesium in the USA – MCS data quotation

In 2023, one company offered 1-gram ampoules of 99.75% (metal basis) rubidium for $100.80, an 8% increase from $93.40 in 2022, and 100-gram ampoules of the same material for $1,818.60, a 9% increase from $1,673.00 in 2022. The price for 10-gram ampoules of 99.8% (metal basis) rubidium formate hydrate was $278.25.

In 2023, the prices for 10 grams of 99.8% (metal basis) rubidium acetate, rubidium bromide, rubidium carbonate, rubidium chloride, and rubidium nitrate were $54.81, $77.70, $52.71, $67.10, and $52.50, respectively. The price for a rubidium-plasma standard solution (10,000 micrograms per milliliter) was $61.53 for 50 milliliters and $109.20 for 100 milliliters, a 7% and 17% increase, respectively, from those in 2022.

In 2023, one company offered 1-gram ampoules of 99.8% (metal basis) cesium for $76.97 and 99.98% (metal basis) cesium for $97.86, 10% increases from $69.90 and $88.90 in 2022, respectively. In 2022, the prices for 50 grams of 99.9% (metal basis) cesium acetate, cesium bromide, cesium carbonate, 99.99% (metal basis) cesium chloride, and cesium iodide were $134.62, $82.43, $118.66, $119.70, and $137.34, respectively, with increases ranging from 3% to 9% from prices in 2023.

The price for a cesium-plasma standard solution (10,000 micrograms per milliliter) in 2023 was $84.53 for 50 milliliters and $129.15 for 100 milliliters, increases of 8% from $78.60 and $120.00 in 2021, respectively. The price for 25 grams of 98% (metal basis) cesium formate was $46.10, an 8% increase from $42.60 in 2022.

Molybdenum

1. Characteristics and use

Average Mo content (and its extent) in the earth's crust (ppm)

1.5 Mo

Industrially important minerals

Molybdenite MoS_2 (60% Mo), wulfenite $PbMoO_4$ (26% No), powellite $CaMoO_4$ (48% Mo)

Industrially important deposit types

1. Copper deposits in porphyries: Climax (USA), Henderson (USA), Questa (USA), El Teniente (Chile), Umalta (Russia), Zhireken (Russia), Karatas (Kazakhstan), Jinduicheng (China), Quishuwan (China), Yulong (China)
2. Uranium infiltration deposits in sandstones: Akouta (Nigeria)

Reserves

2023		
Country	**kt**	**% World**
China	3,700	30.8
USA	2,700	22.5
Chile	1,400	11.7
Russia	430	3.6
Turkey	360	3.0
Armenia	150	1.3
Mexico	130	1.1
Argentina	100	0.8
Canada	72	0.6
Iran	43	0.4
Uzbekistan	21	0.2
World	**12,000**	**100.0**

Source: MCS 2024

Uses

Alloying of steel, cast iron and superalloys. Due to its heat resistance, the metal is used in many chemical applications, including catalysts, lubricants and pigments.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved prognostic resources of molybdenum. At the Hůrky locality in the Čistá-Jesenice Massif, prognostic resources of Mo ores are estimated at 18,327 t of Mo.

3. Registered deposits and other resources of the Czech Republic

In the Czech Republic, 80 million tonnes of prognostic resources (unapproved) of molybdenum ores with an average molybdenum content of 0.176 %, i.e. 18,327 tonnes of molybdenum, were estimated in the Hůrky locality in the Čistá-Jeseník Massif (L. Kopecký 1983) and at the graphite deposit Bližná in the Bohemian Forest Foothils 52 tonnes of Mo have been estimated.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

81029400 – Unwrought molybdenum, including bars, rods obtained by simple sintering

		2019	2020	2021	2022	2023
Import	kg	11,451	548	2,065	736	3,294
Export	kg	13,785	10,171	9,563	10,885	6,973

81029400 – Unwrought molybdenum, including bars, rods obtained by simple sintering

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	854	449	836	1,272	872
Average export prices	CZK/kg	799	740	637	1,016	1,474

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

According to statistics, world production of primary molybdenum developed as follows during 2019–2023:

	2019	2020	2021	2022	2023^{e}
World mine production of molybdenum (according to COCHILCO), kt	278	290	266	272	277
World mine production of molybdenum (according to MCS), kt	297	298	255	253	260^{e}
World mine production of molybdenum (according to WBD), kt	277	285	271	265	N

e – preliminary values;

COCHILCO – Comisión Chilena del Cobre

Main producers according to COCHILCO

Country	2023^{e}	
	t	%
China	90,000	32.5
USA	52,000	18.8
Chile	44,100	15.9
Peru	33,500	12.1
Mexico	16,500	6.0
Arménie	11,900	4.3
Russia	10,800	3.9
Iran	5,800	2.1
Japan	4,400	1.6
Kazachstan	3,800	1.4
World	**277,200**	**100.0**

e – předběžné údaje

Prices of traded commodities

World Mo commodity prices (USD/kg Mo) developed according to DERA yearbooks, Mineral Commodity Summaries (MCS):

Commodity/year	2019	2020	2021	2022	2023
Ferromolybdenum, 65-70% Mo base, free European market (USD/kg) (according to DERA)	26.55	21.30	37.02	45.17	59.35
Molybdenum, annual average (according to MCS) USD/kg	26.50	19.90	36.00	39.25	55.6
Molybdenum, LME cash ** (according to DERA), (USD/t)	40,100	38,000	49,200	58 300	N

The price range of molybdenum includes the lowest and highest monthly price quotes for a given year.

Rare earths

A total of 16 elements belong to the group of rare earths. They can be divided into two subgroups or series. The yttrium series (also referred to as Heavy Rare Earths Elements – HREE) includes yttrium (y), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb) and lutetium (Lu). The cerium subgroup (also referred to as Light Rare Earths Elements – LREE) includes cerium (Ce), lanthanum (La), praseodymium (Pr), neodymium (Nd), promethium (Pm) and samarium (Sm). Sometimes scandium (Sc) is also considered a rare earth element. Rare earth elements are also collectively referred to as lanthanides (Ln) or terrae rarae (TR) or rare earths elements (REE). Sometimes yttrium is not considered a rare earth, as is the case with scandium, other times it is possible to find a definition that rare earths REE is the collective name for 17 chemically similar metal elements – lanthanides, scandium and yttrium.

1. Characteristics and use

Average content (and its extent) in the earth's crust (ppm)

22 Sc, 33 Y, 29 La, 66.5 Ce, 9.2 Pr, 41.5 Nd, 10^{-15} Pm, 7.05 Sm, 2 Eu, 6.2 Gd, 1.2 Tb, 5.2 Dy, 1.3 Ho, 3.5 Er, 0.52 Tm, 3.2 Yb, 0.8 Lu

Industrially important minerals

Monazite $(Ce,La,Y,Nd,Sm,Th)PO_4$ (65% of rare earth oxides), bastnäsite $(Ce,La,Y)CO_3(F,OH)$ (75% of rare earth oxides), xenotime $Y(HREE)PO_4$ (61% of rare earth oxides), loparite $(Ce,Th,Na,Ca)_2(Ti,Nb)_2O_6$ (36% of rare earth oxides); a number of minerals are often REE carriers such as zircon, wolframite, scheelite, apatite, alanite.

Industrially important deposit types

Rare earths occur and are obtained mainly as by-products and co-products of a number of genetic types of deposits. Simplified:

1. Pegmatite, skarn: Kola Peninsula (Russia), Mary Kathleen (Australia),
2. Magmatic-hydrothermal, metasomatic: Olympic Dam (Australia)
3. Magmatic-hydrothermal, metasomatic with carbonatites: Mountain Pass (USA), Bayan Obo (China), Palabora (South Africa), Araxá (Brazil)
4. Volcanogenic-hydrothermal: Gallinas Mountains (USA)
5. Residual: Mrima Hill (Kenya), Araxá (Brazil), Mount Weld (Australia), Xunwu, Longnan (China)
6. Placer: Coastal marine placers with monazite and xenotime – coast of Australia, India (most important producer of monazite), Malaysia (largest miner of xenotime), Sri Lanka, Brazil.

The EU does not have rare earths reserves. (European Minerals Yearbook – version 2023).

Reserves

2023		
Country	**t***	**% World**
China	44,000,000	35.3
Vietnam	22,000,000	17.6
Brazil	21,000,000	16.8
Russia	21,000,000	16.8
India	6,900,000	5.5
Australia	4,000,000	3.2
USA	1,800,000	1.4
Greenland	1,500,000	1.2
Tanzania	890,000	0.7
Canada	830,000	0.7
South Africa	790,000	0.6
World	**120,000,000**	**100.0**

Source: MCS 2024
** recalculated to REO content (Rare Earths Oxides)*

Uses

Rare earth compounds add new, often unusual properties to many materials, even in small admixtures. At the beginning of the 21st century, the majority of REE cerium oxides were consumed worldwide in glass cutting and ceramics. REE compounds are further used in automotive catalysts as well as in oil refining as catalysts and in the chemical industry in general. REE compounds are widely used in metallurgy. REEs are used in the production of television and computer monitors, in lighting and radar technology, etc. The production of highly efficient permanent magnets is not conceivable today without samarium compounds or other REEs (Tb, Dy). Many applications have a significant overlap in military production and REEs have an enhanced strategic importance.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved sources of REE.

3. Registered deposits and other resources of the Czech Republic

IIn the Czech Republic, there are descriptions of estimated resources (unapproved) of rare earth oxidees from various mineralisations and geological formations. For example, the cerium content in uranium ores of uranium-bearing sandstone of the Stráž block in the

Bohemian Cretaceous Basin was evaluated at 4,750 tonnes of cerium. 23.6 t of yttriumoccur at the Bližná v Pošumaví graphite deposit, together with 49 t of REEs in total. There is also an unapproved source of 2 t Sc in the Krásno locality. The tailing pond in Stráž pod Ralskem, where leachate waste from the deposit containing 0.030 to 0.063% of rare earths (lanthanum to gadolinium) has accumulated for decades, but also scandium, yttrium, niobium, zirconium and hafnium is a potential source of these metals. Anomalous rare earth oxide contents are also assumed to occur in the Hůrky locality in the Čistá-Jesenice Massif (along with resources of Mo, Ta, Nb, Zr, and Hf), in alkaline volcanic rocks in the České Středohoří, in volcanic rocks of the Šternberk-Horní Benešov belt in the Nízký Jeseník Mts., in graphitic phyllites of the Železné Hory Mts. Proterozoic, in argillitised tuffs of the Upper Silesian Basin etc.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

28461000 – Cerium compounds

		2019	2020	2021	2022	2023
Import	kg	49,911	30,306	34,186	43,506	1,601
Export	kg	3,570	3,027	3,427	19,313	N

28461000 – Cerium compounds

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	472	450	442	531	149
Average export prices	CZK/kg	551	568	580	158	N

28053010 – Compounds of lanthanum, praseodymium, neodymium or samarium, inorganic or organic

		2019	2020	2021	2022	2023
Import	kg	4,917	2,692	4,695	4,672	N
Export	kg	604	–	2	756	N

28053010 – Compounds of lanthanum, praseodymium, neodymium or samarium, inorganic or organic

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	1,466	1,53	2,300	2,801	N
Average export prices	CZK/kg	2,937	–	9,000	1,269	N

28053090 – Compounds of mixtures of rare-earth metals, yttrium or scandium, inorganic or organic

		2019	2020	2021	2022	2023
Import	kg	46,702	97	31,521	131	60
Export	kg	2,034	53	8	1,215	1

28053090 – Compounds of mixtures of rare-earth metals, yttrium or scandium, inorganic or organic

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	414	4,990	170	2,115	2,250
Average export prices	CZK/kg	159	6,849	26,750	191	0

28053010 – Rare earth metals, scandium and yttrium, intermixed or interalloyed

		2019	2020	2021	2022	2023
Import	kg	711	716	1,175	0	0
Export	kg	0	0	0	0	0

28053010 – Rare earth metals, scandium and yttrium, intermixed or interalloyed

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	215	159	178	–	–
Average export prices	CZK/kg	–	–	–	–	–

28053020 – Cerium, lanthanum, praseodymium, neodymium and samarium, of a purity by weight >= 95 % (excluding intermixed or interalloyed)

		2019	2020	2021	2022	2023
Import	kg	20	1,219	10	24	0
Export	kg	200	50	100	1,151	0

28053020 – Cerium, lanthanum, praseodymium, neodymium and samarium, of a purity by weight >= 95 % (excluding intermixed or interalloyed)

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	3,500	156	42,100	7,750	_
Average export prices	CZK/kg	315	320	250	78	_

28369100 – Lithium carbonates

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	0	0	0	0	0
Average export prices	CZK/kg	0	0	0	0	0

28369100 – Lithium carbonates

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	–	–	–	–	–
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

Statistical data on world production of rare earths for the past five years:

	2019	2020	2021	2022	2023[e]
World mine production, t (according to MCS)	220,000	240,000	290,000	300,000	350,000
World production of concentrates, t (according to WBD)	203,365	229,162	269,003	296,837	N

e – preliminary values

Main producers of rare earths according to WBD

Country	2023	
	t	%
China	168,000	62.4
USA	42,413	15.8
Australia	21,970	8.2
Myanmar	27,100	10.1
Russia	2,276	1.2
India	2,600	0.8
Brazil	580	0.2
Burundi	134	0.0
World	**269,203**	**100.0**

Main producers of rare earths according to MCS

Country	2023[e]	
	t	%
China	210,000	70.0
USA	43,000	14.3
Australia	18,000	6.0
Burma	12,000	3.0
Thailand	7,100	2.4
India	2,900	1.0
Russia	2,600	0.9
Madagascar	960	0.3
World	**300,000**	**100.0**

e – preliminary values

According to MCS estimate, 8,000–12,000 tonnes yearly of Y_2O_3 were produced worldwide in present years. Most of the production comes from China and Burma.

Prices of rare earth oxides (USD/kg) according to the Mineral Commodity Summaries

Commodity/year		2019	2020	2021	2022	2023
Rare earth oxidees, USD/kg	Ce 99,5% min.	2	2	2	1	1
	Dy 99,5% min.	239	261	410	382	323
	Eu 9,99% min.	35	31	31	30	27
	La 99,5% min.	2	2	2	1	1
	Nd 99,5% min.	45	49	98	134	80
	Eu 9,99% min.	507	670	1,346	2,051	1,300

Prices of traded commodities

According to DERA world prices (USD/kg) of commodities with rare earths developed as follows in recent years:

	2019	2020	2021	2022	2023
Cerium oxide. 99%. bulk. FOB China	1,90	1,70	1,49	1,40	1,05
Dysprosium (metal), min 99 %, FOB China	307,02	340,10	518,12	493,08	422,02
Dysprosium (oxide), min. 99 %, FOB China	234,33	259,10	405,83	382,08	329,74
Erbium (oxide), min. 99 %, FOB China	23,96	22,50	35,60	53,48	40,98
Europium (oxide), min. 99 %, FOB China	34,61	29,80	31,86	29,76	26,18
Lanthanum (oxide) min. 99 %, FOB China	1,88	1,60	1,47	1,35	0,96
Lanthanum (oxide), min- 99,999 %, FOB China	3,41	3,30	3,89	5,88	3,20
Neodymium (metal), min. 99 %, FOB China	57,52	61,50	120,80	164,50	96,21
Neodymium (oxide), min. 99 %, FOB China	45,24	48,70	98,43	133,76	78,76
Praseodymium (metal), min. 99 %, FOB China	102,64	91,30	112,23	174,33	129,69
Praseodymium (oxide), min. 99 %, FOB Europe	53,41	43,50	79,24	116,23	77,78
Praseodymium (oxide), min. 99 %, FOB China	54,32	45,70	92,27	128,24	76,69
Samarium (metal), min. 99 %, FOB China	13,87	13,10	13,94	15,48	11,98
Samarium (oxide), min. 99 %, FOB China	1,83	1,80	2,22	3,74	2,19
Scandium (oxide), min. 99,5 %, FOB China, RMB/kg	7,025,24	6,386,10	5,755,00	5,472,79	5,017,25
Terbium (metal), min. 99 %, FOB China	657,57	848,80	1,681,75	2,585,63	1,655,00
Terbium (oxide), min. 99,9 %, FOB China	506,34	663,90	1,322,33	2,044,38	1,314,03
Yttrium (metal), min. 99 %, FOB China	31,03	28,60	37,18	40,56	32,98
Yttrium (oxide), min. 99,999 %, FOB China	2,99	2,90	6,33	11,86	7,35

Selenium, tellurium

1. Characteristics and use

Selenium and tellurium are elements with chemical properties and affinity close to sulphur.

Selenium

Average Se content (and its extent) in the earth's crust (ppm)

0.09 Se

Industrially important minerals

Clausthalite PbSe, ferroselite $FeSe_2$ and berzelianite $Cu_{1-9}Se$. Se is in a lattice of sulphide minerals.

Industrially important deposit types

Selenium is obtained as a by-product from polymetallic deposits and deposits of copper and nickel. Selenium is often separated from sulphur by geological processes and is enriched, for example, in some stratiform uranium deposits (Colorado Plateau, USA).

Reserves

2023		
Country	**t**	**% World**
Russia	20,000	24.7
Peru	13,000	16.0
USA	10,000	12.3
China	6,100	7.5
Canada	6,000	7.4
Poland	3,000	3.7
World	**81,000**	**100.0**

Source: MCS 2024

The EU does not report selenium reserves with the exception of Poland which has 3 kt Se. i.e. 3% of world reserves (MCS 2022, European Minerals Yearbook – version 2022).

Uses

Selenium is used in glass production for decolourising bottle glass, in chemistry and paint production, in electronics and in other industries, including agriculture. Tellurium is used mainly as an additive in the production of engineering steels, in catalysts and chemical production, as an additive in non-ferrous alloys, as a photoreceptor and in thermoelectric devices.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

Tellurium

Average Te content (and its extent) in the earth's crust (ppm)

0.002 Te

Industrially important minerals

Hessite Ag_2Te, nagyágite $[Pb(Pb,Sb)]S_2][Te.Au]$, sylvanite $AuAgTe_4$ and tetradymite Bi_2Te_2S

Industrially important deposit types

Tellurium is obtained as a by-product, mainly from copper deposits. It also occurs in polymetallic deposits, nickel deposits and some gold deposits (Roşia Montană, Romania, Kalgoorlie, Australia, Comstock, USA).

Reserves

2023		
Country	**t**	**% World**
Russia	4,500	14.1
USA	3,500	10.9
China	3,000	9.4
Canada	800	2.5
South Africa	800	2.5
Sweden	670	2.1
World	**32,000**	**100.0**

Source: MCS 2023

In the EU, reserves are reported for Sweden only, approximately 600 t Te, thus 0.2% of the world's Te reserves (MCS 2022, European Minerals Yearbook – version 2023).

Uses

Tellurium is used mainly as an additive in the production of engineering steels, in catalysts and chemical production, as an additive in non-ferrous alloys, as a photoreceptor and in thermoelectric devices.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any approved resources of tellurium. It has an unapproved resource of selenium in the Zlaté Hory district.

3. Registered deposits and other resources of the Czech Republic

In the Czech Republic unapproved prognostic resources of Se, in the Zn-Pb-Cu deposit Zlaté Hory-západ, were evaluated tentatively at more than 13 tonnes (K. Stuchlíková – I. Frolíková 1988).

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

280490 – Selenium

		2019	2020	2021	2022	2023
Import	kg	4,454	7,153	5,181	3,991	2,707
Export	kg	28	16	6	34	1

280490 – Selenium

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	537	449	399	500	419
Average export prices	CZK/kg	4,000	3,750	7,833	1,235	13,000

28045090 – Tellurium

		2019	2020	2021	2022	2023
Import	kg	153	9	4	23	5
Export	kg	0	0	0	0	0

28045090 – Tellurium

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	4,320	8,000	7,250	6,217	16,400
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

Statistical data on selenium and tellurium production have been updated only in recent years. The following are data from the Mineral Commodity Summaries (MCS) and Welt Bergbau Daten (WBD):

	2019	2020	2021	2022	2023
World production of selenium according to MCS, t	2,880	3,120	3,100	3,310	3,600
World production of selenium according to WBD, t	3,533	3,279	3,710	3,735	N
World production of tellurium according to MCS, t	520	562	610	584	640
World production of tellurium according to WBD, t	649	529	459	681	N

Since selenium and telur represent a byproduct in the processing of copper ores, information on production and resources is derived from the situation on Cu ore deposits.The current situation in the production of both metals and the world's major producers are presented in the following tables:

Main producers of selenium according to WBD

Country	2023^{e}	
	t	%
China	1,400	37.5
Japan	710	19.0
Germany	300	8.0
Russia	200	5.4
Philipines	200	5.4
Belgium	200	5.4
Mexico	141	3.8
Finland	130	3.5
USA	120	3.2
Canada	110	3.0
World	**3,735**	**100.0**

Main producers of selenium according to MCS

Country	2023^{e}	
	t	%
China	1,500	41.7
Japan	780	21.7
Russia	360	10.0
Germany	300	8.3
Belgium	200	5.6
Canada	120	3.3
Finland	100	2.8
Poland	95	2.6
Peru	57	1.6
World	**3,600**	**100.0**

e – preliminary values

Main producers of tellurium according to WBD

Country	2022	
	t	%
China	500	73.4
Japan	68	10.0
Russia	40	5.9
Sweden	33	4.9
Canada	24	3.5
USA	10	1.5
Uzbekistan	3	0.4
World	**681**	**100.0**

Main producers of tellurium according to MCS

Country	2023^{e}	
	t	%
China	430	67,2
Russia	75	11,7
Japan	75	11,7
Canada	27	4,2
Sweden	25	3,9
South. Africa	5	0,8
Uzbekistan	3	0,5
World	**640**	**100.0**

Prices of global commodities

According to DERA yearbooks for 2018–2022 the average world prices of selenium and tellurium (USD/kg) were as follows:

Commodity/year	2019	2020	2021	2022	2023^{e}
Selenium, powder, min. 99.5%,	21.42	15.70	22.87	23.55	27.87
Tellurium, min. 99.99%, Europe	63.52	61.50	78.16	71.12	81.73

e – preliminary values

Average prices of selenium and tellurium (USD/kg) in the USA (MCS) were as follows:

Commodity/year	2019	2020	2021	2022	2023^{e}
Selenium metal, powder, min. 99.5%, FOB warehouse U.S.	20.17	14.58	18.18	23.07	23.00
Tellurium, avg.ann.price, 99.95%, warehouse Rotterdam	68.11	59.37	69.72	70.34	80.00

e – preliminary values

Tantalum, niobium

Tantalum and niobium are chemically related elements that occur in nature together. They are concentrated in nature in the late phase of magma crystallisation, most often in pegmatites and also in carbonatites.

1. Characteristics and use

Tantalum

Average Ta content (and its extent) in the earth's crust (ppm)

2.1 Ta

Industrially important minerals

Tantalite $FeTa_2O_6$ (40–81% Ta_2O_5), pyrochlore $NaCaNb_2O_6F$ (0.2–39% Ta_2O_5), microlith $NaCaTa_2O_6F$ (max. 80% Ta_2O_5), wodginite $MnSnTa_2O_8$ (70.5% Ta_2O_5)

Industrially important deposit types

1. Primary deposits in igneous rocks such as carbonatites, pegmatites and nepheline syenites: Araxá (Brazil), Chibiny (Russia), Tanco (Canada), Dajishan and Limu (China).
2. Placers of stable minerals such as columbite, tantalite, pyrochlore: Bukuru (Jos Plato, Nigeria), Ngulla (Tanzania), Mtoko (Zimbabwe).

Reserves

2023		
Country	**t**	**% World**
China	180 000	N
Australia	99 000	N
Brazil	40 000	N
World	**N**	**N**

Source: MCS 2024

The EU does not have tantalum reserves.

Uses

Tantalum is mostly used in electronics, especially in tantalum capacitors in computer technology and in mobile phones. It is also used in the production of superalloys for aircraft engines and metalworking tools.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes

Niobium

Average Nb content (and its extent) in the earth's crust (ppm)

20 Nb

Industrially important minerals

Pyrochlore $NaCaNb_2O_6F$ (40–72% Nb_2O_5), columbite $FeNb_2O_6$ (40–77% Nb_2O_5) a loparite $NaCe(Ti,Nb)_2O_6$ (8–13% Nb_2O_5)

Industrially important deposit types

1. Primary deposits in igneous rocks such as carbonatites, pegmatites and nepheline syenites: Araxá (Brazil), Chibiny (Russia), Tanco (Canada), Dajishan and Limu (China).
2. Placers of stable minerals such as columbite, tantalite, pyrochlore: Bukuru (Jos Plato, Nigeria), Ngulla (Tanzania), Mtoko (Zimbabwe).

Reserves

2023		
Country	**t**	**% World**
Brazil	16,000,000	94.1
Canada	1,600,000	9.4
USA	210,000	1.0
World	**>17,000,000**	**100.0**

Source: MCS 2024

The EU does not have niobium reserves.

Uses

The main consumption of niobium goes to the production of ferroniobium for the steel industry and niobium superalloys for the rocket and aerospace industries.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved sources of Ta and Nb.

3. Registered deposits and other resources of the Czech Republic

In the Czech Republic, prognostic resources (unapproved) were evaluated at 3,238 tonnes in uranium deposits and uranium-bearing sandstone of the Stráž block in the Bohemian Cretaceous Basin (along with TR, Zr and Hf), and another 568 tonnes in the Hůrky locality in the Čistá-Jeseník Massif (along with Mo, TR, Zr and Hf), where 57 tonnes of prognostic tantalum resources were also calculated. In the Krásno and Cínovec area 13,670 t Ta and 19,702 t Nb of prognostic (unapproved) resources were enumerated. Recoverable contents of tantalum and niobium are also known to occur in tungsten and tin concentrates, which were recovered experimentally during the exploration of the tin-tungsten ore deposit of Cínovec-jih (along with Li, Rb and Cs).

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

26159010 – Tantalum and niobium ores and concentrates

		2019	2020	2021	2022	2023
Import	kg	–	–	11,428	10	–
Export	kg	1,451	–	14,829	5,526	–

26159010 – Tantalum and niobium ores and concentrates

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	–	–	784	6,100	–
Average export prices	CZK/kg	1,147	–	1,158	960	–

810320 – Unwrought tantalum

		2019	2020	2021	2022	2023
Import	kg	110,953	40,531	13,390	94,923	3
Export	kg	19,018	28,400	80,597	60,500	485

810320 – Unwrought tantalum

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	5,445	5,497	7,254	7 934	7,320
Average export prices	CZK/kg	8,849	11,425	9,124	10,371	17,930

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

World production of tantalum and niobium in 2019–2023:

	2019	2020	2021	2022	2023^{e}
World production of tantalum (according to MCS) t	1,850	2,100	1,840	2,000	2,400
World production of niobium (according to MCS) t	97,000	67,700	87,600	79,000	83,000

e – preliminary values

	2019	2020	2021	2022	2023
World production of tantalum (according to WBD), t Ta_2O_5	1,645	1,705	1,760	1,726	N
World production of niobium (according to WBD), t Nb_2O_5	134,961	93,508	121,909	118,209	N

Main producers of Ta according to WBD

Country	2022	
	t	%
Congo (Kinshasa)	550	31.9
Brazil	350	20.3
Rwanda	300	17.4
Nigeria	140	8.1
China	92	5.3
Ethiopia	90	5.2
Mozambique	84	4.9
Australia	40	2.3
Sierra Leone	25	1.5
World	**1,726**	**100.0**

Main producers of Ta according to MCS

Country	2023^{e}	
	t	%
D.R.Congo	980	40.8
Rwanda	520	21.7
Brazil	360	15.0
Nigeria	110	4.6
China	79	3.3
Australia	43	1.8
Burundy	36	1.5
Ethiopia	32	1.2
World	**2,400**	**100.0**

e – preliminary values

Main producers of Nb according to WBD

Country	2022	
	t	%
Brazil	110,000	93.1
Canada	6,800	5.8
Russia	549	0,5
Congo (Kinshasa)	520	0,4
Rwanda	195	0,2
Nigeria	60	0,1
China	40	0,0
Mozambique	25	0,0
World	**118,209**	**100.0**

Main producers of Nb according to MCS

Country	2023[e]	
	t	%
Brazil	75,000	88.0
Canada	7,000	9.9
World	**83,000**	**100.0**

e –preliminary values

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023
Ta conc. 30 % Ta_2O_5, CIF China, USD/kg (according to DERA)	203.03	139.55	131.90	197.02	180.86
Ta pentoxide, min. 99,5 %, FOB China, USD/kg (according to DERA)	271.53	194.34	184.90	276.67	247.89
Nb conc. min. 50 % Nb_2O_5, min. 5% Ta_2O_5, CIF China, USD/kg (according to DERA)	35.41	22.93	20.90	36.86	35.01
Nb pentoxide, 99,5 %, FOB China USD/kg (according to DERA)	42.46	33.34	29.40	40.81	42.98
Feroniobium, imports and exports to the USA, USD/kg (according to MCS)	22	20	20	24	25

* *According to Metalary data (https://www.metalary.com/tantalum-price/ and https://www.metalary.com/niobium-price/)*

Zirconium, hafnium

Chemically, zirconium and hafnium have the same behaviour and occur together. Individual Hf minerals are not known. A constant Zr/Hf ratio of 50:1 is typical for ore occurrences of both elements.

1. Characteristics and use

Average Zr and Hf content (and its extent) in the earth's crust (ppm)

160 (130–400) Zr, 3 Hf

Industrially important minerals

Baddeleyite ZrO_2 (94% ZrO_2, 1.5–4% Hf), zircon $ZrSiO_4$ (67% Zr, 1.5–4% Hf)

Industrially important deposit types

1. Primary ores consisting of baddeleyite in carbonatites and nepheline syenites with apatite: Kovdor (Russia), Palabora (South Africa), Jacupiranga (Brazil).
2. Placers of zircon sands, most often of the beach type: East Australian coast (Murray Basin), Ukraine, Brazil, India, South Africa (Richards Bay).

Reserves

Zirconium

2023		
Country	**kt**	**% World**
Australia	48,000	71,4
South Africa	5,900	8,4
Senegal	2,600	3,7
Mozambique	1,800	2,6
China	500	0,7
USA	500	0,7
World	**70,000**	**100**

Source: MCS 2024

The EU does not have zirconium reserves. (European Minerals Yearbook – version 2023)

Hafnium

The world's hafnium reserves are unknown but with the help of the known ratio Zr/ZrO_2 = 91/123 and the ratio Zr/Hf in zirconium = 33–50/1 it can be estimated that world reserves of Hf range from 950 to 1,430 kt. The EU does not have hafnium reserves (European Minerals Yearbook – version 2022).

Uses

Zircon is used mainly in the ceramic and glass industries, in the production of refractory materials and in the manufacture of moulds in foundries. Other areas of Zr application include abrasives, the production of chemicals, metal alloys, protective coatings for welding electrodes and the production of blasting sands. The largest share of hafnium goes to the production of superalloys for the needs of the nuclear energy and chemical industries.

Classification as critical raw materials for the European Union

Zr: 2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no
Hf: 2011 – no, 2014 – no, 2017 – yes, 2020 – yes, 2023 – yes

2. Mineral resources of the Czech Republic

In the Czech Republic, there are unapproved prognostic resources of zirconium and hafnium in uranium bearing sandstone ores and in fenites of Čistá-Jesenice Massif.

3. Registered deposits and other resources of the Czech Republic

In the Czech Republic, prognostic resources of zirconium and hafnium in uranium deposits of uranium-bearing sandstone of the Stráž block in the Bohemian Cretaceous Basin (along with TR, Ta, Nb) were estimated at 285,416 tonnes of zirconium. Assuming a Zr/H ratio in zircon = 33–50/1, the amount of accompanying hafnium can be estimated at 5,700–8,600 tonnes. Another 122,370 tonnes of zirconium and 2,446 tonnes of hafnium are assumed to occur in fenites in the Hůrky locality in the Čistá-Jesenice Massif (along with Mo, TR, Ta, Nb). All the resources are unapproved.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

26151000 – Zirconium ores and concentrates

		2019	2020	2021	2022	2023
Import	kg	566,118	0	0	1,313,954	902,531
Export	kg	4,265	0	0	53,608	142,201

26151000 – Zirconium ores and concentrates

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	49	–	–	95	97
Average export prices	CZK/kg	46	–	–	83	137

81129210 – Unwrought hafnium, hafnium waste and scrap, hafnium powders

		2019	2020	2021	2022	2023
Import	kg	1	18	17	0	0
Export	kg	0	0	0	0	0

81129210 – Unwrought hafnium, hafnium waste and scrap, hafnium powders

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	9,000	33,000	37,706	–	–
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production

Statistical data on zirconium production

	2019	2020	2021	2022	2023e
World production, kt (according to MCS)*	1,480	1,420	1,200	1,300	1,400
World production, kt (according to WBD)	1,569	1,368	1,249	1,456	N

e – preliminary values

** Zr concentrates*

Main producers according to MCS-Zr concentrates

Country	2023[e]	
	t	%
Australia	400	33,3
South Africa	270	22,5
China	140	11,7
Mozambique	110	9,2
USA	70	5,8
Senegal	55	4,6
Indonesia	30	2,5
World	**1,200**	**100.0**

e – preliminary values

Prices of traded commodities

Average annual zircon prices are based on DERA yearbook data and are given in USD/t. Average annual prices of unwrought zirconium and unwrought hafnium are based on MCS data and are given in USD/kg.

Commodity/year	2019	2020	2021	2022	2023
Zircon, standard, bulk shipments, min. 65,5 % ZrO_2, CIF China, USD/t (DERA)	1,413.20	1,510.94	1,398.10	1,433.85	2,034.79
Zircon, USD/t, CIF China, (MCS)	1,948	1,933	1,843	2,025	2,270
Zirconium, unwrought, US import, China USD/kg (MCS)	35	33	21	31	29
Hafnium, unwrought, US market USD/kg MCS	838	775	750	950	1,900

e – preliminary values

MINERALS UNMINED IN THE PAST WITHOUT RESOURCES AND RESERVES

INDUSTRIAL MINERALS

Andalusite, kyanite, sillimanite, mullite

1. Characteristics and use

Andalusite, kyanite (formerly also known as disthene) and sillimanite are mutually polymorphic minerals a $Al_2O_3.SiO_3$ chemism with a high Al content (50–63% Al_2O_3, but with different structures and different physical properties. Andalusite is a typical mineral of metamorphic rocks. Kyanite occurs mainly in crystalline shales (micaschists, gneisses) that are rich in aluminium, more rarely also on contacts, in granulites and eclogites. In some places, they also form independently extractable deposits of practical significance. Sillimanite occurs in metamorphites and also in pegmatites. At temperatures above 1,100 °C, $3Al_2O_3.2SiO_2$ mullite is formed from minerals of the sillimanite group by calcination.

Andalusite, originally from alluvium now from metapelites (from the Bushveld Complex), is mined in South Africa, from metaslates at the Glomel deposit in France, kyanite is mined from kyanite quartzites on Willis Mountain in the USA, kyanite is mined in Bhandara (India), in metasediments of the Kola Peninsula (Russia), sillimanite is mined mainly in India from alluvium (Odisha Sand Complex).

Reserves

They are extensive worldwide, but information are published only by India (688 kt of kyanite, 6,502 kt of sillimanite) (Indian minerals yearbook 2019). EU reserves of andalusite, sillimanite and kyanite have not been published. One of the largest is the French reserves of andalusite, also undisclosed.

Uses

All these minerals are valued mainly for their toughness, resistance to high temperatures, low expansion, excellent insulating properties and corrosion resistance. They are used for the production of special types of porcelain, lining of furnaces, etc. In the production of mullite during the cooling of the melt, elongated needle-like crystals are formed from small crystals, which penetrate the melt and strengthen the fired mass. Mullite provides a number of fire-resistant products (e.g. fireclay) with their most important technological properties. Its content increases heat resistance, heat absorption capacity, resistance to temperature changes, etc. Andalusite is preferred over kyanite because it can be used directly, without calcination and thus save energy.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have resources of andalusite, sillimanite and kyanite.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

250850 – Andalusite, kyanite and sillimanite

		2019	2020	2021	2022	2023
Import	t	5,326	7,406	8,504	5,739	4,359
Export	t	12	10	8	11	16

250850 – Andalusite, kyanite and sillimanite

		2019	2020	2021	2022	2023
Average import prices	CZK/t	12,063	12,557	12,099	14,437	14,488
Average export prices	CZK/t	29,625	31,753	30,663	34,191	36,875

250860 – Mullite

		2019	2020	2021	2022	2023
Import	t	2,031	1,014	2,587	2,223	1,840
Export	t	0,5	2	29	17	21

250860 – Mullite

		2019	2020	2021	2022	2023
Average import prices	CZK/t	11,348	14,567	14,311	14,710	18,470
Average export prices	CZK/t	109,453	27,742	23,669	38,142	56,239

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of kyanite and related minerals

Commodity/year	2019	2020	2021	2022	2023
World mine production of kyanite and related minerals (according to MCS), kt	N	N	N	N	N
World mine production of kyanite and related minerals (according to WBD), kt	N	N	N	N	N

Main producers of kyanite and related minerals – according to MCS

Country*	2023[e]	
	t	%
South Africa (andalusite)	160,000	N
France (kyanite)	85,000	N
USA (kyanite)	65,000	N
India (kyanite and sillimanite)	40,000	N
Peru (andalusite)	10,000	N
World total	**N**	**N**

e – estimate

* *In addition to the countries listed, France continued production of andalusite and Cameroon and China produced kyanite and related minerals. Output was not reported quantitatively, and no reliable basis was available for estimation of output levels.*

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023
Kyanite, average value exports, FAS, USD/t (MCS)	358	369	369	382	420
Andalusite, 57–58% Al_2O_3, FCA Mine, South Africa, 2,000 tonne bulk, EUR/t (IM)*	N	N	N	N	N
Andalusite, 55–59% Al_2O_3, FOB European port, EUR/t (IM)*	N	N	N	N	N
Andalusite, min 57% Al_2O_3, FOB South Africa, EUR/t (IM)*	270–340	260–340	N	N	N
Andalusite, min 57% Al_2O_3, CIF Europe, EUR/t (IM)*	320–450	320–440	N	N	N

* *Price range includes the lowest and the highest monthly price quotes for the given year.*

Asbestos

1. Characteristics and use

Asbestos is a technically usable mineral solid fibre of various mineralogical composition. The highest quality asbestoses are formed by flexible chrysotile fibres (chrysotile $Mg_3Si_2O_5(OH)_4$), less often amosite (amosite – mineralogically anthophyllite, grunerite or cummingtonite – $(Fe>Mg)_7Si_8O_{22}(OH)_2$ (grunerite formula) or by crocydolite $Na_2(Fe^{2+},Mg)_3Fe_2{}^{3+}Si_8O_{22}(OH)_2$. Brittle fibres tend to have an anthophyllite composition $(Mg,Fe^{2+})_7(Si_6O_{22})(OH,F)_2$. Less important are the amphibole asbestoses formed by tremolite $Ca_2Mg_5(Si_8O_{22}(OH,F)_2$ or actinolite $Ca_2(Mg,Fe^{2+})_5(Si_8O_{22}(OH,F)_2$.

Asbestos deposits are formed by hydrothermal processes associated with metamorphosis in ultrabasic rocks, dolomitic limestones or ferrous sedimentary formations. The most important deposits are found in mountain ranges of various ages. Typical examples are the Appalachian Mountains and the Rocky Mountains (USA, Canada) and the Ural (Russia).

The main types of deposits are:

1. Stockwork mineralisations of asbestos in basic and ultrabasic rocks: Eastern Township (Canada), Thetford (Canada), Great Dyke (Zimbabwe), Shabani (Zimbabwe), Coalinga (USA), Paakkila(Finland), Val Malenco (Italy), Yanshan Region (China), Mangnai (China)
2. Deposits in metamorphic banded iron formations (BIF): Penge region (South Africa), Pomfret (South Africa), Asbest (Russia), Kiyembayevskoye (Russia)

Reserves

They are extensive worldwide, but unpublished. The EU does not have any asbestos reserves.

Uses

The properties that make asbestos universal and cost-effective are high ultimate tensile strength, chemical and thermal stability, high flexibility, low electrical conductivity and large surface area. The quality of asbestos is determined by the length of the fibres and their flexibility. The most expensive is the fibre asbestos, the lowest quality raw material is used in the production of asbestos-cement products. The use of asbestos has been limited for many years for health and environmental reasons (e.g. brake linings in the automotive industry).

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023– no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of asbestos.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2524 – Asbestos

		2019	2020	2021	2022	2023
Import	t	–	–	–	–	–
Export	t	–	–	–	–	–

2524 – Asbestos

		2019	2020	2021	2022	2023
Average import prices	CZK/t	–	–	–	–	–
Average export prices	CZK/t	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of asbestos

Commodity/year	2019	2020	2021	2022	2023[e]
World mine production of asbestos (according to MCS), kt	1,170	1,100	1,240	1,330	1,300
World mine production of asbestos (according to WBD), kt	1,137	1,132	1,302	1,258	N

e – estimate

Main producers of asbestos according to MCS

Country*	2023[e]	
	kt	%
Russia	630,000	48.5
Kazakhstan	260,000	20.0
Brazil	200,000	15.4
China	190,000	14.6
World (rounded)	**1,300,000**	**100.0**

e – estimate

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023[e]
Asbestos, price average U.S. customs value on import, USD/t (MCS)	1,570	2,110	1,880	2,630	N

e – estimate

Boron

1. Characteristics and use

Average content (and its extent) in the earth's crust (ppm)

10 (3–50) B

Industrially important minerals

Ulexite $NaCa(B_5O_6(OH)_6).5H_2O$ (43 % B_2O_3), borax (tinkal) $Na_2(B_4O_5(OH_4)).8H_2O$ (36 % B_2O_3), kernite $Na_2(B_4O_6(OH_2)).3H_2O$ (51 % B_2O_3), colemanite $Ca(B_3O_4(OH)_3).H_2O$ (51 % B_2O_3), datolite $CaB(SiO_4)(OH)$ (44 % B_2O_3)

Industrially important deposit types

Boron is mobilized in the earth crust by volcanism or magmatism. Subsequently, solutions of its compounds flow into confined evaporative lake pans and are concentrated in them by evaporation and form sedimentary sequences with other compounds Mg, Ca, Na, K, Li and clastic material. In some areas (e.g. Italy) boric acid (sassoline) H3BO3 springs in hot springs. Sedimentary chemogenic accumulations of boron compounds may undergo metamorphic processing. Or accumulations may be formed by intrusions of magma into carbonate rocks.

1. Sedimentary chemogenic: Kramer (USA), Searles Lake (USA), Salar de Atacama (Chile), Kirka (Turkey), Bigadiç (Turkey), Stassfurt (Germany), Inder (Kazakhstan)
2. Metamorphic: region of Liaoning Peninsula (China), Dalnegorsk (Russia)

Reserves:

2023		
Country	**kt**	**% World**
Turkey – purified borates	950,000	N
USA – especially borax, kernite a borates	48,000	N
Russia – datolite	40,000	N
Chile – ulexite	35,000	N
China – ekvivalent of B_2O_3	20,000	N
Peru – raw borates	4,000	N
World	**N**	**N**

Source: MCS 2023

Global stocks cannot be estimated because country data are not published consistently. The EU does not have boron reserves (European Minerals Yearbook – version 2023).

Uses

Glassmaking – production of fibers and heat-resistant glass, ceramics – enamels and glazes, production of soaps and detergents, metallurgy of ferrous and non-ferrous metals, production of refractory materials, abrasives, semiconductors, herbicides, fertilizers, neutron shields and control rods for nuclear reactors.

Classification as critical raw materials for the European Union

Borates: 2011 – no, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of boron.

3. Registered deposits and other resources of the Czech Republic

They are not.

4. Basic statistical data of the Czech Republic as of December 31

They are not.

5. Foreign trade

25280000 – Natural borates and concentrates thereof (whether or not calcined), but not including borates separated from natural brine; natural boric acid containing not more than 85 % of H_3BO_3 calculated on the dry weight

		2019	2020	2021	2022	2023
Import	t	17,045	19,202	20,520	19,961	14,916
Export	t	0	0.005	0.01	1	0

25280000 – Natural borates and concentrates thereof (whether or not calcined), but not including borates separated from natural brine; natural boric acid containing not more than 85 % of H_3BO_3 calculated on the dry weight

		2019	2020	2021	2022	2023
Average import prices	CZK/t	9,558	9,317	9,037	10,011	12,001
Average export prices	CZK/t	–	57,692	13,333	264,167	–

28045010 – Boron

		2019	2020	2021	2022	2023
Import	t	34	50	20	70	21
Export	t	34	21	15	7	2

28045010 – Boron

		2019	2020	2021	2022	2023
Average import prices	CZK/t	126,064	98,364	222,100	91,471	212,345
Average export prices	CZK/t	29,851	37,424	41,618	93,380	68,400

28100090 – Oxides of boron; boric acids (except boric oxide)

		2019	2020	2021	2022	2023
Import	t	2,161	2,341	3,159	1,753	1,092
Export	t	2	17	13	52	9

28100090 – Oxides of boron; boric acids (except boric oxide)

		2019	2020	2021	2022	2023
Average import prices	CZK/t	17,076	16,382	16,066	22,104	28,569
Average export prices	CZK/t	66,520	140,680	123,267	41,353	94,624

28401910 – Disodium tetraborate pentahydrate

		2019	2020	2021	2022	2023
Import	t	11,208	9,325	13,288	14,558	14,601
Export	t	<1	–	–	0.003	0

28401910 – Disodium tetraborate pentahydrate

		2019	2020	2021	2022	2023
Average import prices	CZK/t	9,919	10,171	9,851	11,844	14,948
Average export prices	CZK/t	–	–	–	–	–

28401990 – Disodium tetraborate (excluding anhydrous and disodium tetraborate pentahydrate)

		2019	2020	2021	2022	2023
Import	t	1,875	4,528	2,861	182	195
Export	t	21	20	12	19	48

28401990 – Disodium tetraborate (excluding anhydrous and disodium tetraborate pentahydrate)

		2019	2020	2021	2022	2023
Average import prices	CZK/t	10,127	10,107	10,152	20,763	23,828
Average export prices	CZK/t	18,087	34,983	58,663	54,546	34,789

28402090 – Borates (excluding sodium borates, anhydrous and disodium tetraborate)

		2019	2020	2021	2022	2023
Import	t	250	155	164	200	587
Export	t	115	41	3	284	–

28402090 – Borates (excluding sodium borates, anhydrous and disodium tetraborate)

		2019	2020	2021	2022	2023
Average import prices	CZK/t	52,030	75,123	57,483	66,973	27,980
Average export prices	CZK/t	58,852	58,249	97,767	34,536	–

28403000 – Peroxoborates (perborates)

		2019	2020	2021	2022	2023
Import	t	24	5	10	8	0.05
Export	t	4	4	3	0.5	0

28403000 – Peroxoborates (perborates)

		2019	2020	2021	2022	2023
Average import prices	CZK/t	17,366	16,419	15,488	18,375	104,000
Average export prices	CZK/t	18,042	16,483	17,982	82,000	–

28499010 – Carbides of boron, whether or not chemically defined

		2019	2020	2021	2022	2023
Import	t	14	25	18	36	12
Export	t	2	0.02	0.001	0.165	0

28499010 – Carbides of boron, whether or not chemically defined

		2019	2020	2021	2022	2023
Average import prices	CZK/t	438,136	373,936	386,696	457,072	462,931
Average export prices	CZK/t	323,920	416,149	4,000,000	557,585	–

6. Prices of domestic market

They are not.

7. Mining companies in the Czech Republic as of December 31, 2023

They are not.

8. World production and world market prices

World mine production of boron

	2019	2020	2021	2022	2023^{e}
World mine production of boron (B_2O_3 content) (according to WBD), kt	4,293	3,601	4,920	N	N

e – estimate

Main producers of boron according to MCS

Country	2023^e	
	kt	%
Turkey (refined borates)	2,200	N
Chile (ulexite)	360	N
China (boric acid equiv.)	200	N
Peru	200	N
Bolivia (ulexite)	170	N
Argentina	130	N
Germany (compounds)	80	N
Russia (datolite ore)	60	N
World total *	**N**	**N**

e – estimate
** Exclusive U.S. production. World totals cannot be calculated because production and reserves are not reported in a consistent manner by all countries (MCS).*

Main producers of boron according to WBD

Country	2023	
	kt	%
Turkey	2,590	48.4
United States	1,160	21.7
Chile	421	7.9
China	300	5.6
Bolivia	295	5.5
Peru	292	5.5
Argentina	164	2.7
Russia	88	1.7
Kazakhstan	30	0.6
Iran	2	0.0
World total	**5,346**	**100.0**

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023^e
Boron, cost, insurance and fright, avg. value of imports to U.S., USD/t (MCS)	373	380	394	485	620

e – estimate

Magnesite

1. Characteristics and use

Magnesite ($MgCO_3$) is the most important magnesium mineral (with a theoretical maximum content of 47.6% MgO). Magnesite deposits are bound to rocks rich in magnesium – dolomites and serpentinites. Magnesite and its deposits can be divided into crystalline and solid (cryptocrystalline) types:

1. Crystalline magnesite with grain dimensions below 10 mm: Eugui-Asturetta (Spain), Namdechon (North Korea), Liaoning (China), Breitenau (Austria), Dúbrava (Slovakia), Almora region (India), Savinsky District (Russia), Malchichinsky District (Russia), Mayardakskaya Region (Russia)
2. Solid magnesite with 0.004 to 0.01 mm grains and a conchoidal fracture resembling porcelain: Bushveld Complex (South Africa), Mantudi (Greece), Susehiri (Turkey), Bela Stena (Serbia), Kunwarara (Australia)

Crystalline magnesite is formed by the hydrothermal contribution of Mg to carbonate rocks, solid magnesite by the contribution of CO_2 to serpentinite. Solid magnesite can also have a sedimentary origin. Magnesite contains impurities of CaO, Fe_2O_3, MnO, Al_2O_3, SiO_2, etc., which affect the quality of the raw material. Magnesite is usually considered to be a raw material with a MgO content of at least 40% and a CaO content of at most 4%.

Reserves

2023		
Country	**kt MgO**	**% World**
Russia	2,300,000	36.36
Slovakia	1,200,000	15.6
China	580,000	7.5
Greece	280,000	3.6
Australia	280,000	3.6
Brazil	200,000	2.6
Turkey	110,000	1.4
India	66 000	0.9
Austria	49 000	0.6
Spain	35 000	0.5
USA	35 000	0.5
World	**7,700,000**	**100.0**

Source: MCS 2024

2023			
Country	**kt MgO**	**% World**	**% EU**
EU	467,500	100.0	6.2
Slovakia	370,000	79.1	4.9
Austria	49,000	10.5	0.6
Spain	35,000	7.5	0.5
Poland* **	13,500	2.9	0.2

** own recalculation to MgO*
*** Bilans zasobów złóż kopalin w Polsce 2023*
Source: MCS 2024

Uses

Magnesite is mainly used for the production of caustic clinker, from which refractory materials and insulation are produced, and together with $MgCl_2$ also the Sorel cement for special floor materials, resistant to acids and oils. Other uses are in the chemical industry, in the production of paper and rayon.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of magnesite.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

251910 – Natural magnesium carbonate (magnesite)

		2019	2020	2021	2022	2023
Import	t	4,379	4,519	4,478	3,434	3,694
Export	t	4	1	4	0.8	1

251910 – Natural magnesium carbonate (magnesite)

		2019	2020	2021	2022	2023
Average import prices	CZK/t	2,604	2,386	2,482	2,959	3,033
Average export prices	CZK/t	94,529	444,166	69,815	221,420	402,000

251990 – Magnesia*, fused, dead-burned, other magnesium oxides

		2019	2020	2021	2022	2023
Import	t	59,814	57,375	54,600	54,920	37,285
Export	t	9,755	10,621	7,918	8,541	6,285

* *MgO*

251990 – Magnesia*, fused, dead-burned, other magnesium oxides

		2019	2020	2021	2022	2023
Average import prices	CZK/t	8,595	8,755	8,353	11,248	11,579
Average export prices	CZK/t	11,237	11,909	11,687	17,558	17,833

** MgO*

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of magnesite

Commodity/year	2019	2020	2021	2022	2023[e]
World mine production of magnesite (according to MCS), kt	27,100	27,000	29,000	21,900	27,000
World mine production of magnesite (according to WBD), kt	27,339	28,255	28,054	26,696	N

e – estimate

Main producers of magnesite according to MCS

Primary production

Country	2023[e]	
	kt	%
China	13,000	59.1
Slovakia	2,600	11.8
Turkey	1,800	8.2
Brazil	1,700	7.7
Russia	960	4.4
Australia	860	3.9
Austria	810	3.7
Spain	670	3.0
Greece	380	1.7
Other countries	400	1.8
World (rounded)	**22,000**	**100.0**

e – estimate

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023[e]
Magnesite, calcianted, agricultural, CIF Europe, EUR/t (DERA)**	N	266.7	277.12	387.50	420.83
Magnesite, dead burned, 97,5% MgO, lump, FOB China, USD/t (DERA)**	N	404.6	458.96	526.88	437.92
Magnesite, fused, 98% MgO, lump, FOB China, USD/t (DERA)**	N	695.4	759.9	893.85	710.83
Magnesite, rax, max. 3,5% SiO_2, Greece, FOB, eastern Mediterranean, EUR/t (DERA)**	N	75.0	8208	130.29	136.04

e – estimate
** Price range of lowest and highest price monthly quotations for the actual year.*
*** Average annual price.*

Perlite

1. Characteristics and use

Perlite is a natural volcanic glass (hyaloclastite) with a spherical texture, consisting of 65–78% SiO_2, mostly rhyolite, sometimes andesite. It is formed by the disintegration of lava pouring into water. Perlite deposits are found in many regions of the world. The world's most important producers include Greece, Turkey, the USA and Japan. Data from China are not known. Greece's global deposits lie in the Aegean Sea, on the islands of Kos and Milos.

Reserves

World reserves are extensive and published only rarely. EU perlite reserves are under-published. They occur in Greece and, among others, in Hungary and Slovakia (in Slovakia they are estimated at 30 million tons). European Minerals Yearbook - version 2023. Mineral resources of the Slovak Republic 2023.

Uses

By heating the perlite to a temperature of about 1000 °C, it expands rapidly to form a glassy foam, increasing the volume four to twenty times, so that the bulk density reaches values of 0.08 to 0.2 t/m^3. Expanded perlite is used in the construction industry for its thermal and sound insulation properties and for the production of aerated concrete, as well as in absorbent mixtures for the removal of oil stains on the water surface. The absorption properties of perlite are also used in the production of feed mixtures and bedding.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any resources of perlite.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

25301010 – Perlite

		2019	2020	2021	2022	2023
Import	t	–	–	–	–	–
Export	t	–	–	–	–	–

25301010 – Perlite

		2019	2020	2021	2022	2023
Average import prices	CZK/t	–	–	–	–	–
Average export prices	CZK/t	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of perlite

Commodity/year	2019	2020	2021	2022	2023^{e}
World mine production of perlite (according to MCS), kt	3,460	4,220	4,150	4,940	4,900
World mine production of perlite (according to WBD), kt	2,831	3,156	3,840	3,161	N

e – estimate

Main producers of perlite according to MCS

Country	2023^e	
	kt	%
China	1,500	30.4
Turkey	1,400	28.3
Greece	1,100	22.3
United States*	450	9.1
Hungary	180	3.6
Iran	80	1.6
Armenia	40	0.8
Slovakia	80	1.6
New Zealand	20	0.4
Mexico	20	0.4
Argentina	20	0.4
World (rounded)	**4,940**	**100.0**

e – estimate
** Processed ore sold and used by producers.*

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023^e
Perlite, average value, FOB mine in U.S., USD/t (MCS)	64	61	64	68	68

e – estimate

Rock salt

1. Characteristics and use

Rock salt (halite) is a sedimentary rock composed entirely or mainly of sodium chloride NaCl. It is usually formed by chemical sedimentation (evaporation) from true solutions. Three types of halite deposits can be distinguished (in solid state):

1. Salt pans in arid or semiarid environments (playas): Searles Lake (USA)
2. Layered deposits: Paradox Basin (USA), Zechstein Formation (Germany), Sergipe (Brazil)
3. Salt domes: Kłodawa (Poland), Zechstein Formation (Germany), Turda (Romania), Gulf Coast Region (USA)

The evaporite sedimentation hypotheses assume sedimentation in sabkhas i.e. either in muddy coastal plateaus lying just above sea level at high tide or in flat inland depressions in semiarid to arid areas, with aeolian sediments and various muds saturated with evaporating brine in sabkhas, as well as in deep-sea basins that have not dried up at all and were not salt basins.

Reserves

2023		
Country	**kt**	**% EU**
Poland	1,794,620	54.2
Slovakia	1,349,614	40.8
Italy	100,000	3.0
Spain	55,568	1.7
Romania	12,000	0.4
EU	**3,311,802**	**100.0**

Source: European Minerals Yearbook – version 2024

Uses

Rock salt (salt) is used in the world mainly in the chemical industry for the production of chlorine, soda and some inorganic salts, in the food industry, as a preservative, for winter gritting material for roads and paths, as well as in the production of rubber and paints, in ceramics, and in agriculture.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any resources of rock salt.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2501 – Salt (inclusive table and denaturated salt), and pure sodium chloride; also in water solution

		2019	2020	2021	2022	2023
Import	t	674,275	399,323	698,482	678,219	659,207
Export	t	39,301	19,020	24,773	28,733	27,074

2501 – Salt (inclusive table and denaturated salt), and pure sodium chloride; also in water solution

		2019	2020	2021	2022	2023
Average import prices	CZK/t	1,756	2,221	1,907	2,294	2,510
Average export prices	CZK/t	5,752	12,550	9,146	10,866	10,244

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of salt

Commodity/year	2019	2020	2021	2022	2023^e
World mine production of salt (according to MCS), kt	283,000	280,000	290,000	270,000	270,000
World mine production of salt (according to WBD), kt	291,324	267,349	269,444	271,885	N

e – estimate

Main producers of salt as estimated by MCS

Country	2023^e	
	kt	%
China	53,000	19.6
United States*	42,000	15.6
India	30,000	11.1
Germany	15,000	5.6
Australia	14,000	5.2
Canada	12,000	4.4
Chile	9,200	3.4
Mexico	9,000	3.3
Turkey	9,000	3.3
Russia	7,000	2.6
Brazil	6,600	2.4
Netherlands	6,000	2.2
France	5,600	2.1
Poland	4,200	1.6
Spain	4,000	1.5
Bulgaria	3,300	1.2
Pakistan	3,000	1.1
Iran	2,700	1.0
Saudi Arabia	2,500	0.9
Great Britain	2,300	0.9
Egypt	2,300	0.9
Italy	2,000	0.7
Ukraine	1,000	0.4
World (rounded)	**270,000**	**100.0**

e – estimate
** Excluding Puerto Rico*

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023^e
Vacuum and open pan salt, USD/t (MCS)*	212	212	204	210	220
Solar salt, USD/t (MCS)*	126	123	154	150	150
Rock salt, USD/t (MCS)*	60	62	60	60	61
Salt in brine, USD/t (MCS)*	7.56	8.36	8.14	8.40	8.50

e – estimate
** U.S. price, average value of bulk, pellets and packaged salt, FOB mine and plant*

Talc

1. Characteristics and use

Talc is a soft, white when uncontaminated, scaly magnesium silicate – $Mg_3Si_4O_{10}(OH)_2$ with a melting point of 1,200 to 1,500 °C. Talc is formed by the contribution of SiO_2 and water to rocks rich in magnesium (dolomites, dolomitic limestones, magnesites, ultrabasics) in the hydrothermal stage and during regional metamorphosis. It is mined in Yellowstone (USA), Treasure (USA), Argonaut (USA), Madoc (Canada), Penhorwood Township (Canada), localities in Parana, Bahia, Sao Paulo and Minas Gerais states (Brazil), Lipasvaara (Finland), Trimouns (France), Rabenwald (Austria), localities in the regions of Leon and Malaga (Spain), Three Springs (Australia), and localities in the state of Rajasthan (India).

Reserves

2023		
Country	**kt**	**% World**
USA	140,000	26.3
India*	110,000	20.5
Japan*	100,000	18.8
China	81,000	15.2
South Korea*	72,000	12.5
Brazil	45,000	8.3
World	**> 545,000**	**100.0**

Source: MCS 2024

Uses

A massive cryptocrystalline variety of talc with high electrical resistance, which is easy to work with, is called steatite. Rock mixtures of talc and magnesite with a frequent admixture of chlorites, called soapstone, have similar properties to talc. The quality of talc is reduced by all additives containing Fe^{3+}, pyrite and Mn oxides. The wide range of uses of talc is due to its properties, especially chemical resistance to acids and alkalis, low electrical and thermal conductivity, high absorption capacity for binding fats, oils and paints, perfect cleavage and in its high-quality varieties also pure white colour.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of talc.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2526 – Natural steatite; talc

		2019	2020	2021	2022	2023
Import	t	20,692	24,743	17,733	18,953	16,807
Export	t	385	294	594	341	304

2526 – Natural steatite; talc

		2019	2020	2021	2022	2023
Average import prices	CZK/t	7,681	5,951	8,032	9,613	9,860
Average export prices	CZK/t	17,638	18,934	10,026	19,114	24,165

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of talc and pyrophyllite

Commodity/year	2019	2020	2021	2022	2023[e]
World mine production of talc and pyrophyllite (according to MCS), kt	6,140	6,720	7,240	7,130	7,000
World mine production of talc and pyrophyllite (according to WBD), kt	7,797	6,856	7,809	7,800	N

e – estimate

Main producers of talc and pyrophyllite according to MCS

Country	2023e	
	kt	%
India (incl. pyrophyllite)	1,600	22.9
China	1,100	15.6
Brazil (incl. pyrophyllite)	600	8.6
USA (crude)	450	6.4
France (crude)	400	5.3
France (raw)	370	5.3
Afghanistan	370	5.3
South Africa	320	4.6
Korea. Republic of (incl. pyrophyllite)	300	4.3
Pakistan	240	3.4
Finland	220	3.1
Canada (unsorted)	200	2.9
Italy (incl. steatite)	180	2.6
Japan (incl. pyrophyllite)	140	2.0
World (rounded)	**7,000**	**100.0**

e – estimate

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023e
Talc, average price, milled, ex-works, sold by U.S. producers, USD/t (MCS)	208	187	334	316	350

e – estimate

Raw materials for the production of industrial fertilisers

1. Characteristics and use

Raw materials for the production of industrial fertilisers, as well as the fertilisers themselves, are divided into nitrogen, phosphorus, potassium and combined. Besides these, this group also includes microelements necessary for the nutrition of organisms. These include: Ca, Mg, B, Cu, Fe, Mn, Mo and Zn. According to the Food and Agriculture Organisation, world demand for industrial fertilisers in 2019 was about 107 million tonnes of N, 47 million tonnes of P_2O_5 and 38 million tonnes of K_2O.

Natural nitrates are known as the Chile saltpeter containing $NaNO_3$, forming a 100 km long narrow strip of deposits in the Atacama Desert in Chile. The production capacity of Chile saltpeter reaches 1 million tonnes, while the world production capacity of synthetic NH_3 is around 190 million tonnes of N. The most widely used N-containing fertilisers are primary ammonium phosphate $(NH_4)_2H_2PO_4$ (also called ammonium dihydrogen phosphate), calcium amide $Ca(NH_2)_2$ and urea CH_4N_2O.

Natural sources of phosphorus are mainly based on the mineral apatite $Ca_5(F,OH,Cl)(PO_4)_3$ (circa 40% P_2O_5) and they can be divided into sedimentary and magmatogenic. They are of the greatest importance for the production of industrial fertilisers:

1. Sedimentary deposits in marine sediments (about 80% of world production): Phosphoria Formation (USA), Mount Isa area (Australia), Al Jalamid (Saudi Arabia), Oulad Abdoun (Morocco), Wengfu (China)
2. Magmatogenic deposits of apatites in alkaline igneous rocks (almost all remaining production): Chibiny (Russia), Palabora Complex (South Africa), Fanshan Complex (China), Siilinjärvi (Finland)

The source of potassium raw materials are almost exclusively the deposits of evaporites, occurring together with rock salt. From the point of view of chemistry, these evaporites are divided into deposits rich in Mg-sulphates, where the main minerals are carnallite $KMgCl_3.6H_2O$, polyhalite $K_2Ca_2Mg(SO_4)4.H_2O$ and epsomite $Mg(SO_4).7H_2O$, and Mg-poor deposits with the main minerals sylvite KCl and carnallite.

Uses

Raw materials for the production of industrial fertilisers have a wider use in the chemical industry, e.g. in pharmacy, production of compounds (e.g. nitric acid), they are used in the glass industry, metallurgy, cryogenic technology, photovoltaics.

Classification as critical raw materials for the European Union

Nitrates: 2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no
Potassium raw material: 2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no
Phosphates: 2011 – no, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes

Reserves

Phosphates

Country	2023	
	mill. t	% World
Morocco and Western Sahara	50,000	69.4
Egypt	2,800	3.9
Tunis	2,500	3.5
China	1,900	2.6
Brazil	1,600	2.2
South Africa	1,600	2.2
Saudi Arabia	1,400	1.9
Australia	1,100	1.5
Finland	1,000	1.4
USA	1,000	1.4
Jordan	800	1.1
Kazakhstan	260	0.4
Peru	210	0.3
Uzbekistan	100	0.1
Israel	60	0.1
Senegal	50	0.1
India	46	0.1
Mexico	30	0.0
Togo	30	0.0
Vietnam	30	0.0
World	**772,000**	**100.0**

Source: MCS 2024

EU phosphate reserves are not published. They occur in Spain and especially in Finland (European Minerals Yearbook – version 2024).

Potassium raw material

2023		
Country	**kt K_2O**	**% World**
Canada	1,100,000	33.3
Belorussia	750,000	22.7
Russia	400,000	12.0
USA	220,000	6.7
China	170,000	5.2
Germany	150,000	4.5
Chile	100,000	3.0
Laos	75,000	2.3
Spain	68,000	2.1
Brazil	2,300	0.1
World	**3,300,000**	**100.0**

Source: MCS 2023

2022			
Country	**kt K_2O**	**% World**	**% EU**
EU	341,000	9.2%	100.0%
Germany	150,000	4.1%	44.0%
Poland*	73,000	2.0%	21.4%
Spain	68,000	1.8%	19.9%
Italy**	50,000	1.4%	14.7%

Source: MCS 2022. European Minerals Yearbook – version 2023
 ** Bilans zasobów złoż kopalin w Polsce 2024*
*** own recalculation to K_2O*

Nitrates

The reserves of nitrates (saltpeter) in Chile amount to 88,730 kt (Minerals Yearbook 2020) but they represent a negligible amount due to atmospheric nitrogen and natural gas which are used to produce N compounds. The EU does not have nitrate reserves.

2. Raw material resources of the Czech Republic

The Czech Republic does not have any sources of raw materials for the production of industrial fertilisers.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

3102 – Nitrogenous fertilizers

		2019	2020	2021	2022	2023
Import	t	527,060	872,714	797,617	797,665	671,735
Export	t	590,675	575,630	641,906	490,751	514,396

3102 – Nitrogenous fertilizers

		2019	2020	2021	2022	2023
Average import prices	CZK/t	4,772	4,936	7,805	17,311	9,574
Average export prices	CZK/t	4,913	4,462	5,781	14, 083	8,419

2510 – Natural phosphates

		2019	2020	2021	2022	2023
Import	t	228	131	103	716	405
Export	t	13	49	1	0	4

2510 – Natural phosphates

		2019	2020	2021	2022	2023
Average import prices	CZK/t	18,833	23,836	39,929	7,292	11,946
Average export prices	CZK/t	3,517	3,185	178,612	1	10,230

2809 – Phosphoric oxides and acids

		2019	2020	2021	2022	2023
Import	t	6,129	6,219	6,321	4,511	2,647
Export	t	45,761	40,950	51,475	9,039	23,909

2809 – Phosphoric oxides and acids

		2019	2020	2021	2022	2023
Average import prices	CZK/t	9,719	7,741	9,712	4,766	29,563
Average export prices	CZK/t	19,578	18,630	19,873	75,845	32,372

3103 – Phosphatic fertilizers

		2019	2020	2021	2022	2023
Import	t	17,309	19,145	19,394	25,285	12,644
Export	t	87	859	337	52	140

3103 – Phosphatic fertilizers

		2019	2020	2021	2022	2023
Average import prices	CZK/t	7,855	7,110	8,505	18,076	11,398
Average export prices	CZK/t	30,091	8,200	15,682	29 212	11,107

3104 – Potassic fertilizers

		2019	2020	2021	2022	2023
Import	t	103,511	104,867	113,576	92,466	96,550
Export	t	4,589	4,682	5,679	6,408	5,158

3104 – Potassic fertilizers

		2019	2020	2021	2022	2023
Average import prices	CZK/t	8,165	7,916	7,989	12,246	13,837
Average export prices	CZK/t	29,465	34,393	28,223	41,280	55,005

3105 – Fertilizers containing several elements

		2019	2020	2021	2022	2023
Import	t	195,723	174,812	156,780	157,628	122,887
Export	t	28,403	28,834	47,015	55,107	34,983

3105 – Fertilizers containing several elements

		2019	2020	2021	2022	2023
Average import prices	CZK/t	9,584	9,290	11,646	20,093	15,449
Average export prices	CZK/t	7,944	10,914	8,131	9,815	11,157

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of phosphate rock and potash

Commodity/year	2019	2020	2021	2022	2023^e
World mine production of phosphate rock (according to MCS), kt	227,000	219,000	226,000	228,000	220,000
World mine production of phosphates (according to WBD), kt P_2O_5 content	68,617	67,492	72,449	70,788	N
World mine production of potash, K_2O equivalent (according to MCS), kt	42,215	44,739	46,334	40,900	39,000
World mine production of potash (according to WBD), kt K_2O content	43,443	42,215	44,739	41,958	N

e – estimate

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023^e
Marketable phosphate rock, avg. weighted value, FOB mine U.S., USD/t (MCS)	67.9	75.5	82.4	98.0	100.0
Phosphate rock, FOB North Africa, USD/t (DERA)	89	76	123.07	265.93	323.50
Potash, average all products, FOB mine USD/t K_2O, (MCS)*	820	850	1,120	1,790	1,210
Potash, average muriate, FOB mine and mill, USD/t K_2O, (MCS)	480	450	650	980	640

e – estimate

** Price range includes the lowest and the highest monthly price quotes for the given year.*

Includes MOP (muriate of potash – KCl), SOP (sulfate of potash – K_2SO_4) and SOPM (sulfate of potash magnesium – $K_2Mg_2(SO_4)_3$, $K_2Mg_2(SO_4)_2.2.4H_2O$). Does not include other chemical compounds that contain potassium.

Main phosphate rock producers according to MCS

Country	2023^e	
	kt	%
China (large mines only)	90,000	40.9
Morocco	35,000	15.9
USA	21,000	9.5
Russia	14,000	6.4
Jordan	12,000	5.5
Saudi Arabia	8,500	3.9
Brazil	5,300	2.4
Egypt	4,800	2.2
Peru	4,200	1.9
Tunisia	3,600	1.6
Israel	2,500	1.1
Senegal	2,500	1.1
Australia	2,500	1.1
Kazakhstan	2,000	0.9
Algeria	2,000	0.9
South Africa	1,800	0.8
India	1,600	0.7
Togo	1,500	0.7
Finland	1,500	0.7
Uzbekistan	950	0.4
Syria	900	0.4
Turkey	800	0.4
Mexico	800	0.4
Other countries	500	0.2
World (rounded)	**220,000**	**100.0**

e – estimate

Main potash producers according to MCS

Country	2023^e	
	kt	%
Canada	13,000	33.3
Russia	6,500	16.7
China	6,000	15.4
Belorussia	3,800	9.7
Germany	2,600	6.7
Israel	2,400	6.2
Jordan	1,800	4.6
Laos	1,400	3.6
Chille	600	1.5
USA	400	1.0
Spain	250	1.1
USA (rounded)	200	0.6
World (rounded)	**39,000**	**100,0**

e – estimate

METALLIC ORES

Aluminium

1. Characteristics and use

Average Al content (and its extent) in the earth's crust (%)

8 (7.4–9) Al

Industrially important minerals

Bauxite ore is an impure mixture of Al minerals gibbsite $Al_2O_3.3H_2O$ (65% Al_2O_3), boehmite $Al_2O_3.H_2O$ (85% Al_2O_3) and diaspore $Al_2O_3.H_2O$ (85% Al_2O_3)

Industrially important deposit types

1. Bauxites from carbonate weathering – "terra rossa" type: Jamaica, Haiti, Dominican Republic, Hungary
2. Bauxites from lateritic weathering of various rocks containing Al: Guyana, Guinea, Suriname, Brazil, India, Ghana, Australia

Reserves

Bauxite

2023		
Country	kt	% World
Guinea	7,400,000	24.7
Vietnam	5,800,000	19.3
Australia	3,500,000	11.7
Brazil	2,700,000	9.0
Jamaica	2,000,000	6.7
Indonesia	1,000,000	3.3
China	710,000	2.4
India	650,000	2.2
Russia	480,000	1.6
Saudi Arabia	180,000	0.6
Kazakhstan	160,000	0.5
USA	20,000	0.1
World	**30,000,000**	**100.0**

Source: MCS 2023

2023			
Country	kt	% World	% EU
EU	463,783	1.5%	100.0%
Greece	370,000	1.2%	79.8%
Hungary*	79,783	0.3%	17.2%
Romania	13,000	0.04%	2.8%
Italy	1,000	0.003%	0.2%

* *Mining and Geological Survey of Hungary-Inventory of mineral resources as of the 1st January 2022*

European Minerals Yearbook – version 2023. Own calculations.

Uses

Some of the many uses of aluminium are in transport (cars, planes, trucks, railway vehicles, seagoing ships, etc.), packaging (cans, foils, etc.), construction (windows, doors, etc.), consumer durables (appliances, kitchen tools, etc.), power lines, machinery and many other applications. Aluminium hydroxide Al $(OH)_3$ is produced from bauxite by leaching with NaOH and its calcination produces alumina – aluminium oxide Al_2O_3. 90% of the produced alumina is a smelter feed for the production of aluminium. The remaining part is used for the production of refractory materials, ceramics, polishes and abrasive materials, paints, fillers for plastics and others.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023– yes

2. Mineral resources of the Czech Republic

The Czech Republic does not have any resources of aluminium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2606 – Aluminium ores and concentrates

		2019	2020	2021	2022	2023
Import	t	20,975	14,658	12,826	11,658	7,124
Export	t	0,3	16	45	388	1,180

2606 – Aluminium ores and concentrates

		2019	2020	2021	2022	2023
Average import prices	CZK/t	4,834	5,153	6,710	7,143	9,133
Average export prices	CZK/t	746,032	72,019	13, 996	11,732	1,356

281820 – Aluminium oxide (other than synthetic corundum)

		2019	2020	2021	2022	2023
Import	t	19,465	19,984	24,430	21,036	16,538
Export	t	6,273	6,739	7,529	8, 638	8,949

281820 – Aluminium oxide (other than synthetic corundum)

		2019	2020	2021	2022	2023
Average import prices	CZK/t	15,748	18,933	13,431	21,242	19,702
Average export prices	CZK/t	6,549	6,249	7,124	7,926	8,787

281830 – Aluminium hydroxide

		2019	2020	2021	2022	2023
Import	t	10,018	9,101	9,195	9,579	8,664
Export	t	6,273	31	33	3	4

281830 – Aluminium hydroxide

		2019	2020	2021	2022	2023
Average import prices	CZK/t	12,235	11,320	11,075	15,296	16,312
Average export prices	CZK/t	6,549	46,346	25,895	50,193	219,024

7601 – Raw (unwrought) aluminium

		2019	2020	2021	2022	2023
Import	t	284 918	221 026	278 655	277,035	276,646
Export	t	105 219	107 704	121 792	109,683	99,546

7601 – Raw (unwrought) aluminium

		2019	2020	2021	2022	2023
Average import prices	CZK/t	46 238	45 723	57 382	74,218	59,809
Average export prices	CZK/t	38 032	37 929	50 754	67,020	54,703

7602 – Aluminium waste and scrap

		2019	2020	2021	2022	2023
Import	t	124,700	122,686	116,463	125,165	107,204
Export	t	68,531	61,783	80,133	75,828	79,781

7602 – Aluminium waste and scrap

		2012	2019	2020	2021	2022
Average import prices	CZK/t	25,108	23,517	34,090	41,420	33,074
Average export prices	CZK/t	25,221	23,690	35,614	44,625	36,261

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of bauxite, production of alumina and aluminium*

Komodita/rok	2019	2020	2021	2022	2023[e]
World mine production of bauxite (according to MCS), kt	358,000	391,000	384,000	400,000	400,000
World production of alumina (according to MCS), kt	133,000	136,000	139,000	140,000	140,000
World smelter production of aluminium (according to MCS), kt	63,200	65,100	67,500	68,400	70,000
World mine production of bauxite (according to WBD), kt	337,382	363,687	379,388	396,754	N
World smelter production of aluminium (according to WBD), kt	63,230	65,404	67,050	68,826	N

e – estimate

** As a general rule, 4 tons of dried bauxite is required to produce 2 tons of alumina, which, in turn, produces 1 ton of aluminium (MCS).*

Main producers of bauxite according to MCS – mine production

Country	2023^e	
	kt	%
Australia	98,000	24.5
China	93,000	23.3
Guinea	97,000	24.3
Brazil	31,000	8.7
Indonesia	20,000	7.8
India	23,000	5.8
Russia	5,800	1.5
Saudi Arabia	4,800	1.2
Kazakhstan	4,300	1.0
Jamaica	6,000	1.5
Vietnam	3,700	1.0
United States	W*	N
World (rounded)	**400 ,00**	**100.0**

e – estimate

W – Witheld to avoid disclosing company proprietary data*

Main producers of aluminium according to MCS – smelter production

Country	2023^e	
	kt	%
China	41,000	58.6
India	4,100	5.9
Russia	3,800	5.4
Canada	3,000	4.3
United Arab Emirates	2,700	3.9
Bahrain	1,600	2.3
Australia	1,500	2.1
Norway	1,300	1.9
Brazil	1,100	1.6
Malaysia	980	1.4
USA	750	1.1
World (rounded)	**41,000**	**58.6**

e – estimate

Main producers of alumina according to MCS – refinery production

Country	2023^e	
	kt*	%
China	82,000	58.6
Australia	19,000	15.5
Brazil	10,000	13.6
India	7,300	5.2
Russia	2,400	1.7
United Arab Emirates	2,300	1.6
Germany	1,900	1.4
Saudi Arabia	1,800	1.3
Ukraine	N	1.3
Canada	1,600	1.1
Jamaica	1,500	1.1
Vietnam	1,400	1.0
Kazakhstan	1,300	0.9
Indonesia	1,200	0.9
Ireland	1,200	0.9
USA	780	0.6
Spain	640	0.5
Guinea	330	0.2
Other countries	880	0.6
World (rounded)	**140,000**	**100.0**

e – estimate

** Converted to Al_2O_3*

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023^{e}
Bauxite, average value, U.S. imports FAS, USD/t (MCS)	32	30	31	32	30
Bauxite, refractory-grade 86%/2.0/3.15-3.2 (0-6 mm), FOB Xingang, China, USD/t (IM)*	430–480	390–450	390–435	N	N
Alumina, average value, U.S. imports FAS, USD/t (MCS)	472	394	462	518	500
Aluminium, ingot, avg. U.S. market (spot), cent/lb (MCS)	99,5	89,7	138,5	152,6	130
Aluminium, high grade primary, cash, in LME warehouse, USD/t (DERA)***	1,793.3	1,700.2	2,474.8	2,706.1	2,326.2
Aluminium, new scrap of aluminium alloy (Angel), EUR/100kg (DERA)***	146.20	128.00	108.90	170.06	N

e – estimate

* *Price range includes the lowest and the highest monthly price quotes for the given year.*

** *86/1.8/3.15 – 86% Al_2O_3, 1.8% Fe_2O_3, 3.15% SiO_2*

*** *Average annual price.*

Beryllium

1. Characteristics and use

Average Be content (and its extent) in the earth's crust (ppm)

2.5 Be

Industrially important minerals

Beryl $Al_2Be_3Si_6O_{18}$ (14% BeO), bertrandite $Be(OH)_2Si_2O_7$ (15% BeO)

Industrially important deposit types

1. Pegmatite bodies, mostly with beryl, from which mainly beryl is obtained simultaneously with muscovite and with the minerals Ta and Li: Bernick Lake (Canada), Black Hills (USA), Bikita (Zimbabwe), Malakialina (Madagascar), Nerchinsk (Russia), Daran-Pich (Afghanistan), Travancore (India).
2. Extensive plutogenic, volcanogenic and metasomatic bodies consisting mostly of bertrandite, then phenakite, helvite, etc.: Sil Lake (Canada), Spor Mountain and Gold Hill (USA), Seward Peninsula (USA).

Reserves

World reserves are not listed. The EU does not have any beryllium reserves.

Uses

Despite its toxicity, beryllium is widely used in the nuclear, astronautic and aerospace industries, in the production of ballistic missiles and in the construction of submarines due to its exceptional physical properties. Alloys of beryllium with Cu, Zn, Pb and Sn are non-sparking and alloys with Al and Mg are part of the superlight materials family. The alloy of Be with Cu is highly sought after and it has the specific designation BCMA (beryllium-copper master alloy). Most of the world's metal and alloy production meets these needs.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of beryllium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

811212 – Unwrought beryllium, beryllium powders

		2019	2020	2021	2022	2023
Import	kg	–	–	–	–	–
Export	kg	–	–	–	–	–

811212 – Unwrought beryllium, beryllium powders

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	–	–	–	–	–
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of beryllium

Commodity/year	2019	2020	2021	2022	2023^{e}
World mine production of beryllium content (according to MCS), t *	250	250	272	313	330
World mine production of beryllium (concentrates) (according to WBD), t	5,927	6,240	6,716	6,803	N

e – estimate

** Based on beryllium content 4% from bertrandite and beryl resources*

Main beryllium producers according to MCS

Based on beryllium content 4% from bertrandite and beryl resources

Country	2023[e]	
	t	%
United States	190	57,6
China	70	21,2
Brazil	40	12,1
Mosambique	24	7,3
Uganda	7	2,5
Madagascar	1	0,3
Rwanda	1	0,3
World (rounded)	**330**	**100,0**

e – estimate

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023[e]
Beryllium-copper master alloy, annual average U.S., USD/kg of contained beryllium (MCS)*	620	620	680	660	1,400

e – estimate

** Calculated from gross weight and customs value of imports; beryllium content estimated to be 4%. Rounded to two significant figures.*

Bismuth

1. Characteristics and use

Average Bi content (and its extent) in the earth's crust (ppm)

0.2 (0.1–1) Bi

Industrially important minerals

Native bismuth (100% Bi), bismutinite Bi_2S_3 (81% Bi)

Industrially important deposit types

Bismuth is obtained mainly from the processing of lead, tungsten, tin, copper and silver ores. Separate deposits of bismuth ores are mined in China and Bolivia.

1. Bismuth as a by-product: Deposits of lead ores, Bi-Co-Ni (U-Ag) five-element formations, copper ores, tungsten ores and Cu-Au ores: Adrasman (Cu-Bi, Kazakhstan), Salsigne (Au-Ag-Bi-As, France), Sangdong (W-Bi, South Korea), Xihuashan (W-Bi, China), Mt. Pleasant (W-Mo-Bi-Sn, Canada), Tennant Creek (Au-Bi-Cu, Australia), Bonfim (Brazil), Nui Phao (Vietnam).
2. Bismuth as a main metal: Deposits of different genetic types – Shizhuyuan (China), Tasna (Bolivia), Ustarasaj (Kazakhstan).

Reserves

Estimates of world bismuth reserves are not published. The EU does not have any bismuth reserves.

Uses

The most common use for bismuth is in easy-fusible alloys for the production of special solders, etc. The new zinc-bismuth alloy is used in galvanising. Bismuth is also used for the production of lubricants, especially for extreme pressures, as well as for the production of ceramic glazes, in the production of mountain crystal and pigments. The superconducting ceramics is made of Bi-Sr-Ca-Cu oxides. Bismuth compounds are used in the pharmaceutical industry and bismuth is also used as an additive in metallurgy. Bismuth is widely used as a non-toxic lead substitute.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – yes, 2020 – yes, 2023 – yes

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved sources of 49.8 t Bi in the Kutná Hora district, 34 t Bi in the Zlaté Hory district, 6,028 t Bi in the Cínovec area.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

81060010 – Unwrought bismuth, including waste and scrap, powders

		2019	2020	2021	2022	2023
Import	kg	67,090	73,542	82,226	57,683	20,102
Export	kg	154	61	3,259	0	16

81060010 – Unwrought bismuth, including waste and scrap, powders

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	163	136	172	179	191
Average export prices	CZK/kg	305	197	341	–	64

81060090 – Wrought bismuth, articles of bismuth, excluding unwrought bismuth, waste, scrap and powders

		2019	2020	2021	2022	2023
Import	kg	2,211	14,564	6,827	24,926	16,171
Export	kg	8,781	2,089	3,126	433	1,111

81060090 – Wrought bismuth, articles of bismuth, excluding unwrought bismuth, waste, scrap and powders

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	1,244	352	823	184	193
Average export prices	CZK/kg	477	1,232	1,173	341	336

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of Bismuth

Commodity/year	2019	2020	2021	2022	2023^e
World refinery production of bismuth (according to MCS), t gross weight	19,200	21,100	19,000	19,000	20,000
World mine production of bismuth (according to WBD), t	9,033	9,513	11,117	10,276	N

e – estimate

Main producers of bismuth according to MCS

Refinery production

Country	2023^e	
	t*	%
China	16,000	80.0
Laos	2,000	10.0
Korea	850	4.3
Japan	500	2.5
Kazakhstan	160	1.1
Bolivia	40	0.2
Bulgaria	50	0.3
Canada	50	0.3
World (rounded)	**20,000**	**100.0**

e – estimate

** Metric tons gross weight*

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023^{e}
Bismuth metal, USD/lb (MCS)*	3.18	2.72	3.74	3.9	4.10
Bismuth metal, refined ≥ 99.99%, USD/kg (DERA)**	6,358.40	5,341.10	7,100.99	6,833.51	7,912.94

e – estimate
* *Price range includes the lowest and the highest daily price quotes for the given year.*
** *Average annual price*

Cadmium

1. Characteristics and use

Average Cd content (and its extent) in the earth's crust (ppm)

0.2 Cd

Industrially important minerals

Separate cadmium minerals, including the most abundant greenockite CdS (76% Cd), are industrially insignificant. Cadmium is an admixture in sulphides, especially in ZnS sphalerite (70–82 000 ppm Cd), chalcopyrite $CuFeS_2$ (30–1 200 ppm Cd), tetrahedrite $Cu_{12}Sb_4S_{13}$ (500–17 900 ppm Cd), bornite Cu_5FeS_4 (16–1 000 Cd) and bournonite $2PbS.Cu_2S.Sb_2S_3$ (50–100 ppm Cd).

Industrially important deposit types

Polymetallic and copper deposits. The Cd content of a typical Zn ore is on average 0.03% (300 ppm).

Reserves

World quantitative estimates are not available (MCS 2021).

According to data (Bilans zasobów złoż kopalin w Polsce 2020), the EU has Cd reserves in Poland. This is a 20 kt Cd.

Uses

Part of the Cd production is used for surface protection of metals against corrosion. However, it must not be used on food contact objects as it reacts easily with acids and soluble Cd compounds are highly toxic. Until recently, most Cd went to the production of Ni-Cd batteries and Cd-Ag and Hg-Cd electric cells (around 83%). However, their use is systematically limited because of environmental protection. A smaller part of Cd is used for the stabilisation of plastics, as well as for the production of pigments and in alloys for solders and fusible metals (e.g. Wood's metal). In the European Union, from 2006 onwards, various measures restricting the use of Cd in electrical engineering and electronics are gradually coming into force.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved cadmium sources in the amount of 1,013 t Cd in the Kutná Hora district and 2,500 t Cd in the Zlaté Hory district.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

810720 – Unwrought cadmium, cadmium powders

		2019	2020	2021	2022	2023
Import	kg	64	233	180	0	0
Export	kg	0	0	0	0	0

810720 – Unwrought cadmium, cadmium powders

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	703	983	1,016	–	–
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of cadmium

Commodity/year	2019	2020	2021	2022	2023^{e}
World refinery cadmium metal production as a byproduct of zinc refining plus cadmium metal from recycling, except USA (according to MCS), t*	24,400	24,000	24,700	22,600	23,000
World mine production of cadmium, (according to WBD), t	26,771	24,885	24,781	24,770	N

e – estimate

** cadmium content*

Main producers of cadmium according to MCS

Country	2023e	
	t*	%
China	9,000	39.1
Korea, Republic of	4,000	17.4
Japan	1,800	7.8
Canada	1,800	7.8
Kazakhstan	1,100	4.8
Mexico	1,000	4.3
Russia	1,000	4.3
Netherlands	790	3.4
Australia	750	3.3
Norway	380	1.7
Bulgaria	380	1.7
Poland	340	1.5
Uzbekistan	230	1.0
Other countries	220	1.0
World (rounded)	**23,000**	**100.0**

e – estimate
** Cadmium content*

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023e
Cadmium metal, annual average, dealer price for 99.95% purity in 5-short-ton lots*, USD/kg (MCS)	2.67	2.29	2.56	3.42	4.10
Cadmium, ingot, >= 99,99 % USD/t (DERA)**	N	N	N	3,161.90	4,441.61

e – estimate
** s.t. (short ton), 1 s.t. = 0,907185 metric ton*
*** year average*

Chromium

1. Characteristics and use

Average Cr content (and its extent) in the earth's crust (ppm)

100 (20–2,700) Cr

Industrially important minerals

Chromite (Fe,Mg)O(Cr,Al,Fe)$_2$O$_3$ (45–55%, max.68% Cr_2O_3)

Industrially important deposit types

They are bound to ultrabasic and basic igneous rocks:

1. Stratiform (larger positions of ore concordant with magma structures): Bushveld (South Africa), Great Dyke (Zimbabwe), Stillwater complex (USA)
2. Podiform (ore lenses in ophthalite dunites): Kempirsay massif with deposits Almaz, Zhemchuzhina, Molodezhnoye, Millionnoye, etc. (Kazakhstan), Saranovskoye (Russia), deposits in Cuba, the Philippines and New Caledonia

Reserves

2023		
Country	**kt**	**% World**
Kazakhstan	230,000	41.1
S. Africa	200,000	35.7
India	100,000	17.9
Turkey	26,000	4.6
Finland	8,300	1.5
USA	630	0.1
World	**560,000**	**100.0**

Notes: ore is normalized to 45% Cr_2O_3 with the exception of Finland (26% Cr_2O_3) and the USA (7% Cr_2O_3)
Source: MCS 2023.

In the EU, only Finland has European reserves (European Minerals Yearbook – version 2023).

Uses

Chromium is an important alloying element in the steel industry, chromites are consumed for the production of refractory materials and slightly less for the needs of the chemical industry. From the point of view of industrial use, the division of chromite ores into metallurgical, chemical and fire-resistant raw materials is important. For metallurgy the minimum content of Cr_2O_3 is 48%, for the chemical industry it is at least 44% Cr_2O_3 and for the refractory industry 32% Cr_2O_3.

Classification as critical raw materials for the European Union

2011 – no, 2014 – yes, 2017 – no, 2020 – no, 2023 – no

2. Raw material resources of the Czech Republic

The Czech Republic does not have any sources of chromium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2610 – Chromium ores and concentrates

		2019	2020	2021	2022	2023
Import	t	3,212	3,290	3,400	2,436	1,830
Export	t	255	348	578	666	509

2610 – Chromium ores and concentrates

		2019	2020	2021	2022	2023
Average import prices	CZK/t	11,017	14,605	7,655	10,405	12,903
Average export prices	CZK/t	4,085	5,320	4,971	8,702	6,452

811221 – Unwrought chromium

		2019	2020	2021	2022	2023
Import	kg	107,946	113,761	228	219,706	141,299
Export	kg	220,327	150,315	54,034	118,251	23,362

811221 – Unwrought chromium

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	197	147	149	241	198
Average export prices	CZK/kg	57	36	74	248	217

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of chromium

Commodity/year	2019	2020	2021	2022	2023^e
World mine production of chromite ore (according to MCS), kt*	44,800	37,000	42,200	41,900	41,000
World mine production of chromium (according to WBD), kt of Cr_2O_3 content	15,779	11,970	14,721	15,530	N

e – estimate
** Gross weight of marketable chromite ore*

Main producers of chromite ore according to MCS

Country	2023^e	
	kt*	%
South Africa	18,000	43.9
Turkey	6,900	16.8
Kazakhstan	6,500	15.8
India	6,000	14.6
Finland	4,200	10.2
World (rounded)	**41,000**	**100.0**

e – estimate
** Gross weight of marketable chromite ore*

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023^e
Chromite ore, gross weight, USD/t (MCS)	482	386	364	275	290
Ferrochromium, chromium content (excl. ferrochromium silicon), USD/t (MCS)	2,203	1,982	3,436	7,070	7,709
Chromium metal, gross weight, USD/t (MCS)	9,098	7,094	9,583	15,685	12,115

e – estimate
** Price range includes the lowest and the highest daily price quotes for the given year.*

Gallium

1. Characteristics and use

Average Ga content (and its extent) in the earth's crust (ppm)
15 Ga

Industrially important minerals
Bauxites (10–140 ppm Ga), nepheline $Na_3K(Al_4Si_4O_{16})$ (20–40 ppm Ga), sodalite $Na_8(Al_6Si_6O_{24})Cl_2$ (70–500 ppm Ga), sphalerite ZnS

Industrially important deposit types
Gallium is obtained as a by-product in the processing of bauxite and Zn concentrates.

Reserves
World reserves are not available. The EU does not have any Ga reserves.

Uses
Most of Ga is used in the form of GaAs (Ga-arsenide) and GaN (Ga-nitride) in optoelectronics for the production of light emitting diodes, laser diodes, photodetectors and for the production of photovoltaic cells.

Classification as critical raw materials for the European Union
2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of gallium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

81129289 – Unwrought gallium, gallium powders

		2019	2020	2021	2022	2023
Import	kg	7	10	0	1	0
Export	kg	0	0	0	0	0

81129289 – Unwrought gallium, gallium powders

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	26,429	7,000	–	36,000	–
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of gallium

Commodity/year	2019	2020	2021	2022	2023^{e}
World mine production of gallium, gallium content in mined ores (according to MCS), t	351	327	434	500	610
World mine production of gallium, gallium content in mined ores (according to WBD), t	323	374	304	434	N

e – estimate

Main producers of gallium according to MCS

Country	2023^{e}	
	t*	%
China	600	98.4
Russia	5	0.8
Japan	3	0.5
Korea, Republic of	2	0.3
World (rounded)	**610**	**100.0**

e – estimate
** Metric tons of gallium content*

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023^{e}
Gallium imports to U.S., high-purity, refined, USD/kg (MCS)*	573	596	625	560	450
Gallium imports to U.S., low-purity, primary, USD/kg e (MCS)**	153	163	254	394	290

e – estimate
** Estimate based on average values of U.S. imports for 99.9999%-99.99999% – pure gallium.*
*** Estimate based on average values of U.S. imports for 99.99% – pure gallium.*

Indium

1. Characteristics and use

Average In content (and its extent) in the earth's crust (ppm)

0.1 In

Industrially important minerals

Particular practical importance is held by the indium contents in the form of solid solutions in ZnS sphalerite; the higher contents are characteristic for ferrous, black sphalerites.

Industrially important deposit types

Indium does not form its own deposits. It is an accompanying raw material for Zn, Pb, Cu and Sn ores. It is represented in the concentrates of these ores as follows (in ppm): Zn concentrates 2–800, Pb concentrates 1–10, Cu concentrates 0.5–100, Sn concentrates 10–124.

Reserves

Worldwide 15–50 kt In (The availability of indium. NREL. U.S. Department of Energy 2015) of which China 75%, Peru 3%, Russia 1%, Canada 1%. USA 1%. The EU has reserves in Ireland. By a rough estimate, these reserves represent at least 3 kt In, thus 6%–20% of its world reserves. Quantitative estimates of In reserves worldwide are not available (MCS 2023).

Uses

Indium is mainly used in electronics, where it forms fine coatings in liquid crystal displays and electroluminescent lamps. Semiconductor compounds of In are used in infrared detectors, high-speed transistors and high-performance photovoltaic devices. Other uses are mainly for solders and alloys.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes

2. Mineral resources of the Czech Republic

The Czech Republic has unapproved indium resources in the total amount of 228.3 t In, located mainly in the Kutná Hora district.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

81129281 – Unwrought indium, indium powders

		2019	2020	2021	2022	2023
Import	kg	0	5	42	10	54
Export	kg	0	0	0	0	1

81129281 – Unwrought indium, indium powders

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	–	16,600	9,000	1,190	10,130
Average export prices	CZK/kg	–	–	–	–	106,000

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of indium

Commodity/year	2019	2020	2021	2022	2023[e]
World refinery production of indium (according to MCS), t	968	960	932	999	990
World mine production of indium (according to WBD), t	918	943	916	1,008	N

e – estimate

Main producers according to MCS

Refinery production

Country	2023[e]	
	t	%
China	650	65.7
Korea, Republic of	180	18.2
Japan	66	6.7
Canada	39	3.9
France	20	1.8
Belgium	18	1.8
Russia	5	0.5
World (rounded)	**990**	**100.0**

e – estimate

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023[e]
Indium, annual average, New York dealer, min. 99.99%, delivered duties paid U.S., USD/kg (MCS)	390	395	N	N	N
Indium, annual average, warehouse Rotterdam, min. 99.99%, duties unpaid, USD/kg (MCS)	182	161	223	250	240
Indium, 99,99%, USA, USD/kg (Investing.com)	177	158	217	252	240
Indium, USD/kg (DERA)*	150.40	213.43	224.36	280 .80	424.99

e – estimate

** prices for indium ≥ 99.99%. Average annual price.*

Magnesium

1. Characteristics and use

Average Mg content (and its extent) in the earth's crust (%)

2.3 Mg, in sea water 0.13 Mg

Industrially important minerals

Forsterite Mg_2SiO_4 (34% Mg), dolomite $CaMg(CO_3)_2$, brucite $Mg(OH)_2$ (41% Mg), magnesite $MgCO_3$ (28% Mg)

Industrially important deposit types

1. Brine deposits underground or on the surface: Manistee (Michigan, USA), Great Salt Lake (Utah, USA), Laguna del Rey (Mexico), Dead Sea (Israel)
2. Large bodies of dolomites, magnesite and brucite: Dashiqiao (China), Konya (Turkey), Satka (Ural), Euboea Island (Greece), Veitsch (Austria), Dúbrava (Slovakia)
3. Evaporite salt deposits: Stassfurt (Germany), Solikamsk (Russia)

Another source of metallic magnesium used is seawater.

Reserves

The world's reserves and resources of magnesium are practically unlimited and even renewable, especially due to its content in seawater.

Uses

Most magnesium compounds are consumed for the production of refractory materials (see the *Magnesite* chapter of this yearbook), otherwise there are various applications in agriculture, chemistry, construction and environmental care. Magnesium alloys with aluminium, zinc and manganese are characterised by high strength and low weight.

Classification as critical raw materials for the European Union

2011 – yes, 2014 – yes, 2017 – yes, 2020 – yes, 2023 – yes

This inclusion is paradoxical given what is stated above in the information on Mg reserves and what is known about magnesite reserves and mining in the EU. They are present in Austria, Greece, the Netherlands, Poland and Slovakia, as the annual extraction of these countries represents about 4 million tonnes of magnesite (European mineral statistics 2008–2023, British Geological Survey). However, it is based on the EU's total dependence on imports of metallic Mg.

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of magnesium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

810411 – Unwrought magnesium, containing at least 99.8 % by weight of magnesium

		2019	2020	2021	2022	2023
Import	t	2,402	2,357	2,219	7,382	1,083
Export	t	1	96	20	88	45

810411 – Unwrought magnesium, containing at least 99.8 % by weight of magnesium

		2019	2020	2021	2022	2023
Average import prices	CZK/t	59,694	55,497	75,455	123,862	86,487
Average export prices	CZK/t	95,588	50,810	2,310	173,993	91,667

810419 – Unwrought magnesium, containing less than 99.8 % by weight of magnesium

		2019	2020	2021	2022	2023
Import	t	111	267	2,675	9,421	4,965
Export	t	7,016	6,437	1,520	7,605	17,155

810419 – Unwrought magnesium, containing less than 99.8 % by weight of magnesium

		2019	2020	2021	2022	2023
Average import prices	CZK/t	98,227	77,272	63,727	141,666	82,274
Average export prices	CZK/t	66,530	66,478	68,222	127,001	88,391

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of magnesium

Commodity/year	2019	2020	2021	2022	2023e
World primary production of magnesium metal (according to MCS), kt*	1,120	1,000	1,070	1,050	940

e – estimate
** Excluding U.S. production.*

Main producers of magnesium metal according to MCS – primary production

Country	2023e	
	kt	%
China	830	88.3
Kazakhstan	27	2.9
Brazil	22	2.3
Israel	22	2.3
Russia	21	2.2
Turkey	14	1.5
Iran	5	0.5
Ukraine	2	0.2
United States	W*	N
World (rounded)	**940**	**100**

e – estimate
W – Withheld to avoid disclosing company proprietary data*

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023e
Magnesium, USD/t (DERA)*	2,502.5	2,320.6	1,987.1	4,030.7	3,237.0
Magnesium metal, U.S. spot Western, USD/lb (Platts Metal Week/MCS)	2.47	2.48	3.73	7.59	5.00
Magnesium metal, China, FOB, USD/t (Platts Metal Week/MCS)	2,426	2,149	5,011	5,206	3,200

e – estimate
** 2018 through 2022 prices are for magnesium >= 99.9% (Shanxi) USD/t. Average annual price.*

Strontium

1. Characteristics and use

Average Sr content (and its extent) in the earth's crust (%)

375 Sr

Industrially important minerals

Celestite $SrSO_4$ (48% Sr), strontianite $SrCO_3$ (45% Sr)

Industrially important deposit types

Celestite is an important deposit-forming mineral. The deposits are predominantly sedimentary Mississippi Valey Type in association with Zn, Pb, Ba and F and more or less affected by diagenetic metasomatosis: Granada district with Ezúcar and Montevives deposits (Spain), Octubre, etc. in the Coahuila area (Mexico), Yunlong-Lanping-Weixi Sr Metalogenetic Belt, Western Basin Qaidam, Gangou (China).

Reserves

MCS 2020 estimates worldwide reserves of celestite to 6,800,000 tonnes, in 2021 does not give an estimate of world reserves. According to MCS 2022, global strontium resources are estimated at more than 1 billion tons. In the EU, Spain has proven reserves of 3,743,200 tons of strontium (European Minerals Yearbook – version 2023).

Uses

Strontium is traded mainly as $SrCO_3$, from which other products are derived – ferrite ceramic permanent magnets, red dye flares and fireworks, fillers, pigments – and utilisation in glass idustry and metallurgy.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – yes, 2023 – yes

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of strontium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

283692 – Strontium carbonate

		2019	2020	2021	2022	2023
Import	t	569	495	588	380	312
Export	t	0	0	22	16	0

283692 – Strontium carbonate

		2019	2020	2021	2022	2023
Average import prices	CZK/t	19,573	19,650	20,212	28,314	29,907
Average export prices	CZK/t	–	–	28,091	29,438	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of strontium

Commodity/year	2019	2020	2021	2022	2023[e]
World mine production of strontium – celestite content (according to MCS), kt	260	220	350	514	520

e – estimate

Main producers of strontium according to MCS
Celestite content in ore

Country	2023^e	
	t	%
Spain	200,000	38.5
Iran	200,000	38.5
China	80, 000	15.4
Mexico	35, 000	6.7
Argentina	700	0.1
World	**520,000**	**100.0**

e – estimate

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023^e
Celestite – average USA import price, export port price, USD/t (MCS)	82	90	210	114	79

e – estimate

Thallium

1. Characteristics and use

Average Tl content (and its extent) in the earth's crust (ppm)
1.2 (0.8–1.26) Tl

Industrially important minerals
Thallium does not have industrially important minerals, it is obtained during the processing of sulphide ores.

Industrially important deposit types
Thallium does not form separate deposits, it is a by-product of polymetallic and Au-Ag ores.

Reserves
World reserves of thallium are not reported. MCS 2020 estimates the world's resources of Tl in Zn ores at 17 kt Tl, mainly in Canada, Europe and the USA. Globally, there is 630 kt of thallium in coal. The EU does not list its Tl reserves (European Minerals Yearbook – version 2023). Poland is an exception with reserves of 150 t of thallium (Bilans zasobów złoż kopalin w Polsce 2023).

Uses
Thallium is obtained by processing fly ash and residues from the compaction of copper, zinc and lead ores. Thallium and its compounds are highly toxic substances. The radioactive isotope 201 is used in medicine to monitor cardiovascular diseases. Tl is also a detector in scintillometer; T1-Ba-Ca and Cu oxides form high temperature superconductors; Tl + As + Se crystals are part of acoustic-optical measuring devices; Tl in an alloy with Hg is used to measure low temperatures. Furthermore, Tl is added to glasses to increase their reflective properties and density, it is used as a catalyst in organic synthesis and for the preparation of high density fluids used in the separation of minerals of different weights.

Classification as critical raw materials for the European Union
2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of thallium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

811251 – Unwrought thallium

		2019	2020	2021	2022	2023
Import	kg	0	0	0	0	0
Export	kg	0	0	0	0	0

811251 – Unwrought thallium

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	–	–	–	–	–
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of thallium

Commodity/year	2019	2020	2021	2022	2023^e
World refinery production of thallium (according to MCS), kg	8,000*	8,000*	10,000*	10,000*	10,000*

e – estimate
** – about*

Main producers of thallium according to MCS
Refinery production

Country*	2023^e	
	kg	%
China	N	N
Kazakhstan	N	N
Russia	N	N
Brazil	N	N
North Macedonia	N	N
World	**~ 10,000**	**100.0**

e – estimate
** Estimated leading producers according to MCS*

Prices of traded commodities

Commodity/year	2019e	2020e	2021e	2022e	2023^e
Thallium metal, 99.99%, granules in 100 gram lots (MCS)	7,600	8,200	8,400	9,400	8,800

e – estimate

Thorium

1. Characteristics and use

Average Th content (and its extent) in the earth's crust (ppm)

15 (0.1–18) Th

Industrially important minerals

Uranothorite $(U,Th)SiO_4$ (1–25% ThO_2), thorite $ThSiO_4$, thorianite $(Th,U)O_2$ (1–25% ThO_2), monazite $(Ce,Th)PO_4$ (25% ThO_2), zirkelite $(Ca,Th,Ce)Zr(Ti,Nb)_2O_7$ (6% Th)

Industrially important deposit types

1. Monazite placers in recent and buried offshore sediments in Australia, Egypt, India, South Africa, Malaysia, Powderhorn (USA)
2. Monazite deposits in primary ores, most often in pegmatites: (e.g. Nellur, Travancore, India, South Dakota – USA, Brazil, China), but also in carbonatites (e.g. Oka – Canada) or in uranium ores (e.g. Sunnyside Inglewood – Australia). Also included are thorianite (Madagascar, Sri Lanka), thorite (e.g. Bancroft – Canada) and zirkelite ores (e.g. Jacupiranga – Brazil).

Reserves

Worldwide 1,200 kt Th, of which Australia 25%, India 24%, Norway 14%, USA 13%, Canada 8% (World thorium occurrences, deposits and resources – IAEA 2019). EU reserves of 224 kt of thorium represent 19% of global reserves; Norway has 76% of EU reserves (= 14% of world reserves); according to the World thorium occurrences, deposits and resources – IAEA 2019 total thorium resources in the EU are around 284–291 kt Th and thus represent 4%–5% of world's Th sources.

Uses

In a magnesium alloy, thorium forms a high-strength and heat-resistant metal. Thorium is prospectively considered as a reserve fuel in nuclear reactors. Besides the energy industry, thorium in various forms is used in demanding ceramic production, for catalytic properties and in welding electrodes.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – no

2. Mineral resources of the Czech Republic

The Czech Republic does not have any sources of thorium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

28443061 – Thorium bars, rods, angles, shapes, sections, wire, sheets, strips

		2019	2020	2021	2022	2023
Import	kg	0	0	0	708	449
Export	kg	0	0	0	1,625	0

28443061 – Thorium bars, rods, angles, shapes, sections, wire, sheets, strips

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	–	–	–	79	478
Average export prices	CZK/kg	–	–	–	12	–

28443069 – Thorium other, not crude, waste, scrap, bars, rods, shapes, wire, sheets

		2019	2020	2021	2022	2023
Import	kg	0	0	0	0	0
Export	kg	0	0	0	0	0

28443069 – Thorium other, not crude, waste, scrap, bars, rods, shapes, wire, sheets

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	–	–	–	–	–
Average export prices	CZK/kg	–	–	–	–	–

28443099 – Thorium salts

		2019	2020	2021	2022	2023
Import	kg	0	0	0	47	0
Export	kg	0	0	0	0	0

28443099 – Thorium salts

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	–	–	–	7,532	–
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of thorium

Commodity/year	2019	2020	2021	2022	2023
World refinery production of thorium (according to MCS), kg*	N	N	N	N	N

** Associated with recovery of monazite in REE heavy-mineral-sand deposits.*

Main producers of thorium

Country*	2023^{e}	
	kt	%
N	N	N
World	**N**	**N**

e – estimate
** Associated with recovery of monazite in REE heavy-mineral-sand deposits.*

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023
Thorium compounds, gross weight, India, USD/kg (MCS)	72	72	N	N	74
Thorium compounds, gross weight, France, USD/kg (MCS)	29	29	29	26	29

Titanium

1. Characteristics and use

Average Ti content (and its extent) in the earth's crust (%)

0.5 (0.24–0.96) Ti

Industrially important minerals

Rutile TiO_2 (over 95% TiO_2), anatase (over 95% TiO_2), ilmenite $FeTiO_3$ (52 (35–70))% TiO_2

Industrially important deposit types

1. Deposits of titanomagnetites in basic rocks and titanite in apatite: Gusevogorsk (Russia), Chibiny (Russia), Damiao (China), Allard Lake (Canada), Powderhorn (USA), Campo Formosa (Brazil), Magnet Hill (JAR).
2. Ilmenite, rutile and zirconium placer deposits in recent and buried offshore sediments and weathered rocks: Irshinskoye (Russia), Murray Basin (Australia), Truro (Canada), Florida, Corridor Sands, Moma (Mozambique), Sierra Rutile (Sierra Leone), Fort Dauphin (Madagascar), locations in South Africa, India, New Zealand.

Reserves

Ilmenite

2023		
Country	**kt TiO_2**	**% World**
China	210,000	30.4
Australia	180,000	26.1
India	85,000	12.3
Canada	52,000	7.5
Brazil	43,000	6.2
Norway	37,000	5.4
South Africa	28,000	4.1
Madagascar	27,000	3.9
Mozambique	22,000	3.2
Ukraine	5,900	0.9
USA	2,000	0.3
Vietnam	1,600	0.2
Other	26,000	3.8
World	**690,000**	**100.0**

Note: TiO_2 content in ores
Source: MCS 2024

2023			
Country	**kt TiO_2**	**% World**	**% EU**
EU	133,972	100.0	18.0
Poland*	97,700	72.9	13.1
Norway	36,068	26.9	4.8
Slovakia	204	0.2	0.03

Source: European Minerals Yearbook – version 2023
** Bilans zasobów złoż kopalin w Polsce 2023*

Rutile

2023		
Country	**kt TiO_2**	**% World**
Australia	35,000	63.3
India	7,400	15.1
South Africa	6,100	13.3
Sierra Leone	2,900	1.0
Ukraine	2,500	5.1
Mozambique	720	1.8
Madagascar	520	1.1
Kenya	70	0.3
World	**55,000**	**100.0**

Zdroj: European Minerals Yearbook – version 2023

Uses
Astronautic and aerospace industries (alloys). TiO_2 is mainly used for the production of titanium white; it is also consumed for the plating of welding electrodes and in the production of titanovanadium, carbide, chemicals and metal.

Classification as critical raw materials for the European Union
2011 – no, 2014 – no, 2017 – no, 2020 – no, 2023 – yes

2. Mineral resources of the Czech Republic

The Czech Republic does not have any resources of titanium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

2614 – Titanium ores and concentrates

		2019	2020	2021	2022	2023
Import	t	138,646	121,706	97,132	167,637	96,636
Export	t	780	581	624	821	455

2614 – Titanium ores and concentrates

		2019	2020	2021	2022	2023
Average import prices	CZK/t	6,081	6,119	6,186	10,757	8,699
Average export prices	CZK/t	27,606	32,021	33,482	42,284	58,604

8108 – Titanium and products of it, including waste and scrap

		2019	2020	2021	2022	2023
Import	t	3,450	2,773	1,687	2,777	2,818
Export	t	2,112	1,592	1,412	1,830	2,133

8108 – Titanium and products of it, including waste and scrap

		2019	2020	2021	2022	2023
Average import prices	CZK/t	433,156	436,724	539,649	672,086	767,013
Average export prices	CZK/t	349,408	381,562	378,851	409,637	345,734

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of titanium

Commodity/year	2019	2020	2021	2022	2023[e]
World mine production of ilmenite concentrate (according to MCS), kt of TiO_2 content	7,700	8,000	8,900	8,800	8,600
World mine production of rutile concentrate (according to MCS), kt of TiO_2 content	654	605	618	9,400	9,200
World mine production of titanium (according to WBD), kt of TiO_2 content	7,995	8,504	8,565	8,943	N

e – estimate

Main producers of ilmenite according to MCS

Country	2023[e]	
	kt*	%
China	3,100	36.0
Mozambique	1,600	18.6
South Africa**	1,000	11.6
Australia	400	4.7
Canada*	500	5.8
Norway	430	5.0
Senegal	340	4.0
Madagascar**	320	3.7
India	210	2.4
United States***	200	2.3
Kenya	140	1.6
Vietnam	140	1.6
Ukraine	60	0.7
Brazil	54	0,6
Other countries	77	0,9
World (rounded)	**8,600**	**100,0**

e – estimate
** Metric tons of titanium content in mined concentrate*
*** Mine production is primarily used to produce titaniferous slag*
**** Including rutile, rounded to the nearest 100,000 tons*

Main producers of rutile according to MCS

Country	2023[e]	
	kt*	%
Australia	200	35.7
Sierra Leone	110	19.6
South Africa	100	17.9
Kenya	58	10.4
Ukraine	50	8.9
India	13	2.3
Madagascar	N	N
Mozambique	9	1.4
Senegal	8	1.6
USA**	N	N
Other countries	14	2.5
World (rounded)	**560**	**100.0**

e – estimate
** Metric tons of titanium content in mined concentrate*
*** Rutile content included in ilmenite production*

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023[e]
Rutile, bulk, min. 95% TiO_2, FOB Australia, USD/t (IM in MCS)*	1,110	1,170	1,300	1,470	1,490
Ilmenite, bulk, minimum 54% TiO_2, FOB Australia, USD/t (IM in MCS)*	478	459	595	530	330
Ilmenite, U.S. import, USD/t (MCS)	186	215	240	285	390
Slag, 80%–95% TiO2, duty-paid U.S. import, USD/t (MCS)	792	757	774	867	1,000
Ferrotitanium, USD/kg (DERA)****	5.0	4.33	7.42	11.77	5.39
Titanium, oxide, pigment, bulk volume, CIF Northern Europe, EUR/t (DERA)*****	N	2,908	3,271	3,920.83	N

e – estimate

* *Average of yearend price. Prices of ilmenite from Australia were discontinued at yearend 2017*

** *Price range includes the lowest and the highest daily price quotes for the given year.*

*** *Price range includes the lowest and the highest monthly price quotes for the given year.*

**** *2018 through 2021 prices for ferrotitanium 60%, FOB Europe. Average annual price.*

***** *Average annual price*

Vanadium

1. Characteristics and use

Average V content (and its extent) in the earth's crust (ppm)

150 (53–200) V

Industrially important minerals

Coulsonite FeV_2O_4 (variable contents of V_2O_5), montroseite (V,Fe)O(OH) (variable contents of V_2O_5), carnotite $K_2(UO_2)_2(VO_4)_2.3H_2O$ (20% V_2O_5), tjujamunite $Ca(UO_2)_2(VO_4)_2.5–8H_2O$ (20% V_2O_5)

Industrially important deposit types

1. Deposits of titanium magnetite ores with increased contents of Ti, V and sometimes also platinoids: Katchkanar (Ural), Lac Dore (Chibougamau District, Canada), Bushveld Massif (South Africa), Otanmäki (Finland), Panzhihua (China), Balla Balla (Australia).
2. Deposits of black shale and bituminous shale and sand with increased V or U content: Kafferskraal (South Africa), Grants, Lisbon Valley, Uravan (USA), Athabasca (Alberta, Kanada), Minas Ragra (Peru).

Reserves

2023		
Country	**kt**	**% World**
China	4,400	18.3
Australia	8,500	35.4
Russia	5,000	20.8
South Africa	750	3.1
Brazil	120	0.5
USA	45	0.2
World	**19,000**	**100.0**

Source: MCS 2024, own estimate

The EU does not have vanadium reserves (European Minerals Yearbook – version 2023).

Uses

Vanadium is an important alloying element in iron metallurgy, most often supplied in the form of ferrovanadium. 80 to 90% of vanadium is consumed by metallurgy. In the chemical industry, V is used as a catalyst in the cracking of crude oil and in the production of certain acids, paints and in rubber processing.

Classification as critical raw materials for the European Union

2011 – no, 2014 – no, 2017 – yes, 2020 – yes, 2023 – yes

2. Mineral resources of the Czech Republic

The Czech Republic does not have any resources of vanadium.

3. Registered deposits and other resources of the Czech Republic

There are none.

4. Basic statistical data of the Czech Republic as of December 31

There are none.

5. Foreign trade

81129291 – Unwrought vanadium, vanadium powders, excluding waste and scrap

		2019	2020	2021	2022	2023
Import	kg	168	163	472	833	4
Export	kg	19	4	128	0	0

81129291 – Unwrought vanadium, vanadium powders, excluding waste and scrap

		2019	2020	2021	2022	2023
Average import prices	CZK/kg	5,452	4,239	4,025	1,229	29,500
Average export prices	CZK/kg	20,053	25,250	37,547	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2023

There are none.

8. World production and world market prices

World mine production of vanadium

Commodity/year	2019	2020	2021	2022	2023e
World mine production of vanadium (according to MCS), t of vanadium content	73,000	105,000	105,000	102,000	100,000
World mine production of vanadium (according to WBD), t of vanadium content	84,947	98,723	105,776	99,969	N

e – estimate

Main producers of vanadium according to MCS

Mine production

Country	2023e	
	kt*	%
China	68,000	68 .0
Russia	20,000	20.0
South Africa	9,100	9.1
Brazil**	6,400	6.4
USA	N	N
World (rounded)	**100,000**	**100.0**

e – estimate
** Thousand of metric tons of vanadium content*
*** Revised based on Government reports*

Prices of traded commodities

Commodity/year	2019	2020	2021	2022	2023e
Vanadium pentoxide (V_2O_5), min. 98%, Europe, USD/lb (MB)	4.45–17.75	4.80–7.75	N	N	N
Vanadium pentoxide (V_2O_5), USD/lb (MCS)*	12.17	6.68	8.17	9.25	9.25
Ferrovanadium, basis 70–80%, USD/kg (MB)**	2700–76.00	26.00–31.00	N	N	N
Ferrovanadium, USD/kg (DERA)***	41.9	25.0	34.27	38.99	32.75

e – estimate
** The prices for 2018–2021 are the China annual average vanadium pentoxide prices.*
*** Price range includes the lowest and the highest daily price quotes for the given year.*
**** Prices for ferrovanadium for 2017 are basis min. 78%, free delivered duty paid, consumer plant, 1st grade Western Europe. Prices for 2018 through 2021 are for ferrovanadium, 70–80%, CIF Europe. Average annual price*

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