



Ministry of the Environment
of the Czech Republic

MINERAL COMMODITY SUMMARIES OF THE CZECH REPUBLIC 2023

**STATISTICAL DATA
TO 2022**

(Data deadline: October 31, 2023)

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, the yearbook Mineral Commodity Summaries of the Czech Republic is being published for the thirtieth time in its history. 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 P₁, P₂, P₃ 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 evolutionary 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, 2021 – 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: $^{\circ}\text{API} = \frac{141.5}{\text{SG at } 60^{\circ}\text{F}} - 131.5$ $\text{SG at } 60^{\circ}\text{F} = \frac{141.5}{^{\circ}\text{API} + 131.5}$ 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 hospodářskou 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	pecially 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

Notes: * Czech Statistic Office

- source – IMF, *World Economic Outlook*, October 2022
- 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

Source: Czech National Bank

Mineral reserve and resource classification in the Czech Republic and its evolutionary comparison with international classifications

Czech classification

After 1948 the reserve classification of the USSR was progressively adopted in Czechoslovakia, of which the Czech Republic formed part. A Commission for Classification of Mineral Reserves (*Komise pro klasifikaci zásob – KKZ*) was established in 1952, as a state agency to review the categorisation and estimation of reserves of all types of minerals, except radioactive ores.

Initially geological reserves (all reserves in their original state in the deposit without subtracting losses from mining, beneficiation and processing) were classified into subdivisions of groups and categories (slightly simplified).

National classification during 1948–1991:

Potentially economic (nebilanční) – currently unminable due to a low grade, small deposit thickness, particularly complicated mining conditions, or due to the unfamiliarity with economic processing methods for the given mineral type, yet which may be considered as exploitable in the future

Economic – minable (bilanční), suitable for industrial utilisation and for the technical mining conditions for extraction

Categories of geological reserves according to the degree of deposit exploration:

A – explored in detail and delimited by mining works or boreholes, or by a combination of these. Geological setting, distribution of quality mineral types in the deposit and the technological properties of the mineral are known to such a degree that allow for the development of a method for beneficiation and processing of the mineral. Natural and industrial types of minerals are given. Reserves A include those parts of the deposit, where the geological setting, hydrogeological conditions and mining conditions are known to such a degree that a deposit development method can be developed.

B – explored and delimited by mining works or boreholes, or by a combination of these in a sparser network than in category A. It further includes reserves of deposits adjoining blocks of category A, verified by exploration works. The manner of geological setting, natural and industrial types of minerals are determined without knowing their detailed distribution in the deposit. The quality and technological characteristics of the minerals are given within a range allowing for a basic choice of a processing method. Hydrogeological conditions and general principles of deposit development are sufficiently clarified.

C₁ – determined by a sparse network of boreholes or mining works, or by a combination of these, as well as reserves which adjoin the reserves of categories A and B, if they are justified from a geological perspective. They also include the reserves of relatively complex deposits with a very irregular distribution of the mineral, even though these deposits were explored in detail. Included here are the deposit reserves partially mined-out with low recovery methods. The setting conditions, quality, industrial types and processing technology of the mineral are defined based on analyses or laboratory tests of samples, or based on analogy with explored

deposits of a similar type. The hydrogeological conditions and the principles of deposit development are defined quite in general.

C₂ – are assumed based on geological and geophysical data, confirmed by sampling of the mineral deposit from outcrops, isolated boreholes or mining works. Also, reserves adjoining the reserves of A, B, C₁ categories, where geological conditions for this exist.

It is further defined that project development and investment amounts for the construction of mining facilities are permitted on the basis of the economic mineral reserves in categories A+B+C₁, which are therefore reserves eligible for industrial utilisation. That is why, in practice, the economic reserves of categories A, B, C₁, or their total A + B + C₁ were designated by the term industrial reserves.

Further improvement of the classification introduced Order of the ČSSR Government no.80 in 1988 [7].

In 1963, KKZ established the prognostic reserves (*prognózní zásoby*) category in an amendment of its Principles for the Classification of Solid Minerals (hereinafter Principles) (*Zásad pro klasifikaci zásob pevných nerostných surovin*). They were defined as unexplored mineral reserves, assumed on the basis of the formation patterns and the distribution of mineral deposits, and investigations, dealing with the geological structure and the history of geological evolution of the evaluated locality. The parameters for the evaluation of prognostic reserves (strike, length, thickness, average grade and the like) are determined according to geological assumptions or they are derived. According to the Principles, prognostic reserves are not listed in the national Register of Reserves (*balance zásob*). They serve only as a basis for future planning of geological exploration.

In 1968, KKZ innovated the definition of prognostic reserves. In the amended Principles for reserve classification, it established the division of reserves into proved (by exploration or mining) and assumed, or prognostic. Prognostic geological reserves are unverified reserves, however they are assumed based on geological, geophysical and other scientific knowledge and material. They are predominantly the reserves of larger localities and formations, and, in isolated cases, the reserves of unexplored parts of large structures or deposits.

Due to the establishment of the prognostic reserve category, geological reserves (*geologické zásoby*) can, with regard to contents, be translated into English as total resources. However up to 1989, the term resources did not appear in Czech or Czechoslovak classifications. But up to now, reserves also represent mineral accumulations, which meet the reserves criteria due to being explored, but which do not meet them due to technical and economic reasons (potentially economic reserves *nebilanční zásoby*). They are therefore mineral resources.

In 1981, the Czech Geological Office issued Directive No. 3 [3], where the present prognostic reserves (*prognózní zásoby*) were divided into categories D₁, D₂, D₃. They are defined as follows:

D₁ – relate to verified mineral deposit reserves, with which they form one whole deposit. Determined in delimited areas and quantifiable based on positive detection of an existing mineral and its basic quality characteristics.

D₂ – territorially independent. They are determined in a delimited area based on positive detection of an existing mineral and its basic quality characteristic. Analogies are also used for their determination.

D₃ – determined on the basis of regional investigation. So far, mineral existence has not been proven in such a way, in order to be able to delimit the area of their occurrence and to quantify the prognosis.

In October 1989, the Czech Geological Office issued Decree No. 121/1989 Coll., which redefined the prognostic reserve categories, changed their designation, and for the first time in the Czech Republic established the term resources. The term prognostic resources has been used instead of the term prognostic reserves ever since. The categories P_1 , P_2 , P_3 were as follows:

P_1 – assumed due to the continuation of an already investigated deposit beyond the reserve outline of category C_2 or due to the discovery of new deposit parts (bodies). The basis for this category are the results of geological mapping, geophysical, geochemical and other work in the area of possibly occurring prognostic resources: geological extrapolation of data results from the investigation, or the verification of part of the deposit. In justified cases this category also includes areas with isolated technical works which do not fulfill the requirements in order to be included in the reserves category C_2 . The quantity and quality of the prognostic resources of this category is estimated according to the given deposit type and its part with detected reserves.

P_2 – assumed in basins districts and geological regions, where deposits of the same formation and generation type were detected. It is based on a positive evaluation of deposit indications and anomalies observed during geological mapping and geophysical, geochemical and other work, whose prospect is, if necessary, confirmed by a borehole or surface excavation work. The prognostic resource estimate of assumed deposits and the concept of the shape and dimensions of the bodies, their composition and quality, are derived by analogy with known deposits of the same type.

P_3 – assumed solely on the basis of conclusions concerning the formation possibilities of the deposit types under consideration with regard to favourable stratigraphic, lithological, tectonic and paleogeographic conditions detected while evaluating the locality during geological mapping, and during analysis of geophysical and geochemical data. The quantity and quality of prognostic resources is estimated according to assumed parameters of the deposit development by analogy with more closely explored localities, where deposits of the same genetical type were detected or verified. The prognostic resources of minerals in category P_3 can only be displayed by a surface projection.

National classification after 1991

The amendment of Mining Act no. 541/1991 Coll. divided the classification of reserves (reserved deposits) according to exploration into the categories of prospected reserves (*vyhledané zásoby*) and explored reserves (*prozkoumané zásoby*), and, according to exploitability conditions, into economic reserves (*zásoby bilanční*) and potentially economic reserves (*zásoby nebilanční*).

Economic – reserves suitable for existing technical and economic conditions in exploiting a reserved deposit.

Potentially economic reserves – currently unexploitable due to being unsuitable for existing technical and economic conditions of exploitation, yet assumed to be exploitable in the future in consideration of expected technical and economic development.

Neither this amendment nor any other regulation defined the content of the terms **prospected** and **explored** reserves. In practice, these categories are identified with the categories of reserve exploration, as they were in effect before the amendment of Mining Act no. 541/1991 Coll., in the following manner: explored reserves = sum of reserve categories A + B + C_1 (also called industrial), prospected reserves = reserves of category C_2 .

International classifications

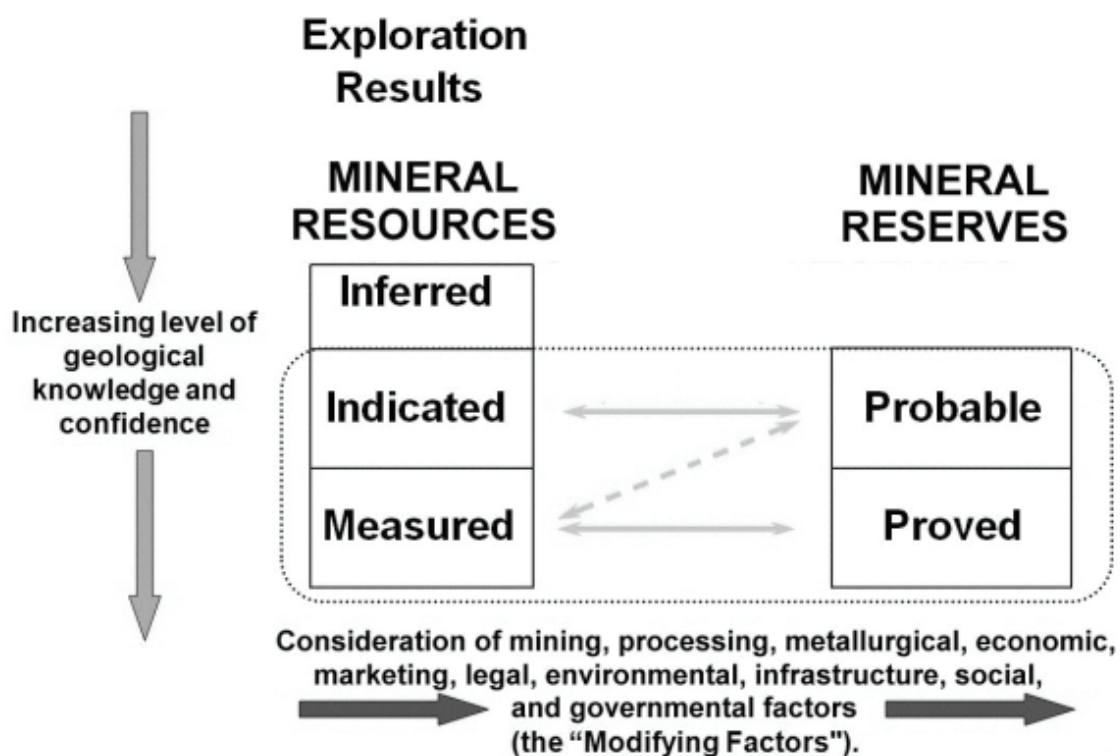
The international initiative to standardise market-related reporting definitions for mineral resources and mineral reserves had its start at the 15th CMMI Congress at Sun City, South Africa in 1994. The mineral definitions working group (later called CRIRSCO) was formed after a meeting at that Congress, and was made up of representatives from 14 countries, with the primary objective of developing a set of international standard definitions for the reporting of mineral resources and mineral reserves.^[1] These principles were requested primarily by the stock exchanges, where many exploration and mining organizations raise funds by issuing their shares. Stock exchanges today have particularly stringent, in many cases even legal, reporting requirements and generally require that they conform to the principles set out by CRIRSCO. Following these agreements, an updated version of the JORC Code was issued in Australia in 1999 (and more recently in 2012), followed by similar codes and guidelines in South Africa, the US, Canada, the UK, Ireland and other Western European countries, Chile and Peru.

As exploration and mining organizations are most commonly listed on the Australian Stock Exchange in Sydney and the Toronto Stock Exchange in Canada, the most commonly used classification systems are the Australasian JORC and Canadian NI 43-101.

In 2001, the Pan European Reserves and Resources Reporting Committee (PERC) published the European Code for Reporting of Mineral Exploration Results, Mineral Resources and Mineral Reserves^[11] and the PERC system is now widely used in Europe.

The following chart shows the main categories of the adopted CRIRSCO system, their sequence and their interrelationships:

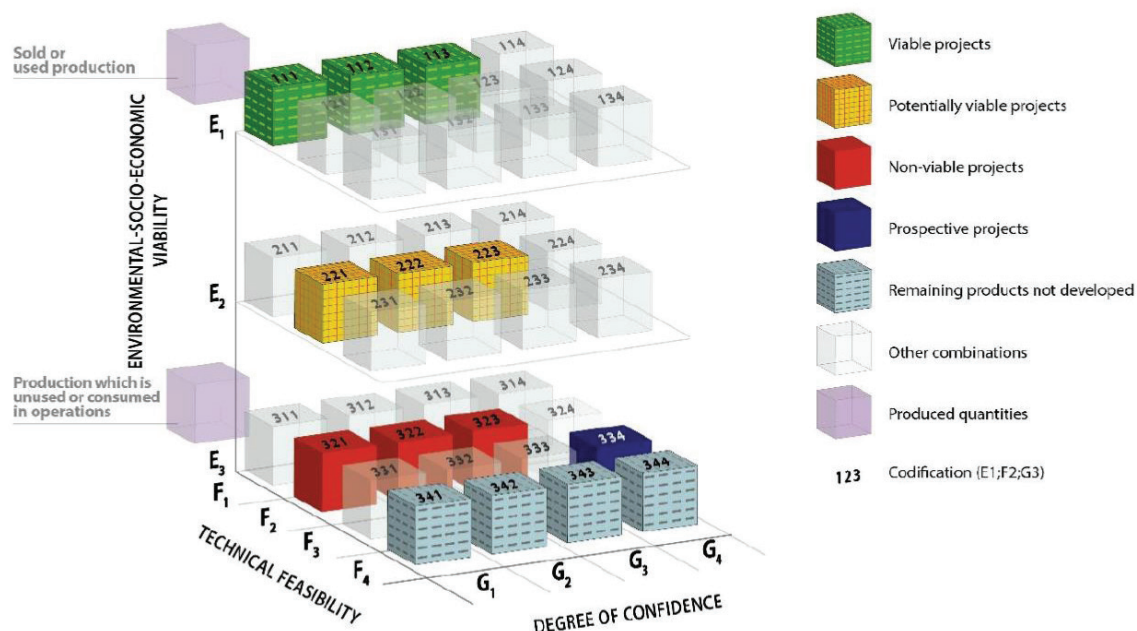
Relationships between reserves and mineral resources, their definition Relationship diagram^[1]



For the purpose of coordinated management of raw materials policy, 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 other resources such as alternative energy sources, water resources or secondary raw materials. UNECE (United Nations Economic Commission for Europe – UNECE) has been developing this classification system since 1992 and the latest update is dated 2019 [9]. Adoption of the UNFC as the standard for reporting of 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), which is likely to come into force in December 2023.

The UNFC is not intended to replace national mineral classification systems or CRIRSCO reporting systems; however, the UNFC is compatible with the CRIRSCO classification. Its main purpose is to be able to compare resources within the European Union to enable a coordinated management approach in this area of the industry.

UNFC is a principles-based system in which the exploration and mining projects are classified in a three-dimensional matrix according to three basic criteria: environmental, social and economic feasibility (E axis), technical feasibility (F axis) and the degree of confidence in the geological data (G axis). The primary level of resource classification is the result of a combination of categories from each of these axes. Each of the main categories, expressed by a three-digit code, has sub-categories that allow a more detailed assessment of the project at present and therefore the recoverability of the mineral deposits.



Three-dimensional UNFC matrix (based on the 2020 UNFC update) [9]

In 1999, agreement was reached with UNECE to incorporate the CMMI-CRIRSCO source/reserves definitions into the UNFC for those categories that were common to both systems. A bridging document between the two systems was developed and updated in late 2023/early 2024.

CRIRSCO Template		UNFC-2009 "minimum" Categories			UNFC-2009 Class
Mineral Reserve	Proved	E1	F1	G1	Commercial Projects
	Probable			G2	
Mineral Resource	Measured	E2	F2	G1	Potentially Commercial Projects
	Indicated			G2	
	Inferred			G3	
Exploration Results		E3	F3	G4	Exploration Projects

Simplified mapping of CRIRSCO template to UNFC-2009 Classes and Categories ^[1]

An important aspect of the principles under the CRIRSCO is the concept of the “competent person”. This person is responsible for the calculation of the resources and reserves and its categories, is a member of a recognised professional society (which guards under sanctions the professionalism and ethics of its members), and has professional and moral qualities. Its calculations are then accepted as reliable by banks and stock exchanges. Competent persons are members of Recognised Overseas Professional Organisation (ROPO), a list of organisations compiled by the Australasian Joint Ore Reserves Committee (JORC).

Comparison of Czech and international classification systems

The Czech classifications still refers to potentially economic reserves, i.e. reserves that are not currently recoverable, which is terminologically inconsistent with the concept of reserves as understood by standard internationally used classifications. In these, only the currently mineable explored resources is considered to be reserves. All other recorded parts of the various exploration activities are resources, not reserves of the mineral in question. It should also be noted that the standardised internationally used classifications report reserves with the inclusion of losses and dilution during extraction. In contrast, Czech reserves are reported in situ without the effects of losses and dilution. The Czech “Economic recoverable reserves” are thus closest to the international standards. However, even in this case there is not complete agreement, because these “reserves” reflect losses but not dilution.

Following the requirements of the European Union, a project managed by the CGS is currently underway to map the possibilities of converting the Czech national system to the UNFC categories so that the balance of national resources can be included in the overall EU balance.

Comparison of the Council of Mining and Metallurgical Industries (CMMI) ^[4] reserve and resource classifications with the categories in the Czech Republic

CMMI category	Czech categories up to 1981	Czech categories in 1981–1989	Czech categories in 1989–1991	Czech categories after 1991
Proved Mineral Reserve	economic reserves – part of exploitable part* A + B	economic reserves – part of exploitable part* A + B	economic reserves – part of exploitable part* A + B	part of exploitable part* of explored economic reserves
Probable Mineral Reserve	economic reserves – part of exploitable part* of A + B + C1	economic reserves – part of exploitable part* of A + B + C1	economic reserves – part of exploitable part* of A + B + C1	part of exploitable part* of explored economic reserves
Inferred Mineral Resource	economic reserves – C2	economic reserves – C2	economic reserves – C2	prospected economic reserves
Measured Mineral Resource	potentially economic reserves – A + B	potentially economic reserves – A + B	potentially economic reserves – A + B	part of explored potentially economic reserves
Indicated Mineral Resource	potentially economic reserves – C1	potentially economic reserves – C1	potentially economic reserves – C1	part of explored potentially economic reserves
Inferred Mineral Resource	potentially economic reserves – C2	potentially economic reserves – C2	potentially economic reserves – C2	prospected potentially economic reserves
Measured Mineral Resource	potentially economic reserves – A + B	potentially economic reserves – A + B	potentially economic reserves – A + B	part of explored potentially economic reserves
Indicated Mineral Resource	potentially economic reserves – C1	potentially economic reserves – C1	potentially economic reserves – C1	part of explored potentially economic reserves
Inferred Mineral Resource	potentially economic reserves – C2 + part of prognostic reserves	potentially economic reserves + part of D ₁	potentially economic reserves + part of P ₁	prospected potentially economic reserves + part of P ₁
not available	part of prognostic reserves	D ₂ + D ₃ + part of D ₁	P ₂ + P ₃ + part of P ₁	P ₂ + P ₃ + part of P ₁

* geological reserves reduced by amount of prospective mining losses

Comparison of classifications of resources and reserves valid in the Czech Republic in the years 1989–1991 and after 1991 with classification standards PERC and JORC taking into account ^[8] and with classification standards of Canadian Institute of Mining, Metallurgy and Petroleum (CIM) used by guideline NI 43-101 for the publication of the economics of mineral projects in Canada (on the Toronto Stock Exchange – TSX) ^[9]

Standards PERC a JORC	Canadian CIM standards used by NI 43-101	Czech categories in 1989–1991	Czech categories after 1991
Proved reserves	Proven reserves	A bilanční vytěžitelné zásoby (economic exploitable reserves)	Bilanční prozkoumané vytěžitelné zásoby (economic explored exploitable reserves)
		B bilanční vytěžitelné zásoby (economic exploitable reserves)	
		C ₁ bilanční vytěžitelné zásoby (economic exploitable reserves)*	
Probable reserves	Probable reserves	C ₁ bilanční vytěžitelné zásoby (economic exploitable reserves)	Bilanční vyhledané vytěžitelné zásoby (economic prospected exploitable reserves)
		C ₂ bilanční vytěžitelné zásoby (economic exploitable reserves)	
Measured resources	Measured resources	A nebilanční zásoby (potentially economic reserves)	Nebilanční prozkoumané zásoby (potentially economic explored reserves)
		B nebilanční zásoby (potentially economic reserves)	
		C ₁ nebilanční zásoby (potentially economic reserves)*	
Indicated resources	Indicated resources	C ₁ nebilanční zásoby (potentially economic reserves)	Nebilanční vyhledané zásoby (potentially economic prospected reserves)
		C ₂ nebilanční zásoby (potentially economic reserves)	
Inferred resources	Inferred resources	P1 prognózní zdroje (prognostic resources)	P ₁ prognózní zdroje (prognostic resources)

* in the case of deposits with a complex geological structure

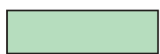
HISTORY OF RESERVE AND RESOURCE CLASSIFICATION ON THE TERRITORY OF THE CZECH REPUBLIC

	RESERVES				PROGNOSTIC RESOURCES		
	EXPLORED		PROSPECTED		P ₁ *	P ₂ *	P ₃ *
	disposable	bound	disposable	bound			
ECONOMIC							
POTENTIALLY ECONOMIC							

* effective from 1989



Geological reserves = all reserves in their original state without considering mining losses and dilution



Exploitable reserves = economic reserves reduced by estimated mining losses

reserves of categories A + B + C (before 1991) = explored reserves (since 1991)
 reserves of category C₂ (before 1991) = prospected reserves (since 1991)
 disposable reserves = reserves mining of which is not made impossible by protection of surface objects and mining workings
 bound reserves = reserves in protection pillars of surface objects and mining workings
 exploitable reserves = economic geological reserves reduced by amount of prospective mining losses connecting with selected mining technology or with natural conditions
 categories A, B, C, = so-called industrial categories of reserves (before 1991)
 reserve of categories A + B + C, = so-called industrial reserves (before 1991), also - in the limited interpretation - economic explored disposable reserves

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- [1] Committee for Mineral Reserves International Reporting Standards (CRIRSCO). – <https://www.criirco.com>
- [2]* Schejbal, C. (2003): Problematika výpočtu a klasifikace zásob a zdrojů pevných nerostných surovin. – Sborník vědeckých prací Vysoké školy báňské – Technické univerzity Ostrava, ročník XLIX, řada hornicko-geologická, monografie 9, s. 139–161 (Transactions of the VŠB – Technical University Ostrava, vol. XLIX, Mining and Geological Series, Monograph 9, pp. 139–161).
- [3]** Směrnice č. 3/1981 Českého geologického úřadu pro hodnocení a evidenci geologických prognóz a prognózních zásob nerostných surovin. – Geologický průzkum, 23, 10: Zpravodaj ČGÚ, 5: 1–2.
- [4] United Nations international framework classification for reserves/resources – solid fuels and mineral commodities. – United Nations Economic and Social Council, Economic Commission for Europe, Committee on Sustainable Energy, 1997. Geneva.
- [5] U. S. Bureau of Mines and U. S. Geological Survey. Principles of a resource/reserve classification for minerals. – U. S. Geological Survey Circular 831, 1980.
- [6]*** Lhotský, P. – Morávek, P. (2002): Ložiskový průzkum a hospodaření se zásobami výhradních ložisek (návrh k analýze třetí části horního zákona). – Uhlí, rudy, geologický průzkum, 5: 8–15.
- [7]**** Nařízení vlády Československé socialistické republiky č.80/1988 Sb., o stanovení kondic, klasifikaci zásob výhradních ložisek a posuzování, schvalování a státní expertize jejich výpočtů.
- [8]***** Pechar T. et al.(2016): Metodika umožňující srovnání údajů zastaralé metodiky hodnocení ložisek s nově navrženými kritérii hodnocení dle PERC a JORC – Certifikovaná metodika č. 2, projekt č. TB030MP013, TAČR Program Beta, MPO. Praha.

- [9] United Nations Framework Classification for Resources, Update 2019. – ECE Energy Series No. 61, United Nations Geneva 2020. (<https://unece.org/sustainable-energy/publications/united-nations-framework-classification-resources-update-2019-ece>)
- [10] CIM definition standards – For mineral resources and mineral reserves. Prepared by the CIM Standing Committee on Reserve Definitions. Adopted by CIM Council on May 10, 2014 (https://www.cirisco.com/docs/cim_definition_standards_20142.pdf)
- [11] PERC Reporting Standard 2021. – <https://percstandard.org/>

Translations of Czech article (and legislation) titles:

- * Problems of evaluation and classification of reserves/resources of solid mineral raw materials
- ** Directive no. 3/1981 of the Czech Geological Office for evaluation and registration of geological prognoses and prognostic reserves of minerals
- *** Mineral exploration and management of reserved deposit mineral reserves (proposal for analysis of the third part of the Mining Act)
- **** Order of the Czechoslovak Socialistic Republic Government, on setting of standards, classification of reserves of reserved deposits and on assessing, approval and the State expertise of their estimates
- ***** Methodology enabling comparison of data of outdated methodology of deposit evaluation with newly proposed evaluation criteria according to PERC and JORC. – Certified methodology No. 2, project No. TB030MP013, TAČR Program Beta, Ministry of Industry and Trade. Prague.

MINERAL BASE OF THE CZECH REPUBLIC AND ITS DEVELOPMENT IN 2022

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 km² or km² piece of exploration area, which increases annually by CZK 1,000 per km² 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 refractory 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 1,000. 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		2018	2019	2020	2021	2022
registered geological works ^{a)}	total	7,718	6,122	6,137	5,376	5,574
	economic geological	18	24	28	17	19
protected deposit areas – number		1,147	1,154	1,161	1,156	1,157
mining leases – total number		960	960	959	952	954
number of exploited reserved deposits		501	497	491	487	487
number of exploited non-reserved deposits		173	170	178	179	179
mine production of reserved deposits, mill. t ^{b)}		114	110	100	103	106
mine production of non-reserved deposits, mill. t ^{b)}		12	13	14	15	15
organizations managing reserved deposits		333	304	305	302	303
organizations mining reserved deposits		173	172	171	153	145
organizations mining non-reserved deposits		157	132	132	105	104

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

a) engineering-geological and hydrogeological works prevail

b) conversions: natural gas 1 mill m³ = 1 kt, dimension and crushed stones 1,000 m³ = 2.7 kt, sand and gravel and brick clays and related minerals 1,000 m³ = 1.8 kt

3. Significance of mining in the Czech economy

Ratio/year	2018	2019	2020	2021	2022
Annual GDP* growth	3.2	3.0	1.4	6.99	2.4
Share of mining and quarrying in GDP, % of current prices	0.6	0.6	0.4	0.5	0.5
Share of mining and quarrying GVA in GVA of industrial production**, % of current prices	2.4	2.1	1.4	1.4	1.4

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	2018	2019	2020	2021	2022
Metallic ores ^{a)}	92	95	95	95	95
Energy minerals	2,804	2,763	2,735	2,686	2,653
of which: uranium (U) (kt)	1	1	1	1	1
crude oil	22	22	22	21	21
natural gas ^{b)}	6	6	5	5	5
Industrial minerals ^{c)}	2,466	2,486	2,503	2,486	2,480
Construction minerals ^{d)}	5,154	5,153	5,161	5,178	5,272

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)

^{b)} natural gas – conversion into kt: 1 mill m³ = 1 kt

^{c)} moldavite bearing rock – conversion into kt: 1,000 m³ = 1.8 kt

^{d)} at reserved mineral deposits including dimension stone, conversion into kt – dimension and crushed stones 1,000 m³ = 2.7 kt, sand and gravel and brick clays and related minerals 1,000 m³ = 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 2022 and newly issued in 2022 (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 2022	Start of validity in 2022
Bituminous coal	–	–	–	–
Crude oil and natural gas	17	–	1	1
Sn-W and Li ores	7	–	1	1
Li ore	–	7	1	1
Cu ore	–	2	–	–
Au ore	1	–	–	–
Graphite	–	–	–	–
Gemstones	3	–	–	–
Kaolin	12	–	1	1
Clays	6	–	1	1
Bentonite	4	–	2	2
Feldspar and feldspar substitutes	16	–	–	–
Silica raw materials	4	–	1	1
Corrective additives for cement production	–	–	–	–
Dimension stone	1	–	–	–
Crushed stone	1	–	–	–
Sand and gravel	9	–	1	1
Underground placement sites, underground reservoirs	5	–	–	–
Total	88	8	3	3

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 area of economic geology, the processing of updated data bases of the publication Mineral commodity summaries of the Czech Republic 2022 was carried out and at the same time the electronic passportisation of deposits and exploration areas continued (Deposit Information System LIS). Areas of prognostic resources of moldavites (category Q) were delimited in the South Bohemian Basins.

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

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

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			

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.

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.

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. a č 284/2021 Sb.

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

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, exercise 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

* 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

* 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 325 registered exclusive deposits of CS only 178 were active in 2022 in the Czech Republic, i.e. with mining authorization, and 54 of the total 220 non-reserved mineral deposits had mining authorization. In total there are 232 active stone quarries in the Czech Republic (but only 211 active and reporting production) and their total annual production of CS was 16.7 million m³ 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 m³, in 2022–16.7 millions m³). 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.

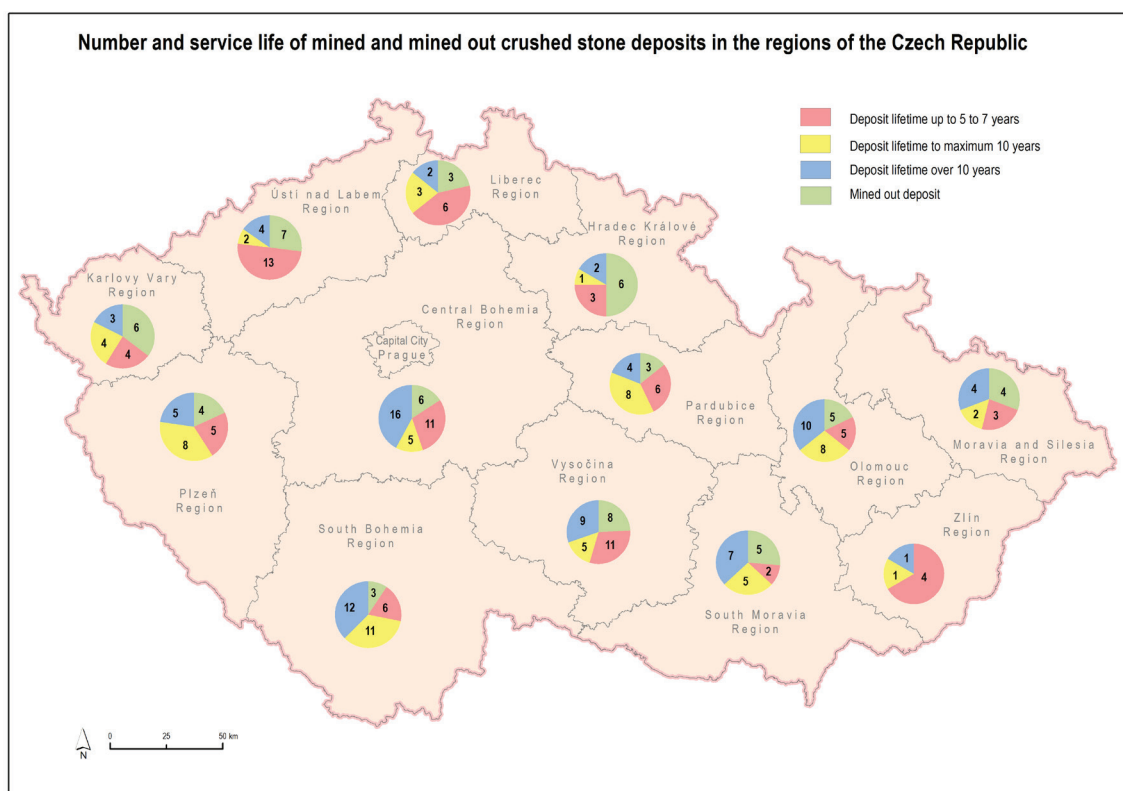
Another aggregate class that will be used in the near future for railway structures is the B0 class 32/63 mm fraction. It is the aggregate used in high-speed tracks. In the Czech Republic high-speed construction railway projects with a design speed of 350 km/h are already being prepared. The B0 class 32/63 mm aggregate fraction will be 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 W_i work index and A_i 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 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 gravel 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 203 registered exclusive deposits of sand and gravel only 76 were active in 2022 in the Czech Republic, i.e. with mining authorization (but only 62 of them were active and reported production), and 102 of the total 328 non-reserved mineral deposits had mining authorization (but only 86 were active and reported production). In total there are 177 active stone sandpits in the Czech Republic (but only 156 active and reporting production) and their total annual production of sand and gravel was 11.8 million m³ in 2022. In recent years the

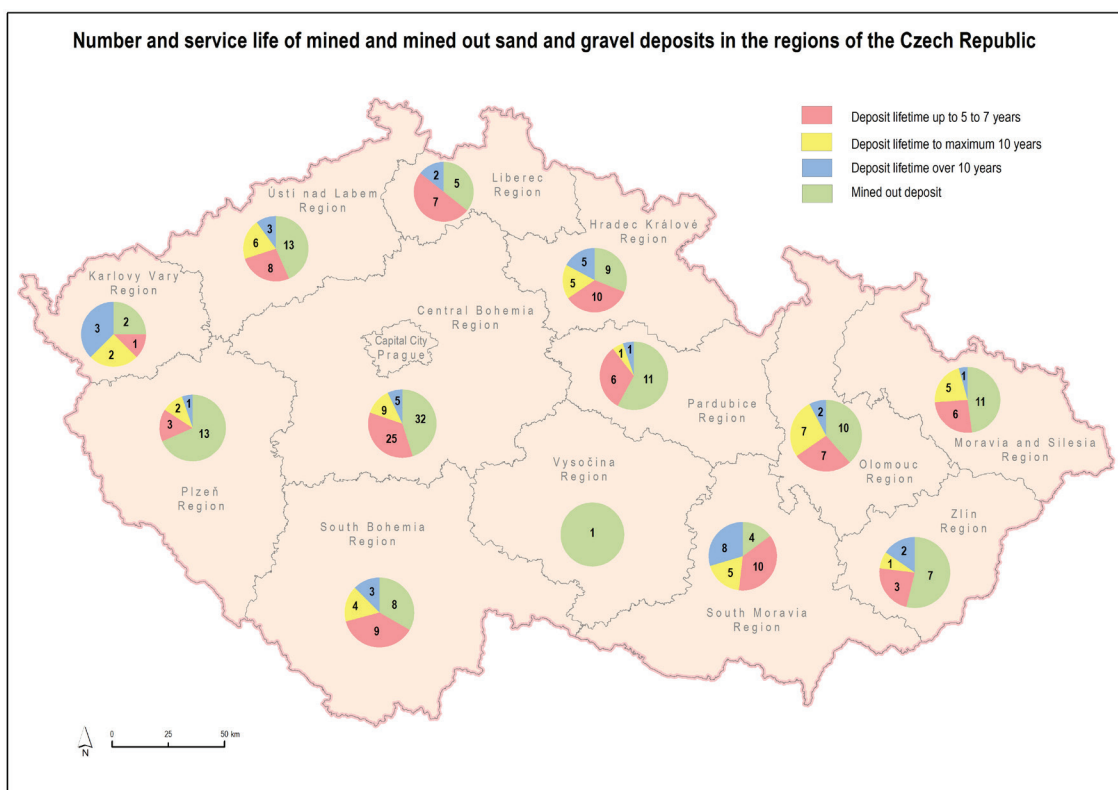
annual amounts of sand and gravel extraction in the Czech Republic have been very stable – around 6.5 million m³ (reserved deposits) + about 5 million m³ (non-reserved deposits). Total aggregate consumption including sand and gravel only in concrete is about 6 million m³/year in the Czech Republic. Sandpits 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 to 47% 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 m³ – just over 26% of the total geological reserves) and the reserves with permitted mining according to DPMP are even lower (133 millions m³ – 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 depletes 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



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.

High-purity manganese products from the Chvaletice–Trnávka tailings

Dr. Ing. Jan Votava – MANGAN Chvaletice, s.r.o.

While manganese is a common metal in many parts of the world, it is very rare in the European Union. The term “high-purity manganese” (HPM) refers to a group of highly refined products that are essential for most lithium-ion batteries. Its use and demand are growing rapidly, especially in Europe. The production of high-purity battery-friendly manganese products is very challenging from an economic, environmental and technical point of view. The Chvaletice–Trnávka tailings recycling project is ideal for HPM production.



View of the current form of the tailings

Introduction

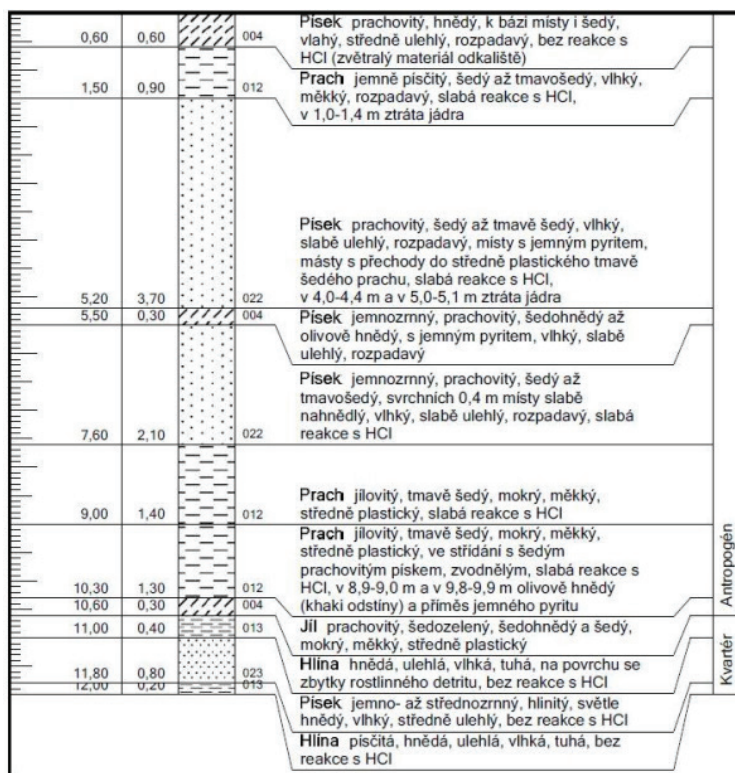
Origin and character of manganese deposit

The presence of manganese and iron minerals was first recorded in the vicinity of today's village of Chvaletice in the 18th century. In 1920, the “Pražská železářská společnost” started open-pit manganese mining here. The ore was transported to steel mills in Czechoslovakia and Germany. During the First World War, mining expanded even more, and between 1922 and 1927 the amount of manganese ore mined amounted to 45 thousand tons. From there, the manganese travelled to the ironworks in Kladno. In 1949, the mining and processing plant “Manganorudné a kyzové závody n. p., Chvaletice”, was established. Between 1951 and 1975, open-pit mining in the area focused on graphitic shale containing 5–8% sulphur and processing of pyrite concentrate, which was used for the production of sulfuric acid. The annual production of this shale was around 1.5 million tons. After the import of sulphur

from Poland began in the 1960s, the extraction of sulphur from pyrite became unprofitable and mining and production was finally terminated in 1975. The waste from these operations gradually created three existing Chvaletice heaps forming a deposit (tailings). In 1980, the Chvaletice deposit, tailings ponds 1 and 2 were registered, and in 1993 the protected deposit area of Řečany, tailings pond 3, was registered. After the end of pyritic ore mining, the surface quarry began to be used as a repository for fly ash from the Chvaletice power plant.

At the end of the 1980s, Bateria Slaný carried out extensive studies of tailings to determine the feasibility of producing manganese dioxide for use in dry battery cells. Although studies have confirmed the great economic potential of the manganese carbonate it contains, further work was stopped after 1989. The deposit was not exploited until September 2014, when the mining rights were granted to a Czech group of companies. In 2017, MANGAN Chvaletice, s.r.o. (a subsidiary of the Canadian company Euro Manganese Inc.) carried out extensive sonic drilling work to evaluate the quantitative and qualitative characteristics of three different tailings deposits. Exploratory drilling has confirmed the significant potential of the deposit. Since then, the implementation of a project called Recycling of the Chvaletice-Trnávka Tailings has been being prepared.

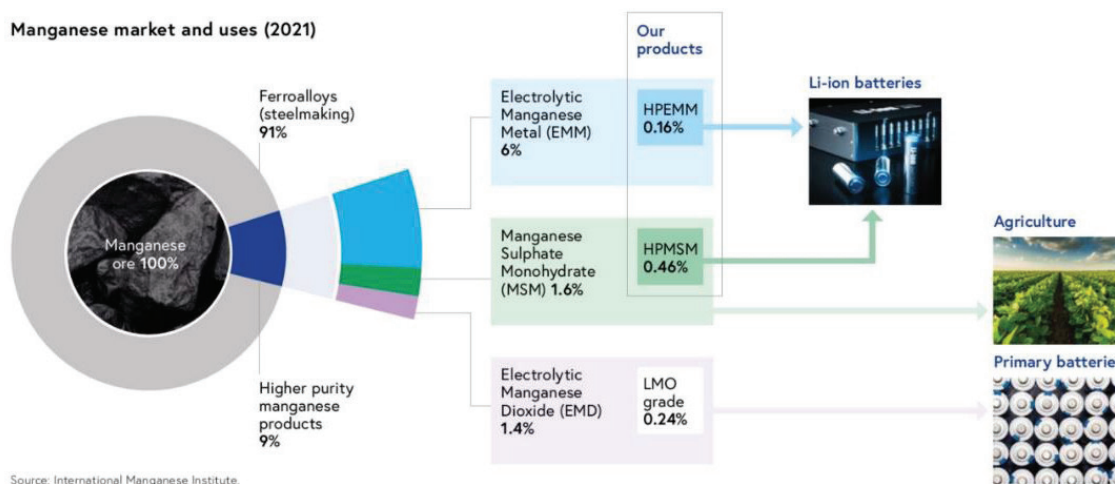
The tailings were founded on Holocene fluvial clays. Pleistocene fluvial sands and gravel sands of the lowest terrace of the Elbe River occur under the Holocene loams. In the bedrock of the river deposits there are Cretaceous marlstones and siltstones of the Elbe region of the Czech Cretaceous Basin. The manganese source in Chvaletice is located in three adjacent flotation heaps, which were located on flat terrain near the flotation plant, which was adjacent to the former Chvaletice mine. Tailings are sandy to fine greyish material that contains approximately 7.5% manganese, mostly occurring in the form of rhodochrosite and kutnohorite, two mineral forms of manganese carbonate.



Geological structure of the deposit

Drill Core Material

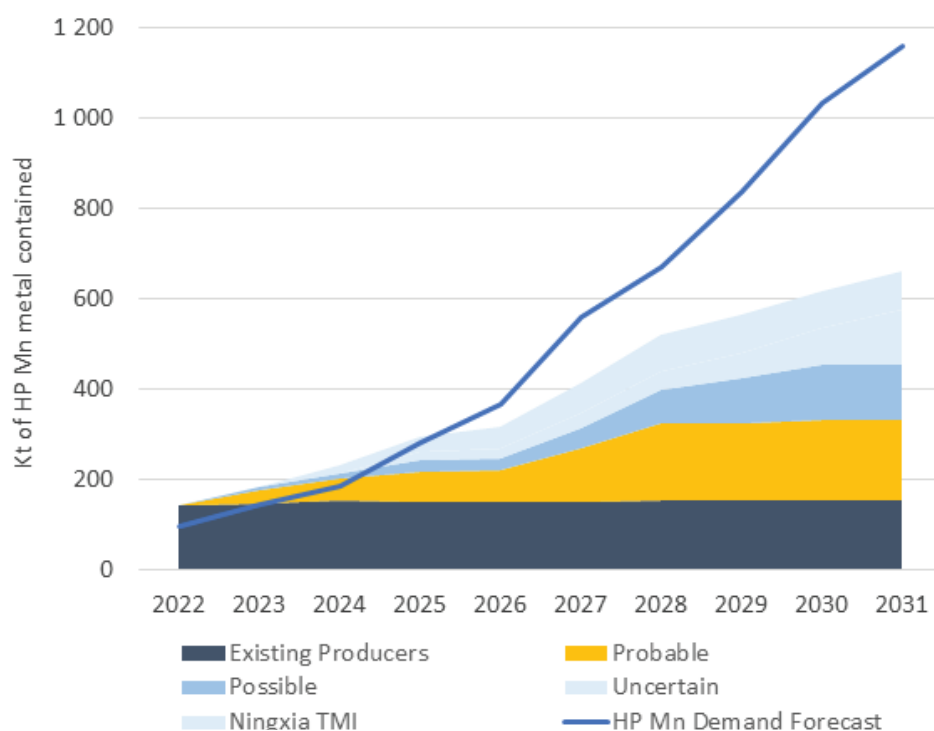
Extensive drilling surveys, along with metallurgical tests and process design studies, show that the production of high-purity manganese (99.9%) will be approximately 50,000 tonnes per year for 25 years. This means that 1.19 million tonnes of high-purity electrolytic manganese (HPEMM) will be produced, two-thirds of which will be converted into high-purity manganese sulfate monohydrate (HPMSM).



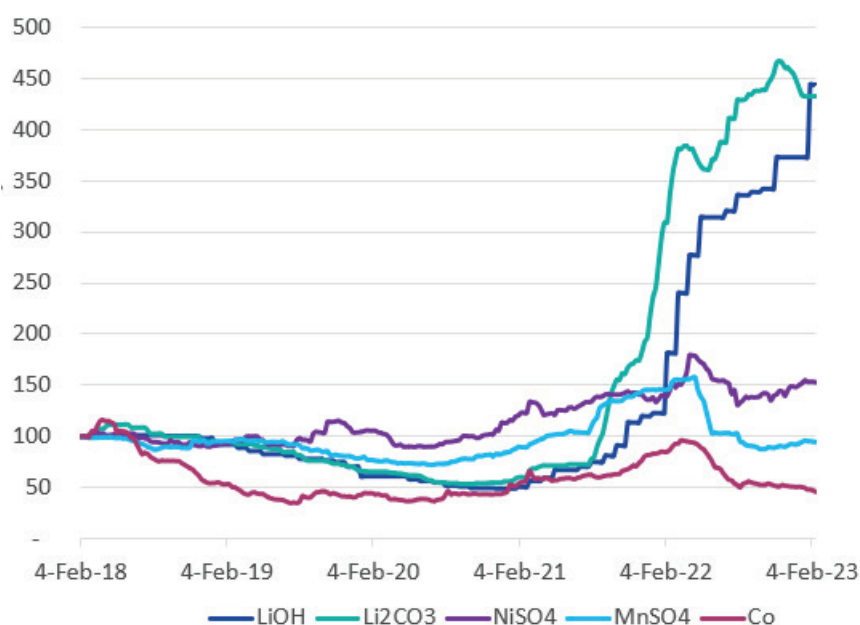
Manganese Market and Annual World Manganese Consumption

Annual global manganese production is approximately 20,225 tonnes. Less than 100 kt of high-purity manganese is produced annually, accounting for 0.5% of the global manganese market. The demand for high-purity manganese is expected to increase significantly in the coming years. By 2030, there is an estimated global deficit of 695 kt of high-purity manganese sulphate monohydrate (HPMSM), a product used by most lithium-ion battery manufacturers. CPM Group expects demand for high-purity manganese to increase thirteen times between 2021 and 2031 (from 90 kt to 1.1 million tonnes of manganese) and fifty-fold between 2021 and 2050 (to 4.5 million tonnes of manganese). To meet the projected demand for HPMSM in 2030, global production needs to increase by more than 12 times compared to 2020. The Chvaletice–Trnávka tailings recycling project offers the potential to provide up to 28% of the projected demand for high-purity manganese in Europe in 2030 and will contribute to the development of a strong, independent European battery supply chain that will help reduce vulnerability to supply disruptions from outside the European Union.

The increased demand for manganese sulphate, especially that which comes from outside China, will lead to a deficit in the market, causing prices to rise significantly – just as lithium and graphite prices have responded to similar dynamics in the industry. Among the macroeconomic factors supporting the increase in demand for high-purity manganese, it is necessary to mention the continued growth of the global electric vehicle market. We predict that in 2030, 50% of new vehicles sold will be electric or hybrid. Most European automakers say they will switch to producing mostly electric vehicles by 2030. VW, Tesla, GM and Stellantis have announced the transition to high-manganese cathodes, and SVOLT, CATL, BASF and Umicore are also focusing on the development of this type of cathode. Both European Union and U.S. legislation also supports the location of supply chains. Europe is planning to introduce a battery passport, batteries sold in the EU will have to have a total carbon footprint, responsible sourcing (human rights and proper supply chain control) and



Global High-Purity Manganese Demand & Supply to 2031



Source: Bloomberg and CPM Group.

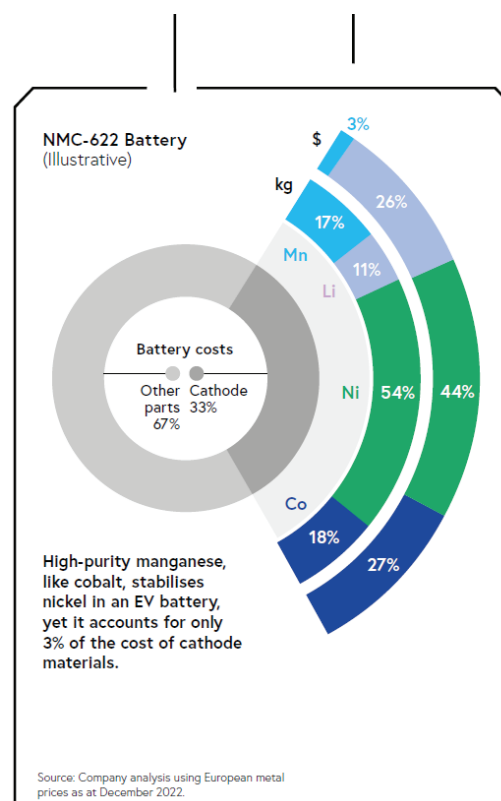
Battery Metal Prices (2018–2023)

a minimum level of recycled content from 2026. The reform of the tax credit for electric vehicles in the United States requires that in 2024, 40% of raw materials for batteries come from the US or from a country with a free trade agreement with the US, with a projected increase of 10% per year, up to 80% by 2027.

Development of electromobility

Only 1% of the manganese mined worldwide is qualitatively suitable for the production of batteries for electric vehicles. There is a significant increase in the importance of manganese in this industry. The vast majority of European car manufacturers have committed to using manganese in their batteries. Especially in the last year, the number of batteries labelled NMC and LMFP has increased. Lithium-ion batteries, which have a nickel-cobalt-manganese (NMC) composition, are high-performance and stable, which is why they are increasingly being used in electric vehicles and energy storage equipment. These batteries store more energy, charge for a shorter period of time, have a longer lifespan, and are considered safer than other commercially available technologies. Cathodes with nickel-manganese-cobalt (NMC) composition currently dominate in EV batteries with ~50% market share. A serious concern for

NMC battery manufacturers is the security of supply of cobalt and its price. The vast majority of cobalt comes from the very unstable African country of Congo. In the currently dominant NMC-111 batteries, cobalt accounts for almost 80% of the cost of materials needed to make the cathode, even though it makes up only 1/3 of its weight. These two factors are leading battery designers to try to “eliminate cobalt” from the battery chemistry, or at least significantly reduce its use. For these reasons, the amount of cobalt is currently being reduced and replaced by manganese, which has therefore become an important cathode material.



EU Critical Raw Materials Act

An important milestone in the preparation of the project was the publication of the European Critical Raw Materials Act this year, which aims to ensure the EU’s access to a secure, diversified, affordable and sustainable supply of critical raw materials, including manganese for battery use. This act should reduce the dependence of supply chains on strategic raw materials. The main objectives of the Act by 2030 are to extract 10% of strategic mineral consumption, process 40%, recycle 15%, and by 2030 no mineral must come from more than 65% of a single third country.

The European Commission will also strengthen the deployment and use of breakthrough technologies in critical raw materials and envisages significant investments in research, innovation and skills.

The Act also introduces a definition of so-called ‘strategic projects’. The purpose of these projects is to ensure the security of supply of strategic minerals. These projects have the status of the highest public interest and support for access to finance and shorter permitting periods (24 months for mining permits and 12 months for treatment and recycling permits) will be available for selected projects.

The uniqueness of the Chvaletice tailings

Europe has several lithium deposits, and the manganese deposit suitable for battery purposes is the only one in the European Union. Currently, more than 90% of battery-fit manganese is imported from China. According to the International Manganese Institute, China maintains its dominant position as a supplier of high-purity manganese products. However, China is largely dependent on ore imports, mainly from South Africa, Australia, Gabon, and Ghana. Only about 2.5% of HPMSM suitable for the battery industry is currently produced in Europe.

Any disruption in the supply of high-purity manganese and a shortage of manganese products would have very unpleasant consequences for the European automotive industry. Potential customers are increasingly interested in diversifying their sources of strategic raw materials and want to support the creation of independent local supply chains, especially in Europe, where the automotive industry directly and indirectly employs more than 14 million people and where automakers have made a strong commitment to the electrification of their fleets.

The project has the potential to contribute to the development of a strong, independent European battery supply chain, which will help reduce vulnerability to supply disruptions and reduce the carbon footprint of manganese production and transport from China.

The uniqueness of the project also lies in the fact that it uses the principle of the so-called circular economy with a great emphasis on the environmental benefits of the project for the tailings and its wide surroundings. This is not mining, but recycling manganese from old waste that was created after pyrite mining in the last century. Since the end of mining, the tailings has been lying fallow. The advantage of this deposit is the relatively homogeneous distribution of manganese, about 6.5%, and at the same time there is a great advantage of already mined, crushed and ground raw material, which eliminates the demanding processes that were carried out more than fifty years ago.

Minimizing environmental impact

A Life Cycle Assessment published in December 2022 showed that Chvaletice's high-purity manganese products have a carbon footprint of about one-third that of existing Chinese industry. Further analysis showed that manganese metal has a significantly lower carbon footprint compared to nickel and cobalt, other metals for battery cathodes.

Positives for local citizens and interested municipalities

Undoubtedly, the biggest benefits for local citizens are the mining fees that will be paid to the municipalities in whose cadastral territory the recycling will take place. In total, it will be about CZK 40 million per year. By opening a production plant, the project will create approximately 400 jobs, which are planned to be filled primarily by regional employees. The economic benefits of the project will also be reflected in an increase in turnover and orders for local companies and institutions. During the project, the area of today's unused tailings will be continuously remediated and reclaimed, and after consultation with experts, a near-natural biologically diverse landscape will be created here.

High Purity Manganese Products

The manufacturing processes and composition of lithium-ion batteries require all raw materials to be of very high purity. The presence of microscopic metal particles or other contaminants can cause a short circuit leading to malfunction, overheating, and possible explosion. Some NMC cathode manufacturers use nanotechnology to mix high-purity manganese, cobalt, and nickel sulphates to prepare cathode surface coatings. The absence of harmful impurities and the consistency of these materials is essential for a high-quality NMC cathode production process.

At present, Europe imports more than 90% of its consumption of high-purity manganese. The newly built Chvaletice plant should process up to 1.3 million tonnes of tailings containing manganese ore from tailings per year and obtain 50,000 tonnes of manganese with a purity of 99.9% per year, which will be used for the production of high-purity manganese sulphate. The total annual production will be about 100,000 tonnes of manganese sulphate and 17,000 tonnes of pure manganese metal, which will cover approximately 25% of European demand. Manganese raw materials for NMC battery cathode material precursors can be supplied in the form of manganese metal or manganese sulphate.



High-purity manganese sulphate produced in Chvaletice



High-purity manganese metal produced in Chvaletice

Current status of the project

In 2021, MANGAN Chvaletice, s.r.o. was granted two important permits: Exploration Permit and Prior Consent to Submit a Proposal for the Determination of the Mining Area, whereby the company continues to be the exclusive explorers in the area of tailings.

The documentation for the Environmental and Human Health Impact Assessment (EIA) has been submitted, and the deadline for issuing the decision on the EIA documentation is expected at the turn of 2023/24.

In the spring of this year, after an extensive reconstruction of two buildings in the EP Chvaletice industrial area, a demonstration plant was launched.

Negotiations are currently underway with customers on sampling from the demonstration plant and future sampling of high-purity manganese products from a large plant. Negotiations take place with many customers along the entire supply chain, from PCAM (active battery materials) manufacturers to automotive OEMs.

Demonstration plant

The demonstration plant was launched in the spring of this year and already has over 20 employees. Its aim is to practically test the proposed technologies and verify the laboratory prerequisites in the production of high-purity manganese together with the qualification of the produced large-volume samples in the supply chain and the training of employees. Its designed daily capacity is about 900 kg of processed material, from which approximately 33 kg of manganese metal or 100 kg of manganese sulphate is produced.



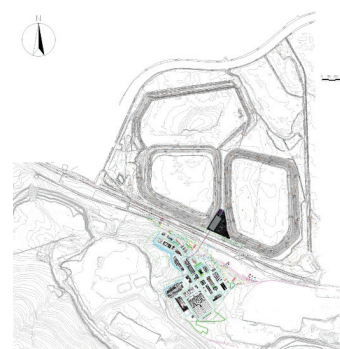
Production technology

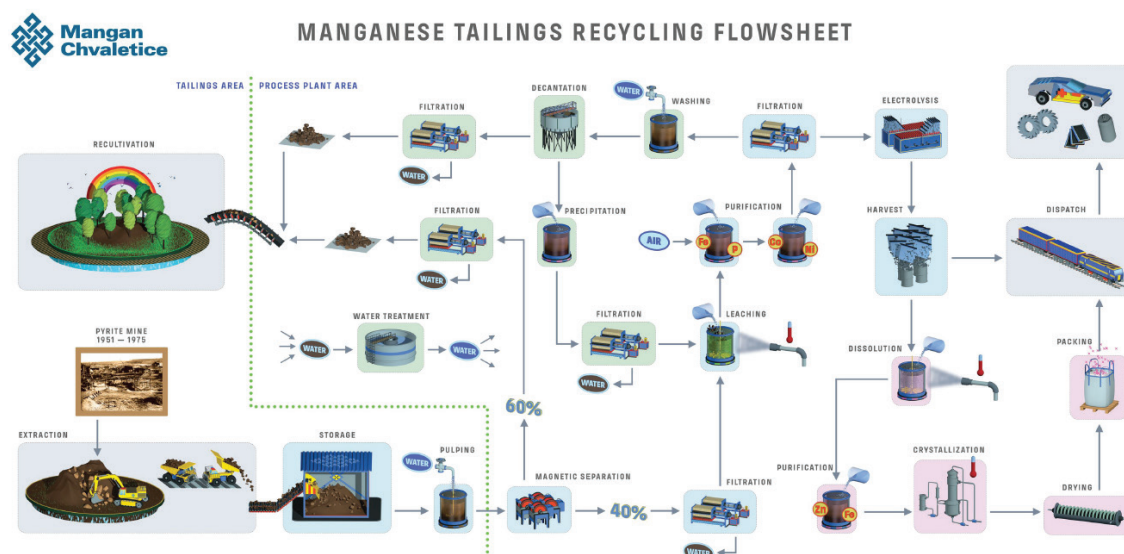
Removal of tailings

A hydraulic excavator removes tailings from a small part of the heap and loads it onto a truck. He transports it to the reservoir at the swimming station. The reservoir and the flooding station will be located in the free space between the two tailings heaps. From the storage room, the tailings are directed to the sieve by means of an automatic crane, where the coarse impurities are separated from it. The roughly cleaned tailings will be mixed in circulating water in the floating tanks to form a suspension. This slurry is pumped through a pipeline placed in the technological bridge into a reservoir in the processing part of the plant.

Magnetic separation

Under the influence of an intense magnetic field, manganese compounds are concentrated. The result will be a proportion of enriched tailings with a manganese content of approximately 15% and a non-magnetic fraction with a minimum residual manganese content. The tailings concentrate then undergoes leaching. The washed and dewatered non-magnetic part of the tailings will be transported by a closed tube conveyor over a technological bridge back to the heap area. Here it will be





stored in a pre-prepared repository. The water from the pressure filters will be pumped back to the flushing station in the heap area, where it will be reused to prepare a fresh tailings suspension.

Purification and electrolysis

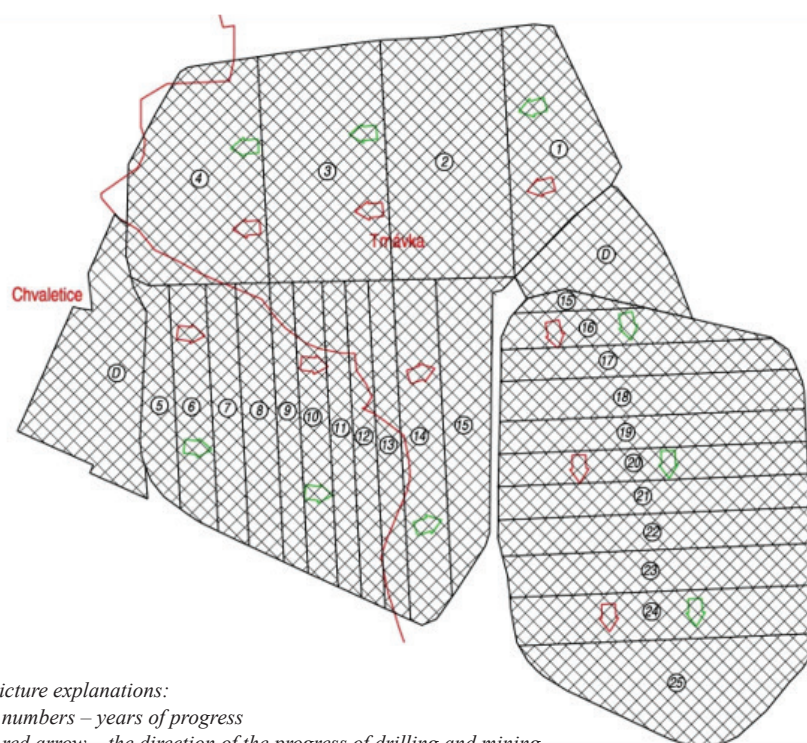
Leaching dissolves a number of compounds contained in the tailings. Therefore, it is essential to remove unwanted soluble salts before further processing of the manganese sulphate solution. The resulting filtrate – a purified solution of manganese sulphate – is ready for the electrolysis process. During the electrolysis of the solution, manganese metal is secreted at the stainless-steel cathodes, which is one of the target products. The exhausted solution after electrolysis still contains a certain amount of manganese, so it is returned to the leaching tanks. This will reduce manganese losses and the amount of waste or by-products produced.

Mechanical peeling of manganese

Manganese metal is deposited in a layer on the cathodes during the electrolytic process. These are then transported to a “peeling machine”. In this machine, the brittle layer of manganese is mechanically separated from the flexible electrode. The process results in manganese scales with a thickness of 0.5–0.7 mm. The scales are either packaged and shipped to customers or used in the second production stage for the production of manganese sulphate monohydrate. Since the dewatered material still contains significant amounts of manganese sulphate and other salts after leaching, these salts need to be recovered and returned to the production process. The residual manganese from the solution is precipitated and the precipitate obtained returns to the leaching stage. This minimizes manganese loss.

Manganese Sulphate Monohydrate Production Process

Approximately 30% of the manganese obtained by electrolysis should be sent directly to customers. The remaining part is processed into manganese sulphate monohydrate. The scales of manganese metal obtained in the previous stage of production will be dissolved in a closed reactor in dilute sulfuric acid at a temperature of about 60 °C for several hours. The chemical reaction of manganese and acid results in a solution of manganese sulphate and hydrogen gas. The manganese sulphate solution will be further purified to remove trace amounts of



Picture explanations:

- numbers – years of progress
- red arrow – the direction of the progress of drilling and mining
- green arrow – direction of progress of reclamation
- red border – boundaries of cadastral areas (Trnávka and Chvaletice)
- area D – area of the landfill (in the east the external storage of mining waste and overburden material from the mining area and in the west the storage of overburden material from the plant area)

Diagram of the progress of stripping, extraction and rehabilitation work in individual years with a drawing of the cadastral areas



Condition of the area after completion of remediation and reclamation (aerial north-west view)

some metals, especially zinc and iron. The purified solution of manganese sulphate will still undergo several stages of treatment, which will lead to the formation of dry crystals. The hydrogen will be washed and dried for further use.

Disposal of cleaned tailings

The washed tailings from the production process will be stored in a pre-prepared repository located in the area of the former tailings. The repository will be designed in accordance with current regulations: upper and lower insulation of the material, drainage into collection tanks, and a stable slope of slopes excluding landslides will be provided. The aim of these measures is to minimise negative impacts on groundwater and the surroundings of the repository. Once the projected height of the repository is reached, continuous reclamation will be carried out.

Remediation and reclamation of the landscape

The design and method of securing the existing tailings corresponds to the customs and technical possibilities at the time of its creation, and therefore does not meet today's requirements for the safe securing of a storage site. The problem is mainly the leaching of pollutants into the subsoil, groundwater and the Elbe River (up to 45.5 kg of manganese, 37.6 kg of iron and 234 kg of sulphur per day) and the removal of the tailings material by wind and water erosion. If the current situation is maintained, contaminants in hazardous concentrations will be released into groundwater until the pollutants contained in the heaps are completely dissolved, which can take hundreds of thousands of years. The current economic conditions make it possible to stop the current groundwater contamination and to ensure a safe and suitable reclaimed form of the entire tailings impoundment area. The aim of the reclamation concept is to create such conditions that will lead to the creation or strengthening of the ecological, aesthetic and landscape-forming function of the site, the creation of a near-natural area with high biodiversity and stability.

Conclusion

Europe is fast becoming the main hub of the global electric and battery industry. There are currently 7 giga battery cell factories in operation. In Europe, local supply chains are being built and, in addition to convenient logistics, companies based in the European single market benefit from all the resulting benefits.

High-performance nickel-cobalt-manganese (NMC) lithium-ion batteries are increasingly being used in electric vehicles and other energy storage devices. These batteries store more energy, take less time to charge, have a longer lifespan, and are considered safer than other commercially available battery technologies.

Manganese is the most affordable and widely used of NMC materials. It has therefore become an important cathode material and is increasingly being used as a primary component in the production of batteries for the electric vehicle industry and for battery storage.

If battery manufacturers for the electric vehicle industry do not come up with an alternative technology in the near future, we expect that the demand for high-purity manganese products will exceed the supply many times over in the coming years, and this precious metal, which is hidden in the tailings near Chvaletice, will play an increasingly important role on the market.

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Outline of domestic mine production

		2018	2019	2020	2021	2022
Energy minerals						
Uranium	t U	34	33	29	27	21
	Concentrate production, t U ⁽¹⁾	29	36	28	26	22
Bituminous coal	kt	4,110	3,150	1,861	2,008	1,281
Brown coal	kt ⁽²⁾	39,187	37,465	29,505	29,278	33,233
Crude oil	kt	109	81	91	83	75
Natural gas	mill m ³	179	146	138	153	165
Industrial minerals						
Pyrope bearing rock	kt	13	12	1	0	3
Moldavite (tectite) bearing rock	ths m ³	61	42	46	49	48
	kt (1 m ³ = 1.8 kt)	110	76	83	88	86
Kaolin	Raw, kt ⁽³⁾	3,622	3,446	3,069	3,454	3,009
	Beneficiated, kt	653	629	626	645	558
Clays	kt	469	441	454	456	478
Bentonite ⁽⁴⁾	kt	277	357	226	198	167
Diatomite	kt	31	43	46	18	44
Feldspar	kt	449	460	419	504	493
Feldspar substitutes	kt	31	33	29	24	21
Silica minerals	kt	16	17	11	20	10
Glass sand	kt	743	740	683	715	664
Foundry sand	kt	559	514	470	583	615
Limestones and corrective additives for cement production	kt	11,727	11,806	11,296	11,480	10,784
Dolomite	kt	451	453	398	393	429
Gypsum	kt	8	10	17	17	20
Construction minerals						
Dimension stone	Mine production in reserved deposits, ths m ³ ⁽⁵⁾	116	117	135	125	112
	Mine production in reserved deposits, kt (1 m ³ = 2.7 kt) ⁽⁵⁾	313	315	365	338	302
	Mine production in non-reserved deposits, ths m ³ ⁽⁶⁾	18	16	47	62	32
	Mine production in non-reserved deposits, kt (1 m ³ = 2.7 kt) ⁽⁶⁾	49	42	127	167	86
Crushed stone	Mine production in reserved deposits, ths m ³ ⁽⁵⁾	14,140	14,057	14,247	14,883	14,883
	Mine production in reserved deposits, kt (1 m ³ = 2.7 kt) ⁽⁵⁾	38,178	37,954	38,467	40,184	40,184
	Mine production in non-reserved deposits, ths m ³ ⁽⁶⁾	1,151	1,449	1,465	1,703	1,805
	Mine production in non-reserved deposits, kt (1 m ³ = 2.7 kt) ⁽⁶⁾	3,108	3,912	3,956	4,598	4,874
Sand and gravel	Mine production in reserved deposits, ths m ³ ⁽⁵⁾	6,499	6,204	6,476	6,602	6,739
	Mine production in reserved deposits, kt (1 m ³ = 1.8 kt) ⁽⁵⁾	11,698	11,167	11,657	11,884	12,130
	Mine production in non-reserved deposits, ths m ³ ⁽⁶⁾	4,875	4,897	4,821	5,270	5,046
	Mine production in non-reserved deposits, kt (1 m ³ = 1.8 kt) ⁽⁶⁾	8,775	8,815	8,678	9,486	9,083
Brick clays and related minerals	Mine production in reserved deposits, ths m ³ ⁽⁵⁾	825	694	560	595	578
	Mine production in reserved deposits, kt (1 m ³ = 1.8 kt) ⁽⁵⁾	1,485	1,249	1,008	1,071	1,040
	Mine production in non-reserved deposits, ths m ³ ⁽⁶⁾	298	301	404	411	558
	Mine production in non-reserved deposits, kt (1 m ³ = 1.8 kt) ⁽⁶⁾	536	542	727	740	806
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

		2018	2019	2020	2021	2022
Energy minerals						
Uranium (U)	world: WNA	0.06%	0.07%	0.06%	0.05%	0.04%
Bituminous coal	world: IEA, BP	0.07%	0.04%	0.03%	0.03%	0.02%
Brown coal + Lignite	world: IEA, BP	4.68%	5.07%	4.62%	4.60%	4.50%
Crude oil	world: BP	0.002%	0.002%	0.002%	0.002%	0.001%
Natural gas	world: BP	0.005%	0.004%	0.004%	0.004%	0.004%
Industrial minerals						
Gemstones	Pyrope bearing rock	N	N	N	N	N
	Moldavite (tectite) bearing rock	N	N	N	N	N
Kaolin	world: MCS	9.79%	8.20%	6.98%	7.04%	6.27%
Clays		N	N	N	N	N
Bentonite	world: MCS	1.32%	1.93%	1.41%	1.27%	0.88%
Diatomite	world: MCS	1.15%	1.48%	2.09%	0.78%	1.76%
Feldspar	world: MCS	1.95%	1.77%	1.82%	1.90%	1.76%
Feldspar substitutes		N	N	N	N	N
Glass + Foundry sand	world: MCS	0.43%	0.38%	0.44%	0.54%	0.34%
Limestones	world: MCS *	0.24%	0.23%	0.22%	0.26%	0.22%
Dolomite		N	N	N	N	N
Gypsum	world: MCS	0.004%	0.007%	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

1,519 reserved and 806 non-reserved mineral deposits were registered in the Czech Republic as of December 31, 2022. The number of exploited deposits was markedly lower – 483 reserved and 168 non-reserved. Only 36 reserved and 8 non-reserved deposits were mined in the specially nature protected areas, which represents 7.45 % and 4.80 % 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 4th zones of the CHKO, nature reserves, national nature monuments and nature monuments),

Specially protected areas (ZCHÚ) in the Czech Republic

Number/year	2018	2019	2020	2021	2022
Total number	2,639	2,663	2,694	2,698	2,708
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	2,678

Source: AOPK ČR (2023)

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 2022

Category of specially protected areas	Number	Area (km ²)	Proportion on the territory of the Czech Republic 78 864 km ² (%)
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 1 st 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)	128	82.7	0.11
National nature reserve (NPR)	116	304.4	0.39
Nature monuments (PP)	1,599	339.0	0.43
Nature reserves (PR)	835	436.8	0.55
NPP, NPR, PP, PR	2,678	1,162.9	1.47
– (from them NPP, NPR, PP, PR on the area of NP, CHKO)	753	472.1	0.59
LARGE-EXTENT AND SMALL-EXTENT ZCHÚ – total	2,708	13,735	17.42

* data from 2013, currently without updating

Source: AOPK ČR (2023)

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 km² and now is called 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				
	2018	2019	2020	2021	2022	2018	2019	2020	2021	2022
Gemstones*	13	8	1	0	2	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***	195	547	494	607	574	0	0	0	0	0
Feldspar	363	360	352	432	414	0	0	0	0	0
Limestone	3,183	3,228	3,040	5,043	3,980	2	0	0	0	0
Dimension stone**	55	48	85	95	57	1,4	1	0,1	0	3
Crushed stone**	3,996	4,454	4,340	4,153	3,542	301	30	21	22	624
Sand and gravel**	1,087	1,474	1,333	1,426	1,307	13	20	18	0	40
Brick clay**	0	0	0	0	0	0	0	0	0	0
Total	8,758	9,865	9,647	11,757	9,874	305	51	39	22	667
Index, 1990 = 100	54	62	61	74	61	–	–	–	–	–
Index, 2000 = 100	95	109	108	131	108	99	17	13	7	221

* *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.

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 km² (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 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	2018	2019	2020	2021	2022
Beskydy Mts.	24	18	43	52	37
Bílé Karpaty Mts.	192	177	197	242	200
Blaník	0	0	0	0	0
Blanský les	718	1,024	806	1,023	1,026
Brdy **	7	0	0	0	11
Broumov region	108	79	153	139	106
České středohoří Mts.	2,300	2,122	2,053	2,025	2,059
Český kras (Bohemian Karst)	3,222	3,293	3,369	3,224	3,288
Český les Mts.	0	0	0	0	0
Český ráj	0	0	0	0	0
Jeseníky Mts.	130	74	68	23	86
Jizerské hory Mts.	12	0	0	0	0
Kokořín region – Máchův kraj	195	547	494	388	574
Křivoklát region	297	346	301	397	214
Labské pískovce (Elbe sandstones)	0	0	0	0	0
Litovelské Pomoraví region	0	0	0	0	0
Lužické hory Mts.	0	5	0,1	0	2
Moravský kras (Moravian Karst)	1,857	1,997	1,822	1,933	1,491
Orlické hory Mts.	0	0	0	0	0
Pálava region	0	0	0	0	0
Poodří region	196	116	200	191	206
Slavkovský les region	255	279	267	302	311
Šumava Mts.	120	170	76	66	95
Třeboň region	1,235	1,186	1,165	1,365	1,379
Žďárské vrchy Mts.	132	165	141	157	133
Železné hory Mts.	30	174	203	161	149
Total mine production (rounded)	11,030	11,772	11,359	11,688	11,161

* in 2014 the CHKO Kokořínsko was extended about 140 km², 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.

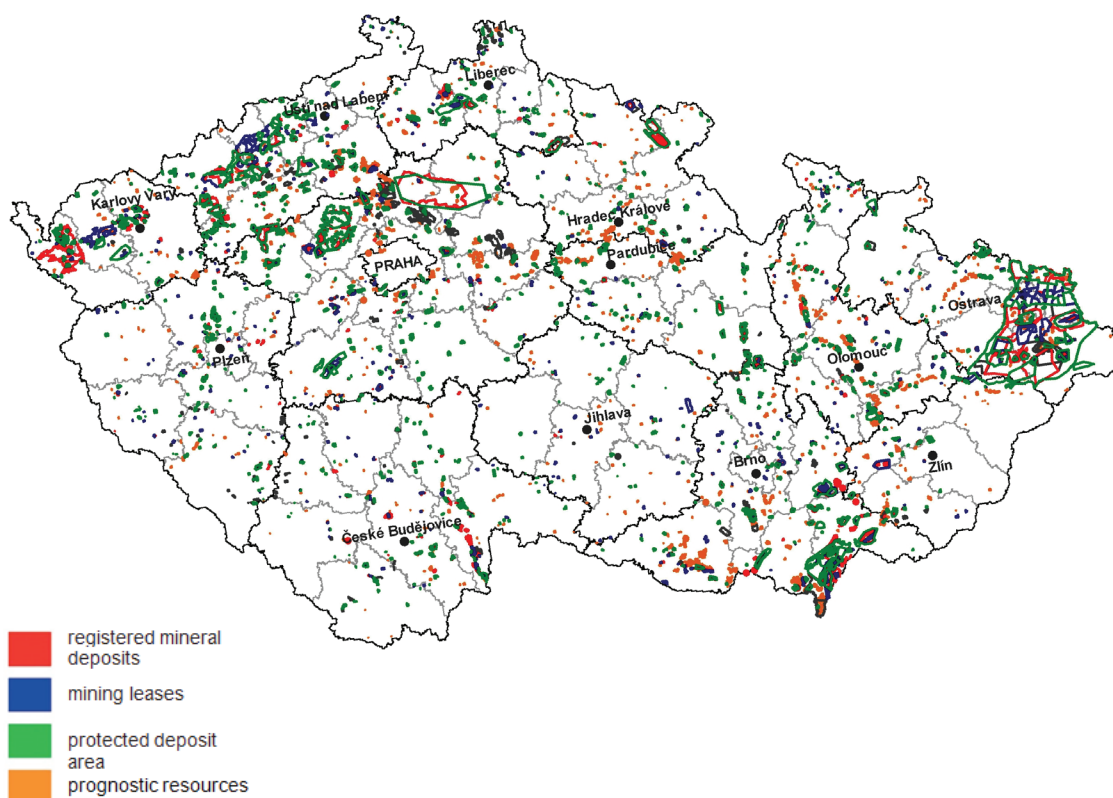
Impact of mining of reserved deposits in CHKO, t/km² in a year
(areas of CHKO as of December 31)

Name of CHKO	area km ² in 2022	2018	2019	2020	2021	2022
Beskydy Mts.	1,205	20	15	35	43	31
Bílé Karpaty Mts.	747	261	240	264	324	268
Blaník	40	0	0	0	0	0
Blanský les	220	3,279	4,655	3,663	4,650	4,664
Brdy*	345	20	0	23	0	0
Broumov region	432	250	183	404	322	245
České středohoří Mts.	1,069	2,152	1,985	1,921	1,894	1,926
Český kras (Bohemian Karst)	132	24,409	24,947	25,523	24,424	24,909
Český les Mts.	466	0	0	0	0	0
Český ráj	182	0	0	0	0	0
Jeseníky Mts.	744	175	100	91	31	116
Jizerské hory Mts.	374	32	0	0	0	0
Kokořín region – Máchův kraj*	410	476	1,334	1,205	946	1,400
Křivoklát region	625	475	554	482	635	342
Labské pískovce (Elbe sandstones)	243	0	0	0	0	0
Litovelské Pomoraví	93	0	0	0	0	0
Lužické hory Mts.	271	0	20	0,5	0	7
Moravský kras (Moravian Karst)	97	19,144	20,588	18,784	19,928	15,371
Orlické hory Mts.	233	0	0	0	0	0
Pálava region	85	0	0	0	0	0
Poodří region	82	2,390	1,415	2,439	2,329	1,403
Slavkovský les	611	418	457	437	494	509
Šumava Mts. (CHKO + NP)	1,680	71	101	45	39	57
Třeboň region	687	1,798	1,726	1,695	1,987	2,007
Žďárské vrchy Mts.	709	186	233	197	221	188
Železné hory Mts.	285	105	611	801	565	523
TOTAL (total mining/total area)	12,065	914	976	942	969	925

Note: an impact exceeding 10,000 t/km² 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 km², 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 profit 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, 2022

Region	Area affected by mining in mining leases (km ²)	Area affected by mining outside mining leases (km ²)
Capital City of Prague	1.13	0.04
Central Bohemia	14.08	1.37
South Bohemia	10.33	0.84
Plzeň	71.12	0.76
Karlovy Vary	45.94	27.63
Ústí nad Labem	111.64	5.80
Liberec	12.16	4.90
Hradec Králové	3.90	0.16
Pardubice	6.35	0.59
Vysočina	4.26	1.66
South Moravia	18.37	1.04
Olomouc	12.82	2.21
Zlín	2.44	0.15
Moravia and Silesia	214.50	5.01
Czech Republic	465.03	52.14

Development of reclamations after mining

km ²		2018	2019	2020	2021	2022
Reserved deposits	Area with manifestation of mining, not yet reclaimed	493	426	414	336	513.4
	Reclamations in process	63	60	63	28	55.5
	Reclamations finished since the start of mining	252	255	271	273	262.4
	Reclamations finished in the given year	5	4	12	2.4	3.3
Non-reserved deposits	Area with manifestation of mining, not yet reclaimed	15	16	17	10.3	16.6
	Reclamations in process	4	5	4	2.3	3.3
	Reclamations finished since the start of mining	3	3	4	4.4	4.1
	Reclamations finished in the given year	0.3	0.2	0.9	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 (*Brodskom 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 minière, Paris*). “This consisted of using cut grass to encourage vegetation growth by spreading it over the

Reclamation after mining of reserved minerals in 2022

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	8	0	43	0	53	0	14	0	57	39	83	34	140	3	42	1
South Moravia	184	0	43	0	2	0	26	0	358	32	192	20	4	0	23	10
Karlovy Vary	135	51	166	203	0	0	69	325	396	1,170	1,409	2,677	559	32	162	117
Hradec Králové	25	0	5	0	3	0	7	0	41	3	67	3	43	0	27	2
Liberec	16	0	29	2	25	0	10	0	90	48	362	32	5	0	15	2
Moravia and Silesia	10	5	304	73	18	2	507	12	873	77	872	192	323	5	515	37
Olomouc	17	0	39	16	112	0	33	0	21	98	26	51	96	4	4	5
Pardubice	6	0	2	1	0	0	5	0	13	0	17	8	76	0	11	2
Plzeň	29	0	55	1	1	0	0	0	4	16	42	44	0	0	18	0
Prague	0	0	0	0	0	0	5	0	1	3	0	0	0	0	3	1
Central Bohemia	122	0	143	3	7	0	24	1	325	75	101	11	90	0	108	16
Ústí nad Labem	433	59	1,134	284	30	7	524	75	2,046	2,360	2,447	2,607	252	213	1,102	1,277
Vysočina	0	0	0	0	0	0	4	6	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	987	115	1,962	582	250	9	1,230	420	4,262	3,975	5,653	5,683	1,589	258	2,037	1,485

[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/km² (without site preparation) and a maximum of 1.36–1.87 EUR/km² (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/km².”

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 biologically 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

**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 2023)

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 2022	data 2022	data 2013*	data 2013*	data 2013*/ data 2022	data 2013*/ data 2022
Central Bohemia	311	17,080	41	817.99	4.78 %	13.18 %
Prague	93	2,431	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	344	11,485	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	5,903	6	244.38	4.12 %	0.48 %
Vysočina	204	5,934	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	335	16,671	18	247.24	1.49 %	0.53 %
Czech Republic total	2,678	116,293	217	3 523.16	3.03 %	8.13 %

* Data from 2023 onwards are not available.

appropriately. This should be covered by mandatory funds generated by the mining 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 be 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, aggressive 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 nepřirodních 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 findings 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

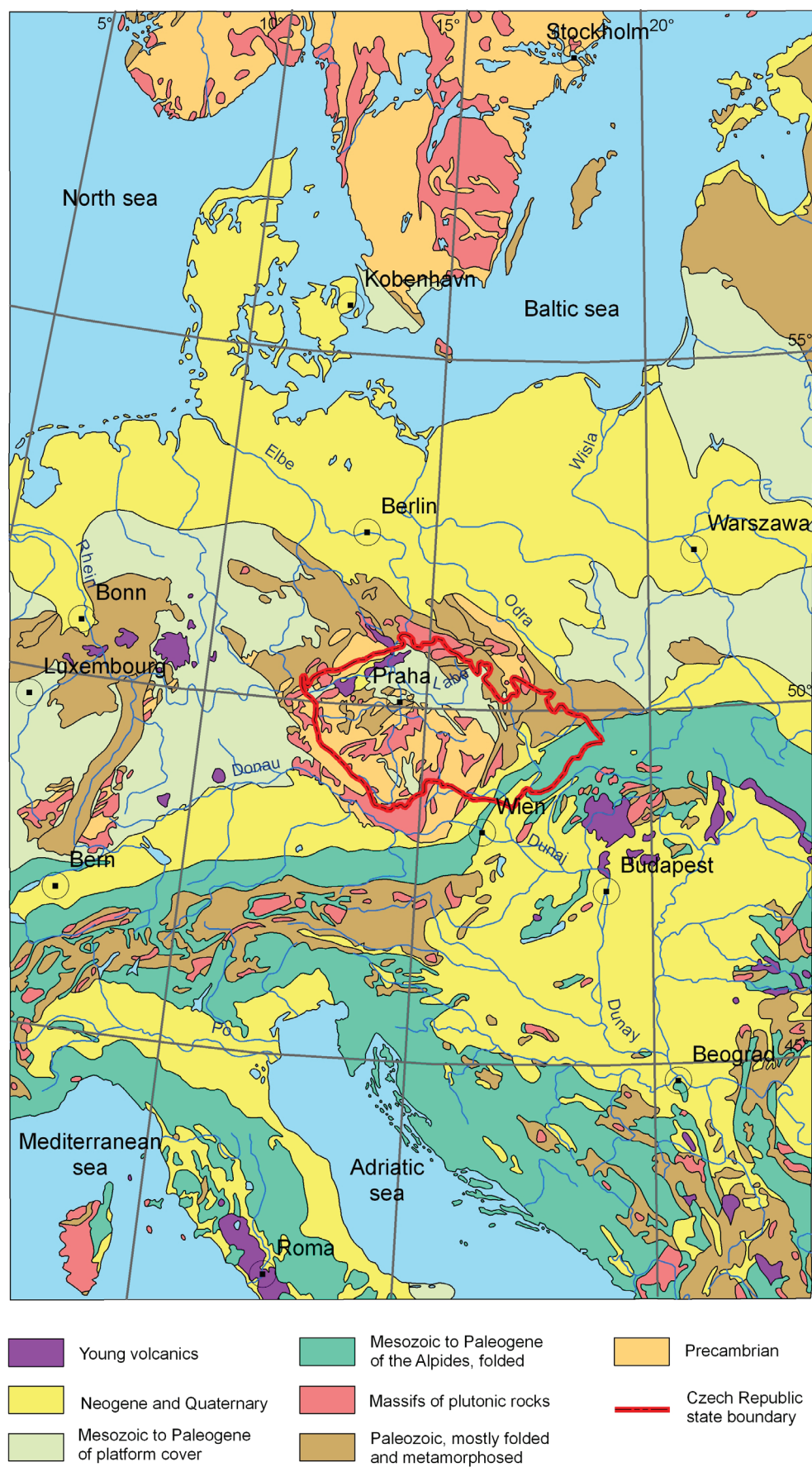


Fig. 1: Geological position of the Czech Republic in Europe

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 19th 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 Svatka 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 granitoid 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.

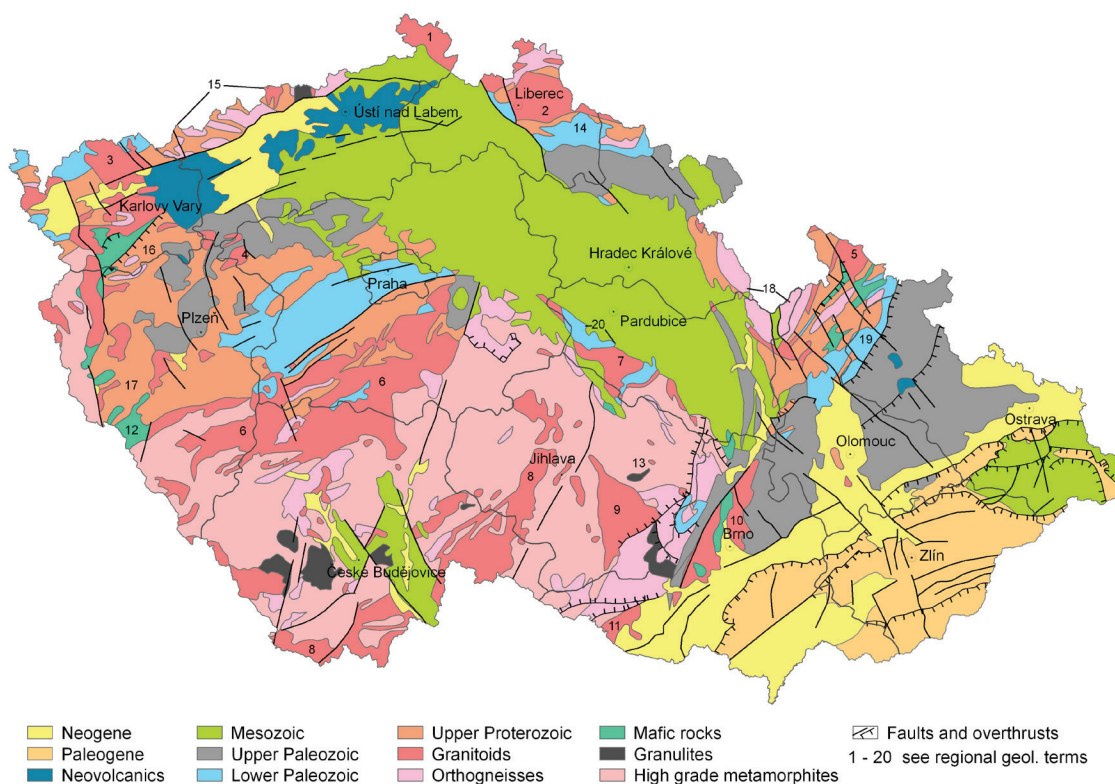


Fig. 2: Geology of the Czech Republic

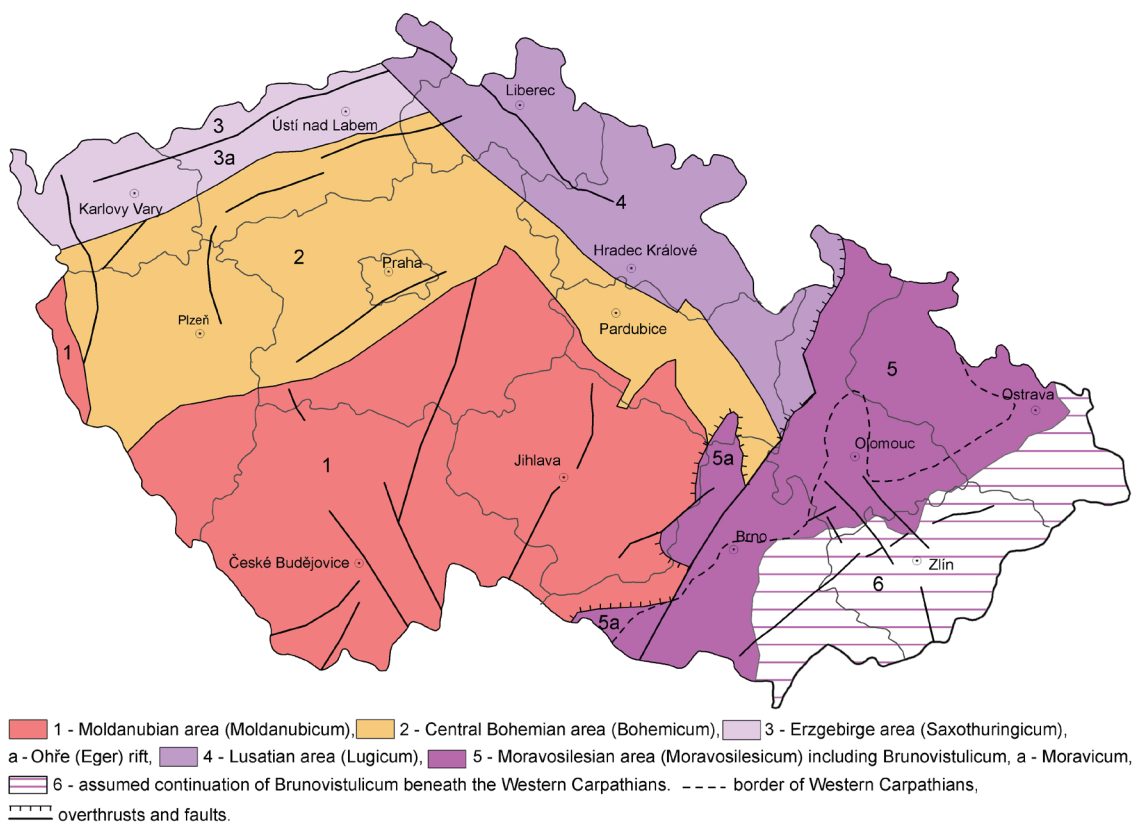


Fig. 3: Regional basement division of the Bohemian Massif on the territory of the Czech Republic

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, Lügicum 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 magmatogenic 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. Mokrý, 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 km² 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 Triassic. 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.

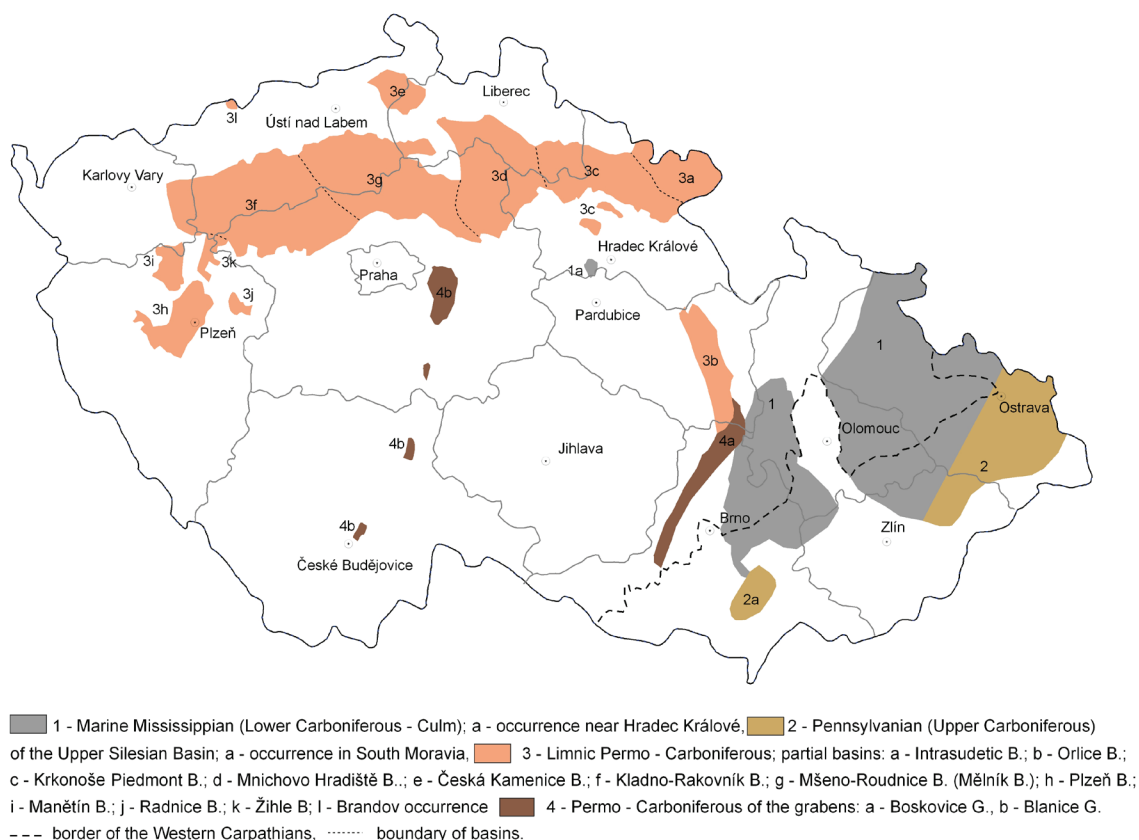
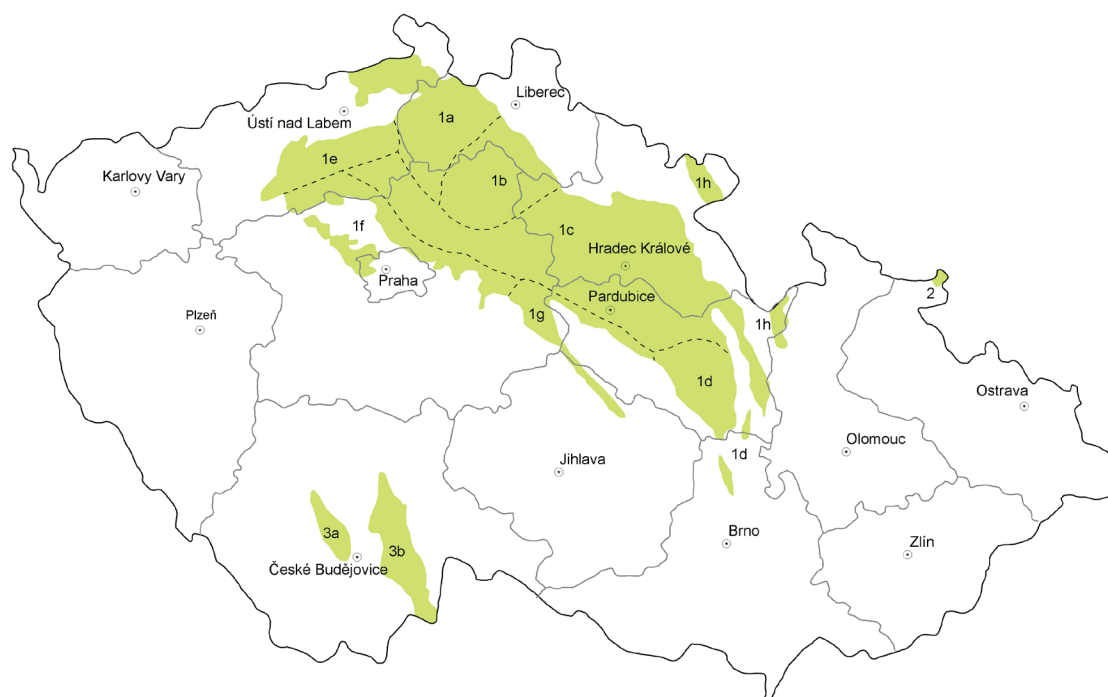


Fig. 4: Carboniferous and Permian in the Bohemian Massif and in the basement of the Western Carpathians on the territory of the Czech Republic

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 Štramberský 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,

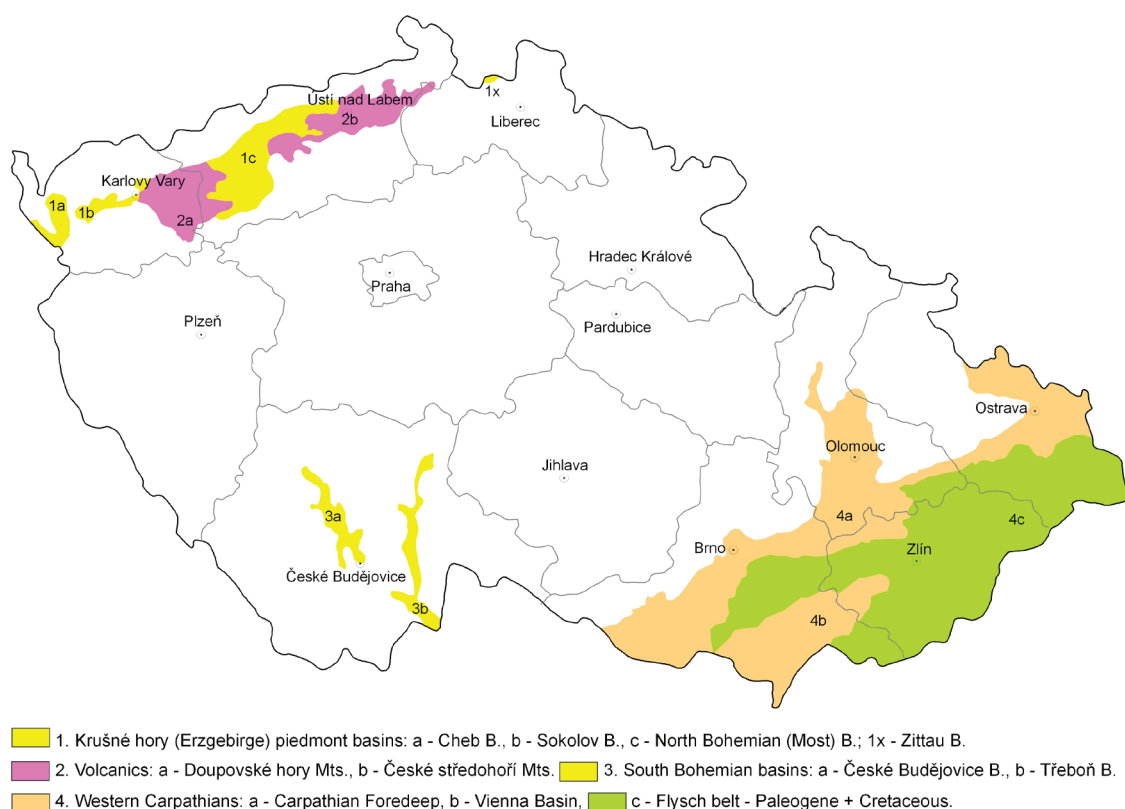


Fig. 6: Tertiary in the Bohemian Massif and Western Carpathians on the territory of the Czech Republic

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 60m) 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

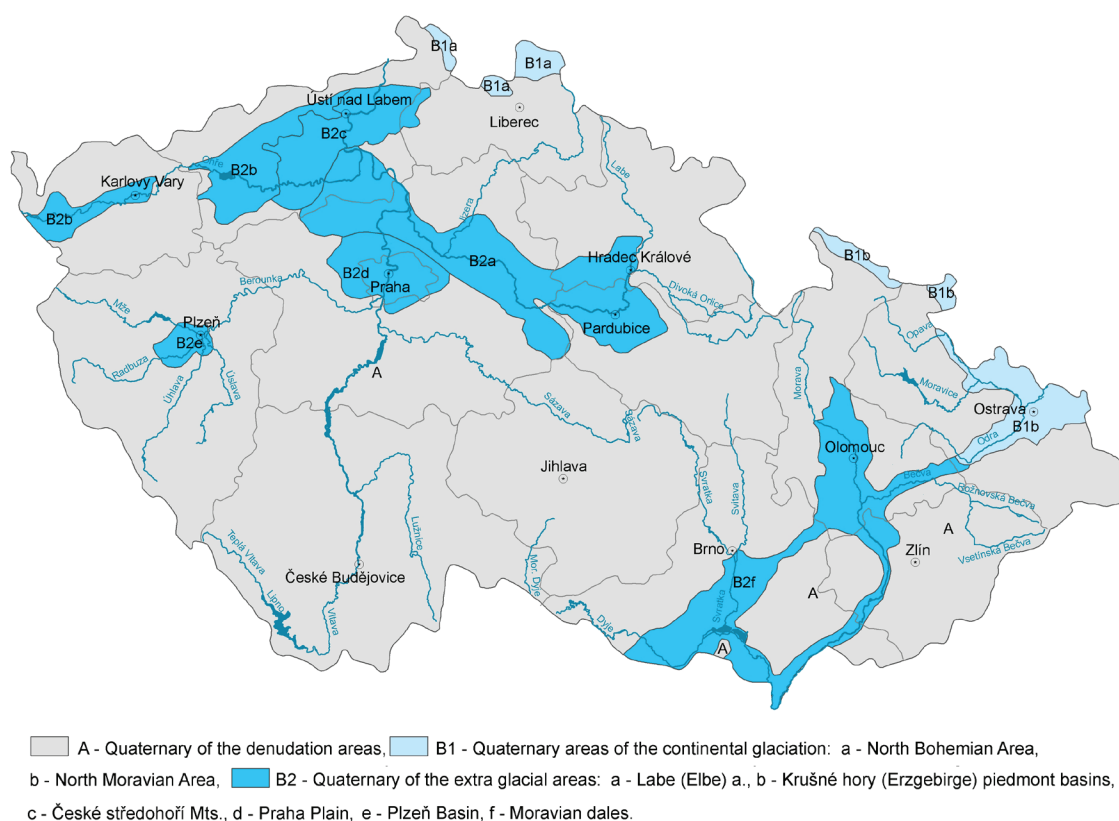


Fig. 7: Quaternary division on the territory of the Czech Republic

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 Bohemikum 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 thickness, 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 Triassic (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 – Štramperk, 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 Moldanubian 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, Ondřej 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).



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.

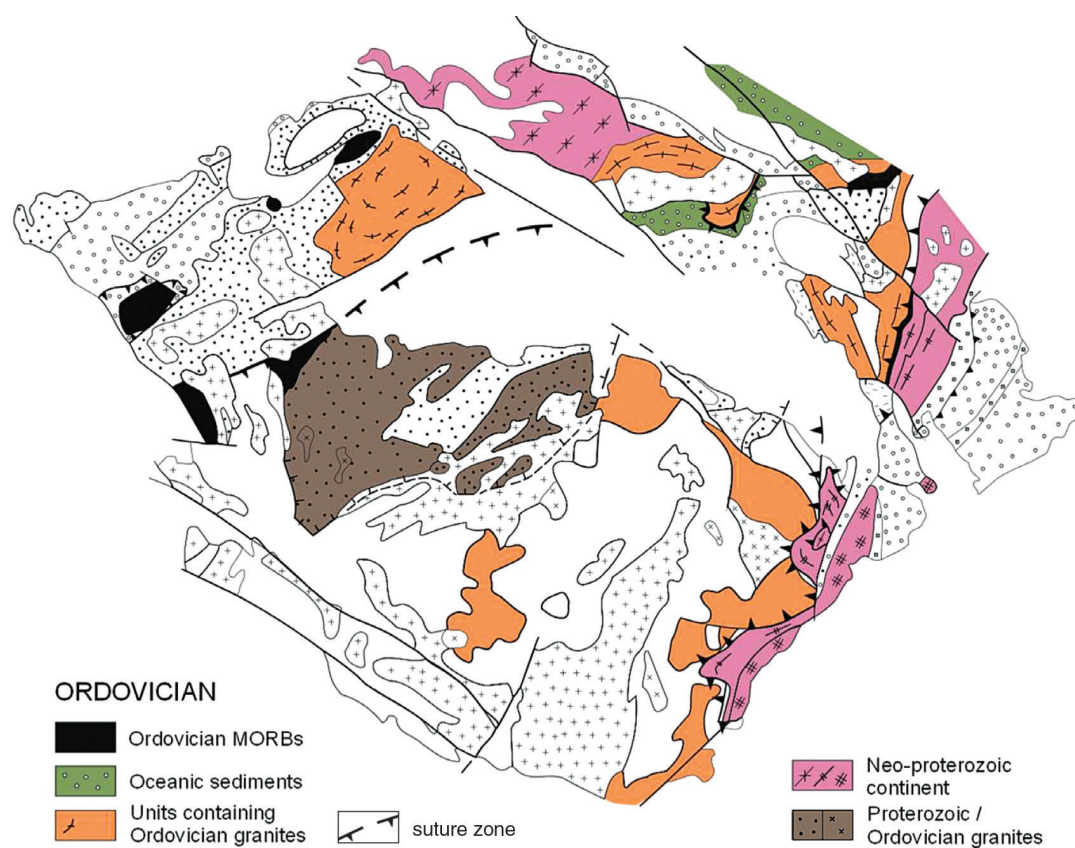


Figure 2a. Architectural evolution of the Bohemian Massif – Ordovician stage

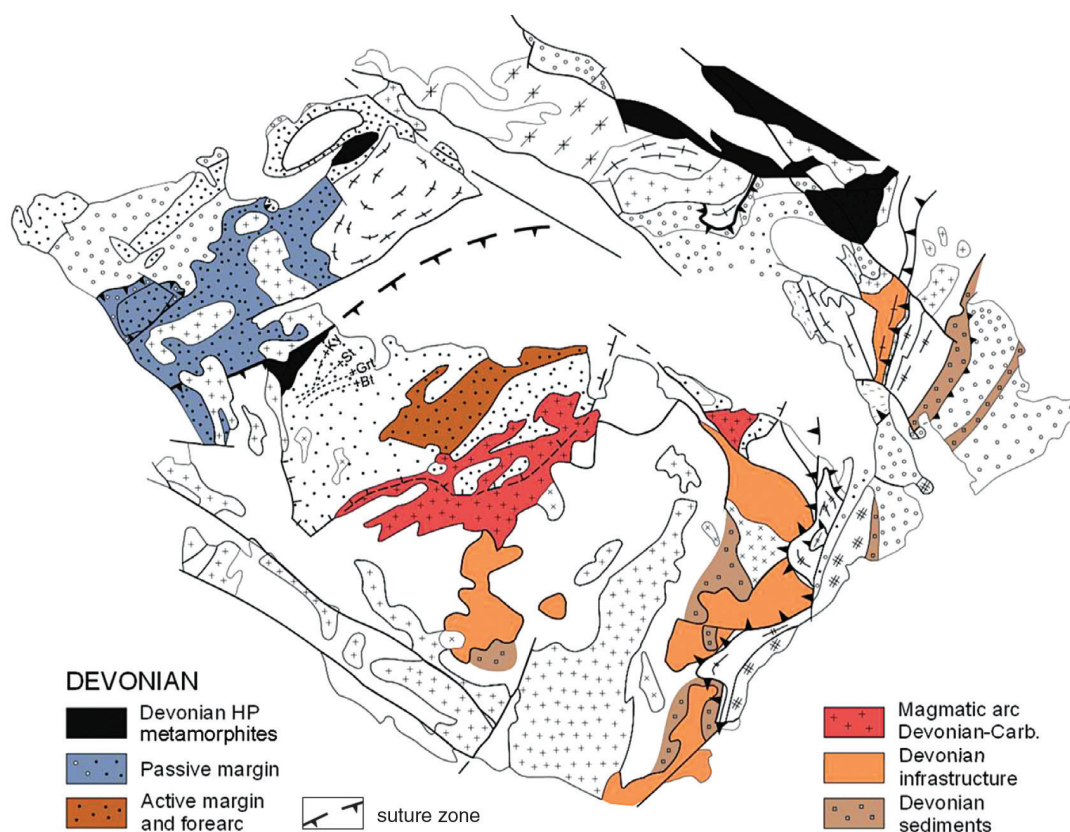
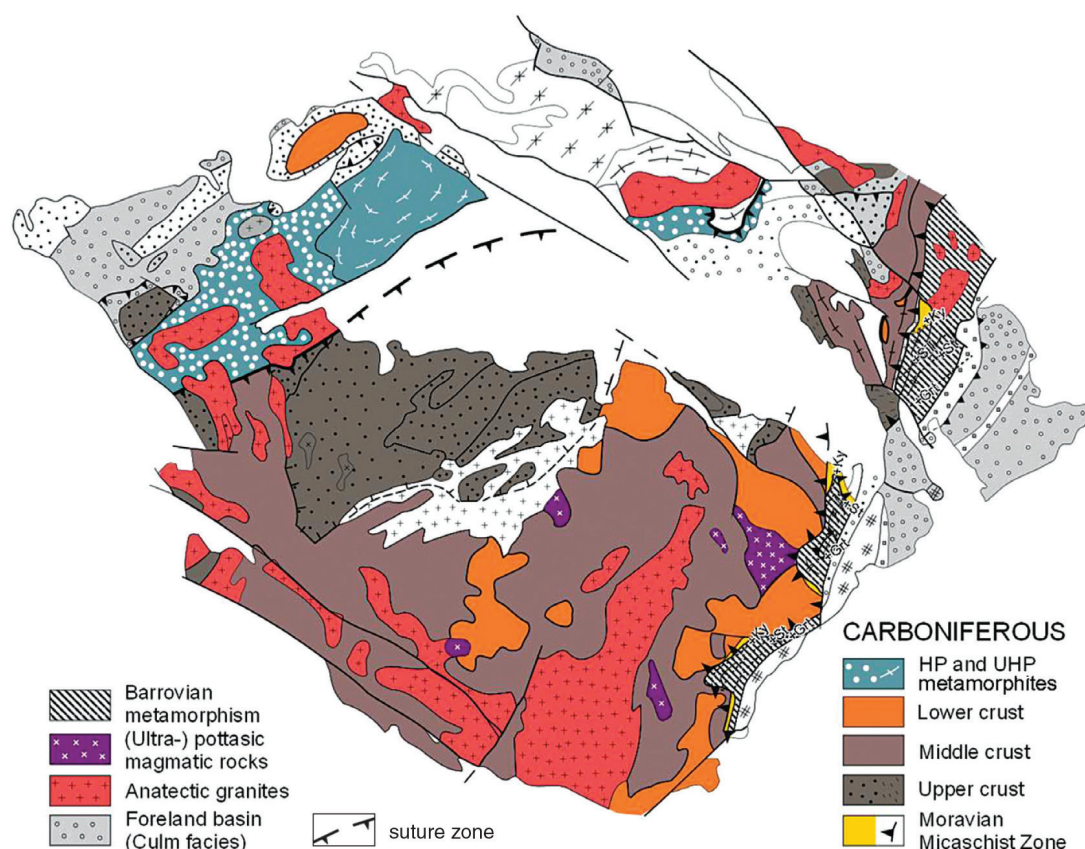


Figure 2b. Architectural evolution of the Bohemian Massif – Devonian stage



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 $^{40}\text{Ar}/^{39}\text{Ar}$ 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 Drosendorf 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 $^{40}\text{Ar}/^{39}\text{Ar}$ 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

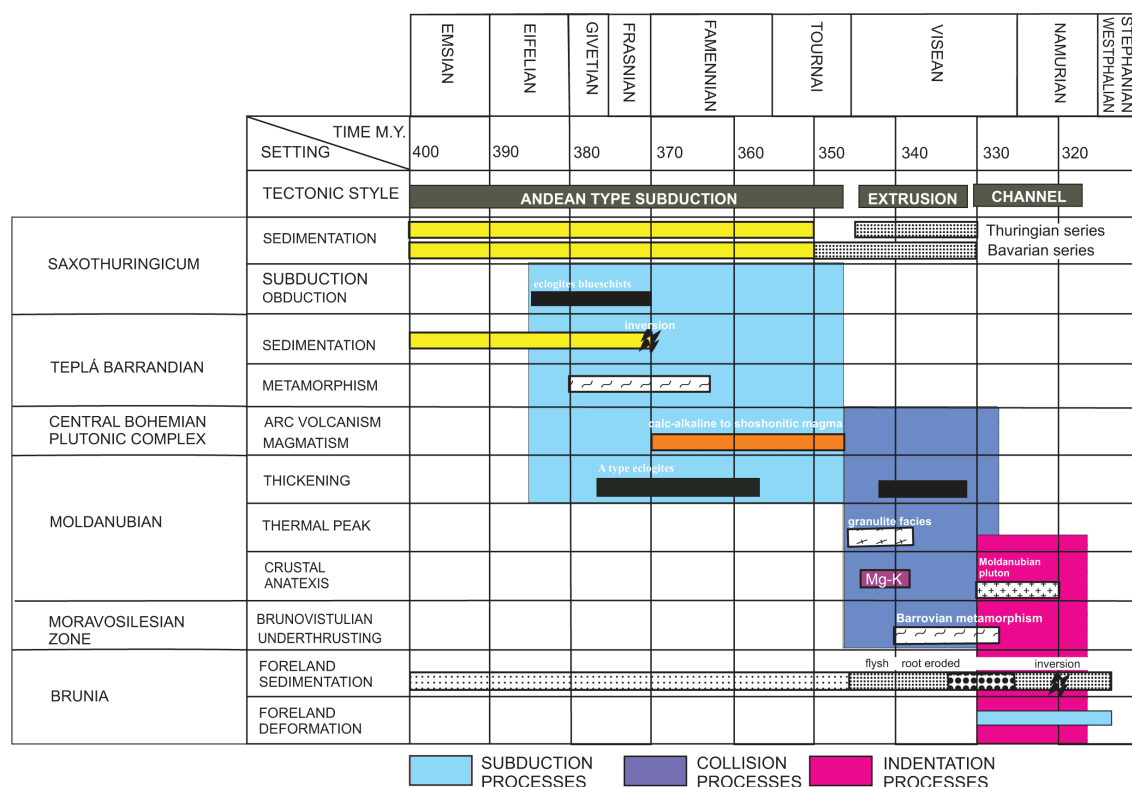


Figure 3. Chronological chart of tectonic events forming Bohemian Massif

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 Teplá-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 fore-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

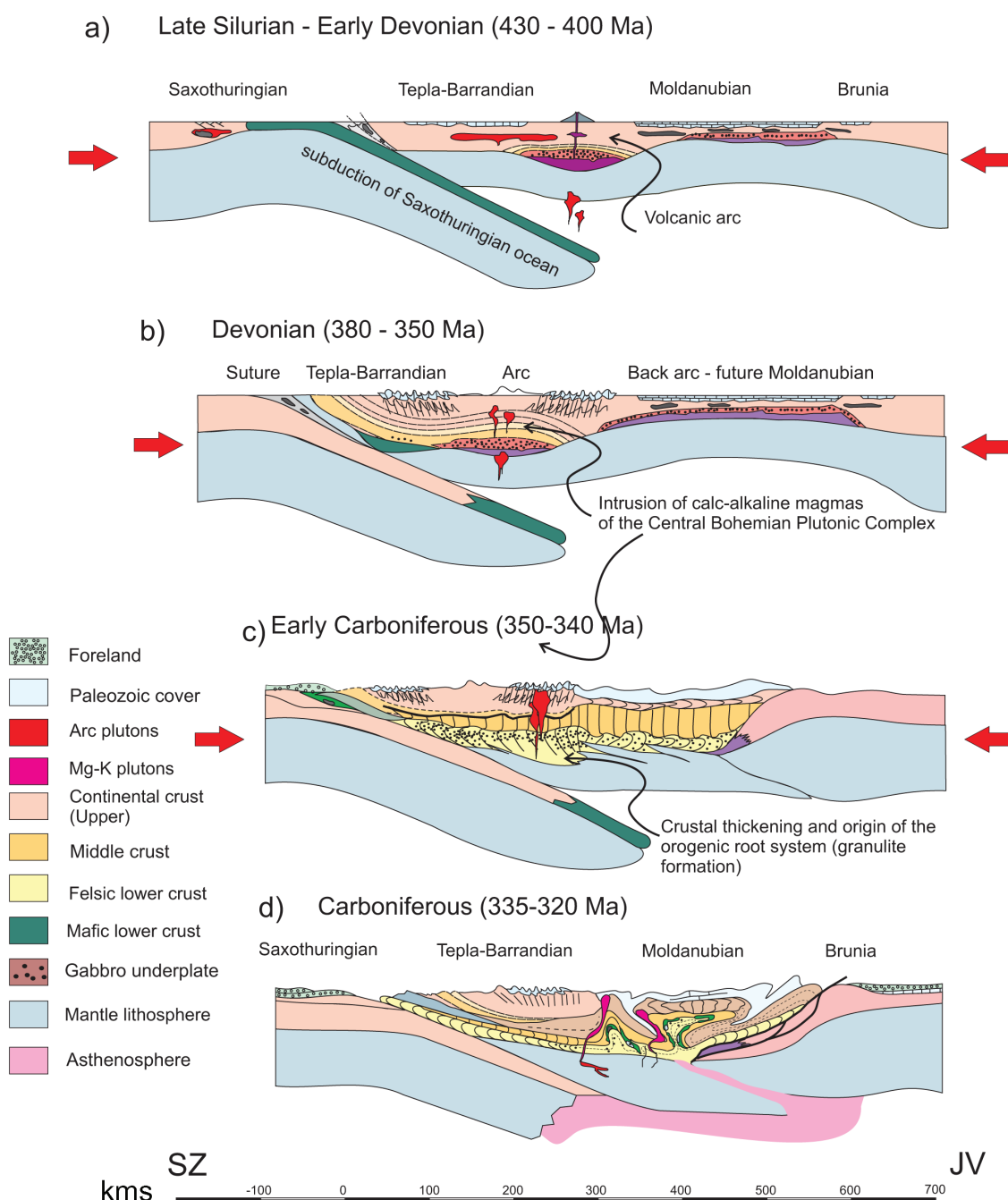


Figure 4. Geodynamics of the Bohemian Massif

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 paleocean 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.

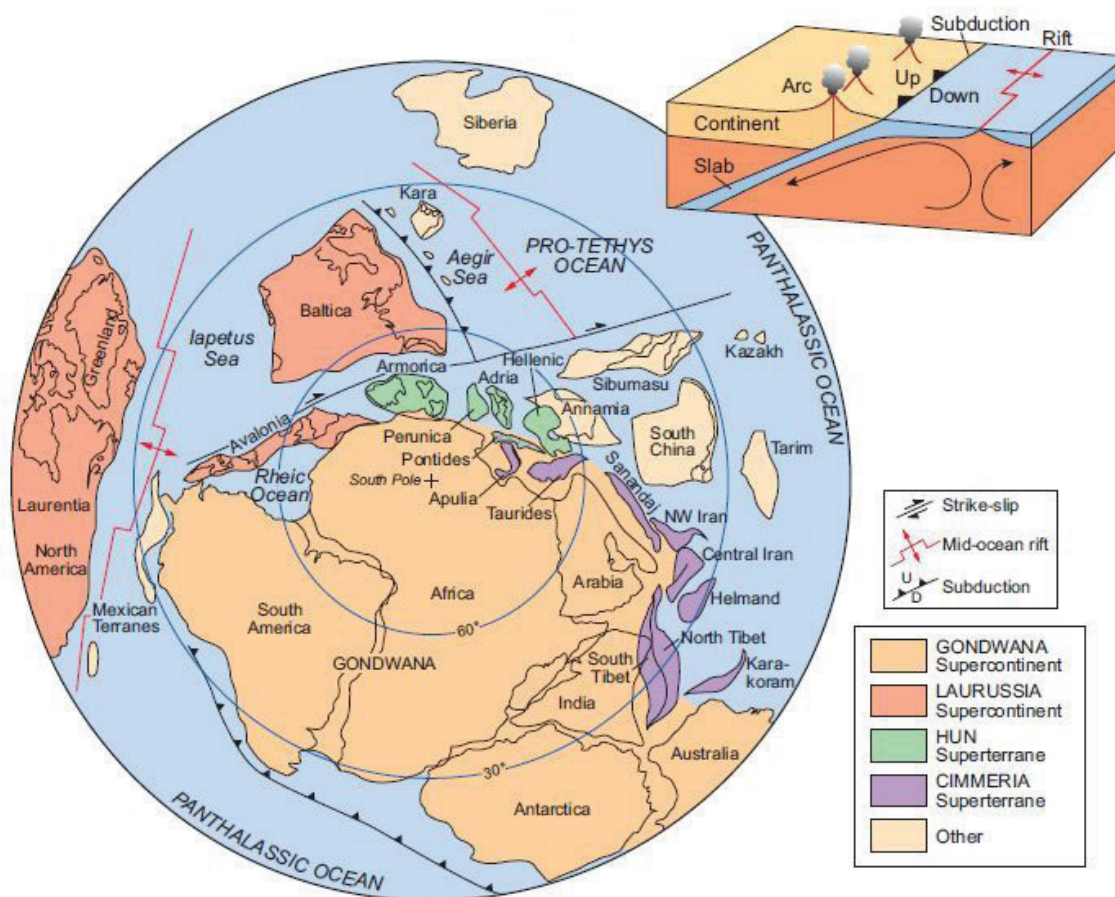


Fig. 1. Paleogeography of Upper Cambrian (before 500 Ma).

Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

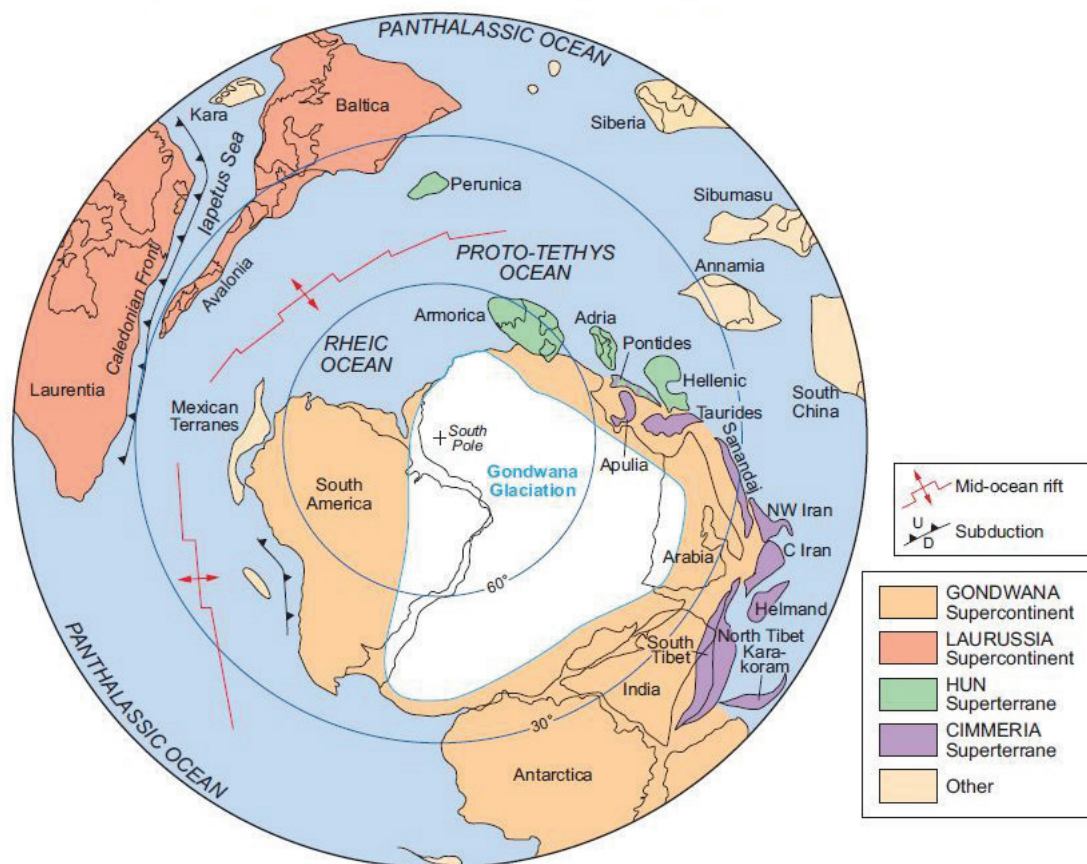


Fig. 2. Paleogeography of the boundary of the Uppermost Ordovician and Lowermost Silurian (before 440 Ma). Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

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 subducted 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

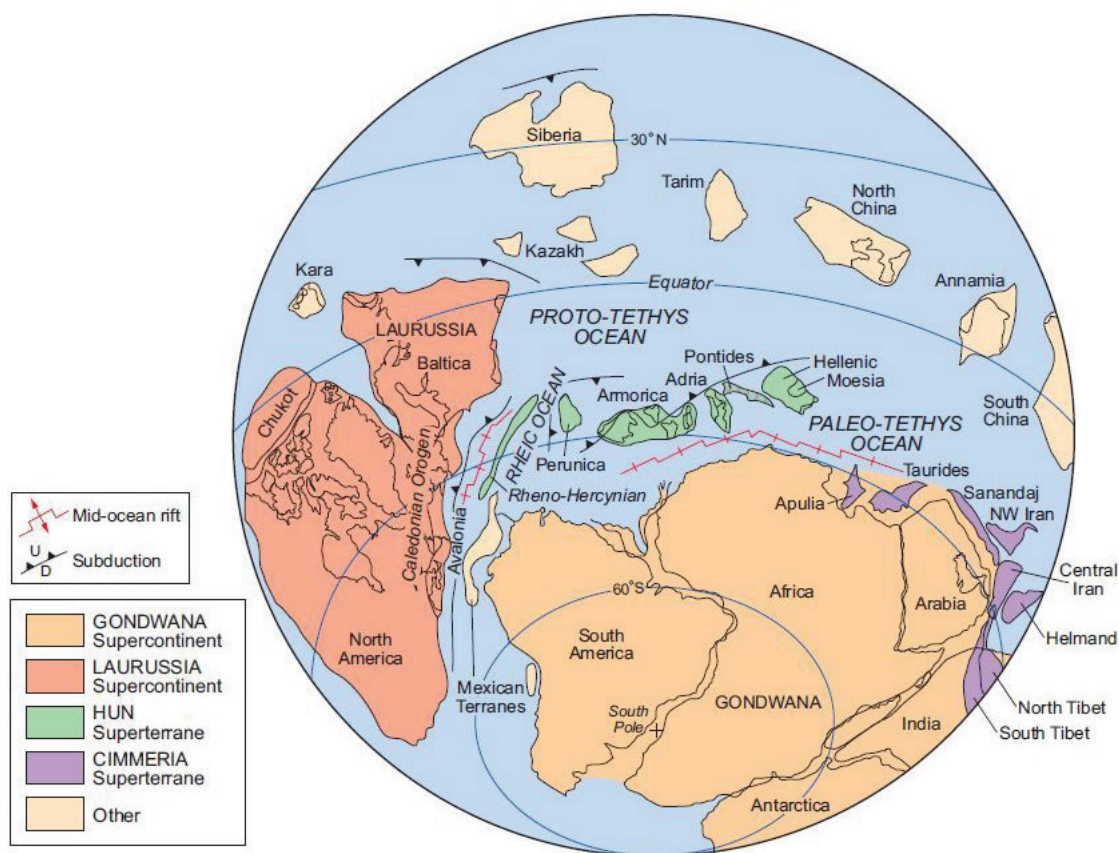


Fig. 3. Paleogeography of the Early Devonian (before 400 Ma).

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

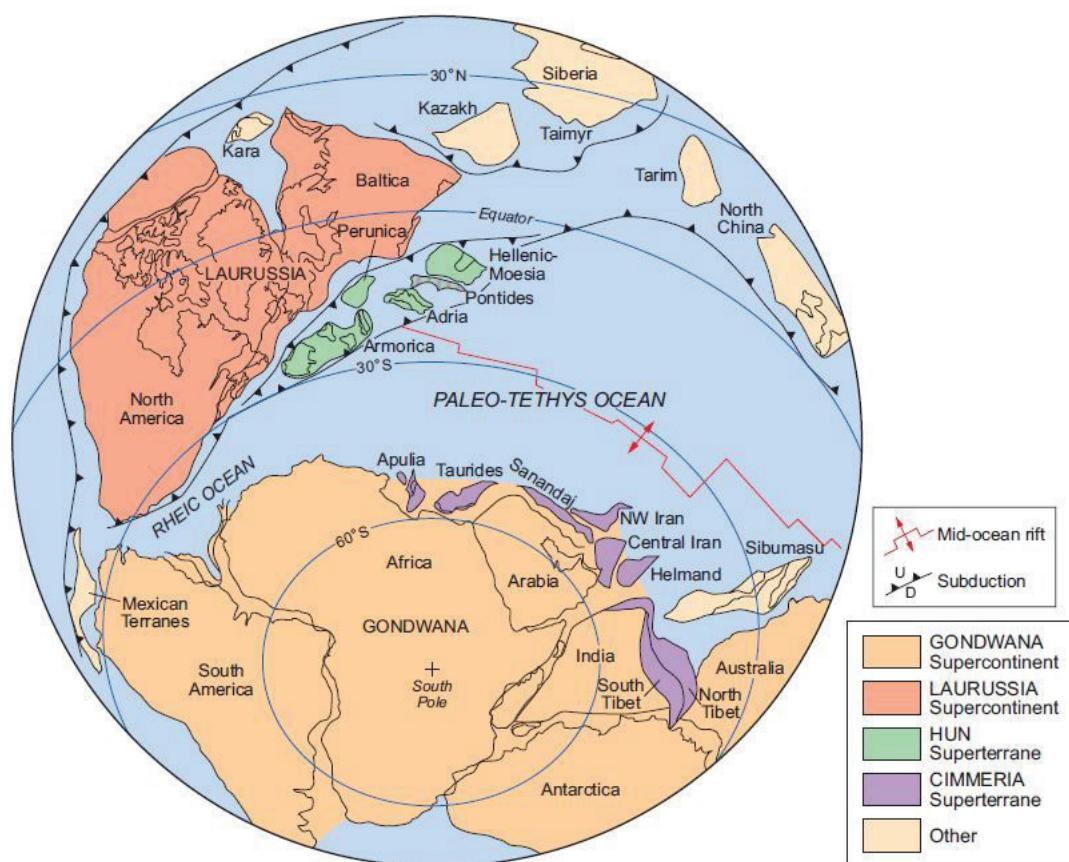


Fig. 4. Paleogeography of the Early Carboniferous (Mississippian before 340 Ma).
Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

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.

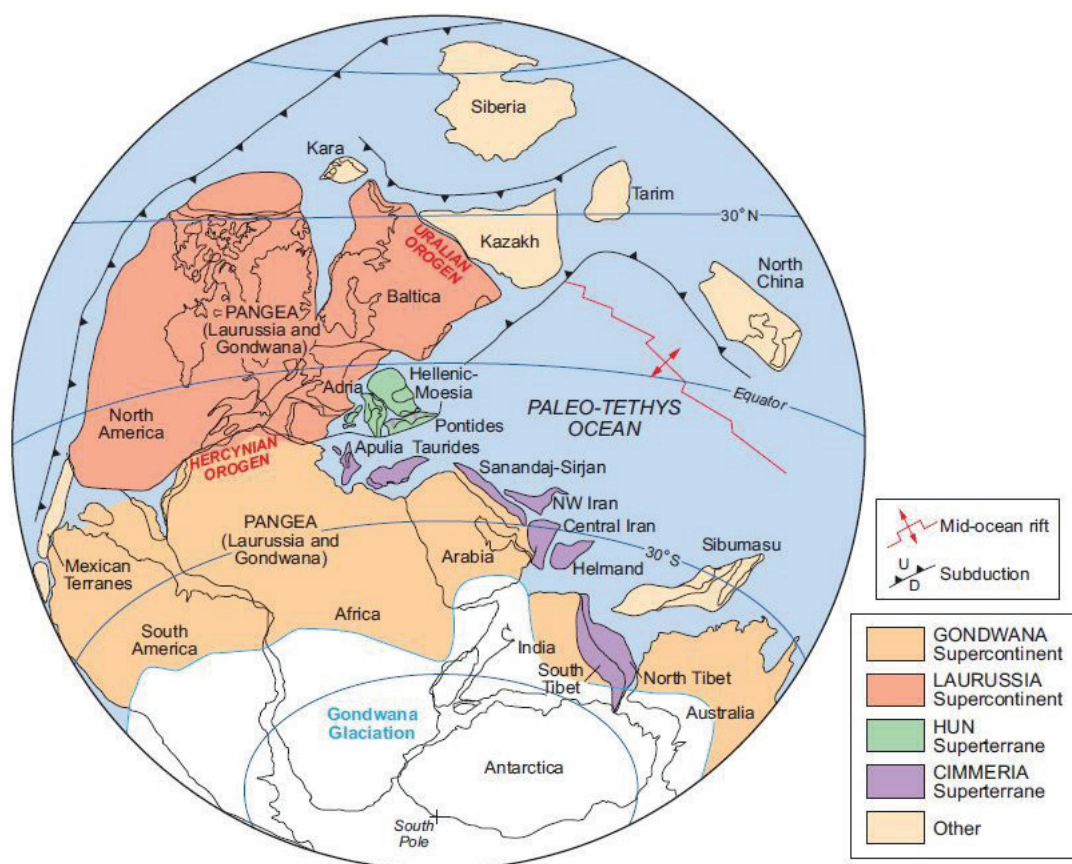


Fig. 5. Paleogeography of the Late Carboniferous (Pennsylvanian before 310 Ma).
 Ruban, D.A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

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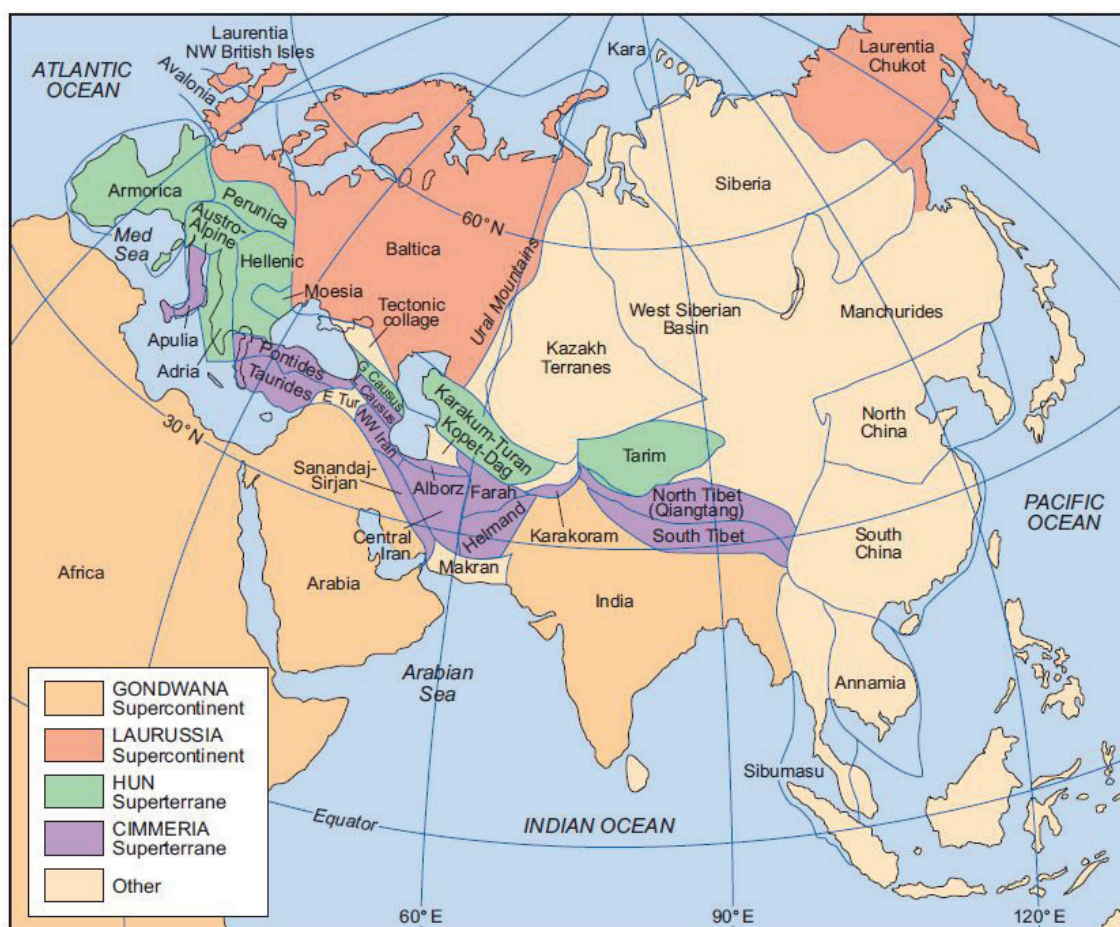


Fig. 6. Current position of Palaeozoic supercontinents, continents and lithological units. Ruban, D. A. – Al-Husseini, M.I. – Iwasaki, Y. (2007).

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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 nearly half 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 a share of 37% 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 (2021) our republic with uranium production below 30 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 1.5 and 2%. 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 m³, from 2010 to 2015 it stabilized at values of around 200 million m³ per year. After that, it ranged from less than 170–180 million m³ and in 2019 it fell to 146 million m³. Czech gas production in 2021 reached 153 million m³. The reason for the decline in extraction was mainly the worldwide decline in prices. 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 tons in 2020. In 2021 reached the bituminous coal production 2.008 millions ton. 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. Bituminous 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%. 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, 1,176/2008 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 $Q_{sm,af}$ (combustion heat on the anhydrous ash-free basis) equal to or greater than 24 MJ/kg at a light reflectance of vitrinite $R_r \geq 0,6\%$. Anthracites include all coals with a vitrinite reflectance $R_r \geq 2\%$. The limit value between meta-anthracite (most coalified anthracite) and semi-graphite is the hydrogen content in the combustible (Hh) 0.8%.

Reserves

2022		
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

2022			
Country	mill. t	% World	% EU
EU	25,539	3.40	100.00
Poland	22,530	3.00	88.20
Czechia	1,081	0.10	4.23
Spain	868	0.12	3.40
Hungary	276	0.04	1.08
Bulgaria	192	0.03	0.80
Romania	11	0.001	0.04

Source: BP Statistical Review of World Energy 2023.

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

Steam coal 2011 – no, 2014 – no, 2017 – no, 2020 – 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.

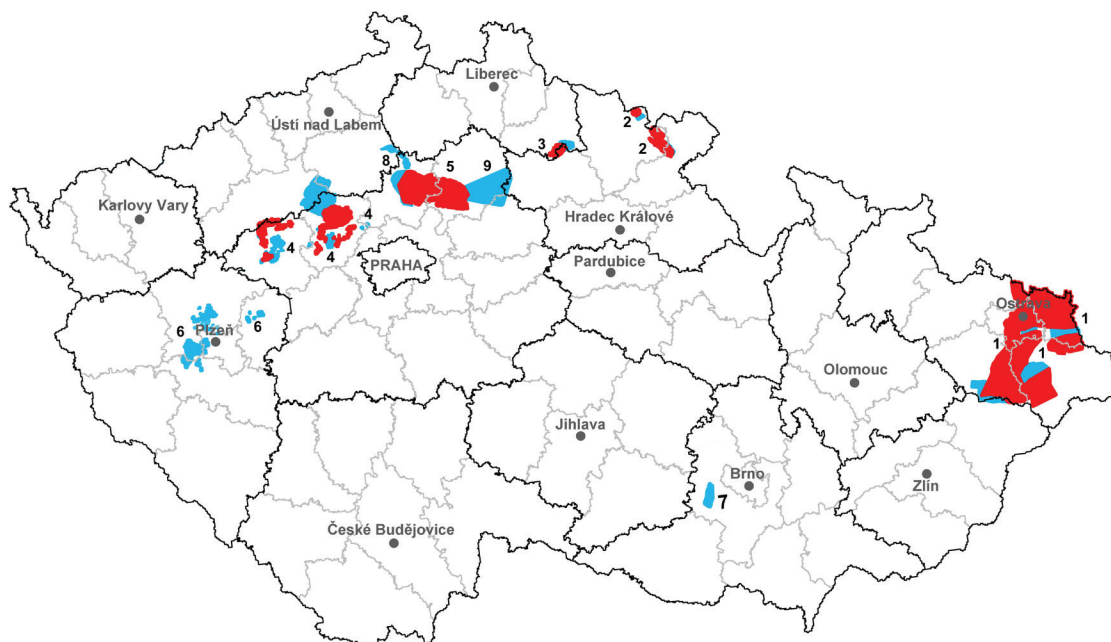
- The Bludovice fault divides the basin into two parts: the northern Ostrava-Karviná and the southern Podbeskydy. The significant tectonic fault (the Orlová Fault) divides the Ostrava-Karviná part of the basin into a western, geologically older and tectonically intensively affected Ostrava part of the basin with a paralic development of sediments¹, and the eastern, less complex Karviná part with not only paralic but also limnic² 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 Karviná 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 Q_{r} of the mined coal is usually between 23–30 MJ/kg, the ash content A_{d} between 10 and 30%. Due to long-term intensive 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 Q_{r} of the mined coal ranged on average between 28–29 MJ/kg, the ash content A_{d} between 11–19%. Relatively large 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 extends into the Beskydy Protected Landscape Area, and therefore its use is not yet planned.

¹ alternation of marine and continental sediments

² only lake sediments

- 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 Q_{ir} of the mined coal ranged on average between 18–20 MJ/kg, the ash content A_d 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 hydrogeological and gas conditions. The average calorific value Q_{ir} is between 18–22 MJ/kg, the ash content A_d 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 Q_{ir} is between 16–20 MJ/kg, the ash content A_d between 24–40%. However, the use of these reserves is currently unrealistic (economic aspects and conflict of interest – drinking water for the Central Bohemian region in the overlying 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-Sudetic 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 significant importance.

3. Registered deposits and other resources of the Czech Republic



■ reserved registered deposits

■ exhausted deposits and other resources

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	2018	2019	2020	2021	2022
Deposits – total number	62	62	62	62	62
exploited	6	6	5	1	1
Total mineral *reserves, kt	15,217,550	16,275,710	16,272,828	16,269,450	16,268,216
economic explored reserves	1,450,481	1,441,494	1,439,817	1,400,735	1,400,481
economic prospected reserves	5,830,315	5,989,227	5,989,111	5,907,419	5,906,193
potentially economic reserves	8,836,754	8,844,989	8,843,900	8,961,296	8,961,542
exploitable (recoverable) reserves	29,192	15,970	3,243	1,360	3,600
Mine production, kt	4,110	3,150	1,861	2,008	1,281

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	kt	3,475	3,577	3,426	4,573	4,402
Export	kt	1,911	1,414	767	1,395	883

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

		2018	2019	2020	2021	2022
Average import prices	CZK/t	3,390	3,409	2,417	3,158	7,209
Average export prices	CZK/t	3,325	3,333	2,608	3,933	7,776

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

		2018	2019	2020	2021	2022
Import	kt	220	221	220	241	237
Export	kt	634	589	536	652	592

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

		2018	2019	2020	2021	2022
Average import prices	CZK/t	5,501	5,376	4,712	6,218	11,411
Average export prices	CZK/t	7,655	7,888	6,260	8,488	14,943

6. Prices of domestic market**OKD, a.s. bituminous coal sales**

Coal type/year			2018	2019	2020	2021	2022
Coking coal	sales*	tonnes	2,286,902	1,892,812	1,059,838	1,560,270	870,235
	revenue	ths CZK	8,715,000	6,953,000	3,458,019	6,691, 000	7,769,000
	average price	CZK/tonne	3,811	3,673	3,263	4,288	8,927
Steam coal	sales*	tonnes	2,006,803	1,396,572	841,188	875,992	1,316,400
	revenue	ths CZK	4,144,000	3,104,000	2,453,174	1,583,000	5,719,000
	average price	CZK/tonne	2,065	2,223	2,916	1,807	4,344

* saleable output

Sources: (OKD Annual Reports)

For 2018 – OKD výroční zpráva 2018, OKD, a.s., pp. 10, 11.

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 2021, OKD, a.s., pp. 10, 11.

7. Mining companies in the Czech Republic as of December 31, 2022

OKD, a.s., Ostrava

8. World production and world market prices

World mine production

During 2018 and 2022, world production of bituminous coal developed as follows:

	2018	2019	2020	2021	2022
Steam coal (WBD), mill. t	5,832.2	5,958.3	5,724.1	5,967.3	N
Coking coal (WBD), mill. t	1,033.0	1,056.3	1,035.8	1,056.2	N
Bituminous coal total (WBD), mill. t	6,865.2	7,014.6	6,759.9	7,023.5	N

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

	2018	2019	2020	2021	2022 ^e
Steam coal	5,726.0	6,025.0	6,175.0	5,707.0	7,221.0
Coking coal	1,000.0	978.0	1,007.0	1,015.9	1,096.0
Bituminous coal total	6,726.0	7,003.0	7,182.0	6,722.9	8,318.0

e – preliminary values

Main producers according to WBD

2021			2021		
Steam coal			Coking coal		
Country	mill. t	%	Country	mill. t	%
China	3,153	52.8	China	572	54.2
India	727	12.2	Australia	171	16.2
Indonesia	565	9.5	Russia	100	9.5
USA	429	7.2	USA	56	5.3
Australia	262	4.4	India	52	4.9
South Africa	248	4.2	Mongolia	27	2.6
Russia	226	3.8	Canada	20	1.9
Kazakhstan	103	1.7	Poland	13	1.2
Columbia	48	0.8	Kazakhstan	9	0.9
Poland	47	0.8	Ukraine	7	0.7
World	5,967	100.0	World	1,056	100.0

* Data 2022 not available.

Main producers according to Coal Information. IAE 2023

2022		
Steam coal		
Country	mill. tonnes	%
China	4,237	50.9
India	893	10.1
Indonesia	622	7.5
USA	594	7.1
Australia	446	5.4
Russia	404	4.9
EU	519	6.2
World	8,318	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	2018	2019	2020	2021	2022
Indonesia	343	375	342	346	360
Australia	208	212	199	200	178
Russia	172	179	169	178	N
Colombia	80	76	52	56	54
South Africa	81	78	75	66	72
USA	48	36	24	35	34
Others	8	20	15	16	174
Total world	940	976	876	897	877

Coking coal (mill. tonnes)

Exporter	2018	2019	2020	2021	2022
Australie	179	183	172	167	160
Kanada	30	34	27	26	28
USA	52	44	35	38	36
Rusko	26	25	29	32	N
Total	291	290	266	266	267

The world's largest importers of bituminous coal according to IEA

Bituminous coal total (million tonnes)					
Country	2018	2019	2020	2021	2022
China	281	298	309	338	285
India	223	247	211	207	221
Japan	184	185	183	183	184
South Korea	136	130	123	123	123
Tchajwan	67	67	63	65	70
Europe	N	N	137	154	176
Southeast Asia	N	N	154	150	148
World	N	N	1,338	1,371	1,341

The world's largest importers of bituminous coal in 2022 according to Enerdata (2023)

2022	
Bituminous coal	
Country	mill. tonnes
China	296
India	246
Japan	183
South Korea	125
Taiwan	64
Germany	40
Turkey	36
Malaysia	29
Thailand	23

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 2016 to 2022) 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
2016	USD	56.19	52.34	53.00	52.61	54.48	59.31	62.94	71.19	71.12	88.52	100.2	100.4
2016	EUR	51.74	47.18	47.75	46.40	48.17	52.82	56.86	63.49	63.43	80.28	92.83	95.24
2017	USD	101.1	97.64	91.16	90.50	85.93	90.25	97.81	97.79	103.1	107.3	110.8	107.2
2017	EUR	95.30	91.75	85.33	84.41	77.72	80.38	84.98	82.83	86.50	91.30	94.36	90.61
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	183.16	344.26	300.64	360.66	372.72	433.43	410.21	430.75	324.12	255.61	290.20

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	2018	2019	2020	2021	2022
Market price in NW Europe (BP)	91.83	60.86	50.16	121.70	N
Spot prices of the US Central Appalachian coal	72.84	57.16	42.77	68.54	N
The spot price of Japanese import coking coal CIF (BP)	117.39	108.58	80.50	130.37	N
Spot price of coal. China. Qinhangdao (BP)	99.45	85.89	83.10	153.55	N
Australian steam coal. 6.300kcal CIF Neawcastle (WB)	107.02	77.89	60.80	138.10	344.90
South African coal (WB)	97.64	71.94	65.70	119.80	240.60

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 ($Q_{s,m,af}$) < 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

2022			2022			
Country	mill. t	% World	Country	mill. t	% World	% EU
Russia	90,447	28.2	EU	53,051	16.6	100.0
Australia	76,508	23.9	Germany	35,900	11.2	67.7
Germany	35,900	11.2	Poland	5,865	1.8	11.1
USA	30,003	9.4	Greece	2,876	0.9	5.4
Indonesia	11,728	3.7	Hungary	2,633	0.8	5.0
Turkey	10,975	3.4	Bulgaria	2,174	0.7	4.1
China	8,128	2.5	Czechia	1,081	0.3	2.0
Serbia	7,112	2.2	Spain	319	0.1	0.6
New Zealand	6,750	2.1	Romania	280	0.09	0.5
Poland	5,865	1.8				
World	320,469	100.0				

Source: BP Statistical Review of World Energy 2023.

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

2. Mineral resources of the Czech Republic

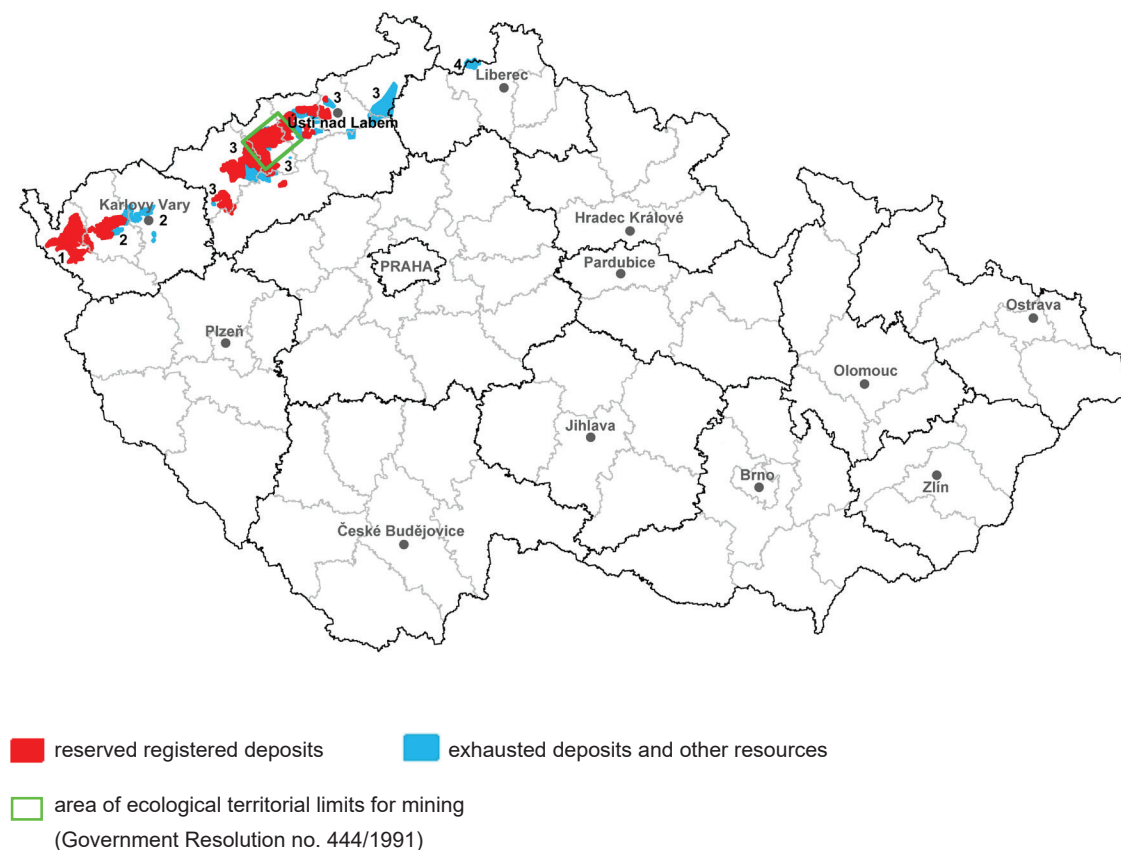
Brown coal is still the main source of energy in the Czech Republic and thus provides state energy security. The largest Czech brown coal basins originated in a tectonic trough and follow the direction parallel to the Ore Mountains and the northwestern border of the Czech Republic. The total area of coal-bearing sedimentation is 1,900 km². 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.

- Currently, 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 (S_d 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_r 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 (S_d usually between 1 and 1.5%) and arsenic. The average thickness of the mined seam is between 20–30 m, the calorific value between Q_r 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 (Komořany, Ervěnice, 2016–2022). At present, this method of mining is no longer practiced. The complex hydraulic, forestry and agricultural reclamation was also completed as part of the revitalisation of the area after the Most – Ležáky quarry, where coal mining was definitively terminated on 31 August 1999. The water area of the Most quarry is 311.1 ha and the total volume of water in the lake is approximately 68.9 million m³.
- 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 Q_{ir} 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 liptodetriles, 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



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

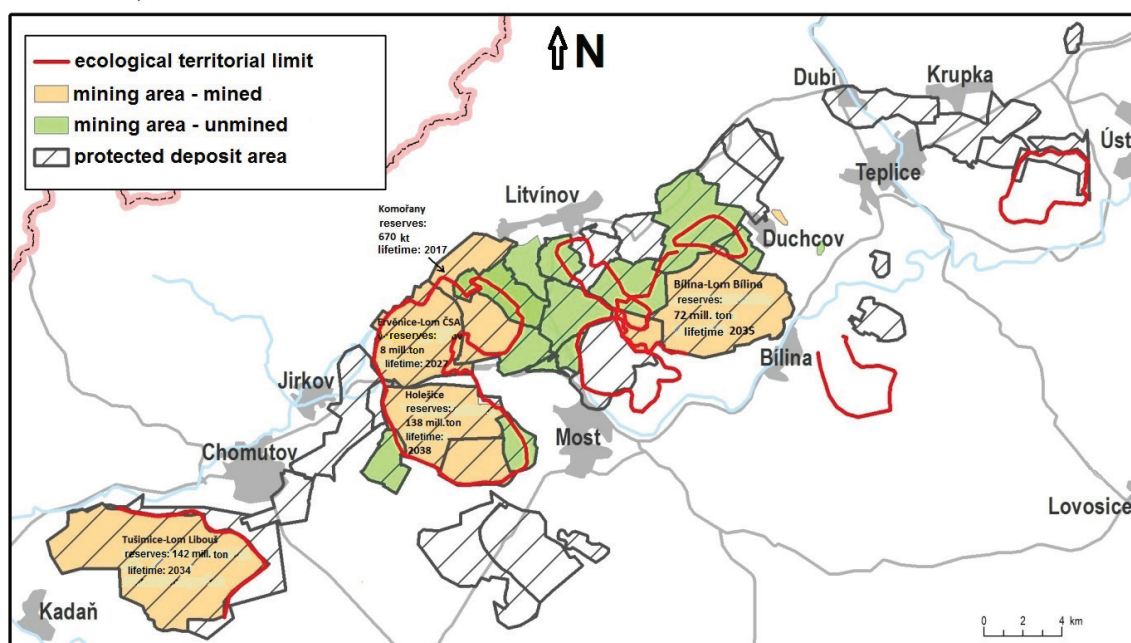
Josef Godány

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 500m 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 %.

Ecological mining limits



Source: CGS

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

Number of deposits; reserves; mine production

Year	2018	2019	2020	2021	2022
Deposits – total number	52	52	52	52	52
exploited	7	7	8	7	6
Total mineral* reserves, kt	8,633,149	8,595,438	8,565,403	8,538,637	8,505,781
economic explored reserves	2,173,864	2,138,948	2,111,604	2,086,805	2,055,968
economic prospected reserves	2,059,859	2,059,859	2,059,854	2,059,854	2,059,854
potentially economic reserves	4,399,426	4,396,631	4,393,945	4,391,978	4,389,959
exploitable (recoverable) reserves	646,528	612,729	586,457	562,735	531,481
Mine production, kt	39,187	37,465	29,505	29,278	33,398

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

		2018	2019	2020	2021	2022
Import	kt	340	246	183	185	213
Export	kt	918	728	549	437	1,046

2702 – Brown coal, also agglomerated, except jet

		2018	2019	2020	2021	2022
Average import prices	CZK/t	1,844	2,170	2,346	2,473	3,326
Average export prices	CZK/t	1,694	1,764	1,864	1,846	2,593

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	2018	2019	2020	2021	2022
graded; cube coal II; 17.6 MJ/kg; Severočeské doly	2,250	2,475	2,475	2,575	3,200
graded; nut coal I; 17.6 MJ/kg; Severočeské doly	2,125	2,340	2,360	2,485	3,150
graded; nut coal II; 17.6 MJ/kg; Severočeské doly	2,090	2,290	2,340	2,555	3,100
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, 2022

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:

	2018	2019	2020	2021	2022
Brown coal and lignite (WBD), mill. t	800.1	734.5	637.1	687.1	N
Brown coal and lignite (IEA), mill. t	801.0	739.0	638.5	N	N

Main producers according to Welt Bergbau Daten (2023)

2021		
Country	mill. t	%
Germany	126.2	18.4
Russia	75.2	10.9
Turkey	84.5	12.3
Poland	52.4	7.6
USA	43.0	6.3
Australia	41.6	6.1
Serbia	39.7	5.8
India	36.4	5.3
Czech Republic	29.3	4.3
Bulgaria	28.4	4.1
World	687.1	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 between 0.75 and 1 t/m³, 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 biochemical decomposition of dead biomass. Oil formation occurs at temperatures of 60–140 °C, at depths of 1,300–5,000 m in pelitic oil-bearing sediments. From there it migrates and accumulates in permeable, porous or cracked collector rocks. Extracted oil is referred to as crude oil and has highly variable properties such as colour, viscosity, molecular weight and specific 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 hydrocarbon 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

Reserves

2022			2022			
Country	Bn tonnes	% World	Country	Bn tonnes	% World	% EU
Venezuela	48.0	19.6	EU	0.3	0.12	100.0
Saudi Arabia	40.9	16.7	Romania	0.1	0.04	33.3
Canada	27.1	11.1	Denmark	0.1	0.04	33.3
Iran	21.7	8.9	Italy	0.1	0.04	33.3
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				

Source: BP Statistical Review of World Energy

2. Mineral resources of the Czech Republic

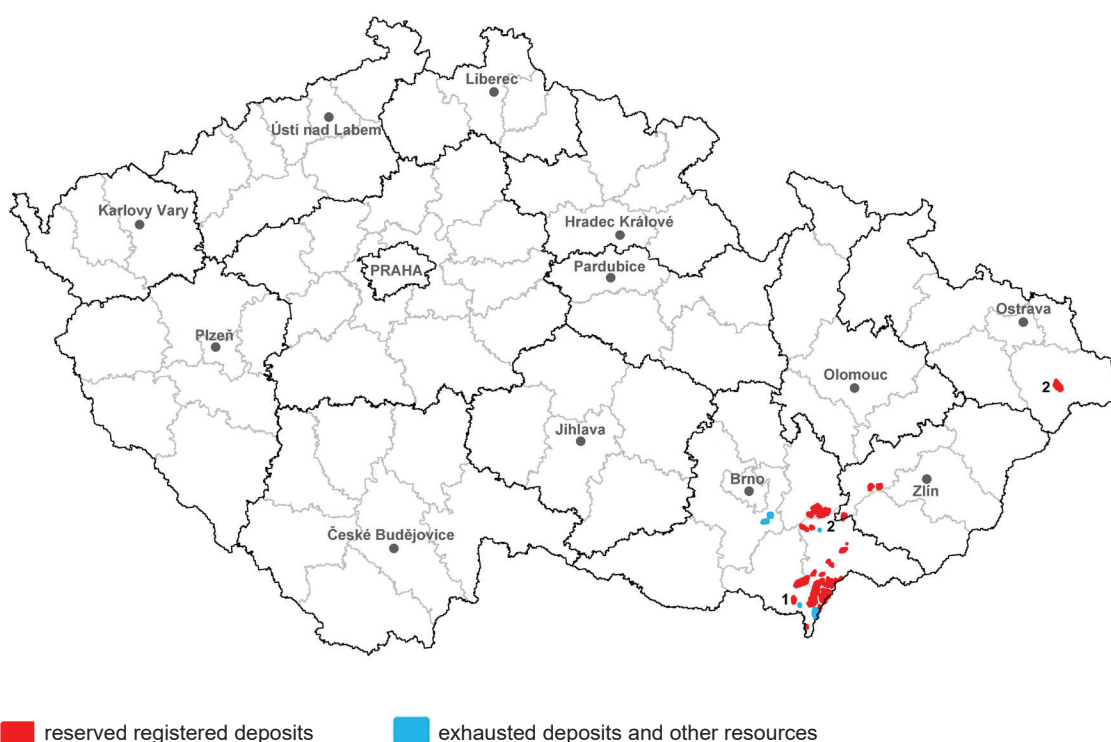
Unlike coal, the Czech Republic does not have sufficient resources for oil or natural gas. Industrially significant oil accumulations occur mainly in southern Moravia and are linked to the geological units of the Western Carpathians and the SE slopes of the Bohemian Massif. Although domestic oil production 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 recoverable 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 present in

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

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/m³ 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	2018	2019	2020	2021	2022
Deposits – total number	39	39	39	39	39
exploited	33	33	34	32	31
Total mineral *reserves, kt	31,562	31,482	31,391	31,308	31,233
economic explored reserves	21,720	21,648	21,565	21,491	21,422
economic prospected reserves	4,027	4,020	3,963	4,004	3,990
potentially economic reserves	5,815	5,814	5,863	5,813	5,813
exploitable (recoverable) reserves	1,575	1,439	1,361	1,359	1,330
Mine production, kt	109	81	91	83	75

* 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

		2018	2019	2020	2021	2022
Import	kt	7,439	7,738	6,174	6,841	7,425
Export	kt	22	0.2	0.4	0.001	0.001

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

		2018	2019	2020	2021	2022
Average import prices	CZK/t	11,644	11,094	7,970	11,404	15,535
Average export prices	CZK/t	10,594	9,833	468,835	235,562	175,544

271011 – Petrol (Gasoline)

		2018	2019	2020	2021	2022
Import	kt	N	N	N	N	N
Export	kt	N	N	N	N	N

271011 – Petrol (Gasoline)

		2018	2019	2020	2021	2022
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

	2018		2019		2020		2021		2022	
Country	kt	CZK/t	kt	CZK/t	kt	CZK/t	kt	CZK/t	kt	CZK/t
Russia	4,003	11,143	3,821	10,585	3,013	7,337	3,417	11,089	4,162	12,937
Azerbaijan	2,183	12,241	2,194	11,662	1,426	8,968	1,096	11,958	33,291	19,291
USA	–	–	277	11,395	728	7,990	804	11,422	468,598	20,566
Kazakhstan	986	12 468	990	11,827	567	10,041	1,239	11,676	726,427	16,009
United Kingdom	–	–	–	–	128	7,811	1	N	1	N
Saudi Arabia	98	11,075	104	10,612	104	3,515	1	N	203,879	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	76	9,991	82	10,773	82	9,816	26	7,967	–	–
Total	7,812	9,498	7,439	11,644	7,738	11,093	6,175	11,940	7,425	15,535

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, 2022

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:

	2018	2019	2020	2021	2022
World crude oil production (WBD), mill. t	4,368.8	4,466.4	4,471.0	4,175.5	N
World crude oil production (BP), mill. t	4,386.4	4,486.8	4,477.6	4,170.9	4,221.4

Note: BP – BP Statistical Review of World Energy, 2023

Main producers according to BP

2022		
Country	mill.t	%
USA	760	17.2
Russia	573	13.0
Saudi Arabia	549	12.5
Canada	274	6.2
Iraq	221	5.0
China	205	4.7
United Arab Emirates	181	4.1
Iran	176	4.0
Brazil	163	3.7
Kuvajt	146	3.3
World	4,407	100

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

The average price quotations of crude oil purchases according to the IEA and BP

Commodity/year	Units	Conversion factor	2018	2019	2020	2021	2022
Brent Crude, CIF Rotterdam	USD/bbl	1 t = 7.560 bbl	71.31	64.21	41.84	70.91	101.32
	USD/t		539.10	485.43	316.31	53.08	765.98
Dubai Crude, CIF Rotterdam	USD/bbl	1 t = 7.596 bbl	70.15	63.71	42.41	68.91	96.38
	USD/t		532.86	483.94	322.15	523.44	732.10
West Texas Intermediate (WTI), CIF Rotterdam	USD/bbl	1 t = 7.400 bbl	65.20	57.03	39.25	68.10	94.58
	USD/t		482.48	422.02	290.45	503.94	699.89
Nigerian Forcados Crude, CIF Rotterdam	USD/bbl	1 t = 7.500 bbl	72.47	64.95	42.31	69.76	101.40
	USD/t		543.53	487.13	317.33	523.20	760.50
OPEC basket, CIF Rotterdam	USD/bbl	1 t = 7.090 bbl	68.90	63.18	42.17	68,24	95.37
	USD/t		488.50	447.95	298.99	483,82	676.17

Note: bbl = abbreviation of term barrel

Natural gas

1. Characteristics and use

Natural gas is a mixture of gaseous hydrocarbons, especially methane (CH₄), 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 CH₄ content 98–99%), moist gas (85–95% CH₄ and hydrocarbon admixture) and gas with an increased proportion of inert components (50–65% CH₄, over 10% N₂ and over 20% CO₂).

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

2022		
Country	Trillion m ³	% World
Russia	37.4	19.9
Iran	32.1	17.1
Qatar	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

2022			
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 2023

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

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.

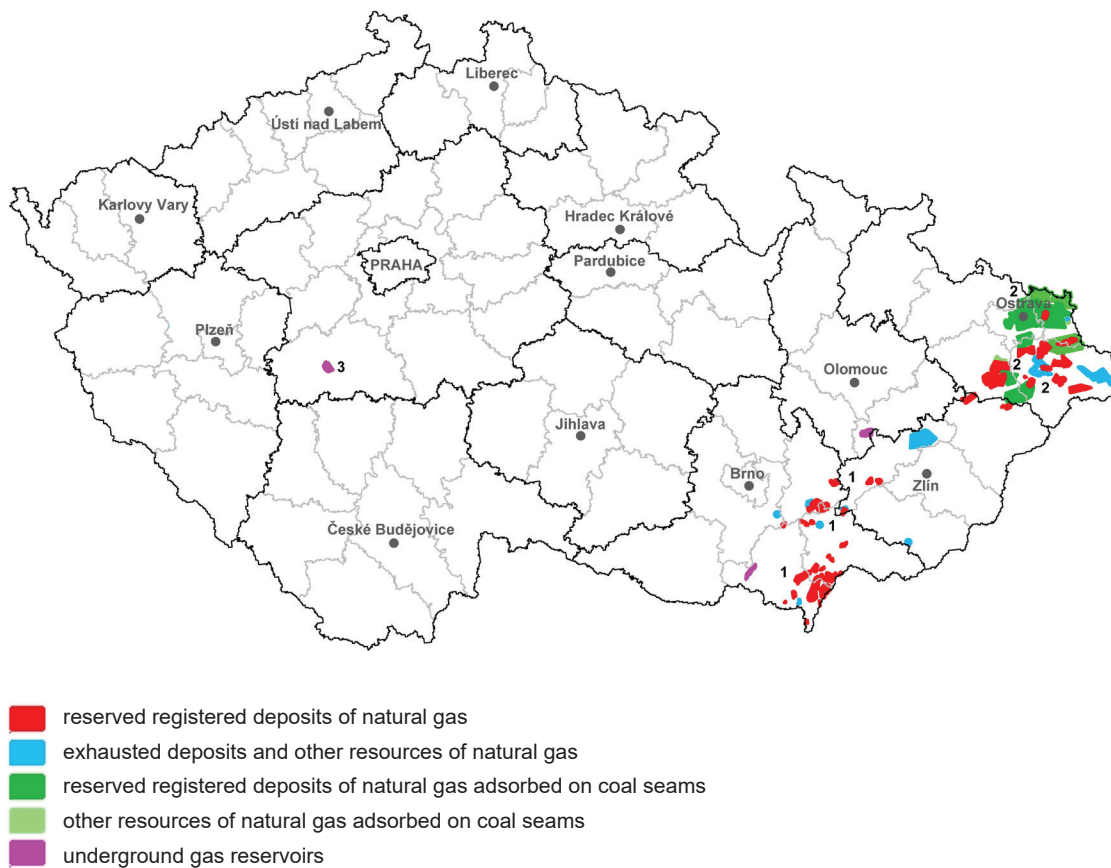
- Natural gas deposits, genetically linked to the formation of oil, are found in the Moravian part of the Vienna Basin. Oil deposits are concentrated mainly in the central part of the basin, gas deposits predominate in the peripheral areas. They are deposited in Baden sediments together with oil deposits 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 CH₄ by volume, it has a calorific value of 35.6 to 37.7 MJ/m³ (dry gas at 0°C), specific gravity 0.72 to 0.85 kg/m³ (at 0°C) and H₂S content below 1 mg/m³. 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, Uhřetice 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 3,900m 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 Uhřetice 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% CH₄; O₂, N₂, CO and CO₂ 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



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 Háj

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

Number of deposits; reserves; mine production

Year	2018	2019	2020	2021	2022
Deposits – total number	96	97	97	98	98
exploited	63	64	67	66	64
Total mineral *reserves, mill m ³	30,594	30,339	30,203	30,071	29,904
economic explored reserves	7,116	6,994	6,799	6,757	6,633
economic prospected reserves	2,852	2,807	2,725	2,776	2,735
potentially economic reserves	20,626	20,538	20,679	20,538	20,536
exploitable (recoverable) reserves	4,623	9,829	10,105	4,098	4,819
Mine production, mill m ³	179	146	138	153	165

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	ths m ³	5,926,963	7,481,881	6,210,123	6,383,792	6,584,327
Export	ths m ³	415,513	645,242	782,138	1,008,928	454,108

271121 – Natural gas

		2018	2019	2020	2021	2022
Average import prices	CZK/ths m ³	8,281	5,906	3,962	11,941	34,760
Average export prices	CZK/ths m ³	9,185	6,132	4,381	4,370	29,510

Natural gas import to the Czech Republic 2018–2022

Natural gas imports into the Czech Republic															
COUNTRY	2018			2019			2020			2021			2022		
	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	6	235	N	5	172	N	1	433	N	2	707	361,822	2	549	297,722
Germany	265,397	2,313,219	8,716	746,572	4,519,729	6,054	1,696,475	5,982,503	3,521	-	-	-	-	-	-
Denmark	2,586	7,334	2,836	3,694	6,322	1,709	-	-	-	553	2,788	5,042	-	-	-
France	3,887	26,548	6,831	295	1,998	6,782	-	-	-	-	-	-	-	-	-
Switzerland	535	1,711	3,198	1,808	3,937	2,178	-	-	-	-	-	-	-	-	-
Luxemburg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Norway	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poland	-	-	-	-	-	-	-	-	-	-	-	-	1,129,340	39,286,111	34,787
Countries and territories not mentioned	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Countries and territories not covered by intra EU trade	85,178	632,071	7,421	-	-	-	-	-	-	-	-	-	-	-	-
Russia	-	-	-	-	-	-	-	3,746	4,632	37,664	421,086	11,181	1,825	40,749	22,328
Slovakia	5,565,633	46,295,240	8,318	6,174,659	37,127,850	6,013	4,512,596	18,616,058	4,125	6,343,113	75,793,796	11,949	5,234,628	182,701,643	34,903
USA	4,248	39,143	9,214	14,835	57,856	3,9	<1	21	N	<1	4	N	-	-	-
Italy	-	-	-	<1	117	N	-	-	-	-	-	-	218,531	6,822,123	31,218
Itálie	-	-	-	250	1,729	6,904	242	1,649	6,813	242,034	1,649	6,813	-	-	-
Ukraine	-	-	-	-	-	-	-	-	-	2,46	8,116	3,299	-	-	-

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.):

	2018	2019	2020	2021	2022
Unigeo a.s. price – CZK/m ³	< 4.7	6	4	14	37

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

		2018	2019	2020	2021	2022
To 630 MWh/delivery point (630 MWh = 59,684 m ³)	CZK/MWh **)	616	533	406	1,619	3,733
	CZK /ths m ³ ***)	6,499	5,629	4,291	17,028	39,402
Over 630 MWh/delivery point (630 MWh = 59,684 m ³)	CZK /MWh **)	613	526	382	1,583	3,677
	CZK /ths m ³ ***)	6,470	5,557	4,037	16,622	38,605

Source: Czech Moravian Commodity Exchange Kladno

Explanations: SSDP (*sdrúžené 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, 2022

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:

	2018	2019	2020	2021	2022
World natural gas production (WBD), mill m ³	3,157	3,252	3,168	3,323	N
World natural gas production (BP), mill m ³	3,856	3,968	3,861	4,053	4,044

Note: BP – BP Statistical Review of World Energy 2023.

Main producers according to BP

2022		
Country	mild. m ³	%
USA	979	24.2
Russia	618	15.3
Iran	259	6.4
China	221	5.5
Canada	185	4.6
Qatar	178	4.4
Australia	153	3.8
Norway	123	3.0
Saudi Arabia	120	3.0
Algeria	98	2.4
World	4,045	100.0

Natural gas prices in various countries according to the BP Statistical Review of World Energy 2023 (USD/mill Btu converted to USD/m³ and USD/MWh)

Country/year		2018	2019	2020	2021	2022
Germany, average import price	USD/mill. Btu	6.66	5.03	8.94	8.94	24.17
	USD/MWh	22.71	17.16	30.51	30.51	82.41
	USD/m ³	0.24	0.19	0.33	0.33	0.88
United Kingdom, Heren NBP Index	USD/mill. Btu	8.06	4.47	15.80	15.80	25.10
	USD/MWh	27.51	15.24	53.92	53.92	85.34
	USD/m ³	0.29	0.17	0.59	0.59	0.91
USA, Henry Hub, spot price	USD/mill. Btu	3.12	2.51	3.84	3.84	6.45
	USD/MWh	10.64	8.56	13.11	13.11	21.98
	USD/m ³	0.11	0.09	0.14	0.14	0.24
Canada (Alberta)	USD/mill. Btu	1.18	1.27	2.75	2.75	N
	USD/MWh	4.02	4.33	9.39	9.39	N
	USD/m ³	0.04	0.05	0.10	0.10	N
Netherlands (TTF)	USD/mill. Btu	7.90	4.45	3.07	16.02	37.48
Japan (CIF), price LNG	USD/mill. Btu	10.07	9.94	7.78	10.07	N

Note:

1) The price conversion from USD/mill Btu to USD/m³ was performed by the use of the following ratios:

1 ft³ (cubic foot) of natural gas = 1,050 Btu (British thermal unit); 1 m³ = 35.31 ft³; 1 m³ = 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 $Ca(UO_2)(PO_4)_2.6H_2O$

Industrially important deposit types

1. Infiltration in sandstones: basin Chu-Sarysu and Syr Darya (Kazakhstan), Kyzylkum (Uzbekistan), Wyoming (USA), Tim Merso (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

2020			2020		
Country	tonnes	% World	Country	tonnes	%
Australia	1,692,700	27.9	Mongolia	144,600	2.4
Kazakhstan	815,200	13.4	Uzbekistan	131,300	2.2
Canada	588,500	9.2	Ukraine	107,200	1.8
Russia	480,900	7.9	Botswana	87,200	1.4
Namibia	470,100	7.7	Tanzania	58,200	1.0
S. Africa	320,900	5.3	Jordan	52,500	0.9
Niger	311,100	5.1	USA	59,400	1.0
Brazil	276,800	4.6	World	6,078,500	100.0
China	223,900	3.7			

Source: *Uranium 2020: Resources, Production and Demand ("Red Book")*

2021			
Country	tonnes	% 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

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.

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

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%.

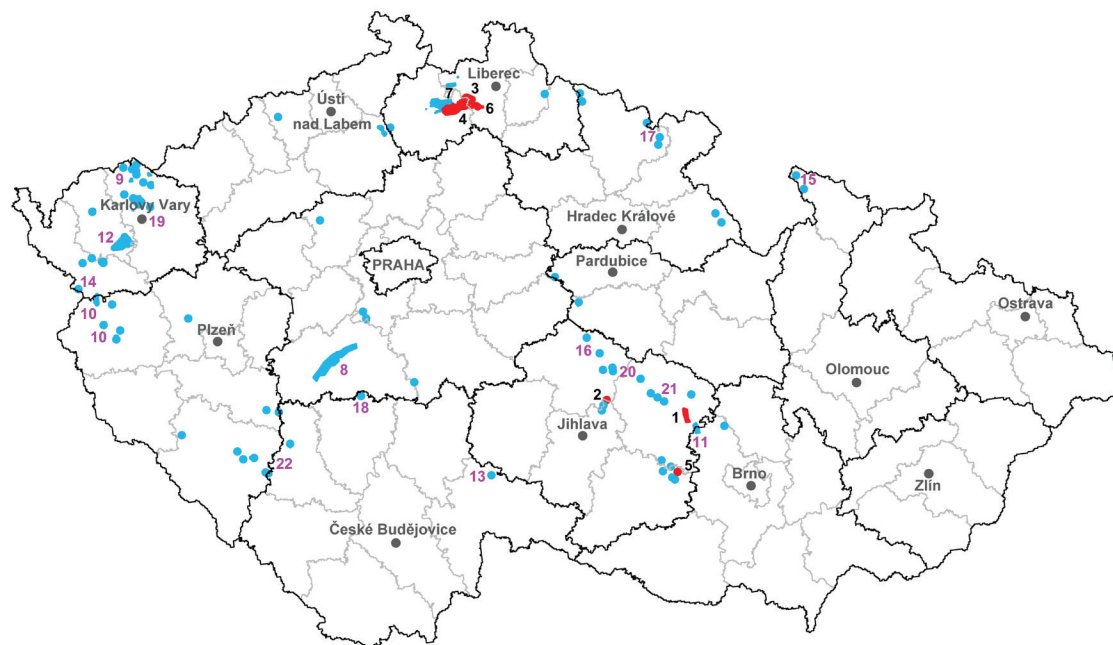
Economically important and especially intensively used deposits in the past were concentrated in five areas. In the following overview, the areas with the type of ore and the most important deposits are listed according to the importance given by the amount of uranium mined. The percentage share of the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

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	2018	2019	2020	2021	2022
Deposits – total number	7	7	7	7	7
exploited	1	0	0	0	0
Total mineral * reserves, t U	134,948	134,862	134,833	134,825	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	114,166	114,114	114,085	114,077	114,055
exploitable (recoverable) reserves	276	276	276	276	267
Mine production, t U	34	33	29	27	21
Production of concentrate, t U **	29	33	28	26	22

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	t U	0	0	0	0	0
Export	t U	0	0	0	0	0

28441030 – Natural uranium – wrought

		2018	2019	2020	2021	2022
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, 2022

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:

	2018	2019	2020	2021	2022
Uranium production, U_3O_8 (according to WBD)	64,083	64,278	55,718	56,155	N
Uranium production, t U (according to WNA*)	54,154	54,742	47,731	47,808	49,355

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	2018	2019	2020	2021	2022
Tonnes U	54,154	54,742	47,731	48,332	48,888

Main producers according to WNA

2022		
t U		
Country	tonnes	%
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

	2018	2019	2020	2021	2022
Long-term price	73.74	80.55	71.37	89.00	101.28
Spot price	44.34	58.00	N*	N*	137.26

** In 2020 and 2021 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 untreated; non-metals or their compounds are also obtained from them. After construction and energy minerals, they represent 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 Provoďín, 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. Deposits 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 industrial 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

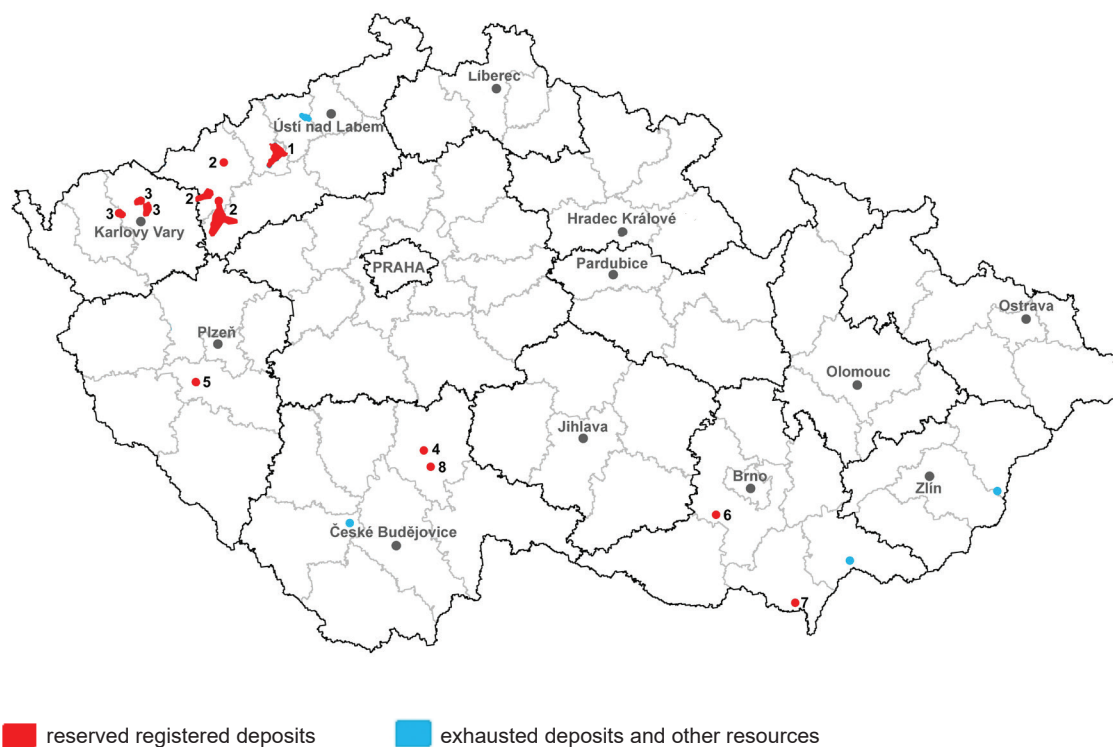
2. Mineral resources of the Czech Republic

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+} and 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 Všebořovice 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 Stránc 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



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	2018	2019	2020	2021	2022
Deposits – total number	38	39	38	39	39
exploited	10	10	9	9	10
Total mineral *reserves, kt	310,355	309,801	309,599	323,772	323,604
economic explored reserves	78,103	77,571	77,369	82,614	82,446
economic prospected reserves	126,880	126,877	126,877	134,488	134,488
potentially economic reserves	105,372	105,353	105,353	106,670	106,670
exploitable (recoverable) reserves	32,276	31,994	32,182	32,182	23,369
Mine production, kt**	277	357	226	198	167

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	kt	68	75	62	71	54
Export	kt	163	166	170	180	183

250810 – Bentonite

		2018	2019	2020	2021	2022
Average import prices	CZK/t	1,985	2,453	3,007	3,125	5,077
Average export prices	CZK/t	3,094	3,251	3,530	3,501	4,529

250820 – Decolourizing earths and fuller's earth

		2018	2019	2020	2021	2022
Import	kt	0	0	0	0	0
Export	kt	0	0	0	0	0

250820 – Decolourizing earths and fuller's earth

		2018	2019	2020	2021	2022
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, 2022

Sedlecký kaolin a.s., Božičany

KERAMOST, a.s., Most

KSB s.r.o.

8. World production and world market prices**World mine production**

	2018	2019	2020	2021	2022 ^e
World mine production (according to MCS), kt	21,000	16,300	18,200	19,000	19,000
World mine production (according to WBD), kt	21,791	21,781	18,907	18,787	N

e – preliminary values

Main producers according to MCS

2022^e		
Country	kt	%
USA	4,500	23.7
India	3,000	15.8
China	2,100	11
Turkey	2,000	10.5
Greece	1,300	6.8
Danmark	1,000	5.3
Iran	700	3.7
Czech Republic	230	1.2
Brazil	220	1.2
Spain	210	1.1
Ukraine	180	0.9
Mexico	79	0.4
Uzbekistan	50	0.3
World	19,000	100

Main producers according to WBD

2021		
Country	kt	%
USA	4,590	24,4
India	3,600	19,1
China	2,500	13,3
Turkey	2,020	10,7
Greece	1,257	6,7
Iran	1,153	6,1
Russia	500	2,7
Germany	363	1,9
Slovakia	274	1,5
Brazil	220	1,2
Czech Republic	198	1,1
Spain	172	0,9
Morocco	134	0,7
World	28,800	100.0

*e – preliminary values***Prices of traded commodities**

Commodity/year		2018	2019	2020	2021	2022
Bentonite, U.S. market price, ex works, average (MCS)	USD/st	98	98	97	100	97
Slovakian bentonite, yearly average price of exports to the Czech Republic (CZSO)	EUR/t	53.93	49.71	53.64	66.78	119.15

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

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

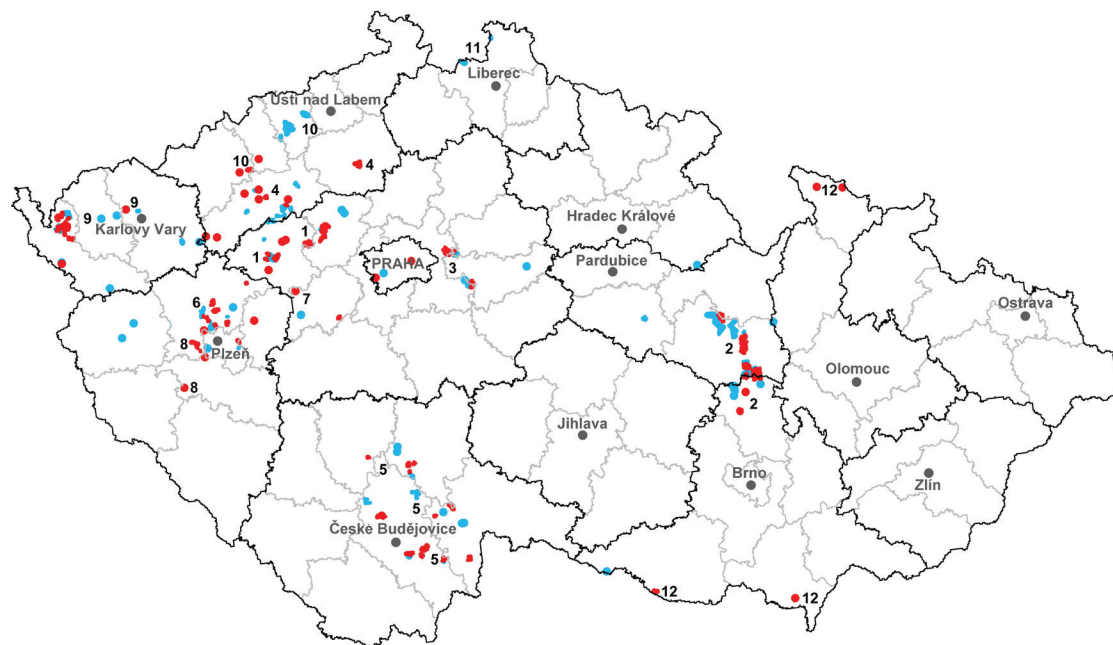
a considerable amount of siderite. In the past, they were considered as a possible source of Al. Today, they are no longer important due to the energy intensity of production and, in addition, they are mostly covered with coal mine dumps.

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 Líš'any 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 Jelnědno 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



■ reserved registered deposits

■ exhausted deposits and other resources

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	2018	2019	2020	2021	2022
Deposits – total number	108	108	108	108	108
exploited	19	13	13	13	13
Total mineral *reserves, kt	915,639	911,289	910,937	910,235	909,917
economic explored reserves	164,596	161,859	160,363	160,165	159,914
economic prospected reserves	391,449	390,864	390,826	390,616	390,616
potentially economic reserves	359,594	358,566	359,748	359,454	359,387
exploitable (recoverable) reserves	39,284	39,997	38,747	33,998	33,793
Mine production, kt	469	441	454	456	478

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	t	100,711	103,748	93,676	109,227	85,575
Export	t	291,306	304,803	299,105	322,088	365,232

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

		2018	2019	2020	2021	2022
Average import prices	CZK/t	3,275	3,389	4,382	4,533	6,156
Average export prices	CZK/t	2,860	2,883	3,153	3,047	3,631

250830 – Refractory (fire) clay

		2018	2019	2020	2021	2022
Import	t	7,952	8,111	7,439	8,901	7,832
Export	t	19,107	18,243	6,173	7,464	12,836

250830 – Refractory (fire) clay

		2018	2019	2020	2021	2022
Average import prices	CZK/t	3,552	3,139	3,168	3,002	3,790
Average export prices	CZK/t	1,822	1,714	3,555	3,335	4,654

250840 – Other clays

		2018	2019	2020	2021	2022
Import	t	14,489	11,590	7,439	9,286	9,216
Export	t	52,005	61,052	64,147	76,621	112,481

250840 – Other clays

		2018	2019	2020	2021	2022
Average import prices	CZK/t	3,959	3,476	3,168	4,519	5,755
Average export prices	CZK/t	973	905	932	945	1,122

250870 – Chamotte or dinas earth

		2018	2019	2020	2021	2022
Import	t	2,895	2,138	8,046	9,075	6,541
Export	t	57,124	59,555	58,600	58,239	56,644

250870 – Chamotte or dinas earth

		2018	2019	2020	2021	2022
Average import prices	CZK/t	7,364	7,148	7,527	7,161	8,636
Average export prices	CZK/t	4,169	4, 236	4,443	4,359	5,463

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 2022 they fluctuated generally between CZK 200–6,000 per tonne.

7. Mining companies in the Czech Republic as of December 31, 2022**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

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:

	2018	2019	2020	2021	2022 ^e
World production, kt	3,220	3,180	3,930	4,040	4,000

e – preliminary values

World production of fuller's earth (MCS)

2022^e		
Country	kt	%
USA	2,100	52.5
India	730	18.3
Spain	560	14
Senegal	120	3.0
Mexico	110	2.8
Turkey	79	2.0
Greece	34	0.9
World	4,000	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	2018	2019	2020	2021	2022
Ball clay, USA market (MCS), USD/t	55	56	58	58	58
Common clay, USA market (MCS), USD/t	17	18	17	17	17
Fire clay, USA market (MCS), USD/t	12	14	12	12	12
Fuller's earth, USA market (MCS), USD/t	88	89	88	88	92
Fire clay, chamotte, Polish, average import price into the Czech Republic (CZSO), EUR/t	59	50	40	38	35,20

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

2. Mineral resources of the Czech Republic

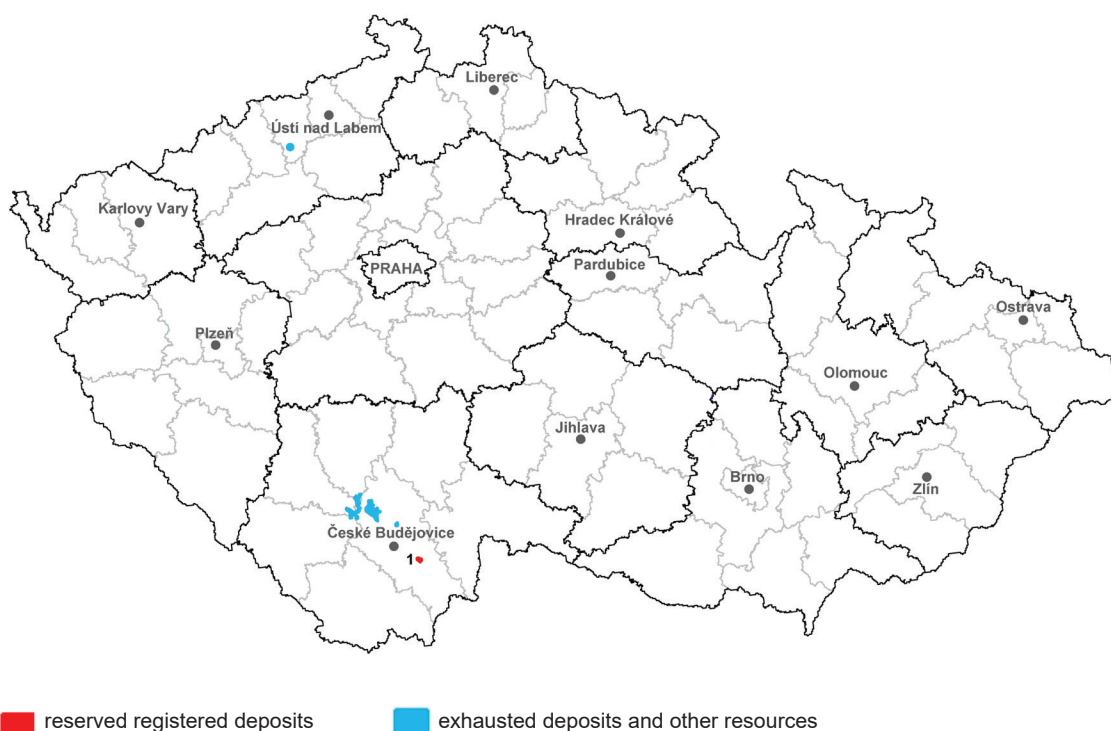
Accumulations of diatomite (diatomaceous earth) in the Czech Republic are related to the areas of occurrence of Tertiary and Quaternary lake sediments, especially to Tertiary sediments of the South Bohemian basins, where our only diatomite deposit is located today. Other occurrences are related to occurrence 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 stiffes 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, Zábोří) 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 (Pouzdrány), 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	2018	2019	2020	2021	2022
Deposits – total number	1	1	1	1	1
exploited	1	1	1	1	1
Total mineral *reserves, kt	2,363	2,316	2,266	2,246	2,197
economic explored reserves	1,661	1,616	1,568	1,550	1,503
economic prospected reserves	0	0	0	0	0
potentially economic reserves	702	700	698	696	694
exploitable (recoverable) reserves	2,363	1,441	1,395	1,377	1,333
Mine production, kt	31	43	46	18	44

* 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

		2018	2019	2020	2021	2022
Import	t	12,274	14,148	12,711	9,700	9,672
Export	t	13,063	9,403	4,847	3,941	3,889

2512 – Siliceous fossil meal*, siliceous earth

		2018	2019	2020	2021	2022
Average import prices	CZK/t	5,521	5,371	5,605	7,014	8,483
Average export prices	CZK/t	4,350	4,681	6,930	7,644	8,940

Note: * diatomite

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

		2018	2019	2020	2021	2022
Import	t	40,244	29,534	43,053	56,958	71,219
Export	t	100	589	742	856	11

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

		2018	2019	2020	2021	2022
Average import prices	CZK/t	1,215	1,406	1,279	1,405	1,597
Average export prices	CZK/t	23,681	2,415	2,357	2,274	69,352

6. Prices of domestic market

Diatomite was sold domestically in 2022 for CZK 15,000–25,000 per tonne.

7. Mining companies in the Czech Republic as of December 31, 2022

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:

	2018	2019	2020	2021	2022 ^e
World mine production (according to MCS), kt	2,840	2,190	2,320	2,450	2,500
World mine production (according to WBD), kt	2,310	2,299	2,260	2,500	N
World mine production (according to World Mineral Statistics), kt	2,600	2,100	2,100	2,150	N

e – preliminary values

Main producers according to MCS

2022^e		
Country	kt	%
USA	830	36.1
Denmark	400	17.4
Turkey	200	8.7
China	140	6.1
Mexico	100	4.3
Peru	90	3.9
Argentina	90	3.9
France	75	3.3
Germany	50	2.2
Russia	50	2.2
Spain	50	2.2
New Zealand	40	1.6
Japan	40	1.6
World	2,300	100.0

e – preliminary values

Prices of traded commodities (USD/t)

Commodity/year	2018	2019	2020	2021	2022
US diatomite, prices average, FOB works, according to MCS	330	340	330	410	430
Czech diatomite, average export price to Austria, EUR/t, CSO	108	104	127	132	154

Dolomite

1. Characteristics and use

Carbonate rocks with MgCO_3 contents above 27.5% and $\text{MgCO}_3 + \text{CaCO}_3$ 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 – metasomatism (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

2. Raw material resources of the Czech Republic

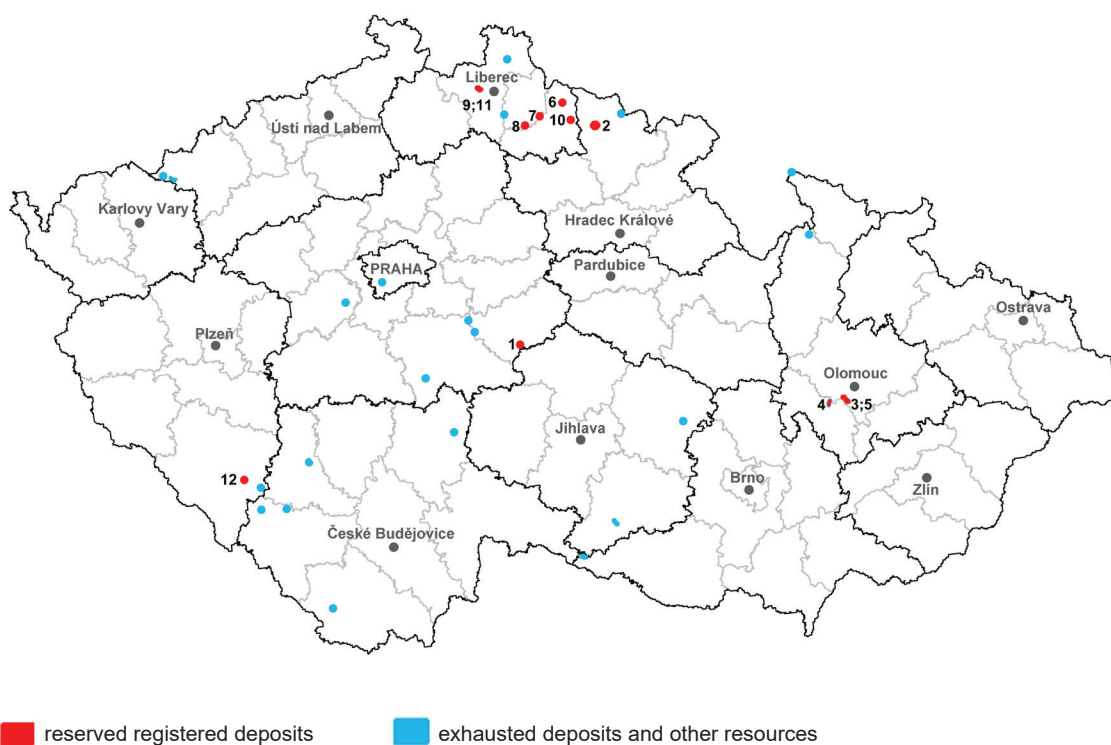
Deposits, resources and occurrences of dolomites and calcareous dolomites in the Czech Republic are concentrated in the following main areas:

- 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 Rožinka 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



Principal areas of deposits presence

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

1 **Bohdaneč**

2 **Lánov**

3 Bystročice

4 Čelechovice na Hané

5 Hněvotín

6 Horní Rokytnice

7 Jesenný-Skalka

8 Koberovy

9 Kryštofovo Údolí

10 Křížlice

11 Machnín-Karlov pod Ještědem

12 Podmokly

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

Number of deposits; reserves; mine production

Year	2018	2019	2020	2021	2022
Deposits – total number	12	12	12	11	11
exploited	2	2	2	1	1
Total mineral *reserves, kt	524,595	524,142	522,028	522,635	521,206
economic explored reserves	83,087	82,643	80,529	80,136	79,707
economic prospected reserves	348,286	337,297	337,297	337,297	337,297
potentially economic reserves	93,222	104,202	104,202	104,202	104,202
exploitable (recoverable) reserves	9,979	9,526	7,526	7,132	6,703
Mine production, kt	451	453	398	393	429

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	t	526,570	443,075	485,996	476,715	434,566
Export	t	131	58	73	105	64

2518 – Dolomite calcined, roughly trimmed or cut; agglomerated

		2018	2019	2020	2021	2022
Average import prices	CZK/t	232	227	235	233	278
Average export prices	CZK/t	3,82	5,472	9,651	6,352	7,875

6. Prices of domestic market

Average domestic prices of traded commodities

Product specification	2018	2019	2020	2021	2022
Dolomite aggregates, CZK/t	300–470	318–376	325–387	320–430	350–480
Ground calcitic dolomite, bulk, CZK/t	729	770–830	780–850	840	1,170–1,250
Ground calcitic dolomite, bagged, CZK/t	1,800	1,900–2,060	1,950–2,100	2,200	2,875–3,150

7. Mining companies in the Czech Republic as of December 31, 2022

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 KAlSi_3O_8 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 $\text{NaAlSi}_3\text{O}_8$, oligoclase, andesine). Alkaline (with a predominance of Ca over Na) members of the plagioclase series (labradorite, bytownite, anorthite $\text{CaAl}_2\text{Si}_2\text{O}_8$) 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

2022		
Země	kt	% svět**
Iran	630,000	N
India	320,000	N
Thailand	240,000	N
Turkey	220,000	N
South Korea	180,000	N
Brazil	150,000	N
Czech Republic*	54,000	N
World	N	N

* *Bilance zásob k 1. 1. 2022 (national Register of Reserves as of 1. 1. 2023, rounded)*

** *Total world reserves are large but not quantified*

Source: MCS 2023

2022			
Země	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

* *Bilance zásob k 1. 1. 2023 (national Register of Reserves as of 1. 1. 2023)*

Source: European Minerals Yearbook – version 2022

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 $\text{Na}_3\text{K}(\text{Al}_4\text{Si}_4\text{O}_{16})$ – 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

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.

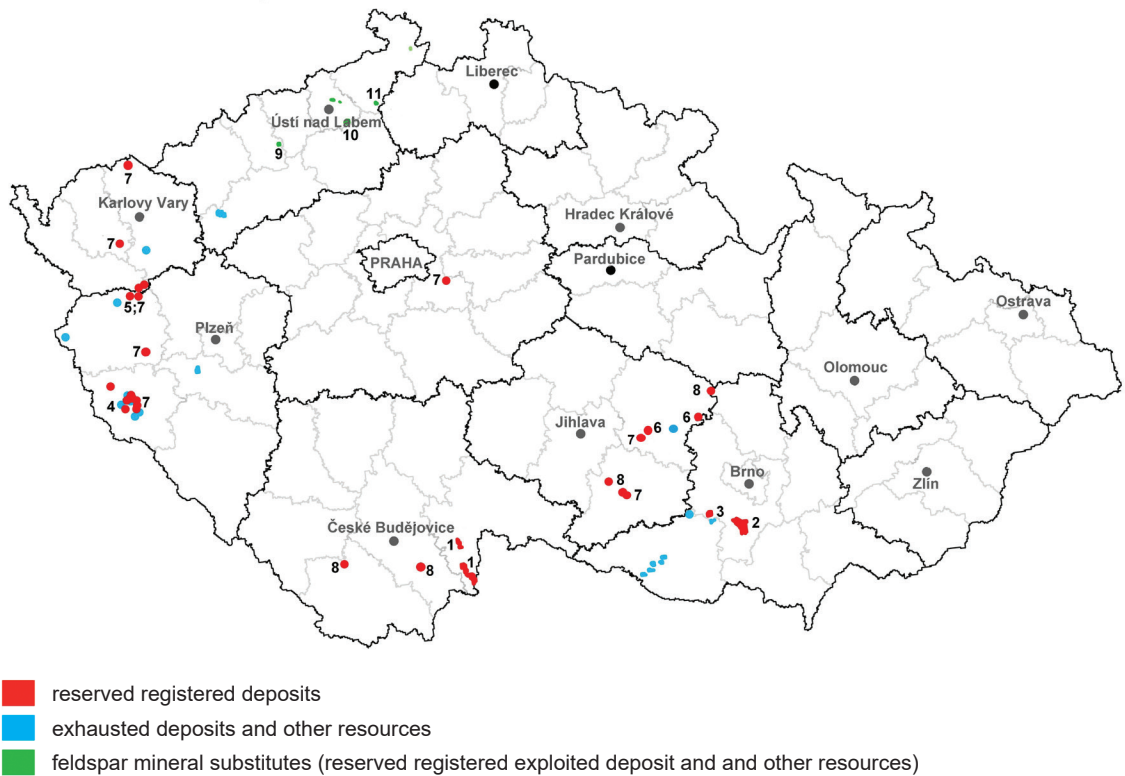
The raw material of fluvial deposits are feldspar gravels with a predominance of potassium feldspars over plagioclase, suitable for the production of utility porcelain, medical ceramics, glass, etc. and, to a limited extent, for the production of glazes.

- 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, Kladruba

(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 (Štíhllice), 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, Mutěnin, Ohnišovice, 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, Křepkovic, 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 microcline 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% Na₂O and 3.5–5% K₂O) makes it possible to reduce melting temperatures and shorten the burning time.

3. Registered deposits and other resources of the Czech Republic



The main deposit areas of feldspar raw material

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

- | | |
|---|---|
| 1 Sediments of the Lužnice River region | 4 Pegmatites |
| 2 Sediments of the Jihlava River | (the Poběžovice-Domažlice region) |
| (the Syrovice-Ivaň Terrace) | 5 Pegmatites (the Teplá region) |
| 3 Sediments of the Jihlava River | 6 Pegmatites (the western Moravia region) |
| (the Ivančice region) | 7 Granitoids |
| | 8 Others |

Feldspar mineral substitutes (nepheline phonolites):

- | | | |
|------------|----------------|--------------------------|
| 9 Želenice | 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	2018	2019	2020	2021	2022
Deposits – total number	40	41	42	42	42
exploited	9	10	10	10	9
Total mineral *reserves, kt	91,722	101,487	102,853	102,324	101,802
economic explored reserves	28,709	29,742	29,334	28,846	28,369
economic prospected reserves	47,157	55,889	57,663	57,622	57,577
potentially economic reserves	15,856	15,856	15,856	15,856	15,856
exploitable (recoverable) reserves	22,596	22,126	21,599	29,709	29,288
Mine production, kt	449	460	419	504	493

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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	2018	2019	2020	2021	2022
Deposits – total number	3	3	3	3	3
exploited	1	1	1	1	1
Total mineral *reserves, kt	199,773	199,709	199,709	199,107	199,635
economic explored reserves	0	0	0	0	0
economic prospected reserves	199,742	199,709	199,680	199,656	199,635
potentially economic reserves	0	0	0	0	0
exploitable (recoverable) reserves	24,173	24,140	24,111	24,086	24,065
Mine production, kt	31	33	29	24	21

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
P ₁	–	–	–	–	–
P ₂ , kt	30,300	30,300	30,300	30,300	30,300
P ₃	–	–	–	–	–

5. Foreign trade

252910 – Feldspar

		2018	2019	2020	2021	2022
Import	t	10,831	7,225	5,607	6,634	4,325
Export	t	252,956	271,561	224,780	244,689	257,161

252910 – Feldspar

		2018	2019	2020	2021	2022
Average import prices	CZK/t	2,713	3,632	3,619	3,354	3,754
Average export prices	CZK/t	1,023	834	859	894	1,066

252930 – Leucite, nepheline and nepheline syenite

		2018	2019	2020	2021	2022
Import	t	3,777	4,524	4,207	4,552	4,150
Export	t	3	482	543	759	244

252930 – Leucite, nepheline and nepheline syenite

		2018	2019	2020	2021	2022
Average import prices	CZK/t	6,264	6,488	6,680	6,562	7,561
Average export prices	CZK/t	9,017	10,866	11,071	10,345	12,092

6. Prices of domestic market

Feldspars were sold domestically for CZK 1,500–5,500 per tonne in 2022 depending on their chemism and usage.

7. Mining companies in the Czech Republic as of December 31, 2022**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	2018	2019	2020	2021	2022 ^e
World mine production of feldspar (according to MCS), kt	25,600	23,000	24,400	27,600	28,000
World mine production of feldspar (according to WBD), kt	35,049	31,000	29,892	35,838	N
World mine production of feldspar (according to WMP), kt	31,952	30,327	30,155	34,356	N

e – preliminary values

Main producers according to MCS

2022 ^e		
Country	kt	%
Turkey	6,200	22.1
China	2,400	8.6
Italy	2,200	7.1
Iran	2,000	8.6
Thailand	1,300	4.6
South Korea	1,000	3.6
Saudi Arabia	820	2.9
Spain	800	2.9
Brazil	630	2.3
Czech Republic	460	1.6
USA	420	1.5
Mexico	320	1.1
World	28,000	100.0

e – preliminary values

Prices of traded commodities (according to IM)

Commodity/year		2018	2019	2020	2021	2022
Feldspar, marketable production, US market, average price, according to MCS	USD/t	97	107	108	110	110
Nepheline syenite, average US import price, according to MCS	USD/t	76	156	163	164	180
Feldspar for the ceramic and glass industry, average export price from the Czech Republic to Poland (CZSO)	EUR/t	37.96	38.24	27.99	26.77	36.62

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

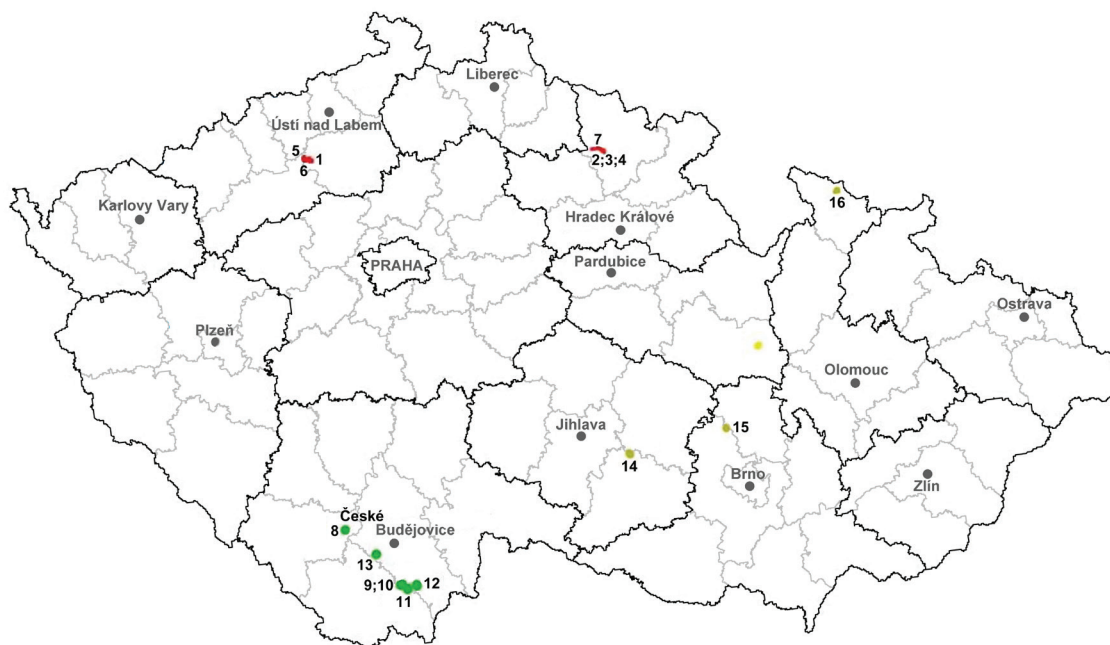
2. Mineral resources of the Czech Republic

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 $\text{Mg}_3\text{Al}_2[\text{SiO}_4]\text{O}_3$, 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 m³ (5 to 8 g per 1 ton) of rock.

3. Registered deposits and other resources of the Czech Republic



- reserved registered deposits of pyrope-bearing rock
- exhausted deposits and other resources of pyrope-bearing rock
- reserved registered deposits of moldavite-bearing rock
- exhausted deposits and other resources of moldavite-bearing rock
- reserved registered deposits of other gemstones
- exhausted deposits and other resources of other gemstones

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	2018	2019	2020	2021	2022
Deposits – total number ^{a)}	12	15	15	15	15
exploited ^{b)}	3	4	4	2	5
Total mineral *reserves, kt ^{a)}	19,353	19,359	19,357	19,357	19,354
economic explored reserves	3,170	3,162	3,161	3,161	3,159
economic prospected reserves	13,002	13,016	13,016	13,016	13,015
potentially economic reserves	3,181	3,181	3,180	3,180	3,180
exploitable (recoverable) reserves	29,562	29,551	29 549	1,099	1,096
Total mineral *reserves, m ³ ^{c)}	373,202	1,466,041	1,415 330	1,372,017	1,324,198
economic explored reserves	36,352	26,352	21,352	9,352	4,452
economic prospected reserves	333,751	1,434,478	1,393 978	1,357,454	1,314,535
potentially economic reserves	3, 099	5,211	5,211	5,211	5,211
exploitable (recoverable) reserves	167,235	281,317	235,817	187,293	140,924
Total mineral *reserves, kt (1 m ³ = 1.8t) ^{c)}	671	1,465	2,556	1,371	2,384
economic explored reserves	65	47	38	9	8
economic prospected reserves	601	1,434	2,509	1,357	2,366
potentially economic reserves	6	9	9	5	9
exploitable (recoverable) reserves	323	506	236	187	253
Mine production, kt ^{a)}	13	12	1	0	3
Mine production, ths m ³ ^{c)}	61	42	46	49	48
Mine production, kt ^{c)} (1 m ³ = 1.8t)	110	76	83	88	86

* 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 P₁, P₂, P₃

Year		2018	2019	2020	2021	2022
P1,	^{b)} kt	749	749	749	749	749
P1,	^{c)} tns 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**

		2018	2019	2020	2021	2022
Import	kg	15,341	30,097	18.0	1,011	73,401
Export	kg	109	5	39	34	56

7102 – Diamonds, whether or not worked, but not mounted or set

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	15,163	7,393	15,554,277	309,815	6,203
Average export prices	CZK/kg	419,761	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

		2018	2019	2020	2021	2022
Import	kg	343,708	374,073	115,537	422,193	589,089
Export	kg	87,394	45,644	78,985	176,699	178,772

7103 – Precious (other than diamond) and semi-precious stones, whether or not worked or graded but not strung, mounted or set

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	232	928	266	310	391
Average export prices	CZK/kg	613	1,575	1,021	591	679

251320 – Emery, natural corundum, natural garnet and other natural abrasives

		2018	2019	2020	2021	2022
Import	t	3,808	4,017	12,711	1,669	3 266
Export	t	182	276	147	139	91

251320 – Emery, natural corundum, natural garnet and other natural abrasives

		2018	2019	2020	2021	2022
Average import prices	CZK/t	7,944	7,810	8,367	8,813	9,665
Average export prices	CZK/t	47,414	10,350	2,860	23,950	19,037

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 2022:

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 2022 Company Granát bought for the jewellery 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	1,350–1,720
	2.15–2.82	1	1,940–2,300
	2.95–3.05	1	2,320–2,580
	3.10–3.20	1	2,650–2,690
	3.30–3.52	1	2,780–2,960
	3.55–3.62	1	2,880–3,000
	4.50	1	3,590
Chlum	3.65–3.75	1	2,050–2,150
	3.80–3.95	1	2,220–2,230
	4.04–4.85	1	2,290–2,750
	5.35–5.42	1	3,170–3,200
	5.50–5.45	1	3,350–3,420
	5.64–6.20	1	3,530–3,750
	7.05	1	4,650

*Note: * moldavites from this locality are visually regarded as the best*

7. Mining companies in the Czech Republic as of December 31, 2022

Pyrope-bearing rock

Granát, družstvo umělecké výroby, Turnov

Moldavite-bearing rock

MAWE CK s.r.o., Český Krumlov

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

	2018	2019	2020	2021	2022 ^e
World production, t	1,120 000	1,100 000	1,100 000	925,000	980,000

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):

	2018	2019	2020	2021	2022 ^e
World mine production (according to MCS)	89,000	82,400	62,300	73,900	76,000
World mine production (according to WBD)	83,460	78,202	62,210	75,334	N

e – preliminary values

Main producers according to MCS

2022 ^e			2022 ^e		
Gem-quality diamonds			Industrial diamonds		
Country	ths carats	%	Country	ths carats	%
Russia	21,000	27.6	Russia	17,000	37.0
Botswana	18,000	23.7	Congo (Kinshasa)	11,000	23.9
Angola	10,000	13.2	Botswana	7,000	15.2
South Africa	3,900	5.1	South Africa	6,000	13.0
Congo (Kinshasa)	2,500	3.3	Zimbabwe	4,000	8.7
Namibia	2,300	3	Others	1,000	2.2
Sierra Leone	680	0.9	World	46,000	100.0
Zimbabwe	470	0.6			
Lesotho	230	0.3			
Guinea	220	0.3			
Brazil	150	0.2			
World	76,000	100.0			

e – preliminary values

e – preliminary values

World production of industrial diamonds was as follows:

	2018	2019	2020	2021	2022 ^e
World production (according to WBD), ths ct	63,929	57,130	45,474	42,923	N
World production (according to MCS), ths ct	58,000	55,000	45,000	46,000	46,000

e – preliminary values

World market prices

Gemstone prices depend on the type, size, and quality of the stones while the price ranges are considerable.

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	2018	2019	2020	2021	2022
Industrial diamonds, US import, USD/ct (according to MCS)	2.96	5.82	8.41	13.00	10.00
Industrial garnets, US import, USD/t (according to MCS)	215	214	250	280	200

Gypsum

1. Characteristics and use

Gypsum is a sedimentary rock composed mainly or completely of the gypsum mineral ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), 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.

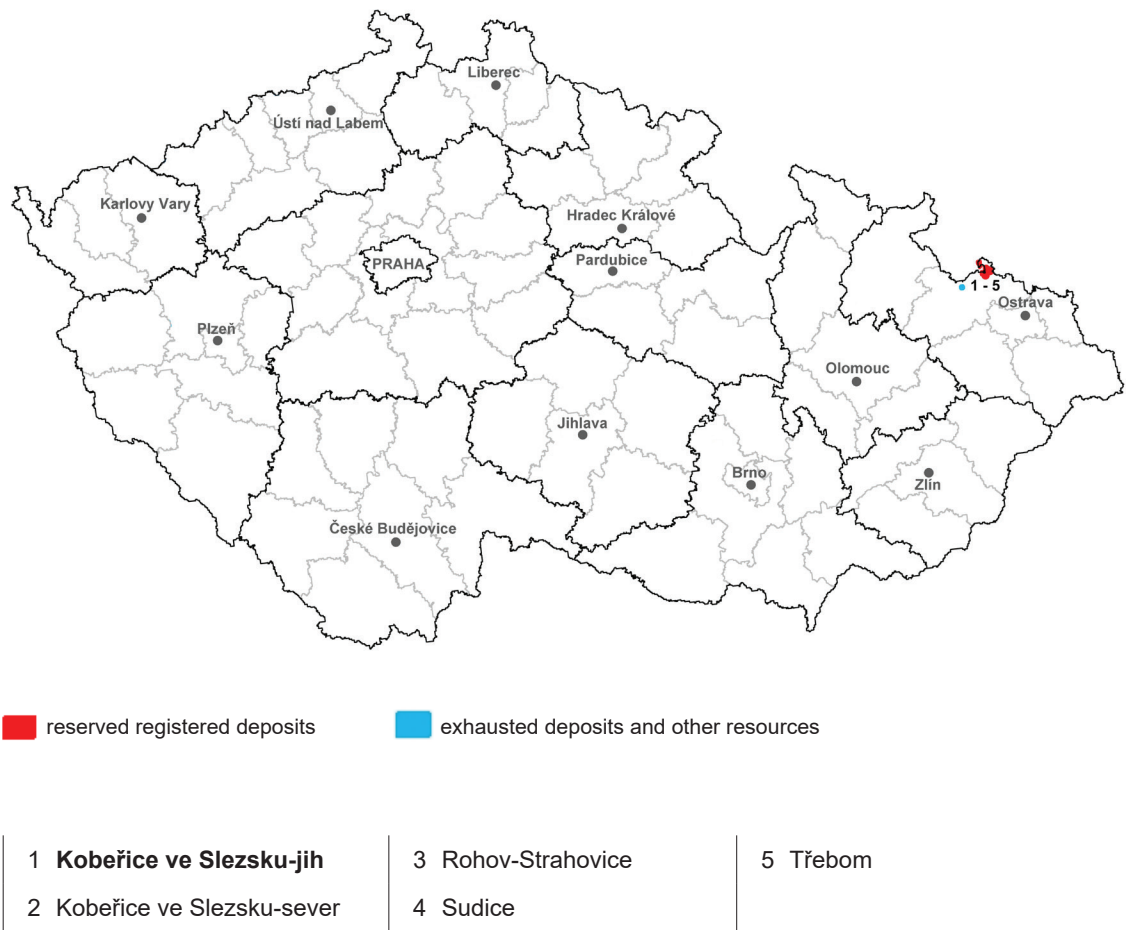
Classification as critical raw materials for the European Union

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

2. Mineral resources of the Czech Republic

Gypsum deposits in the Czech Republic are bound to Miocene (Baden-Wieliczken) 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) – Koberžice 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



(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	2018	2019	2020	2021	2022
Deposits – total number	5	5	5	5	5
exploited	1	1	1	1	1
Total mineral *reserves, kt	504,160	504,159	504,133	504,116	504,096
economic explored reserves	119,033	119,022	119,006	118,989	118,969
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	2,192	2,181	43,652	43,635	2,128
Mine production, kt	6	10	17	17	20

* 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

		2018	2019	2020	2021	2022
Import	t	76,116	79,423	95,403	163,223	176,849
Export	t	72,136	105,680	209,012	174,689	121,438

252010 – Gypsum, anhydrite

		2018	2019	2020	2021	2022
Average import prices	CZK/t	2,048	2,167	1,853	1,137	1,338
Average export prices	CZK/t	30	131	372	293	272

6. Prices of domestic market

Average prices of traded commodities on the domestic market

	2018	2019	2020	2021	2022
mined gypsum, CZK/t	N	N	N	N	N
grey gypsum binder, bagged in 30 kgs, pallets, CZK/t	3,672	4,507	4,625–4,820	4,660–4,860	4,800–5,000
white gypsum binder, bagged in 30 kgs, pallets, CZK/t	6,210	7,627	6,100–8,425	7,540–10,690	7,800–11,000

7. Mining companies in the Czech Republic as of December 31, 2022

GYPSTREND s.r.o., Koberžice

8. World production and world market prices

World mine production

Data on world production of primary gypsum in recent years:

	2018	2019	2020	2021	2022 ^e
World mine production of gypsum (according to MCS), kt	141,000	150,000	148,000	144,000	150,000
World mine production of gypsum (according to WBD), kt	155,849	167,939	160,136	161,909	N

e – preliminary values

Main producers according to MCS

2022^e		
Country	kt	%
USA	21,000	13.7
Iran	16,000	10.5
China	13,000	8.5
Oman	12,000	7.8
Spain	11,000	7.2
Thailand	9,300	6.1
Turkey	9,300	6.1
Mexico	5,400	3.5
Germany	5,200	3.4
Japan	4,300	2.8
Russia	4,100	2.7
Saudi Arabia	4,000	2.6
Canada	2,400	1.6
World	153,000	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

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.

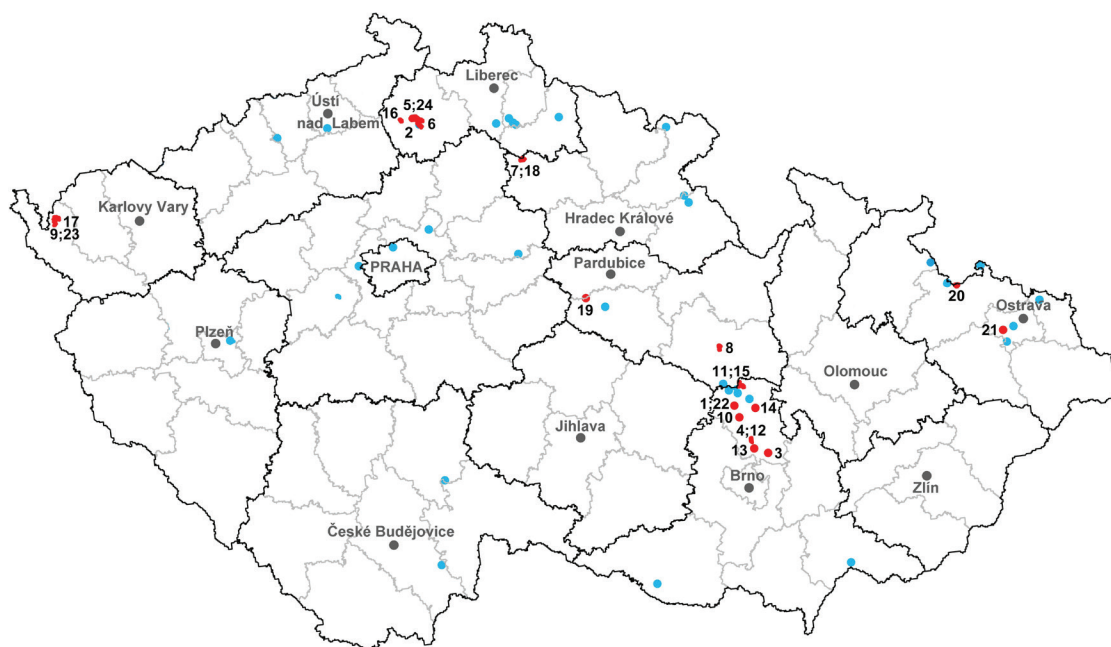
- The second most important area is the southern surroundings of Česká Lípa in the Lusatian facial area of the Czech Cretaceous basin. The raw material consists of weakly consolidated quartz sandstones of mid-Turonian age. The Provodín and Srní 2-Veselí deposits used until recently were exhausted in 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 (Zvěřínec, Kluk) and southern Moravia (Bzenec, Strážnice, Břeclav), fluvial terrace sands of central (Tetín, Serbia, exhausted Kobylišy-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 Voděradý **	18 Mladějov v Čechách*
3 Rudice-Seč **	11 Babolky**	19 Načešice**
4 Spešov-Dolní Lhota **	12 Blansko 1-Jezírka**	20 Palhanec-Vávrovce**
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	2018	2019	2020	2021	2022
Deposits – total number	6	6	7	7	7
exploited	3	4	3	3	3
Total mineral *reserves, kt	248,584	249,379	255,849	255,088	254,378
economic explored reserves	79,437	78,644	77,914	77,153	76,443
economic prospected reserves	24,415	29,970	29,970	29,970	29,970
potentially economic reserves	144,732	147,965	147,965	147,965	147,965
exploitable (recoverable) reserves	73,126	72,337	71,609	36,781	70,139
Mine production, kt	743	740	683	715	664

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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	2018	2019	2020	2021	2022
Deposits – total number	25	25	26	26	26
exploited	7	8	6	6	6
Total mineral *reserves, kt	405,205	409,489	405,761	405,160	404,524
economic explored reserves	125,757	125,227	124,748	124,162	123,538
economic prospected reserves	132,601	133,423	133,412	133,397	133,385
potentially economic reserves	146,847	147,601	147,601	147,601	147,601
exploitable (recoverable) reserves	76,034	73,378	72,891	4,374	71,117
Mine production, kt	559	514	470	583	615

* 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 P₁, P₂, P₃

Year		2018	2019	2020	2021	2022
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**

		2018	2019	2020	2021	2022
Import	t	252,101	500,006	257,395	299,888	331,924
Export	t	506,226	206,347	497,653	563,458	518,411

250510 – Silica sands and quartz sands

		2018	2019	2020	2021	2022
Average import prices	CZK/t	889	476	994	1,082	1,117
Average export prices	CZK/t	442	478	503	520	510

7001 – Cullet and other waste and scrap of glass; glass in the mass

		2018	2019	2020	2021	2022
Import	t	206,606	21,517	209,208	230,866	227,244
Export	t	21,204	21,517	15,357	27,188	16,147

7001 – Cullet and other waste and scrap of glass; glass in the mass

		2018	2019	2020	2021	2022
Average import prices	CZK/t	1,633	1,564	1,533	1,628	1,731
Average export prices	CZK/t	987	850	1,277	1,776	1,513

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 250–3,500 in 2022.

7. Mining companies in the Czech Republic as of December 31, 2022

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.
 PEDOP s.r.o., Lipovec
 LB MINERALS, s.r.o., Horní Bříza

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:

	2018	2019	2020	2021	2022 ^e
Industrial sands (according to MCS), kt	300 000	325 000	235 000	353 000	380 000

e – preliminary values

Main producers according to MCS

2022^e		
Country	kt	%
USA	97,000	25.5
China	88,000	23.2
Netherlands	54,000	14.2
Italy	14,000	3.7
France	12,000	3.2
India	12,000	3.2
Turkey	11,000	2.9
Bulgaria	8,600	2.3
Spain	6,000	1.6
Poland	5,500	1.5
United Kingdom	5,300	1.4
Canada	5,000	1.3
Australia	4,500	1.2
Malaysia	4,000	1.0
World	380,000	100.0

e – preliminary values

Prices of traded commodities – silica sand

Commodity/year		2018	2019	2020	2021	2022^e
Silica sand for industrial use, average price, MCS	USD/t	56.10	46.10	29.5	42.4	58.0

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

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 ($\text{Fe}_2\text{O}_3 + \text{TiO}_2$ 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:

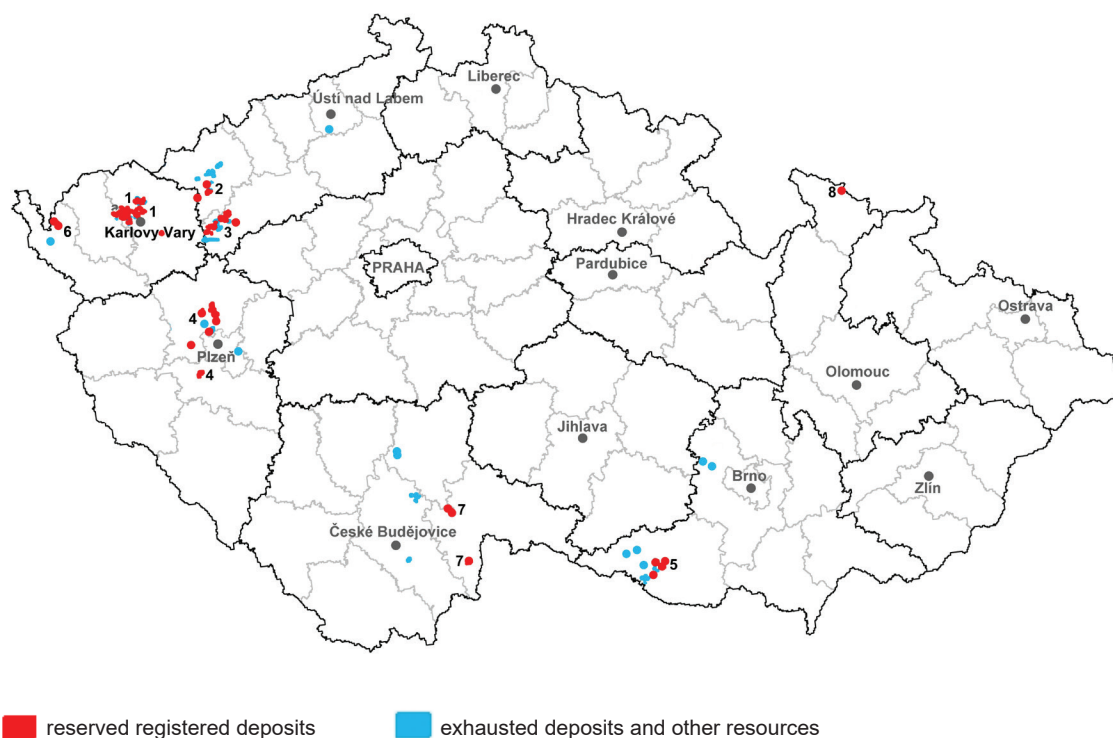
- Karlovy Vary area – the parent rocks were the autometamorphic and mountain granites of the Karlovy Vary massif. It is the most important area of occurrence of the highest quality kaolins for the production of porcelain and their potential substitutes – titanium kaolins. There are also kaolins for the 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**

2 **Kadaň Region**

3 **Podbořany Region**

4 **Plzeň Region**

5 Znojmo Region

6 Cheb Basin

7 Třeboň Basin

8 Vidnava

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

Number of deposits; reserves; mine production

Year	2018	2019	2020	2021	2022
Deposits – total number	71	77	77	77	77
exploited	15	18	18	18	18
Total mineral *reserves, kt	1,174,798	1,147,845	1,148,248	1,162,974	1,158,543
economic explored reserves	247,926	244,432	240,196	247,199	246,781
economic prospected reserves	484,216	461,095	465,952	481,923	481,901
potentially economic reserves	442,656	442,318	442,100	433,852	429,861
exploitable (recoverable) reserves	100,630	106,311	104,278	101,371	108,636
Mine production, kt ^{a)}	3,622	3,446	3,069	3,454	3,009
Beneficiated (water-washed) kaolin production, kt	653	629	626	645	558

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
P ₁ , kt	17,197*	17,197 *	17,197 *	17,197 *	17,197 *
P ₂	–	–	–	–	–
P ₃	–	–	–	–	–

Note: * 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	2018	2019	2020	2021	2022
Deposits – total number	33	34	34	34	34
exploited	8	8	8	8	8
Total mineral *reserves, kt	244,864	244,590	244,294	244,044	243,863
economic explored reserves	47,749	47,483	47,187	46,937	46,756
economic prospected reserves	107,617	107,617	107,617	107,617	107,617
potentially economic reserves	89,498	89,490	89,490	89,490	89,490
exploitable (recoverable) reserves	15,773	23,245	23,079	15,270	22,499
Mine production, kt ^{a)}	313	239	266	226	227

* 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, Jimlikov, Krásný Dvůr-Podbořany, Mírová, Podlesí 2, Podlesí-Čapí hnízdo, Ruprechtov

Number of deposits; reserves; mine production

Kaolin for paper industry	2018	2019	2020	2021	2022
Deposits – total number	31	31	31	31	31
exploited	8	9	9	9	9
Total mineral *reserves, kt	286,2980	285,410	283,549	277,701	276,807
economic explored reserves	60,253	58,732	56,904	57,886	57,563
economic prospected reserves	172,165	172,154	172,131	167,801	167,779
potentially economic reserves	54,563	54,524	54,514	52,014	51,465
exploitable (recoverable) reserves	32,541	31,324	30,441	31,260	30,911
Mine production, kt ^{a)}	1,362	1,256	1,234	1,322	1,189

* 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

		2018	2019	2020	2021	2022
Import	t	36,868	38,914	43,231	37,553	27,276
Export	t	561,503	537,827	471,566	505,634	460,466

2507 – Kaolin and other kaolinic clays, whether or not calcined

		2018	2019	2020	2021	2022
Average import prices	CZK/t	3,211	3,557	3,511	4,249	4,867
Average export prices	CZK/t	2,683	2,945	3,134	3,146	3,591

25070020 – Kaolin

		2018	2019	2020	2021	2022
Import	t	16,766	17,818	20,582	21,586	20,394
Export	t	561,049	537,578	471,370	505,461	460,406

25070020 – Kaolin

		2018	2019	2020	2021	2022
Average import prices	CZK/t	4,991	3,557	4,135	4,258	4,864
Average export prices	CZK/t	2,678	2,942	3,130	3,142	3,590

25070080 – Kaolinic clay (other than kaolin)

		2018	2019	2020	2021	2022
Import	t	20,101	21,097	22,650	15,967	6,882
Export	t	454	249	197	173	59

25070080 – Kaolinic clay (other than kaolin)

		2018	2019	2020	2021	2022
Average import prices	CZK/t	1,725	2,571	2,944	4,236	4,873
Average export prices	CZK/t	9,558	9,598	12,667	13,446	7,427

6. Prices of domestic market

Average prices of traded kaolin on the domestic market

In 2022, production prices of kaolins were in the following ranges:

Kaolin for ceramics manufacturing	CZK/t 2,200–3,500
Kaolin for paper industry	CZK/t 2,500–4,800
Kaolin other	CZK/t 3,400–6,100

7. Mining companies in the Czech Republic as of December 31, 2022

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 2022 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:

	2018	2019	2020	2021	2022 ^e
World mine production (according to MCS), kt	42,200	44,300	46,400	49,300	48,000
World mine production (according to WBD), kt	45,410	44,213	42,634	43,336	N

e – preliminary values

Main producers according to MCS

2022^e		
Country	kt	%
China	8,400	17.5
India	8,400	17.5
Uzbekistan	5,000	10.4
USA	4,600	9.6
Czech Republic	3,100	6.5
Iran	1,900	4.0
Turkey	1,700	3.5
Brazil	1,200	2.5
Ukraine	600	1.3
Spain	270	0.6
Mexico	240	0.5
World	48,000	100.0

e – preliminary values

Prices of traded commodities

Commodity/year		2018	2019	2020	2021	2022^e
Kaolin, average US market price, ex works, according to MCS	USD/st	160	162	160	154	160
Kaolin Czech, average export price into Germany (CZSO)	EUR/t	90.37	96.96	99.06	107.23	134.50

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 silicic 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 silicic 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

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).

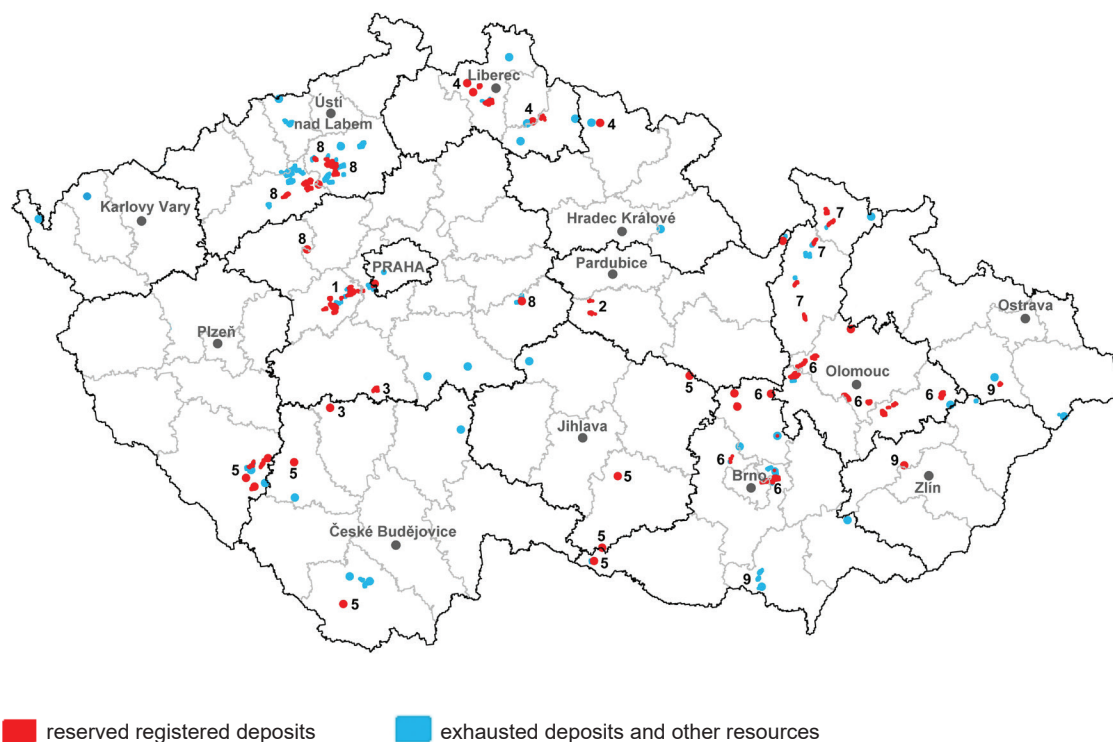
Deposits and the main sources of limestones in the Czech Republic are concentrated in the following main areas:

- 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-Čeřínka (high-percentage and other limestones), Kosoř-Hvízdalka (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-Hejtná (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 Block (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 Štramberské 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 Štramberské 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	2018	2019	2020	2021	2022
Deposits – total number	85	85	85	85	85
exploited	22	22	22	22	22
Total mineral *reserves, kt	4,724,605	4,724,605	4,712,955	4,178,073	4,163,329
economic explored reserves	2,020,399	2,020,399	2,009,011	1,761,116	1,755,163
economic prospected reserves	1,819,749	1,819,749	1,819,539	1,658,910	1,658,803
potentially economic reserves	884,457	884,457	884,405	758,047	749,363
exploitable (recoverable) reserves	1,609,852	1,131,050	1,257,354	1,196,691	1,182,737
Mine production, kt	11,727	11,357	11,296	11,007	10,319

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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 CaCO₃ Number of deposits; reserves; mine production

Year	2018	2019	2020	2021	2022
Deposits – total number	27	27	27	28	28
exploited	10	10	10	8	10
Total mineral *reserves, kt	1,287,127	1,288,592	1,284,292	1,275,664	1,269,274
economic explored reserves	684,084	685,552	681,209	672,717	672,663
economic prospected reserves	417,911	417,911	417,911	417,775	417,775
potentially economic reserves	185,129	185,129	185,172	185,172	178,836
exploitable (recoverable) reserves	506,916	497,389	529,994	514,572	510,328
Mine production, kt	5,311	4,709	4,186	4,450	4,158

* 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 CaCO₃ Approved prognostic resources P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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	2018	2019	2020	2021	2022
Deposits – total number	48	48	48	49	50
exploited	17	17	17	17	16
Total mineral *reserves, kt	2,311,489	2,311,976	2,305,870	2,303,207	2,299,070
economic explored reserves	968,030	968,552	962,716	963,761	959,636
economic prospected reserves	811,904	811,694	811,694	807,986	807,879
potentially economic reserves	531,555	531,460	531,460	531,460	531,555
exploitable (recoverable) reserves	577,988	593,759	568,906	644,359	639,391
Mine production, kt	4,824	5,601	5,523	5,451	5,122

* 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 P₁, P₂, P₃**

Year		2018	2019	2020	2021	2022
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		2018	2019	2020	2021	2022
Deposits – total number		13	13	13	13	14
exploited		2	2	2	2	2
Total mineral *reserves, kt		523,420	522,971	522,419	521,882	533,332
economic explored reserves		240,277	239,828	239,276	238,739	238,171
economic prospected reserves		156,785	156,785	156,785	156,785	160,791
potentially economic reserves		126,358	126,358	126,358	126,358	134,370
exploitable (recoverable) reserves		151,956	151,506	150,955	150,328	153,664
Mine production, kt		650	449	551	473	465

* 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 P₁, P₂, P₃**

Year		2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	t	357,831	294,296	343,891	421,109	476,629
Export	t	239,339	225,111	166,275	177,504	186,282

2521 – Limestone flux; limestone and other calcareous stone, of kind used for the manufacture of lime or cement

		2018	2019	2020	2021	2022
Average import prices	CZK/t	198	166	192	214	248
Average export prices	CZK/t	446	473	506	522	617

2522 – Quicklime, slaked lime and hydraulic lime

		2018	2019	2020	2021	2022
Import	t	81,256	91,140	78,831	102,793	136,237
Export	t	298,530	235,827	214,435	173,518	84,036

2522 – Quicklime, slaked lime and hydraulic lime

		2018	2019	2020	2021	2022
Average import prices	CZK/t	1,722	1,711	1,737	2,300	2,985
Average export prices	CZK/t	1,986	2,096	2,220	2,140	2,792

2523 – Portland cement, aluminous cement, slag cement, supersulphate cement and similar hydraulic cements, whether or not coloured or in the form of clinkers

		2018	2019	2020	2021	2022
Import	t	640,371	583,569	617,179	688,642	634,710
Export	t	749,334	785,000	568,895	621,962	448,994

2523 – Portland cement, aluminous cement, slag cement, supersulphate cement and similar hydraulic cements, whether or not coloured or in the form of clinkers

		2018	2019	2020	2021	2022
Average import prices	CZK/t	1,687	1,766	1,921	1,965	2,371
Average export prices	CZK/t	1,522	1,621	1,832	1,789	2,127

6. Prices of domestic market

Average prices of traded commodities on the domestic market

Product specification	2018	2019	2020	2021	2022
Cement CEM I, 42,5 R, on pallets, CZK/t	2,640	2,840	2,840	2,920	3,700
Cement CEM I, 42,5 R, on pallets, covered with foil, CZK/t	2,700	2,900	2,900	3,000	3,750
Cement CEM III A, 32,5 R, on pallets, CZK/t	2,300	2,600	2,660	2,720	3,350
Cement CEM III A, 32,5 R, on pallets, covered with foil, CZK/t	2,360	2,660	2,660	2,720	3,350
Dolomitic hydrated lime, bulk, CZK/t	3,000–3,790	5,840	4,100	4,500	5,600
Quicklime, ground, bulk, CZK/t	1,773–2,755	1,981–2,880	3,650–4,020	3,400–4,100	4,100–5,000
Limestone, ground, bulk, CZK/t	595–669	425–690	430–710	440–750	550–930
Limestone, crushed, CZK/t	189–408	253–450	190–550	200–550	250–650

7. Mining companies in the Czech Republic as of December 31, 2022

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

Lafarge Cement, 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	2018	2019	2020	2021	2022 ^e
World cement production, mill. t	4,050	4,100	4,200	4,400	4,100
World lime production, mill. t	424	432	427	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	2018	2019	2020	2021	2022 ^e
World limestone production derived from the global cement production, mill. t	4,050	4,100	4,200	4,400	4,100
World limestone production derived from the global lime production, mill. t	848	862	854	860	860
World limestone production derived from the global lime production and cement production, mill. t	4,898	4,962	5,054	5,260	4,960

e – preliminary values

Main producers according to MCS

2022 ^e			2022 ^e		
Cement			Lime		
Country	kt	%	Country	kt	%
China	2,100,000	56.8	China	310,000	72.1
India	370,000	7.5	USA	17,000	4.0
Vietnam	120,000	2.3	India	16,000	3.7
USA	95,000	2.1	Russia	11,000	2.6
Turkey	85,000	1.7	Brazil	8,400	2.0
Indonesia	64,000	1.5	Germany	5,600	1.3
Brazil	65,000	1.5	Japan	7,000	1.6
Iran	62,000	1.4	South Korea	5,200	1.2
Russia	61,000	1.3	Turkey	4,800	1.1
Saudi Arabia	54,000	1.3	Iran	3,900	0.9
World	4,100,000	100.0	World	430,000	100.0

e – preliminary values

Prices of traded commodities – calcium carbonate

Commodity/year		2018	2019	2020	2021	2022
Cement, at plant USA (MCS)	USD/t	121	124	125	130	130
Quick lime, at plant USA (MCS)	USD/t	125.20	128.30	131.40	133.40	140
Hydrated lime, at plant USA (MCS)	USD/t	151.60	154.60	156.00	159.60	160
Limestone, Slovakian, yearly average price of import into the Czech Republic (CZSO)	EUR/t	6.19	6.11	6.19	6.56	8.30

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 (semiconductors 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

2. Mineral resources of the Czech Republic

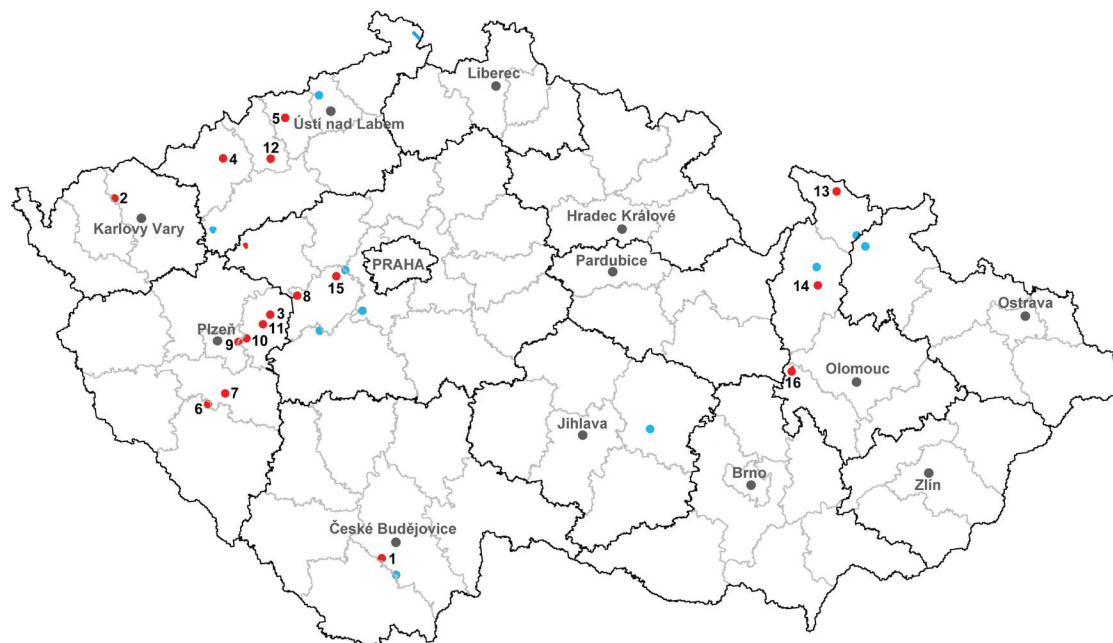
In the Czech Republic, silica materials are divided into silica materials and silica materials for special glasses. Deposits of silica materials are mainly related to the occurrences of “amorphous” Tertiary quartzite, Cretaceous “crystalline” quartzite and Ordovician quartzite, and to a lesser extent 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 (silicified 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-Dobruška, Stránský, Skřín) 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 Block (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 (Litohlav, 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**

2 Černava-Tatrovice

3 Drahoňův Újezd-Bechlov

4 Chomutov-Horní Ves

5 Jeníkov-Lahošť

6 Kaliště

7 Kbelnice

8 Kublov-Dlouhá Skála

9 Kyšice-Pohodnice

10 Litohlavy-Smrkový vrch

11 Sklená Huť

12 Stránce

13 Velká Kraš

14 Víkřovice

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	2018	2019	2020	2021	2022
Deposits – total number	16	17	15	15	15
exploited	1	1	1	1	1
Total mineral *reserves, kt	25 166	26,679	26,668	26,526	26,519
economic explored reserves	763	763	763	924	914
economic prospected reserves	20,214	21,727	21,716	21,416	21,416
potentially economic reserves	4,189	4,189	4,189	4,189	4,189
exploitable (recoverable) reserves	445	428	417	188	178
Mine production, kt	16	17	11	20	10

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	t	12,526	15,128	11,971	43,350	67 198
Export	t	64	8	1	69	29

2506 – Quartz (other than natural sands); quartzite, whether or not roughly trimmed or merely cut

		2018	2019	2020	2021	2022
Average import prices	CZK/t	2,185	2,210	2,223	689	720
Average export prices	CZK/t	4,891	1,166	68,571	63,611	51,787

720221 – Ferrosilicon

		2018	2019	2020	2021	2022
Import	t	31,943	25,397	23,659	26,843	23,220
Export	t	13,662	11,997	10,598	12,576	12,897

720221 – Ferrosilicon

		2018	2019	2020	2021	2022
Average import prices	CZK/t	33,411	26,785	25,930	38,498	62,955
Average export prices	CZK/t	29,911	23,458	21,849	34,262	54,388

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, 2022

Budějovické štěrkopísky, spol. s r.o., Vrábče

8. World production and world market prices

World mine production

World production of silicon in recent years:

	2018	2019	2020	2021	2022 ^e
Silicon production (according to MCS), kt	7,400	8,410	8,120	9,150	8,500

e – preliminary values

Main producers according to MCS – Si metal and Si in ferrosilicon

Country	2022 ^e	
	kt	%
China	6,000	68.2
Russia	640	7.3
Brazil	400	4.5
Norway	360	4.1
USA	310	3.5
France	120	1.4
Kazakhstan	120	1.4
Iceland	110	1.3
Malaysia	92	1.0
Bhutan	85	1.0
India	59	0.7
World	8,800	100.0

e – preliminary values

Prices of traded commodities –

– **silicon** (US\$/lb), US market, according to MCS

Commodity/year	2018	2019	2020	2021	2022
Silicon metal, metallurgical grade	134	106	97	220	400

– **ferrosilicon** (EUR/t), according to MCS

Komodita/rok	2018	2019	2020	2021	2022
Ferrosilicon, 50% Si, price average, US\$/lb (MCS)	104	102	103	138	N
Ferrosilicon, 75% Si, price average, US\$/lb (MCS)	108	89	87	192	350

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 2022 their mining reached 63 million tonnes), their share in the total extraction of raw materials is gradually increasing and currently is about 60%. In 2022 76% of the production of construction minerals comes from reserved deposits, which account 48 million tonnes. The decisive importance have crushed stone and sand and gravel, which together make up 97% of the volume (over 62 million tonnes) of all extracted construction minerals. The share of production from reserved deposits in crushed stone and sand and gravel together is 77% (in 2022 47 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

2. Mineral resources of the Czech Republic

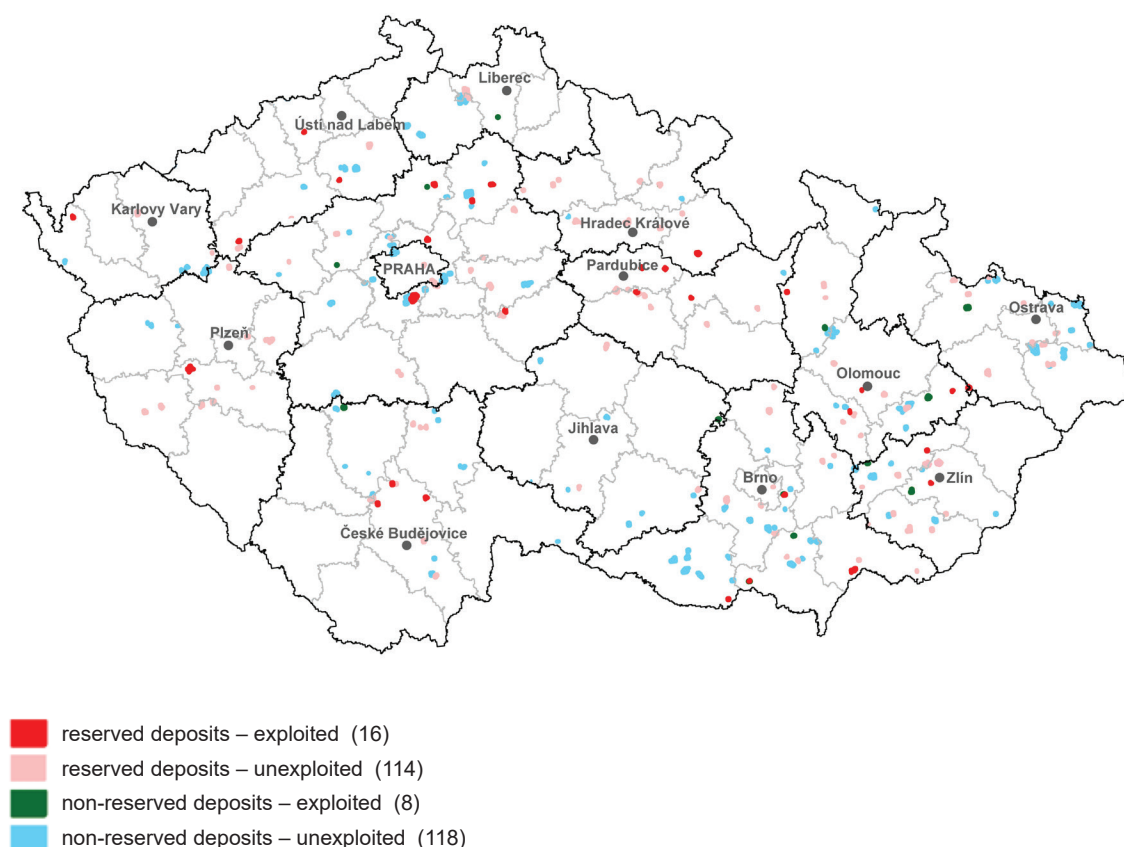
Among the brick clays in the Czech Republic, Quaternary loams of various genesis predominate as the basic component. The source of natural corrective raw materials are mostly deposits of pre-Quaternary age.

- 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 Permo-carbon 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



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	2018	2019	2020	2021	2022
Deposits – total number	130	129	129	126	130
exploited	17	15	15	16	16
Total mineral *reserves, ths m ³	529,033	527,679	526,197	525,687	524,943
economic explored reserves	196,673	194,738	193,821	193,458	193,311
economic prospected reserves	228,123	227,968	227,884	227,971	227,376
potentially economic reserves	104,237	104,973	104,492	104,258	104,256
exploitable reserves	57,541	56,505	59,553	65,882	67,472
Mine production in reserved deposits, ths m ³	825	694	560	595	578

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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	2018	2019	2020	2021	2022
Deposits – total number	125	125	123	126	126
exploited	6	6	7	8	8
Total mineral *reserves, ths m ³	693,821	693,532	692,192	692,731	699,271
economic explored reserves	63,622	63,622	63,609	65,612	59,718
economic prospected reserves	523,346	523,057	521,313	519,845	517,213
potentially economic reserves	106,853	106,853	107,270	107,274	122,340
exploitable reserves	10,621	10,514	10,697	10,654	11,026
Mine production in non-reserved deposits, ths m ³ a)	298	301	404	411	448

* 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

690410 – Building bricks

		2018	2019	2020	2021	2022
Import	ths pcs	19,080	17,304	14,568	22,592	20,835
Export	ths pcs	17,725	15,399	15,606	18,637	16,204

690410 – Building bricks

		2018	2019	2020	2021	2022
Average import prices	CZK/piece	18.3	22.0	21.4	22.2	29.9
Average export prices	CZK/piece	26.2	32.5	35.1	34.8	47.01

690510 – Roof tiles

		2018	2019	2020	2021	2022
Import	ths pcs	10,883	9,395	8,697	13,855	19,314
Export	ths pcs	11,572	9,608	9,979	10,924	17,739

690510 – Roof tiles

		2018	2019	2020	2021	2022
Average import prices	CZK/piece	18.0	18.7	21.2	18.7	16.6
Average export prices	CZK/piece	17.0	18.4	18.8	20.6	22.7

6. Prices of domestic market

Domestic prices of brick clay and brick products

Product specification	2018	2019	2020	2021	2022
Brick clay; CZK/t	95	95	95	95	105
Full brick; CZK/piece	3.9–5.9	5.0–9.4	6.5–10	8.9	6.5–11
Honeycomb brick; CZK/piece	10.8	10.5–13.0	14	17	12.5–18
Facing bricks; CZK/piece	20–54	20–55	22–50	23–53	24–56
Brick blocks Porotherm; CZK/piece	62–180	62–180	71–210	80–250	90–320
Clay (ground clay bricks for tennis courts); CZK/t	1,550–2,550	1,550–3,190	1,550–2,950	1,750–2,950	2,300–2,950
Roof tiles; CZK/t	25.8–51	25–51	29–55	28–62	35–86
Ventilating, boundary tile; CZK/t	71–230	68–246	269	275	284–312
Classical shingle tile; CZK/t	13–32	9–32	14–35	17–43	19–47

7. Mining companies in the Czech Republic as of December 31, 2022

Brick clays and related minerals – reserved deposits

Wienerberger Cihlářský průmysl, a.s., Č. Budějovice

Cihelna Kinský s.r.o., Kostelec n.Orl.

HELUZ cihlářský průmysl v.o.s., Dolní Bukovsko

Cihelna Hodonín, s.r.o.

Cihelna Vysoké Mýto s.r.o.

LB MINERALS, s.r.o., Horní Bříza

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

Ing. Ladislav Konečný-Cihelna Šitbořice

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

2. Mineral resources of the Czech Republic

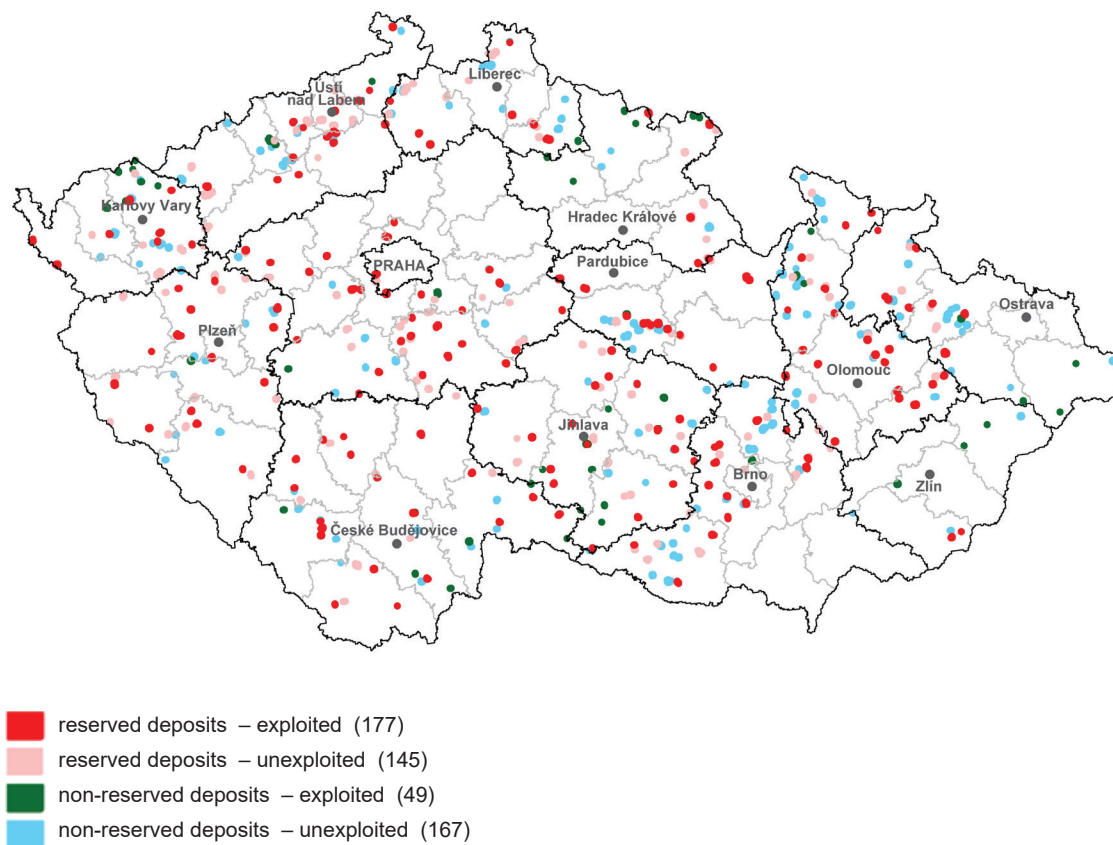
Industrially usable deposits of building stone are widespread throughout the Bohemian Massif, significantly less in its basin areas. In the Western Carpathians, deposits are present only rarely.

- 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 (micaschists, 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 Dražanská 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



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	2018	2019	2020	2021	2022
Deposits – total number	321	319	320	322	325
exploited	180	176	175	177	178
Total mineral *reserves, ths m ³	2,439, 218	2,457,253	2,478, 611	2,491,395	2,512,650
economic explored reserves	1,118,023	1,173,441	1,183, 964	1,181,819	1,220,713
economic prospected reserves	1,172,439	1,133, 231	1,142,587	1,157,520	1,142,092
potentially economic reserves	148,756	150,581	152,060	152,056	149,845
exploitable reserves	744,315	693,865	703,856	739,016	726,590
Mine production in reserved deposits, ths m ³	14,140	14,057	14,247	14,883	14,883

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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	2018	2019	2020	2021	2022
Deposits – total number	221	222	215	216	220
exploited	45	47	48	49	48
Total mineral *reserves, ths m ³	1,029,172	1,030,196	1,030,658	1,090,666	1,081,742
economic explored reserves	39,380	40,544	40,480	41,801	42,592
economic prospected reserves	911,485	911,345	912,416	918,307	908,272
potentially economic reserves	78,307	78,307	77,762	130,558	130,878
exploitable reserves	47, 469	52,878	48,268	55,069	57,702
Mine production in non-reserved deposits, ths m ³ ^{a)}	1,151	1,449	1,465	1,703	1,805

* 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

		2018	2019	2020	2021	2022
Import	t	684,531	1,147,319	1,177,472	1,161,633	1,500,310
Export	t	551,516	723,318	355,755	504,742	408,077

251710 – Pebbles, gravel, broken or crushed stone

		2018	2019	2020	2021	2022
Average import prices	CZK/t	229	188	205	173	256
Average export prices	CZK/t	217	200	202	180	208

6. Prices of domestic market

Domestic prices of crushed stone – nationwide

Product specification	2018	2019	2020	2021	2022
crushed stone, spilite, fraction 4–8mm, CZK/t	308	334	369	405	462
crushed stone, amphibolite, fraction 4–8mm, CZK/t	378	386	384	420	498
crushed stone, granite, fraction 4–8mm, CZK/t	355	353	368	394	434
crushed stone, gneiss, fraction 4–8mm, CZK/t	341	342	345	418	476
crushed stone, porphyry, fraction 4–8mm, CZK/t	329	318	355	394	408
crushed stone, granodiorite, fraction 4–8mm, CZK/t	351	349	376	401	485
crushed stone, greywacke, fraction 4–8mm, CZK/t	343	376	343	407	508
crushed stone, basalt, fraction 4–8mm, CZK/t	315	338	365	373	460
crushed stone, hornfels, fraction 4–8mm, CZK/t	283	307	292	341	469
crushed stone, limestones, fraction 4–8mm, CZK/t	333	329	375	377	414
crushed stone, spilite, fraction 8–16mm, CZK/t	285	295	326	342	383
crushed stone, amphibolite, fraction 8–16mm, CZK/t	298	301	307	343	428
crushed stone, granite, fraction 8–16mm, CZK/t	266	282	288	318	361
crushed stone, gneiss, fraction 8–16mm, CZK /t	270	287	276	335	405
crushed stone, porphyry, fraction 8-16 mm, CZK/t	273	264	295	296	337
crushed stone, granodiorites, fraction 8–16mm, CZK /t	276	293	316	332	389
crushed stone, greywacke, fraction 8–16mm, CZK /t	288	334	288	312	390
crushed stone, basalt, fraction 8–16mm, CZK /t	283	310	316	323	384
crushed stone, hornfels, fraction 8–16mm, CZK /t	268	282	268	300	372
crushed stone, limestones, fraction 8–16mm, CZK /t	282	289	315	313	355

**Average domestic prices of crushed stone in 2022 –
subdivided by rocks and regions which the rocks are mined in**

Rock-mineral	2022	Average prices of (listed) fractions (CZK/t)							In region	In all regions
	Size fraction Region/average of fraction price	0-4 mm	0-32 mm	0-63 mm	4-8 mm	8-16 mm	32-63 mm	LK unsorted		
opoka-sandstone	Central Bohemia	FN	FN	230	FN	FN	FN	150	190	
	Střih	FN	295	290	485	FN	345	FN	354	
	Average of fraction price	FN	295	260	485	FN	345	FN		346
serpentine	Central Bohemia	160	200	245	485	385	315	287	296	
	Average of fraction price	160	200	245	485	385	315	287		296
limestone	Central Bohemia	270	238	235	350	295	265	300	276	
	Prague	260	260	260	420	340	300	FN	307	
	Olomouc	265	255	270	350	405	315	265	336	
	South Bohemia	206	255	255	370	FN	305	250	283	
	Hradec Králové	367	259	252	374	355	FN	169	299	
	Moravia and Silesia	245	250	252	420	360	290	225	292	
	Average of fraction price	272	258	253	414	355	295	246		299
basaltic rocks	Karlovy Vary	315	279	251	421	345	314	247	310	
	Hradec Králové	290	267	242	405	326	297	240	296	
	Central Bohemia	246	275	266	457	366	351	337	331	
	Písek	228	225	226	364	344	261	254	271	
	Pardubice	282	254	264	517	FN	276	262	306	
	Prague	250	265	265	495	405	340	415	345	
	Moravia and Silesia	280	FN	FN	460	440	FN	FN	400	
	Liberec	210	257	295	521	429	311	295	336	
	Čadca and Liberec	281	302	306	457	399	324	306	340	
	Average of fraction price	262	267	265	460	384	309	292		320
greywacke	South Bohemia	220	245	255	450	275	256	246	275	
	South Moravia	207	235	250	360	460	342	400	356	
	Olomouc	195	255	251	551	410	309	324	327	
	Moravia and Silesia	276	260	265	469	395	309	274	321	
	Average of fraction price	224	248	254	508	390	304	311		320
slam	Central Bohemia	250	250	250	405	350	260	240	284	
	Average of fraction price	250	250	250	405	350	260	240		284
gneiss	Písek	220	255	242	415	395	290	250	293	
	South Moravia	200	245	240	445	375	332	270	301	
	Vysočina	225	239	225	465	370	295	302	302	
	Pardubice	247	215	215	467	420	294	305	310	
	Central Bohemia	225	300	300	457	356	351	332	336	
	Olomouc	221	250	265	555	406	266	259	318	
	Hradec Králové	325	320	325	550	460	395	325	389	
	Average of fraction price	238	256	260	476	405	321	292		321
hornfels	Pardubice	355	212	246	545	420	262	260	329	
	Central Bohemia	170	256	254	592	525	289	310	279	
	Average of fraction price	253	224	240	469	372	276	295		304
amphibolite	Písek	276	247	259	445	367	322	252	310	
	South Moravia	195	240	250	470	420	280	230	224	
	Olomouc	265	297	282	441	412	332	272	329	
	Central Bohemia	206	255	255	560	415	310	265	323	
	Hradec Králové	345	315	355	524	485	410	355	396	
	Vysočina	325	295	295	545	470	360	315	372	
	Average of fraction price	270	275	282	498	428	336	277		338
granitic rocks	South Moravia	250	225	242	452	369	277	275	295	
	Karlovy Vary	200	190	215	260	245	240	200	221	
	Pardubice	275	246	254	455	402	317	264	317	
	Hradec Králové	215	235	250	425	355	285	260	289	
	Central Bohemia	215	245	261	479	400	314	355	325	
	South Bohemia	245	274	276	495	375	306	242	317	
	Vysočina	202	235	231	472	375	300	255	293	
	Čadca and Liberec	210	302	200	FN	FN	FN	350	261	
	Average of fraction price	224	244	241	434	361	291	270		295
granulite	South Bohemia	292	282	297	506	360	317	247	332	
	Average of fraction price	292	282	297	506	360	317	247		332

Explanations: FN: fraction is not produced; LK: quarry stone; basaltic rocks: melaphyre+spilite+basalt+phonolite; granitic rocks: granodiorite+granite+syenite+diorite+porphyry; limestone: limestone+dolomite+marble

Average domestic prices of crushed stone in 2022 – subdivided by regions and rocks mined in them

Region	2022	Average prices of (listed) fractions (CZK/t)							In region
	Size fraction	0-4	0-32	0-63	4-8	8-16	32-63	LK	
	Rock/mineral/price	mm	mm	mm	mm	mm	mm	unsorted	
Píseň	gneiss	180	220	225	359	275	258	175	
	amphibolite	261	255	225	392	326	275	240	
	basaltic rocks	220	217	210	391	316	250	219	
	meta-greywacke	258	274	239	422	366	289	241	
	Average of fraction prices in the region	224	242	224	391	322	262	218	269
South Moravia	greywacke	235	235	250	480	480	345	350	
	gneiss	185	215	212	375	290	257	260	
	granitic rocks	210	236	215	375	315	240	209	
	amphibolite	195	215	210	375	335	235	220	
	Average of fraction prices in the region	206	225	221	401	353	264	267	277
Karlovy Vary	granitic rocks	200	190	212	352	280	260	200	
	basaltic rocks	245	245	216	350	290	257	210	
	trachyt	190	195	185	FN	FN	235	200	
	Average of fraction prices in the region	211	211	204	351	285	251	203	245
Moravia and Silesia	limestone	180	195	205	582	270	210	200	
	greywacke	225	205	206	561	309	255	220	
	basaltic rocks	205	FN	FN	291	349	FN	FN	
	Average of fraction prices in the region	205	199	207	351	309	225	210	243
Pardubice	gneiss	240	180	207	410	340	275	250	
	granitic rocks	211	205	211	405	350	267	211	
	basaltic rocks	240	250	225	450	320	255	250	
	hornfels	FN	205	200	335	310	240	225	
	Average of fraction prices in the region	230	205	211	395	325	254	229	264
Olomouc	limestone	227	206	210	407	309	217	206	
	greywacke	210	205	198	408	340	247	225	
	gneiss	250	229	229	459	351	229	206	
	amphibolite	221	209	221	576	315	246	212	
	Average of fraction prices in the region	222	212	215	413	328	235	212	262
Central Bohemia	limestone	202	190	194	564	294	260	255	
	gneiss	230	255	260	440	360	285	245	
	granitic rocks	180	210	220	568	342	264	265	
	amphibolite	170	215	215	455	325	255	218	
	hornfels	165	210	205	347	290	252	265	
	basaltic rocks	250	252	250	580	345	295	290	
	opoka-sandstone	FN	FN	220	FN	FN	FN	160	
	serpentine	190	200	210	350	290	240	300	
	slam	205	245	250	595	340	280	240	
	Average of fraction prices in the region	197	220	220	387	323	264	253	266
Prague	basaltic rocks	210	215	FN	580	320	315	325	
	limestone	240	240	240	420	340	300	FN	
	Average of fraction prices in the region	225	228	240	400	330	308	325	294
South Bohemia	limestone	165	255	265	514	FN	259	222	
	greywacke	225	255	250	480	480	345	350	
	granitic rocks	215	245	255	419	315	260	215	
	granulite	165	255	255	415	322	272	215	
	Average of fraction prices in the region	202	247	251	407	373	284	259	265
Ústí nad Labem	granitic rocks	185	255	200	FN	FN	FN	550	
	basaltic rocks	240	250	227	375	326	255	260	
	Average of fraction prices in the region	213	243	214	378	326	255	227	265
Liberec	basaltic rocks	206	250	255	438	375	267	260	
	Average of fraction prices in the region	206	250	258	438	375	267	260	293
Vysočina	gneiss	177	206	212	401	315	259	252	
	granitic rocks	206	205	205	598	305	255	220	
	amphibolite	270	240	240	480	390	320	265	
	Average of fraction prices in the region	218	217	218	426	338	278	246	277
Hradec Králové	limestone	357	259	352	574	553	FN	189	
	gneiss	225	255	264	480	411	365	250	
	granitic rocks	210	215	220	425	355	265	260	
	amphibolite	270	215	245	480	380	295	260	
	basaltic rocks	210	205	206	520	265	297	240	
	Average of fraction prices in the region	260	236	237	412	349	310	240	292
Jičín	opoka-sandstone	FN	295	290	470	FN	355	FN	
	Average of fraction prices in the region	FN	295	290	470	FN	355	FN	348

Explanations: FN: fraction is not produced; LK: quarry stone; basaltic rocks: melaphyre+spilite+basalt+phonolite; granitic rocks: granodiorite+granite+syenite+diorite+porphyry; limestone: limestone+dolomite+marble

Average domestic prices of crushed stone in 2022 – by regional units

2022	Average prices of (listed) fractions (CZK/t)																	In regions
REGION	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	unsorted material	pit material	over-burden	
Hradec Králové	319	FN	229	294	299	247	475	417	FN	430	FN	374	368	340	286	480	FN	80
Píseň	254	289	145	256	245	235	424	352	315	361	352	355	295	256	240	374	98	110
Central Bohemia	201	239	219	251	248	216	448	364	FN	380	363	345	300	265	299	403	105	95
Liberec	210	237	FN	287	298	205	521	429	450	338	400	358	311	302	295	410	100	90
Pardubice	248	220	FN	242	246	216	478	376	320	384	356	317	294	268	250	346	85	95
Ústí nad Labem	281	185	323	305	309	270	457	389	275	387	404	372	324	319	320	357	FN	105
South Moravia	200	FN	180	229	243	229	461	390	FN	358	330	324	306	327	308	435	85	125
Karlovy Vary	271	197	224	249	245	232	368	315	351	335	354	306	293	257	225	454	120	130
South Bohemia	251	188	190	278	281	258	494	378	342	372	380	355	308	293	245	310	100	107
Olomouc	214	255	244	257	254	220	522	402	308	383	310	377	307	303	289	415	90	110
Zlín	FN	175	FN	295	290	270	470	FN	FN	FN	FN	360	335	380	FN	490	FN	80
Moravia and Silesia	277	260	150	261	263	201	473	401	FN	405	360	361	309	311	274	326	100	120
Vysočina	215	217	181	246	243	251	483	383	225	373	374	347	313	297	287	399	80	110
Prague	235	FN	230	253	253	FN	455	373	FN	FN	405	368	320	335	410	FN	FN	FN
Czech Republic - total	244	224	210	265	266	235	466	382	323	376	366	351	313	304	287	400	96	104

Explanation: FN – fraction is not produced

7. Mining companies in the Czech Republic as of December 31, 2022**Crushed stone – registered deposits**

EUROVIA Kamenolomy a.s.

Českomoravský štěrk a.s.

KAMENOLOMY ČR s.r.o.

KÁMEN Zbraslav a.s.

COLAS CZ a.s.

Kámen a písek s.r.o.

M – SILNICE a.s.

GRANITA s.r.o.

Basalt s.r.o.

Basalt CZ s.r.o.

Berger Bohemia a.s.

Lom Klečany s.r.o.

Kámen Brno s.r.o.

CEMEX Sand k.s.

C4SC78 s.r.o.

BES s.r.o.

Rosa s.r.o.

SHB s.r.o.

Silnice Čáslav – Holding a.s.

RENO Šumava a.s.

Českomoravský cement a.s.

Moravské kamenolomy s.r.o.

Froněk s.r.o.

Žula Ráčov s.r.o.

Ludvík Novák

LOMY MOŘINA s.r.o.

Hutira – Omice s.r.o.

LOM DEŠTNŮ a.s.

BISA s.r.o.

Froněk s.r.o.

FORTEX STAVBY s.r.o.

RESTA DAKON s.r.o.

ZD Šonov u Broumova

DOLESA s. r. o.

Madest s.r.o.

František Matlák

Kamenolom Číměř s.r.o.

KARETA s.r.o.

LOM HAMR s.r.o.

Kozákov – družstvo

PEDOP s.r.o.

HERLIN s.r.o.

EKOZIS s.r.o.

EKOSTAVBY Louny s.r.o.

LB s.r.o.

Kalivoda DC s.r.o.

Stavební recyklace s.r.o

SATES ČECHY s.r.o.

ERB invest s.r.o.

GRANIO s.r.o.

Lom Drahenický Málkov s.r.o.

Kamenolom KUBO s.r.o.

UNIKOM a.s.

Důl Svatoňovice a.s.

NATRIX a.s.

Crushed stone – non-registered deposits

Silnice Morava s.r.o.

Basalt s.r.o.

Českomoravský štěrk a.s.

Kámen a písek s.r.o.

COLAS CZ a.s.

Sokolovská uhelná p.n. a.s.

KAMENOLOMY ČR s.r.o.

EUROVIA Kamenolomy a.s.

SP Bohemia k.s.

KÁMEN Zbraslav a.s.

ZAPA beton a.s.

ZETKA Strážník a.s.

Stavební recyklace s.r.o.

Moravské kamenolomy s.r.o.

ZUD a.s.

RENO Šumava a.s.

Stavoka Kosice a.s.

SENECO s.r.o.

TS služby s.r.o.

Obec Hošťálková

LOM DEŠTNO a.s.

GRANITA Lomy s.r.o.

Kalcit s.r.o.

KERAMOST a.s.

Ligranit a.s.

Lom Kozárovce a.s.

Lesostavby Frýdek-Místek a.s.

Kamenolom Žlutava s.r.o.

LB s.r.o.

Vojenské lesy a statky ČR s.p.

UNI – STONE JÁCHYMOV s.r.o.

EKOZIS s.r.o.

Josef Máca

Lesní družstvo obcí

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.

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

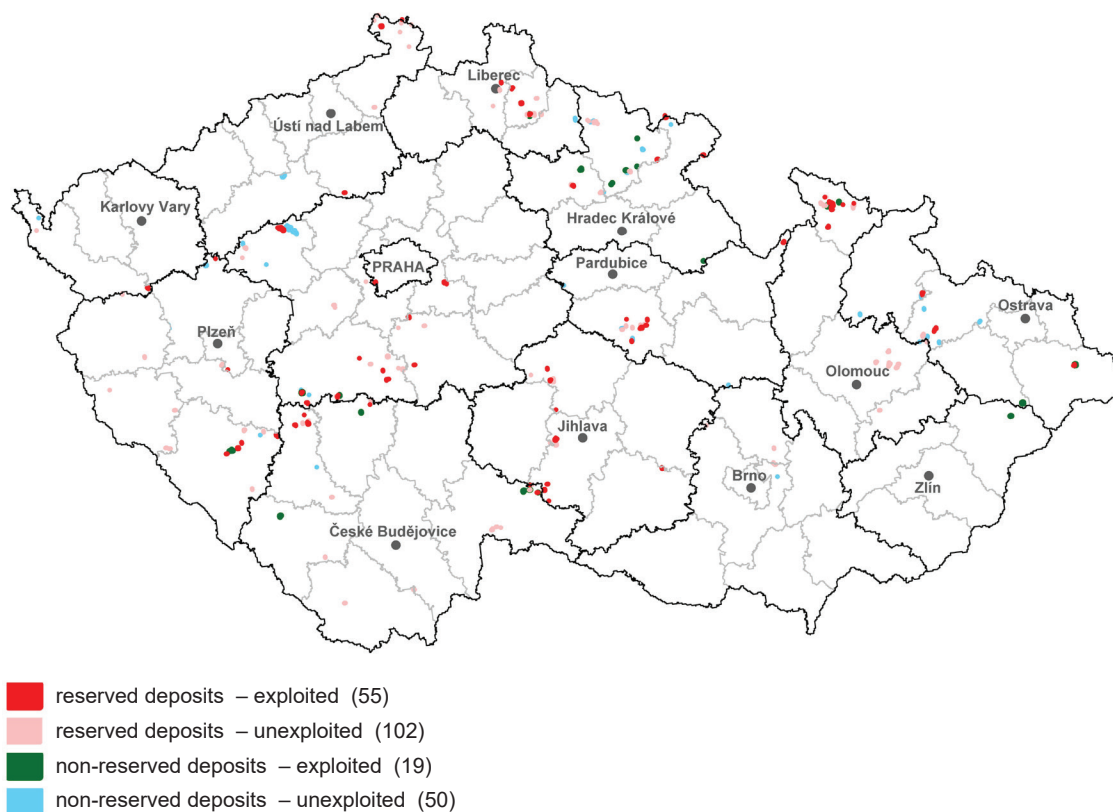
2. Mineral resources of the Czech Republic

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 Nasavrky 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). Serpentine mined in Moravia and western Bohemia were and are still used.

3. Registered deposits and other resources of the Czech Republic



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	2018	2019	2020	2021	2022
Deposits – total number	159	158	158	158	157
exploited	64	63	64	54	55
Total mineral *reserves, ths m ³	181,568	181,383	184,236	182,835	183,139
economic explored reserves	77,688	77,511	78,320	78,031	77,729
economic prospected reserves	64,386	64,380	66,427	65,753	66,300
potentially economic reserves	39,494	39,492	39,489	39,051	39,110
exploitable reserves	74,519	77,407	108,505	79,798	85,108
Mine production in reserved deposits, ths m ³	116	117	135	125	112

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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	2018	2019	2020	2021	2022
Deposits – total number	68	69	69	70	69
exploited	22	21	21	21	19
Total mineral *reserves, ths m ³	33,256	33,250	26,096	26,520	26,285
economic explored reserves	2,158	2,152	2,132	2,101	2,039
economic prospected reserves	28,142	28,124	21,008	21,463	21,290
potentially economic reserves	2,956	2,956	2,956	2,956	2,956
exploitable reserves	1,610	1,192	1,875	1,931	4,585
Mine production in non-reserved deposits, ths m ³ ^{a)}	18	16	47	62	32

* 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 roughly worked or cut

		2018	2019	2020	2021	2022
Import	t	16,873	12,328	10,311	12,215	8,903
Export	t	6,807	7,476	7,066	9,477	4,372

2514 – Slate, also roughly worked or cut

		2018	2019	2020	2021	2022
Average import prices	CZK/t	1,254	1,391	1,260	1,354	1,499
Average export prices	CZK/t	1,003	1,118	1,088	1,329	1,348

2515 – Marble, travertine, ecaussine and other calcareous stone

		2018	2019	2020	2021	2022
Import	t	4,019	4,509	5,198	5,513	4,770
Export	t	1	23	39	24	1

2515 – Marble, travertine, ecaussine and other calcareous stone

		2018	2019	2020	2021	2022
Average import prices	CZK/t	7,368	8,956	8,989	8,384	8,007
Average export prices	CZK/t	82,969	37,815	48,627	76,749	62,308

2516 – Granite, porphyry, basalt, sandstone and other stone

		2018	2019	2020	2021	2022
Import	t	8,266	10,163	5,344	5,019	9,692
Export	t	11,856	3,498	2,880	3,339	1,654

2516 – Granite, porphyry, basalt, sandstone and other stone

		2018	2019	2020	2021	2022
Average import prices	CZK/t	5,323	7,267	8,563	11,020	6,503
Average export prices	CZK/t	2,675	4,070	4,245	5,365	3,581

6801 – Setts, curbstones and flagstones of natural stone (except slate)

		2018	2019	2020	2021	2022
Import	t	28,747	22,079	20,859	29,325	37,981
Export	t	43,223	31,731	33,823	34,981	23,156

6801 – Setts, curbstones and flagstones of natural stone (except slate)

		2018	2019	2020	2021	2022
Average import prices	CZK/t	2,492	2,189	2,479	2,533	2,648
Average export prices	CZK/t	2,202	2,367	2,554	2,455	2,793

6802 – Worked monumental and crushed stone (except slate) and stonework

		2018	2019	2020	2021	2022
Import	t	25,734	27,301	25,392	26,962	33,015
Export	t	34,777	29,279	51,707	71,629	59,709

6802 – Worked monumental and crushed stone (except slate) and stonework

		2018	2019	2020	2021	2022
Average import prices	CZK/t	13,606	14,530	14,783	16,983	18,092
Average export prices	CZK/t	5,292	6,253	4,727	4,088	5,456

6803 – Worked slate and articles of slate or of agglomerated slate

		2018	2019	2020	2021	2022
Import	t	2,554	1,976	1,817	1,482	1,870
Export	t	124	79	90	133	79

6803 – Worked slate and articles of slate or of agglomerated slate

		2018	2019	2020	2021	2022
Average import prices	CZK/t	13,650	21,318	19,505	34,521	28,407
Average export prices	CZK/t	93,263	150,651	135,629	147,490	211,015

6. Prices of domestic market

Product specification				Unit	2016	2017	2018	2019	2020
greyish blue Hlinec granite	cobblestones			CZK/t	2,150–2,600	2,150–2,600	2,250–2,800	2,250–2,800	2,680–4,200
	margin stones			CZK/bm	320–450	320–450	340–450	340–450	450–550
	cleaved prisms			CZK/m²	2,100	2,100	2,100	2,100	2,500
	curbstones			CZK/bm	1,000–1,200	1,000–1,200	1,000–1,200	1,000–1,200	1,000–1,300
	slabs	polished, thickness 2–8 cm		CZK /m²	1,800–3,800	1,800–3,800	1,800–3,800	1,800–3,800	2,000–4,200
		emery grounded, thickness 2–8 cm		CZK /m²	1,600–3,600	1,600–3,600	1,600–3,600	1,600–3,600	1,800–4,000
		sand blasted finish, thickness 2–8 cm		CZK /m²	1,400–1,200	1,400–1,200	1,400–1,200	1,400–1,200	1,500–1,800
		formatted suitable as pavement, thickness 3 cm		CZK /m²	1,560–2,260	1,560–2,260	1,560–2,260	1,560–2,260	1,650–2,500
Granite Kozárvice Chlum Řečice	cobblestones 18/18–4/6			CZK/t	2,000–2,400	2,000–2,500	2,600	2,800	3,200
	curbstones 10/20/40–20/10/40			CZK/t	2,300 –2,400	2,500	2,500–2,800	3,000	3,500
	margin stones			CZK/t	350	350	350	350	400
	blocks 0.5–0.99 to 2.0–2.49 m³			CZK /m³	5,500–7,600	5,500–7,600	5,500–7,600	5,500–7,600	6,000–8,500
	blocks 2.5–2.99 to 4.0–5.0 m³			CZK /m³	8,500–9,500	8,500–9,500	8,500–9,500	8,500–9,500	8,700–10,000
light Silesian granite	cobblestones			CZK/t	1,900–3,000	1,900–3,000	2,400–3,000	2,450–2,750	1,800–3,100
	margin stones			CZK/bm	300–330	300–369	400–450	500–520	2,000–3,500
	cleaved prisms			CZK/m²	1,650	1,650	2,000	2,200	2,400–4,000
Mrákovin type granite – pavement slabs			sand blasted finish, thickness 2–8 cm	CZK/m²	1,450–2,250	1,320–2,500	1,500–2,600	1,600–2,750	1,800–3,100
			emery grounded, thickness 2–8 cm	CZK/m²	1,580–2,480	1,600–2,500	1,700–2,850	1,750–3,000	2,000–3,500
			polished, thickness 2–8 cm	CZK/m²	1,900–2,700	2,000–3,200	2,100–3,200	2,200–3,350	2,400–4,000
granite blocks				Kč/m³	<1,5 m³ = 7,000 >1,5 m³ = 9,000	<1,5 m³ = 8,000 >1,5 m³ = 10,000	<1,5 m³ = 8 500 >1,5 m³ = 11,000	<1,5 m³ = 8,700 >1,5 m³ = 11,500	<1,5 m³ = 9,000 >1,5 m³ = 12,000
sandstone – cut slabs	thickness 5 cm			CZK/m²	1,000–1,930	1,000–1,930	1,000–1,930	1,000–1,930	1,200–2,200
	thickness 10 cm			CZK/m²	2,770–3,410	2,770–3,410	2,770–3,410	2,770–3,410	3,000–3,600
	thickness 15 cm			CZK/m²	4,190–5,180	4,190–5,180	4,190–5,180	4,190–5,180	4,300–5,400
marble – pavement	cut	Supíkovice marble		CZK/m²	280–1,100	280–1,100	320–1,200	350–1,300	450–1,500
		Lipová marble		CZK/m²	280–1,190	280–1,190	340–1,250	360–1,300	450–1,500
	smoothed	Supíkovice marble		CZK/m²	360–1,240	360–1,240	380–1,300	380–1,300	450–1,500
		Lipová marble		CZK/m²	360–1,350	360–1,350	380–1,400	380–1,400	450–1,500
	polished	Supíkovice marble		CZK/m²	390–1,280	390–1,280	420–1,300	420–1,300	550–1,600
		Lipová marble		CZK/m²	390–1,390	390–1,390	420–1,450	420–1,450	550–1,600
basalt	column 131–160 cm		quarry Sou-těsky	Kč/t	5,000	5,000	–	–	–
	paving thick 2 cm		quarry Sou-těsky	Kč/m²	650	650	–	–	–
	paving thick 10 cm		quarry Sou-těskv	Kč/m²	750	750	–	–	–

Notice: bm (běžný metr) – running metre

7. Mining companies in the Czech Republic as of December 31, 2022

Dimension stone – reserved deposits

Slezské kamenolomy a.s.
 RESTA DAKON s.r.o.
 MEDIGRAN s.r.o.
 Plzeňská žula a.s.
 Granit Lipnice s.r.o.
 SATES ČECHY s.r.o.
 HERLIN s.r.o.
 Průmysl kamene a.s.
 ABAKRON s.r.o.
 KÁMEN OSTROMĚŘ s.r.o.
 Ligranit a.s.
 ČESKÁ ŽULA s.r.o.
 Lom Drahenický Málkov s.r.o.
 Granit Zedníček s.r.o.
 Kámen Hudčice s.r.o.
 GRANIT-ZACH s.r.o.
 RESTA DAKON s.r.o.
 Těžba nerostů a.s.
 ABAKRON s.r.o.
 LOM DEŠTNO a.s.
 KAVEX – Granit Holding a.s.
 Důl Svatoňovice a.s.
 Lom Matula Hlinsko a.s.

GRANITES s.r.o.
 GRANIO s.r.o.
 Třebocký lom CZ s.r.o.
 KÁMEN OSTROMĚŘ s.r.o.
 Kamenoprůmysl. závody s.r.o.
 Krákorka a.s.
 M. & H. Granit s.r.o.
 Mšenské pískovce s.r.o.

Dimension stone – non-reserved deposits

RENO Šumava a.s.
 Lom Kozárovce a.s.
 PROFISTAV Litomyšl a.s.
 Josef Máca
 KOKAM s.r.o.
 Lom Horní Dvorce s.r.o.
 WÜHNANOFF s.r.o.
 SATES ČECHY s.r.o.
 Žula s.r.o.
 Jiří Sršeň
 Lesostavby Frýdek-Místek a. s.
 HERLIN s.r.o.
 SPONGILIT PP s.r.o.

8. World production and world market prices

Global 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.

Project EuroLithos, which was part of the GeoERA program was finalised during 2021. It mapped decoration and dimension stone deposits in 14 European countries and the results including a database and an interactive map can found at <https://www.eurolithos.org/> and <https://geoera.eu/projects/eurolithos1/>.

Dimension stone is subject to global trade while prices are determine by corporate price lists. Dimension stone prices depend on the quality and colour of the rock and the degree of processing. They can be estimated by price levels in the US market (*Source: <https://www.usgs.gov/centers/national-minerals-information-center/dimension-stone-statistics-and-information>. Advance Data Release of the 2020 Annual tables. Posted: November 17, 2021*):

Dimension stone sold or used in the US in 2021, classification by types

	Amount, t	Value, ths USD	Average price, USD/t
Granite	436,000	110,000	258
Limestone	1,140,000	195,000	171
Marble	35,300	10,600	300
Sandstone	493,000	51,500	104
Slate	43,200	21,400	495
Other types of stone	204,000	35,700	177

Dimension stone export from the US in 2021, 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)	95	10,200	107	Canada, 48%
Marble, travertine, crude or roughly trimmed	6	5,830	972	Italy, 85%
Marble, travertine, merely cut, by sawing or otherwise (blocks or slabs)	4	2,900	725	Canada, 40%
Granite, crude or roughly trimmed	14	4,850	346	China, 44%
Granite, merely cut, by sawing or otherwise (blocks or slabs)	21	6,250	298	Canada, 63%
Slate, worked and articles of slate	2	3,070	1,535	Canada, 37%
Slate, whether or not roughly trimmed or merely cut (blocks or slabs)	3	301	100	UK, 43%
Other calcareous, memorial, or building stone; alabaster (other than marble and travertine; crude, roughly cut or simply cut into blocks or slabs)	17	7,770	457	Canada, 95%
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	5,710	317	Canada, 72%

Dimension stone export from the US in 2021, classification – marble, travertine

	Amount, ths tonnes	Value, ths USD	Average value, USD/t	Main destination by value
Marble, travertine, alabaster worked (further worked than simply cut with a flat surface)	74 400	51 100	687	Turkey, 25 %

Salient statistics USA – dimension stone sold or used by producers

Year	2018	2019	2020	2021	2022^e
Tonnage (kt)	2,660	2,520	2,130	2,330	2,500
Value (mill USD)	437	415	414	466	520
Imports for consumption (mill USD)	2,090	1,890	1,750	2,200	2,400
Exports (mill USD)	70	59	47	47	49
Price	Variable, depending on type or product				

Granite only, sold or used by producers

Tonnage (kt)	484	430	436	464	470
Value (mill USD)	108	105	110	128	130
Imports (mill USD)	915	862	794	903	910
Exports (mill USD)	19	17	13	11	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

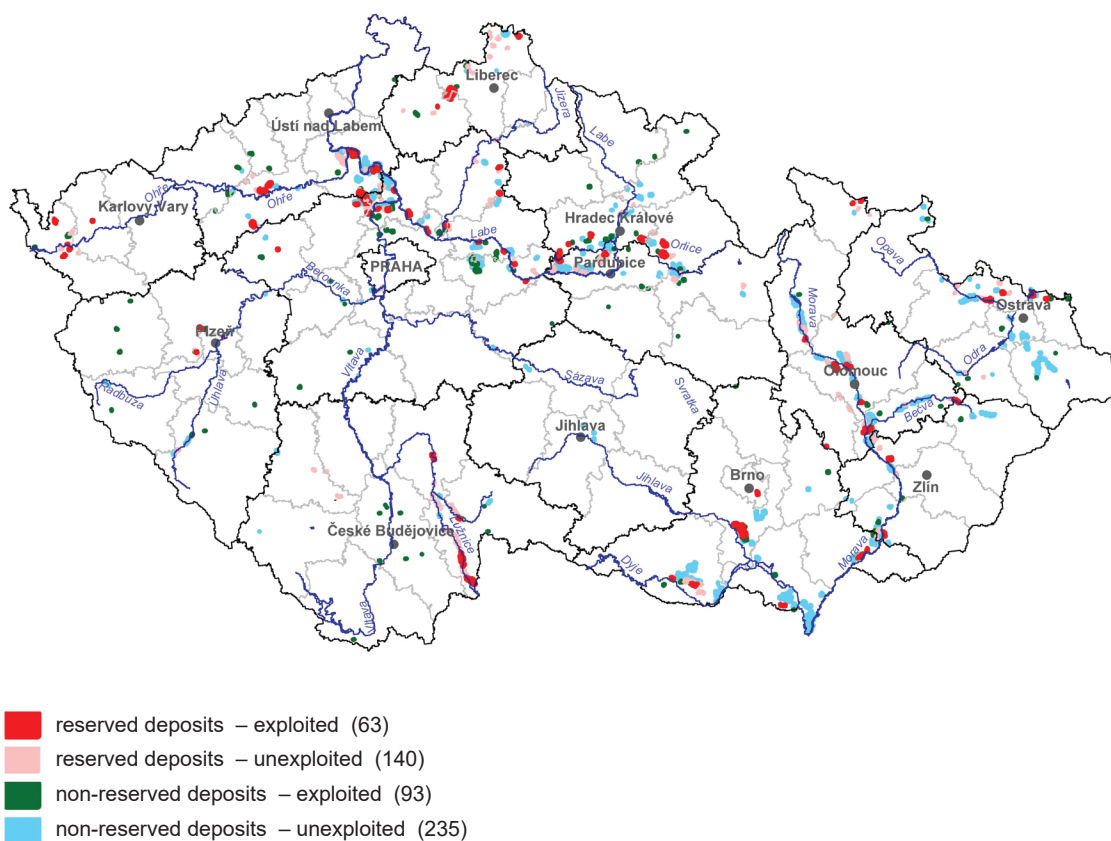
2. Mineral resources of the Czech Republic

In the Czech Republic, the vast majority of deposits are of Quaternary origin, namely of fluvial origin, much less represented are the deposits of fluviolacustrine, glacialfluvial, glaciallacustrine 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 reach 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



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	2018	2019	2020	2021	2022
Deposits – total number	203	205	204	203	203
exploited	67	65	63	64	63
Total mineral *reserves, ths m ³	2,100,538	2,118,240	2,109,426	2,100,932	2,093,692
economic explored reserves	1,072,587	1,073,155	1,066,585	1,076,839	1,072,133
economic prospected reserves	786,625	803,566	801,125	782,356	778,692
potentially economic reserves	241,326	241,519	241,716	241,737	242,867
exploitable reserves	344,315	397,770	400,093	555,455	567,049
Mine production in reserved deposits, ths m ³	6,499	6,204	6,476	6,602	6,739

* 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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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	2018	2019	2020	2021	2022
Deposits – total number	359	343	339	332	328
exploited	93	92	93	94	93
Total mineral *reserves, ths m ³	2,095,997	2,071,278	2,080,395	2,076,102	2,077,863
economic explored reserves	104,232	104,040	104,479	104,150	104,067
economic prospected reserves	1,755,963	1,731,561	1,740,272	1,736,587	1,737,672
potentially economic reserves	235,802	235,677	235,644	235,365	236,124
exploitable reserves	57,025	55,169	59,751	60,123	71,638
Mine production in non-reserved deposits, ths m ³ a)	4,875	4,897	4,821	5,270	5,046

* 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)

		2018	2019	2020	2021	2022
Import	kt	217,493	131,022	159,963	153,723	104,900
Export	kt	103,568	60,227	9,011	1,534	1,246

250590 – Other sand (natural sand of all kinds, also coloured, except sand containing metals and except silica sand and quartz sand)

		2018	2019	2020	2021	2022
Average import prices	CZK/t	381	491	352	382	565
Average export prices	CZK/t	330	387	1,557	10,785	9,313

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 2022 – by regional units

2022	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	150	160	138	165	376	404	353	346	FN	434	403	FN	390	110	145	90	95	251
Pízeň	145	180	210	142	FN	215	FN	336	381	287	FN	481	340	352	105	FN	80	105	240
Central Bohemia	170	233	179	148	FN	307	381	282	308	FN	284	379	FN	370	150	159	100	95	236
Liberec	FN	265	208	185	185	155	192	610	535	240	FN	350	FN	300	137	140	90	130	248
Pardubice	FN	266	218	227	FN	365	365	355	368	FN	574	368	FN	390	145	120	FN	90	296
Ústí nad Labem	150	230	195	210	200	265	250	315	290	FN	380	363	FN	395	169	170	63	86	233
South Moravia	FN	244	213	182	203	252	213	356	414	FN	341	448	237	328	240	120	90	80	248
Karlovy Vary	FN	215	190	190	200	285	264	310	315	FN	335	425	FN	314	160	130	90	85	234
South Bohemia	228	259	256	305	190	165	165	334	387	FN	FN	405	FN	505	135	FN	80	90	250
Olomouc	290	399	310	400	315	290	285	511	436	374	416	460	328	411	145	155	80	140	319
Zlín	440	385	365	FN	FN	275	329	550	420	FN	435	468	410	410	385	FN	FN	FN	406
Moravia and Silesia	418	200	321	310	354	325	315	501	490	FN	410	380	FN	FN	FN	196	95	125	317
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	263	252	235	222	227	273	288	401	391	300	401	411	329	379	171	148	86	102	273

Average domestic prices of sand and gravel in 2018–2022 (CZK/t)

Region/year	2018	2019	2020	2021	2022
Hradec Králové	147	162	180	202	251
Plzeň	203	203	217	220	240
Central Bohemia	143	153	184	187	236
Liberec	205	208	202	235	248
Pardubice	185	183	289	269	296
Ústí nad Labem	191	190	220	230	233
South Moravia	162	169	202	204	248
Karlovy Vary	182	180	194	213	234
South Bohemia	181	198	191	216	250
Olomouc	213	233	265	277	319
Zlín	257	273	293	338	406
Moravia and Silesia	249	272	267	263	317
Vysočina	Sand and gravel are not mined in this region				
Prague	208	not mined	not mined	not mined	not mined
Czech Republic total	194	202	225	238	273

7. Mining companies in the Czech Republic as of December 31, 2022**Sand and gravel – registered deposits**

České štěrkopísky s.r.o.
Českomoravský štěrk a.s.
KÁMEN Zbraslav a.s.
LB MINERALS s.r.o.
CEMEX Sand k.s.
Písky – J. Elsnic s.r.o.
Družstvo DRUMAPO
TVARBET Moravia a.s.
MIROS Pardubice a.s.
CEMEX Czech Republic s.r.o.
ZAPA beton a.s.
Kinský dal Borgo a.s.
Písek – Beton a.s.
Pískovna Sojovice s.r.o.
KAMENOLOMY ČR s.r.o.
Městské lesy Hradec Králové a.s.
DOBET s.r.o.
Budějovické štěrkopísky s.r.o.

NZPK s.r.o.
Václav Maurer
EUROVIA Kamenolomy a.s.
Pískovna Černovice s.r.o.
TAPAS Borek s.r.o.
Lubomír Krunc
BS Cost s.r.o.
ZECHMEISTER s.r.o.
Těžba štěrkopísku s.r.o.
Ladislav Šeda
Obec Kostomlátky
KM Beta Moravia s.r.o.
ZOD Brniště a.s.
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.	VRAMAT CZ s.r.o.
Písek Žabčice s.r.o.	Ing. Václav Luka
ZEPIKO s.r.o.	Písky – Skviřín s.r.o.
Písník Kinský s.r.o.	ZOD Brniště a.s.
DRACAR OLOMOUC s.r.o.	Českomoravský štěrk a.s.
Severočeské pískovny a štěrkovny s.r.o.	Hradecký písek a.s.
REALMA – PÍSKOVNA DOLANY s.r.o.	INGEA realizace s.r.o.
Moravia Tech a.s.	Obec Rabštejnská Lhota
Pískovna Mistřín s.r.o.	KORA – VODOSTAVING s.r.o.
Plzeňské štěrkopísky s.r.o.	DOBET s.r.o.
ZS Kratonohy a.s.	Ilona Seidlová
Farma U Jezera s.r.o.	Impectus s.r.o.
Sušárna a.s. Kratonohy	Obecní lesy Bludov s.r.o.
LIKOD s.r.o.	ZEPOS a.s.
Rovina Písek a.s.	Jan Holub
Pískovna Pohořelice s.r.o.	Kobra Údlice s.r.o.
Silnice Klatovy a.s.	Očenášek – Mikulkam s.r.o.
SPONGILIT PP s.r.o.	Silnice Čáslav – Holding a.s.
Technické služby CZ s.r.o.	Technické služby Strakonice s.r.o.
Václav Maurer	Oldřich Psotka
Vodhosp. stavby Javorník – CZ s.r.o.	TAPAS Borek s.r.o.
MORAS a.s.	Zemědělské družstvo Kokory
KAMENOLOMY ČR s.r.o.	AZS RECYKLACE ODPADU s.r.o.
M&M Dresler s.r.o.	Kateřina Honsová
ROBA štěrkovny Nové Sedlo s.r.o.	Martin Čermák
BEST a.s.	Recyklace-štěrkovna Frýdlant s.r.o.
INTERAGENCIE Business Services s.r.o.	Václav Merhulík
STAVOKA Hradec Králové a.s.	ZAPA beton a.s.
SABIA s.r.o.	Silnice Čáslav – Holding a.s.
Pískovna Klíčany HBH s.r.o.	Václav Merhulík

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

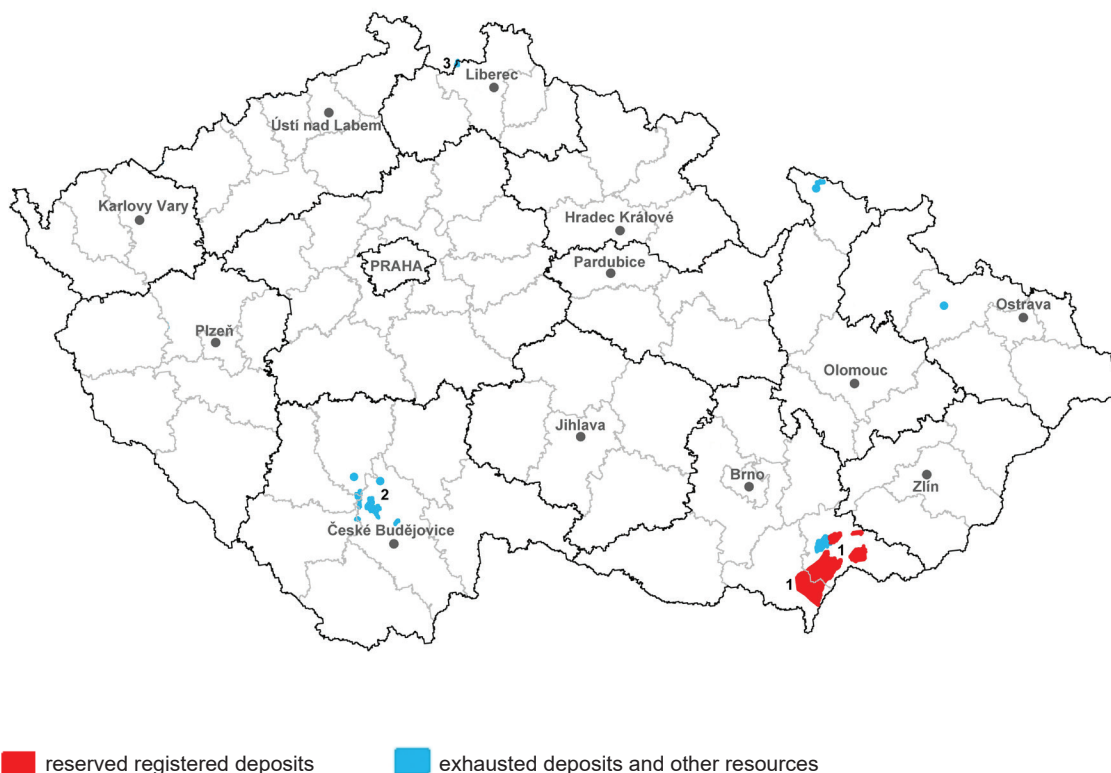
2. Mineral resources of the Czech Republic

- 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



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	2018	2019	2020	2021	2022
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 P₁, P₂, P₃

Year	2018	2019	2020	2021	2022
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, 2022

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 BaSO₄. 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

2022		
Country	kt	% World
Iran	100,000	14
Kazakhstan	85,000	11
India	51,000	7
Pakistan	40,000	5
China	36,000	5
Turkey	35,000	5
Russia	12,000	2
World*	740,000	100

* Estimate of the total identified reserves

Source: MCS 2023

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

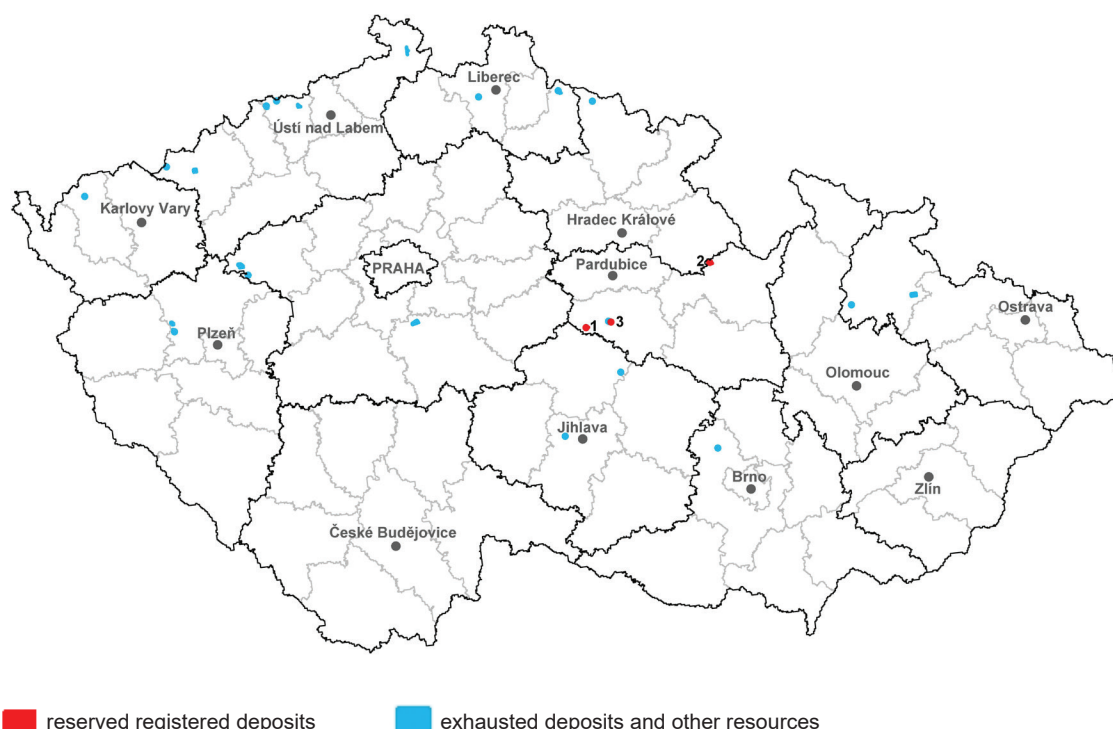
2. Mineral resources of the Czech Republic

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. Běstvína, 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 Pernárec 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 Běstvína, 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 Běstvína 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



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	2018	2019	2020	2021	2022
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)

		2018	2019	2020	2021	2022
Import	t	8,618	7,972	7,674	7,401	7,047
Export	t	167	146	205	272	258

251110 – Natural barium sulphate (barite)

		2018	2019	2020	2021	2022
Average import prices	CZK/t	9,998	9,953	10,115	10,873	12,177
Average export prices	CZK/t	15,859	15,530	18,017	15,121	16,363

251120 – Natural barium carbonate (witherite)

		2018	2019	2020	2021	2022
Import	t	11	0	0	0	0
Export	t	0	0	0	0	0

251120 – Natural barium carbonate (witherite)

		2018	2019	2020	2021	2022
Average import prices	CZK/t	10 000	–	–	–	–
Average export prices	CZK/t	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production

World barite production was as follows in recent years:

	2018	2019	2020	2021	2022 ^e
World mine production of barite (according to MCS), kt	9,180	8,870	6,840	6,730	7,900
World mine production of barite (according to WBD), kt	9,632	9,514	8,086	8,369	N

e – preliminary values

Main producers according to MCS

Country	2022 ^e	
	kt	%
China	1,900	25.0
India	2,600	32.1
Morocco	1,300	16.5
Kazakhstan	500	6.3
Mexico	320	4.0
Turkey	300	3.8
Iran	220	2.8
Russia	150	1.9
World	7,900	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		2018	2019	2020	2021	2022
Drilling-grade, ground						
Drilling-grade, ground Ex-works US, MCS	USD/t	176	179	183	167	170
Spanish barite, annual average price of imports into the Czech Republic (CZSO)	EUR/t	535	508	488	546	631

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 $\text{Ca}_5(\text{PO}_4)_3\text{F}$ (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

2022		
Country	kt	% World
Mexico	68,000	26.15
China	49,000	18.8
South Africa	41,000	15.8
Mongolia	22,000	8.5
Spain	10,000	3.8
Vietnam	5,000	1.9
USA	4,000	1.5
Iran	3,400	1.3
Others	55,000	21.2
World	260,000	100.0

Source: MCS 2023

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

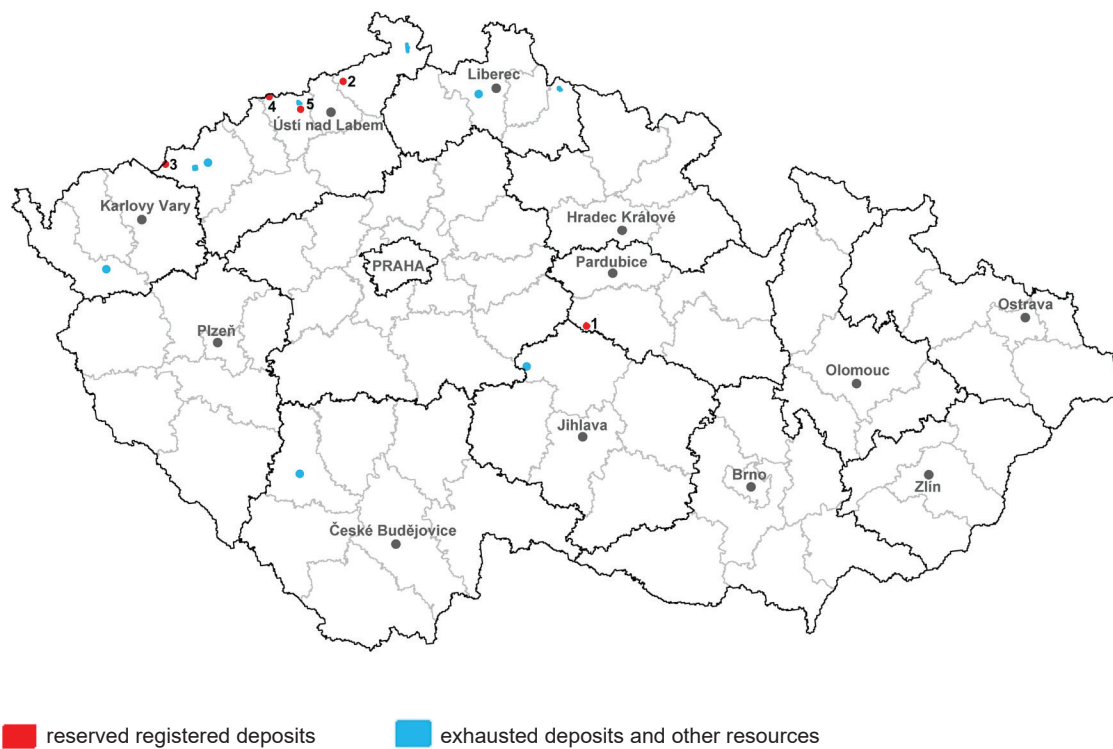
2. Mineral resources of the Czech Republic

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 (Běstvína). 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 Běstvína, Kovářská and exhausted deposits 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 Ledec nad Sázavou during the two world wars) and lasted until the first quarter of 1994, when the exploitation of the last used Jílové, Běstvína 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



Registered deposits and other resources are not mined

1 Běstvína

2 Jílové u Děčína

3 Kovářská

4 Moldava

5 Proboštov – tailing pond Přítkov

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

Number of deposits; reserves; mine production

Year	2018	2019	2020	2021	2022
Deposits – total number ^{a)}	5	5	5	5	5
exploited	0	0	0	0	0
Total mineral *reserves, kt	2,210	2,210	2,210	2,726	2,726
economic explored reserves	0	0	0	678	678
economic prospected reserves	32	32	32	459	459
potentially economic reserves	2,178	2,178	2,178	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

		2018	2019	2020	2021	2022
Import	t	3,432	2,495	2,688	2,387	2,703
Export	t	242	137	159	459	157

252921 – Fluorspar, containing 97 wt % or less of calcium fluoride

		2018	2019	2020	2021	2022
Average import prices	CZK/t	3,432	6,729	8,021	8,805	13,907
Average export prices	CZK/t	2,454	14,000	14,777	12,628	14,101

252922 – Fluorspar, containing more than 97 wt % of calcium fluoride

		2018	2019	2020	2021	2022
Import	t	13,515	12,403	9,519	9,130	8,319
Export	t	11,242	9,562	6,279	6,916	6,009

252922 – Fluorspar, containing more than 97 wt % of calcium fluoride

		2018	2019	2020	2021	2022
Average import prices	CZK/t	6,798	10,064	9,955	8,902	10,201
Average export prices	CZK/t	9,493	12,754	13,377	12,377	13,672

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices**World mine production**

World fluorspar production in recent years was as follows:

	2018	2019	2020	2021	2022 ^e
World mine production of fluorspar (according to MCS), kt	5,680	6,720	8,240	8,680	8,300
World mine production of fluorspar (according to WBD), kt	6,970	7,662	7,742	8,392	N

e – preliminary values

Main producers according to MCS

Country	2022 ^e	
	kt	%
China	5,700	68.7
Mexico	970	11.7
South Africa	420	5.1
Mongolia	350	4.2
Vietnam	220	2.7
Spain	160	1.9
Kazakhstan	77	0.9
Germany	67	0.8
Pakistan	65	0.8
World	8,300	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	2018	2019	2020	2021	2022
Average price USA market, CIF – acid grade (MCS), USD/t	276	304	309	322	360
Average price USA market, CIF – metallurgical grade (MCS), USD/t	258	292	149	151	140
Yearly average import price into the Czech Republic (CSO) from Germany, both qualities total, CZK/t	6,181	6,521	9,916	10,438	9,667
Yearly average import price into the Czech Republic (CSO) from Germany, both qualities total, EUR/t	6,181	6,521	9,916	10,438	9,667

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

2022		
Country	kt	% World
Turkey	90,000	27.3
Brazil	74,000	24.4
China	52,000	15.8
Madagascar	26,000	7.8
Mozambique	25,000	7.1
Tanzania	18,000	5.5
India	8,000	2.4
Czech Republic*	7,900	2.4
Uzbekistan	7,600	2.3
Mexico	3,100	0.9
North Korea	2,000	0.6
Sri Lanka	1,500	0.5
Norway	600	0.2
World	**330,000	100.0

2022			
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 k 1. 1. 2022 (national Register of Reserves as of 1. 1. 2023)*

** *own estimate*

European Minerals Yearbook – version 2023

Source: MCS 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

2. Raw material resources of the Czech Republic

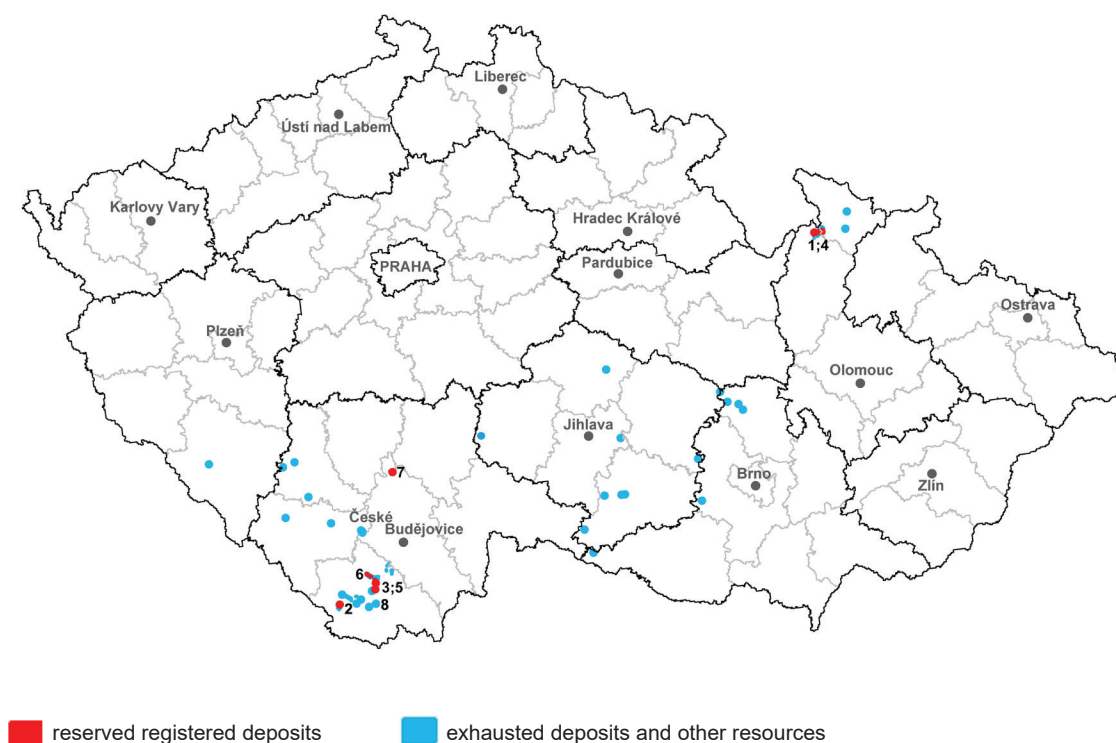
In the Czech Republic, there are only smaller deposits and sources of graphite. The quality of the raw material also fluctuates and the graphite contents (C_{graph}) mostly range between 20–40% in deposits and sources of amorphous graphite and between 10–20% in deposits and sources of crystalline graphite. All graphite deposits in the Czech Republic are of the metamorphogenic genetic type. It was formed during the regional metamorphism 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, Mokrý, 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 metamorphism. 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



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	2018	2019	2020	2021	2022
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 P₁, P₂, P₃

Year		2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	t	5,419	4,182	2,509	2,142	4,174
Export	t	2,851	2,004	2,582	2,450	2,138

2504 – Natural graphite

		2018	2019	2020	2021	2022
Average import prices	CZK/t	21,554	22,985	24,642	30,558	27,511
Average export prices	CZK/t	31,165	28,710	28,404	27,286	32,356

3801 – Artificial graphite; colloidal or semi-colloidal graphite; preparations based on graphite

		2018	2019	2020	2021	2022
Import	t	4,032	2,780	2,302	3 099	7,075
Export	t	8,068	4,961	1,113	2 968	4,502

3801 – Artificial graphite; colloidal or semi-colloidal graphite; preparations based on graphite

		2018	2019	2020	2021	2022
Average import prices	CZK/t	44,238	57,246	59,594	57,840	49,629
Average export prices	CZK/t	33,548	37,506	46,496	34,269	41,058

6903 – Other refractory ceramic goods (for example, retorts, crucibles, muffles, nozzles, plugs, supports, cupels, tubes, pipes, sheaths and rods)

		2018	2019	2020	2021	2022
Import	t	5,663	6,714	4,068	6,181	5,553
Export	t	25,679	25,193	21,258	27,142	25,809

6903 – Other refractory ceramic goods (for example, retorts, crucibles, muffles, nozzles, plugs, supports, cupels, tubes, pipes, sheaths and rods)

		2018	2019	2020	2021	2022
Average import prices	CZK/t	104,970	80,763	114,159	100,402	158,617
Average export prices	CZK/t	112,530	114,246	127,488	119,886	144,804

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

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.

	2018	2019	2020	2021	2022 ^e
World mine production of graphite (according to MCS), kt	1,120	1,100	966	1,130	1,300
World mine production of graphite (according to WBD), kt	1,029	1,128	955	1,167	N

e – preliminary values

Main producers according to MCS

Country	2022 ^e	
	kt	%
China	850	65.0
Mozambique	170	13.1
Madagascar	110	13.0
Brazil	87	6.7
Canada	15	1.2
Russia	15	1.2
Norway	10	0.8
India	8.3	0.6
Korea, North	8.1	0.6
Vietnam	5	0.4
Sri Lanka	4.3	0.3
Mexico	1.9	0.1
Ukraine	3	0.2
World	1,300	100.0

e – preliminary values

Prices of traded commodities (USD/t)

Commodity/year	2018	2019	2020	2021	2022
Prices of imports to the USA in foreign ports – flake, USD/t, according to MCS	1,520	1,340	1,340	1,390	1,300
Prices of imports to the USA in foreign ports – lump and chip (Sri Lanka), USD/t, according to MCS	1,890	2,380	2,940	2,010	2,500
Prices of imports to the USA in foreign ports – amorphous, USD/t, according to MCS	319	511	567	622	560

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 2023 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 $\text{Cu}(\text{Co},\text{Ni})_2\text{S}_4$ (29% Co), asbolane $\text{Mn}(\text{O},\text{OH})_2 \cdot (\text{Co},\text{Ni},\text{Ca})_x(\text{OH})_2 \cdot n\text{H}_2\text{O}$ (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

2022		
Country	t	% World
Congo (Kinshasa)	4,000,000	49.3
Australia	1,500,000	19.7
Indonesia	600,000	8.5
Cuba	380,000	7.0
Philippines	260,000	3.7
Russia	250,000	3.5
Canada	220,000	3.1
Madagascar	100,000	1.4
China	140,000	1.1
USA	69,000	1.0
Papua New Guinea	47,000	0.7
Morocco	13,000	0.2
World	8,300,000	100.0

Source: MCS 2023

2022			
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

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**

		2018	2019	2020	2021	2022
Import	kg	500	476	1,348	2,300	3,200
Export	kg	0	0	0	0	10

2605 – Cobalt ores and concentrates

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	1,570	1,637	492	250	233
Average export prices	CZK/kg	–	–	–	–	900

8105 – Cobalt mattes and other intermediate products of cobalt metallurgy; cobalt and articles thereof, including waste and scrap

		2018	2019	2020	2021	2022
Import	t	90	117	80	95	91
Export	t	49	53	33	71	48

**8105 – Cobalt mattes and other intermediate products of cobalt metallurgy;
cobalt and articles thereof, including waste and scrap**

		2018	2019	2020	2021	2022
Average import prices	CZK/t	1,789,808	1,406,61	1,500,534	1,482,289	1,702,747
Average export prices	CZK/t	1,163,094	1,317,312	1,151,138	1,077,027	1,353,907

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production

Statistical data on world cobalt production:

	2018	2019	2020	2021	2022 ^e
Mine production of cobalt (according to CI), t	124,344	153,700	145,000	163,514	197,791
Mine production of cobalt (according to MCS), t	148,000	144,000	142,000	165,000	190,000
Mine production of cobalt (according to WBD), t	158,317	124,518	130,056	134,476	N

e – preliminary values, (CI – Cobalt Institute)

Main producers according to MCS

Country	2022 ^e	
	t	%
Congo (Kinshasa)	130,000	68.4
Indonesia	10,000	5.3
Russia	8,900	4.7
Australia	5,900	3.1
Canada	3,900	2.1
Cuba	3,800	2.0
Philippines	3,800	2.0
Madagascar	3,000	1.6
Papua New Guinea	3,000	1.6
Turkey	2,700	1.4
Morocco	2,300	1.2
China	2,200	1.2
USA	800	0.4
World	190,000	100.0

e – preliminary values

The world's largest cobalt miners / producers according to INN.com

1. Glencore
2. Euroasian Resources Group
3. China Molybdenum
4. Gecamines
5. Zhejiang Huayou Cobalt

Prices of traded commodities

Annual prices according to yearbooks DERA, MCS

Commodity/year	2018	2019	2020	2021	2022
99.8% Co free market, in warehouse, Rotterdam (USD/kg)(DERA)	81.16	39.52	38.08	57.68	64.51
Co cathodes, US spot market, annual average, USD/lb (MCS)	37.4	17.0	15.7	24.2	31.1
99.8% Co, LME, in warehouse, cash (USD/t) (DERA)	72,361	72,621	32,796	31,331	63,553

**) Engineering&Mining Journal: 12 monthly quotations average*

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 $\text{Cu}_{12}\text{Sb}_4\text{S}_{13}$ (max. 45% Cu)

Industrially important deposit types

1. Porphyry (with Mo): Chuquibambilla (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

2022		
Country	mill. t	% World
Chile	190	21.3
Australia	97	10.9
Peru	81	9.1
Russia	62	7.0
Mexico	53	6.6
USA	44	4.9
Congo (Kinshasa)	31	3.5
Poland	30	3.4
China	27	3.0
Indonesia	24	2.7
Kazakhstan	20	2.3
Zambia	19	2.1
Canada	8	0.9
World	890	100.0

2022			
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 kopalni w Polsce 2023

Source: European Minerals Yearbook – version 2023

Source: MCS 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

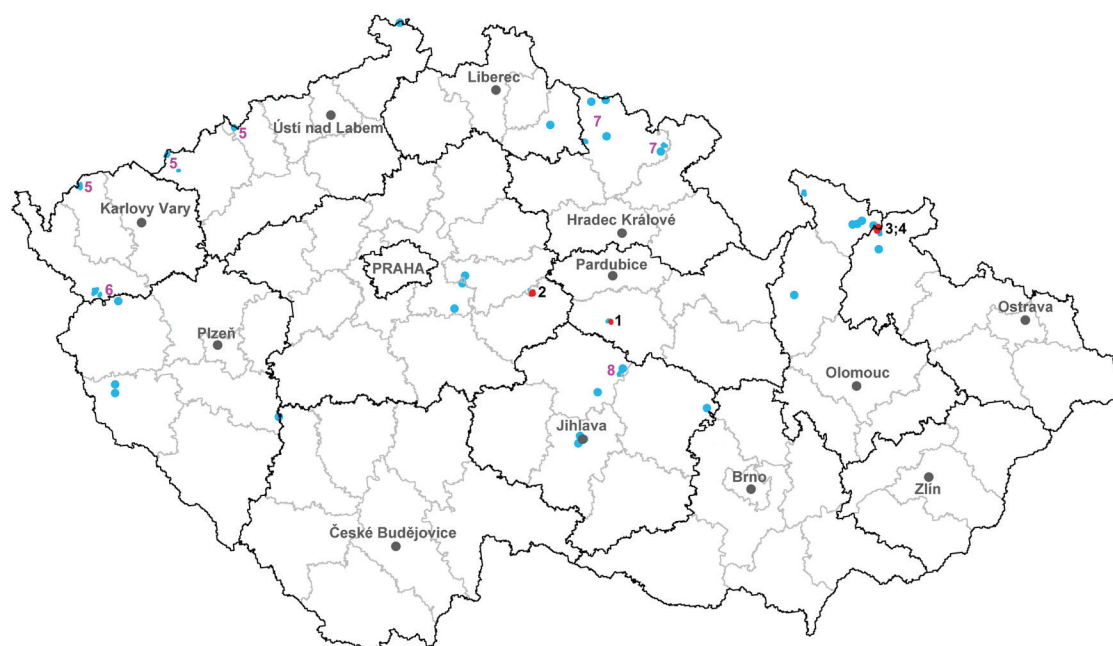
2. Mineral resources of the Czech Republic

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. Foothills (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



■ reserved registered deposits

■ exhausted deposits and other resources

Registered deposits and other resources are not mined

Reserved registered deposits:

1 Křižanovice

2 Kutná Hora

3 Zlaté Hory-Hornické Skály

4 Zlaté Hory-východ

Exhausted deposits and other resources:

5 in Krušné hory Mts. (Erzgebirge Mts.)
and Tisová

6 Tři Sekery and surroundings

7 in Krkonose Mts. Piedmont Basin
and Intracudetic Basin

8 Staré Ransko

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

Number of deposits; reserves; mine production

Year	2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	t	0.014	0.013	0	1	0
Export	t	0	0	0	0	0

2603 – Copper ores and concentrates

		2018	2019	2020	2021	2022
Average import prices	CZK/t	357,143	384,615	–	76,000	–
Average export prices	CZK/t	–	–	–	–	–

7402 – Unrefined copper

		2018	2019	2020	2021	2022
Import	t	25	181	114	168	0
Export	t	0	0.006	242	112	0

7402 – Unrefined copper

		2018	2019	2020	2021	2022
Average import prices	CZK/t	308,624	94,232	131,927	149,047	–
Average export prices	CZK/t	–	333,333	110,809	80,814	–

7403 – Refined copper and copper alloys

		2018	2019	2020	2021	2022
Import	t	7,879	7,350	6,541	7,133	493
Export	t	2,329	1,447	1,550	2,005	275

7403 – Refined copper and copper alloys

		2018	2019	2020	2021	2022
Average import prices	CZK/t	94,769	92,006	84,585	102,693	118,185
Average export prices	CZK/t	127,384	133,823	138,954	139,621	126,723

7404 – Copper waste and scrap

		2018	2019	2020	2021	2022
Import	t	7,688	5,844	7,499	7,134	747
Export	t	61,158	57,088	57,719	66,761	4,139

7404 – Copper waste and scrap

		2018	2019	2020	2021	2022
Average import prices	CZK/t	100,304	82,131	85,355	102,694	124,687
Average export prices	CZK/t	103,640	97,739	97,979	136,214	140,805

740311 – Copper cathodes and sections of cathodes unwrought

		2018	2019	2020	2021	2022
Import	t	1,001	1,474	1,429	1,853	2,392
Export	t	25	19	3	7	31

740311 – Copper cathodes and sections of cathodes unwrought

		2018	2019	2020	2021	2022
Average import prices	CZK/t	141,402	138,457	140,871	200,613	207,812
Average export prices	CZK/t	147,302	156,819	156,471	225,445	235,049

740321 – Copper-zinc base alloys, unwrought

		2018	2019	2020	2021	2022
Import	t	6,074	5,204	4,528	4,599	3,962
Export	t	2,080	1,260	1,396	1,748	3,992

740321 – Copper-zinc base alloys, unwrought

		2018	2019	2020	2021	2022
Average import prices	CZK/t	72,457	64,822	53,147	45,224	32,062
Average export prices	CZK/t	130,285	141,36	144,216	144,026	140,339

740322 – Copper-tin base alloys, unwrought

		2018	2019	2020	2021	2022
Import	t	186	126	81	84	22
Export	t	180	129	147	245	178

740322 – Copper-tin base alloys, unwrought

		2018	2019	2020	2021	2022
Average import prices	CZK/t	225,240	243,627	240,841	359,526	300,449
Average export prices	CZK/t	102,776	76,484	88,881	104,318	88,229

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production

World production of primary copper has been rising in recent years:

	2018	2019	2020	2021	2022 ^e
World mine production of copper (according to COCHILCO), kt	20,176	20,386	20,742	20,660	N
World mine production of copper (according to MCS), kt	20,000	20,400	20,400	20,600	21,000
World mine production of copper (according to WBD), kt	20,084	20,702	20,650	20,788	N

e – preliminary values

COCHILCO (Comisión Chilena del Cobre)

Main producers according to MCS

Country	2022 ^e	
	kt	%
Chile	5,200	23.6
Peru	2,200	10.0
China	1,900	8.6
Congo (Kinshasa)	2,200	10.0
USA	1,300	5.9
Russia	1,000	4.6
Indonesia	920	4.2
Australia	830	3.8
Zambia	770	3.5
Mexico	740	3.4
Kazakhstan	580	2.6
Canada	530	2.4
Poland	390	1.8
Other	3,400	15.5
World	22,000	100.0

Main producers to COCHILCO*

Country	2022	
	kt	%
Chile	5,625	26,3
Peru	2,299	10,8
Congo (Kinshasa)	1,878	8,8
China	1,741	8,2
USA	1,228	5,8
Zambia	881	4,1
Russia	881	4,1
Australia	818	3,8
Kazakhstan	741	3,5
Mexico	734	3,4
World	21,354	100,0

* COCHILCO (Comisión Chilena del Cobre, Chilean state agency for copper)

e – preliminary values

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	2018	2019	2020	2021	2022
Electrolytic Cu, grade A, min. 99.9%, LME, in warehouse, cash (according to DERA)	6,524.80	6,004.40	6,167.90	9,311.89	8,813.00
Electrolytic Cu, grade A, min. 99.9935%, contractual price (according to WB)	6,530.00	6,010.00	6,174.00	9,317.00	N
Copper, grade A, LME, annual average, US\$/lb (according to MCS)	296.00	272.40	279.80	422.50	400.00

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 $\text{Cu}_{13}\text{Fe}_2\text{Ge}_2\text{S}_{16}$), 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 2022.

The EU does not have Ge reserves. Source: European Minerals Yearbook – version 2022.

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

2. Mineral resources of the Czech Republic

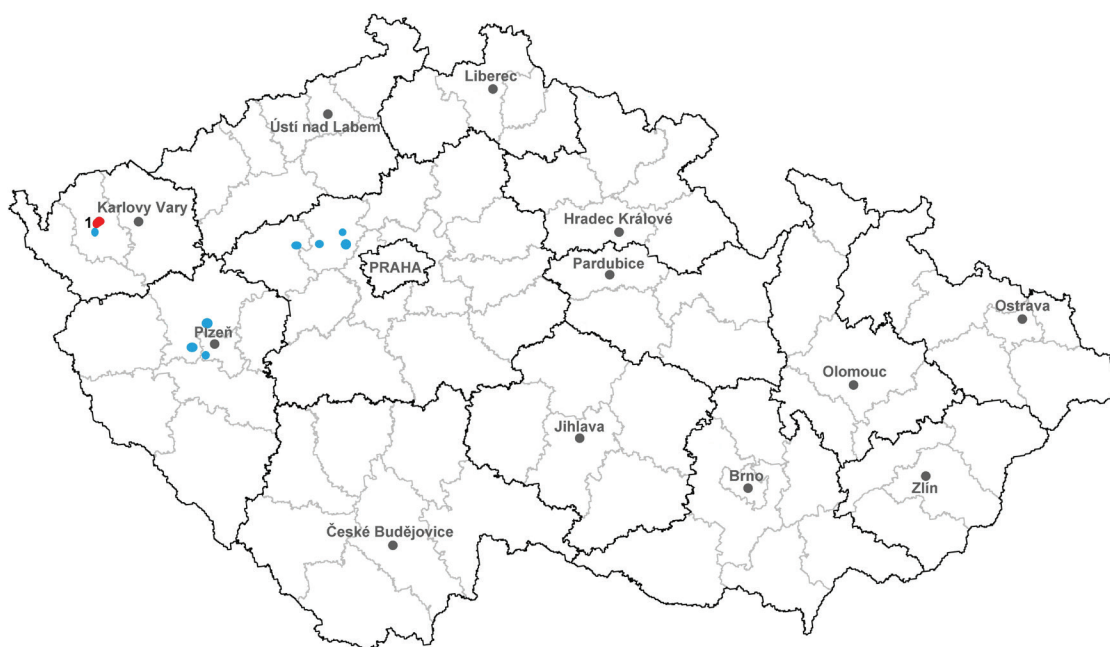
The Czech Republic has 1,248 t of unapproved Ge resources bound to brown and bituminous coal deposits.

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



■ reserved registered deposits

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	2018	2019	2020	2021	2022
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 evolutionary comparison with international classifications** of this yearbook

5. Foreign trade

81129295 – Unwrought germanium, germanium powders; excluding waste and scrap

		2018	2019	2020	2021	2022
Import	kg	4	4	2	5	807
Export	kg	1	0	0	0	0

81129295 – Unwrought germanium, germanium powders; excluding waste and scrap

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	51,500	73,500	51,000	34,800	N
Average export prices	CZK/kg	90,000	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production

World germanium production was as follows in recent years:

	2018	2019	2020	2021	2022 ^e
World germanium production (according to MCS), t	130	131	140	140	N
World germanium production (according to WBD), t	106	95	96	142	N

e – preliminary values

Main producers according to MCS

Country	2022 ^e	
	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

e – preliminary values

Prices of traded commodities

Price data are based on the US Mineral Commodity Summary (MCS)

	2018	2019	2020	2021	2022
GeO ₂ , yearly average, European market, USD/kg, MCS	731	913	724	770	840
Ge metal, annual average, European market, MCS	1,543	1,236	1,046	1,187	1,300

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)Te₄ (25% Au), calaverite AuTe₂ (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

2022		
Country	t	% World
Australia	8,400	16.2
Russia	6,800	13.1
South Africa	5,000	9.6
USA	3,000	5.8
Peru	2,900	5.6
Indonesia	2,600	5.0
Brazil	2,400	4.6
Canada	2,300	4.4
China	1,900	3.7
Uzbekistan	1,800	3.5
Mexico	1,400	2.7
Papua N.G.	1,100	2.1
Ghana	1,000	1.9
Kazakhstan	1,000	1.9
Others	9,200	17.7
World	52,200	100.0

Source: MCS 2023.

2022			
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), Bingham (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-Tasseyevoje 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 thesaurisation 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

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.

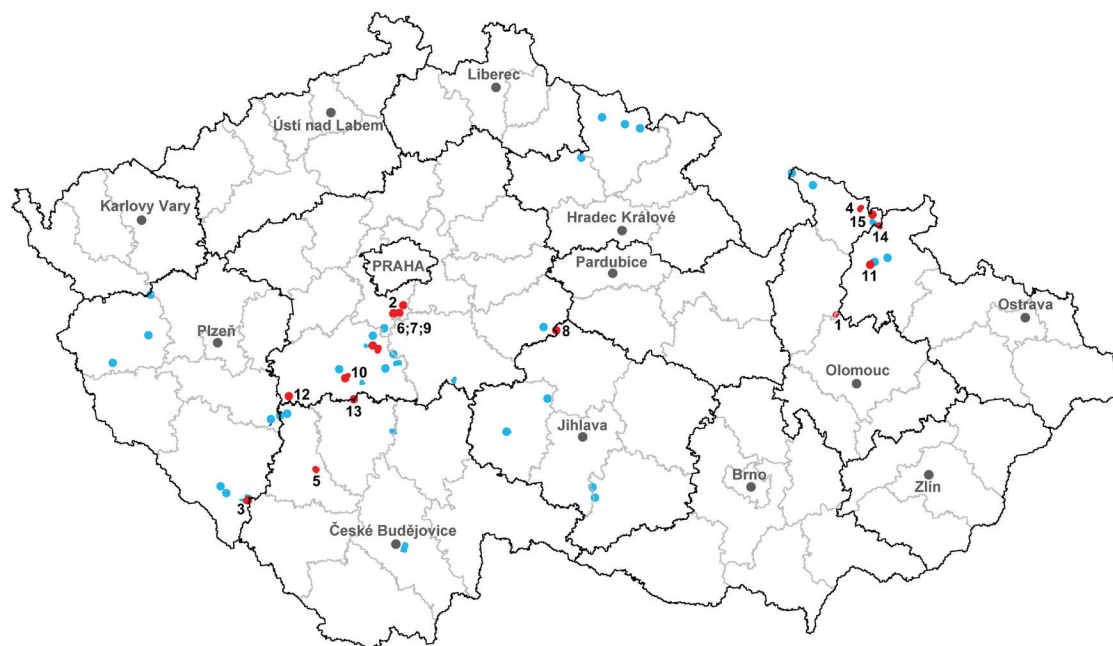
- A substantial part of Au ore mineralisation is bound to regionally metamorphosed volcanic-sedimentary complexes, in places penetrated by Variscan granitoids. In the Central Bohemian region the Jílové zone with a predominance of Au-quartz mineralisation (deposits Jílové, Mokrsko, Čelina, etc.) represents 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



■ reserved registered deposits

■ exhausted deposits and other resources

Registered deposits and other resources are not mined.

1 Břevenec

2 Jílové u Prahy

3 Kašperské Hory

4 Mikulovice u Jeseníka

5 Modlešovice

6 Mokrsko

7 Mokrsko-východ

8 Podmoky

9 Prostřední Lhota-Čelina

10 Smolotely-Horní Líšnice

11 Suchá Rudná-střed

12 Vacíkov

13 Voltýřov

14 Zlaté Hory-východ

15 Zlaté Hory-Zlatý potok

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

Number of deposits; reserves; mine production

Year	2018	2019	2020	2021	2022
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 P₁, P₂, P₃

Au metal in ores

Year		2018	2019	2020	2021	2022
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		2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	kg	6,235	4,790	6,348	9,011	9,206
Export	kg	5,919	6,766	5,417	3,418	3,434

7108 – Gold in unwrought or semi-manufactured form, gold powder

		2018	2019	2020	2021	2022
Average import prices	CZK/g	861.5	952.5	1,189.3	1,175.2	1,326.8
Average export prices	CZK/g	256.7	344.4	380.1	335.3	599.4

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production

Trend in the world's primary gold production

	2018	2019	2020	2021	2022 ^e
Mine production of gold, t (according to COCHILCO)	3,280	3,288	3,235	3094	N
Mine production of gold, t (according to MCS)	3,300	3,300	3,030	3,090	3,100
Mine production of gold, t (according to WBD)	3,336	3,328	3,205	3,235	N

e – preliminary values

COCHILCO – Comisión Chilena del Cobre (Chilean state agency for copper)

Main producers according to MCS

Country	2022 ^e	
	t	%
China	330	10.6
Australia	320	10.3
Russia	320	10.3
Canada	220	7.1
USA	170	5.0
Kazakhstan	120	3.9
Mexico	120	3.9
Peru	100	3.2
Ghana	90	4.3
Indonesia	70	2.3
World	3,100	100.0

Main producers according to COCHILCO

Country	2021	
	t	%
China	329	10,7
Australia	315	10,2
Russia	309	10,0
Canada	187	6,1
USA	187	6,1
Mexico	125	4,1
Ghana	118	3,8
Kazakhstan	115	3,7
South Africa	105	3,4
Indonesia	103	3,3
World	3,075	100,0

e – preliminary values

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	2018	2019	2020	2021	2022
Gold 99.9%. LME, in warehouse (according to DERA)	1,270	1,392	1,767	1,800	1,803
Au 99.5% (UK), LME average daily quotation (WB)	1,269	1,392	1,770	1,800	1,801
Au metal, annual price average (MCS)	1,272	1,395	1,774	1,801	1,800

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 $\text{FeO} \cdot \text{Fe}_2\text{O}_3$ (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 =

2022		
Country	kt	%
Australia	25,000,000	29.4
Brazil	15,000,000	17.6
Russia	14,000,000	16.5
China	6,900,000	8.1
India	3,400,000	4.0
Ukraine	2,300,000	2.7
Canada	2,300,000	2.7
Iran	1,500,000	1.8
Peru	1,500,000	1.8
USA	1,000,000	1.2
Kazakhstan	900,000	1.1
South Africa	670,000	0.8
Sweden	600,000	0.7
Turkey	38,000	0.01
others	9,500,000	11.2
World	85,000,000	100.0

2022			
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

Source: MCS 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

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 oolitic 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 (Měděňec, 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

		2018	2019	2020	2021	2022
Import	t	6,015,283	5,335,440	4,915,243	6,035,837	4,897,574
Export	t	6,874	3,343	26	1	6

2601 – Iron ores and concentrates

		2018	2019	2020	2021	2022
Average import prices	CZK/t	2,008	2,590	2,694	3,882	N
Average export prices	CZK/t	2,932	3,742	5,405	–	13,500

7201 – Crude iron

		2018	2019	2020	2021	2022
Import	t	60,738	54,504	47,175	56,918	48,080
Export	t	147,970	45,748	51,827	85,714	39,099

7201 – Crude iron

		2018	2019	2020	2021	2022
Average import prices	CZK/t	9,630	9,545	9,090	13,556	17,709
Average export prices	CZK/t	7,745	8,563	8,535	11,542	18,264

7204 – Ferrous waste and scrap, remelted scrap ingots or iron or steel

		2018	2019	2020	2021	2022
Import	t	469,056	443,433	441,663	509,861	460,103
Export	t	2,286,842	2,263,155	2,188,727	2,388,140	2,120,044

7204 – Ferrous waste and scrap, remelted scrap ingots or iron or steel

		2018	2019	2020	2021	2022
Average import prices	CZK/t	7,135	6,085	5,854	9,338	9,891
Average export prices	CZK/t	7,385	6,600	6,216	10,009	11,143

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

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:

	2018	2019	2020	2021	2022 ^e
World mine production of iron ore (according to MCS), mill. t	2,460	2,450	2,470	2,680	2,600
World mine production of iron ore (according to WBD), mill. t	1,524	1,552	1,523	1,650	N

e – preliminary values

Main producers according to MCS

Country	2022 ^e	
	mill. t	%
Australia	880	33.1
Brazil	410	1.8
China	380	14.6
India	290	11.2
Russia	90	3.5
Ukraine	76	2.9
South Africa	76	2.9
Iran	75	2.9
Kazakhstan	66	2.5
Canada	58	2.2
USA	46	1.8
Sweden	39	1.5
Peru	17	0.7
Turkey	16	0.6
Mauretania	13	0.5
Mexico	11	0.4
Others	59	2.3
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		2018	2019	2020	2021	2022
Iron ore, any origin, spot price, (according to the World Bank)	USD/dmt	69.8	93.8	108.9	161.7	121.3
Iron ore, US market, annual average (according to MCS)	USD/t	93.0	92.4	91.3	141.8	114.0
Ukrainian iron ore, yearly average of import prices (according to CZSO)	USD/t	95.85	90.84	114.26	114.38	178.84

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 (Pb₅Sb₄S₁₁ (55% Pb), bournonite CuPbSbS₃ (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

2022		
Country	mill. t	% World
Australia	37,000	43.5
China	12,000	14.1
Russia	6,000	7.1
Mexico	5,600	6.6
Peru	5,300	6.2
USA	4,600	5.4
India	2,500	2.9
Sweden	1,700	2.0
Bolivia	1,600	1.9
Turkey	860	1.0
Other countries	5,900	6.9
World	85,000	100.0

2022			
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*

Source: *MCS 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

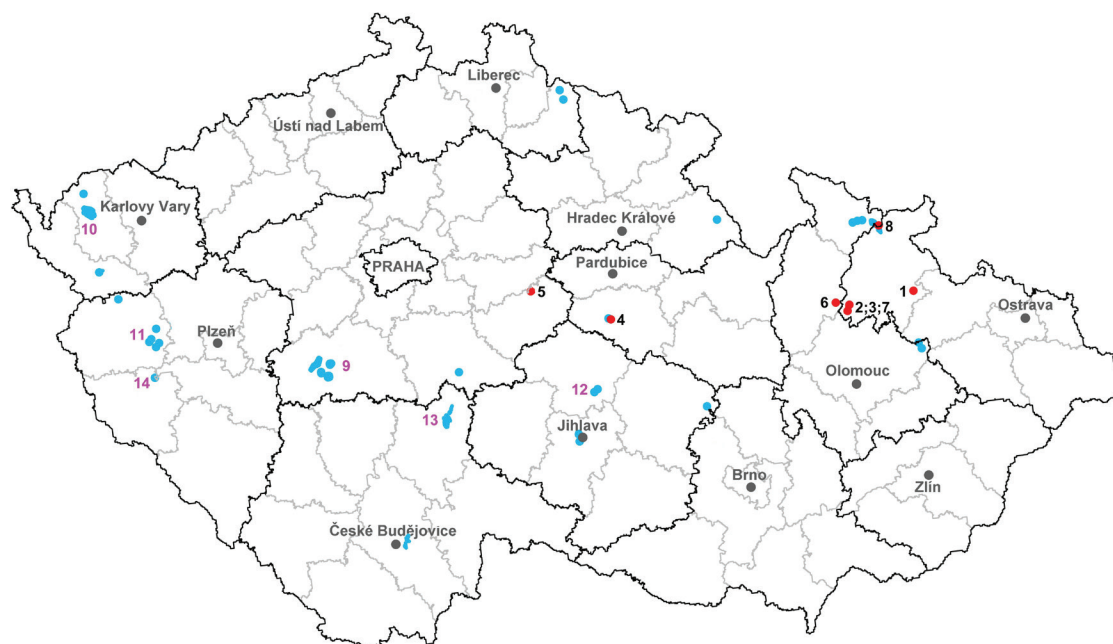
2. Mineral resources of the Czech Republic

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	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	12 Havlíčkův Brod (Dlouhá Ves + Bartoušov + Stříbrné Hory)
10 Oloví	13 Ratibořské Hory + Stará Vožice
11 Stříbro	14 Černovice

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

Number of deposits; reserves; mine production

Year	2018	2019	2020	2021	2022
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 P₁, P₂, P₃

Polymetallic (Pb – Zn ± Cu) ores

Year	2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	t	0	0	0	0	0
Export	t	0	0	0	0	0

2607 – Lead ores and concentrates

		2018	2019	2020	2021	2022
Average import prices	CZK/t	–	–	–	–	–
Average export prices	CZK/t	–	–	–	–	–

7801 – Unwrought lead

		2018	2019	2020	2021	2022
Import	t	151,534	422,312	164,067	179,418	163,975
Export	t	45,976	40,600	38,209	38,650	30,313

7801 – Unwrought lead

		2018	2019	2020	2021	2022
Average import prices	CZK/t	56,260	17,841	38,113	49,391	52,995
Average export prices	CZK/t	55,275	37,688	46,383	50,378	56,119

7802 – Lead waste and scrap

		2018	2019	2020	2021	2022
Import	t	8,608	10,435	6,946	8,746	8,694
Export	t	904	894	3,522	4,771	836

7802 – Lead waste and scrap

		2018	2019	2020	2021	2022
Average import prices	CZK/t	39,857	39,088	36,284	39,461	40,211
Average export prices	CZK/t	32,208	37,688	19,376	24,259	34,261

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

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:

	2018	2019	2020	2021	2022 ^e
World mine production of lead (according to ILZSG*), kt	4,572	4,697	4,441	4,540	4,448
World mine production of lead (according to MCS), kt	4,560	4,720	4,380	4,550	4,500
World mine production of lead (according to WBD), kt	4,629	4,942	4,746	4,681	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	2022 ^e	
	kt	%
China	2,000	44.4
Australia	440	9.8
USA	280	6.2
Mexico	270	6.0
Peru	250	5.6
India	240	5.3
Russia	200	4.4
Bolivia	90	2.0
Turkey	75	1.7
Sweden	65	1.4
Tajikistan	55	1.2
Other countries	220	4.9
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	2018	2019	2020	2021	2022 ^e
99.97% Pb, LME (according to DERA)	2,243.35	1,996.90	1,823.70	2,203.83	2,152.08
Refined 99.97 %, contractual price (according to WB)	2,240.00	1,997.00	1,825.00	2,200.00	2,151.00
Lead, LME, annual average, spot market, US\$/lb (according to MCS)	101.8	90.6	82.7	100.0	97.0

e – preliminary values

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 $\text{BaMn}_3\text{O}_{16}$ (45–60% Mn), manganite MnOOH (50–62% Mn), braunite $\text{Mn}^{2+}\text{Mn}^{3+}_6\text{SiO}_{12}$ (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), Chiatara (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 $2.5 \cdot 10^{12}$ 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

2022		
Country	kt	% World
South Africa	640,000	37.6
China	280,000	16.5
Australia	270,000	15.9
Brazil	270,000	15.9
Ukraine, concentrate	140,000	8.2
Gabon	61,000	3.6
India	34,000	2.0
Ghana	13,000	0.8
Kazakhstan, concentrate	5,000	0.3
Mexico	5,000	0.3
World	1,700,000	100.0

Source: MCS 2023

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

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 metamorphism, 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 gossan 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	2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	t	27,292	38,875	38,875	49,576	46,251
Export	t	57	61	61	71	36

2602 – Manganese ores and concentrates

		2018	2019	2020	2021	2022
Average import prices	CZK/t	3,782	3,987	4,156	2,479	4,216
Average export prices	CZK/t	15,267	17,799	19,046	17,930	15,352

720221; 720229 – Ferromanganese

		2018	2019	2020	2021	2022
Import	t	26,152	25,089	21,816	27,968	15,642.1
Export	t	1,176	869	1,263	2,902	2,021

720221; 720229 – Ferromanganese

		2018	2019	2020	2021	2022
Average import prices	CZK/t	29,126	28,490	24,893	27,968	70,349
Average export prices	CZK/t	27,616	28,221	25,368	20,717	44,452

720230 – Ferrosilicomanganese

		2018	2019	2020	2021	2022
Import	t	44,832	36,389	37,321	37,321	33,227
Export	t	1,548	839	1,762	1,762	1,318

720230 – Ferrosilicomanganese

		2018	2019	2020	2021	2022
Average import prices	CZK/t	25,168	17,496	24,232	33,216	37,875
Average export prices	CZK/t	29,513	24,309	20,818	26,868	37,586

8111 – Manganese and articles thereof, including waste and scrap

		2018	2019	2020	2021	2022
Import	t	1,679	960	1,028	1,387	920
Export	t	74	63	77	90	155

8111 – Manganese and articles thereof, including waste and scrap

		2018	2019	2020	2021	2022
Average import prices	CZK/t	52,104	60,361	51,336	67,931	106,620
Average export prices	CZK/t	60,564	48,325	42,084	76,625	35,665

2820 – Manganese oxides

		2018	2019	2020	2021	2022
Import	t	1,057	740	1,093	840	577
Export	t	13	19	8	8	12

2820 – Manganese oxides

		2018	2019	2020	2021	2022
Average import prices	CZK/t	25,243	17,901	17,651	17,040	29,448
Average export prices	CZK/t	21,721	36,230	47,663	414,549	319,750

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

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:

	2018	2019	2020	2021	2022 ^e
World mine production of manganese (according to MCS), kt	17,900	19,600	18,900	20,100	20,000
World mine production of manganese (according to WBD), kt	19,610	21,165	19,623	21,219	N

e – preliminary values

Main producers according to MCS

Country	2022 ^e	
	kt	%
South Africa	7,200	36.0
Gabon	4,600	23.0
Australia	3,300	16.5
China	990	5.0
Ghana	940	4.7
India	480	2.4
Brazil	400	2.0
Ukraine, concentrate	400	2.0
Ivory Coast	360	1.8
Malaysia	360	1.8
Mexico	230	1.2
Georgia	220	1.1
Burma	200	1.0
Kazakhstan, concentrate	110	0.6
World	20,000	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		2018	2019	2020	2021	2022
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	7.16	5.63	4.59	5.27	6.50
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	N	1,387	1,266
Electrolytic (EMM), min. 99.7%, export (FOB), domestic (DERA)	USD/t	N	N	N	3,929	3,167

Nickel

1. Characteristics and use

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

99 Ni

Industrially important minerals

Pentlandite $(\text{Ni,Fe})_9\text{S}_8$ (35% Ni), nickeline NiAs (44% Ni), garnierite $(\text{Ni,Mg})_6(\text{OH})_8\text{Si}_4\text{O}_{10}$ (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

2022		
Country	kt	% World
Australia	21,000	21.0
Indonesia	21,000	21.0
Brazil	16,000	16.0
Russia	7,500	7.5
New Caledonia	7,100	7.1
Philippines	4,800	4.8
China	2,200	2.2
Canada	2,100	2.1
USA	370	0.4
Others	20,000	21.1
World	>100,000	100.0

Source: MCS 2022

2022			
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

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**

		2018	2019	2020	2021	2022
Import	t	0	0.004	9	37	11
Export	t	0	0	0	0	0

2604 – Nickel ores and concentrates

		2018	2019	2020	2021	2022
Average import prices	CZK/t	–	475,000	67,699	55,241	862,455
Average export prices	CZK/t	–	–	–	–	–

7502 – Unwrought nickel

		2018	2019	2020	2021	2022
Import	t	2,871	3,111	2,683	2,851	2,540
Export	t	211	198	175	124	91

7502 – Unwrought nickel

		2018	2019	2020	2021	2022
Average import prices	CZK/t	324,572	338,675	352,008	412,361	556,377
Average export prices	CZK/t	280,721	297,879	298,750	356,520	583,491

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production of nickel

Commodity/year	2015	2018	2019	2020	2021 ^e
World mine production of nickel (according to MCS), kt*	2,400	2,610	2,510	2,730	3,300
World mine production of nickel (according to WBD), kt	2,377	2,707	2,477	2,812	N

e – estimate

* Nickel content

Main producers of nickel according to MCS

Country	2022 ^e	
	kt*	%
Indonesia	1,600	48.5
Philippines	330	10.0
Russia	220	6.7
New Caledonia	190	5.8
Australia	160	4.8
Canada	130	3.9
China	110	3.3
Brazil	83	2.5
USA	18	0.5
Other countries	440	13.3
World	3,300	100.0

e – estimate

* Nickel content

Prices of traded commodities

Commodity/year	2018	2019	2020	2021	2022 ^e
Nickel, annual average, cash, LME, USD/t (MCS)	13,903	13,772	13,903	18,476	25,000
Nickel, annual average, cash, LME, USD/lb (MCS)	5,948	6,306	6,250	8,380	11,000
Nickel, LME, primary, min. 99.8%, cash in LME warehouse, USD/t (DERA)*	13,113.7	13,902.9	13,772.0	18,475.8	25,814.8

*e – estimate*** Average annual price*

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 Ag₂S (87% Ag), polybasite (Ag,Cu)₁₆Sb₂S₁₁ (74% Ag), proustite Ag₃AsS₃ (65% Ag), pyrargyrite Ag₃SbS₃ (60% Ag), chlorargyrite AgCl (75% Ag), tetrahedrite (freibergite) Cu₆(Ag,Fe)₆Sb₄S₁₃ (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

2022		
Country	t	% World
Peru	98,000	17.8
Australia	92,000	16.7
Poland	65,000	11.8
China	71,000	12.9
Russia	45,000	8.2
Chile	26,000	4.7
USA	23,000	4.2
Bolivia	22,000	4.0
Other countries	57,000	10.4
World	550,000	100.0

Source: MCS 2023

2022			
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

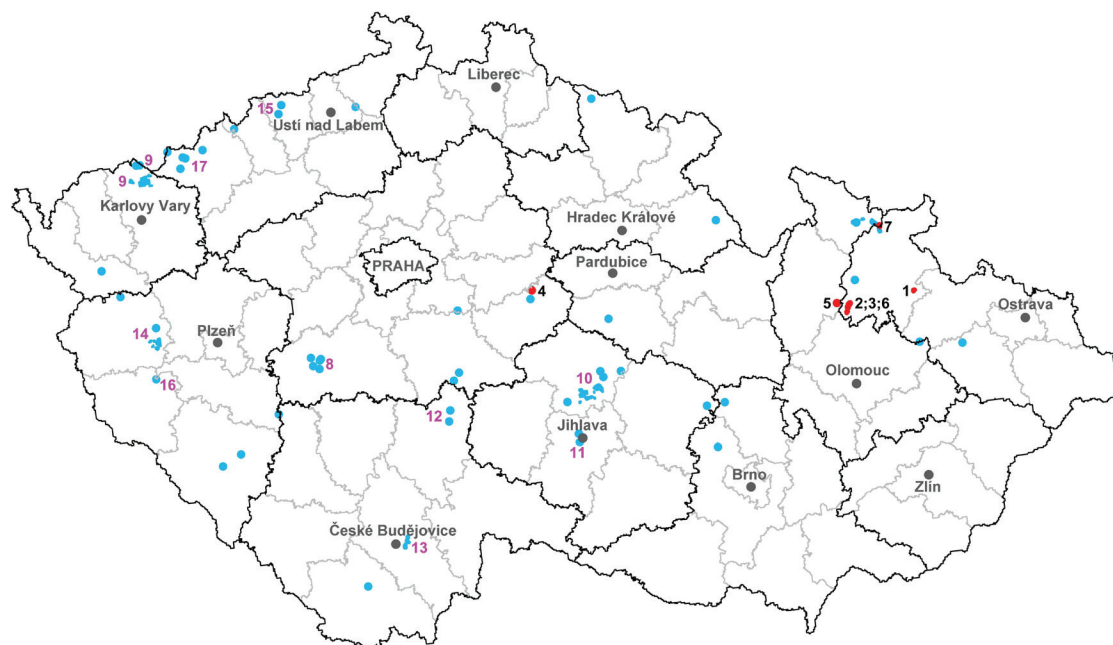
2. Mineral resources of the Czech Republic

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	4 Kutná Hora	7 Zlaté Hory-východ
2 Horní Město	5 Oskava	
3 Horní Město-Šibenice	6 Ruda u Rýmařova-sever	

Exhausted deposits and other resources:

8 Příbram surroundings	13 Rudolfov
9 Jáchymov surroundings	14 Stříbro
10 Havlíčkův Brod surroundings	15 Hrob + Mikulov
11 Jihlava surroundings	16 Nalžovské hory
12 Ratibořské hory + Stará Vožice	17 Vejprty + Hora sv. Kateřiny

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

Number of deposits; reserves; mine production

Year	2018	2019	2020	2021	2022
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 P₁, P₂, P₃

Ag metal in ores

Year		2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	kg	0	0	1,906	0	0
Export	kg	2	26	0	0	0

261610 – Silver ores and concentrates

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	–	–	12	–	–
Average export prices	CZK/kg	9,500	2,962	–	–	–

7106 – Silver, unwrought or in semi-manufactured or powder form

		2018	2019	2020	2021	2022
Import	kg	33,760	229,138	482,481	569,818	511,643
Export	kg	30,684	36,244	35,995	51,812	53,649

7106 – Silver, unwrought or in semi-manufactured or powder form

		2018	2019	2020	2021	2022
Average import prices	CZK/g	7.9	5.2	4.1	4.9	5.4
Average export prices	CZK/g	8.6	11.3	15.6	16.2	16.4

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

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:

	2018	2019	2020	2021	2022
World mine production of silver (according to COCHILCO), t	26,606	26,344	24,413	25,743	N
World mine production of silver (according to MCS), t	26,900	26,500	23,500	25,000	26,000
World mine production of silver (according to WBD), t	27,055	28,086	26,343	25,939	N

e – preliminary values

COCHILCO (Comisión Chilena del Cobre, Chilean state agency for copper)

Main producers according to MCS

Country	2022	
	t	%
Mexico	5,600	23.3
China	3,400	14.2
Peru	3,000	12.5
Chile	1,600	6.7
Poland	1,300	5.4
Australia	1,300	5.4
Russia	1,300	5.4
USA	1,000	4.2
Bolivia	1,000	4.2
Kazakhstan	450	1.9
World	24,000	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	2018	2019	2020	2021	2022
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)	15.71	16.22	20.54	25.20	21.80
Silver metal, Platts Metal Week quotations (according to MCS)	15.73	16.24	20.58	25.23	21.00

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 $\text{Cu}_2\text{FeSnS}_4$ (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 metasomatites: San Rafael (Peru), Dachang (China)
5. Alluvial deposits: in Malaysia, Nigeria, Central Africa, Niushipo (China), Dachang District (China)

Reserves

2022		
Country	kt	% World
Indonesia	800,000	17.4
China	720,000	15.7
Burma	700,000	15.2
Australia	570,000	12.4
Russia	430,000	9.3
Brazil	420,000	9.1
Bolivia	400,000	8.7
Congo (Kinshasa)	130,000	2.8
Peru	130,000	2.8
Vietnam	11,000	0.2
Other countries	310,000	6.7
World	4,600,000	100.0

Source: MCS 2022

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

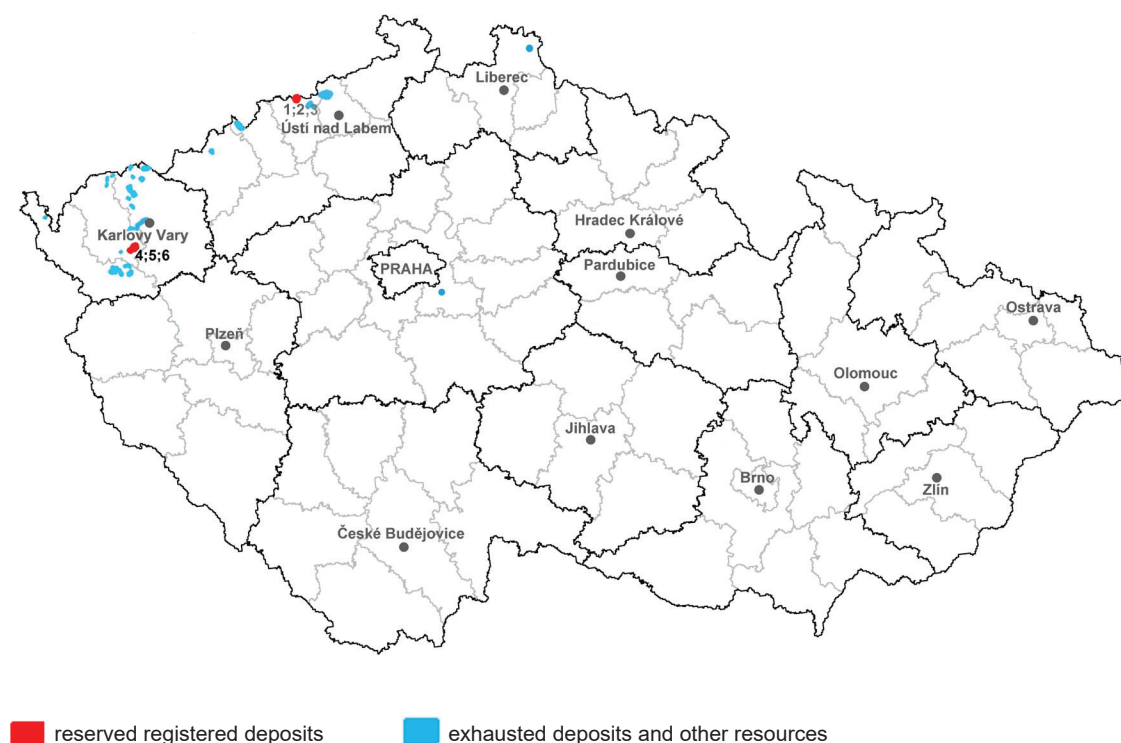
2. Mineral resources of the Czech Republic

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 (Čínovec, 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 Čínovec 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 Čínovec-jih deposit a year earlier. Larger residual reserves of poor-content ores remained only in the deposits in the Krásno – Horní Slavkov and Čínovec 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

2 Cínovec-východ

3 Cínovec-severozápad

4 Krásno

5 Krásno-Horní Slavkov

6 Krásno-Koník

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

Number of deposits; reserves; mine production

Year	2018	2019	2020	2021	2022
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 P₁, P₂, P₃ Sn metal in ores

Year		2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	t	2	1	2	4	2
Export	t	0	0	0	0	0.04

2609 – Tin ores and concretates

		2018	2019	2020	2021	2022
Average import prices	CZK/t	482,949	465,921	467,139	596,439	985,067
Average export prices	CZK/t	–	–	–	–	900,000

8001 – Unwrought tin

		2018	2019	2020	2021	2022
Import	t	1,017	928	460	167	443
Export	t	51	62	31	27	21

8001 – Unwrought tin

		2018	2019	2020	2021	2022
Average import prices	CZK/t	309,240	300,536	368,573	269,401	662,844
Average export prices	CZK/t	142,104	166,640	178,356	496,823	580,328

8002 – Tin waste and scrap

		2018	2019	2020	2021	2022
Import	t	13	19	15	7	11
Export	t	84	83	65	98	80

8002 – Tin waste and scrap

		2018	2019	2020	2021	2022
Average import prices	CZK/t	456,195	275,104	465,113	569,069	758,818
Average export prices	CZK/t	414,104	456,855	421,390	469,208	685,328

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices**World mine production**

World production of primary tin was as follows in recent years:

	2018	2019	2020	2021	2022 ^e
World mine production of tin (according to MCS), kt	318	296	264	305	310
World mine production of tin (according to WBD), kt	317	294	277	271	N
World mine production of tin (according to WMS), kt	325	317	292	257	N

e – preliminary values

Main producers according to MCS

Country	2022 ^e	
	t	%
China	95,000	30.6
Indonesia	74,000	23.9
Burma	31,000	10.0
Peru	29,000	9.3
Congo (Kinshasa)	20,000	6.5
Bolivia	18,000	5.8
Brazil	18,000	5.8
Australia	9,700	3.1
Vietnam	5,200	1.7
Malaysia	5,000	1.6
Russia	2,700	0.9
Nigeria	1,700	0.6
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) | 6. Thaisarco (Thailand) |
| 2. Minsur (Peru) | 7. EM Vinto (Bolivia) |
| 3. PT Timah (Indonesia) | 8. Jiangxi New Nanshan (China) |
| 4. Yunnan Chengfeng (China) | 9. Aubris Beerse (Belgium) |
| 5. MSC (Malaysia) | 10. Guangxi China Tin (China) |

Prices of traded commodities

According to 2018–2022 (DERA) yearbooks and the World Bank (WB), the world's tin prices in USD/t developed as follows:

Commodity/year	2018	2019	2020	2021	2022
Tin, min. 99.85%, LME, in warehouse, cash (according to DERA)	20,251	18,660	17,323	32,587	31,354
High grade min. 99.85%, LME contractual (WB)	20,145	18,661	17,125	32,384	31,335

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)WO₄ (with 76.5% WO₃), scheelite CaWO₄ (with 80.6% WO₃)

Industrially important deposit types

1. Skarns: King Island (Australia), Baoshan (China), Footweg (Canada), Pine Creek (USA)
2. Greisens: Cinovec-Zinnwald (Czechia – Germany, Panasqueira (Portugal), Hongshuizhai (China)
3. Magmatic-hydrothermal: Climax (USA), Lianhuashan (China), Jeddah (Russia), Endako (Canada), Mittersill (Austria)

Reserves

2022		
Country	Mill. t	%
China	1,800,000	52.9
Russia	400,000	11.8
Vietnam	100,000	2.9
Spain	56,000	1.6
Austria	10,000	0.3
Portugal	3,100	0.1
Others	880,000	25.9
World	3,400,000	100.0

Source: MCS 2022

2022			
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 2022

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

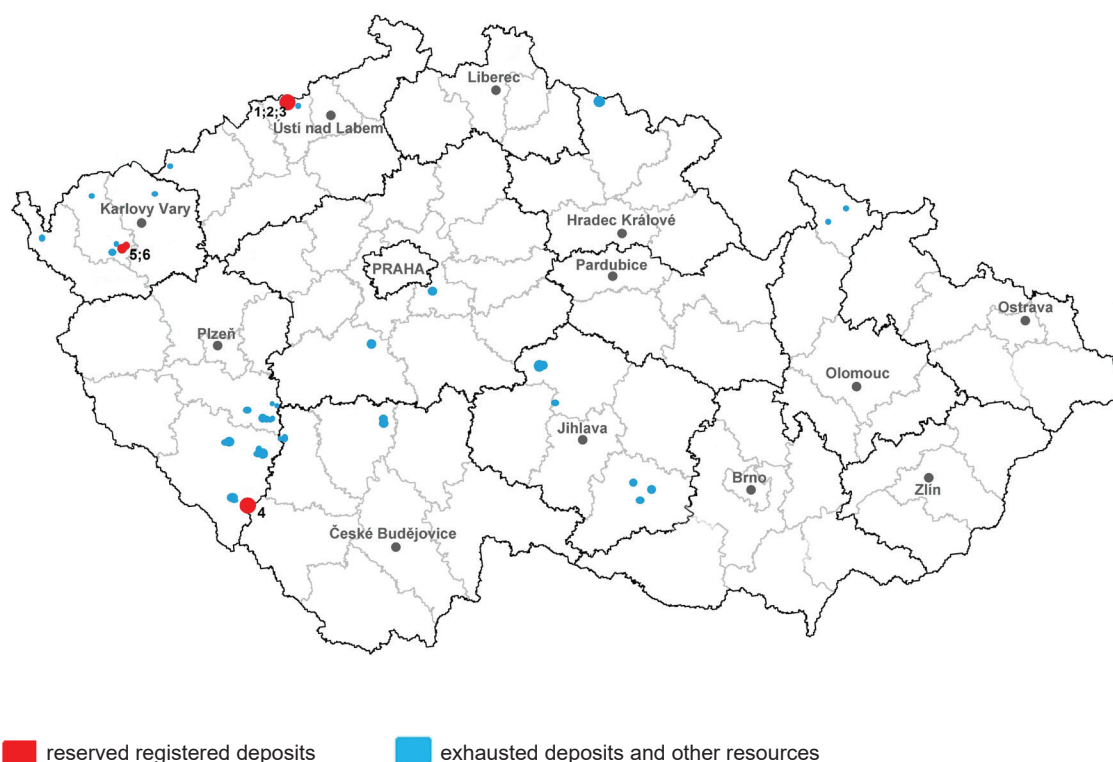
2. Mineral resources of the Czech Republic

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 | 4 Kašperské Hory |
| 2 Cínovec-severozápad | 5 Krásno |
| 3 Cínovec-východ | 6 Krásno-Horní Slavkov |

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

Number of deposits; reserves; mine production

Year	2018	2019	2020	2021	2022
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 P₁, P₂, P₃ W metal in ores

Year		2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	kg	0	0	0	0	0
Export	kg	0	0	0	0	0

2611 – Tungsten ores and concentrates

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	–	–	–	–	–
Average export prices	CZK/kg	–	–	–	–	–

8101 – Tungsten and its products, including waste and scrap

		2018	2019	2020	2021	2022
Import	kg	695,253	240,849	378,244	738,967	808,257
Export	kg	931,960	1,060,611	1,152,964	1 436,063	986,578

8101 – Tungsten and its products, including waste and scrap

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	301	588	884	635	649
Average export prices	CZK/kg	897	676	805	899	920

720280 – Ferro-tungsten and ferrosilicotungsten

		2018	2019	2020	2021	2022
Import	kg	35,685	16,863	34,518	71,567	80,580
Export	kg	20,872	10,969	25,462	33,413	34,350

720280 – Ferro-tungsten and ferrosilicotungsten

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	734	569	467	541	694
Average export prices	CZK/kg	682	591	475	556	735

810196 – Tungsten wires

		2018	2019	2020	2021	2022
Import	kg	71,959	61,342	42,080	37,965	36,634
Export	kg	33,626	24,959	20,082	23,281	16,602

810196 – Tungsten wires

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	2,016	1,935	2,661	3,143	3,311
Average export prices	CZK/kg	3,329	5,506	5,125	5,083	6,972

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production

World production of primary tungsten

	2018	2019	2020	2021	2022 ^e
Mine production, kt (according to MCS)	81.1	83.8	78.4	83.48	84.0
Mine production, kt (according to WBD)	84.1	88.9	85.0	88.5	N

e – preliminary values

Main producers according to MCS

Country	2022 ^e	
	t	%
China	71,000	84.5
Vietnam	4,800	5.7
Russia	2,300	2.7
Bolivia	1,400	1.7
Rwanda	1,100	1.3
Austria	900	1.1
Spain	700	0.8
Portugal	500	0.6
Others	1,400	1.7
World	84,000	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	2018	2019	2020	2021	2022
Tungsten concentrate, Rotterdam, USD/mtu WO ₃ (MCS)	261.00	198.00	172.00	225.00	270.00
Tungsten in ATP form, min. 88,5% WO ₃ ; USD/mtu (DERA)	299.29	271.37	219.49	279.15	330.08
Ferrotungsten, 75%, Evropa, USD/kg W (DERA)	37.25	30.99	28.90	35.85	40.99
Tungsten in powder form 2–10 µm, min. 99,7%, FOB, USD/kg (DERA)	42.47	35.28	30.70	37.94	44.53

Podle údajů společnosti Metalary (<http://www.metalary.com//tungsten.price/>) dosahovaly roční ceny wolframu těchto hodnot (USD/t):

Commodity/Year	2018	2019	2020	2021	2022
Tungsten metal	30,300	31,000	N	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

2022		
Country	kt	% World
Australia	66,000	26.4
China	31,000	14.8
Russia	22,000	10.5
Mexico	12,000	5.7
Peru	17,000	8.1
India	9,600	4.6
Kazakhstan	7,400	3.5
USA	7,300	3.5
Sweden	4,000	1.9
Canada	1,800	0.8
Others	34,000	16.2
World	210,000	100.0

Source: MCS 2023

2022			
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

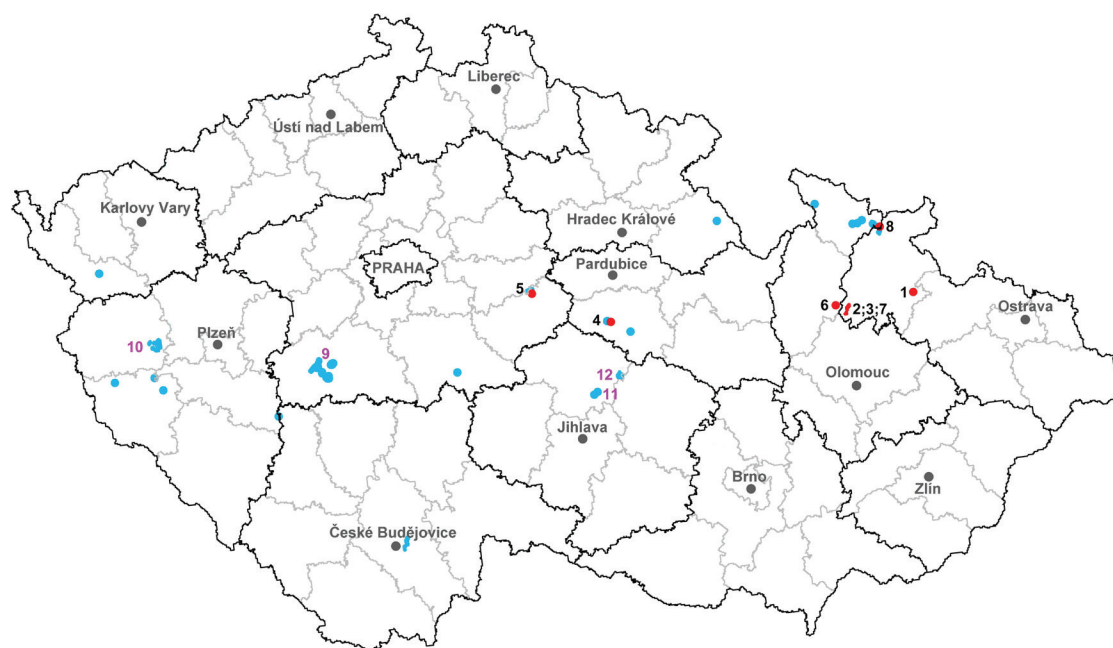
2. Mineral resources of the Czech Republic

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



■ 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 Stříbro

11 Havlíčkův Brod (Dlouhá Ves + Bartoušov + Stříbrné Hory)

12 Staré Ransko

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

Number of deposits; reserves; mine production

Year	2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	t	11	11	17	12	10
Export	t	43	1	0	0	0

2608 – Zinc ores and concentrates

		2018	2019	2020	2021	2022
Average import prices	CZK/t	82,571	82,818	58,567	84,416	82,115
Average export prices	CZK/t	3,256	58,000	–	–	–

7901 – Unwrought zinc

		2018	2019	2020	2021	2022
Import	t	33,214	33,964	33,369	37,187	34,190
Export	t	3,582	1 498	1,299	925	1,122

7901 – Unwrought zinc

		2018	2019	2020	2021	2022
Average import prices	CZK/t	69,354	63,741	55,858	67,835	88,173
Average export prices	CZK/t	65,241	57,327	51,425	55,666	81,842

7902 – Zinc waste and scrap

		2018	2019	2020	2021	2022
Import	t	966	350	467	693	1,181
Export	t	3,446	3,168	2,767	3,260	2,646

7902 – Zinc waste and scrap

		2018	2019	2020	2021	2022
Average import prices	CZK/t	39,781	44,356	67,835	67,835	22,434
Average export prices	CZK/t	41,469	35,575	43,695	43,695	50,812

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

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:

	2018	2019	2020	2021	2022 ^e
Mine production of zinc, kt (according to ILZSG)	12,745	12,799	12,223	12,775	12,427
Mine production of zinc, kt (according to MCS)	12,500	12,700	12,000	12,700	13,000
Mine production of zinc, kt (according to WBD)	12,257	13,082	12,668	12,929	N

e – preliminary values

Main producers according to MCS

Country	2022 ^e	
	kt	%
China	4,200	32.3
Peru	1,400	10.8
Australia	1,300	10.0
India	830	6.4
USA	770	5.9
Mexico	740	5.8
Bolivia	520	4.8
Canada	250	1.9
Russia	240	1.8
Kazakhstan	200	1.5
Others	2,000	15.4
World	13,000	100.0

e – preliminary values

Prices of traded commodities

According to DERA, World Bank (WB), and Metal Bulletin (MB), world zinc prices in USD/t developed as follows:

Commodity/year	2018	2019	2020	2021	2022
Special high grade, min. 99.995% cash, LME, in warehouse (according to DERA)	2,924.55	2,548.34	2,263.90	3,003.92	3,481.67
High quality min. 99.95%, LME contractual price (according to WB)	2,922.00	2,550.00	2,266.00	3,003.00	3,481.00
Zinc, annual average, American market, US\$/lb (according to MCS)	141.00	124.10	110.80	145.80	190.00

**) Engineering & Mining Journal: 12 monthly quotations 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 $\text{Cu}(\text{Ag}, \text{Fe}, \text{Zn})_3\text{Sb}(\text{As}, \text{Bi})\text{S}_{3.25}$ (very approximately 29% Sb)

Industrially important deposit types

1. Stratiform sedimentary exhalative deposits (“sedex”): Gravelotte, United Jack (South Africa), Xikouangshan (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

2022		
Country	t	% World
China	480,000	25.3
Russia	350,000	18.4
Bolivia	310,000	16.3
Kyrgyzstan	260,000	13.7
Australia	100,000	7.4
Turkey	100,000	5.3
Canada	78,000	4.1
USA	60,000	3.2
Tajikistan	50,000	2.6
Pakistan	26,000	1.4
Mexico	18,000	0.9
World	1,900,000	100.0

Source: MCS 2023

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 2021).

Uses

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

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

		2018	2019	2020	2021	2022
Import	kg	8,500	8,897	12,521	14,019	8,179
Export	kg	0	0	0	0	0

261710 – Antimony ores and concentrates

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	156	184	249	208	364
Average export prices	CZK/kg	–	–	–	–	–

8110 – Antimony and articles thereof, including waste and scrap

		2018	2019	2020	2021	2022
Import	t	102	103	101	49	52
Export	t	0	0,01	0,3	0,4	2

8110 – Antimony and articles thereof, including waste and scrap

		2018	2019	2020	2021	2022
Average import prices	CZK/t	220,720	201,281	184,581	159,638	264,878
Average export prices	CZK/t	–	333,333	128,280	1 302,500	455,392

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices**World mine production**

Trend in the world's primary antimony production in 2017–2021

	2018	2019	2020	2021	2022 ^e
Mine production of antimony, kt (according to MCS)	137	147	162	111	110
Mine production of antimony, kt (according to WBD)	149	145	134	128	N

e – preliminary values

Main producers according to MCS

Country	2022 ^e	
	t	%
China	60,000	54.5
Russia	25,000	22.7
Tajikistan	13,000	11.8
Australia	3,400	3.1
Bolivia	2,700	2.5
Burma	2,200	2.0
Turkey	1,300	1.2
other countries	2,400	2.2
World	110,000	100.0

e – preliminary values

Prices of traded commodities according to IM (USD/t) and MCS (USD/lb)

Commodity/year	2018	2019	2020	2021	2022
Antimony, purity 99.65%, CIF US ports (according to MCS), USD/lb	3.77	3.81	3.04	2.67	5.20

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 złóż 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

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

		2018	2019	2020	2021	2022
Import	kg	10,287	8,182	8,118	8,169	8,499
Export	kg	0	0	0	0	0

280480 – Arsenic

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	166	212	117	174	193
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World production and world market prices

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:

	2018	2019	2020	2021	2022 ^e
World production of arsenic, kt (according to MCS)	34.6	33.4	32.3	60.0	59.0
World production of arsenic, kt (according to WBD)	57.4	51.7	55.2	51.9	N

e – preliminary values

Main producers according to MCS

Country	2022 ^e	
	kt	%
China	24,000	46.2
Peru	19,014	36.6
Morocco	7,694	14.8
Belgium	1,000	1.9
Russia	100	0.2
Bolivia	50	0.1
World	51,898	100.0

e – preliminary values

Prices of traded commodities

According to the Mineral Commodity Summaries (MCS), prices ranged as follows:

Commodity/year	2018	2019	2020	2021	2022
Arsenic metal, China, USD/kg (MCS)	1.56	1.43	1.92	1.51	1.28

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) $(\text{Cu,Hg})_3\text{SbS}_{3-4}$ 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

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

		2018	2019	2020	2021	2022
Import	kg	2,215	5,426	6,751	20,225	704
Export	kg	140	8,651	4,211	89,069	59,792

280540 – Mercury

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	657	312	317	233	439
Average export prices	CZK/kg	1,414	593	1,159	1	2

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production

World mine production of mercury (t)

	2018	2019	2020	2021	2022 ^e
World mine production of mercury (according to MCS)	3,790	4,060	3,900	2,490	2,300
World mine production of mercury (according to WBD)	2,396	2,864	2,313	2,290	N

e – preliminary values

Main producers according to MCS

Country	2022 ^e	
	t	%
China	2,000	80.3
Tajikistan	170	6.8
Mexico	40	1.6
Argentina	30	1.2
Peru	20	0.8
Norway	15	0.6
Kyrgyzstan	11	0.4
World	2,490	100.0

e – preliminary values

Prices of traded commodities

Annual prices according to MCS yearbook

Commodity/Year		2018	2019	2020	2021	2022
Mercury, min. 99.99%, EU market, annual average (MCS)	USD/flask	1,041	1,100	N	N	N
Mercury, 99.99% in warehouse, avg. midpoint of free market global locations.	USD/flask	1,273	2,709	2,550	N	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 (260–1200) 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 złóż 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

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

		2018	2019	2020	2021	2022
Import	t	72,711	70,374	65,190	71,918	74,497
Export	t	1,843	5,738	8,193	5,954	9,262

2503 – Sulphur of all kinds, other than sublimed, precipitated and colloidal

		2018	2019	2020	2021	2022
Average import prices	CZK/t	2,707	2,835	2,735	2,650	3,082
Average export prices	CZK/t	2,960	2,054	2,535	2,707	3,182

2802 – Sulphur, sublimed or precipitated; colloidal sulphur

		2018	2019	2020	2021	2022
Import	t	29,508	35,976	40,745	43,006	45,596
Export	t	1	2	0.4	0.1	0.1

2802 – Sulphur, sublimed or precipitated; colloidal sulphur

		2018	2019	2020	2021	2022
Average import prices	CZK/t	1,825	1,737	1,843	1,802	1,950
Average export prices	CZK/t	162,441	157,191	217,742	291,667	400,000

2807 – Sulphuric acid

		2018	2019	2020	2021	2022
Import	t	45,711	34,655	55,506	28,307	49,283
Export	t	70,399	77,389	81,669	66,358	64,732

2807 – Sulphuric acid

		2018	2019	2020	2021	2022
Average import prices	CZK/t	1,587	3,034	2,246	2,509	2,286
Average export prices	CZK/t	1,506	1,364	1,562	1,755	2,175

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

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:

	2018	2019	2020	2021	2022 ^e
World sulphur production (according to MCS), kt	80,200	79,400	80,000	79,800	80,000
World sulphur production (according to WBD), kt	79,348	81,223	81,548	77,978	N

e – preliminary values

Main producers according to MCS

Country	2022 ^e	
	kt	%
China	17,000	21.3
USA	8,100	10.1
Russia	7,500	9.4
Saudi Arabia	6,500	8.1
United Arab Emirates	6,000	7.5
Canada	4,900	6.1
Kazakhstan	4,500	5.6
India	3,500	4.4
South Korea	3,100	3.9
Japan	3,000	3.8
Iran	2,200	2.8
other countries	13,700	17.1
World	80,000	100.0

e – preliminary values

Prices of sulphur according to Industrial Minerals (IM) and MCS in USD/t

Commodity/year		2018	2019	2020	2021	2022
Canadian, solid, spot price, FOB, Vancouver	AgM	140–155	140–155	40–130	40–80	90–140
Middle East, FOB	AgM	119–135	119–135	40–130	40–80	80–120
Reported US average price, FOB, mine and/or plant, elemental sulphur	MCS	46.40	81.16	51.08	24.40	90.00

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 $\text{LiAlSi}_2\text{O}_6$ (contains 5.8–7.6% Li_2O), lepidolite $\text{K}_2\text{Li}_4\text{Al}_2[(\text{F},\text{OH})_2\text{Si}_4\text{O}_{10}]_2$ (contains 3.2–4.4% Li_2O), petalite $\text{LiAlSi}_4\text{O}_{10}$ (contains 3.4–4.1% Li_2O)

Reserves

2022		
Country	tonnes 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. 2023 (national Register of Reserves as of 1. 1. 2023)*

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

2022			
Country	tonnes 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), Jadara (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

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 Rb₂O in some microclines), lepidolites (1–3.5% Rb₂O) and zinwaldites K(Li,Fe,Al)₃ (AlSi₃O₁₀) (OH,F)₂ (content = 1.5% Rb₂O)

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

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 $\text{Cs}(\text{AlSi}_2\text{O}_6)\cdot\text{H}_2\text{O}$ (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

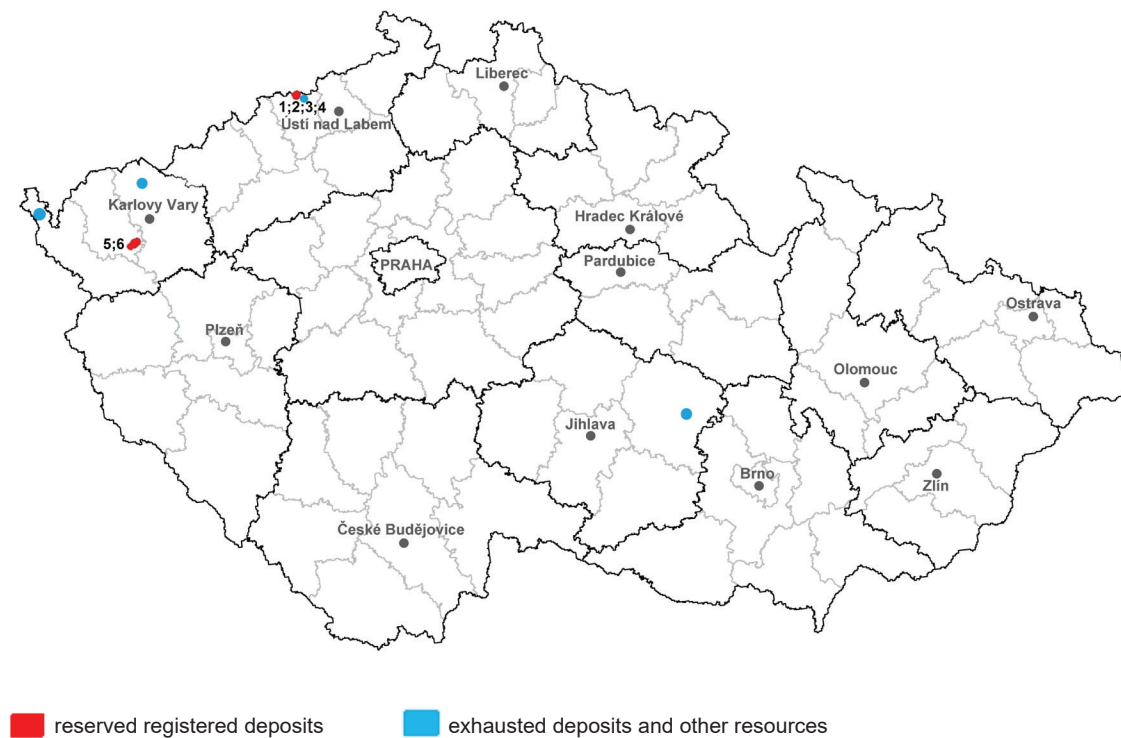
2011 – no, 2014 – no, 2017 – no, 2020 – no

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 Verněřov 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.
- Resources 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	2018	2019	2020	2021	2022
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 evolutionary 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 Čínovec and its surroundings alone. As for the potentially economic deposit of tin-tungsten ores of Čínovec-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 Čínovec-sever-lomová těžba (79 kt), Čínovec-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 m³ 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 P₁, P₂, P₃ Li in ore

Year	2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Import	kg	41,993	29,124	71,432	41,283	15,782
Export	kg	601	87	28	109	66

280519 – Lithium, potassium, rubidium, cesium

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	489	757	294	524	1,226
Average export prices	CZK/kg	241	184	179	8 303	76

28369100 – Lithium carbonates

		2018	2019	2020	2021	2022
Import	kg	65,937	76,403	46,981	101,644	74,747
Export	kg	7,495	3,402	2,886	5,537	8,779

28369100 – Lithium carbonates

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	358	313	191	265	250
Average export prices	CZK/kg	245	266	139	32	44

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

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	2018	2019	2020	2021	2022 ^e
World mine production of lithium (according to MCS), t	95,000	86,000	82,500	107,000	130,000
World mine production of Li ₂ O (according to WBD), t	198,930	192,065	186,955	232,530	N

e – preliminary value

Data on rubidium and cesium mining are not provided.

Main producers according to MCS

Country	2022 ^e	
	t	%
Australia	61,000	46.9
Chile	39,000	30.0
China	19,000	14.6
Argentina	6,200	4.8
Brazil	2,200	1.7
Zimbabwe	800	0.6
Portugal	600	0.5
World	130,000	100.0

e – preliminary values

The world's largest lithium miners / producers

1. Jiangxi Ganfeng Lithium
2. Mineral Resources
3. Pilbara Minerals
4. Albemarle Corporation
5. Sichuan Tianqi Lithium
6. Sociedad Química y Minera de Chile (SQM)
7. Allkem
8. Livent Corporation
9. Companhia Brasileira de Lítio
10. Bikita Minerals

Prices of traded commodities containing lithium according to IM

Commodity/year		2018	2019	2020	2021	2022 ^e
Lithium carbonate, battery quality, annual average (according to MCS)	USD/t	16,000	11,700	8,400	12,600	37,000

e – předběžné údaje

**Prices of sold commodities containing rubidium and cesium in the USA –
MCS data quotation**

In 2022, one company offered 1-gram ampoules of 99.75% (metal basis) rubidium for \$100.80, an 8% increase from \$93.40 in 2021, and 100-gram ampoules of the same material for \$1,818.60, a 9% increase from \$1,673.00 in 2021. The price for 10-gram ampoules of 99.8% (metal basis) rubidium formate hydrate was \$278.25.

In 2022, 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 2021.

In 2022, 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 2021, 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 2021.

The price for a cesium-plasma standard solution (10,000 micrograms per milliliter) in 2022 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 2021.

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% Mo), 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

2022		
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 2023

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

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 Foothills 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

		2018	2019	2020	2021	2022
Import	kg	1,880	11,451	548	2,065	736
Export	kg	3,633	13,785	10,171	9,563	10,885

81029400 – Unwrought molybdenum, including bars, rods obtained by simple sintering

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	513	854	449	836	1,272
Average export prices	CZK/kg	737	799	740	637	1,016

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

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 2018–2022:

	2018	2019	2020	2021	2022 ^e
World mine production of molybdenum (according to COCHILCO), kt	274	278	300	269	N
World mine production of molybdenum (according to MCS), kt	297	297	294	298	300
World mine production of molybdenum (according to WBD), kt	270	277	285	268	N

e – preliminary values;

COCHILCO – Comisión Chilena del Cobre

Main producers according to COCHILCO

Country	2022 ^e	
	t	%
China	95,300	35.5
Chile	49,400	18.4
USA	40,500	17.7
Peru	34,100	15.1
Mexico	18,900	7.0
Arménie	11,300	4.2
Russia	10,800	4.0
Canada	1,400	0.5
Mongolia	2,600	1.0
Iran	3,000	1.1
World	268,800	100.0

e – předběžné údaje

Main producers according to MCS

Country	2022 ^e	
	t	%
China	100,000	40.0
Chile	44,000	17.6
USA	42,000	16.8
Peru	32,000	12.8
Mexico	16,000	6.4
Armenia	7,800	3.1
Iran	3,500	1.4
Mongolia	2,300	0.9
Russia	1,700	0.7
Uzbekistan	1,600	0.6
Canada	970	0.4
Korea, Republic of	400	0.2
World	250,000	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	2018	2019	2020	2021	2022
Ferromolybdenum, 65-70% Mo base, free European market (USD/kg) (according to DERA)	29.00	26.55	21.30	37.02	45.17
Molybdenum, annual average (according to MCS) USD/kg	27.04	26.50	19.90	36.00	39.25
Molybdenum, LME cash (according to DERA), (USD/t)	24,000–30,350	40,100	38,000	49,200	58,300

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 rariae (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)PO₄ (65% of rare earth oxides), bastnäsite (Ce,La,Y)CO₃(F,OH) (75% of rare earth oxides), xenotime Y(HREE)PO₄ (61% of rare earth oxides), loparite (Ce,Th,Na,Ca)₂(Ti,Nb)₂O₆ (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 2022).

Reserves

2022		
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 2022

* 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

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

In the Czech Republic, there are descriptions of estimated resources (unapproved) of rare earth oxides 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 yttrium occur 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

		2018	2019	2020	2021	2022
Import	kg	54,386	49,911	30,306	34,186	43,506
Export	kg	6,167	3,570	3,027	3,427	19,313

28461000 – Cerium compounds

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	546	472	450	442	531
Average export prices	CZK/kg	595	551	568	580	158

28053010 – Compounds of lanthanum, praseodymium, neodymium or samarium, inorganic or organic

		2018	2019	2020	2021	2022
Import	kg	2,623	4,917	2,692	4,695	4,672
Export	kg	15	604	–	2	756

28053010 – Compounds of lanthanum, praseodymium, neodymium or samarium, inorganic or organic

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	1,740	1,466	1,53	2,300	2,801
Average export prices	CZK/kg	52,800	2,937	–	9,000	1,269

28053090 – Compounds of mixtures of rare-earth metals, yttrium or scandium, inorganic or organic

		2018	2019	2020	2021	2022
Import	kg	126,535	46,702	97	31,521	131
Export	kg	11	2,034	53	8	1,215

28053090 – Compounds of mixtures of rare-earth metals, yttrium or scandium, inorganic or organic

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	738	414	4,990	170	2,115
Average export prices	CZK/kg	25,818	159	6,849	26,750	191

28053010 – Rare earth metals, scandium and yttrium, intermixed or interalloyed

		2018	2019	2020	2021	2022
Import	kg	561	711	716	1,175	0
Export	kg	0	0	0	0	0

28053010 – Rare earth metals, scandium and yttrium, intermixed or interalloyed

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	282	215	159	178	–
Average export prices	CZK/kg	–	–	–	–	–

28053020 – Cerium, lanthanum, praseodymium, neodymium and samarium, of a purity by weight $\geq 95\%$ (excluding intermixed or interalloyed)

		2018	2019	2020	2021	2022
Import	kg	18	20	1,219	10	24
Export	kg	194	200	50	100	1,151

28053020 – Cerium, lanthanum, praseodymium, neodymium and samarium, of a purity by weight $\geq 95\%$ (excluding intermixed or interalloyed)

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	21,944	3,500	156	42,100	7,750
Average export prices	CZK/kg	835	315	320	250	78

28369100 – Lithium carbonates

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	0	0	0	0	0
Average export prices	CZK/kg	0	0	0	0	0

28369100 – Lithium carbonates

		2018	2019	2020	2021	2022
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, 2022

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:

	2018	2019	2020	2021	2022 ^e
World mine production, t (according to MCS)	190,000	220,000	240,000	290,000	300,000
World production of concentrates, t (according to WBD)	182,193	203,365	229,162	269,203	N

e – preliminary values

**Main producers of rare earths
according to WBD**

Country	2021	
	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	2022 ^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 Y₂O₃ 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		2018	2019	2020*	2021	2022
Rare earth oxidees, USD/kg	Ce 99,5% min.	2	2	2	2	2
	Dy 99,5% min.	179	239	261	400	390
	Eu 9,99% min.	53	35	31	31	30
	La 99,5% min.	2	2	2	2	1
	Nd 99,5% min.	50	45	49	49	130
	Eu 9,99% min.	455	507	670	1,300	2,000

Prices of traded commodities

According to DERA world prices (USD/kg) of commodities with rare earths developed as follows in recent years:

	2018	2019	2020	2021	2022
Cerium oxide. 99%. bulk. FOB China	2.00	1.90	1.70	1.49	1.40
Dysprosium (metal), min 99%, FOB China	261.97	30702	340.10	518.12	493.08
Dysprosium (oxide), min. 99%, FOB China	177.41	234.33	259.10	405.83	382.08
Erbium (oxide), min. 99%, FOB China	24.66	23.96	22.50	35.60	53.48
Europium (oxide), min. 99%, FOB China	51.32	34.61	29.80	31.86	29.76
Lanthanum (oxide) min. 99%, FOB China	0	1.88	1.60	1.47	1.35
Lanthanum (oxide), min- 99,999%, FOB China	3.53	3.41	3.30	3.89	5.88
Neodymium (metal), min. 99%, FOB China	63.72	57.52	61.50	120.80	164.50
Neodymium (oxide), min. 99%, FOB China	49.92	45.24	48.70	98.43	133.76
Praseodymium (metal), min. 99%, FOB China	114.48	102.64	91.30	112.23	174.33
Praseodymium (oxide), min. 99%, FOB Europe	67.21	53.41	43.50	79.24	116.23
Praseodymium (oxide), min. 99%, FOB China	63.63	54.32	45.70	92.27	128.24
Samarium (metal), min. 99%, FOB China	14.88	13.87	13.10	13.94	15.48
Samarium (oxide), min. 99%, FOB China	2.14	1.83	1.80	2.22	3.74
Scandium (oxide), min. 99,5 %, FOB China	7,025.44	7,025.24	6,386.10	5,755.00	5,472.79
Terbium (metal), min. 99%, FOB China	604.25	657.57	848.80	1,681.75	2,585.63
Terbium (oxide), min. 99,9%, FOB China	454.83	506.34	663.90	1,322.33	2,044.38
Yttrium (metal), min. 99%, FOB China	35.24	31.03	28.60	37.18	40.56
Yttrium (oxide), min. 99,999%, FOB China	3.21	2.99	2.90	6.33	11.86

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

2022		
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 2023

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

Tellurium**Average Te content (and its extent) in the earth's crust (ppm)**

0.002 Te

Industrially important mineralsHessite Ag_2Te , nagyágite $[\text{Pb}(\text{Pb},\text{Sb})]\text{S}_2$ [Te.Au], sylvanite AuAgTe_4 and tetradymite $\text{Bi}_2\text{Te}_2\text{S}$ **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

2022		
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 2022).

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

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

		2018	2019	2020	2021	2022
Import	kg	7,927	4,454	7,153	5,181	3,991
Export	kg	3	28	16	6	34

280490 – Selenium

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	810	537	449	399	500
Average export prices	CZK/kg	4,333	4,000	3,750	7,833	1,235

28045090 – Tellurium

		2018	2019	2020	2021	2022
Import	kg	89	153	9	4	23
Export	kg	0	0	0	0	0

28045090 – Tellurium

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	8,803	4,320	8,000	7,250	6,217
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

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):

	2018	2019	2020	2021	2022
World production of selenium according to MCS, t	2,810	2,880	3,120	3,100	3,200
World production of selenium according to WBD, t	3,056	3,533	3,279	3,710	N
World production of tellurium according to MCS, t	460	520	562	610	640
World production of tellurium according to WBD, t	649	529	459	734	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	2021	
	t	%
China	1,400	37.70
Japan	720	19.40
Germany	300	8.10
Russia	230	6.19
Belgium	200	5.39
Philippines	200	5.39
Mexico	135	3.63
Finland	100	2.69
USA	70	1.89
Poland	66	1.78
World	3,710	100.00

Main producers of selenium according to MCS

Country	2022 ^e	
	t	%
China	1,300	37.61
Japan	730	25.64
Russia	350	10.26
Germany	300	10.26
Belgium	200	6.84
Poland	75	3.42
Finland	65	2.22
Canada	65	2.05
Turkey	50	1.71
World	3,000	100.00

e – preliminary values

**Main producers of tellurium
according to WBD**

Country	2021	
	t	%
China	530	72.20
Japan	68	9.26
Russia	60	8.17
Sweden	41	5.59
Canada	25	3.41
Bulgaria	3	0.41
USA	2	0.27
World	734	100.00

**Main producers of tellurium
according to MCS**

Country	2022 ^e	
	t	%
China	340	53.13
Russia	80	12.50
Japan	70	10.93
Canada	50	7.81
Uzbekistan	50	7.81
Sweden	40	6.25
Bulgaria	4	0.63
World	640	100.00

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	2018	2019	2020	2021	2022
Selenium, powder, min. 99.5%,	37.89	21.42	15.70	22.87	23.55
Tellurium, min. 99.99%, Europe	40.42	63.52	61.50	78.16	71.12

Average prices of selenium and tellurium (USD/kg) in the USA (MCS) were as follows:

Commodity/year	2018	2019	2020	2021	2022 ^e
Selenium metal, powder, min. 99.5%, FOB warehouse U.S.	17.68	9.27	6.67	8.38	9.00
Tellurium, avg.ann.price, 99.95%, warehouse Rotterdam	73	60	56	67	66

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 $\text{NaCaNb}_2\text{O}_6\text{F}$ (0.2–39% Ta_2O_5), microlith $\text{NaCaTa}_2\text{O}_6\text{F}$ (max. 80% Ta_2O_5), wodginite $\text{MnSnTa}_2\text{O}_8$ (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

2022		
Country	t	% World
China	180 000	N
Australia	99 000	N
Brazil	40 000	N
World	N	N

Source: MCS 2022

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

Niobium

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

20 Nb

Industrially important minerals

Pyrochlore $\text{NaCaNb}_2\text{O}_6\text{F}$ (40–72% Nb_2O_5), columbite FeNb_2O_6 (40–77% Nb_2O_5) a loparite $\text{NaCe}(\text{Ti},\text{Nb})_2\text{O}_6$ (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

The EU does not have niobium reserves.

2022		
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 2023

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

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 13,670t 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

		2018	2019	2020	2021	2022
Import	kg	11,293	–	–	11,428	10
Export	kg	–	1,451	–	14,829	5,526

26159010 – Tantalum and niobium ores and concentrates

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	851	–	–	784	6,100
Average export prices	CZK/kg	–	1,147	–	1,158	960

810320 – Unwrought tantalum

		2018	2019	2020	2021	2022
Import	kg	128,135	110,953	40,531	13,390	94,923
Export	kg	22,702	19,018	28,400	80,597	60,500

810320 – Unwrought tantalum

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	6,429	5,445	5,497	7,254	7 934
Average export prices	CZK/kg	9,681	8,849	11,425	9,124	10,371

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production

World production of tantalum and niobium in 2018–2022:

	2018	2019	2020	2021	2022 ^e
World production of tantalum (according to MCS) t	1,890	1,850	2,100	1,840	2,000
World production of niobium (according to MCS) t	68,200	97,000	67,700	87,600	79,000

e – preliminary values

	2018	2019	2020	2021	2022
World production of tantalum (according to WBD), t Ta ₂ O ₅	2,301	2,037	1,645	1,706	1,706
World production of niobium (according to WBD), t Nb ₂ O ₅	91,980	109,023	134,960	93,509	121,902

Main producers of Ta according to WBD

Country	2021	
	t	%
Congo (Kinshasa)	505	28.7
Brazil	350	19.9
Rwanda	245	13.9
China	180	10.2
Nigeria	160	9.1
Mozambique	75	4.3
Australia	70	4.0
Ethiopia	64	36.0
Russia	39	2.2
Malaysia	1	0.1
World	1,760	100.0

Main producers of Ta according to MCS

Country	2022 ^e	
	t	%
Congo (Kinshasa)	700	33.3
Brazil	470	22.4
Rwanda	270	12.9
Nigeria	260	12.4
China	76	3.6
Australia	62	3.0
Mozambique	52	2.5
Ethiopia	43	2.0
World	2,100	100.0

e – preliminary values

Main producers of Nb according to WBD Main producers of Nb according to MCS

Country	2021	
	t	%
Brazil	85,572	70.2
Canada	6,400	5.3
Russia	617	0.7
Congo (Kinshasa)	565	0.5
Rwanda	160	0.1
Nigeria	80	0.1
China	30	0.0
Mozambique	17	0.0
Ethiopia	11	0.0
World	121,902	100.0

Country	2022 ^e	
	t	%
Brazil	66,000	88.0
Canada	7,400	9.9
World	75,000	100.0

*e –preliminary values***Prices of traded commodities**

Commodity/year	2018	2019	2020	2021	2022
Niobium metal (USD/kg)*	193	214	158	158	150
Tantalum metal (USD/t)*	N	203.03	139.55	131.90	197.02
Tantalite, dollars per kilogram of Ta ₂ O ₅ content (MCS)	193	214	158	158	150
Ta conc. 30 % Ta ₂ O ₅ , CIF China, USD/kg (according to DERA)	N	203.03	139.55	131.90	197.02
Ta pentoxide, min. 99,5 %, FOB China, USD/kg (according to DERA)	N	271.53	194.34	184.90	276.67
Nb conc. min. 50 % Nb ₂ O ₅ , min. 5 % Nb ₂ O ₅ , CIF China, USD/kg (according to DERA)	N	35.41	22.93	20.90	36.86
Nb pentoxide, 99,5 %, FOB China USD/kg (according to DERA)	N	42.46	33.34	29.40	40.81
Feroniobium, imports and exports to the USA, USD/kg (according to MCS)	21	22	20	20	24

* 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

2022		
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 2023

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 $\text{Zr}/\text{ZrO}_2 = 91/123$ 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

Hf: 2011 – no, 2014 – no, 2017 – yes, 2020 – 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

		2018	2019	2020	2021	2022
Import	kg	596,784	566,118	0	0	1,313,954
Export	kg	6,170	4,265	0	0	53,608

26151000 – Zirconium ores and concentrates

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	43	49	–	–	95
Average export prices	CZK/kg	40	46	–	–	83

81129210 – Unwrought hafnium, hafnium waste and scrap, hafnium powders

		2018	2019	2020	2021	2022
Import	kg	1	1	18	17	0
Export	kg	0	0	0	0	0

81129210 – Unwrought hafnium, hafnium waste and scrap, hafnium powders

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	12,000	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, 2022

There are none.

8. World production and world market prices**World mine production**

Statistical data on zirconium production

	2018	2019	2020	2021	2022 ^e
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	2022 ^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	2018	2019	2020	2021	2022
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 with $\text{Al}_2\text{O}_3 \cdot \text{SiO}_2$ 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, $3\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$ 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

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

		2018	2019	2020	2021	2022
Import	t	5,667	5,326	7,406	8,504	5,739
Export	t	425	12	10	8	11

250850 – Andalusite, kyanite and sillimanite

		2018	2019	2020	2021	2022
Average import prices	CZK/t	10,705	12,063	12,557	12,099	14,437
Average export prices	CZK/t	11,717	29,625	31,753	30,663	34,191

250860 – Mullite

		2018	2019	2020	2021	2022
Import	t	1,764	2,031	1,014	2,587	2,223
Export	t	15	0,5	2	29	17

250860 – Mullite

		2018	2019	2020	2021	2022
Average import prices	CZK/t	15,496	11,348	14,567	14,311	14,710
Average export prices	CZK/t	18,743	109,453	27,742	23,669	38,142

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production of kyanite and related minerals

Commodity/year	2018	2019	2020	2021	2022
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*	2022 ^e	
	t	%
South Africa (andalusite)	160,000	N
USA (kyanite)	100,000	N
India (kyanite and sillimanite)	15,000	N
Peru (andalusite)	42,000	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	2018	2019	2020	2021	2022
Kyanite, average value exports, FAS, USD/t (MCS)	347	358	369	369	400
Andalusite, 57–58% Al ₂ O ₃ , FCA Mine, South Africa, 2,000 tonne bulk, EUR/t (IM)*	N	N	N	N	N
Andalusite, 55–59% Al ₂ O ₃ , FOB European port, EUR/t (IM)*	N	N	N	N	N
Andalusite, min 57% Al ₂ O ₃ , FOB South Africa, EUR/t (IM)*	260–320	270–340	260–340	N	N
Andalusite, min 57% Al ₂ O ₃ , CIF Europe, EUR/t (IM)*	390–430	320–450	320–440	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 $\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4$), less often amosite (amosite – mineralogically anthophyllite, grunerite or cummingtonite – $(\text{Fe} > \text{Mg})_7\text{Si}_8\text{O}_{22}(\text{OH})_2$ (grunerite formula) or by crocydolite $\text{Na}_2(\text{Fe}^{2+}, \text{Mg})_3\text{Fe}_2^{3+}\text{Si}_8\text{O}_{22}(\text{OH})_2$. Brittle fibres tend to have an anthophyllite composition $(\text{Mg}, \text{Fe}^{2+})_7(\text{Si}_6\text{O}_{22})(\text{OH}, \text{F})_2$. Less important are the amphibole asbestoses formed by tremolite $\text{Ca}_2\text{Mg}_5(\text{Si}_8\text{O}_{22}(\text{OH}, \text{F})_2$ or actinolite $\text{Ca}_2(\text{Mg}, \text{Fe}^{2+})_5(\text{Si}_8\text{O}_{22}(\text{OH}, \text{F})_2$.

Asbestos deposits are formed by hydrothermal processes associated with metamorphism 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

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

		2018	2019	2020	2021	2022
Import	t	0.68	–	–	–	–
Export	t	0	–	–	–	–

2524 – Asbestos

		2018	2019	2020	2021	2022
Average import prices	CZK/t	123,529	–	–	–	–
Average export prices	CZK/t	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production of asbestos

Commodity/year	2018	2019	2020	2021	2022 ^e
World mine production of asbestos (according to MCS), kt	1,150	1,170	1,100	1,240	1,300
World mine production of asbestos (according to WBD), kt	1,237	1,138	1,132	1,292	N

e – estimate

Main producers of asbestos according to MCS

Country*	2022 ^e	
	kt	%
Russia	700,000	53.8
Kazakhstan	230,000	17.7
Brazil	190,000	14.6
China	130,000	10.0
World total (rounded)	1,300,000	100.0

*e – estimate***Prices of traded commodities**

Commodity/year	2018	2019	2020	2021	2022 ^e
Asbestos, price average U.S. customs value on import, USD/t (MCS)	1,670	1,570	2,110	1,880	1,900

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 $\text{NaCa}(\text{B}_5\text{O}_6(\text{OH})_6) \cdot 5\text{H}_2\text{O}$ (43 % B_2O_3), borax (tinkal) $\text{Na}_2(\text{B}_4\text{O}_5(\text{OH})_4) \cdot 8\text{H}_2\text{O}$ (36 % B_2O_3), kernite $\text{Na}_2(\text{B}_4\text{O}_6(\text{OH})_2) \cdot 3\text{H}_2\text{O}$ (51 % B_2O_3), colemanite $\text{Ca}(\text{B}_3\text{O}_4(\text{OH})_3) \cdot \text{H}_2\text{O}$ (51 % B_2O_3), datolite $\text{CaB}(\text{SiO}_4)(\text{OH})$ (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) H_3BO_3 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:

2022		
Country	kt	% World
Turkey – purified borates	1,200,000	N
USA – especially borax, kernite a borates	40,000	N
Russia – datolite	40,000	N
Chile – ulexite	35,000	N
China – equivalent of B_2O_3	24,000	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

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

		2018	2019	2020	2021	2022
Import	t	18,072	17,045	19,202	20,520	19,961
Export	t	<1	0	0.005	0.01	1

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

		2018	2019	2020	2021	2022
Average import prices	CZK/t	9,101	9,558	9,317	9,037	10,011
Average export prices	CZK/t	26,667	–	57,692	13,333	264,167

28045010 – Boron

		2018	2019	2020	2021	2022
Import	t	68	34	50	20	70
Export	t	19	34	21	15	7

28045010 – Boron

		2018	2019	2020	2021	2022
Average import prices	CZK/t	76,060	126,064	98,364	222,100	91,471
Average export prices	CZK/t	36,774	29,851	37,424	41,618	93,380

28100090 – Oxides of boron; boric acids (except boric oxide)

		2018	2019	2020	2021	2022
Import	t	3,020	2,161	2,341	3,159	1,753
Export	t	14	2	17	13	52

28100090 – Oxides of boron; boric acids (except boric oxide)

		2018	2019	2020	2021	2022
Average import prices	CZK/t	15,793	17,076	16,382	16,066	22,104
Average export prices	CZK/t	186,669	66,520	140,680	123,267	41,353

28401910 – Disodium tetraborate pentahydrate

		2018	2019	2020	2021	2022
Import	t	13,373	11,208	9,325	13,288	14,558
Export	t	<1	<1	–	–	0.003

28401910 – Disodium tetraborate pentahydrate

		2018	2019	2020	2021	2022
Average import prices	CZK/t	9,854	9,919	10,171	9,851	11,844
Average export prices	CZK/t	6,667	–	–	–	–

28401990 – Disodium tetraborate (excluding anhydrous and disodium tetraborate pentahydrate)

		2018	2019	2020	2021	2022
Import	t	572	1,875	4,528	2,861	182
Export	t	13	21	20	12	19

28401990 – Disodium tetraborate (excluding anhydrous and disodium tetraborate pentahydrate)

		2018	2019	2020	2021	2022
Average import prices	CZK/t	12,407	10,127	10,107	10,152	20,763
Average export prices	CZK/t	61,983	18,087	34,983	58,663	54,546

28402090 – Borates (excluding sodium borates, anhydrous and disodium tetraborate)

		2018	2019	2020	2021	2022
Import	t	348	250	155	164	200
Export	t	141	115	41	3	284

28402090 – Borates (excluding sodium borates, anhydrous and disodium tetraborate)

		2018	2019	2020	2021	2022
Average import prices	CZK/t	40,232	52,030	75,123	57,483	66,973
Average export prices	CZK/t	57,216	58,852	58,249	97,767	34,536

28403000 – Peroxoborates (perborates)

		2018	2019	2020	2021	2022
Import	t	16	24	5	10	8
Export	t	5	4	4	3	0.5

28403000 – Peroxoborates (perborates)

		2018	2019	2020	2021	2022
Average import prices	CZK/t	19,085	17,366	16,419	15,488	18,375
Average export prices	CZK/t	15,943	18,042	16,483	17,982	82,000

28499010 – Carbides of boron, whether or not chemically defined

		2018	2019	2020	2021	2022
Import	t	45	14	25	18	36
Export	t	3	2	0.02	0.001	0.165

28499010 – Carbides of boron, whether or not chemically defined

		2018	2019	2020	2021	2022
Average import prices	CZK/t	338,102	438,136	373,936	386,696	457,072
Average export prices	CZK/t	306,280	323,920	416,149	4,000,000	557,575

6. Prices of domestic market

They are not.

7. Mining companies in the Czech Republic as of December 31, 2022

They are not.

8. World production and world market prices**World mine production of boron**

	2018	2019	2020	2021	2022 ^e
World mine production of boron (B ₂ O ₃ content) (according to WBD), kt	4,492	4,293	3,601	4,920	N

e – estimate

Main producers of boron according to MCS

Country	2022 ^e	
	kt	%
Turkey (refined borates)	1,700	N
China (boric acid equiv.)	300	N
Chile (ulexite)	300	N
Bolivia (ulexite)	250	N
Germany (compounds)	200	N
Russia (datolite ore)	130	N
Argentina (crude ore)	80	N
Peru (crude borates)	60	N
World *	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).

Hlavní producenti boru dle WBD

Country	2022	
	kt	%
Turkey	2,540	51.6
United States	900	18.3
Chile	363	7.4
Bolivia	310	6.3
China	250	5.1
Peru	246	5.0
Argentina	135	2.7
Kazakhstan	30	0.6
Iran	2	0.0
World	4,920	100.0

Prices of traded commodities

Commodity/year	2018	2019	2020	2021	2022 ^e
Boron, cost, insurance and freight, avg. value of imports to U.S., USD/t (MCS)	404	373	380	394	430

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

2022		
Country	kt MgO	% World
Russia	2,300,000	33.8
China	580,000	8.5
Slovakia	370,000	5.4
Australia	290,000	4.3
Greece	280,000	4.1
Turkey	110,000	1.6
Brazil	200,000	2.9
India	82,000	1.2
Austria	49,000	0.7
Spain	35,000	0.5
USA	35,000	0.5
World	6,800,000	100.0

2022			
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 złoż kopalin w Polsce 2022

Source: MCS 2023

Source: MCS 2023

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

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)

		2018	2019	2020	2021	2022
Import	t	4,326	4,379	4,519	4,478	3,434
Export	t	3	4	1	4	0.8

251910 – Natural magnesium carbonate (magnesite)

		2018	2019	2020	2021	2022
Average import prices	CZK/t	1,996	2,604	2,386	2,482	2,959
Average export prices	CZK/t	51,387	94,529	444,166	69,815	221,420

251990 – Magnesia*, fused, dead-burned, other magnesium oxides

		2018	2019	2020	2021	2022
Import	t	66,676	59,814	57,375	54,600	54,920
Export	t	10,056	9,755	10,621	7,918	8,541

* MgO

251990 – Magnesia*, fused, dead-burned, other magnesium oxides

		2018	2019	2020	2021	2022
Average import prices	CZK/t	7,609	8,595	8,755	8,353	11,248
Average export prices	CZK/t	10,839	11,237	11,909	11,687	17,558

* MgO

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices**World mine production of magnesite**

Commodity/year	2018	2019	2020	2021	2022 ^e
World mine production of magnesite (according to MCS), kt	27,100	27,100	27,000	29,000	27,000
World mine production of magnesite (according to WBD), kt	28,945	27,339	27,255	28,013	N

*e – estimate***Main producers of magnesite according to MCS****Primary production**

Country	2022 ^e	
	kt	%
China	17,000	65.0
Slovenia	2,600	9.6
Turkey	1,800	6.9
Brazil	1,500	5.6
Russia	950	3.5
Australia	800	2.9
Spain	620	2.3
Greece	480	1.8
Other countries	400	1.5
World total (rounded)	27,000	100.0

e – estimate

Prices of traded commodities

Commodity/year	2018	2019	2020	2021	2022 ^e
Magnesite, Greece, rax, <3,5% SiO ₂ , FOB eastern Mediterranean, USD/t (IM)*	70–80	70–80	70-80	N	N
Magnesite, calcinated, agricultural, CIF Europe, EUR/t (DERA)**	N	N	266.7	277.12	387.50
Magnesite, dead burned, 97,5% MgO, lump, FOB China, USD/t (DERA)**	N	N	404.6	458.96	526.88
Magnesite, fused, 98% MgO, lump, FOB China, USD/t (DERA)**	N	N	695.4	759.9	893.85
Magnesite, rax, max. 3,5% SiO ₂ , Greece, FOB, eastern Mediterranean, EUR/t (DERA)**	N	N	75.0	82.08	130.29

e – estimate

** The price range includes the lowest and highest monthly price quotes in a given year.*

*** Average annual price.*

Perlite

1. Characteristics and use

Perlite is a natural volcanic glass (hyaloclastite) with a spherical texture, consisting of 65–78% SiO₂, 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 2021. Mineral resources of the Slovak Republic 2017.

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/m³. 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

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

		2018	2019	2020	2021	2022
Import	t	–	–	–	–	–
Export	t	–	–	–	–	–

25301010 – Perlite

		2018	2019	2020	2021	2022
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, 2022

There are none.

8. World production and world market prices

World mine production of perlite

Commodity/year	2018	2019	2020	2021	2022 ^e
World mine production of perlite (according to MCS), kt	4,020	3,460	4,220	4,150	4,300
World mine production of perlite (according to WBD), kt	2,713	2,823	3,129	3,702	N

e – estimate

Main producers of perlite according to MCS

Country	2022 ^e	
	kt	%
China	1,500	34.9
Turkey	1,100	25.6
Greece	710	16.5
United States*	520	12.1
Hungary	180	4.2
Iran	80	1.9
Armenia	40	0.9
Slovakia	30	0.7
New Zealand	20	0.5
Mexico	20	0.5
Argentina	20	0.5
Other countries	40	0.9
World total (rounded)	4,300	100.0

*e – estimate*** Estimated production of crude ore***Prices of traded commodities**

Commodity/year	2018	2019	2020	2021	2022 ^e
Perlite, average value, FOB mine in U.S., USD/t (MCS)	69	64	61	64	66

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

2022		
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 2023*

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

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

		2018	2019	2020	2021	2022
Import	t	564,468	674,275	399,323	698,482	678,219
Export	t	33,051	39,301	19,020	24,773	28,733

2501 – Salt (inclusive table and denaturated salt), and pure sodium chloride; also in water solution

		2018	2019	2020	2021	2022
Average import prices	CZK/t	1,839	1,756	2,221	1,907	2,294
Average export prices	CZK/t	6,150	5,752	12,550	9,146	10,866

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production of salt

Commodity/year	2018	2019	2020	2021	2022 ^e
World mine production of salt (according to MCS), kt	286,000	283,000	280,000	290,000	290,000
World mine production of salt (according to WBD), kt	290,534	292,279	267,753	273,766	N

e – estimate

Main producers of salt as estimated by MCS

Country	2022 ^e	
	kt	%
China	64,000	22.1
United States*	42,000	14.5
India	45,000	15.5
Germany	15,000	5.2
Australia	13,000	4.5
Canada	11,000	3.8
Chile	9,000	2.9
Mexico	9,000	2.9
Brazil	7,400	2.6
Turkey	6,900	2.4
Netherlands	6,200	2.1
Russia	6,000	2.1
France	5,500	1.9
Spain	4,200	1.5
Poland	4,000	1.4
Pakistan	3,300	1.4
United Kingdom	2,800	1.0
Iran	2,700	0.9
Saudi Arabia	2,400	1.1
Italy	2,000	0.7
Ukraine	1,000	0.3
Other countries	32,000	11.0
World (rounded)	290,000	100.0

*e – estimate*** Excluding Puerto Rico***Prices of traded commodities**

Commodity/year	2018	2019	2020	2021	2022 ^e
Vacuum and open pan salt, USD/t (MCS)*	214	212	215	220	230
Solar salt, USD/t (MCS)*	114	126	120	125	130
Rock salt, USD/t (MCS)*	61	60	58	57	60
Salt in brine, USD/t (MCS)*	8.30	7.56	8.0	8.0	8.5

*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 – $\text{Mg}_3\text{Si}_4\text{O}_{10}(\text{OH})_2$ 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 metamorphism. 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

2022		
Country	kt	% World
USA	140,000	26.3
India*	110,000	20.7
Japan*	100,000	18.8
China	81,000	15.2
South Korea*	56,000	10.5
Brazil	45,000	8.5
World	> 532,000	100.0

Source: MCS 2023

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

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

		2018	2019	2020	2021	2022
Import	t	19,611	20,692	24,743	17,733	18,953
Export	t	428	385	294	594	341

2526 – Natural steatite; talc

		2018	2019	2020	2021	2022
Average import prices	CZK/t	8,074	7,681	5,951	8,032	9,613
Average export prices	CZK/t	23,674	17,638	18,934	10,026	19,114

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production of talc and pyrophyllite

Commodity/year	2018	2019	2020	2021	2022 ^e
World mine production of talc and pyrophyllite (according to MCS), kt	6,600	6,140	6,720	7,240	7,300
World mine production of talc and pyrophyllite (according to WBD), kt	8,327	7,797	6,856	7,695	N

e – estimate

Main producers of talc and pyrophyllite according to MCS

Country	2022 ^e	
	kt	%
India (incl. pyrophyllite)	1,750	24.0
China	1,100	15.1
Brazil (incl. pyrophyllite)	660	9.0
USA (crude)	580	7.9
France (crude)	350	4.8
Korea. Republic of (incl. pyrophyllite)	300	4.1
Pakistan	300	4.1
Finland	230	1.7
Turkey(incl. pyrophyllite)	220	3.0
Italy (incl. steatite)	165	2.4
Japan (incl. pyrophyllite)	160	2.3
Other countries	150	3.4
World (rounded)	7,300	100.0

*e – estimate***Prices of traded commodities**

Commodity/year	2018	2019	2020	2021	2022 ^e
Talc, average price, milled, ex-works, sold by U.S. producers, USD/t (MCS)	227	240	265	321	320

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 $KMgCl_3 \cdot 6H_2O$, polyhalite $K_2Ca_2Mg(SO_4)_4 \cdot H_2O$ and epsomite $Mg(SO_4) \cdot 7H_2O$, 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

Potassium raw material: 2011 – no, 2014 – no, 2017 – no, 2020 – no

Phosphates: 2011 – no, 2014 – yes, 2017 – yes, 2020 – yes

Reserves**Phosphates**

Country	2022	
	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 2023

EU phosphate reserves are not published. They occur in Spain and especially in Finland (European Minerals Yearbook – version 2022).

Potassium raw material

2022			2021			
Country	kt K ₂ O	% World	Country	kt K ₂ O	% World	% EU
Canada	1,100,000	33.3	EU	341,000	9.2%	100.0%
Belorussia	750,000	22.7	Germany	150,000	4.1%	44.0%
Russia	400,000	12.0	Poland*	73,000	2.0%	21.4%
USA	220,000	6.7	Spain	68,000	1.8%	19.9%
China	170,000	5.2	Italy**	50,000	1.4%	14.7%
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. *European Minerals Yearbook – version 2021*

* Bilans zasobów złoż kopalni w Polsce 2022

** own recalculation to K₂O

Source: MCS 2023

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

		2018	2019	2020	2021	2022
Import	t	872,766	527,060	872,714	797,617	797,665
Export	t	576,463	590,675	575,630	641,906	490,751

3102 – Nitrogenous fertilizers

		2018	2019	2020	2021	2022
Average import prices	CZK/t	4,914	4,772	4,936	7,805	17,311
Average export prices	CZK/t	4,434	4,913	4,462	5,781	14,083

2510 – Natural phosphates

		2018	2019	2020	2021	2022
Import	t	7	228	131	103	716
Export	t	13	13	49	1	0

2510 – Natural phosphates

		2018	2019	2020	2021	2022
Average import prices	CZK/t	326,742	18,833	23,836	39,929	7,292
Average export prices	CZK/t	2,723	3,517	3,185	178,612	1

2809 – Phosphoric oxides and acids

		2018	2019	2020	2021	2022
Import	t	6,200	6,129	6,219	6,321	4,511
Export	t	50,748	45,761	40,950	51,475	9,039

2809 – Phosphoric oxides and acids

		2018	2019	2020	2021	2022
Average import prices	CZK/t	9,066	9,719	7,741	9,712	4,766
Average export prices	CZK/t	19,042	19,578	18,630	19,873	75,845

3103 – Phosphatic fertilizers

		2018	2019	2020	2021	2022
Import	t	18,620	17,309	19,145	19,394	25,285
Export	t	154	87	859	337	52

3103 – Phosphatic fertilizers

		2018	2019	2020	2021	2022
Average import prices	CZK/t	7,598	7,855	7,110	8,505	18,076
Average export prices	CZK/t	18,609	30,091	8,200	15,682	29,212

3104 – Potassic fertilizers

		2018	2019	2020	2021	2022
Import	t	104,768	103,511	104,867	113,576	92,466
Export	t	7,342	4,589	4,682	5,679	6,408

3104 – Potassic fertilizers

		2018	2019	2020	2021	2022
Average import prices	CZK/t	7,583	8,165	7,916	7,989	12,246
Average export prices	CZK/t	20,920	29,465	34,393	28,223	41,280

3105 – Fertilizers containing several elements

		2018	2019	2020	2021	2022
Import	t	185,651	195,723	174,812	156,780	157,628
Export	t	18,885	28,403	28,834	47,015	55,107

3105 – Fertilizers containing several elements

		2018	2019	2020	2021	2022
Average import prices	CZK/t	9,224	9,584	9,290	11,646	20,093
Average export prices	CZK/t	11,670	7,944	10,914	8,131	9,815

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production of phosphate rock and potash

Commodity/year	2018	2019	2020	2021	2022 ^e
World mine production of phosphate rock (according to MCS), kt	249,000	227,000	219,000	226,000	220,000
World mine production of phosphates (according to WBD), kt P ₂ O ₅ content	71,496	71,500	69,697	75,370	N
World mine production of potash, K ₂ O equivalent (according to MCS), kt	43,300	41,300	44,000	46,300	40,000
World mine production of potash (according to WBD), kt K ₂ O content	43,443	42,215	44,739	45,154	N

e – estimate

Prices of traded commodities

Commodity/year	2018	2019	2020	2021	2022 ^e
Marketable phosphate rock, avg. weighted value, FOB mine U.S., USD/t (MCS)	70.80	68.00	75.90	83.10	90.00
Phosphate rock, FOB North Africa, USD/t (DERA)	88	89	76	123.07	265.93
Potash, average all products, FOB mine USD/t K ₂ O, (MCS)*	750	820	850	1,120	1,700
Potash, average muriate, FOB mine and mill, USD/t K ₂ O, (MCS)	440	480	450	650	1,000

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 – K₂SO₄) and SOPM (sulfate of potash magnesium – K₂Mg₂(SO₄)₃, K₂Mg₂(SO₄)₂·2.4H₂O). Does not include other chemical compounds that contain potassium.

Main phosphate rock producers according to MCS

Country	2022 ^e	
	kt	%
China (large mines only)	85,000	38.6
Morocco	40,000	18.2
USA	21,000	9.5
Russia	13,000	5.9
Jordan	10,000	4.5
Saudi Arabia	9,000	4.1
Brazil	5,500	2.3
Egypt	5,000	2.3
Vietnam	4,500	2.0
Peru	4,200	2.2
Tunisia	4,000	1.8
Israel	3,000	1.4
Senegal	2,600	1.2
Australia	2,500	1.1
South Africa	1,600	0.7
Kazakhstan	1,500	0.7
India	1,400	0.6
Algeria	1,800	0.8
Togo	1,500	0.7
Finland	1,000	0.5
Uzbekistan	900	0.4
Turkey	800	0.4
Mexico	450	0.2
Other countries	1,000	0.5
World (rounded)	220,000	100.0

e – estimate

Main potash producers according to MCS

Country	2022 ^e	
	kt	%
Canada	16,000	40,0
China	6,000	15,0
Russia	5,000	12,5
Belorussia	3,000	7,5
Germany	2,800	7,0
Israel	2,500	6,3
Jordan	1,700	4,3
Chile	850	2,1
Laos	600	1,5
Spain	450	1,1
USA (rounded)	440	1,1
Brazil	270	0,7
Other countries	350	0,9
World (rounded)	40,000	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 $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ (65% Al_2O_3), boehmite $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$ (85% Al_2O_3) and diasporite $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$ (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

2022		
Country	kt	% World
Guinea	7,400,000	23.9
Vietnam	5,800,000	18.7
Australia	5,100,000	16.5
Brazil	2,700,000	8.7
Indonesia	1,000,000	3.2
China	710,000	2.3
India	660,000	2.1
Russia	500,000	1.6
Saudi Arabia	180,000	0.6
Kazakhstan	160,000	0.5
USA	20,000	0.1
World	31,000,000	100.0

2022			
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.

Source: MCS 2023

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 $\text{Al}(\text{OH})_3$ 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

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

		2018	2019	2020	2021	2022
Import	t	42,640	20,975	14,658	12,826	11,658
Export	t	103	0,3	16	45	388

2606 – Aluminium ores and concentrates

		2018	2019	2020	2021	2022
Average import prices	CZK/t	3,518	4,834	5,153	6,710	7,143
Average export prices	CZK/t	14,821	746,032	72,019	13,996	11,732

281820 – Aluminium oxide (other than synthetic corundum)

		2018	2019	2020	2021	2022
Import	t	15,969	19,465	19,984	24,430	21,036
Export	t	6,319	6,273	6,739	7,529	8,638

281820 – Aluminium oxide (other than synthetic corundum)

		2018	2019	2020	2021	2022
Average import prices	CZK/t	17,567	15,748	18,933	13,431	21,242
Average export prices	CZK/t	6,400	6,549	6,249	7,124	7,926

281830 – Aluminium hydroxide

		2018	2019	2020	2021	2022
Import	t	9,969	10,018	9,101	9,195	9,579
Export	t	26	6,273	31	33	3

281830 – Aluminium hydroxide

		2018	2019	2020	2021	2022
Average import prices	CZK/t	10,995	12,235	11,320	11,075	15,296
Average export prices	CZK/t	39,831	6,549	46,346	25,895	50,193

7601 – Raw (unwrought) aluminium

		2018	2019	2020	2021	2022
Import	t	290,073	284,918	221,026	278,655	277,035
Export	t	97,784	105,219	107,704	121,792	109,683

7601 – Raw (unwrought) aluminium

		2018	2019	2020	2021	2022
Average import prices	CZK/t	51,877	46,238	45,723	57,382	74,218
Average export prices	CZK/t	45,731	38,032	37,929	50,754	67,020

7602 – Aluminium waste and scrap

		2018	2019	2020	2021	2022
Import	t	119,634	124,700	122,686	116,463	125,165
Export	t	72,361	68,531	61,783	80,133	75,828

7602 – Aluminium waste and scrap

		2012	2018	2019	2020	2021
Average import prices	CZK/t	31,126	25,108	23,517	34,090	41,420
Average export prices	CZK/t	31,770	25,221	23,690	35,614	44,625

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices**World mine production of bauxite, production of alumina and aluminium***

Komodita/rok	2018	2019	2020	2021	2022 ^e
World mine production of bauxite (according to MCS), kt	327,000	358,000	391,000	384,000	380,000
World production of alumina (according to MCS), kt	131,000	133,000	136,000	139,000	140,000
World smelter production of aluminium (according to MCS), kt	63,600	63,200	65,100	67,500	69,000
World mine production of bauxite (according to WBD), kt	337,375	361,800	378,992	379,851	N
World smelter production of aluminium (according to WBD), kt	64,443	63,214	65,381	67,668	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	2022 ^e	
	kt	%
Australia	100,000	26.3
China	90,000	23.7
Guinea	86,000	22.6
Brazil	33,000	8.7
Indonesia	21,000	5.5
India	17,000	4.5
Russia	5,000	1.3
Saudi Arabia	4,800	1.3
Kazakhstan	4,400	1.2
Jamaica	3,900	1.0
Vietnam	3,800	1.0
United States	W*	N
World (rounded)	380,000	100.0

e – estimate

W – Withheld to avoid disclosing company proprietary data*

Main producers of aluminium according to MCS – smelter production

Country	2022 ^e	
	kt	%
China	40,000	58.0
India	4,000	5.8
Russia	3,700	5.4
Canada	3,000	4.3
United Arab Emirates	2,700	3.9
Bahrain	1,600	2.3
Australia	1,500	2.2
Norway	1,400	2.0
USA	860	1.2
Island	750	1.1
World (rounded)	69,000	100.0

e – estimate

Main producers of alumina according to MCS – refinery production

Country	2022 ^e	
	kt*	%
China	76,000	54.3
Australia	20,000	14.3
Brazil	11,000	7.9
India	7,400	5.3
Russia	3,100	2.2
United Arab Emirates	2,000	1.4
Saudi Arabia	2,000	1.4
Ireland	1,800	1.3
Spain	1,700	1.2
Vietnam	1,500	1.1
Kazakhstan	1,400	1.0
Canada	1,300	0.9
USA	1,200	0.9
Indonesia	1,100	0.8
Germany	750	0.5
Ukraine	740	0.5
Jamaica	480	0.3
Guinea	440	0.3
World (rounded)	140,000	100.0

e – estimate

** Converted to Al₂O₃*

Prices of traded commodities

Komodita/rok	2018	2019	2020	2021	2022 ^e
Bauxite, average value, U.S. imports FAS, USD/t (MCS)	31	32	30	31	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)	486	592	480	412	450
Aluminium, ingot, avg. U.S. market (spot), cent/lb (MCS)	114.7	99.5	89.7	138.8	150
Aluminium, high grade primary, cash, in LME warehouse, USD/t (DERA)***	2,109.9	1,793.3	1,700.2	2,474.75	2,706.1
Aluminium, new scrap of aluminium alloy (Angel), EUR/100kg (DERA)***	146.2	128.0	108.9	170.06	250.60

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 $\text{Al}_2\text{Be}_3\text{Si}_6\text{O}_{18}$ (14% BeO), bertrandite $\text{Be}(\text{OH})_2\text{Si}_2\text{O}_7$ (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

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

		2018	2019	2020	2021	2022
Import	kg	–	–	–	–	–
Export	kg	1	–	–	–	–

811212 – Unwrought beryllium, beryllium powders

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	–	–	–	–	–
Average export prices	CZK/kg	1,000	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production of beryllium

Commodity/year	2018	2019	2020	2021	2022 ^e
World mine production of beryllium content (according to MCS), t *	240	250	250	272	280
World mine production of beryllium (concentrates) (according to WBD), t	6,111	5,927	6,240	6,716	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	2022 ^e	
	t	%
United States	180	64.3
China	70	25.0
Mozambique	13	4.6
Uganda	7	2.5
Brazil	3	1.1
Madagascar	1	0.4
Nigeria	1	0.4
Rwanda	1	0.4
World (rounded)	280	100.0

*e – estimate***Prices of traded commodities**

Commodity/year	2018	2019	2020	2021	2022 ^e
Beryllium-copper master alloy, annual average U.S., USD/kg of contained beryllium (MCS)*	590	620	620	680	730

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

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

		2018	2019	2020	2021	2022
Import	kg	102,695	67,090	73,542	82,226	57,683
Export	kg	361	154	61	3,259	0

81060010 – Unwrought bismuth, including waste and scrap, powders

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	223	163	136	172	179
Average export prices	CZK/kg	139	305	197	341	–

81060090 – Wrought bismuth, articles of bismuth, excluding unwrought bismuth, waste, scrap and powders

		2018	2019	2020	2021	2022
Import	kg	3,356	2,211	14,564	6,827	24,926
Export	kg	2,491	8,781	2,089	3,126	433

81060090 – Wrought bismuth, articles of bismuth, excluding unwrought bismuth, waste, scrap and powders

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	1,114	1,244	352	823	184
Average export prices	CZK/kg	1,154	477	1,232	1,173	341

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production of Bismuth

Commodity/year	2018	2019	2020	2021	2022 ^e
World refinery production of bismuth (according to MCS), t gross weight	19,200	21,100	19,000	20,000	20,000
World mine production of bismuth (according to WBD), t	10,886	9,073	9,513	11,143	N

e – estimate

Main producers of bismuth according to MCS

Refinery production

Country	2022 ^e	
	t*	%
China	16,000	80.0
Laos	2,000	10.0
Korea	950	4.8
Japan	480	2.4
Kazakhstan	220	1.1
Bolivia	60	0.3
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	2018	2019	2020	2021	2022^e
Bismuth metal, USD/lb (MCS)*	4.61	3.18	2.72	3.74	3.90
Bismuth metal, refined ≥ 99.99%, USD/kg (DERA)**	9,381.20	6,358.40	5,341.10	7,100.99	6,833.51

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 $\text{Cu}_{12}\text{Sb}_4\text{S}_{13}$ (500–17 900 ppm Cd), bornite Cu_5FeS_4 (16–1 000 Cd) and bournonite $2\text{PbS} \cdot \text{Cu}_2\text{S} \cdot \text{Sb}_2\text{S}_3$ (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 złóż 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

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

		2018	2019	2020	2021	2022
Import	kg	222	64	233	180	0
Export	kg	0	0	0	0	0

810720 – Unwrought cadmium, cadmium powders

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	883	703	983	1016	–
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production of cadmium

Commodity/year	2018	2019	2020	2021	2022 ^e
World refinery cadmium metal production as a byproduct of zinc refining plus cadmium metal from recycling, except USA (according to MCS), t*	25,100	24,400	24,000	24,700	24,000
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	2022 ^e	
	t*	%
China	10,000	41.7
Korea, Republic of	4,000	16.7
Japan	1,900	7.9
Canada	1,800	7.5
Kazakhstan	1,200	5.0
Mexico	1,200	5.0
Russia	1,000	4.2
Netherlands	500	2.1
Germany	420	2.1
Australia	400	1.8
Norway	350	1.5
Peru	300	1.3
Uzbekistan	300	1.3
Other countries	10,000	41.7
World (rounded)	24,000	100.0

*e – estimate*** Cadmium content***Prices of traded commodities**

Commodity/year	2018	2019	2020	2021	2022 ^e
Cadmium metal, annual average, dealer price for 99.95% purity in 5-short-ton lots*, USD/kg (MCS)	2.89	2.67	2.29	2.56	3.30
Cadmium, ingot, >= 99.99% USD/t (DERA)**	N	N	N	2,654.88	3,161.90

*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)₂O₃ (45–55%, max.68% Cr₂O₃)

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

2022		
Country	kt	% World
Kazakhstan	230,000	40.4
South Africa	200,000	35.1
India	100,000	17.5
Turkey	26,000	4.6
Finland	13,000	2.3
USA	620	0.1
World	570,000	100.0

Notes: ore is normalized to 45% Cr₂O₃ with the exception of Finland (26% Cr₂O₃) and the USA (7% Cr₂O₃)

Source: MCS 2023.

In the EU, only Finland has European reserves (European Minerals Yearbook – version 2021).

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 Cr₂O₃ is 48%, for the chemical industry it is at least 44% Cr₂O₃ and for the refractory industry 32% Cr₂O₃.

Classification as critical raw materials for the European Union

2011 – no, 2014 – yes, 2017 – no, 2020 – 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

		2018	2019	2020	2021	2022
Import	t	3,761	3,212	3,290	3,400	2,436
Export	t	656	255	348	578	666

2610 – Chromium ores and concentrates

		2018	2019	2020	2021	2022
Average import prices	CZK/t	12,190	11,017	14,605	7,655	10,405
Average export prices	CZK/t	5,894	4,085	5,320	4,971	8,702

811221 – Unwrought chromium

		2018	2019	2020	2021	2022
Import	kg	91,654	107,946	113,761	228,000	219,706
Export	kg	239,493	220,327	150,315	54,034	118,251

811221 – Unwrought chromium

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	211	197	147	149	241
Average export prices	CZK/kg	52	57	36	74	248

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production of chromium

Commodity/year	2018	2019	2020	2021	2022 ^e
World mine production of chromite ore (according to MCS), kt*	43,100	44,800	37,000	42,200	41,000
World mine production of chromium (according to WBD), kt of Cr ₂ O ₃ content	15,189	15,779	11,968	14,676	N

e – estimate

* Gross weight of marketable chromite ore

Main producers of chromite ore according to MCS

Country	2022 ^e	
	kt*	%
South Africa	18,000	43.9
Turkey	6,900	16.8
Kazakhstan	6,500	15.9
India	4,200	10.2
Finland	2,200	5.4
World (rounded)	41,000	100.0

e – estimate

* Gross weight of marketable chromite ore

Prices of traded commodities

Commodity/year	2018	2019	2020	2021	2022 ^e
Chromite ore, gross weight, USD/t (MCS)	279	248	179	197	340
Ferrochromium, chromium content (excl. ferrochromium silicon), USD/t (MCS)	2,549	2,094	1,878	2,837	6,800
Chromium metal, gross weight, USD/t (MCS)	11,344	10,393	7,931	8,787	21,000
Chromium, free market, aluminothermic, min. 99%, USD/t (MB)*	7,700–13,995	6,000–10,400	5,285–6,400	N	N

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 $\text{Na}_3\text{K}(\text{Al}_4\text{Si}_4\text{O}_{16})$ (20–40 ppm Ga), sodalite $\text{Na}_8(\text{Al}_6\text{Si}_6\text{O}_{24})\text{Cl}_2$ (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

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

		2018	2019	2020	2021	2022
Import	kg	0	7	10	0	1
Export	kg	0	0	0	0	0

81129289 – Unwrought gallium, gallium powders

		2018	2019	2020	2021	2022
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, 2022

There are none.

8. World production and world market prices

World mine production of gallium

Commodity/year	2018	2019	2020	2021	2022 ^e
World mine production of gallium, gallium content in mined ores (according to MCS), t	413	351	327	434	550
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	2022 ^e	
	t*	%
China	540	98.2
Russia	5	0.9
Japan	3	0.6
Korea, Republic of	2	0.4
World (rounded)	550	100.0

*e – estimate*** Metric tons of gallium content***Prices of traded commodities**

Commodity/year	2018	2019	2020	2021	2022 ^e
Gallium imports to U.S., high-purity, refined, USD/kg (MCS)*	508	573	596	625	640
Gallium imports to U.S., low-purity, primary, USD/kg e (MCS)**	185	153	163	254	420

*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 2022).

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

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

		2018	2019	2020	2021	2022
Import	kg	0	0	5	42	10
Export	kg	0	0	0	0	0

81129281 – Unwrought indium, indium powders

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	–	–	16,600	9,000	1,190
Average export prices	CZK/kg	–	–	–	–	–

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production of indium

Commodity/year	2018	2019	2020	2021	2022 ^e
World refinery production of indium (according to MCS), t	741	968	960	932	900
World mine production of indium (according to WBD), t	830	917	942	917	N

e – estimate

Main producers according to MCS**Refinery production**

Country	2022 ^e	
	t	%
China	530	58.9
Korea, Republic of	200	22.2
Japan	66	6.5
Canada	55	7.3
France	20	3.8
Belgium	20	2.2
Russia	5	0.6
World (rounded)	900	100.0

*e – estimate***Prices of traded commodities**

Commodity/year	2018	2019	2020	2021	2022 ^e
Indium, annual average, New York dealer, min. 99.99%, delivered duties paid U.S., USD/kg (MCS)	375	390	395	N	N
Indium, annual average, warehouse Rotterdam, min. 99.99%, duties unpaid, USD/kg (MCS)	206	285	161	223	250
Indium, 99.99%, USA, USD/kg (Investing.com)	281	177	158	217	250
Indium, USD/kg (DERA)*	167.4	150.4	213.43	224.36	224.36

*e – estimate*** prices for indium $\geq$ 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 $\text{CaMg}(\text{CO}_3)_2$, brucite $\text{Mg}(\text{OH})_2$ (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

This classification is paradoxical with regard to 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 2008–2012, British Geological Survey). However, it is based on the EU's total dependence on imports of metallic Mg (Study on the review of the list of critical raw materials, Critical Raw Materials Factsheets, European Commission, June 2017).

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

		2018	2019	2020	2021	2022
Import	t	1,125	2,402	2,357	2,219	7,382
Export	t	25	1	96	20	88

810411 – Unwrought magnesium, containing at least 99.8 % by weight of magnesium

		2018	2019	2020	2021	2022
Average import prices	CZK/t	54,484	59,694	55,497	75,455	123,862
Average export prices	CZK/t	62,134	95,588	50,810	2,310	173,993

810419 – Unwrought magnesium, containing less than 99.8 % by weight of magnesium

		2018	2019	2020	2021	2022
Import	t	210	111	267	2,675	9,421
Export	t	7,467	7,016	6,437	1,520	17,605

810419 – Unwrought magnesium, containing less than 99.8 % by weight of magnesium

		2018	2019	2020	2021	2022
Average import prices	CZK/t	58,430	98,227	77,272	63,727	141,666
Average export prices	CZK/t	62,856	66,530	66,478	68,222	127,001

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production of magnesium

Commodity/year	2018	2019	2020	2021	2022 ^e
World primary production of magnesium metal (according to MCS), kt*	996	1,120	1,000	1,070	1,000

e – estimate

* Excluding U.S. production.

Main producers of magnesium metal according to MCS – primary production

Country	2022 ^e	
	kt	%
China	900	94.7
Russia	50	5.3
Brazil	20	2.1
Israel	20	2.1
Kazakhstan	15	1.6
Turkey	13	1.4
Ukraine	2	0.2
United States	W*	N
World (rounded)	1,020	100

e – estimate

W* – Withheld to avoid disclosing company proprietary data

Prices of traded commodities

Commodity/year	2018	2019	2020	2021	2022 ^e
Magnesium, USD/t (DERA)*	2,502.5	2,320.6	1,987.1	4,030.73	4,681.01
Magnesium metal, U.S. spot Western, USD/lb (Platts Metal Week/MCS)	2.17	2.45	2.49	3.55	7.60
Magnesium metal, China, FOB, USD/t (Platts Metal Week/MCS)	2,550	2,425	2,149	5,008	5,500
Magnesium, European free market, USD/t (MB)**	2,050– 2,855	2,300– 2,800	2,150– 2,800	N	N

e – estimate

* 2018 through 2022 prices are for magnesium ≥99.9% (Shanxi) USD/t. Average annual price.

** Price range includes the lowest and the highest daily price quotes for the given year

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 Valley Type in association with Zn, Pb, Ba and F and more or less affected by diagenetic metasomatism: Granada district with Ezúcar and Montevives deposits (Spain), Octubre, etc. in the Coahuila area (Mexico), Yunlong-Lanping-Weixi Sr Metallogenetic 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 2019).

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 industry and metallurgy.

Classification as critical raw materials for the European Union

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

		2018	2019	2020	2021	2022
Import	t	565	569	495	588	380
Export	t	0	0	0	22	16

283692 – Strontium carbonate

		2018	2019	2020	2021	2022
Average import prices	CZK/t	18,371	19,573	19,650	20,212	28,314
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, 2022

There are none.

8. World production and world market prices

World mine production of strontium

Commodity/year	2018	2019	2020	2021	2022 ^e
World mine production of strontium – celestite content (according to MCS), kt	260	220	350	340	340

e – odhad

Main producers of strontium according to MCS

Celestite content in ore

Country	2022 ^e	
	t	%
Spain	130,000	38.2
Iran	110,000	25.0
China	80,000	32.4
Mexico	22,000	6.5
Argentina	700	0.2
World	340,000	100.0

*e – estimate***Prices of traded commodities**

Commodity/year	2018	2019	2020	2021	2022 ^e
Celestite - average USA import price, export port price, USD/t (MCS)	78	82	89	209	140

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 złóż 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 ²⁰¹Tl is used in medicine to monitor cardiovascular diseases. Tl is also a detector in scintillometer; Tl-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

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

		2018	2019	2020	2021	2022
Import	kg	0	0	0	0	0
Export	kg	0	0	0	0	0

811251 – Unwrought thallium

		2018	2019	2020	2021	2022
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, 2022

There are none.

8. World production and world market prices

World mine production of thallium

Commodity/year	2018	2019	2020	2021	2022 ^e
World refinery production of thallium (according to MCS), kg	< 9,000	< 8,000	< 8,000	~ 10,000	~ 10,000

e – estimate

Main producers of thallium according to MCS**Refinery production**

Country*	2022 ^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	2018	2019	2020	2021	2022 ^e
Thallium metal, 99.99%, granules in 100 gram lots (MCS)	N	7,600	8,200	8,400	9,400

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)SiO₄ (1–25% ThO₂), thorite ThSiO₄, thorianite (Th,U)O₂ (1–25% ThO₂), monazite (Ce,Th)PO₄ (25% ThO₂), zirkelite (Ca,Th,Ce)Zr(Ti,Nb)₂O₇ (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

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

		2018	2019	2020	2021	2022
Import	kg	0	0	0	0	708
Export	kg	0	0	0	0	1,625

28443061 – Thorium bars, rods, angles, shapes, sections, wire, sheets, strips

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	–	–	–	–	79
Average export prices	CZK/kg	–	–	–	–	12

28443069 – Thorium other, not crude, waste, scrap, bars, rods, shapes, wire, sheets

		2018	2019	2020	2021	2022
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

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	–	–	–	–	–
Average export prices	CZK/kg	–	–	–	–	–

28443099 – Thorium salts

		2018	2019	2020	2021	2022
Import	kg	0	0	0	0	0
Export	kg	0	0	0	0	0

28443099 – Thorium salts

		2018	2019	2020	2021	2022
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, 2022

There are none.

8. World production and world market prices**World mine production of thorium**

Commodity/year	2018	2019	2020	2021	2022
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*	2022 ^e	
	kt	%
N	N	N
World total	N	N

e – estimate

* Associated with recovery of monazite in REE heavy-mineral-sand deposits.

Prices of traded commodities

Commodity/year	2018	2019	2020	2021	2022
Thorium compounds, gross weight, India, USD/kg (MCS)	73	72	72	N	N
Thorium compounds, gross weight, France, USD/kg (MCS)	29	29	29	29	26

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

2022		
Country	kt TiO_2	% World
China	190,000	29,2
Australia	160,000	24,6
India	85,000	13,1
Brazil	43,000	6,6
Norway	37,000	5,7
Canada	31,000	4,8
South africa	30,000	4,6
Mozambique	26,000	4,0
Madagascar	22,000	3,4
Ukraine	5,900	0,9
USA	2,000	0,3
Vietnam	1,600	0,2
Other	26,000	4,0
World	650,000	100,0

2022			
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 kopalni w Polsce 2023

Note: TiO_2 content in ores

Source: MCS 2023

Rutile

2022		
Country	kt TiO ₂	% World
Australia	31,000	63.3
India	7,400	15.1
South Africa	6,500	13.3
Ukraine	2,500	5.1
Mozambique	890	1.8
Sierra Leone	490	1.0
Madagascar	400	0.8
Kenia	170	0.3
World	49,000	100.0

Zdroj: European Minerals Yearbook – version 2023

Uses

Astronautic and aerospace industries (alloys). TiO₂ 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

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

		2018	2019	2020	2021	2022
Import	t	107,438	138,646	121,706	97,132	16,637
Export	t	861	780	581	624	821

2614 – Titanium ores and concentrates

		2018	2019	2020	2021	2022
Average import prices	CZK/t	5,674	6,081	6,119	6,186	10,757
Average export prices	CZK/t	23,900	27,606	32,021	33,482	42,284

8108 – Titanium and products of it, including waste and scrap

		2018	2019	2020	2021	2022
Import	t	2,747	3,450	2,773	1,687	2,777
Export	t	1,612	2,112	1,592	1,412	1,830

8108 – Titanium and products of it, including waste and scrap

		2018	2019	2020	2021	2022
Average import prices	CZK/t	478,419	433,156	436,724	539,649	672,086
Average export prices	CZK/t	365,125	349,408	381,562	378,851	409,637

6. Prices of domestic market

There are none.

7. Mining companies in the Czech Republic as of December 31, 2022

There are none.

8. World production and world market prices

World mine production of titanium

Commodity/year	2018	2019	2020	2021	2022 ^e
World mine production of ilmenite concentrate (according to MCS), kt of TiO ₂ content	5,540	6,870	7,700	8,000	8,400
World mine production of rutile concentrate (according to MCS), kt of TiO ₂ content	770	594	654	605	630
World mine production of titanium (according to WBD), kt of TiO ₂ content	7,120	7,549	7,907	8,424	N

e – estimate

Main producers of ilmenite according to MCS

Country	2022 ^e	
	kt*	%
China	3,400	38.2
Mozambique	1,200	13.5
South Africa**	900	10.1
Australia	660	7.4
Senega	520	5.8
Canada*	470	5.3
Norway	430	4.8
Madagascar**	300	3.4
Ukraine	200	2.2
India	200	2.2
United States***	200	2.2
Kenya	180	1.8
Vietnam	160	1.8
Brazil	32	0.4
Other countries	77	0.9
World (rounded)	8,900	100.0

Main producers of rutile according to MCS

Country	2022 ^e	
	kt*	%
Australia	190	32.2
Sierra Leone	130	22.0
South Africa	95	16.1
Kenya	73	12.4
Ukraine	57	9.7
India	11	1.9
Madagascar	N	N
Senegal	9	1.5
Mozambique	8	1.4
USA**	N	N
Other countries	14	2.4
World (rounded)	590	100.0

e – estimate

* Metric tons of titanium content in mined concentrate

** Rutile content included in ilmenite production

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

Prices of traded commodities

Commodity/year	2018	2019	2020	2021	2022 ^e
Rutile, bulk, min. 95% TiO ₂ , FOB Australia, USD/t (IM in MCS)*	1,025	1,150	1,175	1,450	1,500
Ilmenite, bulk, minimum 54% TiO ₂ , FOB Australia, USD/t (IM in MCS)*	407	478	459	595	580
Ilmenite, U.S. import, USD/t (MCS)	219	186	215	240	290
Slag, 80%–95% TiO ₂ , duty-paid U.S. import, USD/t (MCS)	664	738	792	757	750
Titanium ore concentrate, bulk, 95% TiO ₂ , USD/t (MB)**	710–1,100	1,000–1,200	1,100–1,200	N	N
Titanium ore concentrate, bulk, 54% TiO ₂ , USD/t (MB)**	160–200	164–220	190–230	N	N
Leucoxene, min. 91% TiO ₂ , max. 1% ZrO ₂ , bagged, FOB W. Australia, USD/t (IM)***	700-802	N	N	N	N
Rutile, concentrate, min. 95% TiO ₂ , bulk, CIF China, USD/t (IM)***	850–1,100	1,150–1,250	1,200–1,250	N	N
Ferrotitanium, USD/kg (DERA)****	4.9	5.0	4.33	7.42	11,77
Titanium, oxide, pigment, bulk volume, CIF Northern Europe, EUR/t (DERA)*****	N	N	2,908	3,271	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 $(\text{V,Fe})\text{O}(\text{OH})$ (variable contents of V_2O_5), carnotite $\text{K}_2(\text{UO}_2)_2(\text{VO}_4)_2 \cdot 3\text{H}_2\text{O}$ (20% V_2O_5), tjujamunite $\text{Ca}(\text{UO}_2)_2(\text{VO}_4)_2 \cdot 5\text{--}8\text{H}_2\text{O}$ (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

2022		
Country	kt	% World
China	9,500	19.4
Australia	6,000	12.2
Russia	5,000	10.2
South Africa	3,500	7.1
Brazil	120	0.2
USA	45	0.1
World	24,000	100.0

Source: MCS 2023, 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

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

		2018	2019	2020	2021	2022
Import	kg	329	168	163	472	833
Export	kg	27	19	4	128	0

81129291 – Unwrought vanadium, vanadium powders, excluding waste and scrap

		2018	2019	2020	2021	2022
Average import prices	CZK/kg	1,228	5,452	4,239	4,025	1,229
Average export prices	CZK/kg	1,037	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, 2022

There are none.

8. World production and world market prices

World mine production of vanadium

Commodity/year	2018	2019	2020	2021	2022 ^e
World mine production of vanadium (according to MCS), t of vanadium content	71,200	73,000	105,000	105,000	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	2022 ^e	
	kt*	%
China	70,000	70.0
Russia	17,000	17.0
South Africa	9,100	9.1
Brazil**	6,200	6.2
USA	0	0
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	2018	2019	2020	2021	2022 ^e
Vanadium pentoxide (V ₂ O ₅), min. 98%, Europe, USD/lb (MB)	9.60–29.15	4.45–17.75	4.80–7.75	N	N
Vanadium pentoxide (V ₂ O ₅), USD/lb (MCS)*	16.40	12.17	6.68	8.17	9.2
Ferrovanadium, basis 70–80%, USD/kg (MB)**	43.25–140.00	27.00–76.00	26.00–31.00	N	N
Ferrovanadium, USD/kg (DERA)***	80.0	41.9	25.0	34.27	38.99

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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