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Development of the diatomite production, reserves and its processing in the Czech Republic in 1999–2018

Introduction

Diatoms are a unicellular group of eukaryote microorganisms living in the oceans, rivers and soils worldwide (Round et al. 2007). Their role in the environment is crucial because they significantly contribute to the production of oxygen on Earth and significantly affect the silicon and nutrient cycles (e.g., Hader et al. 1998; Khan and Ansari 2005; Sundback et al. 1991; Yool and Tyrrell 2003). The ability of diatoms to use silicon for building cell walls attracts biologists, biochemists and other life science experts because of the lack of a full understanding of the silicon-handling mechanism (Martin-Jezequel et al. 2000;

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Thamatrakol et al. 2006). The resolution of this biochemical pathway has potential for multiple biotechnologies (e.g., Vrieling et al. 1999). In diatoms, silica is produced in a defined way to create hard and porous cell covers of diatoms, which are known as frustules and which give rise to sediments (Round et al. 2007).

Diatomite is a soft siliceous sedimentary rock consisting of frustules and the debris of dead planktonic diatoms. Diatomite may originate in freshwater and marine environments where a large population of diatoms lives and their remains accumulate (Boggs 2009). The prerequisite for a large number of these microorganisms in the environment is a photic zone rich in nutrients. Deposits are formed within basins with low levels of dissolved Ca^{2+} in water and with suspended aluminosilicates. The most favorable environments for creating diatomite are highly mineralized waters near volcanic areas (Barron 1987).

Present-day diatomite reserves are not given by most countries. However, most likely, the largest deposits are reported from the United States (250 Mt) and China (110 Mt) according to Crangle (2018a).

This work summarizes the resources, reserves, production and processing of diatomite in the Czech Republic between 1999 and 2018. Crangle (2018a) erroneously placed the Czech Republic in second place among the world producers with 450 kt produced in 2017, while the country produced only 26 kt of diatomite (Starý et al. eds. 2017) and ranks somewhere between 25th and 35th place worldwide and between 5th and 10th place within Europe. Diatomite is used in a modified state as a filtering material for the food industry (brewery, wine, and raw fruit juices) in the Czech Republic. Material with lower quality is used in combination with bentonite to prepare cat litter products.

1. Diatomite occurrences and deposits in the Czech Republic

The accumulation of diatomite in the Czech Republic is linked to the areas of Tertiary and Quaternary limnic sediments of the South Bohemian basins and Cheb Basin and the sediments in the vicinity of the Central Bohemian Uplands volcanic centers.

The earliest notes about diatomite production within the Central Bohemian Uplands (North Bohemia) date back to the first half of the 19th century, when diatomite was locally extracted for the production of abrasives and polishing powders. There were ca. 50 diatomite outcrops situated in the vicinity of Děčín and Bílina Towns (Fig. 1; Řeháková 1968; Gabriel 1970). A maximum diatomite thickness of 8.6 m was found during borehole prospecting near Stadice Village. Local diatomites are typical for their high density and Fe^{3+} content and are therefore not suitable for use in the food industry (Gabriel 1971). The last deposit in this area, Kučlín, was abandoned in 1966 after the depletion of reserves. The Kučlín deposit was composed of 3 layers of lithified Tertiary diatomites 1.4, 0.3, and 2.9 m thick, separated by diatomaceous cherts and clays (Mrázek and Procházka 1954; Gabriel 1983).

An important historical production area was situated in the Cheb Basin (Western Bohemia, Fig. 1). The Soos deposit (later renamed Hájek) is renowned for the first reports of fossil

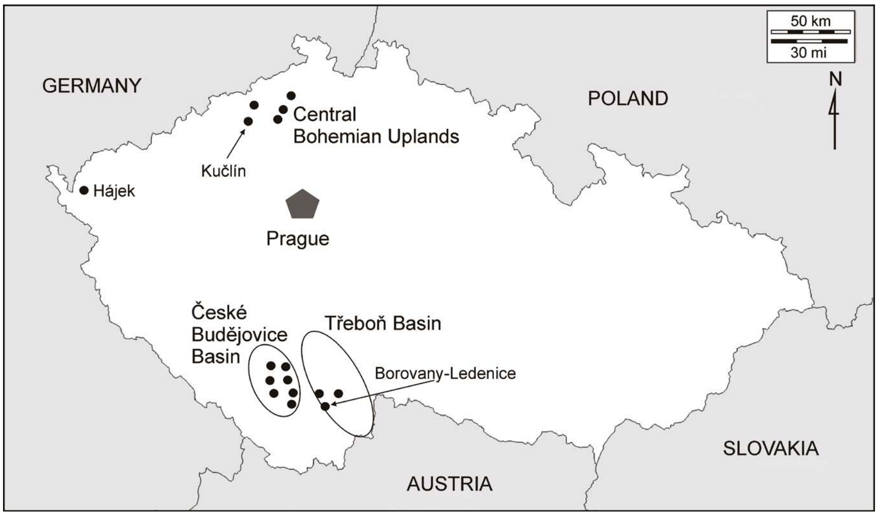

Fig. 1. Diatomite deposit locations in the Czech Republic

Rys. 1. Lokalizacja złóż ziemi okrzemkowej w Czechach

diatoms (and therefore diatomite rock) by German scientist Christian Gottfried Ehrenberg (1836). This Holocene diatomite deposit with a thickness of up to several meters (Dohnal 1958) was abandoned in 1962 because of the establishment of the Soos National Natural Monument (Zahradnický and Mackovčin eds. 2004).

The South Bohemian basins are two sedimentary areas located in the southern part of the country (Fig. 1). The larger one is called the České Budějovice (Budweis) Basin, and the smaller one is the Třeboň Basin. The largest accumulation of diatomite in the Czech Republic is found in the České Budějovice Basin (e.g., the Číčenice, Malovice, Hlavatce, Čtyři dvory, and Záluží deposits). Unfortunately, the quality of local diatomite is rather poor, which makes it unsuitable for industrial use (Smetana 1936; Řeháková 1965; Gabriel 1983).

The only registered and extracted diatomite deposit in the Czech Republic (Borovany--Ledenice) is located in the Třeboň Basin, where the sedimentation of diatomite occurred in a tectonically limited area on the Moldanubian basement (Gabriel 1983). The current production of diatomite is limited to the Borovany Quarry and a factory located within the South Bohemian Region. This quarry is operated by the LB MINERALS, s.r.o. mining company. The first mention of mining from local resources dates back to the end of the 19th century. In 1919, the mining of raw materials from the deposit was initiated by Calofrig a.s. (Vilímek et al. 1969; LB MINERALS 2018). LB MINERALS, s.r.o., is the legal successor of the original mining company.

As mentioned above, the only diatomite deposit currently extracted in the Czech Republic is located approximately 13 km southeast of the České Budějovice regional center in the southern part of the country. The quarry (Fig. 2) is situated between the Ledenice and Borovany villages, approximately at GPS coordinates (center) N 48° 55.250 E 014° 37.800.

Fig. 2. Borovany-Ledenice diatomite and clay deposit in the South Bohemian Region.
Phot. Jan Zahradník 2017

Rys. 2. Złoża ziemi okrzemkowej i gliny w Borovany-Ledenice, Kraj południowoczeski

The deposit is geologically located at the outlet of the southwestern edge of the Třeboň Basin. This part was tectonically transported by a series of faults in the northwest and southeast direction (Mrázek 1954; Vohanka et al. 1992).

The geological basement of the Borovany-Ledenice deposit is formed by weathered Moldanubian migmatized paragneisses to migmatites–arterites (Table 1). Most of the sedimentary fill of the Třeboň Basin is composed of the Upper Cretaceous (Senonian) freshwater Klikov Formation with a thickness of up to 320 m. After a sedimentary hiatus, the next sediments belong to the Lipnice Formation (Oligocene), reaching a thickness of 40 m. The upper boundary of this formation is also a sedimentary break (hiatus). The Zliv Formation (Helvetian) sediments have a relatively small thickness with a maximum of 15 m (Vilímek et al. 1969; Chvátal et al. 2012).

The base of the deposit body (Fig. 3) is formed by the Mydlovary Formation of Miocene age. This formation reaches up to 70 m thick in the Třeboň Basin; it is 40–50 m thick in the deposit area. The typical lithology contains clay sands, coal (lignite) clays, and diatomites. The following are found in the "classic" development (from the base to the top):

- Gray-green clay sands containing sharp-edged quartz clasts and intercalations of sediments cemented by Fe-oxides (ortsteins). These sands are interpreted as sediments washed into the tectonically founded depressions.
- Thick horizon of olive-green clays.
- The lithology passes to coal clays in the vicinity of Mydlovary, but the lignite seam itself is not developed in the area of the diatomite deposit.
- Green diatomite clays (Vilímek et al. 1969; Chvátal et al. 2012).

Clays are composed of kaolinite, montmorillonite, and illite. Shallowing of the sedimentary basin during the sedimentation of the Mydlovary Fm. is evident from the lithology. The diatomite horizon following after clays is most prominent. Diatomite sedimentation ends in the layer of spongodiatomite and spongolite, *i.e.*, sediment composed predominantly

Table 1. Stratigraphic column of the Třeboň Basin near the town of Borovany.
The marked part is opened by the Borovany-Ledenice deposit (Chvátal et al. 2012)

Tabela 1. Tabela stratygraficzna Kotliny Trzebońskiej w pobliżu miasta Borovany.
Oznaczona część jest udostępniona jako złoże Borovany-Ledenice

Quaternary				sandy loam	0–2 m
Cenozoic	Neogene	Pliocene	Ledenice Formation	dark-gray clays and coal clays	15–20 m
				blue-gray kaolinitic clays	
		Miocene	Domanín Formation	green clays with diatomites	0–30 m
			Mydlovary Formation	diatomite clays, diatomite	40–50 m
				coal clays and xylite	
				olive-green clays	
				gray-green clay sands	
			Zliv Formation	sands to conglomerate	15 m
	Paleogene	Oligocene	Lipnice Formation	freshwater clays and sands	5–15 m
Mesozoic	Cretaceous	Upper	Klikov Formation	kaolinitic sands to conglomerates	up to 350 m
				colorful claystones	
				dark clays and coal residues	
Paleozoic	Moldanubian Unit			gneiss, migmatite, granitoids	

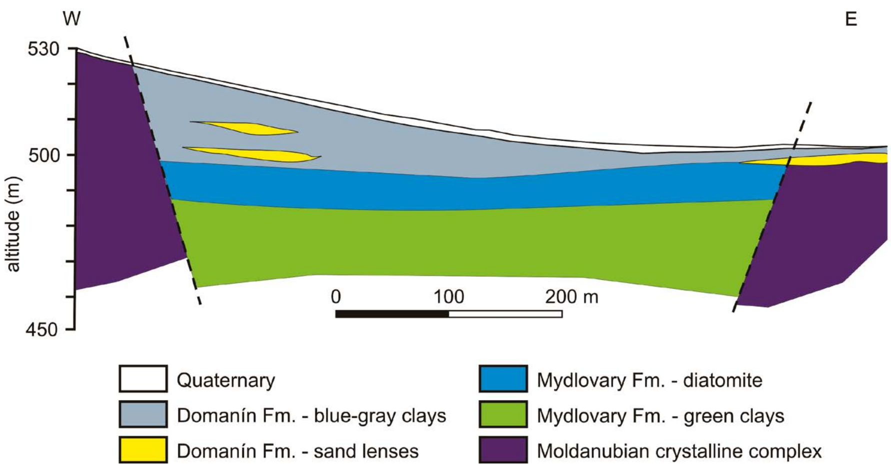

Fig. 3. Geological cross-section in the central part of the of the Borovany-Ledenice deposit.
According to: Franče 1983

Rys. 3. Przekrój geologiczny w centralnej części złoża Borovany-Ledenice of sponge spicules (Fig. 4A; Vilímek et al. 1969). It reaches thickness up to 3 metres and is rich in SiO_2 content. Both horizons are not welcomed for diatomite products due to their higher density and lower permeability (see Chapter 2; Vohanka et al. 1992). Diatom associations (examples at Fig. 4B–D) detect freshwater to the brackish lake environment, with signs of communication with the Alpine Foredeep (Řeháková 1965).

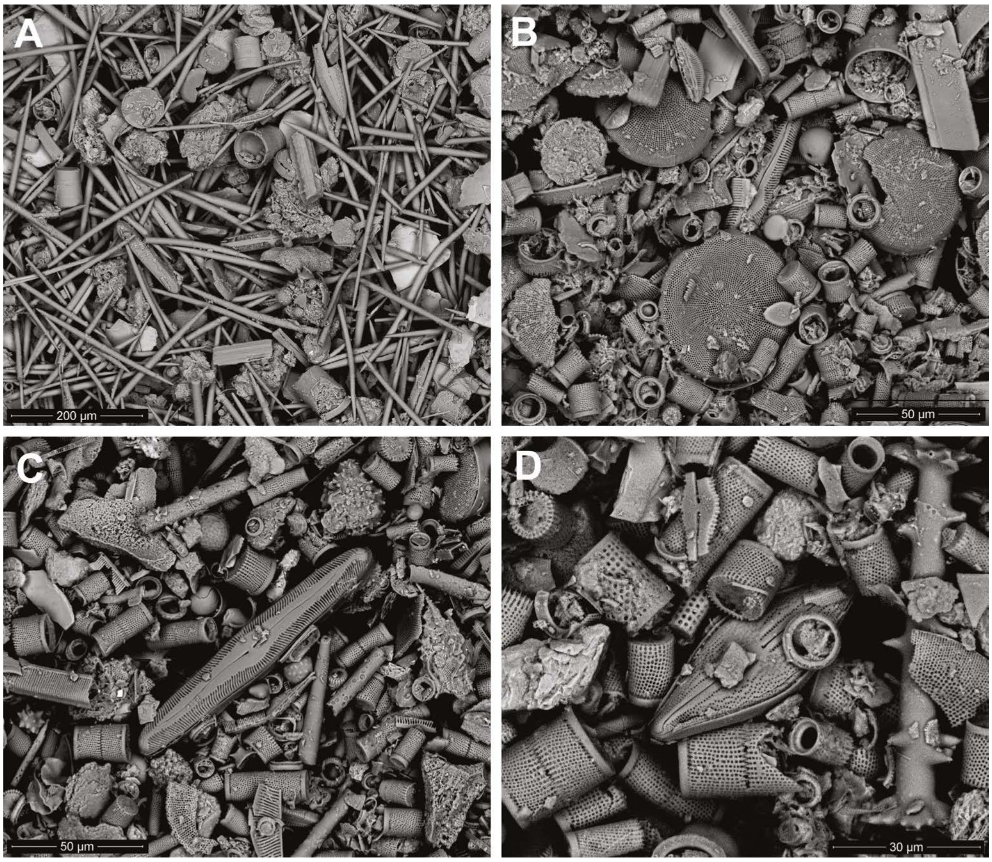

Fig. 4. Back-scattered electron (BSE) image of washed diatomite from the Borovany-Ledenice deposit. A+B – particle size < 0.125 mm, C+D – particle size < 0.063 mm. A – diatomite passing to spiculite, i.e., siliceous sediment composed predominantly of sponge spicules; B – partly broken fragments of diatom frustules with large circular *Cosinodiscus* sp.; C – diatom frustules, prevailing cylindrical *Melosira* sp. with *Pinnularia* sp. in the centre; D – diatom frustules, prevailing cylindrical *Melosira* sp. with *Anomoeoneis sphaerophora* in the centre, sponge spicule on the right side. Phot. D. Matýsek 2018

Rys. 4. Elektrony wstecznie rozproszone (BSE) oczyszczonej ziemi okrzemkowej ze złoża Borovany-Ledenice. A+B – wielkość cząstek <0,125 mm, C+D – wielkość cząstek <0,063 mm. A – ziemia okrzemkowa przechodząca w spikulit, tj. Osad krzemionkowy złożony głównie z gąbek (spikuli); B – częściowo połamane fragmenty pancerzy okrzemkowych o dużych okrągłych *Cosinodiscus* sp.; C – pancerzyki okrzemkowe, przeważające cylindryczne *Melosira* sp. z *Pinnularia* sp. w centrum; D – pancerzyki dwuatomowe, przeważające cylindryczne *Melosira* sp. z *Anomoeoneis sphaerophora* w środku, spikule (gąbki) po prawej. Fot. Matýsek 2018

The Domanín Formation is composed of freshwater green clays with a diatomite admixture, pale green diatomite clays, and green to blue-gray clays. A maximum thickness of 30 m is known from the Domanín area. According to some authors (e.g., Chvátal et al. 2012), the occurrence of this formation in the deposit overburden is questionable.

The Ledenice Formation is the youngest stratal unit of the deposit (Table 1). Its occurrence is limited to the periphery of the Třeboň Basin, where it reaches up to 20 m thick. Geological surveys showed that the Ledenice Formation can also be found in the České Budějovice Basin. The Ledenice Formation contains freshwater pale-gray sandy kaolinitic clays and bluish gray clays (Nesrovnal et al. eds. 1991). They origin in a fluvial to a lacustrine environment (Vilímek et al. 1969). Bluish gray clays are extracted for the ceramic industry under the MM trademark.

The main source of the diatomite is the Mydlovary Formation, which is massively widespread throughout the Třeboň Basin. All the above-mentioned types of raw materials are extracted from this formation at the Borovany Quarry. The deposit demarcation is based on the presence of high-quality diatomite. The current economically prospected resources are bounded with diatomite Vj marks (see Chapter 3 for explanation). The basement of the deposit is formed predominantly by weathered gneiss and migmatites of the Moldanubian Unit (Vohanka et al. 1992).

2. Classification of Czech diatomites

The Czech Republic classification of diatomite is rather limited and reflects the diatomite classification in the Borovany Quarry. The official classification recognizes only one type of this siliceous sedimentary rock – diatomite (“DT”). Unofficially, there are two types and two subtypes of diatomite that are recognized according to their material properties and subsequent usage. Such a limited classification is the result of the absence of abundant sources of raw material with different physicochemical qualities. This fact is also historically reflected in the raw materials policies of the Czech Republic (Starý et al. eds. 2004).

The conditions of the reserve exploitability (values of parameters, according to which different groups of the reserves are established, hereinafter referred to as conditions) for the diatomite were approved by the mining company in 2012 (Table 2; Chvátal et al. 2012). Two basic types of raw material were recognized according to the quality: diatomite L for filtering material and diatomite S for cat litter preparation. The two major types of diatomite are accompanied by subtypes Lf and Vj diatomite. These subtypes of diatomite are used mainly for homogenizing the final products and maintaining their required properties.

Overall, there are four types of diatomite in the Borovany-Ledenice deposit designated according to their composition and application in production:

- Diatomite **Lf** is the best material, is white to white beige in color and has a bulk density lower than 450 kg/m^3. Lf is used for the highest-quality products and for homogenization with the material type L according to the filter diatomite production needs.

- Diatomite **L** is intended for the production of filter diatomite in all of the product types. The material has a white-gray to gray-white color with an iron content of up to 2.4%.
- Spongodiatomite to spongolite **S** is a low-quality material for the preparation of cat litter. Material with a bulk density lower than 650 kg/m^3 is mixed with bentonite.
- Diatomite **Vj** is a material with a higher proportion of the clay component. It is also used for homogenization to obtain the desired properties of the final products.

Table 2. Conditions of exploitability for diatomite reserves/resources in the Borovany-Ledenice deposit (Chvátal et al. 2012)

Tabela 2. Rezerwy/zasoby ziemi okrzemkowej w złożu Borovany-Ledenice

Type		Loss on ignition (%)	Al_2O_3 (%)	Fe_2O_3 (%)	SiO_2 (%)	Bulk density (kg/m^3)
Economic reserves	Lf	< 8	≤ 15	< 2.0	≥ 77	< 450
	L	< 8	≤ 15	< 2.4	≥ 72	< 450
	S	< 9	≤ 20	< 3.0	≥ 65	< 650
Potentially economic resources	Vj	< 9	≤ 22	< 3.5	≥ 65	< 650

3. Mine production, reserves, and resources

The Borovany-Ledenice deposit is mined in an open pit mine, which was developed at the beginning of the 20th century. On average, approximately 35 kt per year was mined (total of all trade labels) during the period between 1999 and 2018. This amount represents the average of raw material required per year for the production of filter diatomite and cat litter. Table 3 shows sharp fluctuations in mining raw material consumption from 0 to 83 kt in last two decades. These fluctuations can be explained by the existence of a large stockpile of extracted raw material near the production facilities. The stockpiles were established as the result of mining experiences in the quarry, where mining depends on climatic conditions.

Concerning the total volume of mining production, the lifetime of diatomite mining in the Czech Republic is estimated to be approximately 50 years. In 2012, the reserves of the Borovany-Ledenice deposit were re-evaluated and recalculated (Chvátal et al. 2012). This fact is well evident in Table 3. Reason for this re-calculation was finished geodetic survey of the quarry.

Overall, the diatomite reserves and resources are relatively small due to the very limited diatomite sedimentation in the territory of the Czech Republic in geological history. An increase in reserves and resources would require an investment in new exploratory works, probably on the territories of old exhausted diatomite deposits and other resources.

Table 3. Key data on diatomite in the Czech Republic (Starý et al. eds. 2017, 2014, 2011, 2009, 2007, 2004; the years 2017 and 2018 amended by the team of authors)

Tabela 3. Podstawowe dane dotyczące ziemi okrzemkowej w Czechach

	1999	2000	2001	2002	2003	2004	2005
Total number of deposits	1	1	1	1	1	1	1
Extracted deposits	1	1	1	1	1	1	1
Total mineral resources (kt)	4,845	4,800	4,699	4,661	4,607	4,562	4,519
Economic proved reserves (kt)	4,517	4,472	4,371	4,333	4,279	4,234	4,191
Economic probable reserves (kt)	328	328	328	328	328	328	328
Potentially economic resources (kt)	0	0	0	0	0	0	0
Mineable reserves (kt)	–	–	–	–	–	–	–
Mine production (kt)	37	34	83	28	41	33	38

	2006	2007	2008	2009	2010	2011
Total number of deposits	1	1	1	1	1	1
Extracted deposits	1	1	1	1	1	1
Total mineral resources (kt)	4,451	4,432	4,401	4,401	4,367	4,318
Economic proved reserves (kt)	4,123	4,104	4,073	4,073	4,039	3,990
Economic probable reserves (kt)	328	328	328	328	328	328
Potentially economic resources (kt)	0	0	0	0	0	0
Mineable reserves (kt)	–	–	–	4,381	4,349	4,303
Mine production (kt)	53	19	31	0	32	46

	2012	2013	2014	2015	2016	2017	2018
Total number of deposits	1	1	1	1	1	1	1
Extracted deposits	1	1	1	1	1	1	1
Total mineral resources (kt)	2,573	2,520	2,482	2,463	2,434	2,397	2,364
Economic proved reserves (kt)	1,859	1,808	1,772	1,755	1,728	1,693	1,660
Economic probable reserves (kt)	0	0	0	0	0	0	0
Potentially economic resources (kt)	714	712	710	708	706	704	702
Mineable reserves (kt)	1,673	1,624	1,590	1,575	1,549	1,515	1,484
Mine production (kt)	43	49	34	15	26	34	31

4. Diatomite processing

The processing of diatomite begins with its extraction at the quarry, where the raw diatomite is divided into two basic technological types. The first type consists of diatomite L, and the second type is diatomite S (Table 4). Both basic types of material are individually distributed from the quarry to the plant premises.

Table 4. Average basic chemical composition of diatomite in Borovany-Ledenice for the period from 01/2010 to 03/2018. Data from the LB MINERALS, s.r.o. Laboratory

Tabela 4. Średni skład chemiczny ziemi okrzemkowej w Borovanach-Ledenice dla okresu od 01.2010 do 03.2018

Raw material – Diatomite L and diatomite S		
Content in %	Diatomite L	Diatomite S
SiO_2	72.33	66.89
Al_2O_3	16.22	19.61
Fe_2O_3	2.17	3.09
TiO_2	0.54	0.64
CaO	0.19	0.25
MgO	0.32	0.37
Na_2O	0.06	0.07
K_2O	0.79	0.82
Loss on ignition	7.31	8.25
Bulk density (kg/m^3)	340	477
Moisture (%)	49.33	40.37

4.1. Diatomite L – filter diatomite

Raw diatomite L is the highest-quality material used for the production of filter diatomite in the Borovany-Ledenice operation. Crude diatomite with a moisture content of approximately 50% is transported from the depot by a wheel loader into the feeder and further by means of a conveyor belt to a wet treatment (Fig. 5 – processes 1–5). This procedure leads to the removal of undesirable ingredients in the raw material, such as: clay particles, pebbles, and organic residues. The precleaned raw material is further transferred to the tank for the cleaning screen and subsequently to a two-stage hydrocyclone system (350 mm and 150 mm in diameter, Fig. 5 – process 6).

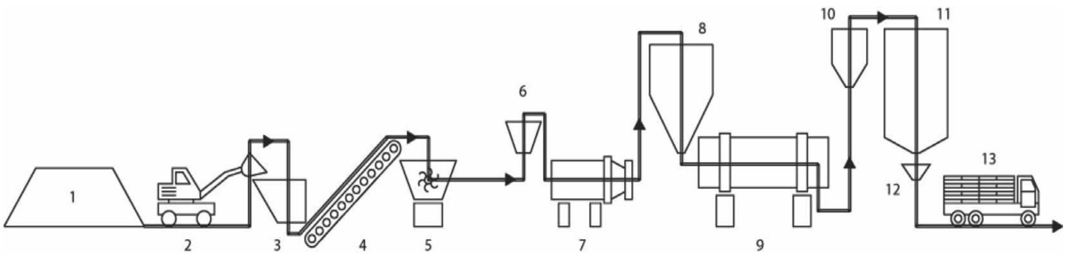

Fig. 5. Schematic representation of filter diatomite processing and production line (Vlček 2017)
Processing steps: 1 – basic raw materials; 2 – wheel loader; 3 – feed feeder; 4 – conveyor belt; 5 – wet treatment, 6 – hydrocyclone; 7 – spray drying; 8 – treatment with soda; 9 – rotary oven; 10 – grading; 11 – homogenization, 12 – storage; 13 – transportation

Rys. 5. Schemat przetwarzania ziemi okrzemkowej w celu jej wykorzystania jako środka filtrującego oraz linia produkcyjna
Etapy przetwarzania: 1 – nieprzetworzone surowce; 2 – ładowarka kołowa; 3 – podajnik; 4 – przenośnik taśmowy; 5 – obróbka na mokro; 6 – hydrocyklon; 7 – suszenie rozpyłowe; 8 – kalcynowanie sodą; 9 – piec obrotowy, 10 – klasyfikacja; 11 – homogenizacja; 12 – przechowywanie; 13 – transport

The hydrocyclone-treated material undergoes a final purification on the sorting pad, where the remaining debris and large fragments of diatomite frustules are removed. The sorting limit is 5 µm. The cleaned raw material suspension is pumped into a spray dryer where it is sprayed against a hot air stream (Fig. 5 – process 7). This action causes material desiccation to a final moisture content of 3–6%. The subsequent processing step is the separation of the product labeled F4. Other material continues to be treated with soda, which results in the formation of the calcination mixture. The calcination mixture is fed into rotary furnaces, where the material undergoes calcination. This process results in larger aggregate formation with optimal filtering properties. Filtration products (individual types of filter diatomite) are obtained by means of air classifiers. The entire process is highlighted schematically in Figure 5, and the final parameters and chemical compositions are summarized in Tables 5 and 6, respectively.

4.2. Diatomite S – cat litters

Poor-quality raw material diatomite S (with higher proportions of clay components) is used for the production of cat litter products. The raw materials are processed at the Borovany plant on the Borcat line.

Diatomite S is weighed and blended with activated bentonite using a wheel loader with an integrated weighing machine to obtain a specific ratio. Bentonite is supplied from Slovakia (Lastovce deposit) and is modified before dosing into the recipe by so-called natrification. This simple chemical activation by Na_2CO_3 significantly increases the surface of bentonite and enhances its adsorption properties.

Table 5. Parameters and types of filter diatomite (Vlček 2017)

Tabela 5. Parametry i rodzaje filtrów diatomitowych

Trade labels		F 4	F 10	F 15	F 25	F 50	F 60	F 70	F 100
Filtration speed	$l \cdot min^{-1} \cdot m^2$	10–30	50–80	80–130	180–280	450–550	550–650	650–750	780–900
Permeability	Darcy	0.012–0.03	0.05–0.10	0.10–0.18	0.2–0.3	0.5–0.7	0.60–0.85	0.8–1.2	0.9–1.4
Bulk density	$kg \cdot m^{-3}$	250	250	220	250	300	300	320	320
Particle size 0.25 mm	% (max.)	0	0	0	0	0	0	0	0
Particle size 0.045 mm	% (max.)	1	3	3	3	15	15	15	15
SiO_2	% (min.)	75	78	78	78	78	78	78	78
Al_2O_3	% (max.)	15	15	15	15	14.5	14.5	14.5	14.5
Fe_2O_3	% (max.)	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7

Table 6. Average basic chemical composition of filter diatomite products for the period from 01/2016 to 12/2017. Data from the LB MINERALS, s.r.o. Laboratory

Tabela 6. Średni skład chemiczny ziemi okrzemkowej w Borovanach dla okresu od 01.2016 do 12.2017

Content in %/label	F 4	F 10	F 15	F 25	F 50	F 60	F 70	F 100
SiO_2	77.75	81.89	81.94	81.63	80.72	79.68	79.59	79.97
Al_2O_3	12.04	11.68	13.31	12.59	12.91	12.99	12.6	12.13
Fe_2O_3	1.43	1.4	1.53	1.57	1.5	1.57	1.43	1.52
TiO_2	0.46	0.44	0.49	0.48	0.49	0.49	0.48	0.5
CaO	0.15	0.15	0.17	0.16	0.16	0.17	0.16	0.16
MgO	0.22	0.21	0.23	0.23	0.23	0.24	0.23	0.24
Na_2O	0.09	3.09	1.12	2.19	2.88	3.79	4.48	4.42
K_2O	0.78	0.75	0.83	0.81	0.84	0.82	0.82	0.86
Loss on ignition	7.06	0.38	0.39	0.32	0.26	0.26	0.21	0.21

The production mixture gradually passes from the feeder through passage to the mixer. The mixture drops into a plastic molding machine, which is followed by a scraper. These devices ensure the perfect mixing and treatment of the raw material. The material then goes into the dryer where the humidity is decreased to only 7%. The desiccated products in the form of pellets (noodles) are crushed in two stages on the HOSOKAWA and ROMIL crushers. The crushed material is sorted on a six-sided MOGENSEN sorter for two basic types of products – BORCAT Standard with particle sizes ranging from 0.7 to 4 mm and BORCAT Ultra with particle sizes ranging from 0.7 to 2 mm. Partitioned fractions are separately stored in the silos before further processing and packaging.

Discussion and conclusion

For more than one hundred years, diatomite has been one of the industrial minerals extracted and used on the territory of the Czech Republic. The production of diatomite is quite variable and ranges between 0 and 83 kt per year with an average of 35 kt in the last 20 years. Since the exact figures of production, reserves, and resources are not given by most countries, we can only estimate that the Czech Republic ranks somewhere between 25th and 35th place worldwide and between 5th and 10th place within Europe. The second-place ranking within the world top producers according the Mineral Commodity Summaries 2018 with 450 kt produced in 2016 (Crangle 2018a) is erroneous information.

Produced diatomite is used for filtration or cat litter products after processing. We can expect that diatomite extraction will continue for at least 40 years at the Borovany--Ledenice deposit. An increase in raw diatomite production would require large-scale investments in geological prospecting, which is not expected due to unfavorable geological conditions.

Even the relatively small Czech diatomite production is rather large compared to neighboring Central European countries. Diatomite is only extracted in Poland. With total reserves ca. 10 Mt located in four deposits, the production was only 0.5 kt in 2017 (Bońda 2018). The only extracted deposit – Jawornik – is producing diatomite since 1992, mostly for use as a sorbent (Guzik 2014). Deposit is situated in Lower Miocene sedimentary sequence within Outer Carpathian belt (Figarska-Warchoł et al. 2015). Other nearby deposits have smaller amount of reserves/resources and are generally of lower quality (Kotlarczyk et al. 1986). Slovakia has 8.4 Mt of diatomite (total reserves) in three deposits, which are currently not exploited (Kúšik et al. eds. 2017). They originate in a Neogene lacustrine intra-volcanic basins (Kraus and Kužvart 1987; Vass 1998). No extraction was recorded in recent years in Austria (BMWFW 2017; Crangle 2018b) and Germany (D-EITI 2017; Crangle 2018b).

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DEVELOPMENT OF DIATOMITE PRODUCTION, RESERVES AND ITS PROCESSING IN THE CZECH REPUBLIC IN 1999–2018

Keywords

diatomite, miocene, processing, reserves, resources

Abstract

This paper aims to characterize and interpret the trends in reserves, resources, and mine production of diatomite in the Czech Republic in last two decades. With more than 2.4 million tonnes of total reserves, 1.6 million tonnes of exploitable (recoverable) reserves, and average annual production of 35 kt, diatomite is not one of the key industrial minerals of the Czech Republic, which ranks among the top 10 European producers. Historical diatomite deposits were situated within the Cheb Basin, where the Holocene Hájek diatomite deposit was abandoned in 1955 because of the establishment of the Soos National Natural Monument. The group of Tertiary diatomite deposits situated in the Central Bohemian Upland ceased extraction when the last deposit (Kučlín) was abandoned in 1966 after depletion of reserves. The last group of diatomite deposits is located within the Southern Bohemian basins, where the last productive deposit, Borovany-Ledenice, is situated. Miocene diatomites are extracted by open pit mining there. Production of crude diatomite varied from 0 to 83 kt, with an average of 35 kt, between 1999 and 2018 according to stockpiles. Raw diatomite is classified into two groups according to the chemical-technological properties. Better-quality diatomite ($SiO_2 \geq 72\%$, $Al_2O_3 \leq 15\%$, $Fe_2O_3 < 2.4\%$, bulk density 450 kg/m^3, loss on ignition < 8%) is processed for filtration in the food industry (brewery, wine, and raw fruit juices). Material with lower quality is used in combination with bentonite to prepare cat litter products.

PRODUKCJA, ZASOBY I PRZETWARZANIE ZIEMI OKRZEMKOWEJ W CZECHACH W LATACH 1999–2018

S ł o w a k l u c z o w e

ziemia okrzemkowa, miocen, przetwarzanie, rezerwy, zasoby

S t r e s z c z e n i e

Niniejszy artykuł ma na celu scharakteryzowanie i zinterpretowanie trendów dotyczących zasobów wydobywalnych i geologicznych oraz wydobycia ziemi okrzemkowej w Czechach w ciągu ostatnich dwóch dekad. Przy ponad 2,4 mln ton łącznych zasobów, 1,6 mln ton zasobów eksploatacyjnych (wydobywalnych) oraz średniej rocznej produkcji wynoszącej 35 tys. ton, ziemia okrzemkowa nie należy do kluczowych minerałów przemysłowych w Republice Czeskiej, która to plasuje się wśród 10 największych europejskich producentów tego surowca. Historyczne złoża ziemi okrzemkowej znajdowały się w obrębie Kotliny Chebskiej, gdzie w 1955 r. zamknięto holoceńskie złoże diatomitu Hájek, czego przyczyna było ustanowienie Narodowego rezerwatu przyrody Soos. Trzeciorzędowe złoża ziemi okrzemkowej Czeskiego Średniogórza zaprzestały wydobycia wraz z opuszczeniem ostatniego złoża (Kučlín) w roku 1966 wskutek wyczerpania zasobów. Ostatnia grupa złóż ziemi okrzemkowej znajduje się na terenie południowych kotlin czeskich, gdzie znajduje się ostatnie eksploatowane złoże Borovany-Ledenice. Mioceńskie diatomity są wydobywane w kopalni odkrywkowej. W latach 1999–2018, produkcja diatomitu wahała się, w zależności od zapasów, od 0 do 83 kt, przy średniej wynoszącej 35 kt. Surowa ziemia okrzemkowa dzieli się na dwie grupy zgodnie z właściwościami chemiczno-technologicznymi. Lepszy jakościowo diatomit ($SiO_2 \geq 72\%$, $Al_2O_3 \leq 15\%$, $Fe_2O_3 < 2,4\%$, gęstość nasypowa 450 kg/m^3, straty podczas prażenia <8%) jest przetwarzany i używany jako środek filtrujący w przemyśle spożywczym (browarnictwo, produkcja win i surowych soków owocowych). Surowca o niższej jakości używa się w połączeniu z bentonitem w procesie produkcji żwirku dla kotów.