The occurrence of clays in sedimentary complexes is significant namely in the Miocene, Paleogene, Carpathian flysch, autochthonous Oligocene, Jurassic, and Lower Carboniferous. Exceptionally high tectonic pressures were proved in Miocene trenches of the Vienna Basin, and are supposed also in allochthonous Paleogene complexes of the Flysch Carpathians and the Lower Carboniferous — the Culm. In the whole area of SE slopes of the Bohemian Massif hydrostatic pressures can be observed throughout the sedimentary complexes. It indirectly points to vertical — capillary connection of fluids closed in sediments. The theory of ions balance and chemical alteration of deep waters was based on Janák (1955). Diffusion processes give rise both to low- and higher-mineralized solutions, which differ in shift of δD values from the evaporated ones.

Conclusions

From the discussion several types of water can be presumed. The low-mineralized brines were primarily brackish waters with approx. 60—70 % marine water contents. The brines with mineralization of 35—50 g/l were originally marine waters concentrated by evaporation without any salt precipitation. Later these primary brines were diluted by infiltration of meteoric waters at different climatic stages. The low-mineralized brines with more positive δD values may in fact be hyperfiltrated primary brines. Only one of the waters studied was mineralized by evaporite dissolution.
Translated by G. Vladyková

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Abstrakt

V rámci prospekce ropoplynonosnosti JV svahů Českého masívu byly vzorkovány vody doprovázející ropu a plyn. Vody byly analyzovány chemicky a izotopicky (D,^{18}O). Podle mineralizace jde o formační vody naředěné srážkovými vodami. Rozsah zředění primárních solanek byl určen ze závislosti δD na δ ^{18}O. Porovnáním obsahů chloridů a izotopického složení deuteria bylo určeno složení primárních formačních roztoků. Jde o brakické solanky s obsahem cca 70 % mořské vody. Více mineralizované roztoky byly nakoncentrovány pouze odparem, ne rozpouštěním evaporitů. Zřeďování primárních solanek probíhalo v různých klimatických obdobích.

Zusammenfassung

Im Rahmen der Erdöl- und Erdgaserkundung an der SO-Abdachung der Böhmischen Masse wurden Proben von Erdöl- und Erdgasbegleitwässern entnommen. Es wurden ihre chemische Zusammensetzung und ihre Isotopenverhältnisse untersucht. Aufgrund des Mineralgehaltes handelt es sich um durch Niederschlagswasser verdünnte Formationswässer. Das Ausmaß der Verdünnung ursprünglicher Salzwässer wurde aus der Beziehung δD — δ^{18}O bestimmt. Aus dem Vergleich von Chloridgehalt und Wasserstoffisotopenverhältnis wurde die Zusammensetzung der ursprünglichen Formationswässer ermittelt. Es handelt sich um Brackwasser mit einem Meerwasseranteil von etwa 70 %. Für die Entstehung stärker mineralisierter Wässer sind ausschließlich Verdampfungsprozesse verantwortlich, nicht die Auflösung von Evaporiten. Die Verdünnung der ursprünglichen Salzwässer erfolgte während unterschiedlicher Klimastadien.

GENETIC TYPES OF THE KAOLIN DEPOSITS IN THE BOHEMIAN MASSIF

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Introduction

The deposits of kaolins of the Bohemian Massif (B. M.) belong (with exception of some non-economic occurrences of kaolins of hydrothermal or chemogenic origin) to the weathering type and, apart from the kaolins in the Inner Phyllites of Moravikum, have originated by kaolinization of the rocks rich in feldspars. The majority of these deposits are primary, however a very important volume of kaolins are redeposited. These secondary kaolins, represented by only two deposits (Kaznějov and Horní Bříza) probably experienced a short transport. Parent rocks of the primary kaolins of the B. M. are granitoids, metamorphites (orthogneisses to granulitic gneisses, paragneisses, phyllites), sediments (arkosic sandstones to arkoses, feldspar sands) and occasionally volcanites (Permo-Carboniferous). Kaolinization has occurred in two periods: 1, Carboniferous (Westphalian C — Stephanian) and 2, (Jurassic-) Cretaceous — Paleogene (-Middle Miocene). KÖSTER (1980) also mentioned kaolinization of Triassic age from the w. border of the B. M.

Geological summaries of the kaolin deposits of the ČSSR, were presented by KUŽVART (1969) and KUŽVART et al. (1983). Characteristics of the particular types of the deposits summarized in our paper come from the publications cited below. Newly, mineralogical studies (XRD, EDX, SEM) of 16 samples of kaolins taken from exploited or opened deposits of ČSSR were performed in the laboratories of the Institut für Baugeologie, Vienna. The results were studied from the point of view of the genesis of the deposits (Plates 1—4). Comparative material was taken from the Horná Prievrana deposit near Lučenec, the Carpathian Mts.

The location of the kaolin deposits of the B. M. are shown in Fig. 1. In the following text, the deposits are described according to particular genetic type, parent rock and regional geological positions. The proportion of different types with the raw material reserves and the extraction amount, production of the washed kaolins are shown in Fig. 2.

1.0 Primary (residual) kaolins of climatic weathering origin

1.1 Kaolinitic residuals of granitoids

1.1.1 The Karlovy Vary Massif

The Karlovy Vary region is a classical area of kaolins used for the production of porcelain. The kaolins represent residual kaolinitic weathering products of the surface portions of granites in the Sokolov Basin, with preserved original granitic texture. The climatic weathering origin is documented by the dependence of the depth of kaolinization to the fossil river course (KUŽVART et al., 1983). Kaolins originated in both the basic granite types — so called normal (or Mountain) type, and the finer autometamorphic (Erzgebirge) type. The type of the parent granite substantially influences the quality of the resulting kaolin. The deposits of the best quality originated from fine to medium-grained bright autometamorphic granite and the medium-grained two-mica facies of the normal granite. The parent granites are of Carboniferous age and the kaolinization has occurred continuously before and during the Paleogene; always with the same intensity (BABŮREK, 1970). The tectonically controlled extent of the preserved fossil weathering crust is 85 km². Kaolinization potentially reaches 50 m, occasionally 100 m, however the zone of completely kaolinitized phenocrysts of K-feldspar reaches only 20—30 m (KUŽVART et al., 1983). On the top of kaolins redeposited kaolinitic clays locally occur along with quartz sands and quartzites as well as Upper Oligocene to Miocene sediments.

In the whole region the complete typical kaolinitic weathering profile is preserved. Three zones of kaolinization are recognized (from top to bottom): 1, all feldspars are kaolinized, 2, cores of phenocrysts remain preserved, 3, cores of feldspars in the matrix are preserved. With depth the total porosity of the rock and the content of organic substance diminish. The relative polarity of the organic compounds (FALC, 1968) as well as the character of accessory minerals (KONTA, 1969) and trace elements (BABŮREK, 1971) also change. The very pronounced vertical zonality is disturbed locally by the intercalations of kaolins of lesser quality with illite and chlorite, within the profile. Primarily, different types of parent granites are concerned.

In the area, about 30 deposits of kaolins are known. Today, only the deposits Osmosa (Božíčany), Jimlíkov, Podlesí, Katzenholz (Otovice) and Hájek (Bystřice-Hroznětín) are extracted. From the non-extracted ones, the deposits of Bohemia, Brázda, Čankovská-Rybáře, Marta-Epiag, Mírová, Zátiší, Čapí Hnízdo, Ruprechtov, Smolnice, Nová Role, Vintířov, Ztracený rybník, Počerny-Stará Role etc., are mentioned. Most of the deposits are presently being geologically investigated. Kaolin from the terminated deposit Zettlitz (Sedlec) is a world standard of kaolin for the production of fine ceramics since 1924.

The petrography and geochemistry of the main parent rock of the kaolins were described by NEUŽIL and KONTA (1965), the petrography of kaolins from the particular deposits by BABŮREK et al. (1959), KONTA and MRÁZ (1965), KONTA (1968), KONTA and KOSCELNÍK (1968), KONTA (1975) etc. KONTA and KOSCELNÍK (l. c.) described nine petrographical types of primary kaolins that can be distinguished macroscopically: coarse-grained with biotite + muscovite; or only with muscovite; medium-grained with biotite + muscovite; or only with muscovite; fine-grained with rare muscovite (without tourmaline); fine-grained with frequent muscovite and tourmaline; very fine-grained (with muscovite); large feldspar pseudomorphs after feldspar; and fine-grained type without micas (only with quartz). The redeposited kaolin in the top is fine-grained and contains quartz and muscovite. The kaolinitic residuals in the Karlovy Vary region contain 20—30 %, occasionally (Ti-kaolins) up to 35—40 % of the washable kaolin amount.

The raw kaolins contain, apart of the clay fraction, grains of the primary minerals of parent granites: quartz (in the top portions of the deposits chemically corroded and rounded), muscovite and biotite. Siderite originates from the cement. From accessory minerals, the most frequent ones are primary tourmaline and zircon, and secondary pyrite, anatas, rutile and oxidic Fe minerals (maghemite, hematite, goethite). With the depth of kaolinization, siderite prevails over pyrite, and, within the Ti minerals, rutile diminishes; tourmaline, with the colour reduced to green one in the upper parts, remains brown (KONTA, 1969).

Among the clay minerals kaolinite (95 %) prevails. It is nearly the pM type, rarely the T type (in the Jimlíkov deposit; KONTA, 1975). Illite is omnipresent (5—10 %) and its amount rises with depth. Montmorillonite is always absent, but is an accessory mineral at the base of the profile.

XRD	TOTAL MINERAL CONTENT		CLAY MINERAL CONTENT <2 μm	
Božíčany-Osmosa				
Kaolin A	Quartz	+++	Kaolinite	81 %
	Muscovite	++	Fire Clay	19 %
	Kaolinite	+++	Illite	Tr.
Weathered Granite	Quartz	+++	Kaolinite	78 %
	Feldspar	+++	Fire Clay	22 %
	Muscovite	+	Illite	Tr.
	Kaolinite	+		
Granite	Quartz	+++	Kaolinite	74 %
	Feldspar	+++	Fire Clay	26 %
	Muscovite	+	Illite	Tr.
Aplite	Quartz	+++	Kaolinite	70 %
	Feldspar	+++	Fire Clay	30 %
	Muscovite	+	Illite	Tr.
	Kaolinite	+		
Jimlíkov				
Weathered Granite	Quartz	+++	Kaolinite	76 %
	Muscovite	+++	Fire Clay	24 %
	Kaolinite	+++	Illite	Tr.
Kaolin B	Quartz		Kaolinite	97 %
	Muscovite		Fire Clay	3 %
	Feldspar		Illite	Tr. %
	Kaolinite			
Podlesí				
Kaolin C	Quartz		Kaolinite	83 %
	Muscovite		Fire Clay	17 %
	Feldspar		Illite	Tr. %
	Kaolinite			
Otovice-Katzenholz				
Kaolin D	Quartz		Kaolinite	75 %
	Muscovite		Fire Clay	25 %
	Kaolinite		Illite	Tr.
Hájek (Hroznětín)				
Kaolin E—1	Quartz		Kaolinite	92 %
	Muscovite		Fire Clay	8 %
	Kaolinite		Illite	Tr.
Kaolin E—2	Quartz	+++	Kaolinite	90 %
	Kaolinite	+++	Fire Clay	10 %
	Muscovite	Tr.	Illite	Tr.
			Halloysite	Tr.

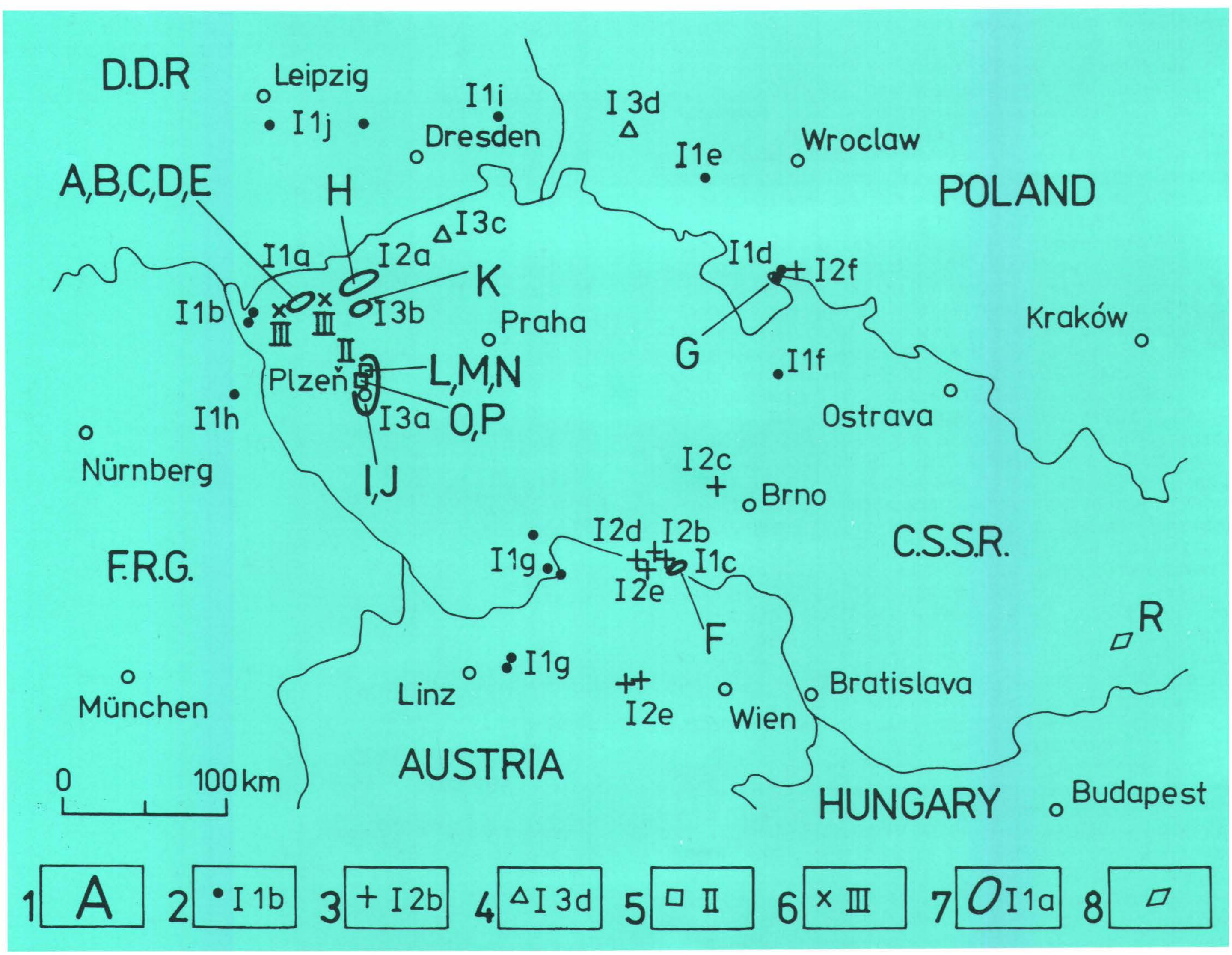
Mineralogically (XRD, SEM) we have newly studied samples of all the deposits exploited (Božíčany-Osmosa, Jimlíkov, Podlesí, Otovice-Katzenholz, Hájek). (Plates 1—1 to 1—6 and 2—1 to 2—4.)

The parent granites of the Karlovy Vary kaolins are poor in colouring oxides (Fe_2O_3, FeO, TiO_2). This is a very important condition of the origin of very good quality kaolins. FeO is present in illite, Fe_2O_3 in oxidic Fe minerals. Industrially, two types of kaolins are distinguished: kaolin for fine ceramics with TiO_2 below 0.4 %, and the so-called titanic kaolin with TiO_2 = 0.4—0.7 %. The parent rock of the kaolins was primarily rich in Ti (in biotite). We must distinguish among them kaolins that are perfectly kaolinized and highly white ones, and the little kaolinized ones with illite and chloritized biotite (FRANČE et al., 1973). The source of trace elements within the kaolins was principally biotite of the parent granites. The amount of the elements Ti, V, Cu, Sr, Ba etc. rises with the grade of kaolinization (BABŮREK, 1970, 1971). Mn was concentrated in oxidizing conditions of the upper parts of the profiles (Božíčany, Hroznětín) while Cr in reduction conditions of the lower parts (Sedlec).

A most characteristic feature of the Karlovy Vary kaolins from the technological point of view is the high strength in green state (after drying), excellent moulding properties, white colour after firing and transparency of the fired products — all this is appreciated in fine ceramics (porcelain). Ti kaolins of an enormously high whiteness in green state, exceeding 90 % of the ideal scale, can be used as a filler in paper industry as well as in rubber, cosmetics, plastics etc., as a raw material to produce mullite grog, in electroceramics and sanitary ceramics. When used as coating kaolins in the paper industry, they show rather worse rheological properties in comparison with the kaolins from Kaznějov (2.1.1). They are exploited only in the Otovice-Katzenholz deposit even if they represent great portion of the reserves of kaolins in the area.

1.1.2 The Smrčiny Massif (Fichtelgebirge)

The muscovite granite of the massif with a low content of colouring oxides, also of Carboniferous age, similar to the granites of the Karlovy Vary massif, suffered climatic kaolinization in the Cretaceous to Paleogene age. In comparison with the former, we know here only a limited number of



1. Sketch location of kaolin deposits of the Bohemian Massif
1 — samples under study; 2 — kaolins over granites (I1b — Smrčiny, Fichtelgebirge Massif; I1d — Žulová Massif; I1e — Strzegom Massif; I1f — Šumperk Massif; I1g — Moldanubian Pluton; I1h — Falkenberg Massif; I1i — Lužice, Lausitzer Massif; I1j — rhyolites); 3 — kaolins over metamorphites (I2b — Bíteš, Bitescher Orthogneiss; I2c — Svratka Orthogneiss; I2d — Inner Phyllites of Moravicum; I2e — Orthogneisses and granulites of Moldanubicum; I2f — Mantle of the Žulová Massif); 4 — kaolins over feldspar sediments (I3c — Zálezly; I3d — North-Sudetian Depression); 5 — secondary (redeposited) kaolins (Kaznějov, Horní Bříza); 6 — other genetic types (Sokolov Basin, Kyselka); 7 — greater kaolin areas (I1a — Karlovy Vary Massif; I1c — Dyje, Thaya Massif; I2a — Krušné hory, Erzgebirge Crystalline Complex; I3a — Plzeň Basin; I3b — Podbořany area); 8 — Carpathian kaolins (Horní Prievrana)

deposits: in the outcropping part of the massif, the deposits were denuded and served as a source material of the Tertiary sediments of the Cheb basin, which may cover some unknown deposits. Deposits are known from the border of granites with basin sediments, a finished deposit at Lomany near Cheb and several deposits near Plesná and Velký Luh. The primary position of the kaolins is documented by the existence of a zonal kaolin profile (BYLOVÁ et al., 1976, ŠINDELÁŘ, 1979) of a 30—60 m thickness. Maximum thickness of the quality kaolins is only 4 m.

The kaolin raw material is petrographically sandy- to clayey-sandy residual (ŠINDELÁŘ, 1979). Apart from the clay substance, it contains quartz and relics of feldspars, in the lower portions sericite (originated from feldspars), and of the accessories, tourmaline, secondary calcite, andalusite, sphene, zircon and chlorite. Washed kaolin amount varies from 10—25 %. In the clay substance kaolinite prevails over a mica mineral whose quantity rises with depth (BYLOVÁ et al., 1976). The crystallinity of kaolinite represents nearly the T type (index according to Hincley = 1.04—1.50). The kaolin of the Plesná deposit was appreciated as a filler material for paper industry.

1.1.3 The Dyje (Thaya) Massif

Deposits of kaolins are kaolinitic residuals of granitoids of the Proterozoic age, mostly of the mylonitized and partly cleaved leucocratic biotite-(muscovite) granodiorite. To a lesser extent the relics of the cover of the massif (hornblende diorite, migmatitized para- and orthogneisses) were also kaolinized. A kaolin of higher quality has originated from pegmatites and aplites. The kaolinization happened before Tertiary sedimentation (Cretaceous-Paleogene). Its intensity rapidly diminishes with depth (a primary weathering profile). The kaolinization process was made easier by the Variscan dynamometamorphosis (cataclasis, mylonitization). Young tectonics influenced the preservation of the deposits in depressed blocks. The preserved portions represent mostly only the lower parts of the kaolin profile (thickness of 5—13 m). The kaolins of the upper parts were redeposited in the Paleocene to Eocene. The cover of the deposits form Oligocene to Lower Miocene sediments (1—18 m) and Quarternary loess (4—6 m).

Deposits are concentrated in the surroundings of Únanov and Mašovice (Únanov, Tvořihráz, Liščí Díra, Mašovice, Mašovice-Hradiště, Přímětice, Podmolí etc.). Only the deposit Únanov-North is being exploited. In Austria lies the deposit Niederfladnitz, covered by redeposited kaolinitic sands (WIEDEN, 1978).

Petrographically, the kaolins are feldspar-quartz-kaolinite residual (BATÍK et al., 1979). They contain in average 33 % quartz, 12 % (6—20 %) alkali feldspar, and 55 % of the clay substance. Locally, biotite is present. The spectrum of accessoric heavy minerals is very varied thanks to the varied parent substrate; nevertheless, their contents are very low (pyroxenes, amphiboles, zircon, monazite, kyanite, sillimanite, andalusite, chlorite, muscovite, ilmenite, rutile, brookit, anatase, garnet, pyrite, sphene, tourmaline, staurolite, baryte, apatite, hematite, spinel, epidote, limonite, Mn-oxides, leucoxene, siderite, and other carbonates). Washed kaolin amount reaches 15—49 %.

In the clay substance, kaolinite prevails (37.5—87 %) apart from an admixture of illite (2-18.5 %) which unfortunately raises the FeO content. In various samples, halloysite was identified, and sometimes chlorite. Montmorillonite is present only in the upper redeposited kaolins (up to 9 % of the total content of clay minerals; PAVLÍK, 1987). The kaolinite is of low crystallinity (the 1 pM type). The crystallinity index after Hincley rises with the intensity of kaolinization (0.24—0.78; NEUŽIL and KUŽVART, 1972; NEUŽIL et al., 1980). Newly, we have mineralogically (XRD, SEM) studied a sample from the Tvořihráz deposit (Plate 2—5).

Tvořihráz

Kaolin F	Quartz	Kaolinite	73 %
	Muscovite	Fire Clay	17 %
	Feldspar	Illite	10 %
	Kaolinite	Halloysite	Tr. %
		Mixed Layer	Tr. %

The modes of use of the kaolins of the Thaya massif are substantially limited by the variability of the parent rocks. The reserves of kaolins with relics of non-kaolinized feldspars exceed the reserves of perfectly kaolinized rocks by 15 times. The latter can be used — after dressing — as a filler in paper industry (Únanov, Mašovice-Hradiště). Most of the feldspar kaolins (even if their washed kaolin amount is high enough) do not suit the norms not only because of their elevated contents of Fe which elevates the colouring and reduces whiteness, but also because of their low strength in green state (after drying), low refractoriness, and high content of the rubber poisons (Cu, Mn). In the green state, without dressing, they can be used after milling and homogenization in sanitary and utility ceramics.

1.1.4 The Žulová Massif

A deposit of kaolin originated by weathering of the Carboniferous medium- to coarse-grained biotite granite is known from Vidnava, and from Biskupów in Poland. The Vidnava deposit was exploited in the past; recently, an investigation is being performed. The deposit is very variable and apart from the white kaolins, it is composed of the red (with admixture of goethite) and the green ones (with admixture of chlorite). Thickness of kaolinization reaches 40 m while thickness of industrial kaolins only 13 m. In the cover, Miocene clays (up to 10 m) and Quarternary sands (redeposited granite eluvials, up to 20 m) are developed. The washed kaolin amount is 16-25 %. We have mineralogically (XRD, SEM) studied a sample of white kaolin from Vidnava (Plate 2—6).

Vidnava

White kaolin G	Quartz	Kaolinite	95 %
	Muscovite	Fire Clay	5 %
	Kaolinite	Illite	Tr. %

The Vidnava kaolins are good products. The white kaolins can be used in the paper industry (filling as well as coating kaolin) and rubber industry, the coloured types can be used in ceramics (refractories, tiles).

1.1.5 The Strzegom Massif

In Poland, several kaolin deposits are known from the surroundings of Zarów and Bolesławice, originated from the Carboniferous two-mica granite of the Strzegom-Sobótka Massif. The thickness of kaolinization is 50—80 m. The age of the kaolinization is Paleogene. In the cover of the kaolins Upper Miocene clays are present (GAWRONSKI and KOZYDRA, 1968).

A primary position is documented by the preserved original granitic textures. The kaolins are used for the production of refractories.

1.1.6 The Šumperk Massif

The biotite granodiorite of the Carboniferous age was kaolinized near Bludov. The resulting kaolin is of a low quality. The washed kaolin amount reaches occasionally 13 % (KAMENSKÝ, 1973).

1.1.7 The Moldanubian Pluton

The supposed kaolin weathering crust developed on the Moldanubian block was denuded after its uplift by the end of Miocene. Some relics covered by younger sediments are preserved (e. g. by the Klikov group of beds of the Senonian age). Kaolinization occurred probably in the Carboniferous or Lower Cretaceous.

Near Kolenec-Pecák, medium- to finely-grained two mica granite of the Mrákotín type (a facies of the Eisgarn type granite) was kaolinized up to the depth of 10 m. The age of the parent granite is Carboniferous. The thickness of cover (the Klikov group of beds) is 20 m. The kaolin has a low whiteness and refractoriness (KUŽVART et al., 1983). A similar but smaller deposit is known below the cover of the Klikov group of beds near Klikov. Medium-grained Číměř facies of the Eisgarn type granite was kaolinized in this case. The kaolins of both the deposits are suitable for ceramic production. WIEDEN (1978) mentioned kaolinization of the Eisgarn granite a short distance from here, in Gramastetten near Gmünd in Austria. The deposit is covered by redeposited clays.

A tectonically depressed block of the Pre-Oligocene weathering crust over the Variscan Mauthausen type granite, with a cover of Oligocene sands and clays, is known from Kriechbaum and Weinzierl near Schwertberg, Austria (KIRNBAUER, 1965; WIEDEN, 1978). A preserved transition into non-kaolinized granite prooves the primary position of the kaolins and the climatic weathering origin. The thickness of kaolins reaches 4—30 m, the deposits are up to 1.3 km long. Because of the thick Tertiary cover (up to 120 m), the deposit is mined by means of galleries. Indices of kaolins are known also from the neighbouring Weinsberg type granite. The raw kaolin from Kriechbaum is formed (WIEDEN, l. c.) by quartz, relics of feldspars, muscovite, accessoric heavy minerals, and up to 47 % of the clay substance (kaolinite + 1—3 % of illite). An admixture of halloysite was confirmed. The washed kaolin amount (in this case represented by the fraction below 35 μm) is 50 %. The 80 % of the kaolins are used as a filler in the paper industry (whiteness of up to 79 % of MgO), the rest in ceramics.

1.1.8 The Falkenberg Massif

Deposits of kaolin originated by kaolinization of the biotite-muscovite granite of the Moldanubicum of the Český Les Mts., are known from Tirschenreuth and Schönheid in the F.R.G. (KÖSTER, 1974, 1980). While plagioclase and biotite were kaolinized completely, the K-feldspar and muscovite remain rather fresh. This result is being caused by climatic weathering in situ. The heavy minerals, tourmaline, andalusite and ilmenite, and, in a smaller amount beryl, apatite and spinel are present. The clay substance contains (apart from kaolinite) an admixture of a I—M mixed layer mineral. From traces, rather elevated amounts of Pb, Cu, Cr, Ni, P and Ti were confirmed. The kaolinite — K-feldspar raw material is being used as so called "pegmatite" in the ceramic industry.

1.1.9 The Lužice (Lausitzer) Massif

Granodiorite of the massif was kaolinized near Caminau (n. of Bautzen) in the G.D.R. and the Rumburk-type granite near Turów in Poland. The age of the kaolinization is probably Tertiary (STÖRR et al., 1968 a, b). The clay substance is formed by 90 % kaolinite and 10 % illite. The kaolin is used in the building ceramics and refractories.

1.1.10 Rhyolites

Kaolinization (or better clayey weathering) of rhyolites of Carboniferous age is known from the nw. periphery of the B. M. from Saxonia (G.D.R.). The age of the weathering is probably Tertiary (STÖRR et al., 1968 a). The rhyolite from Kemmlitz (the Rochlitz body) gives rise to a kaolin of about 50—79 % kaolinite and 5—30 % of a IM mixed layer mineral. The raw material of the Seilitz deposit near Meissen (the Dobritz body) can hardly be called a "kaolin": it contains 43 % of a IM mixed layer mineral and only 38 % kaolinite (apart from quartz). The kaolinized rhyolites are used in the building and refractory ceramics.

1.2 Kaolinitic residuals of metamorphics

1.2.1 The Krušné hory (Erzgebirge) Crystalline Complex

A kaolin weathering crust is preserved only in the depressed area of the North Bohemian Tertiary basins, where it was covered by their sediments. The outcrops of kaolin deposits are known only from the nw. border of the Chomutov-Pětipsy Basin, and from the Střezov ridge that separates the Kadaň and Pětipsy local basins. The deposits form two parallel belts in SW—NE direction. Parent rocks of the kaolin were various metamorphics rich in feldspars, mostly the fine-grained biotite granulitic orthogneiss of the Ohře (Eger) type (Kadaň, Klášterec n. Ohří, Mikulovice, Pruněřov, Kralupy u Chomutova, Horní Ves, Chomutov, Vlkáň, Krásný Dvoreček, Rokle) and leaky orthogneiss (Zásada, Černovice, Spořice-Brány, Prahly, Tušimice-Libouš) and mica schist (Jirkov, Březenec, Vysoká Pec). The parent metamorphics are of the Precambrian age and were kaolinized in several periods (CÍLEK, 1964): before the Carboniferous, during the Carboniferous, Cretaceous, Oligocene and Miocene. Kaolinization reaches the depth of 10—30 m (occasionally up to 64 m), but the upper 4 m are formed by a secondary coloured red kaolin (below a cap of Tertiary volcanoclastics). The primary position is proved by a preserved weathering profile with a 5 m thick transition zone. Weakened kaolinization is accompanied by diminishing washed kaolin amounts (NEUŽIL, 1970). A part of the kaolins was redeposited during Lower Turonian, Medium Oligocene, and Miocene (CÍLEK, l. c.).

The deposits of Klášterec, Mikulovice, Kralupy, Pruněřov, Zásada, Černovice, Spořice-Brány, Chomutov, Horní Ves and Jirkov have originated in the n. belt (border of the basin); the deposits of Vlkáň, Krásný Dvoreček, Rokle, Kadaň, Prahly and Tušimice-Libouš in the s. belt (the Střezov ridge). The deposits of Klášterec and Prahly were exploited in the past. Today the deposit Kadaň is nearly worked out and the deposit Rokle is being prepared for extraction.

The granulitic orthogneiss of the Ohře type, the parent rock of all the most important deposits of the area, is very rich in feldspars (56,6 % including 3/4 parts of K-feldspars), that is a very important pre-condition for rich kaolins (washed kaolin amount = 25—40 %). The raw kaolin contains about 35 % quartz, whitened biotite, and, in the lower parts, relics of feldspars. Among the accessories, kyanite, rutile, garnet, zircon and apatite are present. The clay substance is formed by well crystallized kaolinite (nearly the T type) with an admixture of illite (from biotite) and chlorite (from garnet).

Newly, we have mineralogically studied (XRD, SEM) kaolin from the Rokle deposit (Plate 3—1).

Rokle

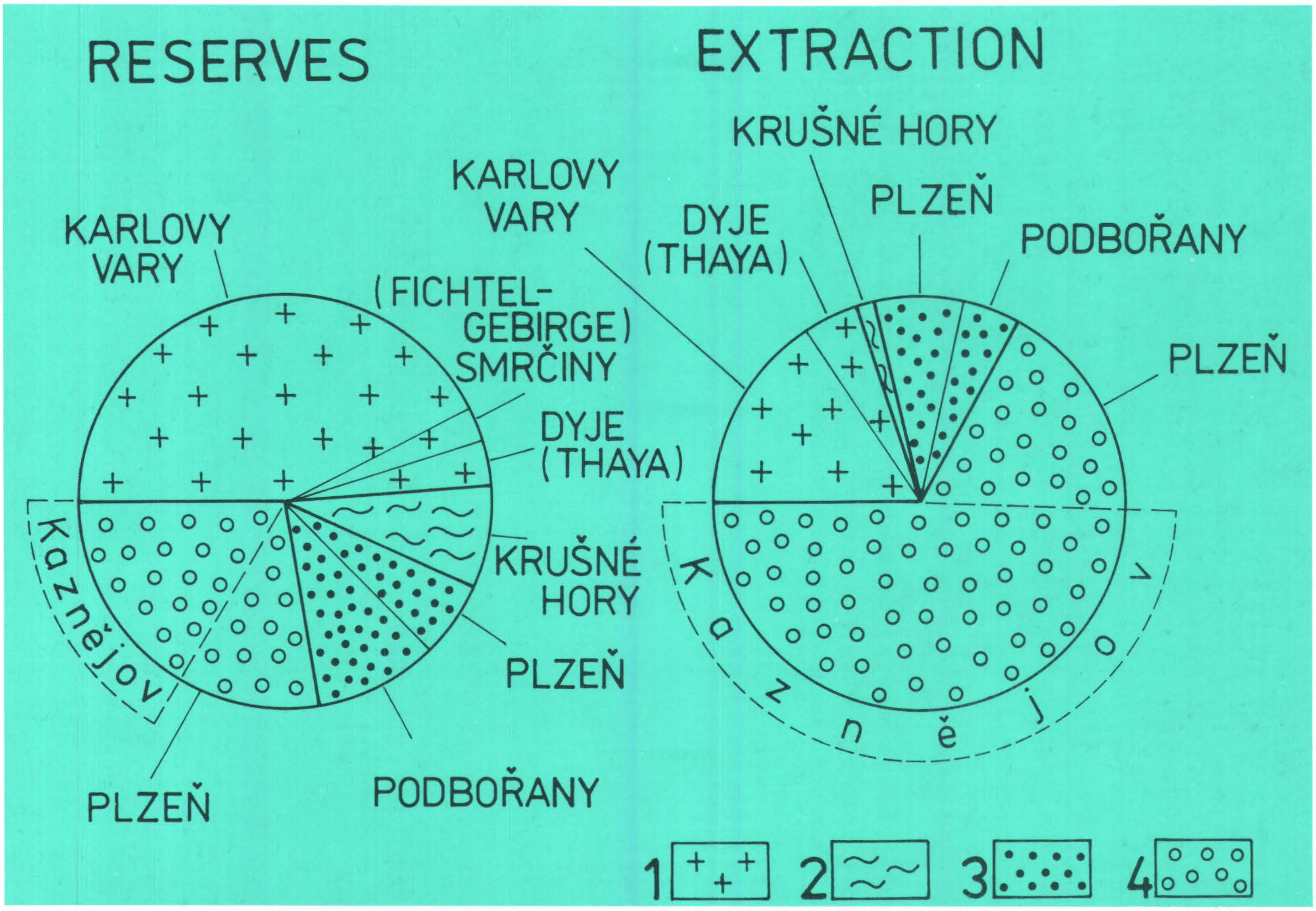
Kaolin H	Quartz	+++	Kaolinite	81 %
	Muscovite	+	Fire Clay	19 %
	Kaolinite	++	Illite	Tr. %
	Alunit	(?)		

Kaolin of the Kadaň area is mostly used as a filler in the paper industry, somewhat for ceramics. The kaolin from Vlkáň, thanks to its high whiteness and excellent rheological properties, can be used as a coating paper kaolin.

Recently, a new kaolin occurrence was encountered in a borehole near Budov, some 27 km s. of Kadaň. The parent rocks of the kaolin are mica-schists to paragneisses of the Barrandian Proterozoic. The kaolinite is close to the T type.

1.2.2 The Bíteš (Bitescher) Orthogneiss

Weathering crusts, developed on the Bíteš Orthogneiss of the Proterozoic age, are preserved as small relics in the area of ČSSR and Austria. In Czechoslovakia, only the deposit Plenkovice, and several occurrences near Žerůtky, Horní Břečkov and Hluboké Mašůvky, are known (KUŽVART et al., 1983). In Austria, only the deposit Mallersbach,



2. Proportion of reserves (left) and annual extraction (right) of the kaolins of the Bohemian Massif according to the particular genetic types and main areas of their occurrences
1 — kaolins over granites; 2 — kaolins over metamorphites;
3 — kaolins over feldspar sediments; 4 — secondary (redeposited) kaolins

formed by two small lenses of kaolins, exists (SCHERMANN, 1968; WIEDEN, 1978). The kaolins keep their original structure inherited from the parent rocks and, similarly as the deposits of the Thaya Massif, they are of in situ weathering origin. Equally, the age of kaolinization is Cretaceous to Paleogene. The underlying rock of the deposit Plenkovice is a mylonitized to phyllonitized orthogneiss; that is the reason why the kaolinitization grade seems to be of higher intensity in depth. WIEDEN (l. c.) considers the origin of the deposit Mallersbach as hydrothermal; evidently, it is also of the climatic weathering origin (montmorillonite forms only thin fillings of faults). Both the deposits have the NE—NNE direction and they are limited by the faults of the same direction accompanied by mylonitization. The origin of the Plenkovice deposit was enabled by tectonical fracturation of the parent rock in the tectonic contact with the Inner Phyllites (thickness of kaolin 10—50 m, max. up to 81 m).

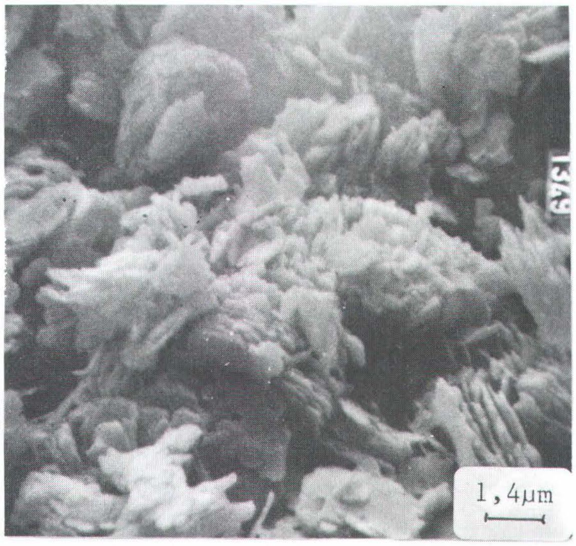
The raw kaolin is formed by 42 % quartz and relics of fresh feldspars, 8 % micas (partly newly formed), accessories, and 50 % clay substance. In the clay substance kaolinite prevails with an admixture of halloysite and mixed layer mineral. The finest fraction of the kaolins (below 1 μm) is constantly rich in CaO in the form of a calcite admixture (KLEMENT and BABŮREK, 1968). Washed kaolin amount reaches 26 % (Plenkovice) up to 51 % (Mallersbach). The kaolin from Mallersbach is occasionally used in ceramics while that of Plenkovice forms reserves for refractory production.

1.2.3 The Svratka Orthogneiss

Kaolinization of phyllonitized granodiorite is known from the contact with the Inner Phyllites. A small deposit extracted in the past near Lažánky (w. of Brno) originated by weathering of phyllonitized Proterozoic metagranites (cataclastic biotite orthogneiss) in a tectonic contact with Devonian limestones. The thickness of kaolins is 10—40 m, covered by 5—8 m of Miocene clays. The total thickness of the zone of kaolinization exceeds 113 m. Apart from kaolinite (nearly the PM type), illite and admixtures of montmorillonite and IM mixed layer mineral are present, more quartz and sericite in the raw material (NEUŽIL and KUŽVART, 1976). The washed kaolin amount reaches 25 %. The kaolin was used in paper and stoneware production.

1.2.4 The Inner Phyllites of Moravicum

REICHELT and NEUŽIL (1973) mentioned three occurrences of kaolins near Kasárny, w. of Únanov. Genetical relations to the deposits of the Thaya massif, Bitescher and Svratka orthogneisses, are evident. The parent rock is sericite- to chlorite-sericite phyllite. The age of kaolinization is probably Tertiary. The thickness of the residual kaolins is 20—40 m. They contain well crystallized T type kaolinite (originated from sericite!), chlorite, pyrite, and accessoric rutile and tourmaline. Washed kaolin amount varies between 22 and 58 %, but the quality of the kaolin is very low



Osmosa (Božíčany) deposit, 1.1.1

Fig. 1: Typical in situ weathering evidenced by kaolin books; single plates show rounded and thickened rims (kaolin A).

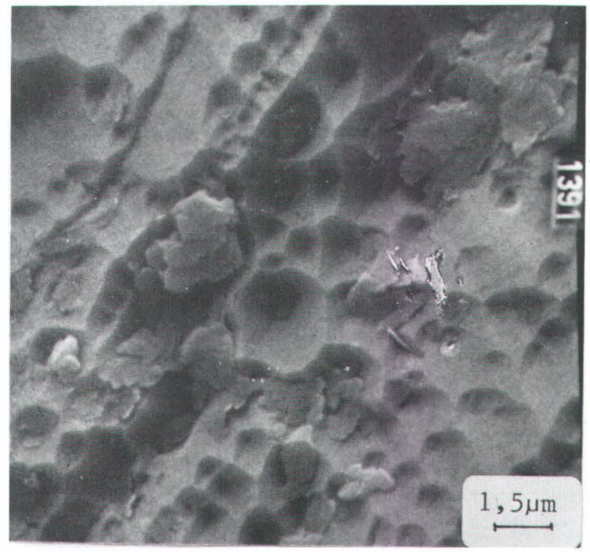


Fig. 2: Surface of strongly weathered quartz grain showing etched pits (kaolin A).

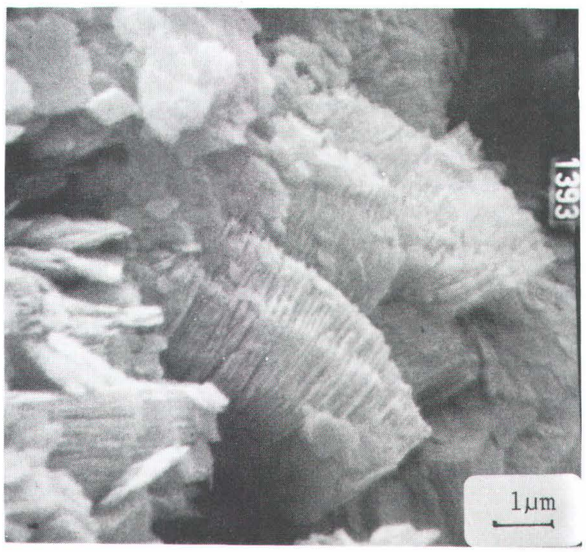


Fig. 3: Kaolinite with vermicular and booked growth (weathered granite).

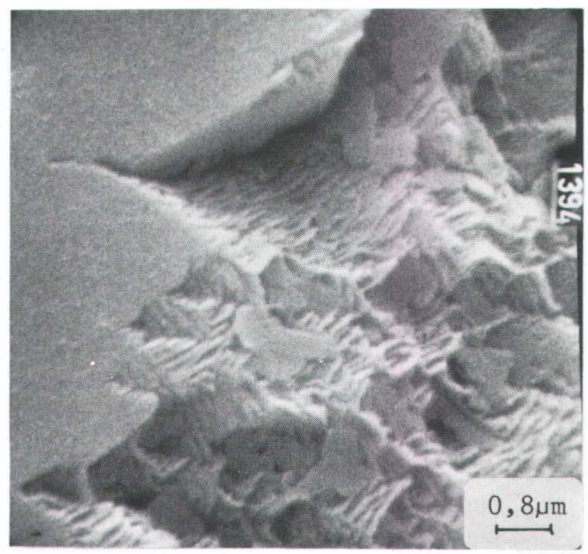


Fig. 4: Twinned feldspar grain with heringbone pattern formed by pseudomorphs of kaolinite (parent granite).

Fig. 5: Stacks of kaolinite with idiomorphic pseudohexagonal crystals (parent granite).

Jimlíkov deposit, 1.1.1.

Fig. 6: The microfabric indicates irregular distribution of predominating single plates together with some aggregates of kaolinite (rounded and thickened rims are characteristic similar to the Osmosa samples, see Fig. 1) (kaolin B).

because of high content of colouring oxides and pyrite that weathers to limonite.

1.2.5 Orthogneisses and granulites of Moldanubicum

Kaolinitic weathering crust after the uplift of the Moldanubian block in the Upper Miocene is preserved only in relics in bordering tectonically elongated blocks, for example in the border of Moldanubicum and Moravicum near Petřín and Lančov, where orthogneisses of the Gföhl type (KUŽVART et al., 1983) are developed.

Pure kaolinitic weathering products of granulites in situ are known from Unter Wölbling in Austria. They are purplish kaolins with limonitic spots, used as moulding clays in foundries. As a cover, Tertiary redeposited clays and sands with a bed of coal occur.

South of the Danube River, a new deposit was discovered near Karlstetten, ne. to St. Pölten, originated also by in situ climatic weathering from granulites (MÜLLER, SCHERMANN, SCHWAIGHOFER, 1983). The deposit is covered by Upper Oligocene sediments. Mineralogically, the clay substance is formed exclusively by halloysite. The washed halloysite amount (below 20 μm) is 97—100 %; an admixture forms illite (3 %) and traces of kaolinite.

1.2.6 Mantle of the Žulová Massif

In Poland, near Wyszonowice, the Devonian paragneiss of the mantle of the Carboniferous Strzelin-Žulová Massif is kaolinized to a depth of 40—50 m (GAWRONSKY and KOZYDRA, 1968). As in the case of the kaolins developed on the granites (Vidnava, 1.1.4), the kaolins are also of varying colours: red, greenish and white. The age of the kaolinization is Paleogene; the deposits are covered by the Upper Miocene sediments (10—80 m).

1.3 Kaolinized feldspar sediments (arkoses)

1.3.1 Kaolinized arkoses and arkosic sandstones of the Plzeň Basin

The sediments of the Middle-Bohemian Upper Carboniferous (Westphalian B—C — Stephanian C) represent an innermountain molasse of the Variscan mountains in the stream- and river-lake facies, typical for its mass occurrence of arkosic sediments. Great part of feldspars of the sediments are rather weathered and partly kaolinized (mostly plagioclase). The kaolin deposits have originated only in the westernmost Plzeň basin and sourrounding separated small basins (Tymákov, Kyšice). Indices of kaolins are also known from the Manětín basin. The thickness of the kaolins of this type reaches about 30 m. The deposits occur in all the four formations of the basins: the Kladno F. (but only in its upper beds — the Nýřany Beds, Westphalian D: Orlík, Ledce, Chlumčany, Obora and Tymákov deposits), the Týnec F. (Stephanian A: Chotíkov, Sokolka, Lité, Lomnička, Mrtník, Nekmíř, Žilov, Nevřeň), the Slaný F. (Stephanian B: the Ledce-Chotíkov area) and the Líně F. (Stephanian C: Chotíkov A and B deposits, Líně-Moguntia). Most of the deposits are situated in the Týnec Formation where some portions of them were redeposited to give rise to new deposits (type 2.1.1: Kaznějov, Horní Bříza). Some redeposition might have occurred also in other deposits; they are not exploited. All the deposits of the Týnec Formation occur in the n. part of the basin in the axes of two confluencing ancient streams (PEŠEK, 1968). The occurrence of pseudomorphs of kaolinite after feldspar (Lomnička, Mrtník, Kaznějov, Nekmíř, surroundings of Horní Bříza) are not unambiguous proofs because their kaolinitization might occur even after sedimentation of a clastic material with kaolinite cement. The kaolinization of feldspars was surely going on in the course of transport and sedimentation as well as after sedimentation (both directly after the deposition and during the Cretaceous-Miocene period in the outcrops of the rocks).

Because in this type of kaolin deposits no weathering profile can be developed (opposite to the type of granitic kaolins), the mode of genesis is very difficult to ascertain. The primary position can be confirmed only where outcrops of arkosic sediments were kaolinized in younger periods so that the underlying kaolins pass through the zone of kaolins with preserved feldspars to fresh arkoses. This postsedimentary kaolinization gave origin to the deposits in the Kladno Formation (Chlumčany: KNAPP et al., 1968; Chotíkov, Ledce, Líně-Moguntia). In the uppermost parts of the Chlumčany deposit however some redeposition of the kaolinized material already occurred, as shown from the SEM photographs (Plate 3—3), probably on a short distance. A new proof of the late postsedimentary kaolinization gives a small occurrence near Kyšice where arkoses of the Kladno Formation formed a small island during the Tertiary lake sedimentation (exploited deposit of ceramic clays) and were kaolinized to highly white kaolins; the intensity of their kaolinization substantially decreases with depth. Other proofs of the postsedimentary kaolinization are given by KUŽVART et al. (1975): preserved relics of kaolinized rocks and leucoxenic rims of ilmenite — both of them could not suffer a long transport; an occurrence of a kaolinized bed of tuff in fresh arkoses near Řevničov, etc.

Today, only the Chlumčany deposit is exploited. In some deposits extraction was terminated in the past (Ledce, Orlík). The rest of the deposits are not extracted, although small scale extraction may have occurred in the past.

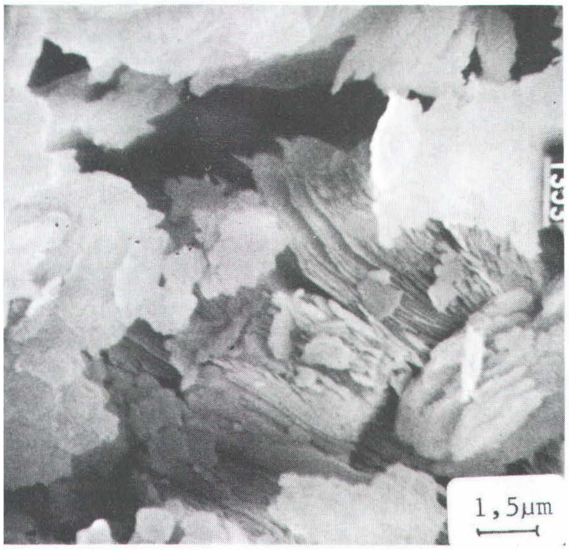
The primary kaolins of the Plzeň basin petrographically represent kaolinized arkosic sediments (arkoses, arkosic conglomerates, sandstones and siltstones). They contain 50—60 % quartz. The provenance area of the sedimentary material was very wide and it resulted in mixing of material of varied origin. The best proof of the provenance of the sedimentary material is the character of heavy minerals (andalusite, kyanite, staurolite, epidote, garnet, ilmenite, rutile, anatas, leucoxen, siderite, zircon, monazite, xenotime) and of the fragments of rocks in coarser fractions (granitoids, hornfelses, quartzites, silicites). The feldspar material mostly comes from adjacent Pre-Carboniferous granitoids (the Louny- and the Stod massifs).

In the clay substance, kaolinite prevails (well crystallized, type T; KUŽVART et al., 1975), locally with a small admixture of illite. In the Ledce kaolin, BABŮREK and STÖRR (1966) identified — apart from kaolinite — illite, I—M—CH mixed layer mineral, montmorillonite, chlorite, feldspar, quartz, and an amorphous silica form. The washed kaolin amounts vary between 15 and 25 %.

We performed a new mineralogical study (XRD, SEM) with two samples from the Chlumčany deposit — one sample from the base of the deposit (so called feldspar kaolin), and the other from the uppermost exploited part (Plate 3—3 to 3—6).

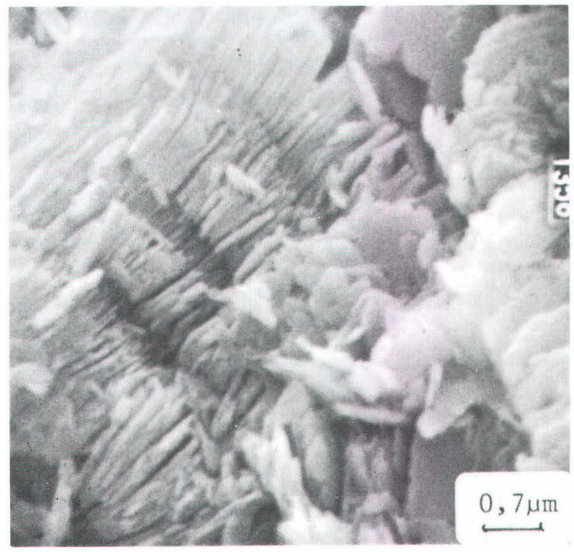
Chlumčany				
Kaolin I	Quartz	+ + +	Kaolinite	78 %
	Muscovite	+	Fire Clay	22 %
	Kaolinite	+ +	Illite	Tr.
	Feldspar	Tr.		
Feldspar kaolin J	Quartz	+ + +	Kaolinite	71 %
	Muscovite	+	Fire Clay	29 %
	Kaolinite	+	Illite	Tr.
	Feldspar	+ +		

The kaolins of the primary deposits of the Plzeň basin are used thanks to their high whiteness as fillers in paper industry; some part is used in ceramics (tiles). A special type of the raw material is represented by the "feldspar kaolins" or "pegraf" from the bases of the kaolin profiles (Chlumčany, Tymákov).



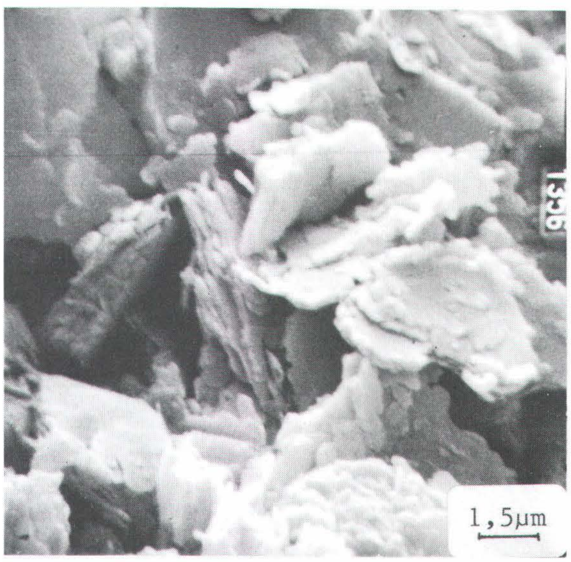
Podlesí deposit, 1.1.1.

Fig. 1: Stacks of kaolinite together with strongly rounded and thickened single plates (kaolin C).



Otovice (Katzenholz) deposit, 1.1.1.

Fig. 2: Book-like aggregates with rounded single plates of kaolinite (kaolin D).



Hájek (Hroznětín) deposit, 1.1.1.

Fig. 3: Typical development of Karlovy Vary kaolin deposits with chemically corroded and rounded kaolinite plates (kaolin E).

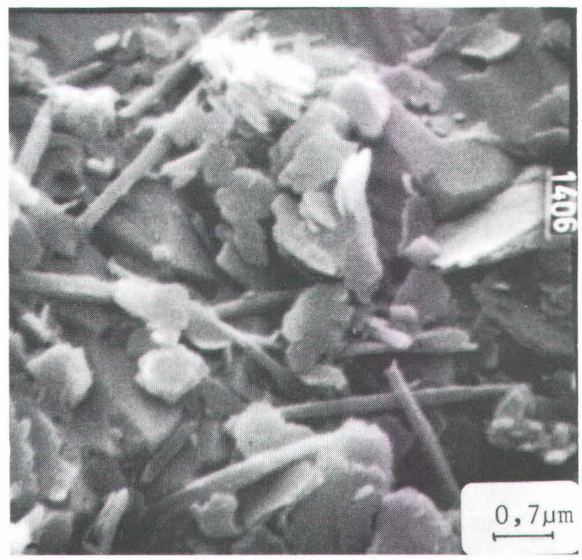
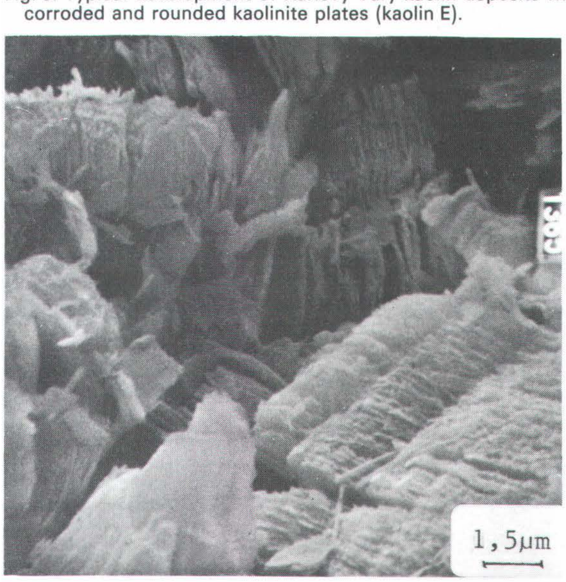
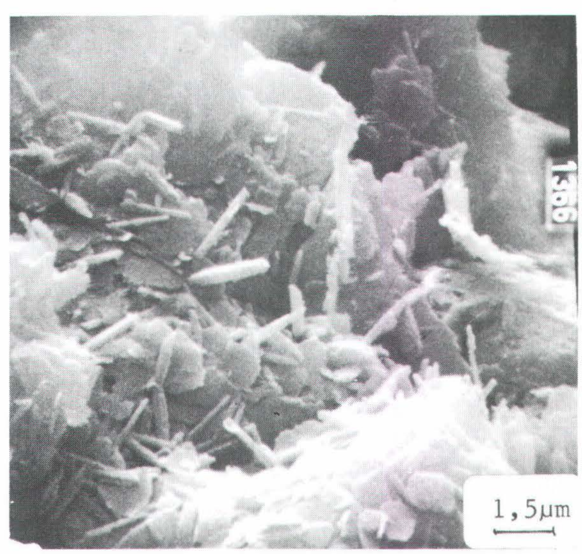


Fig. 4: Secondary components of tubular halloysite beside flakes of platy kaolinites (kaolin E).



Tvořihráz deposit, 1.1.3.

Fig. 5: Aggregates of tubular halloysite and single plates of kaolinite (kaolin F).



Vidnava deposit, 1.1.4.

Fig. 6: Vermicular kaolinite aggregates and rounded platy flakes (kaolin G).

1.3.2 Kaolinized arkosic sandstones of the Podbořany area

In the surroundings of Podbořany, several kaolin deposits are known that originated by in situ climatic weathering of arkosic sandstones of Carboniferous age (the Líně Formation). Their primary position is proved by the presence of the kaolinite pseudomorphs after feldspars. With depth, the number of nonkaolinized feldspar grains increases while the corrosion of quartz grains decreases. The supposed provenance area of the sediments is the crystalline complex of the Krušné hory Mts. (Erzgebirge) to the NW. The sedimentation of the arkosic material took place in stream- and delta-lake facies. The kaolinization is supposed to have occurred during two periods: in the Permo-Carboniferous, directly after the sedimentation (proved by the presence of clay interbeds), and during Cretaceous to Paleogene (before the Oligocene). The thickness of the quality kaolins is about 30 m, but the transitional zone is up to 100 m thick (MILICKÝ et al., 1968).

In the present time, two deposits are exploited: Krásný Dvůr and Dětáň. Other deposits of the region are: Blšany, Hlubany, Skytaly-Vrbička, Dvérce, Nepomyšl, Rybnický mlýn.

The raw kaolins have a high admixture of quartz, in the lower parts also of non-kaolinized feldspar, and admixture of a mica mineral and accessoric heavy minerals (tourmaline, staurolite, garnet, rutile, ilmenite, anatase, leucoxene, limonite, hematite, siderite, magnetite; KUŽVART et al., 1983). In the clay substance, kaolinite of the T-type prevails, while with the depth the admixture of illite, montmorillonite and chlorite rises. The washed kaolin amount is between 22 and 28 %.

We have newly studied the mineralogy (XRD, SEM) of the Krásný Dvůr deposit (Plate 3—2).

Podbořany (Krásný Dvůr)

Kaolin K	Quartz	+++	Kaolinite	84 %
	Muscovite	+	Fire Clay	16 %
	Kaolinite	++	Illite	Tr.
			Mixed Layer	Tr.

The most characteristic technological properties of the Podbořany kaolins are (according to KŘELINA, 1970): high whiteness, low content of the colouring oxides, high strength in a green state, and bad liquefaction which can be optimalized by an activation according to a Czechoslovak patent. About 85 % of the Podbořany kaolins are used as fillers in the paper industry, the rest in ceramics and electro-porcelain production (after activation, they can be used also for the porcelain production).

1.3.3 Kaolinitic sands from Zálezly (Ústí nad Labem)

The deposit originated by kaolinization of quartz-feldspar sands of an unknown age (Oligocene ?, Emscherian ?) after deposition, partly during the sedimentation (KUŽVART et al., 1983). It is covered by the Miocene volcanoclastics and volcanites. The washable kaolin amount is 7—15 %.

1.3.4 Kaolinitic sandstones of the North-Sudetian Depression

STOCH (1986) mentiones kaolinitic sandstones of the Santonian age from the Bolesławiec Trough in Lower Silesia (Poland), covered by younger Tertiary and Quaternary sediments. From the SEM studies (STOCH, l. c.) it follows that the origin of kaolinite is postsedimentary and clearly diagenetic. The kaolins are mined by means of galleries and they are dressed at Ołdrzychów. Petrographically they are sandstones with a kaolinite cement and with mica (muscovite). The kaolinite content reaches only about 5 %. The kaolinite has a high grade of crystallinity (the crystallinity index = 0.7).

2.0 Secondary (redeposited) kaolins of climatic weathering origin

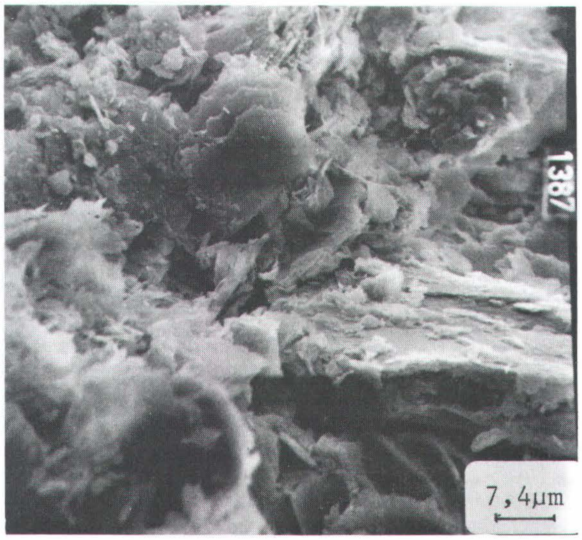
2.1. Kaolinitic conglomerates, sandstones and siltstones

2.1.1 The Plzeň Basin

Even if most of the deposits of the Plzeň basin are of primary deposition (1.3.1), we have segregated this group of deposits that is genetically specific within the kaolins of the B.M.; nevertheless, their genesis does not suit this particular origin entirely. A part of the source material was kaolinized during transport, during sedimentation and shortly after it. Because the explanation of such a transport of kaolinitic clastics without separation of the clayey — and coarse-grained clasts is difficult, the distance of transport was probably not long. We suppose that redeposition of pebbles and blocks occurred in a dense mud suspension. The most striking arguments for the presedimentary kaolinization are: 1, alternations of kaolins and non-kaolinized arkoses in dm-m beds in the base of the deposits; intercalations of red rocks (clays, kaolinitic siltstones and kaolinitic conglomerates) within the white kaolin sequence; 2, intercalations of white clays and kaolinitic siltstones that represent a redeposited material of pre-existing kaolinitic rocks; 3. fresh feldspar grains in highly kaolinitic rocks (JIRÁNEK, 1976, 1977): 4, geochemical characteristics that do not correspond to that of the primary weathering profiles, with an irregular distribution of the main as well as trace elements in the vertical direction, a common increase of trace elements as well as alkalies and alkali earths in the kaolin outwash accompanied by decrease of the kaolinite content (JIRÁNEK, 1982). The proofs of the postsedimentary kaolinization in the area of the Plzeň basin were summarized by KUŽVART et al. (1975); none of their proofs deal with the deposits that we have put into this group. The new SEM photographs (Plate 4—1 to 4—6) confirm that kaolinites of both modes of origin are present. The deposits have originated in the oxidizing conditions (Mn:Cr = 3:1 to 15:1). They are characterized further by a considerable vertical and horizontal variability and by an absence of any regular variations with depth. All the established changes are connected with changes of the petrographical (or granulometrical) character of the rocks. The age of the kaolinization is Carboniferous, the sedimentation occurred in Stephanian A (the Týnec Formation). The limits of the deposits are mostly tectonic, but intertongueing with economically unsuitable portions is present, too. The faults served also as tracks for deferrizing solutions in later periods (Cretaceous-Miocene?) that enabled natural whitening and improving of the raw material (JIRÁNEK, 1976). In the cover of the deposits, Quaternary soils of thicknesses up to 20 m are developed.

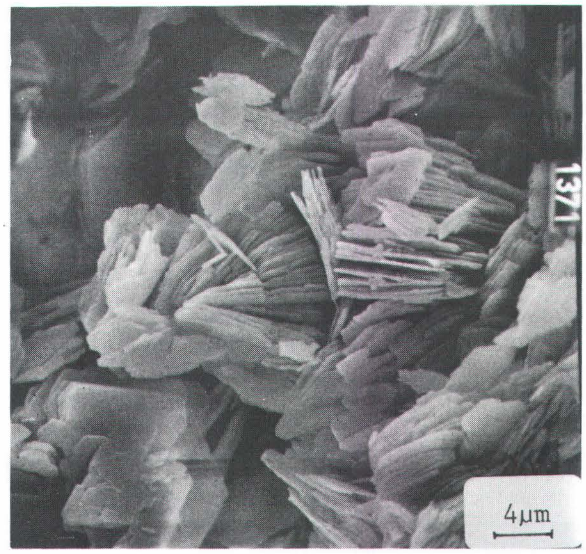
Even if the number of the deposits put in this group is small, the most important kaolin deposits of the B.M. are concerned, reaching up to 3.9 × 1.2 km and thicknesses up to 140 — 200 m (Kaznějov, Horní Bříza).

The kaolins of this group represent products of the fluviolacustrine sedimentation, mostly of the stream and river-lake facies types. Petrographical names of the rocks of the deposits are based on their granulometric composition. According to the KONTA's (1973) classification limits, they include groups of conglomerates with kaolinite cement and varying grain sizes (sandy-silty, silty-sandy, and clayey-sandy c.), silty-conglomeratic to conglomeratic-silty kaolinitic sandstones (with macroscopically well distinguishable end members that represent the best type of the kaolins of the deposit), and clayey-silty to silty-clayey kaolinitic sandstones. Occurrence of other types (e.g. clayey-conglomeratic kaolinitic sandstone) is limited (JIRÁNEK, 1977). Non-economical interbeds form sandy to clayey-sandy siltstones („šlika") with a considerable admixture of fine quartz and mica, and sandy clays, both white and coloured. The kaolin contains up to 30 % washable kaolin (the long-



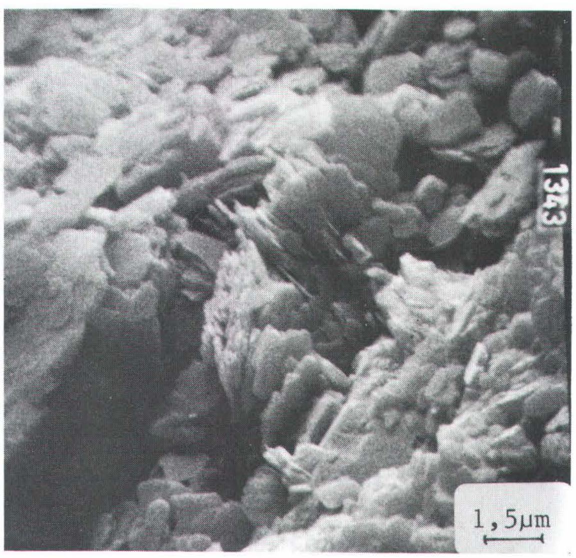
Rokle deposit, 1.2.1.

Fig. 1: The microfabric indicates irregular distribution of predominating flakes of kaolinite (kaolin H).



Podbořany (Krásný Dvůr) deposit, 1.3.2.

Fig. 2: Stacks of idiomorphic pseudohexagonal kaolinite plates (kaolin K).



Chlumčany deposit, 1.3.1.

Fig. 3: Predominating single plates of kaolinite (kaolin I).

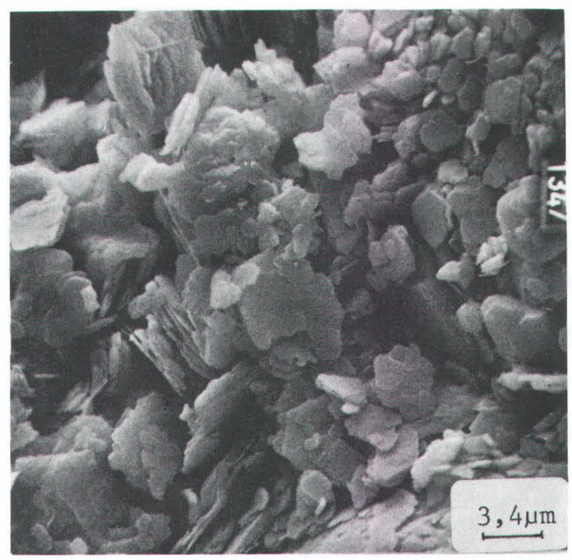
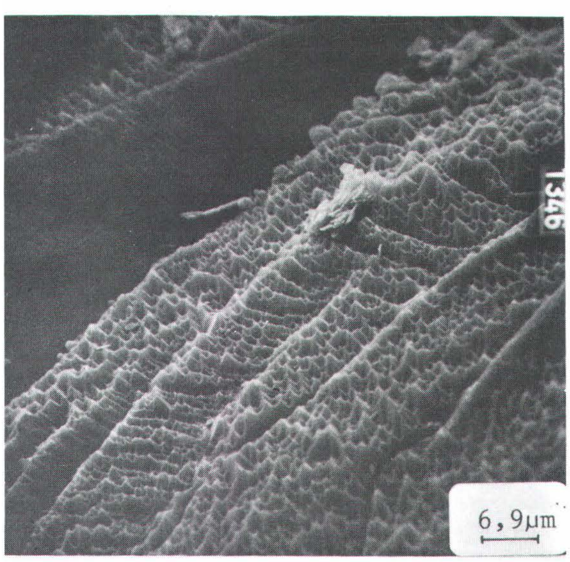


Fig. 4: Individual platy kaolinite crystals have well-defined boundaries (feldspar kaolin J).



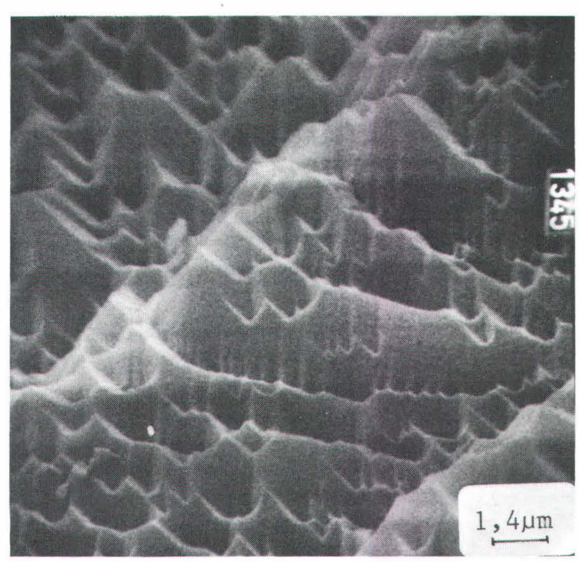


Fig. 5, 6: The surface of feldspar grains indicates chemical weathering (feldspar kaolin J).

term average is 18.5) and 50 — 60 % quartz, the rest are rock fragments and micas. With the total coarseness of the sediment, the relative coarseness of washed kaolin proportionally rises (JIRÁNEK, 1988). The washable kaolin amount decreases rapidly in the end members of the granulometric scale (conglomerates and siltstones).

Within the heavy minerals, the wide provenance area is reflected (granitoid massifs, Proterozoic sediments and volcanics, mesozonal to katazonal crystalline complexes). Rutile and zircon prevail (over 25 %) over monazite, staurolite and leucoxene (over 10 %). Tourmaline and anatase (over 1 %) and accessoric minerals (hematite, ilmenite, kassiterite, kyanite, magnetite, muscovite, pyrite, sphene, black spinelide, topaz and gold) are present as well.

The clay substance is formed — apart from the admixture of fine quartz — by well crystallized well ordered kaolinite of the T type (index of crystallinity = 1.0 — 1.2) with an admixture of mica (illite-sericite), rare montmorillonite, mixed layer mineral and alunite (?).

Mineralogically (XRD, SEM), we have newly studied three different samples from the Kaznějov deposit: silty-conglomeratic kaolinitic sandstone („coarse-grained kaolin" L), clayey-silty kaolinitic sandstone („medium-grained kaolin" M) and kaolinitic siltstone („šlika" N). Furthermore, two samples from the Horní Bříza deposit (the uppermost and lowermost exploiting portions) were examined (Plate 4—1 to 4—6).

Kaznějov				
Coarse-grained Kaolin L	Quartz	+++	Kaolinite	85 %
	Muscovite	Tr.	Fire Clay	15 %
	Kaolinite	++	Illite	Tr.
Medium-grained Kaolin M	Quartz	+++	Kaolinite	95 %
	Muscovite	+	Fire Clay	5 %
	Kaolinite	+	Illite	Tr.
Siltstone („šlika") N	Quartz	+++	Kaolinite	86 %
	Muscovite	Tr.	Fire Clay	14 %
	Kaolinite	+	Illite	Tr.
Horní Bříza				
Top kaolin 0	Quartz		Kaolinite	87 %
	Muscovite		Fire Clay	8 %
	Kaolinite		Illite	5 %
Bottom kaolin P	Quartz		Kaolinite	92 %
	Muscovite		Fire Clay	8 %
	Kaolinite		Illite	Tr.

In the Kaznějov deposit, a relative increase of most of the trace elements analyzed (mainly Ni, Sr, V) was established, along with a correlation of their contents with the geochemical composition of the parent rocks (granitoid K-feldspar: Ba, Pb, Sr; weathering products of the Proterozoic sediments and volcanics: Cr, Ni, V, Zn etc.).

Because of the fine granulometric composition of the washed kaolins, the crystallinity as well as derived rheological and technological properties, the kaolins from Kaznějov and Horní Bříza are used mainly in the paper industry as filler and coating kaolin, and, furthermore, as filler of rubber, plastics etc. A part of them is used in the fine ceramics, and a small part for other purposes (glass fibres, pharmaceutical industry, insecticides, cosmetics, etc.).

2.1.2 Overlying beds of the other deposits

The redeposited kaolins to kaolinitic clays are evidently known from the overburden of some of the described types of deposits (1.1.1, 1.1.3, 1.1.6, 1.2.1, 1.2.2, 1.2.5). They have been mentioned above.

2.2 Kaolinitic clays and claystones

Kaolinitic clays and claystones forming part of the sedimentary filling principally of the Carboniferous, Cretaceous and Tertiary of the B.M. (where also climatic kaolinization was confirmed), represent a redeposited weathering crust and prove the mentioned case of the separation of the clayey fraction during transport (the Plzeň basin, the Cheb basin, the Sokolov basin, the North-Bohemian basin, Kyšice, s. Bohemia, Maiersch in the Horn basin, etc.). In central Europe, the secondary clays of this type are not considered as kaolins. There is a great number of such deposits and they are not the subject of this work.

3.0 Other Genetic types

Kaolins of other types of genesis than the climatic weathering ones described above do not represent in the B.M. an economical genetic type. Some occurrences of kaolinite of the hydrothermal origin are known from the ore deposits and faults. Non economical is also the occurrence of kaolinite in a granite in association with rising hot mineral waters described by ŠANTRŮČEK (1980) from boreholes reaching the underlying rocks of the Sokolov basin. The kaolinite occurs in association with montmorillonite and newly formed calcite and pyrite. The temperature probably does not exceed 45° C.

KUŽVART et al. (1983) also mention kaolinization of the granite of the normal („Mountain") type of the Karlovy Vary Massif, and of a basalt in its neighbourhood, in a contact with a cool mineral water with $NaHCO_3$ near Kyselka (Kysibel). A sheer kaolin body 25 m thick and 500 m long is known to the depth of about 100 m.

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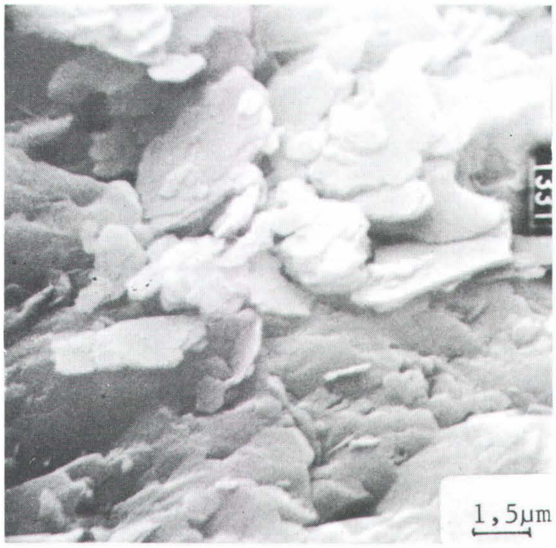
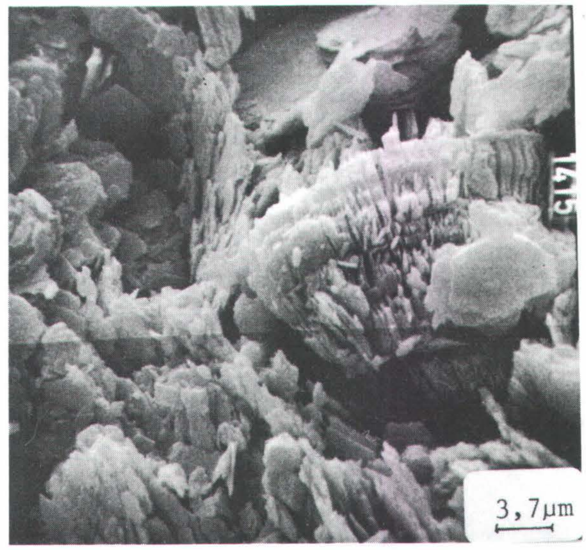




Kaznějov deposit, 2.1.1.

Fig. 1, 2: Predominating single pseudohexagonal kaolinite plates and small stacks (coarse-grained kaolin L).

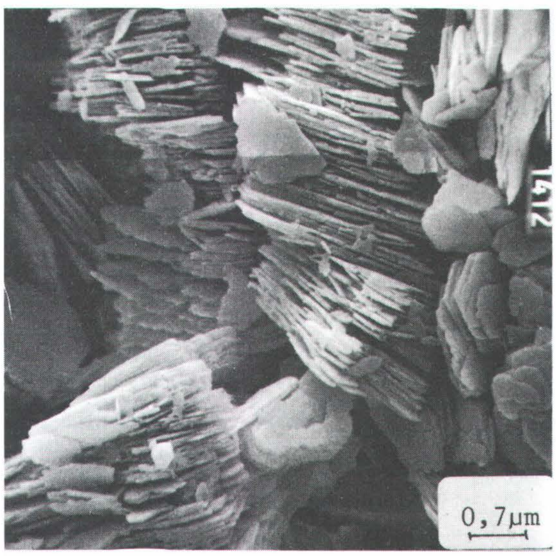


Fig. 3: Stacks of idiomorphic pseudohexagonal kaolinite plates (siltstone, "šlika" N).

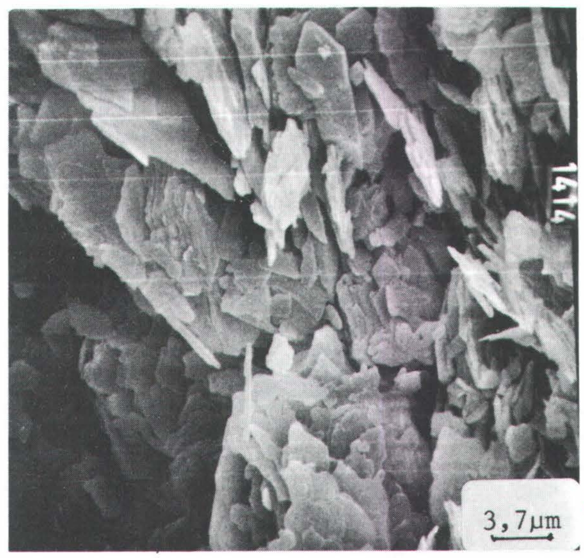
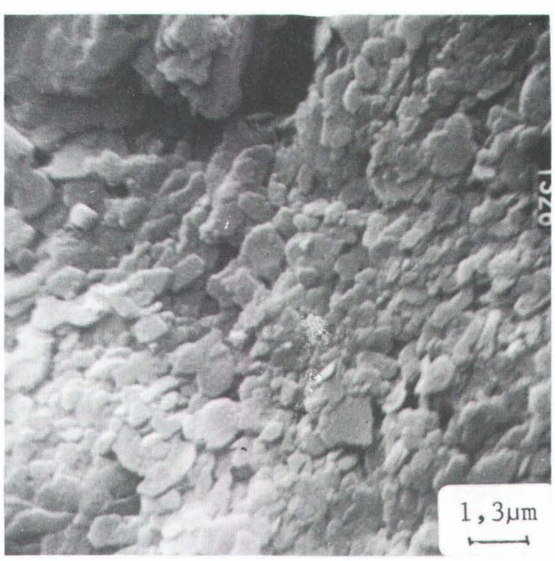


Fig. 4: Single flakes of kaolinite indicate the sedimentary bonding (siltstone, "šlika" N).



Horní Bříza deposit, 2.1.1.

Fig. 5: Single plates of kaolinite redeposited (top kaolin O).

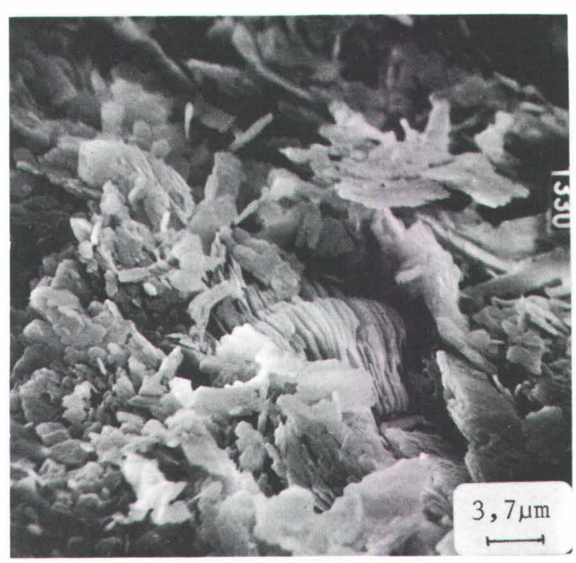


Fig. 6: Stacks of kaolinite and redeposited single flakes (bottom kaolin P).

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Abstrakt

Byly shrnuty poznatky o genezi kaolínových ložisek Českého masívu na území ČSSR a sousedních států. Ložiska jsou přiřazena k jednotlivým genetickým typům a vlastnosti jejich kaolínů stručně charakterizovány. Nově provedená mineralogická studia (SEM) potvrzují primární pozici kaolinitu ve většině hornin. U objemově i průmyslově velmi významných ložisek v s. části plzeňské pánve (Kaznějov, Horní Bříza) byl vedle in situ kaolinizovaných zrn živců potvrzen významný podíl sedimentovaného kaolinitu. Znamená to, že tato ložiska vznikla redepozicí již dříve kaolinizovaného materiálu z neznámé vzdálenosti; po usazení byla dodatečně kaolinizována dosud relativně čerstvá zrna živců. Ostatní ekonomicky významná ložiska kaolínů v Českém masívu jsou vesměs zvětrávacího původu a představují kaolinitická rezidua granitoidů, metamorfitů a živci bohatých sedimentů in situ.

Zusammenfassung

Die Entstehung der Kaolinlagerstätten der Böhmischen Masse in der ČSSR und ihren Nachbarstaaten wird zusammenfassend dargelegt. Die Vorkommen werden getrennt nach genetischen Typen beschrieben und kurz charakterisiert. Aufgrund neuer mineralogischer Untersuchungen (Röntgendiffraktometrie, Rasterelektronenmikroskopie) konnte die primäre Entstehung der meisten Lagerstätten bestätigt werden. Bezüglich der großen, wirtschaftlich bedeutenden Vorkommen im nördlichen Teil des Beckens von Plzeň (Kaznějov, Horní Bříza) konnte festgestellt werden, daß abgesehen von in situ kaolinisierten Feldspatkörnern hauptsächlich sedimentierte Kaolinite vorliegen. Diese Vorkommen entstanden durch Umlagerung. Anschließend wurden die relativ frischen Feldspatkörner kaolinisiert. Die übrigen wirtschaftlich bedeutenden Kaolintone sind Verwitterungslagerstätten und stellen Residualtone von Granitoiden, Metamorphiten und feldspatreichen Sedimenten dar.

MONITORING OF EXPLORATORY WELLS AND HIGH-PRESSURE DETECTION IN POLYGENETIC STRUCTURED AREAS

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1. Introduction

Registration and interpretation of well data have become increasingly important to ÖMV exploration.
During drilling it's necessary to collect all data available, which are useful to get information about porosities, porepressures and formations.

For these reasons every well drilled is connected to a data unit, to get all the information needed.

Which drilling parameters are being used and which geological conclusions may be drawn, will be presented and discussed based on selected examples.

The following data were registered during drilling:

Drilling parameters:
- Time (minutes)
- Depth (meters)
- Weight on hook (tons)
- Rate of penetration (meter/hour)
- Torque
- RPM — Rotary per minute
- Pumpstrokes (strokes/minute)

Mud parameters:
- Mud weight in/out
- Temperature in/out
- Flow
- Pit volume
- Gas readings

Several sensors which transfer the data directly to the data unit were mounted on the rig-site.
There these data were digitally registered and permanently transferred on to „strip charts". Furthermore, the P.C. stores and evaluates all data on a discette.

Therefore, the aim is the registration and interpretation of all drilling parameters.
The data can be used as a helpful tool for logging-DST and casing decisions before entering a high pressure environment.

2. Criteria to predict high pressure zones and some genetic aspects

To identify transition-zones, the following criteria are decisive:

I. D-exponent
II. Gas readings
III. Shape of cuttings