MINERALOGIA POLONICA
Vol. 16, No 1—1985

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MINERALOGICAL AND PETROGRAPHIC FEATURES OF KAOLINITE ROCK (TONSTEIN) FROM "BEŁCHATÓW" BROWN COAL MINE

Abstract. Thin beds of kaolinite rock, referred to as tonstein, occur among Tertiary sediments in the "Bełchatów" brown coal strip mine. The vertical section through these beds reveals zones differing in grain size, sedimentary structures and colour. The principal mineral component of the rocks in question is kaolinite which forms cryptocrystalline groundmass, oval concentrations and macrocrystals. X-ray, IR spectroscopic and thermal studies have shown that the above forms of kaolinite differ markedly in the degree of crystalline perfection. The degree of order increases in the sequence: kaolinite groundmass → oval concentrations → macrocrystals. Kaolinite is accompanied by quartz (fragments of volcanic phenocrysts, terrigenic grains and neogenic crystals), relics of feldspars, fragments of volcanic glass, biotite flakes, and heavy minerals.

GEOLOGICAL SETTING

Three thin beds of kaolinite rock have been exposed in a cut opening the „Bełchatów" brown coal deposit, in the top part of a sequence of Tertiary sediments (Fig. 1). One bed (TS-1) is 3—5 cm in thickness and occurs within the series of coaly clays and sands. The second one (TS-2), attaining a thickness of 18 cm and in places up to 60 cm, is located in a brown coal seam. The third bed (TS-3) up to a few cm thick has been found among coaly clays. All these beds are traceable over the whole length of the opening cut (over 1.5 km), providing an excellent correlation horizon (Kasza et al. 1981).

MACROSCOPIC FEATURES

The beds of kaolinite rock are light-yellow, light-grey or nearly white in colour, depending on the moisture content. Owing to this, they stand out sharply against brown coal or coaly clay. In vertical section the beds show zonal structure, which is particularly pronounced in the TS-2 bed. In the bottom part of this bed, the rock

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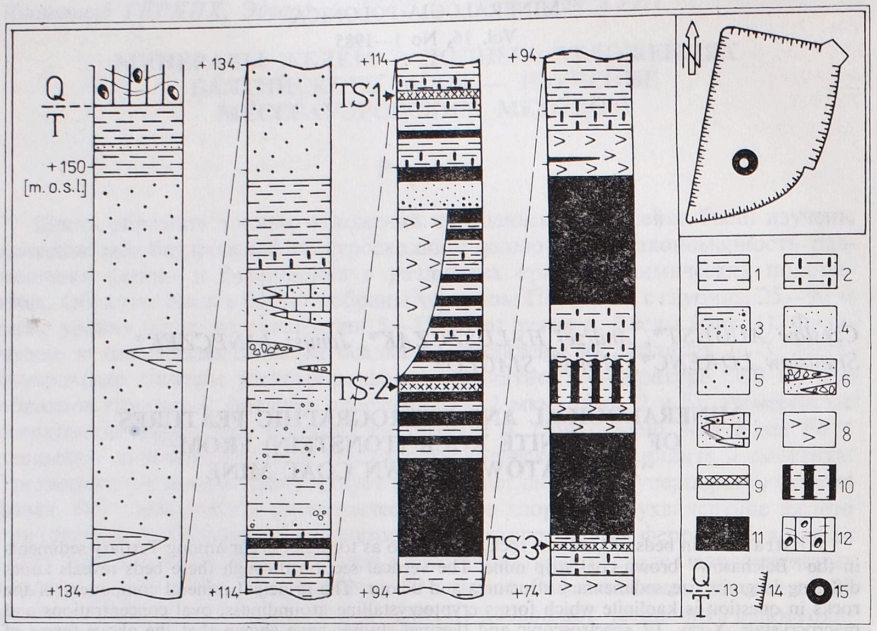

Fig. 1. Geological setting of kaolinite rock beds in the top part of a sequence of Tertiary sediments in the "Bełchatów" brown coal mine

1 — clay, *2* — coaly clay, *3* — irregular intercalations of sandy clay, sand and gravel, *4* — fine- and medium-grained sand, *5* — medium- and coarse-grained sand, *6* — lenses of gravel-stone sediments, *7* — medium- and coarse-clastic sediments, strongly cemented, *8* — carbonate sediments with coal, *9* — kaolinite rock (tonstein), *10* — brown coal with clay, *11* — brown coal, *12* — glacial till, *13* — contact of Tertiary and Quaternary sediments, *14* — outlines of strip mine, *15* — location of the profile

is very fine-grained, somewhat darker in colour, and contains small fragments of phytogenic substance. The higher zone is distinguished by numerous oval concentrations up to 2 mm, and sometimes even more than 5 mm, in size (Plate I, Phot. 1). Somewhat lighter oval concentrations are randomly distributed throughout the darker fine-grained groundmass, giving the texture of a mud-supported type. Since the lower boundary of this zone is fairly sharply defined, and the amount and size of concentrations decreases markedly upwards, this zone can be said to have normal grading. The main zone above is fine-grained and shows faint planar parallel or flaser lamination. It contains sporadic lighter concentrations and single fragments of phytogenic substance. The main zone occupies about 2/3 of the bed thickness. The boundary between the higher and main zone is not sharply defined. In the top, very fine-grained, somewhat darker rock appears again, abounding in small phytogenic elements.

The size of constituents and the percentage of respective fractions are shown on cumulative grain-size distribution curves obtained from granulometric analyses made with the combined sieve-sedimentation method (Fig. 2). It appears from the curves that the pelitic fraction (0.004 mm) make up about 30% and the aleuritic fraction (0.004—0.063 mm) 40—50% of the rock volume. The lack of sorting of the sediment is evident.

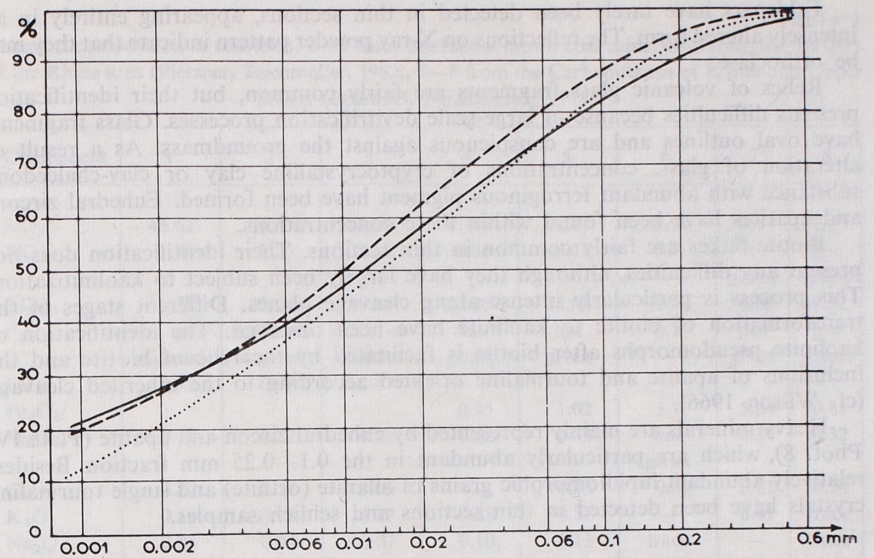

Fig. 2. Cumulative grain-size distribution curves for kaolinite rock (tonstein) from Bełchatów

MICROSCOPIC FEATURES

The essential element observed under the microscope is cryptocrystalline, nearly isotropic clay groundmass with ferruginous pigment dispersed in places. Embedded in the groundmass are phytogenic particles, as well as crystals or aggregates of kaolinite, quartz grains, relics of feldspar grains and biotite flakes, altered fragments of volcanic glass, and heavy minerals. The oval concentrations described earlier in this paper are cryptocrystalline aggregates of clay or clay-chalcedony substance. Kaolinite crystals detectable under the microscope apear in the form of flakes varying from a thousandth part of millimetre to 3 mm in diameter. They often form fan-shaped or vermicular aggregates (Plate II, Phots. 3—4), the latter sometimes attaining a length of 2.5 mm. Their lustrous surfaces are sometimes corroded, displaying all sorts of depressions. In places, the concentration of kaolinite crystals is so high that the rock can be referred to as crystalline tonstein (cf. Schüller 1956).

Quartz appears in several forms. Most common are diversiform, often wedge-shaped and always sharp-edged, fragments of volcanic phenocrysts, sometimes slightly corroded. Quartz is also represented by a few well-rounded grains with matt surfaces, which may point to their terrigenic origin. The third group consists of transparent authigenic quartz crystals in the form of short bipyramids with poorly defined prism faces, characterized by intense glassy lustre and bluish (chalcedony) interference colours. Some of them contain drop-like liquid inclusions (Plate IV, Phot. 7). Besides crystals with well-developed full crystallographic forms, there are ones that have only partly developed the prism and pyramid faces. Where the faces have not been developed, the boundary between a quartz crystal and the surrounding groundmass is not sharply defined, indicating that the crystal grew at the expense of the groundmass. It has also been found that neogenic quartz grows on phenocryst fragments or on detrital quartz grains.

Feldspars have rarely been detected in thin sections, appearing entirely in an intensely altered form. The reflections on X-ray powder pattern indicate that they may be orthoclase.

Relics of volcanic glass fragments are fairly common, but their identification presents difficulties because of large-scale devitrification processes. Glass fragments have oval outlines and are conspicuous against the groundmass. As a result of alteration of glass, concentrations of cryptocrystalline clay or clay-chalcedony substance with abundant ferruginous pigment have been formed. Euhedral zircons and apatites have been found within these concentrations.

Biotite flakes are fairly common in thin sections. Their identification does not present any difficulties, although they have largely been subject to kaolinitization. This process is particularly intense along cleavage planes. Different stages of the transformation of biotite to kaolinite have been observed. The identification of kaolinite pseudomorphs after biotite is facilitated by the relic of biotite and the inclusions of apatite and tourmaline oriented according to the inherited cleavage (cf. Wilson 1966).

Heavy minerals are mainly represented by euhedral zircon and apatite (Plate IV, Phot. 8), which are particularly abundant in the 0.1—0.25 mm fraction. Besides, relatively abundant hipidiomorphic grains of allanite (orthite) and single tourmaline crystals have been detected in thin sections and schlich samples.

CHEMICAL COMPOSITION

Three chemical analyses have been carried out in the samples studied. The results are listed in Table 1, along with chemical analyses of similar rocks from the Tertiary sediments of the Rhine area (Pietzner, Teichmüller 1962). To obtain comparative data, an analysis of refractory schist (tonstein) from the coal-bearing Carboniferous sediments of the Upper Silesian Coal Basin (Bolewski 1974) has been included in the table. All the analyses reveal the dominant content of SiO_2 and Al_2O_3, the Al_2O_3 content in the kaolinite rock from Bełchatów being closer to that in Carboniferous tonstein than in the Tertiary sediments of the Rhine area. All the analyses also show the insignificant content of alkali metal and alkaline earths oxides.

PHASE ANALYSIS

X-ray, thermal and infrared spectroscopic studies were carried out to determine the mineralogical composition of clay groundmass and oval concentrations, and the degree of crystalline perfection of kaolinite. Accordingly, untreated samples, clay groundmass, oval concentrations and kaolinite macrocrystals were subjected to investigations.

X-ray analysis

X-ray diffraction patterns of oriented and reoriented samples were obtained with a DRON-2.0 diffractometer, using CuKα (Ni filter) and CoKα (Fe filter) radiation (Fig. 3).

X-ray patterns of kaolinite macrocrystals, kaolinite from oval concentrations and from the groundmass differ widely from one another. The powder pattern of macrocrystals shows features characteristic of kaolinites intermediate between Tc —

Table 1

Chemical composition of tonsteins: 1—3 from Bełchatów brown coal mine, 4—6 from the Tertiary of the Rhine area (Pietzner, Teichmüller, 1962), 7—8 from the Carboniferous of Lower and Upper Silesia (Bolewski, Parachoniak, 1974)

Component	1	2	3	4	5	6	7	8
SiO_2	46.62	44.53	42.07	47.65	46.77	36.90	38.53	42.65
TiO_2	1.76	1.25	1.59	0.35	0.35	0.5	not given	not given
Al_2O_3	36.78	38.24	39.14	33.20	35.08	30.50	36.08	38.32
P_2O_5	not investigated	not investigated	not investigated	not given	not given	0.1	not given	not given
FeO	0.99	0.98	1.47					
Fe_2O_3				0.45	1.02	3.1	5.54	0.81
MgO	0.13	0.22	0.15	0.22	0.33	not given	0.34	0.32
CaO	0.87	0.77	1.05	—	0.13	0.03	0.21	0.74
K_2O	0.18	0.19	0.17	0.38	0.51	—	0.41	trace
Na_2O	0.04	0.04	0.07	0.10	0.13	trace	—	trace
H_2O^+	10.40	10.27	10.25	not given	not given	4.80	not given	not given
H_2O^-	2.20	2.68	2.87					
Organic matter	0.80	1.45	1.47	not given	not given	not given	not given	not given
Loss on ignition	not investigated			18.04	17.01	23.40	18.64	15.98

and disordered kaolinites. This is indicated by the disappearance or diffusion of reflections for which $k \neq 3n$. Despite the decreased intensity and considerable broadening, the $11\bar{1}$ peak is still distinct.

The X-ray diffraction pattern of kaolinite from oval concentrations is characterized by lower intensity and marked broadening of basal reflections. Moreover, the separation of the peak triad in the angle range $2\theta_{Cu} = 40—43°$ is less pronounced. Besides kaolinite reflections, there appears a broad and strong peak at 8.93 Å, which may be attributed to smectite or mixed-layer phase.

The diffractogram of kaolinite groundmass is typical of kaolinites with a defective structure (D-kaolinite). This is evidenced by the few reflections, the absence of peaks for which $k \neq 3n$, the strong asymmetric *020* peak (with the $1\bar{1}0$ peak on its slope), complete diffusion of the $11\bar{1}$ peak, the displacement of the *001* reflection toward low 2θ angles ($d = 7.3$ Å), the decrease in intensity, and by the substantial breadth of basal reflections.

The degree of structural ordering of kaolinites was determined from the index of Hinckley (H), Lietard (R_2) (fide Cases et al. 1982), and also from the X-ray crystallinity index $I_{020}/I_{1\bar{1}0}$ of Stoch and Sikora (1966). The H and R_2 indices increase and the $I_{020}/I_{1\bar{1}0}$ ratio decreases as the degree of crystalline perfection deteriorates. The values of these indices are given below:

Index	Crystals	Oval concentration	Groundmass
H	0.7—0.5	0.5	0.3
R_2	0.8—0.7	0.6	0.3
$I_{020}I_{1\bar{1}0}$	1.05	1.2	1.3

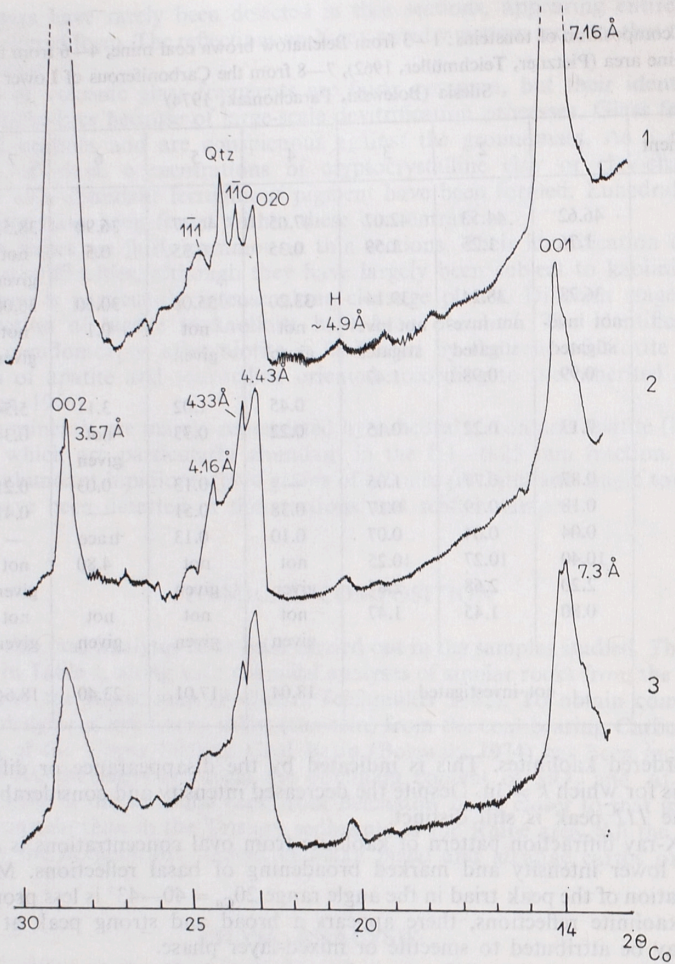

Fig. 3. X-ray diffraction patterns of kaolinites from Bełchatów

1 — macrocrystals (reoriented sample), *2* — oval concentrations, *3* — cryptocrystalline kaolinite groundmass, *H* — hydrargillite (probable), *Qtz* — quartz

Macrocrystals and oval concentrations were treated with hydrazine, adopting the procedure described by Range et al. (1969). After seven days, the *001* peak attained a value of $d = 10.4$ Å in both samples. After the samples were washed with distilled water and saturated with glycerol, the *001* peak shifted, to a value of $d = 7.2$ Å. It appears, therefore, that the kaolinites studied behave like the kaolinites of group I or II, according to the classification of Range et al. (op. cit.).

The degree of crystalline perfection can also be assessed from the size of crystallites. In order to determine the crystallite size of Bełchatów kaolinites, the integral breadth of the *001* and *060* peaks was measured and corrected for non-diffraction factors. The crystallite size calculated for macrocrystals and kaolinite groundmass from Scherrer's equation is respectively: 275 and 140 Å in the [*001*] direction, and

252 and 192 Å in the [*010*] direction. It should be remembered, however, that the broadening of the diffraction line depends not only on the crystallite size but also on the crystal lattice strain.

Kaolinite macrocrystals were also subjected to X-ray diffraction analysis during their heating to 1000°C in a UWD-2000 high-temperature attachment. Heated kaolinite did not show any changes in structural ordering, while the intensity of the *001* reflection increased steadily up to 700°C. The stabilization of the *001* reflection intensity points to the transformation to metakaolinite. At 950—1000°C a strong mullite reflection ($d = 3.35$ Å) appeared besides the only (*001*) kaolinite line.

X-ray diffraction studies show that the degree of crystalline perfection of kaolinites from the tonstein studied increases in the sequence: groundmass → oval concentrations → macrocrystals. However, even the latter cannot be said to have an ordered structure (Hinckley index below unity).

X-ray diffraction patterns of all the samples studied display a weak, broad peak ($d = 4.9$ Å) which may be owing to the presence of insignificant admixtures of hydrargillite.

Infrared spectroscopic analysis

Infrared spectra were recorded between 4000 and 900 cm^{-1} with a Spektromom 2000 spectrometer, and between 1100 and 400 cm^{-1} with a Specord 72-IR spectrometer. In the region of OH vibrations 3700—3600 cm^{-1}, spectra were obtained with a Perkin-Elmer 180 spectrometer. The samples were prepared in the form of suspensions in 1 : 3-hexachlorobutadiene and Nujol mulls.

All the spectra obtained (Fig. 4) show absorption bands characteristic of kaolinite. The degree of structural ordering was assessed from the outlines, sharpness and intensity of absorption bands. It has been found that the degree of crystallinity of the samples compared increases in the sequence: kaolinite groundmass → oval concentrations → kaolinite macrocrystals → Sedlec kaolinite (standard). The assessment was based on the following criteria:

— differences in absorption at 915—935 cm^{-1} (Nemecz 1981);
— intensity and distinctness of the 3650 and 3670 cm^{-1} bands in the region of OH stretching vibrations (Cases et al. 1982);
— intensity of the 1100 cm^{-1} band, corresponding to Si—O stretching vibrations (Wiewióra 1982).

The spectrum of kaolinite groundmass can be defined as corresponding to D-kaolinite in the degree of order. The spectrum of oval concentrations points to a higher degree of crystallinity. The spectrum of kaolinite macrocrystals shows close similarity to that of the Sedlec kaolinite which was used as standard. The slight differences noted between these two spectra seem to arise from the fact that samples prepared by grinding of so large crystals are practically oriented in the *001* plane (0° orientation).

An inconspicuous but perceptible feature in these spectra is absorption bands testifying to the presence of molecular water, namely the bending close to 3430 cm^{-1} caused by OH vibrations, and a weak, diffuse band at 1630 cm^{-1} caused by H_2O bending vibrations. These small amounts of water are either due to the admixtures of other minerals or provide evidence that kaolinitization has not proceeded to completion.

Thermal analysis

Thermal analysis was carried out on an OD 102 derivatograph under standard analytical conditions. To obtain reliable data, each kaolinite sample was analysed four times. The results, presented in Table 2 and in Figure 5, were fully reproducible.

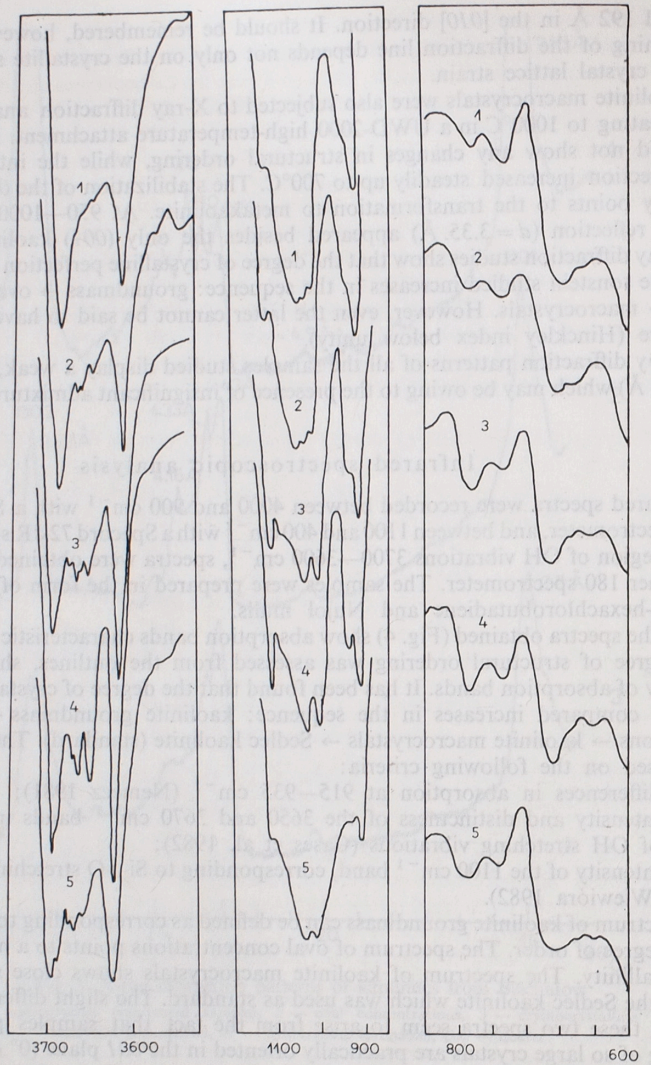

Fig. 4. Infrared absorption spectra of kaolinites

1 — cryptocrystalline kaolinite groundmass (Bełchatów), *2* — oval concentrations (Bełchatów), *3* — kaolinite macrocrystals (Bełchatów), *4* — kaolinite from Sedlec (standard), *5* — biotite showing evidence of kaolinization (Bełchatów)

Thermal curves obtained for the samples studied show that the main thermal reaction due to dehydroxylation of kaolinite occurs at the highest temperature in kaolinite macrocrystals (about 600°C), at a lower temperature in kaolinite groundmass (575°C), and at the lowest temperature in kaolinite from oval concentrations (555°C). The shape index (*S*) of this endothermic reaction is highest for macrocrystals, lower for oval concentrations, and lowest for the groundmass.

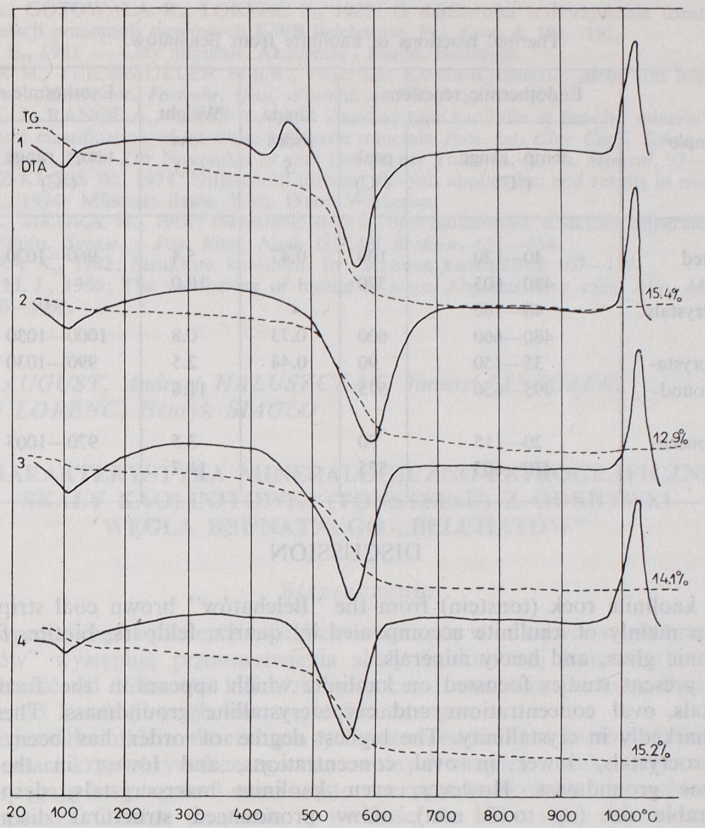

Fig. 5. DTA, DTG and TG curves for kaolinites from Bełchatów

1 — untreated sample, *2* — macrocrystals, *3* — cryptocrystalline kaolinite groundmass, *4* — oval concentrations

The TG curves of all the samples show a weight loss due to dehydroxylation, as well as a weight loss due to the removal of molecular water. The smallest weight loss has been noted for macrocrystals (0.8 wt. %), and the greatest for oval concentrations (3.5 wt. %).

It is generally held (e.g. Cases et al. 1982, Smykatz-Kloss 1974, Stoch 1974) that the thermal characteristics of kaolinites depend mainly on the grain size and the degree of crystallinity. The studies of the Bełchatów kaolinites seem to confirm this view, although they do not provide conclusive evidence in support of one or the other factor, as kaolinites of different grain size were investigated. When considering the crystalline perfection of the Bełchatów kaolinites, the presence of molecular water cannot be neglected, as it may cause structural disturbances, such as the translation of layers along the b-axis.

Basing on the thermal data and assuming that the internal structure of samples afftects their thermal reactions, it can be stated that the kaolinites studied show different degrees of crystallinity, macrocrystals having a better ordered structure than kaolinites from oval concentrations and the groundmass.

Table 2

Thermal reactions of kaolinite from Bełchatów

Sample	Endothermic reactions		Shape index S	Weight loss (%)	Exothermic reactions	
	temp. range (°C)	peak (°C)			temp. range (°C)	peak (°C)
Untreated sample	40—120	100	0.47	5.4	960—1020	1000
	480—605	570		10.0		
Macrocrystals	40—160					
	480—660	600	0.73	0.8	1000—1030	1010
Cryptocrystalline groundmass	35—150	90	0.44	2.5	990—1030	1020
	495—650	575		11.6		
Oval concentrations	20—115	70		3.5	970—1005	995
	470—605	555		11.7		

DISCUSSION

The kaolinite rock (tonstein) from the "Bełchatów" brown coal strip mine is made up mainly of kaolinite accompanied by quartz, feldpars, biotite, fragments of volcanic glass, and heavy minerals.

The present studies focussed on kaolinite which appears in the form of macrocrystals, oval concentrations and cryptocrystalline groundmass. These forms differ markedly in crystallinity. The highest degree of order has been observed in macrocrystals, lower in oval concentrations, and lowest in the cryptocrystalline groundmass. However, even kaolinite macrocrystals, despite their considerable size (up to 3 mm), show pronounced structural disorder due to the displacement of layers with respect to one another. Structural disorder in large kaolinite crystals that commonly form vermicular aggregates was noticed by Wiewióra (1982). This fact confirms in some measure the assumption emerging from microscopic observation that macrocrystals could have formed by transformation of biotite. Oval concentrations are presumably altered lapilli, originally made up mainly of volcanic glass. Such genesis of oval concentrations is also indicated by the mode of their distribution in the groundmass, and especially by the gradation according to size and amount, described earlier in this paper.

The pyroclastic origin of the kaolinite rock in question is also evidenced by fragments of volcanic quartz phenocrysts, relics of volcanic glass, and the association of heavy minerals.

Translated by Hanna Kisielewska

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CHARAKTERYSTYKA MINERALOGICZNO-PETROGRAFICZNA SKAŁY KAOLINITOWEJ (TONSTEINU) Z ODKRYWKI WĘGLA BRUNATNEGO „BEŁCHATÓW"

Streszczenie

W stropowej części sekwencji osadów trzeciorzędu w odkrywce węgla brunatnego „Bełchatów" występują przewarstwienia skały kaolinitowej (tonsteinu). Osiągają one miąższość od kilku do kilkudziesięciu cm i stanowią poziomy litologiczne przydatne do korelacji pokładów węgla brunatnego.

Głównym składnikiem mineralnym tych przewarstwień jest kaolinit, który występuje w postaci kryptokrystalicznego tła, owalnych skupień i makrokryształów. Te ostatnie osiągają średnicę do 3 mm i często tworzą robaczkowate lub wachlarzowate agregaty (stosy). Owalne skupienia, o wielkości do kilku mm, rozmieszczone są w skale w sposób gradacyjny, zarówno pod względem ilości jak i wielkości. Obok kaolinitu występuje kwarc, relikty skaleni, biotyt, fragmenty szkliwa wulkanicznego oraz minerały ciężkie, wśród których dominują cyrkon, apatyt i allanit (ortyt). Na podkreślenie zasługuje obecność 3 typów genetycznych kwarcu: wulkanicznego, terygenicznego i diagenetycznego.

Pod względem chemicznym, a zwłaszcza pod względem zawartości Al_2O_3 kaolinitowe przewarstwienia z Bełchatowa są bardzo podobne do karbońskich tonsteinów z Górnego Śląska.

Przeprowadzone badania fazowe (rentgenograficzne, spektralne w podczerwieni i termiczne) oprócz wyjaśnienia składu mineralnego kryptokrystalicznego tła i owalnych skupień dostarczyły informacji o stopniu uporządkowania struktury kaolinitu. Najniższy stopień uporządkowania struktury wykazuje kaolinit tworzący kryptokrystaliczne tło (kaolinit D), wyższy kaolinit tworzący owalne skupienia, a najwyższy makrokryształy kaolinitu. Jednakże nawet te ostatnie mimo znacznych rozmiarów nie osiągają struktury uporządkowanej (wskaźnik Hinckleya poniżej jedności). W pewnym stopniu tłumaczyć to może przypuszczenie wynikające z obserwacji mikroskopowych, że makrokryształy kaolinitu powstać mogły przez przeobrażenie biotytu.

Skład mineralny, tekstura i struktura skały oraz forma występowania wskazują, że kaolinitowe przewarstwienia są przeobrażonymi osadami piroklastycznymi.

OBJAŚNIENIA FIGUR

Fig. 1. Pozycja geologiczna warstw skały kaolinitowej w stropowej części sekwencji osadów trzeciorzędu z KWB "Bełchatów"
1 — ił, *2* — ił zawęglony, *3* — nieregularne przewarstwienia iłu piaszczystego, piasku i żwiru, *4* — piasek drobno- i średnioziarnisty, *5* — piasek średnio- i gruboziarnisty, *6* — soczewy osadów żwirowo-kamienistych, *7* — osady średnio- i grubookruchowe, silnie scementowane, *8* — osady węglanowe, zawęglone, *9* — skała kaolinitowa (tonstein), *10* — węgiel brunatny zailony, *11* — węgiel brunatny, *12* — glina zwałowa, *13* — kontakt osadów trzecio- i czwartorzędu, *14* — zarys odkrywki, *15* — lokalizacja profilu

Fig. 2. Kumulacyjne krzywe uziarnienia skały kaolinitowej (tonsteinu) z KWB "Bełchatów"

Fig. 3. Dyfraktogramy kaolinitów z KWB "Bełchatów"
1 — makrokryształy (próbka reorientowana), *2* — owalne skupienia, *3* — kryptokrystaliczne tło kaolinitowe *H* — hydrargilit (prawdopodobny), *Qtz* — kwarc

Fig. 4. Widma spektralne w podczerwieni kaolinitów
1 — kryptokrystaliczne tło kaolinitowe, KWB "Bełchatów" *2* — owalne skupienia (KWB "Bełchatów"), *3* — makrokryształy kaolinitu (KWB "Bełchatów", *4* — kaolinit z Sedlec (wzorzec), *5* — biotyt z oznakami, kaolinityzacji (KWB "Bełchatów")

Fig. 5. Termogramy kaolinitów z KWB "Bełchatów"
1 — próbka surowa, *2* — makrokryształy, *3* — kryptokrystaliczne tło kaolinitowe, *4* — owalne skupienia

OBJAŚNIENIA FOTOGRAFII

Fot. 1. Owalne skupienia (przeobrażone lapille?) wypreparowane ze skały kaolinitowej
Pow. 10×

Fot. 2. Obraz mikroskopowy owalnego skupienia (przeobrażonej lapilli?)
Nikole skrzyżowane, pow. 60×

Fot. 3. Agregaty (stosy) makrokryształów kaolinitu
Mikroskop skaningowy, pow. 35×. Preparat i zdjęcia wykonał J. Kassner

Fot. 4. Makrokryształ (blaszka) kaolinitu
Mikroskop skaningowy, pow. 35×. Preparat i zdjęcia wykonał dr J. Kassner

Fot. 5. Kryptokrystaliczne tło kaolinitowe
Mikroskop skaningowy, pow. 3500×. Preparat i zdjęcia wykonał dr J. Kassner

Fot. 6. Neogeniczny kwarc i wachlarzowaty agregat kaolinitu w kryptokrystalicznej masie kaolinitowej
Nikole równoległe, pow. 60×

Fot. 7. Neogeniczny kwarc z kroplowymi inkluzjami ciekłymi
Nikole skrzyżowane, pow. 220×

Fot. 8. Autigeniczne cyrkony wypreparowane ze skały kaolinitowej
1 nikol, pow. 220×

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MINERALOGO-PETROGRAFICZNA CHARAKTERYSTYKA KAOLINITOWEJ SKAŁY (TONSTEINU) Z KWB "BEŁCHATÓW"

Streszczenie

W stropowej części sekwencji osadów trzeciorzędu w profilu kopalni węgla brunatnego "Bełchatów" występują przewarstwienia skały kaolinitowej (tonsteinu). Osiągają one miąższość od kilku do kilkudziesięciu centymetrów i stanowią litologiczne horyzonty użyteczne w korelacji pokładów węgla brunatnego.

Главным минеральным компонентом этих прослойков является каолинит, который представлен в виде криптокристаллической основной массы, овальных скоплений и макрокристаллов. Эти последние достигают 3 мм в диаметре и часто образуют червеобразные или веерообразные агрегаты (кучи). Овальные скопления, размером до нескольких миллиметров, размещены в породе градационным образом, как в отношении количества так и размеров. Кроме каолинита, присутствуют кварц, реликты полевых шпатов, биотит, фрагменты вулканического стекла, а также минералы тяжелой фракции, среди которых преобладает циркон, апатит и ортит. Заслуживает внимания наличие трех генетических типов кварца — вулканогенного, терригенного и диагенетического.

В химическом отношении, в частности в отношении содержания Al_2O_3, каолинитовые прослойки из Белхатува весьма походи на каменноугольные тонштейны в Верхней Силезии.

Проведенные фазовые (рентгенографические, ИК-спектральные, и термические) исследования, кроме выяснения минерального состава криптокристаллической основной массы и овальных скоплений, дали сведения о степени упорядоченности структуры каолинита. Самую низкую степень упорядоченности структуры каолинита обнаруживает каолинит, образующий криптокристаллическую основную массу (каолинит D), более высокую — каолинит, образующий овальные скопления, а самую высокую — макрокристаллы каолинита. Однако даже те последние, несмотря на значительные размеры, не получают упорядоченной структуры (индекс Хинклейя ниже единицы). В некоторой степени это может объяснять возникающее из микроскопических наблюдений предположение, что макрокристаллы каолинита могли образоваться в итоге превращения биотита.

Минеральный состав, текстура и структура породы, а также форма нахождения указыват, что каолинитовые прослойки являются видоизмененными пирокластическими отложениями.

ОБЪЯСНЕНИЯ К ФИГУРАМ

Фиг. 1. Геологическая позиция слоев каолинитовой породы в кровельной части секвенции третичных отложений из буроугольного карьера (БУК) «Белхатув»
1 — глина, *2* — глина с примесью угля, *3* — неправильные прослои песчанистой глины, песка и гравия *4* — мелко- и среднезернистый песок, *5* — средне- и крупнозернистый песок, *6* — линзы гравийно-галечных отложений, *7* — сильно цементированные средне- и крупнообломочные отложения, *8* — карбонатные отложения с примесью угля, *9* — каолинитовая порода (тонштейн), *10* — бурый уголь с примесью глины, *11* — бурый уголь, *12* — валунный суглинок, *13* — контакт третичных и четвертичных отложений, *14* — контур карьера, *15* — местоположение разреза

Фиг. 2. Кумулятивные кривые зернистости каолинитовой породы (тонштейна) из БУК «Белхатув»

Фиг. 3. Дифрактограммы каолинитов из БУК «Белхатув»
1 — макрокристаллы (реориентированный образец), *2* — овальные скопления, *3* — криптокристаллическая каолинитовая основная масса, *H* — гидраргиллит (вероятный, *Qtz* — кварц)

Фиг. 4. ИК-спектры каолинитов
1 — криптокристаллическая каолинитовая основная масса, БУК «Белхатув», *2* — овальные скопления (БУК «Белхатув»), *3* — макрокристаллы каолинита (БУК «Белхатув»), *4* — каолинит из Сэдлец (эталон), *5* — биотит с признаками каолинитизации (БУК «Белхатув»)

Фиг. 5. Термограммы каолинитов из БУК «Белхатув»
1 — сырой образец, *2* — макрокристаллы, *3* — криптокристаллическая каолинитовая основная масса, *4* — овальные скопления

ОБЪЯСНЕНИЯ К ФОТОГРАФИЯМ

Фото 1. Овальные кристаллы (видоизмененные лапилли?)
Выделенные из каолинитовой породы. Увел. ×10

Фото 2. Микроскопическое избражение овального скопления (видоизмененного лапилли?)
Скрещенные николи, увел. ×60

Фото 3. Агрегаты (кучи) макрокристаллов каолинита
Сканирующий микроскоп, увел. ×35. Препарат и фото д-ра Я. Касснера

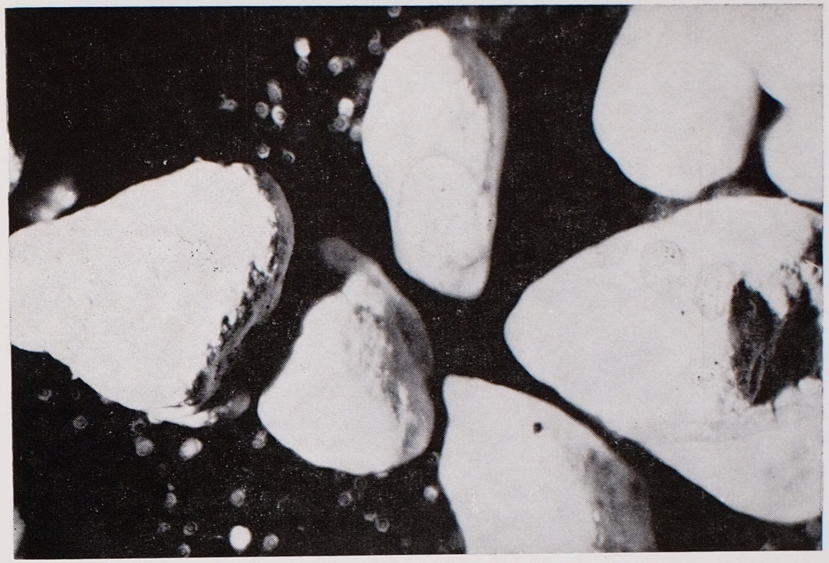
Фото 4. Макрокристалл (пластинка) каолинита
Сканирующий микроскоп, увел. ×35. Препарат и фото д-ра Я. Касснера

Фото 5. Криптокристаллическая каолинитовая основная масса
Сканирующий микроскоп, увел. ×3500. Препарат и фото д-ра Я. Касснера

Фото 6. Неогенический кварц и веерообразный агрегат каолинита в криптокристаллической каолинитовой массе
Параллельные николи, увел. ×60

Фото 7. Неогенический кварц с каплевидными жидкими вростками
Скрещенные николи, увел. ×220

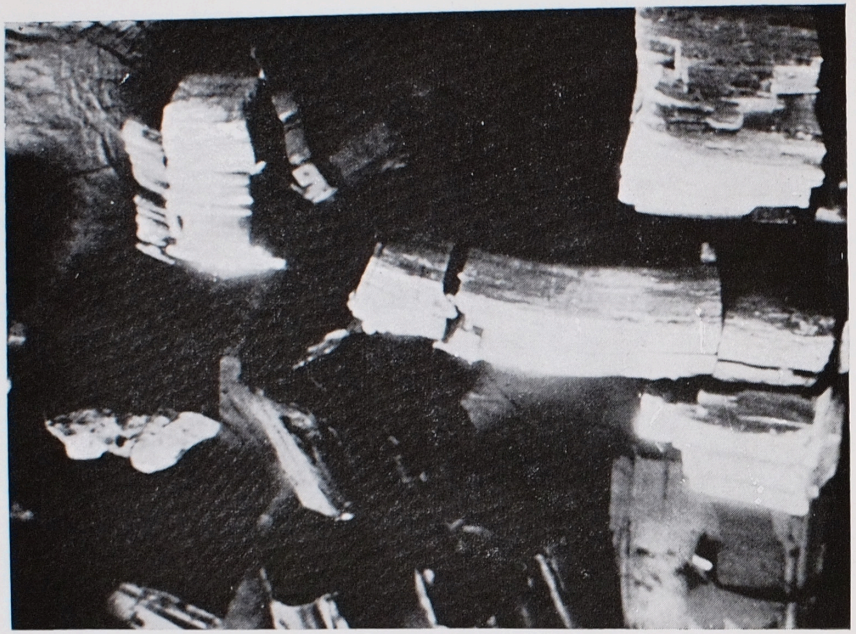
Фото 8. Аутигенические цирконы, выделенные из каолинитовой породы
Один николь, увел. ×220



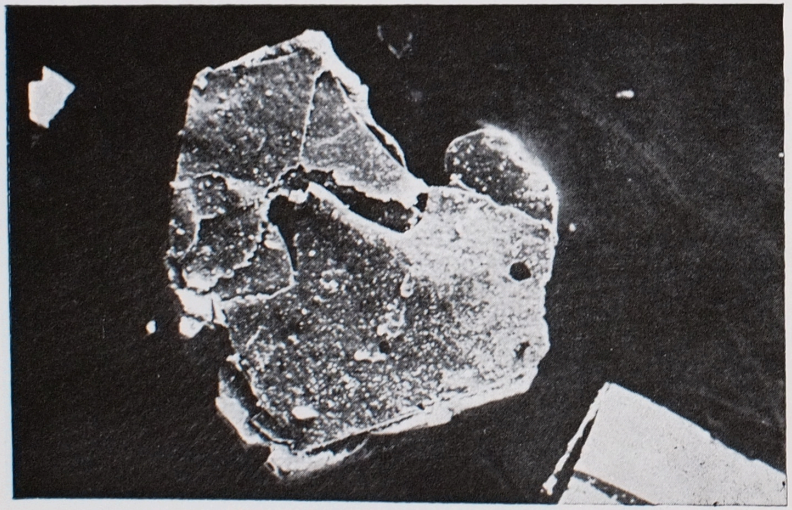
Phot. 1. Oval concentrations (altered lapilli?) isolated from kaolinite rock
10 ×

Phot. 2. Microscopic image of an oval concentration (altered lapilli?)
Crossed nicols, 60 ×

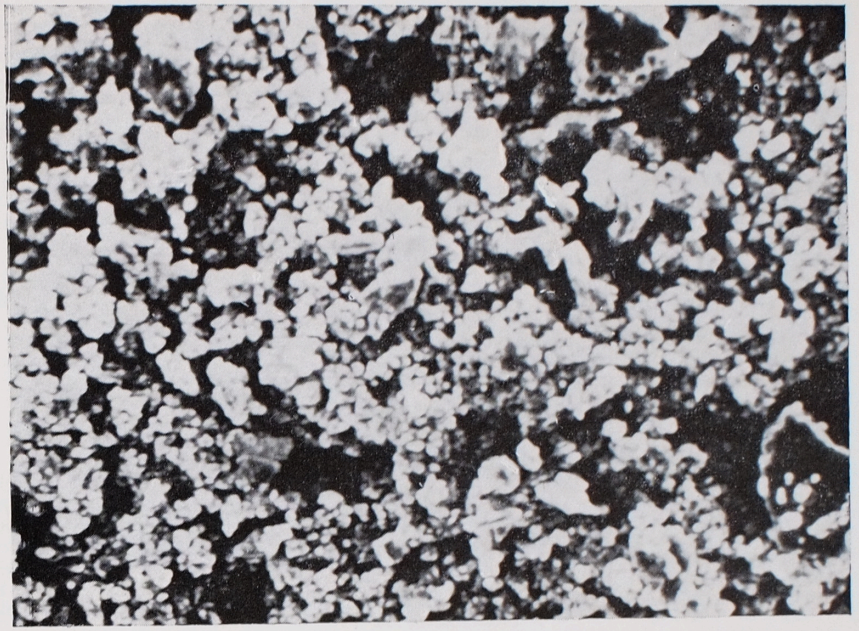
Czesław AUGUST, Andrzej HAŁUSZCZAK, Janusz JANECZEK, Stanisław LORENC, Henryk SIAGŁO — Mineralogical and petrographic features of kaolinite rock (tonstein) from "Bełchatów" brown coal mine



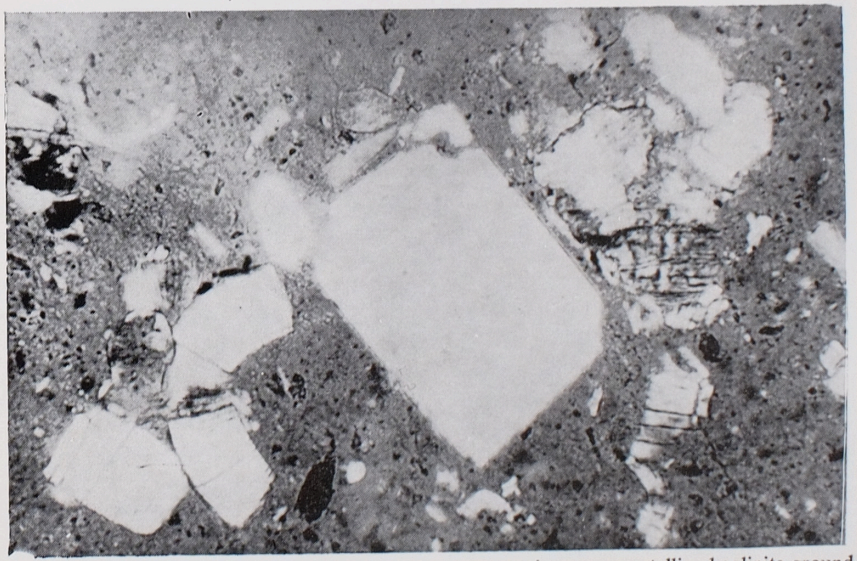
Phot. 3. Aggregates (stacks) of kaolinite macrocrystals
SEM, 35 ×. Sample and photographs made by J. Kassner



Phot. 4. Kaolinite macrocrystal (flake)
SEM, 35 ×. Sample and photographs made by J. Kassner

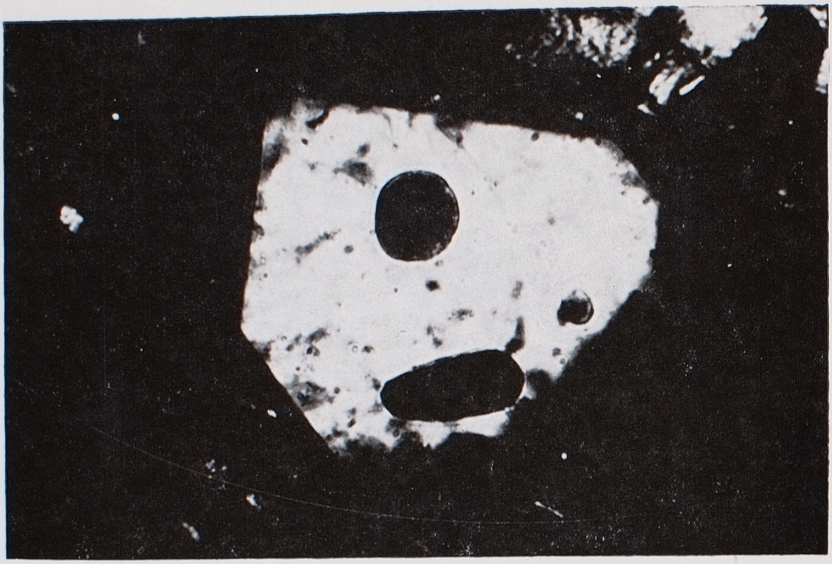


Phot. 5. Cryptocrystalline kaolinite groundmass
SEM, 3500 ×. Sample and photographs made by J. Kassner

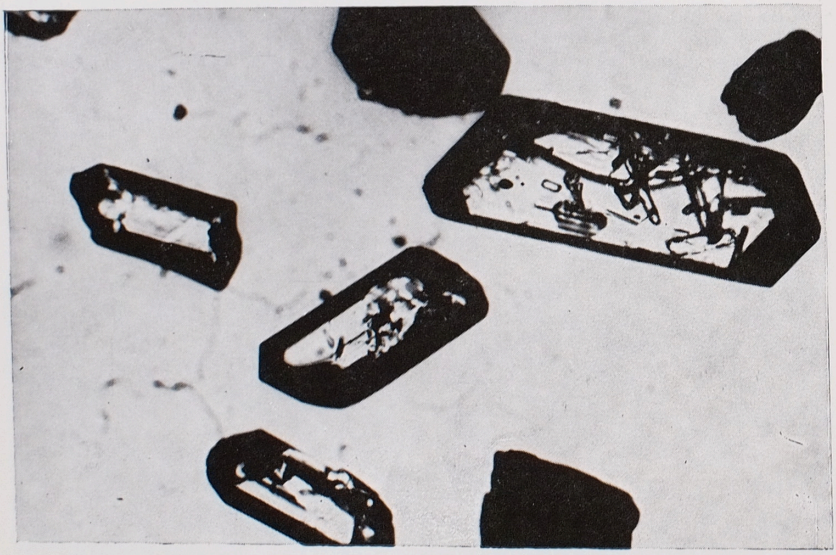


Phot. 6. Neogenic quartz and fan-shaped kaolinite aggregate in cryprocrystalline kaolinite groundmass

Plane polarized light, 60



Phot. 7. Neogenic quartz with drop-like liquid inclusions
Crossed nicols, 220 ×



Phot. 8. Authigenic zircon isolated from kaolinite rock
Plane polarized light 220 ×