

RESEARCH WORK ON CLAY MINERALS AND ARGILLACEOUS ROCKS IN CZECHOSLOVAKIA

by

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ABSTRACT

The investigation of clay minerals and argillaceous rocks started in the territory of Czechoslovakia as early as the later part of the eighteenth century and has continued up to today. During this long period many interesting results have been obtained. In about 1949 modern laboratory techniques were introduced. Most of the work in this country deals with the mineralogy, petrology, and geology of argillaceous rocks, the chemical composition and physical properties of clay materials which are useful for the purposes of the ceramic, glass, chemical, construction-engineering and mining industries, etc. This paper is subdivided into the following parts: (a) Classical research period; (b) Modern research period; (c) Kaolins (primary); (d) Other argillaceous rocks of sedimentary origin; (e) Bentonites; (f) Laterites and bauxitic rocks; (g) Clay minerals in sedimentary iron ores; (h) Clay minerals in carbonaceous rocks; (i) Clay minerals of hydrothermal origin; (j) Kinds of apparatus for DTA and gravimetric thermal analysis; (k) Imbibometric study using water and organic liquids; (l) Problems of classification and terminology.

CLASSICAL RESEARCH PERIOD

The large deposits of kaolin and other argillaceous rocks in Czechoslovakia have made this country well known. Various laboratories throughout the world use the kaolin from Sedlec, Bohemia, as a world kaolin standard as approved in the International Congress for Theoretical and Applied Chemistry held in Copenhagen in 1924.

Clay minerals and argillaceous materials were studied in the territory of Bohemian Kingdom as early as the late eighteenth century and much work was done in the nineteenth century. For example the name "cimolite" was proposed by Klaproth (1795) for the material from Bílina, northern Bohemia, which we know today as a mixture of anauxite and amorphous SiO_2 . From the same locality anauxite was discovered and named by Breithaupt (1838) and more detailed work on this mineral was done by Reuss (1840). Further, a number of workers, including Zepharowich (1853), Haidinger (1861), Schrauf (1877), Kennigott (1878) and Katzer (1894) described argillaceous materials under such terms as cimolite, strakonicite, chloropal, pinguite, hoefelite, bole, etc., which are not valid today. In the works of the above-named authors we find comprehensive megascopic descriptions of the clay

minerals or, to put it better, argillaceous materials, their partial chemical analyses, and finally some data on chemical and physical properties, such as solubility in acids, density, etc.

During the late nineteenth-century and early twentieth-century research work in this line took definite shape, particularly from chemical and microscopical points of view. For this much credit must be paid to Kovář (1896; 1898a; 1898b; 1899; 1901a; 1901b; 1902–3) who strictly differentiated molecular water (H_2O-) from water of constitution (H_2O+) in the chemical analyses. Bukovský (1906) also deserves some credit. Magnesium hydrosilicates from Bohemia and Moravia were studied by the well-known Russian mineralogist and geochemist Fersman (1908; 1912) and clay minerals from oolites in sedimentary iron ores by Slavíková and Slavík (1917).

In the years to follow, up to 1949, greater emphasis was laid on quantitative chemical analysis and microscopical study; X-ray study was seldom used during this period. In the field of pedology much attention was centered around the methods of determining particle size of soil colloids. In ceramic technology the broader problems connected with plasticity, chemical purity and heat resistivity were being solved. Main workers who contributed to this work are Kallauner and Bárta (1918), Kallauner and Matějka (1926), Šplíchal (1921–2), Sokol (1921), Kratochvíl (1927), Dittler and Hibsč (1923), Noll (1930), Zartner (1932), Hibsč (1930; 1934), Bárta (1930), Pelíšek (1933), Orlov (1941a, b; 1942a, b, c; 1944), Rost (1944; 1947) and Jarka (1947). Orlov (1938a, b) also contributed many valuable chemical and petrographic data on the bauxitic rocks.

The period of modern clay mineralogy and petrology research work using new laboratory methods was begun in 1949 in Czechoslovakia. This period is linked, of course, with the long-established mineralogical, petrological and chemical research traditions of the classical time.

MODERN RESEARCH PERIOD

Publications of Czechoslovak authors in the modern period deal with an all-round study of natural clay materials for geological and industrial purposes. The characteristic feature of these works is the versatility of the methods used in the investigation of any argillaceous material or of any petrological problem: megascopic and microscopic study, X-ray analysis, differential thermal analysis, gravimetric thermal analysis, electron microscopy, chemical analysis, and often also determination of trace elements, chemical sorption, density, ion exchange, etc.

Kaolins (Primary)

Most of the kaolin deposits in the Bohemian Massif were formed as products of weathering on granitic and gneissic rocks. Konta (1957) studied the kaolinites of some kaolin deposits and other clay minerals occurring in various argillaceous rocks, using chemical analysis, optical study, X-ray analysis,

differential thermal analysis, gravimetric thermal analysis, electron microscopy and other methods. Procházka (1957) explained the relationship between the crystal structure and technological properties of kaolinites from several Czechoslovak kaolin deposits. Babůrek, Konta and Svoboda (1959) led the petrologic and geochemical investigations of the Karlsbad kaolin (deposit at Otovice) having a profile of several tens of meters. Here, besides kaolinite, they also recognized illite and a chloritic mineral. The iron released during weathering was bound by the newly formed siderite.

Kukla (1959) worked on the kaolin deposits in western Bohemia and published several new chemical analyses of granite which had been kaolinized to different degrees. He also tackled the question of the age of kaolinization in this area and is of the opinion that it took place during Cretaceous and Early Tertiary time. Pouba (1959), in work based on broad geological study, came to the conclusion that kaolinization in western Bohemia took place in two different periods, namely in the Carboniferous and probably the Tertiary. The formation of ochre deposits containing illite, kaolinite and goethite, associated closely with some of these kaolin deposits, is connected with the kaolinization in this area. These are the weathered products of Proterozoic pyritic shales.

Kužvart (1960) identified various kaolinites, of structure ranging between very well and poorly developed, from some kaolin deposits in Moravia and Silesia. These kaolins were formed by weathering of gneissic and granitic rocks mainly during Early Tertiary time; some of them, however, before sedimentation of Upper Cretaceous rocks.

Konta and Pouba (1961) have compiled the data available concerning the geology, mineralogy, petrography and technological properties of the western Bohemian kaolins and some ceramic clays of sedimentary origin.

Other Argillaceous Rocks of Sedimentary Origin

Kallauner (1949) studied chemically and by modern methods the halloysitic rocks from Michalovce. Šatava (1949) dealt with the study of the sorption capacity of some clays having different mineralogical composition. Bárta, Šatava, Vachtl and Vašíček (1950) studied the green clay from Vonšov. By chemical, thermal, microscopic and X-ray analysis they concluded that the predominating mineral in this clay is an illite having a high sorption capacity. This illite later was identified by Konta and Pouba (1961) as "open" illite.

Šiške (1950) found gibbsite as a second essential constituent in the kaolinitic underclays rich in titanium (up to 10 percent TiO_2) from the Sub-Ore Mountains brown coal basin. A larger number of chemical analyses of Cenomanian kaolinitic claystones from the Bohemian and Moravian Cretaceous strata were published in the works of Vachtl (1950) and Soukup (1954).

Konta and Kužvart (1956) studied the green, blue and white clays from the Cheb basin. They observed that the green clay with predominating illite and a slight admixture of kaolinite swells strongly when brought in contact with water. They also identified kaolinite pM and kaolinite having a structure between kaolinite pM and T. By study of "heavy" and "light" minerals

they have concluded that the source rock of the white kaolinitic clays is the kaolinized granite of Fichtelgebirge. Špičák (1957) identified kaolinite pM as an essential mineral in the Tertiary clays from Kalinovo and Poltár in Slovakia which are used in the earthenware industry. Slánský (1958) studied the mineral composition of silty-sandy kaolinitic clays from some localities in western Bohemia and discovered kaolinite pM as the essential mineral.

Čech (1958) studied by differential thermal analysis, X-ray analysis, chemical analysis and staining tests a larger number of kaolinitic and montmorillonitic clays from a part of the Sub-Ore Mountains brown coal basin. Kukul (1959a, b) found "sericite" as the only clay mineral in Ordovician shales of the Barrandian Basin, and in his work special attention was paid to the question of origin of red, gray and green shales and to their chemistry. These argillaceous sediments form approximately one-third of the total bulk of the Ordovician clastic rocks in the Barrandian Basin.

Malkovský (1959) discovered that in most parts of the claystones of Carboniferous age in Ostrava Basin illite predominates over kaolinite in the sediments of marine origin, whereas in the freshwater sediments the proportion is the reverse. In the Upper Cretaceous kaolinitic clays in southern Slovakia, Mišík, Čížel and Marková (1959) found crystals of kaolinite pM of about 1 mm diameter with holes in the center. High-temperature quartz, idiomorphic crystals and twins of tridymite and a smaller amount of cristobalite are found as admixture in these clays. The source of these clays is considered to be the dacite and rhyolite tuffaceous rocks found in the vicinity.

Michalíček and Přikryl (1959) studied argillaceous sediments of potential oil areas in Czechoslovakia (mostly of Neocene and Paleocene age). In them they discovered illite as a predominating mineral, and also montmorillonite which is associated with the horizons of tuffaceous material. The sorbed cations of clay minerals were studied by Michalíček (1959). By means of the cations he postulates the hydrochemical character of sedimentation (whether marine, brackish or freshwater) and makes use of this for solving the stratigraphical problems of the oil-bearing sediments of the northern part of Wien Basin in southern Moravia.

Melka and Slánský (1959) identified by X-rays some kaolinites T and pM and the intermediate types between these two. Further, they have also studied montmorillonite and irregularly interstratified illite-montmorillonite from Füzéradvány, Hungary, where they have found a higher ratio of illite to montmorillonite than is described in the literature.

Laterites and Bauxitic Rocks (and Similar Weathering Crusts)

The territory of Czechoslovakia, though very rich in kaolin deposits, is poor in bauxitic rocks. The few bauxitic rocks with free aluminum hydroxides that occur in this country contain a considerable admixture of clay minerals; mainly kaolinite and also hematite. The age of the lateritic weathering which has given rise to the primary lateritic profiles and the sedimentary bauxitic rocks of freshwater origin is considered by all authors to be Cretaceous.

Vachtl and Konta (1953) studied the geology, petrology and chemistry of

the lateritic crust on the biotitic granodiorite of Skuteč. Bauxitic rocks from Rychnov studied by Konta (1954a) show great petrologic variations. They contain besides boehmite and hematite a considerable amount of kaolinite and a small admixture of gibbsite; the porous variety contains diaspore. The greenish boehmitic bauxite of Rychnov is one of the rare examples of the rock containing chamosite of freshwater origin. An analogous chloritic mineral in the form of spherulitic aggregates occurs as a constituent of small reduction spots in bauxite-hematite rock in Markušovce, Slovakia (Konta, 1954b). The essential constituents of these clayey-bauxitic rocks are boehmite, kaolinite and hematite. The paper contains numerous chemical and differential thermal analyses.

Slánský (1955) identified pimelite and nepouite among the hydrosilicates of nickel in the weathered crust of a serpentine rock at Křemže. Konta (1958c) studied a bauxite-hematite ore from Ransko and stated that the oölites differ from the interstitial material only in their higher content of hematite. After removing hematite under reducing conditions in a slightly acidic medium the author identified gibbsite, boehmite and kaolinite. Matějka (1958) identified boehmite, gibbsite and hematite in a bauxite from Drienovec.

Bentonites

In recent years new deposits of clay having a high content of montmorillonite were discovered and studied in detail. A large cristobalite content (up to 40 percent by weight) in the montmorillonitic clay from Kuzmice, Slovakia, was determined by Konta (1955b). The octahedral deformed crystals of cristobalite reach a size as large as 10 μ . This rock had been chemically and thermally studied earlier by Bárta, Čáp and Šatava (1949). Chemical and physical properties of montmorillonitic clays containing cristobalite from two new deposits in eastern Slovakia were studied by Gregor and Izáková (1959).

Gregor, Masár and Mocik (1959) determined the adsorption isotherms of the water solution of methylene blue and basic fuchsine for bentonitic rocks from five deposits in Slovakia. Příkryl (1959) studied the influence of Na-phosphates on the stability of Mg- and Na-bentonite suspensions, and he further investigated the relationship between adsorption of these phosphates and the sorbed cations of montmorillonite. Finally he studied a method of separating the ions of alkaline earths from bentonite suspensions. He also ascertained that in suspensions of Mg-bentonite the flocculation ability decreases in the series orthophosphate—tripolyphosphate—hexametaphosphate. Esterka (1959) studied the composition of lignines and their influence on the stability of bentonitic suspensions. He found that the dispersion properties of the alkaline sulfitolignines increase with the number of electronegative groups in the molecule of the compound (Cl, OH, NO₂ and quinoid bonds). The influence of phenols on the colloidal and rheological properties of bentonite suspensions in an alkaline environment was studied by Příkryl and Esterka (1960). They concluded that the effects depend firstly on the position and number of hydroxyl groups of the benzene core, and further on

the amount of dipole moment and on the ability to form quinoid bonds in alkaline environments.

Clay Minerals in Sedimentary Iron Ores

The silicate iron ores of middle Bohemia were studied in detail microscopically by Slavíková and Slavík (1917), who described precisely the optical properties of a micaceous flaky mineral which is now identified as illite. In recent years the data on clay minerals from these ores are becoming more precisely known. Melka (1957a) separated comparatively pure chamosite of the kaolinite type from Bohemian Ordovician oölitic ores and studied it by modern methods. Novák and Vtělenský (1960) identified 1M illite from the same oölitic iron ores and found that this mineral is an abundant constituent of the tuffaceous rocks underlying the ores. Almost pure polymorphous 1M modification occurs in the Petrovka locality; monolayer polymorphous modification of illite is found to predominate over montmorillonite structure (1M illite > montmorillonite) in the Velíz locality.

In the low-grade silicate iron ores of Ordovician age Netolický (1960) found alternating coatings of chamosite and illite in oölites, and illite was found to predominate in the interstitial material.

Clay Minerals In Carbonaceous Rocks

Attention has been paid to the clay minerals found in the carbonaceous rocks of Silurian age which are used as raw material for the production of cement. Konta (1955a) detected illite as the predominating clay mineral in insoluble residues of the Upper Silurian clayey carbonaceous rocks in middle Bohemia. Fine quartz of organic origin is the next most abundant essential constituent of these residues. Some layers contain a small amount of montmorillonite of tuffaceous origin. Kaolinite has been found (along with illite in the approximate ratio 1:3) only in the coarse-grained organoclastic limestones that contain very little insoluble residue. The author advocates a terrestrial origin of these clay minerals as most probable. Kukul (1955) also found illite in the insoluble residues of the Silurian carbonaceous rocks, and only in coarse-grained limestones an admixture of kaolinite.

Clay Minerals of Hydrothermal Origin

The study of clay minerals found in hydrothermal veins has been gaining more importance day by day, since the clay mineralogy depicts well the full picture of the hydrochemical and thermal regime of the solutions. The conditions of formation in this natural association are very similar to the conditions under which clay minerals are synthesized in many laboratories. Comparison of these natural and artificial associations of clay minerals helps us to understand with considerable accuracy the conditions of genesis and the thermodynamic stability of clay minerals.

In Czechoslovakia much attention has been paid to the study of several magnesium minerals from fissure fillings and clay minerals from ore veins of various types. Konta (1951) identified by microscopic, X-ray, thermal and

chemical analysis different varieties of deweylite from the fissure fillings in the serpentine at Mladotice. In a later study Konta and Šindelář (1955) found saponite in fissure fillings in amphibolites in the neighborhood of Čáslav, eastern Bohemia. Here the mineral is associated with either albite-oligoclase or calcite, epidote, analcime, laumontite, natrolite and kaolinite in a so-called Alpine paragenesis. The fibrous mineral in fissure fillings in amphibolite from Templštejn, Moravia, which was named "parasepiolite" by Fersman (1913), was identified by Konta (1956b) as trioctahedral magnesium illite.

Novák *et al.* (1956) have studied an orthorhombic chamosite from ore veins in Kutná Hora found in association with quartz and sulfides of iron, zinc, arsenic and copper. On the same lines as Brindley and Knorring (1954), who have named the orthohexagonal variety of monoclinic antigorite *orthoantigorite*, these authors have named the orthorhombic chamosite *ortho-chamosite*. The orthochamosite from Kutná Hora, just as the cronstedtite from this locality, has been formed by hydrothermal decomposition of sulfides rich in iron, particularly pyrite and pyrrhotite, and of the silicates from the surrounding gneiss.

Šindelář (1957) has studied the deep-green, kidney-shaped masses of talc from the fissure fillings of an amphibolitic rock near the contact with a peridotitic rock. Novák and Kupka (1960) found hydromuscovite in the auriferous quartz veins of Roudný, Bohemia. This mineral is made up of a monolayer monoclinic polymorphous modification with a small admixture of $2M_1$ structure ($1M \gg 2M_1$).

The clay minerals in the cassiterite-wolframite and molybdenite ore veins of northern Bohemia were studied by Konta (1960d). He found that in the veins that are filled with clay material the three-layer minerals predominate, with predominance of hydromuscovite over montmorillonite. In the open veins, where circulation of hot solutions was easy, dickite containing a small amount of kaolinite predominates and sometimes montmorillonite is present as an admixture. In further work, Konta (1961b) determined the temperatures of crystallization of these minerals by application of the decrepitation method to the associated quartz, fluorite, topaz and beryl. Klír (1959) studied the clay minerals from the dislocation planes of various rocks in several types of ore deposits.

Apparatuses for Differential Thermal Analysis and Gravimetric Thermal Analysis

Many efforts have been made to simplify and perfect the apparatus for differential thermal analysis (DTA). Vašíček (1954) described the historical development of DTA and referred to the different types of DTA apparatuses. Šatava (1957) described a simple, inexpensive, recording thermobalance. Formánek and Bauer (1957) published a scheme of a new thermobalance construction with direct registration. Blažek (1957) developed an automatic thermobalance with the possibility of simultaneous registration of DTA curves and disintegrating gassy products. Pospíšil and Beránek (1957)

constructed a fully automatic apparatus for DTA which differs from the hitherto used apparatuses by a new shape of hollow, pressed sample and by a precise method of checking temperature. Vintera and Bergstein (1957) have recommended a new arrangement of DTA without reference sample, and with the pulverized sample pressed into the shape of a small hollow cylinder having a firm bottom. These authors have recommended the method for recording slight changes in temperature in the sample, especially for some structural changes. Neužil (1959) constructed an automatic DTA apparatus and explained the main factors influencing the results. Gašparín, Proks and Šiške (1959) constructed an apparatus for rapid DTA with variable heating speed: the temperature of 1000°C is attained during an interval of 90, 60, 45, 30, 15, or only 10 min. A great number of analyses were done in air as well as in a CO₂ atmosphere.

Voldán (1959) constructed an apparatus for thermal analysis in which the electric conductivity of the finely pulverized samples could be measured using a heating rate of 3–4°C/min up to 1000°C. The crystallization of new compounds has an influence on the electrical conductivity of the sample. The analysis was used for vitreous samples solidified from melted basaltic rocks but probably can be used also for clay minerals. Šatava and Trousil (1960) described a simple construction of an automatic program temperature controller for DTA with the use of semiconductive elements. Vaniš and Koráb (1960) constructed a simple apparatus for rapid DTA having a heating rate of 100°C/min, suitable for routine laboratory work. Šiške and Proks (1961) described an instrument for DTA which can record the temperature precisely and can follow the reactions at lower temperatures from –40 to +300°C. The experimental part of the work is directed towards the study of properties of the water adsorbed by different materials. By means of this instrument they also studied (Proks and Šiške, 1961) the course of solidification and hardening of cement.

Quantitative Mineralogical Analysis of Clay Minerals

In recent years great emphasis has been laid on quantitative mineralogical analysis. Procházka (1954) presented examples where by means of a thermobalance constructed by him the quantitative estimation of the kaolinite–montmorillonite clay minerals can be done with an accuracy of 5–10 percent, and the content of sericite in metallurgical quartzites could be determined within an accuracy of 1 percent. Konta (1958d) re-examined and applied Vendel's quantitative microscopic analysis for the estimation of very finely dispersed light-coloured minerals in bauxitic rocks after removal of iron oxide pigment. Values of refractive indices of iron-free residues, determined by the immersion method using sodium light, give the bulk percentage of boehmite and kaolinite.

Pospíšil (1959) used the exothermic peak of kaolinite for quantitative determination of this mineral in various European kaolins and clays. He also studied the influence of some admixtures on the height of this peak. Proks (1961) explained in a relatively simple way the mathematical relationships

existing between the constant increase of heating and the factors important in evaluation of DTA curves. One of the seven equations, $U \cdot \Delta_R H = \text{const} \cdot P_T$, shows the advantage of the curves in which ΔT (= temperature difference) depends on the rate of heating, particularly for quantitative determination of a mineral from the area of a suitable peak: $U \cdot {}_R H = \text{const} \cdot A_T$ (where U = the constant rate of temperature increase in $\text{grad}/\text{sec}^{-1}$; ${}_R H$ = reaction enthalpy related to the total substance of the analyzed material, in cal.; A_T = total area of the peak).

Neužil (1961) prepared artificial mixtures of various clay minerals and dealt with the influence of different factors on the form of the DTA curves of these mixtures. Konta (1961c) has studied by means of gravimetric thermal analysis, DTA, and compensation DTA the content of kaolinite in various size fractions of the floated kaolin from Sedlec.

Imbibometric Study Using Water and Organic Liquids

In the Petrological Institute of the Charles University a new method was developed by Konta (1956a) for rapid identification of clay minerals and determination of various physical properties of argillaceous rocks. This method is based on the course of imbibition of a drop of water and a drop of ethylene glycol on ground flat sections of argillaceous rocks. Imbibometry is useful not only for identification of clay minerals but also in engineering geology, ceramic technology and other branches where the problems are connected with the mutual effect of the liquid and the porous clay material. In further work Konta (1959a, b) has contributed toward the study of total and effective porosity and imbibition capacity of unconsolidated argillaceous rocks of various mineralogical compositions. He has also proposed new diagrams for identification of clay minerals based on this method. In his recent publication (Konta, 1961) the mathematical explanation of the imbibometric method is given, and in this work the influence of effective porosity and total surface area of the particles on the speed of imbibition of water and ethylene glycol has also been explained. Cimbáľníková (1960) and Šrbená (1960) have applied the imbibometric method to identification of clay minerals in loess near Prague.

Problems of Classification and Terminology

The complicated problem of classification and terminology of clay minerals and argillaceous rocks is well known. The various authors are influenced by the traditions of their own schools and the literature around them and also, of course, by their own research work. Kouřimský and Šatava (1954) have contributed towards the classification and terminology of the serpentine group of minerals, not only of mineral species but also varieties. They have given the optical properties and the original DTA curves for most of these minerals. Konta (1955c) has found that dillnite from Banská Belá is a specific mineral and not a mixture of kaolinite and diaspore as hitherto thought. In further work Konta and Mráz (1961) published more comprehensive chemical data on dillnite and explained its relation to zunyite.

Melka (1957b) has summarized existing opinions about the classification of chlorites according to chemical and physical points of view. On the request of the Commission for the terminology of minerals, Czechoslovak Academy of Sciences, Konta (1958a) has listed and briefly defined the clay minerals for Czechoslovak scientific workers. Konta (1958b) has also dealt with the classification and terminology of the rocks in the series bauxite–clay–iron oxide ore. Havlena (1959) has worked out a proposal for a quantitative classification of the rocks in the series coal–argillaceous rock. He has shown the variations in the terms when the rocks are studied megascopically on the one hand and microscopically on the other. Mišík (1959) has summarized the up-to-date proposals for classification of the rocks in the series clay–carbonaceous rock.

Konta (1960a, b) has proposed rules for quantitative descriptive classification and terminology of the sedimentary rocks, including the argillaceous rocks. The rules are such that the basic genetic differences in the rocks are perceptible. Konta (1960c) has also discussed the schemes of clay mineral classification proposed by Caillère and Hénin (1957) and Mackenzie (1959). The author (Konta, 1960c) has named the groups of clay minerals after the best known and most widely occurring mineral, as is usual in the whole mineralogical system, e.g. kaolinite group, montmorillonite group, etc. He has also recommended that the mineral species be differentiated principally from the varieties and that the structural formulas be written in a uniform way. Bárta (1957) has proposed in collaboration with others a uniform nomenclature and abbreviations in thermography.

Problems of Clay Mineralogy in Ceramic Industry

The data of clay mineralogy and petrology are being used more and more in ceramic industry. Bárta and Srbek (1954a) published a method for the dressing of loams having a large content of illite and montmorillonite and have shown how they can be used for the manufacture of good quality bricks by mixing the sand available from the floated kaolin. In a further study Bárta and Srbek (1954b) showed the utility of the kaolinitic claystone from the brown-coal basin of northern Bohemia with a content of 42 to 56 percent Al_2O_3 and up to about 10 percent TiO_2 , the essential minerals being kaolinite, gibbsite and anatase.

Šatava (1954) has discussed the mechanism of hydration of clay minerals and has described a new rapid method for measuring the grade of swelling in argillaceous rocks. Wendler (1954) constructed a useful nomogram for calculating the particle size after Andreasen's equation. Vytasil (1954) studied with the help of a modified Sharples supercentrifuge the dispersion curves of the standard kaolin from Sedlec, blue clay from Vonšov containing kaolinite pM in predominance over illite and another kaolinite–illite clay from Poltár.

Babčan (1959) studied the products of thermal decomposition of chloritic minerals having kaolinite structure, i.e. chamosite from Kutná Hora and cronstedtite from Příbram, and also normal chlorites. During ignition of septechlorites in a hydrogen atmosphere at 500°C the elementary iron is

liberated, and spinel $[(\text{FeO} \cdot \text{MgO}) \cdot \text{Al}_2\text{O}_3]$ and quartz are formed. The elementary iron is not liberated from normal chlorites but is bound in $\text{MgO} \cdot (\text{Fe}_2\text{O}_3 \cdot \text{Al}_2\text{O}_3)$. These results can have considerable importance for the problem of the character of the dehydroxylation product of kaolinite. Babčan presumes from this that at the temperature given, thermal decomposition into amorphous oxides takes place, and no compound analogous to metakaolin arises. Šatava (1961) has summarized the various opinions regarding the reactions taking place when kaolinite is heated to a temperature higher than 1200°C .

Miscellaneous Studies

Štovík and Melka (1959) constructed a new apparatus for determination of refractive index by the bivariation method directed especially toward clay mineral study. Konta (1959c) has dealt with the question of working on clay minerals under constant laboratory temperature and humidity conditions. For better differentiation of the content of molecular water and hydroxyl water in any clay material he has recommended that every published chemical analysis should be accompanied by a gravimetric thermal curve. Příkryl and Krajča (1960) constructed an apparatus for measurement of electrophoretic mobility (ζ -potential) of clay particles. This apparatus is constructed more simply than the well-known apparatus of Tiselius. As an example, the course of stabilization of a Wyoming bentonite suspension has been measured on this instrument.

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