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CORRELATION OF MINERAL COMPOSITION OF THE PARENT ROCK WITH THE MINERAL COMPOSITION OF KAOLIN

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ABSTRACT

Commercial kaolin deposits are only formed from acid rock. In the weathering processes quartz grains of primary rock are conserved without any changes of size. Large kaolinite flakes arise in the place of mica by epitaxial growth on a mica sheet. Some part of iron and titanium is preserved in special minerals formed within pseudomorphs after biotite. K-feldspar changes into small newly formed kaolinite flakes. On acid plagioclase halloysite appears but on andesine-labrador montmorillonite arises. Properties of commercial kaolin depend upon all the peculiarities of the mineral transformations.

There is no doubt that relationship exists between the chemical and mineralogical composition of kaolins and the preexistent parent rocks of the kaolins. The relationship is revealed by exploitations of kaolin deposits and results of their study.

As a sufficiently well-known example one may refer to the dimensions of quartz particles in kaolins and parent rocks. The large quartz crystals are retained in kaolins formed from coarse-grained granites; beneficiation of these kaolins is performed very easily. Contrary of this, kaolins formed from fine-grained granitoids contains high quantities of fine sand and therefore beneficiation of these kaolins is much more difficult. Also one may note the kaolins in South-Eastern G. D. R. The kaolins, formed from coarse-crystalline quartz-porphyries, in the neighbourhood of Kemmlitz and Gruppensdorf, are beneficiated comparatively easily because they contain sufficiently coarse quartz, as the parent rocks do. There is the opposite situation in the small kaolin deposit at Seilitz near Meissen. Here pitchstones are developed; these rocks are almost analogous in chemistry to quartz-porphyries of previous deposits, but do practically not contain well-crystallized minerals. As a result of weathering of these pitchstones exclusively clean and homogenous kaolins were formed. These kaolins contain high quantities of fine-grained quartz, which is retained in beneficiation processes. However, these kaolins, due to their homogeneity and cleannes are used in Meissen ceramic works for the highest quality artistic porcelain wares.

In kaolins, among other minerals of the parent rocks kaolinite pseudomorphs after biotite, chloritized biotite and muscovite can be recognized very easily. The pseudomorphs after biotites are coarser than kaolinite particles; they have approximately the same size, as the biotite which was replaced, however, almost all titanium and iron of biotite are retained within the pseudomorphs and form individual minerals piercing through the kaolinite particles. These minerals form very distinctive "sagenitic lattice" in the flake.

Observations on sagenitic lattice represents the limits of possibilities of light-microscopy. Much more information about the weathering processes can be received by electron microscope. Especially interesting results were received by the method of decoration with gold [GRITSAENKO, SAMOTOIN, 1966].

Fig. 1 shows the growth of the kaolinite on the surface of cleavage plane 001 of microcline. It is very remarkable that the kaolinite crystals, consisting of few unit layers, have rhomboidal forms, and only after receiving a thickness of at least 10—20 unit layers the crystals obtain characteristic hexagonal forms. *Fig. 1* shows well the growth of the kaolinite crystals on a microcline surface in distinctive orientations. Here the main crystallcgraphic axes a_k and b_k of kaolinite coincide with the main crystallographic axes a_m and b_m of microcline.

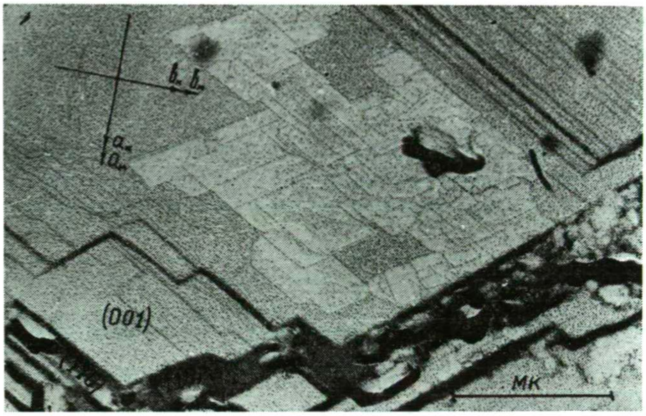

Fig. 1. Kaolinite microcrystals on the surface 001 of microcline. Arrows show directions of main crystallographic axes of microcline (a_m, b_m) and kaolinite (a_k, b_k). Weathered microcline, Eastern Siberia.

In *Fig. 2* the weathering of microcline has a prcgressively prograded as compared to *Fig. 1;* here the mechanism of weathering is shown well. Open surfaces of microcline have been dissolved intensively; cleavage planes are not so distinct as they are in *Fig. 1* and the etching pits are shown very well on the microcline surface. The kaolinite growing on the microcline has a large thickness and is an aggregate of many grown crystals. It is characteristic that crystals of the aggregate have almost the same orientation and hexagonal form.

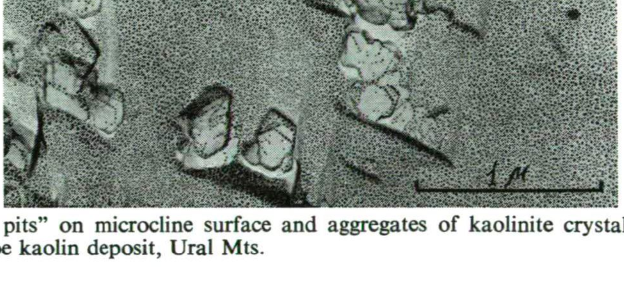

Fig. 2. "Etching pits" on microcline surface and aggregates of kaolinite crystals growing on it. Eleninskoe kaolin deposit, Ural Mts.

It is very interesting, that the influence of parent crystals, on which clay minerals have grown, is reflected in the finest details. In granitoids microcline crystals often contain albite and albite-oligoclase perthitic intergrowths. As the study of weathered perthitic intergrowths has shown they are replaced by halloysite rather than kaolinite [PETROV *et al.*, 1978]. *Fig. 3* shows the oligoclase surface on which oriented halloysite tubes have been grown. Originally halloysite, as kaolinite also, form rhomblike crystals, which, at a further stage, grow in typical tubular halloysite crsytals [CHEKIN *et al.*, 1976]. The rhomblike crystals are shown at the bases of some tubular crystals (*Fig. 3*). Halloysite nature of these rhomblike crystals has been judged with the method of selected area diffraction.

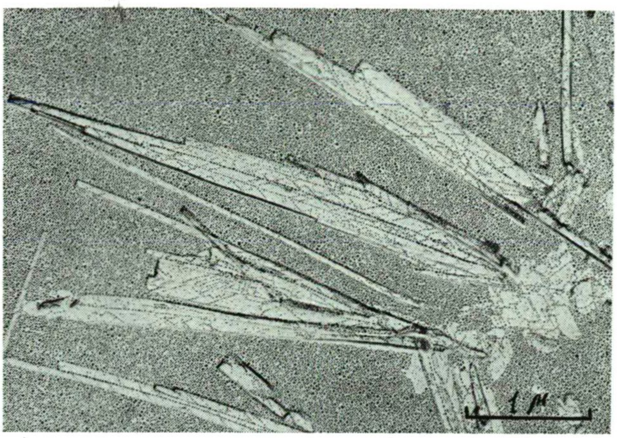

Fig. 3. Platy and tubular halloysite (7 Å?) crystals on the surface of weathered oligoclase. Soyuznoe kaolin deposits, Ural Mts.

The other clay minerals are formed on the more basic plagioclases. In the western part of Ukraine the weathering has changed the large Volynskii anorthosite massif, in which the main rock-forming mineral is andesine-labradorite feldspar (47—53% anorthite component). The first clay mineral, which has been formed by the weathering of the labradorite, is montmorillonite.

Fig. 4 shows fine sheets of montmorillonite on the cleavage surface of a labradorite crystal.

The weathering of Volynskii gabbros has been studied in detail by N. I. BUCHINSKAYA [1972]. The author has shown, that in lower section of the old crust of weathering with a thickness of more than 50 metres, montmorillonite clays are developed and they are changed upwards in kaolins. It is very interesting, that there are some alumina minerals (up to 7—10%; rarely more than 10%) in the transitional zone which is of comparatively low thickness (few metres).

The vertical change of the mineral composition of the weathering crust is also influenced by the parent rock's composition. Invariable presence of kaolinite in the upper part of the crust of weathering suggests the acid character of the superficial weathering solutions; in the lower parts of the crust of weathering the solutions have reacted with gabbros, enriched by alkaline and alkaline-earth elements and got alkalinity. As a result of this at the lower parts of the crust montmorillonite was formed, i. e. a mineral characteristic of an alkaline environment. Naturally, here a neutral intermediate zone was formed containing gibbsite — a mineral characteristic of a neutral environment.

The authors have studied the weathered andesine-intermediate plagioclase between oligoclase and labradorite in Kazakhstan, where the crust of weathering was developed on granodiorites. Newly formed clay minerals have intermediate characteristics here. On the cleavage surface of andesine both fine sheets of montmorillonite and tubular halloysites were formed (*Fig. 5*).

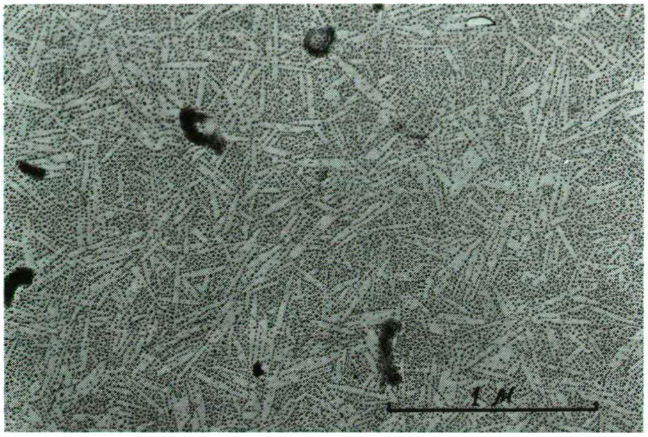

Fig. 4. Montmorillonite sheets on the cleavage surface of weathered labradorite crsytal. Golovinskoe labradorite deposit. Ukraine.

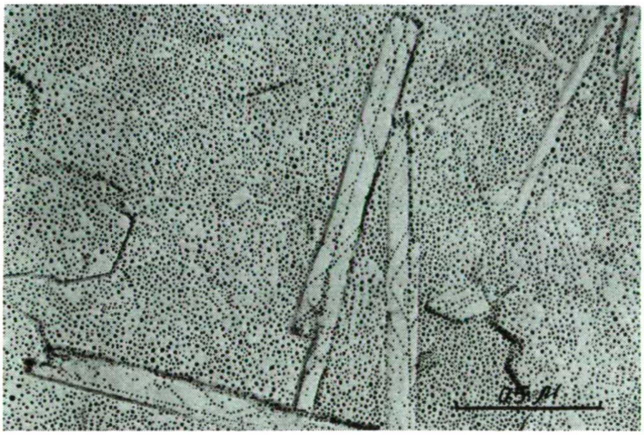

Fig. 5. Tubular crystals of halloysite (7 Å?) and montmorillonite sheets in weathered andesine. Alekseevskoe kaolin deposit, Kazakhstan.

The results of study of weathered micas are also very remarkable. It was shown, that kaolinite crystals always grow on the sheets and within the sheets of mica [Chekin *et al.*, 1977]. Therefore, the basic mica lattice is not preserved during the replacement of mica by kaolinite. There is only epitaxial growth of kaolinite crystals on mica sheets (*Fig. 6*) and the dissolution of mica sheets. Therefore, a kaolinite flake, which is a pseudomorph after a mica crystal, is not a single crystal but is a pseudotwin intergrowth of many fine crystals.

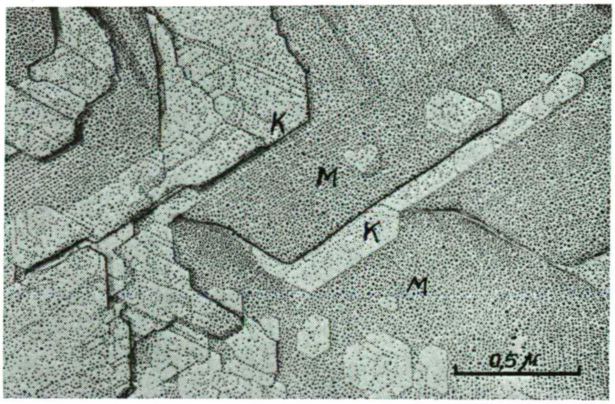

Fig. 6. Kaolinite crystals growing on the surface of muscovite crystal. Weathered sericite slate Kazakhstan.

The number of examples similar to those discussed above could be increased but even now one could see:

Firstly, the composition and properties of kaolins are controlled largely by the composition of parent rocks. Quantity of plagioclase and content of its anorthite component are factors controlling quantities of halloysite, and also often those of montmorillonite in a predominantly kaolinitic mass and, consequently, properties of kaolin such as wet strength, firing strength and melting point temperature. Ferrous admixtures in parent rocks and especially biotite content determine the colouration of kaolin and its paper filler properties.

Secondly, it was shown, that in the course of the weathering process minerals of a parent rock dissolved completely and newly formed minerals grow from a solution acting as weathering agent.

Orientation of newly formed minerals inherits often the orientation of the mineral of the parent rock due to epitaxial growth of newly formed minerals on minerals of the parent rocks.

The authors believe that the electron-microscopic method of decoration with gold is one of the most promising methods of investigation of weathering processes.

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