CORRELATION OF KAOLINITE MORPHOLOGY AND CRYSTALLINITY

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ABSTRACT. — Samples of kaolinite displaying various degrees of crystallinity determined by x-ray analysis were selected for electron microscope study to determine the relationship of kaolinite crystallinity and morphology. The hexagonal outlines of kaolinite platelets were found to be associated with both ordered and disordered kaolinite, suggesting that the hexagonal shape is conditioned by some factor other than perfection of internal order.

This report presents the results of a study of the morphology of kaolinite as related to crystallinity to determine if the hexagonal outline of kaolinite is always associated with well-developed crystallinity. Three samples of kaolinite, selected by X-ray analysis to show different degrees of crystallinity, were used for the electron microscope study: (1) a Cretaceous clay, commonly called Georgia kaolinite, from the Georgia Kaolin Company, Dry Branch, Georgia; (2) a Cretaceous—Tertiary clay from Anna, Illinois; and (3) a Pennsylvanian flinty clay from Vigo County, Indiana.

Unfractionated clay was gently ground to a fine powder and X-rayed in a diffraction unit (CuK α radiation, Ni filter, 1° slit). The dispersion technique was used to prepare the kaolinite for electron microscope study. Drops of dispersed clay were dried on copper 200-mesh electron microscope grids. Electron photomicrographs were taken of selected fields.

The degree of crystallinity is defined to include the degree of disorder within the crystallographic unit layer and the stacking variations of the unit layers (Murray, 1954). Murray used the following criteria to determine the degree of crystallinity by use of X-ray techniques: (1) sharpness of reflections; (2) number of reflections; (3) amount of shift in the (001) or basal spacing from the normal position; (4) resolution of closely spaced reflections; and (5) absence of certain reflections. The resolution of closely spaced reflections provides the best indication of the degree of crystallinity. Murray stated that the closely spaced reflections on a powder photograph of kaolinite with a good degree of crystallinity are well resolved as exemplified by reflections adjacent to the (020) and the (003) reflections, while these reflections are hazy and less resolved with poorer crystallinity. The coupling of the (020) $(1\bar{1}0)$ $(1\bar{1}1)$ $(1\bar{1}\bar{1})$ reflections into a band indicates the disordered state described by Hendricks (1939) and discussed by Brindley and Robinson (1946). They stated that the disorder is the result of displacement of layers occurring in the b-direction only and of a magnitude of nb/3. This type of randomness of layers leaves reflections of types $K = 3n$ unaffected but diffuses all combinations for which $K \neq 3n$ (Brindley and Robinson, 1946).

Murray and Lyons (1956) studied kaolins displaying various degrees of

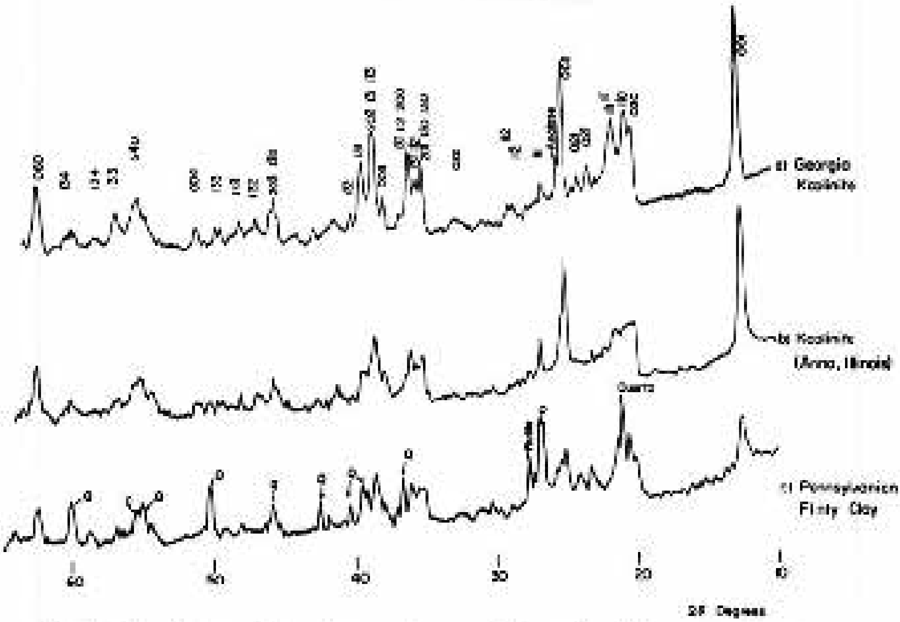

FIGURE 1.—X-ray diffraction patterns of three kaolinite samples from the Georgia Kaolin Co., Anna, Illinois, and Vigo County, Indiana.

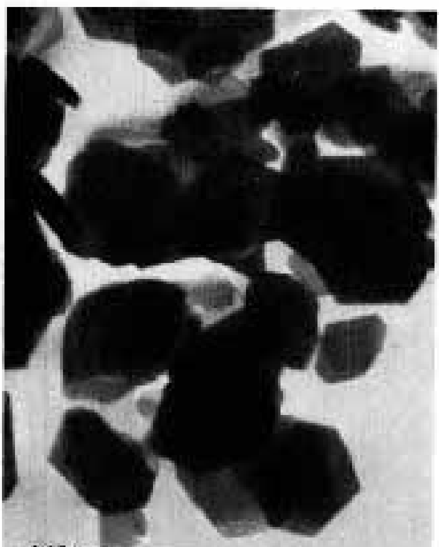

FIGURE 2.—Electron micrograph of Georgia kaolinite clay. x61700.

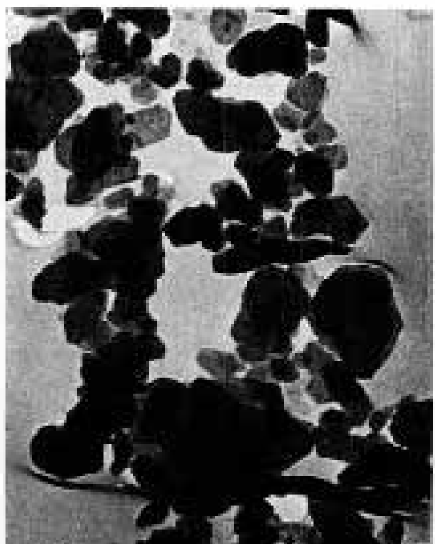

FIGURE 3.—Electron micrograph of kaolinite from Anna, Illinois. x40000.

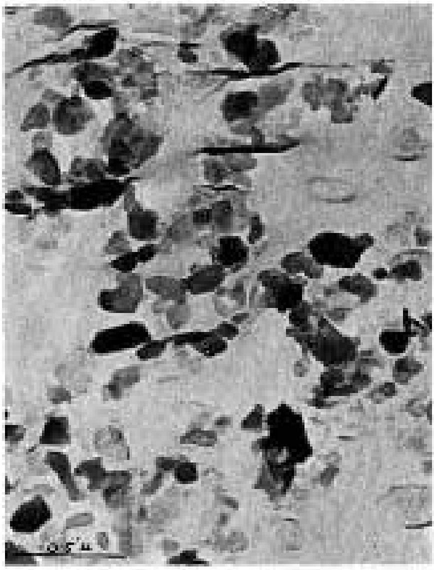

FIGURE 4.—Electron micrograph of a Pennsylvanian flinty clay, Vigo County, Indiana. x40000.

crystal perfection. From X-ray diffraction traces of kaolins they prepared a diagrammatic representation of kaolin clays arranged in order of crystallinity or degree of crystal perfection. In describing the crystallinity of our clays, comparison was made to the traces published by Murray and Lyons. In addition, the Brindley and Robinson indexing scheme was utilized for the X-ray traces with special attention to the resolution of peaks near the (020) and (003) reflections.

RESULTS

The X-ray trace of the Georgia kaolinite sample displays numerous, well-resolved, sharp reflections, indicating well-crystallized kaolinite (Fig. 1a). An electron micrograph shows a sharp hexagonal outline of the kaolinite platelets (Fig. 2). Kaolinite from Anna, Illinois also has a hexagonal outline (Fig. 3); however, the X-ray trace exhibits the diffusion to a band for the K + 3n combinations (Fig. 1b). Those (hkl) reflections for which K = 3n remain recognizable. The X-ray trace of the Pennsylvanian flinty clay retains reflections for combinations with K + 3n with a relative prominence comparable with that seen on the trace of the Georgia kaolinite, but shows loss of definition among K = 3n combinations (Fig. 1c). The electron micrograph shows that the platelets are irregularly shaped and nonhexagonal in outline (Fig. 4).

DISCUSSION

The data indicates a correlation of the hexagonal outline with the well developed crystallinity of Georgia kaolinite but a lack of correlation with the crystallinity of Anna kaolinite and the Pennsylvanian flinty clay. The reason for the deteriorated state of crystalline perfection in the latter two kaolinites may be due to plastic deformation along the b-axis and strain along the a-axis (respectively). The b-axis plastic deformation apparently was sufficient to produce internal disorder while maintaining the hexagonal form of the Anna kaolinite. On the other hand, a-axis strain maintains internal order while producing a nonhexagonal outline. It is concluded that the hexagonal shape of the kaolinite plates is conditioned by some factor other than the perfection of internal order.

LITERATURE CITED

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