

# CLAYS and CLAY MINERALS

at a glance

Volume 18

December 1970

Scientific Contributions  
News

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## THE ORIGIN OF PYROPHYLLITE AND RECTORITE IN SHALES OF NORTH CENTRAL UTAH

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Pyrophyllite is widespread in pelitic rocks of the Manning Canyon Shale in north central Utah, and the association of this mineral with other clay minerals, especially rectorite is related to the origin. The regular mixed-layer clay mineral rectorite seems to form as a result of the alteration of muscovite-paragonite during late stages of diagenesis and represents an intermediate metastable phase in the mineral paragenetic sequence. Pyrophyllite subsequently formed from the alteration of rectorite during advancing metamorphism and is the stable end member of the clay mineral assemblage.

Structural interpretation of rectorite found in the Manning Canyon Shale shows a regular, alternating sequence which consists of a fixed layer of 9.6 Å and an expandable layer, varying from 10 Å to 17 Å. With ethylene glycol saturation in the natural state a basal reflection of 26.60 Å is recorded.

## CLAY MINERALS IN PENNSYLVANIA SOILS Relation to Lithology of the Present Rock and Other Factors—I

Leon J. Johnson

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Clay mineral data have been obtained on 348 soil profiles representing 117 different soil series from 28 of Pennsylvania's 67 counties. The surface rock from which the soils were formed ranged from Pre-Cambrian to Tertiary-Pliocene and includes igneous, metamorphic and various types of sedimentary rocks. Major attention was focused on the subsoil mineralogy. Mica was found to be the most predominant clay mineral in terms of amounts and frequency of occurrence. It is dominant or co-dominant in 82 per cent of the profiles. In shale derived soils it is important in 95 per cent of the cases and in 68 per cent of the limestone soils. Kaolinite is a prominent component of soils derived from sandstone and metamorphic rocks. Montmorillonite was detected in over half of the soils but is very infrequently a prominent

component and is more frequently found in the poorly drained soils. A mica-kaolinite suite is characteristic of soils from Pennsylvanian age rock whereas soils derived from Devonian, Mississippian, and Ordovician age rock had a mica-chlorite suite. The chlorite is frequently found weathered to chlorite-vermiculite in a 1:1 ratio. Gibbsite, talc, and pyrophyllite have been identified but only rarely occur. A difference in clay mineral types is frequently found among different profiles of the same soil series. Soils derived from limestone and highly calcareous rock may have rather unusual clay suites such as the dominance of a well-crystallized trioctahedral chlorite, well crystallized mica, and soils approaching a monomineralic character in mica.

## PRECIPITATION OF KAOLINITE AT 25°C AND 1 ATM

J. A. Kittrick

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The 0.2–5 μ particle size fraction of montmorillonite from three sources was equilibrated with various solutions at room temperature. After 3–4 yr, kaolinite was found in some of the samples that were supersaturated with respect to kaolinite, but not in any of the under-saturated samples or in the original montmorillonite. X-ray diffraction analysis of the precipitated kaolinite showed no interlayer expansion of glycerated, oriented samples. Random powder samples indicated a poor crystallinity. The thermal stability of the precipitated material was indistinguishable from that of crystalline kaolinite. The electron microscope did not reveal any distinctive sizes or shapes.

Equilibration behavior of several samples defined a single kaolinite solubility line at or above which kaolinite apparently begins to precipitate. The solubility line is equivalent to a standard free energy of formation ( $\Delta G$ ) of  $-904.2$  kcal per mole of kaolinite. This represents highly crystalline kaolinite. The stability of kaolinite actually precipitated at room temperature probably depends upon precipitation conditions. Thus kaolinite stability could range from poorly crystalline up to the equivalent of the kaolinite solubility line at which initial precipitation begins.

### A HYDROMUSCOVITE FROM THE SHAKANAI MINE, AKITA PREFECTURE, JAPAN

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A hydromuscovite in association with gypsum and anhydrite was collected from the Shakanai mine, Akita Prefecture, Japan. Chemical composition:  $\text{SiO}_2$ , 47.14%;  $\text{TiO}_2$ , 0.34%;  $\text{Al}_2\text{O}_3$ , 37.09%;  $\text{Fe}_2\text{O}_3$ , 0.49%;  $\text{MgO}$ , 0.83%;  $\text{CaO}$ , 0.57%;  $\text{Na}_2\text{O}$ , 0.35%;  $\text{K}_2\text{O}$ , 7.10%;  $\text{H}_2\text{O}^+$ , 5.18%;  $\text{H}_2\text{O}^-$ , 0.99%;  $\text{P}_2\text{O}_5$ , 0.01%; total, 100.09%. Differential thermal and i.r. absorption analyses were similar to those of hydromuscovite. The X-ray diffraction pattern differed clearly from those of the  $1M$  and/or  $2M_1$  polymorphs and it was similar to that of the  $2M_2$  polymorph, which is known to occur in lepidolites.

### VERMICULITE AS A MODEL SYSTEM IN THE TESTING OF DOUBLE LAYER THEORY

John P. Friend and Robert J. Hunter

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The microelectrophoretic and adsorption behavior of lithium vermiculite has been studied as a function of lithium chloride concentration. This was done in an attempt to establish the applicability of such systems to the testing of theories of interaction of flat plates, and in so doing to throw further light on swelling measurements performed on such materials. The studied behavior, while highly unusual, gave quite good agreement between adsorption and microelectrophoretic parameters and agreed, qualitatively, with some earlier measurements on similar materials.

The observed properties appear to be due to some rather specific structuring effects, either of the oxide surface or of the electrolyte ions. If this is so, these systems are far from ideal models for the testing of the theory of interaction of two uniform flat plates.

### POLYTYPISM OF CHLORITE IN SEDIMENTARY ROCKS

John B. Hayes

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Four chlorite polytypes of Bailey and Brown (1962) have been identified by X-ray diffraction in clay-size chlorites of soils, sediments, and sedimentary rocks: (1)  $11b$ , the polytype of common metamorphic and igneous chlorites; (2)  $1b(\beta = 90^\circ)$ ; (3)  $1b(\beta = 97^\circ)$ ; (4)  $1a$ . An additional stacking arrangement,  $1b_a$ , is defined herein as disordered chlorite which lacks an  $h0l$  diffraction band in the 2.4–2.5 Å region.

Most type-I chlorites are authigenic, as demonstrated by thin-section petrography. Type-I chlorites form during diagenesis, or less commonly during halmyrolysis, at temperatures and pressures less than those of low-grade metamorphism. A type-I crystallization sequence is proposed, from least to most stable:  $1b_a \rightarrow 1b(\beta = 97^\circ) \rightarrow 1b(\beta = 90^\circ)$ . Conditions of low-grade metamorphism usually are necessary to cause conversion of  $1b(\beta = 90^\circ)$  to  $11b$ , the most stable and common polytype. Chemical composition has little or no influence upon polytype relative stabilities; temperature is much more important.

Sediment source areas with high relief, abundant rainfall, cold climate, and which contain  $11b$ -chlorite-bearing metamorphic rocks, may yield essentially unweathered  $11b$  chlorite to sites of deposition. Thus, clay-size  $11b$  chlorite in unmetamorphosed sedimentary rocks can be interpreted as detrital. Caution is required, however, because  $11b$  may be able to form authigenically at submetamorphic temperatures, because it is the most stable polytype. Petrographic evidence is useful in such cases.

Chlorite polytypism as a geothermometer can be applied to several geologic problems: (1) the authigenic versus detrital origin of clay minerals in sedimentary rocks, particularly in graywacke matrix; (2) the recognition of diagenetic facies or gradients, areally and stratigraphically, within given geologic provinces; (3) the detection of hydrothermal and incipient metamorphic effects. Chlorite polytypism merits general application as an interpretive tool.