

# CLAYS and CLAY MINERALS

at a glance

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## CLAY MINERALS IN HYDROTHERMALLY ALTERED ROCKS AT WAIRAKEI, NEW ZEALAND

A. Steiner

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Geothermal fluid discharged by steam wells, core drilled to depths as much as 4500 ft at Wairakei, New Zealand, has altered Pliocene to Pleistocene volcanics, tuffs, and breccias. Measured temperatures (max. 265°C) indicate epithermal to mesothermal conditions in buried fault fissures, the locus of both the hydrothermal fluid and most intense alteration. A supergene kaolinite alteration zone is distinguished from hypogene Ca-montmorillonite and combined micaceous and chloritic zones. The hypogene zones are usually wide, are temperature dependent and localized along fault fissures. Other common hypogene minerals are alkali feldspars, wairakite, epidote, quartz, calcite, laumontite, pitilite, pyrite, pyrrhotite, and rare prehnite. The micaceous clays (illite and mixed-layer illite-montmorillonite) and chloritic clays result from alteration of earlier formed Ca-montmorillonite. The stability of the hydrothermal minerals is controlled by the temperatures and chemical composition of the geothermal fluid ascending along the fault fissures.

## ELECTRON-OPTICAL STUDY OF HYDROTHERMAL FRINGE ALTERATION OF PLAGIOCLASE IN QUARTZ MONZONITE, BUTTE DISTRICT, MONTANA

J. M. Guilbert and R. L. Sloane

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Andesine plagioclase is one of the outermost minerals destroyed in the hydrothermal alteration of quartz monzonite of the Butte district, Montana. Replicas of fresh, incipiently, and thoroughly montmorillonitized grains

reveal a complex sequence of events that may follow alternate equivalent paths. Quantitatively most important is the formation of a hobnail texture composed of approx. 0.5  $\mu$  discoids of amorphous material on feldspar cleavage surfaces. These discoids appear to fuse laterally to form amoeboid or lobate amorphous clusters. Some assume progressively more polygonal outlines characterizing the montmorillonite morphology, or their fringes become flake-like montmorillonite which peels away in wisps from the pitted feldspar surface. Far less commonly, plagioclase appears to develop micrograins and wisps of montmorillonite directly without a discernible amorphous stage. The alternative paths are probably influenced by the chemical activity of magnesium in the system.

## HYDROTHERMAL ALTERATION OF A RHYOLITE FLOW BRECCIA NEAR SAN LUIS POTOSI, MEXICO, TO REFRACTORY KAOLIN

W. D. Keller and Robert F. Hanson

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A refractory kaolin clay deposit at the General Zaragosa Mine was formed by hydrothermal argillation of part of a fault block of rhyolite flow breccia and probably welded tuff. A silica-rich gossan caps the deposit. Optical, X-ray, DTA, and chemical studies show the following progressive sequence of alteration. (a) Bleaching of the breccia matrix accompanied by mobilization of much of the iron. (b) Mobilization of alkali and alkaline earth metals to form montmorillonite. Mobilization of silica to form disseminated quartz and peripheral tripolitic rock. (c) Further desilication of silica and clay to yield poorly ordered kaolinite-halloysite as the most intense end product of argillation. Most of the silica was redeposited as opal and chalcedony in a gossan overlying the clay. (d) Minor alunite at two places may mark the loci of the rising solutions.

**FORMATION OF HYDROXY-AL AND -Fe  
INTERLAYERS IN MONTMORILLONITE AND  
VERMICULITE: INFLUENCE OF PARTICLE SIZE  
AND TEMPERATURE**

D. D. Carstea

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Hydroxy-Al and -Fe interlayers were prepared in "monomineralic" fine and coarse clay montmorillonite and in coarse clay and silt vermiculite at 3°C and 21°C. At comparable particle size, regardless of temperature, the amounts of interlayers formed in montmorillonite greatly exceed those formed in vermiculite. The aluminum systems exhibited a higher degree of interlayering than iron systems. Within montmorillonite, the amount of interlayers increased as the particle size decreased, regardless of temperature. Within vermiculite systems equilibrated at 3°C, more hydroxy-Al interlayers were recorded in coarse clay than in silt, whereas at 21°C about equal amounts were formed. By contrast, hydroxy-Fe interlayering was favored by the silt fraction at both temperatures. The formation of aluminum interlayers in both minerals increased with increasing temperature. The formation of hydroxy-Fe interlayers in montmorillonite was generally not temperature dependent, but in vermiculite increased slightly with increasing temperature.

**MORPHOLOGY OF PARTICLES IN  
SIZE-FRACTIONATED Na-MONTMORILLONITES**

H. E. Roberson, A. H. Weir and R. D. Woods

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Electron microscopy of particles in four size fractions obtained by centrifugation of four samples of Na-saturated montmorillonite from Wyoming, Arizona, and Texas has shown details of particle morphology. The finest fraction of each montmorillonite consists predominantly of very thin, separate flakes whereas all coarser fractions, totaling 80 per cent or more by weight of the samples studied, are composed of microaggregates. For all the samples, preferred orientation is best developed in specimens formed from flakes of the finest fractions. Microaggregates are stable in dilute suspension although they swell to give large interlayer spacings, but can be disrupted into smaller, thinner flakes by ultrasonic vibration. Differences in dispersion behaviour between separate flakes and microaggregates are not due to differences in interlayer charge or chemical composition, which are very small between fractions of each sample, but are thought to be

due to the interlocking of flakes in microaggregates during crystal growth, which prevents their complete separation in dilute suspension.

**BORON FIXATION BY ILLITES**

Elton L. Couch and Ralph E. Grim

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The controversial mechanism of boron uptake by illitic clays and the factors controlling such uptake have been studied by treating three illites (Beavers Bend, Marblehead, and Fithian) in solutions containing boron. Boron concentration, salinity, temperature, and time were varied independently over rather wide ranges. Irreversible uptake of boron was increased by increasing boron concentration, salt concentration, temperature, and time of treatment. The amount of boron fixed also varied with the type of illite. The amount of fixation was controlled primarily by the specific surface area of the clay and also by the crystallinity, K-content, and/or amount of mixed-layer material (frayed-edges?), and apparently was independent of the original boron content of the clay. A two-step mechanism is proposed for boron fixation by illite, consisting of rapid chemical adsorption of the tetrahedral  $B(OH)_4^-$  anion at the frayed edge of the illite flake followed by much slower diffusion of boron into the tetrahedral part of the structure.

**ORIGIN OF THE WOODSTOWN, NEW JERSEY,  
MACRO-KAOLINITE**

Wayne C. Ispording and William Lodding

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A kaolin bed in which many of the individual kaolinite platelets exceed 0.2 mm in size occurs in the immediate vicinity of the base of the middle-Miocene Kirkwood Formation, near Woodstown, New Jersey. These platelets appear to have resulted from breakdown of pre-existing illite and montmorillonite coupled with concurrent epitaxial growth and diagenetic growth of primary kaolinite. The alteration of the clay minerals is thought to be a product of upward leaching (dialysis) by groundwaters in the underlying Vincentown Sand. This is further evidenced by abnormally high percentages of clay-size kaolinite in the clays that lie above the Vincentown Sand but beneath the macro-kaolinite horizon. Growth of the macro-kaolinite was facilitated by face-to-edge sedimentation and the resultant high permeability of the stratum.