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# CLAY MINERALOGY OF LOWER TERTIARY CONTINENTAL DEPOSITS OF THE SAN JUAN BASIN, COLORADO

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Early Eocene and Paleocene continental rocks are exposed in the central portion of the San Juan Basin in northwestern New Mexico and southwestern Colorado. The clay-mineral study is part of a general investigation of late Cretaceous and early Tertiary rocks in the vicinity of the University of Illinois Geological Summer Field Camp, Fort Lewis A. & M. College, Colorado (fig. 1).

In early and middle Paleocene, streams deposited clays, siltstones, and channel sandstones of the Naciemiento (Simpson, 1948) formation. About 450 feet of this formation crop out in Colorado. Streams continued to deposit over 2000 feet of clays, siltstones, and sandstones of the San Jose (Simpson, 1948) formation in late Paleocene and early Eocene time. Both formations crop out typically in color-banded badlands.

The Lance (late Cretaceous, Wyoming, Dorf, 1942) and Vermejo flora (late Cretaceous, Colorado, Knowlton, 1917) indicate a warm, subtropical climate in the Rocky Mountain region. Knowlton (1917, 1924) also shows that the Raton, Laramie, Wilcox, Animas, and Denver assemblages indicate the climate was warm-temperate, possibly subtropical. Early and middle Eocene floras from the Rocky Mountain region indicate a warm-temperate to subtropical climate (see Berry in Osborn, 1929). The San Jose flora contains species common to the Animas and Raton flora (Droste, 1953).

Brooks (1926) believes that the climate was a subtropical mediterranean-type with moderate winter rain and long hot, dry summers. Van Houten (1948) suggests that conditions were savanna-like—the interstream areas were large open parks and forests were found only along the rivers. The climates of the source area and basin of deposition must have been the same.

## Clay Mineralogy

X-ray spectrometer traces were made of the red, purple, brown, yellow, olive, and gray clays that comprise the sediments. The raw samples were fractionated and the sizes less than two microns were used. Mixed-layer montmorillonite, chlorite, and illite occurred in all samples.

Mixed layering and poor crystallinity made identification difficult. A diffuse reflection in the untreated sample from 10 to 15.5 a.u. can be attributed to montmorillonite, illite, and/or chlorite. After treatment with glycol, 17-a.u. reflections suggest the presence of montmorillonite and 10-a.u. reflections suggest the presence of illite. In most cases, the broad 17-a.u. reflection masked the first order 14-a.u. reflection of chlorite. In a few samples a weak 14-a.u. reflection for chlorite was seen. As the even-order basal reflections of chlorite (002,004,006, etc.) almost coincide with successive basal reflections of kaolinite (001,002,003, etc.), and as the odd-order basal reflections of chlorite (001,003,005, etc.) are weak, it is often difficult to distinguish between chlorite and kaolinite reflections. In every sample a weak (003) reflection (4.66 a.u.) of chlorite confirmed the presence of that mineral. Heat treatment (Johns and Grim, 1952), which serves to differentiate chlorite and kaolinite, indicated that no kaolinite was present. Chlorite reflections are lost after heating to 450°C. If kaolinite was present, its reflections should still remain after ignition to 450°C. All chlorite reflections were lost, suggesting the absence of kaolinite. Johns and Grim (1952) have discussed this procedure in detail.

### Upland and Basin Soils

Van Houten (1948) suggests that a thick well-leached regolith developed on the uplands surrounding the lower Tertiary basins in Colorado and Wyoming. In the present climate the well-leached, lateritic soils are predominately kaolinitic with or without hydrous alumina. As neither kaolinite nor hydrous alumina was found in any of the clay samples, and as in a nonmarine environment clay minerals usually suffer little alteration (Grim, 1951), it is unlikely that kaolinite was ever present in the clays or on the upland source-areas. Consequently it is believed that the loose materials on the uplands must have been removed by normal gullying and sheet-flood ero-

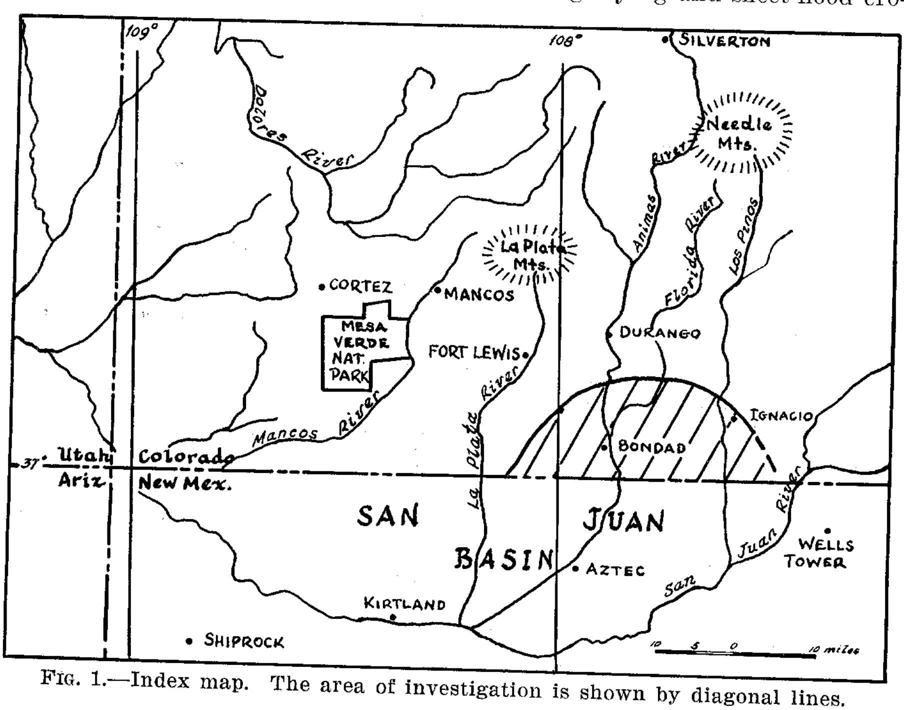


Fig. 1.—Index map. The area of investigation is shown by diagonal lines.

sion before they had suffered much weathering. This would occur if the climate was one of alternating dry and wet seasons. During the dry seasons the vegetation would die and be oxidized, so that during the wet seasons the loose regolith, without benefit of plant cover to hold it in place, was quickly transported to the basins of deposition. Around rivers and permanent lakes, where vegetation could live through the dry periods, the environment was probably reducing. The clay minerals of the gray and olive clays show that, even around permanent streams, groundwater did not cause extensive leaching.

It is quite possible that the direction of groundwater movement was upward during most of the year. This is certainly true for the wide park-like interstream areas, where the Eh of environment was certainly positive. In these areas the illite and chlorite in the soil absorbed potassium and magnesium respectively into their lattice and became more crystalline, and montmorillonite absorbed sodium and calcium in exchange positions on its lattice. However, the Eh of the environment of deposition apparently had no influence on the clay minerals of these beds. The same clay minerals are found in the beds deposited in oxidizing (red beds) and reducing (gray and green beds) environment.

## Summary

Mixed-layer montmorillonite, chlorite, and illite are found to be the clay mineral constituents of the lower Tertiary continental strata in southwestern Colorado. The clay mineral assemblage, coupled with the absence of kaolinite and hydrous alumina, suggests that the clay material was rapidly removed from the uplands before extensive weathering and soil development.

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