ALTERED SILICEOUS VOLCANICS AS A SOURCE OF REFRACTORY CLAY

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ABSTRACT

In the intermountain states, a region deficient in kaolinite and alumina clays, there is an increasing demand for refractory clay. In this arid region residual kaolins are not developed in quantity from feldspathic intrusives. Glassy, siliceous extrusives alter commonly to montmorillonite of the montmorillonite-beidellite series. Zeolites, principally analcime and heulandite, often are alteration products. Under certain conditions kaolinite, halloysite, or saponite will form; several tuffaceous deposits were investigated in an attempt to determine these environmental conditions, especially the physico-chemical environment necessary to produce kaolin clay.

Zeolites are developed where the pyroclastics are deposited in an alkaline lake; saponite is formed locally in this environment as a result of hot-spring activity. On river slopes and spurs the siliceous volcanics alter to kaolinite and montmorillonite; where associated with calcareous hot-spring activity in a fresh-water lake, halloysite results. Montmorillonite-beidellite develops where these special conditions do not obtain.

The prospects of finding a residual kaolinite deposit developed from siliceous volcanics are not good. Hydrothermal alteration appears to be the only means by which a siliceous volcanic will be converted to a sizeable refractory clay deposit in this region.

INTRODUCTION

The intermountain west is deficient in known sources of high-duty refractory clay (PCE > 30), and as a consequence every potential prospect is examined. As yet no commercial sedimentary deposits have been located, although high-grade kaolinitic clays of Cretaceous age extend from Colorado into the southeast corner of Utah. These deposits are so remote from transportation at the present time, however, that it is cheaper to import from Colorado and Missouri.

Hydrothermal deposits are numerous but normally are halloysitic, characterized by excessive shrinkage and requiring expensive prefiring. Even so, a large halloysite deposit like that found in the Dragon Mine would be used for refractory purposes if it did not bring a higher market price as a catalyst. In this arid to semi-arid climate, residual kaolinite deposits are not developed from feldspathic intrusives, but under certain conditions the glassy, siliceous extrusives alter to kaolin clay. Our objective was to determine the alteration products of these siliceous extrusives, especially pyroclastics, in various environments. These environments include weathering of the siliceous volcanics on mountain slopes, in river channels, in alkaline and fresh-water lakes, and adjacent to hot springs. Such data are of interest in understanding clay genesis and, from an applied standpoint, as an aid in prospecting for refractory clay in an area where every potential must be investigated. Since the objective of this paper is to

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discuss the altered volcanics as a potential source, only a brief summary of the clay mineralogy of the deposits investigated will be presented.

The field relations of six deposits of acid extrusives were studied and their alteration products determined in the laboratory; the excellent description of a seventh deposit was used without further investigation. The locations of these deposits are shown in Figure 1. From north to south they include altered volcanics in the Snake River Basin, Idaho; on the flanks of the Wasatch Mountains east of Salt Lake City, Utah; on the west edge of the Lake Mountains, Utah; in Railroad Valley and Pioche, Nevada; and Ivanpah and Hector, California.

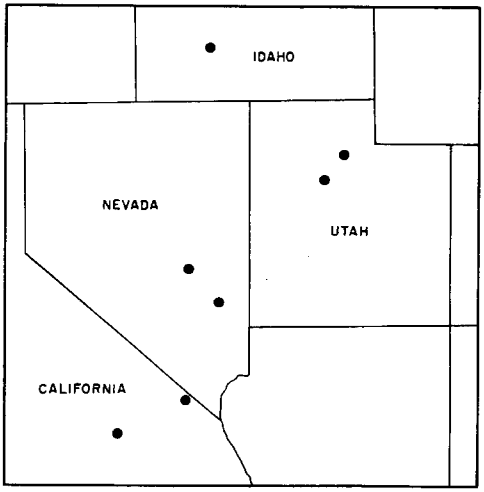

FIGURE 1. — Locations of siliceous volcanic deposits mentioned in this article.

RESULTS OF INVESTIGATION

Snake River Basin, Mountain Home, Idaho

Glassy, siliceous volcanics form a part of the mountain slopes bordering on the Snake River plain from eastern to western Idaho (Kirkham, 1931, p. 582). They weather predominantly to montmorillonite and a much lesser amount of kaolinite. Post-Pleistocene erosion has exposed more than one thousand feet of lacustrine clays derived from this mantle (Anderson, personal communication).

Wasatch Mountains, Salt Lake City, Utah

Tertiary volcanics occur on mountain slopes east of Salt Lake City, Utah. Several locations were sampled and, as with the volcanics near the Snake River Basin, they were found to weather to montmorillonite with some kaolinite.

Fox Deposit, Lake Mountains, Utah County, Utah

This halloysitic deposit probably has received more attention than any other clay deposit in Utah (Stringham and Sharp, 1950), and its genesis has been a

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controversial subject. A study was made of the deposit and a detailed mineralogical report on this interesting locality will be published in a subsequent paper. The clay was found to be formed by the alteration of tuff by hot spring activity in a fresh-water lacustrine environment. Halloysite was formed as an alteration product adjacent to the travertine, and montmorillonite predominated at a distance from the center of hot spring activity.

The halloysitic clay from this deposit fires to a high cone but has an abnormal unidirectional shrinkage typical of all halloysite (Hampel and Cutler, 1953, p. 32). An electron micrograph of the halloysite is shown in Figure 2.

Railroad Valley, Nye County, Nevada

Tertiary volcanics that form mountain slopes in this area have undergone very little alteration as a result of weathering. Small amounts of montmorillonite that altered from the glass were found admixed with vermiculite-biotite

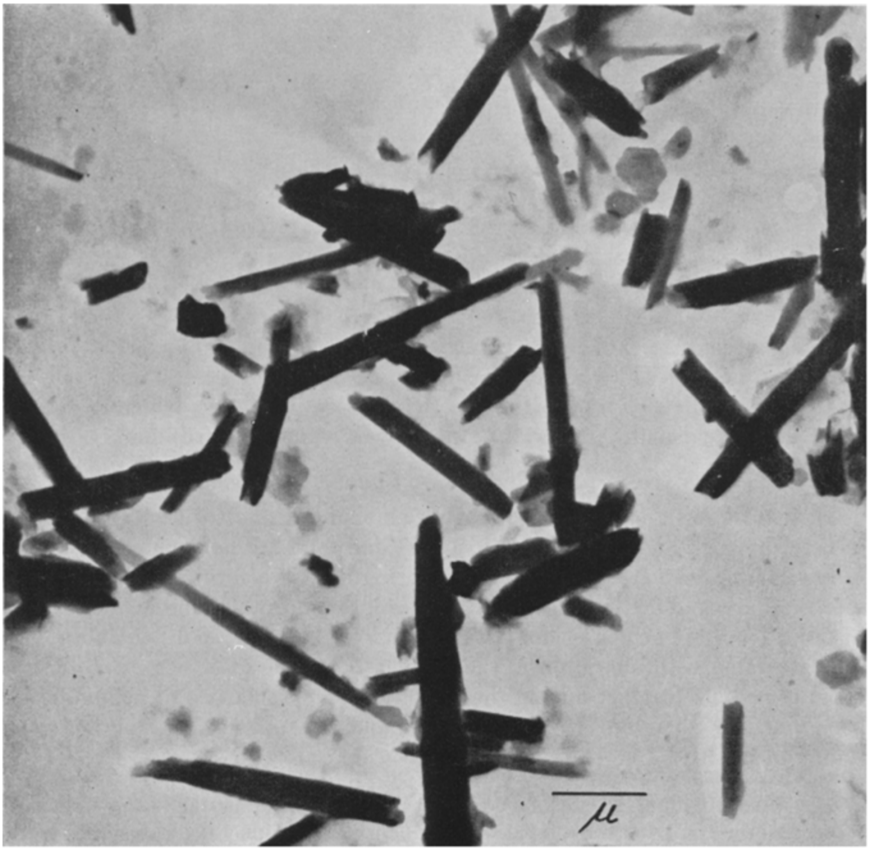

FIGURE 2. — Electron micrograph of Fox halloysite. By J. J. Comer.

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mixed-layered minerals formed by weathering of the biotite. In general, however, alteration by weathering does not keep pace with the spasmodic, but rapid, erosion that is typical of the mountain slopes of this region.

Pioche, Nevada

This locality was not visited, but since the description and conclusions of Schroter and Campbell (1942, p. 199–200) were similar to our findings on the Hector deposit, they are pertinent to this discussion. Schroter and Campbell reported volcanics and clastic sediments altered to saponite and minor amounts of sepiolite in an alkaline lake environment associated with hot spring activity. Development of saponitic clays from low-magnesium parent material was attributed to the influence of hot springs in recirculating the magnesium-containing lake waters.

Ivanpah, San Bernardino County, California

Tertiary rhyolites twelve miles east-southeast of Ivanpah are reported to be altered to refractory clay (Wright and others, 1953, p. 156). The deposit presently is being mined and is designated the C-1 Hart (Coors) Quarry. The area is marked by river erosion and channeling. Tuffs are associated with rhyolites, and the alteration products are principally kaolinite with some montmorillonite. Wright and others (1953) have attributed the formation of this deposit to hydrothermal action along fracture zones. It is probable that most of the alteration was hydrothermal since the deposit contains a small portion of undecomposed ferro-magnesian minerals. A detailed study would be required to determine the importance of weathering to development of the clay along these river slopes. An electron micrograph of the clay is shown in Figure 3.

Holliman and Murphy claims are located on the western slope of the Mid Hills about ten miles west of Ivanpah (Dietrich, 1928, p. 195). Three distinct, nearly horizontal beds of white kaolinitic clay can be traced for several thousand feet on the strike. Dietrich reports the clay to be a bloating kaolin evidently derived from highly feldspathic material. This deposit seems to be residual.

Hector, San Bernardino County, California

This well-known occurrence of magnesian bentonite, hectorite, was examined in detail (Ames, Sand, and Goldich, 1956) and found to be dacitic tuff altered in an alkaline lake associated with hot spring activity. Lithium-fluorine saponite is adjacent to the travertine and grades into a normal montmorillonite at a distance from the center of hot spring activity. Analcime and heulandite also are associated with alteration of the pyroclastics. The existence of zeolites as an intermediate product during the alteration of pyroclastics to bentonite has been noted by Shannon (1925), Bramlette and Posnjak (1933), and Kerr and Cameron (1936).

DISCUSSION

A reconnaissance of the alteration products of siliceous volcanics in the intermountain west emphasizes the variety of clays formed in different physico-

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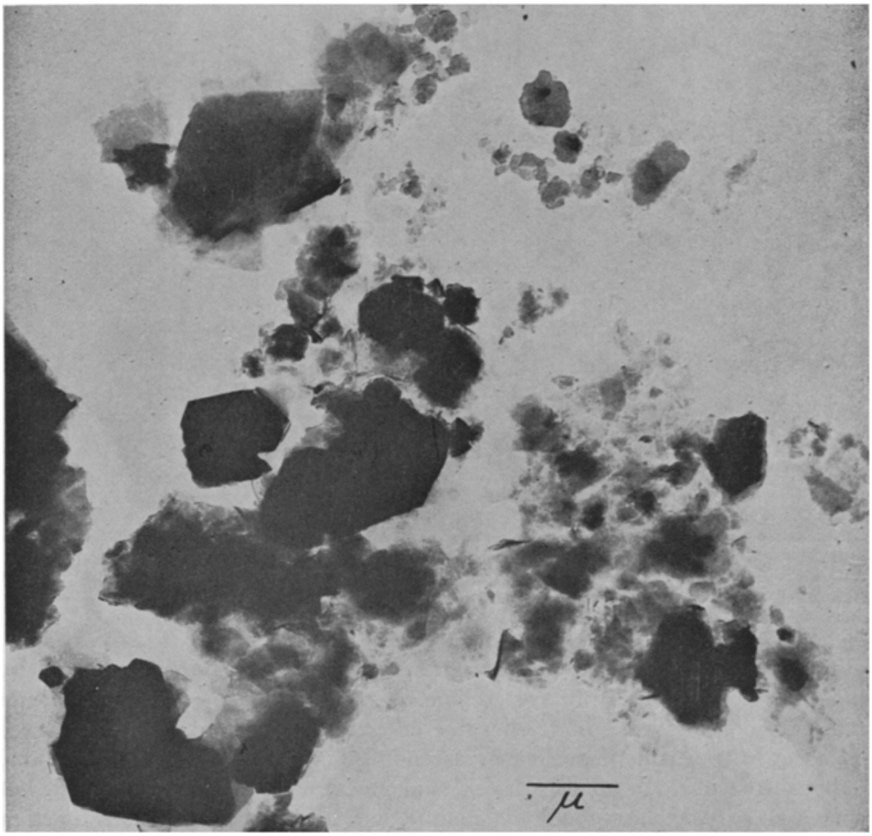

FIGURE 3. — Electron micrograph of Ivanpah kaolinite (with montmorillonite). By J. J. Comer.

chemical environments. The textures of the refractory clays derived from relatively the same type of parent rock can be considerably different, as shown in Figure 4.

The ceramic properties of the clay are derived in large part from the crystal morphology. The striking differences in morphology between halloysite and kaolinite are well known; their development is a function of the physicochemical environment and mixtures are common.

The crystal morphology of montmorillonite especially is reflective of formational environment (Roy and Sand, 1956, p. 505). Bentonite from Hector, California, varies from well-defined laths in the waxy material nearest the hot spring activity to poorly defined flakes at a distance from the source of hot spring waters.

Figure 5 diagrammatically presents the loci of clay minerals formed by alter-

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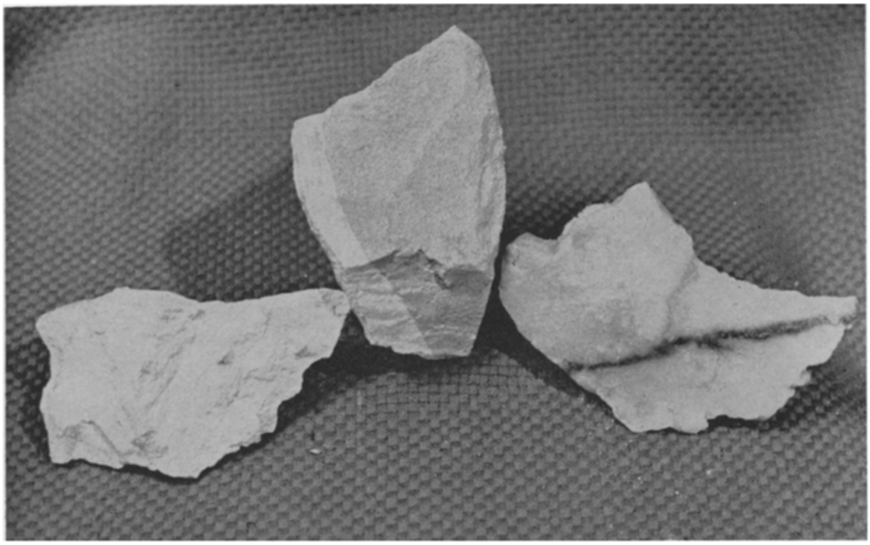

FIGURE 4. — Hand specimens of Ivanpah clay, left; Fox halloysite, middle; and Hector bentonite, right. Note differences in texture.

ation of the glassy, siliceous volcanics. On mountain slopes bordering the basin, montmorillonite forms. In river channels entering the basin, kaolinite and montmorillonite form. In fresh-water lakes, montmorillonite results; where adjacent to travertine deposited by ascending hot waters along normal faults, halloysite results. In alkaline lakes, analcime results; where adjacent to hot spring activity, saponite, montmorillonite, and heulandite result as a function of proximity to the hot springs.

A good deposit of refractory clay developed by alteration of siliceous volcanics is found only in an area of hydrothermal action or where there has been relatively intensive leaching during weathering, as on river slopes. Even under these optimum conditions for development of kaolinite in this region, montmorillonite is present as an adulterant. It is unlikely that a high grade halloysite deposit will be formed by hot spring activity in a fresh-water lake. Rapid and erratic gradation into almost pure montmorillonite obtains in such an occurrence. A detailed mineralogical and geomorphological study of such a deposit would be necessary before exploitation could be warranted, since the formation of a residual deposit of high duty refractory clay is very localized.

Since montmorillonite is the principal clay formed on the slopes bordering the basins, lacustrine sediments would consist mainly of this clay. What had been considered a sedimentary halloysite deposit was found to be altered lithified tuff. Thus lake sediments have little potential as a source of refractory clay. The prospects are not good in this region for finding a large body of refractory clay developed from siliceous volcanics. However, small localized deposits are

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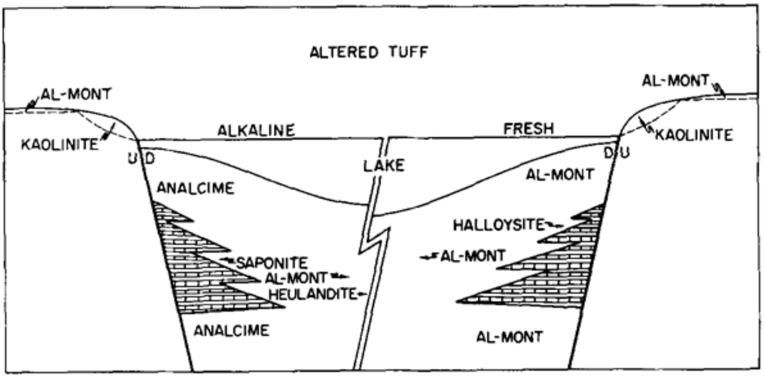

FIGURE 5. — Diagrammatic sketch of loci of alteration products of siliceous volcanics.

formed and warrant attention during prospecting.

Additional information obtained during the study on genesis of halloysite indicates that the presence of alkalis or alkaline earths in the system seemingly is essential. Preliminary investigation along these lines has been presented briefly (Sand and Ames, 1956).

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