MINERALOGY OF PALAGONITIC SOILS FROM HAWAII; D. C. Golden[1], R. V. Morris[1], D. W. Ming[1], R. K. Vempati[1], and H. V. Lauer[2], [1]NASA Johnson Space Center, Houston, TX 77058, and [2]Lockheed Eng. & Sci. Co., Houston, TX 77058.

Spectral properties of certain palagonitic soils found on Mauna Kea, Hawaii are similar to the spectral properties measured by earth-based telescopes for Martian soils [1,2,3]. There is relatively little information available on the mineralogy of these soils [4,5]. The objectives of this study were (i) to examine the mineralogy of soils sampled from the slopes of Mauna Kea at an elevation of 13,600 feet and (ii) to determine the surface compositions of soil particles which influence the reflectance spectra of these soils.

MATERIALS AND METHODS

Three layers with distinctly different colors (upper red, middle black, lower yellow) were sampled from hydrothermally altered basaltic tephra just below the summit of Mauna Kea. The red layer, black layer, and yellow layer have been designated in this paper as HWMK11, HWMK12, and HWMK13, respectively. The < 1 mm size fraction of each bulk soil was dispersed by ultrasonification in deionized H_2O and then fractionated into 1-0.02 mm, 20-5 μm, 5-2 μm, 2-0.2 μm (coarse clay) and <0.2 μm (fine clay) size fractions by sedimentation and centrifugation. Samples were dialysed against deionized H_2O and freeze-dried after fractionation. Coarse-clay and fine-clay fractions were examined by X-ray diffraction (XRD) as oriented mounts on glass slides. Silt and sand fractions were ground under acetone and examined as powder mounts for XRD analysis. The clay-sized fractions were deposited on holey carbon grids, carbon coated, and observed by transmission electron microscopy (TEM). Unfractionated soil particles were evenly distributed over adhesive silver tape cemented to Al-stubs and coated with approximately 20 nm Au-Pd prior to scanning electron microscopic (SEM) observations. Electron microprobe analysis (EMPA) was performed on C-coated polished thick sections of epoxy embedded soil particles. Standard thin sections were used for petrographic observations.

RESULTS

Optical microscopy of thin sections of sample HWMK11 revealed a reddish-brown matrix of weathered glass containing phenocrysts of plagioclase. The reddish-brown color is due to a dispersed iron-oxide pigment in the weathered matrix. Sample HWMK12 contained a few grains (<5%) of reddish-brown particles similar to those of sample HWMK11. The majority of soil particles in sample HWMK12 were rather dark, consisting of relatively unaltered basaltic glass. Near the surface of some soil grains in sample HWMK12 were light colored zones where the surface has partially altered to zeolites. Sample HWMK13 was mostly devitrified glass. The cavities and surfaces of the glass were covered with zeolites. XRD analysis indicated that the <0.2 μm fraction consisted of smectite in all three samples, whereas the mineralogical composition of the rest of the fractions consisted of varying amounts of erionite (a zeolite), smectite, hematite, plagioclase, olivine, and pyroxenes (Table 1). Mineral compositions obtained by microprobe analysis indicate the presence of titanium in hematite and spinel-type minerals.

TEM and SEM investigations provided morphological information on the minerals and their distribution on soil particle surfaces. TEM of the coarse-clay fraction of sample HWMK11 showed evidence for hexagonal hematite particles. Fine clays from all three samples were predominantly smectitic. Sample HWMK13 contained well-formed hexagonal rods of erionite (Fig. 1). Nearly all of the particle surfaces of the three samples were covered with a thin layer of smectite. The smectite was associated with very-fine particles of iron-titanium oxides. Infrared spectra and the formula calculated from chemical data suggested some iron substitution in the smectite structure.

DISCUSSION

All three soil samples were collected from an arid climate zone where little leaching of bases has occurred. The formation of the zeolite erionite is expected in this type of environment where percolating solutions (e.g., occasional rains, moisture condensations) have caused the dissolution of Si and Al and the subsequent precipitation of zeolites. Alkali metal ions (e.g., K, Na) in solution from basalt have helped to maintain pH conditions (i.e., high pH solutions) conducive to zeolite formation. The dissolution of basaltic glass and formation of zeolites is greatly enhance under hydrothermal conditions.

Most of the iron released during weathering of basalt precipitated as poorly-crystalline iron oxides. Some of the Fe has substituted for the octahedral cations in the structure of authigenic smectites. The Ti-hematite in sample HWMK11, however, may be the result of the oxidation of Ti-magnetite by a thermal process as inferred from their large crystallite size determined by Mossbauer spectroscopy and XRD analysis. The spectral properties of palagonitic soils are influenced by ferric iron-containing minerals.

REFERENCES

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TABLE 1. Mineralogy of Hawaiian palagonitic soils.

Sample Number	Size Fraction				
	<0.2 μm	0.2-2 μm	2-5 μm	5-20 μm	20 μm-1 mm
HWMK11	smectite Fe-oxide?	smectite hematite plag.	plag. hematite smectite	plag. hematite ilmenite?	plag. hematite
HWMK12	smectite	smectite plag. erionite	smectite erionite plag.	plag. smectite erionite	plag.
HWMK13	smectite	smectite erionite plag.	erionite smectite plag.	erionite plag. smectite	plag. erionite

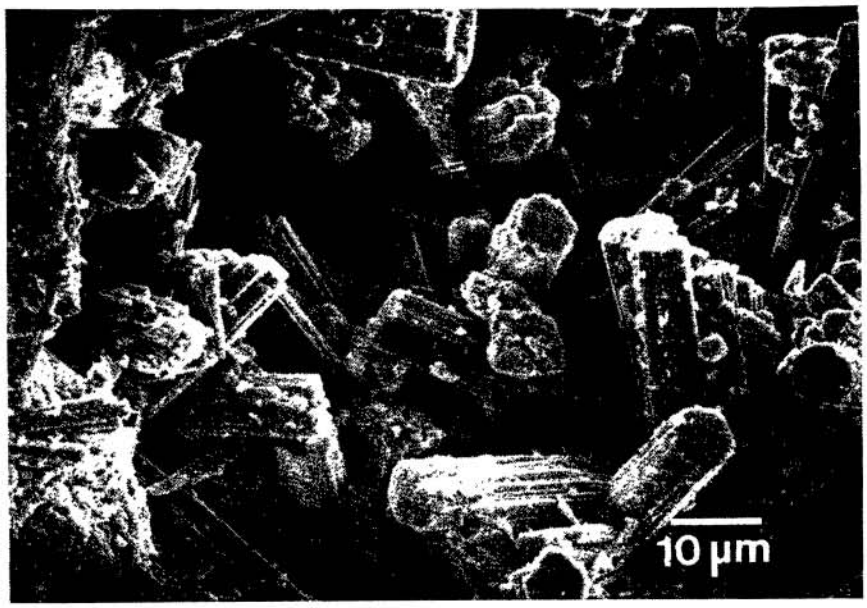

FIGURE 1. Scanning electron micrograph of erionite rods with hexagonal symmetry from soil HWMK13 sampled from the slopes of Mauna Kea, Hawaii.