THERMAL INFRARED REMOTE SENSING OF MODIFICATION PROCESSES AT CIMA VOLCANIC FIELD, CALIFORNIA

Catherine M. Weitz, Department of Planetary Sciences, Caltech, Pasadena, CA, 91125,
Tom G. Farr, Jet Propulsion Laboratory, Caltech, Pasadena, CA, 91109

Thermal infrared emittance spectra from both laboratory and remote sensing instruments were used to determine if different age lava flows with varying amounts of surficial modification could be differentiated. A similar study done in Hawaii demonstrated that Hawaiian basalts showed spectral differences in the thermal infrared that were related to the development of a glassy crust, oxidation of iron, and accretion of silica-rich surface veneers [1]. Because the Cima volcanic field in the eastern Mojave Desert, California is also composed of basaltic lava flows of different ages and because the modification processes affecting the flows at Cima differ from those at Hawaii, we chose the Cima volcanic field as the site for our study. We divided our study into three steps: 1) a study of the surface evolution of the lava flows at Cima, 2) measurements of laboratory thermal infrared reflectances of the different age flows, and 3) thermal infrared spectra extracted from remote sensing images of the different age flows.

The Cima volcanic field, which is composed of roughly 40 cinder cones and 60 associated lava flows, spans three periods of eruptive history: 1) 7.5-6.5 my, 2) 4.5-3.6 my, and 3) 1.0-0.015 my [2]. A process-response model of lava-flow surface evolution developed for the volcanic field includes 1) eruption of a basaltic lava flow, 2) desert varnish development, 3) mechanical breakdown (rubbling), 4) episodes of aeolian deposition, 5) soil development and 6) erosion and exposure of caliche fragments. Basalt is the dominant component of the surfaces of the youngest flows, aeolian dust becomes important on intermediate-age flows, with caliche appearing on the oldest flows.

Thermal infrared spectra were extracted from field samples of the different age flows using an Analect Fourier Transform Infrared Spectrometer. The weathered basalts have a narrow low in the emissivity at 9.6 μm while the fresh basalt surfaces have a broad emission low from 9.6-11.5 μm and a shoulder at 8.4-8.9 μm that matches laboratory spectra for labradorite. The feature at 9.6 μm in the weathered basalt matches a desert varnish feature at 9.7 μm in studies by Potter and Rossman [3] They determined that the desert varnish was composed of over 70% clays. In our study, we found that illite and montmorillonite spectra taken by John Salisbury of the USGS [4] could explain the narrow low at 9.6 μm in our weathered basalts. As the basalts age, a shoulder in the emissivity between 8.4-9.3 μm also found in the plagioclase spectra seems to show through the varnish coating, suggesting that the varnish coating is weathering away on the older flows.

Spectral signatures extracted from remote sensing images taken by the Thermal Infrared Multispectral Scanner (TIMS) indicate that young flows have the lowest emissivities. Older flows have higher emissivities and a shoulder appearing at 8.6-9.1 μm, which is consistent with the FTIR spectra. Because atmospheric effects are affecting the spectra from TIMS, future work will include normalizing the TIMS spectra to limestone, which is spectrally flat in the 8-12 μm region.

A preliminary analysis of additional data collected this summer as part of the Geologic Remote Sensing Field Experiment (GRSFE) at the Lunar Crater volcanic field in Nevada are consistent with the results from the Cima volcanic field. Therefore, it now appears that TIMS can be used for identification of surficial processes and for mapping relative surficial ages of arid lava flows based on their state of modification. Because a Thermal Emission Spectrometer (TES) will be flown on Mars Observer, this study of the modification of arid terrestrial lava flows can be applied to TES data to identify surficial processes and map surficial geology on Mars.

THERMAL INFRARED REMOTE SENSING OF CIMA VOLCANIC FIELD
Weitz, C.M., and Farr, T.G.

REFERENCES:

[1] Kahle, A.B. et al, 1988, JGR, 93, p. 15239-15251
[2] Dohrenwend, J.C., Wells, S.G., and Turrin, B.D., 1986, GSA Bull., 97, p. 421-427
[3] Potter, R.M., and Rossman, G.R., 1977, Science, 196, p. 1446-1448.
[4] Salisbury, J., Walter, L., and Vergo, N., 1987, USGS Open-File Report 87-263.

Fig. 1 CIMA VOLCANIC FIELD: FTIR SPECTRA

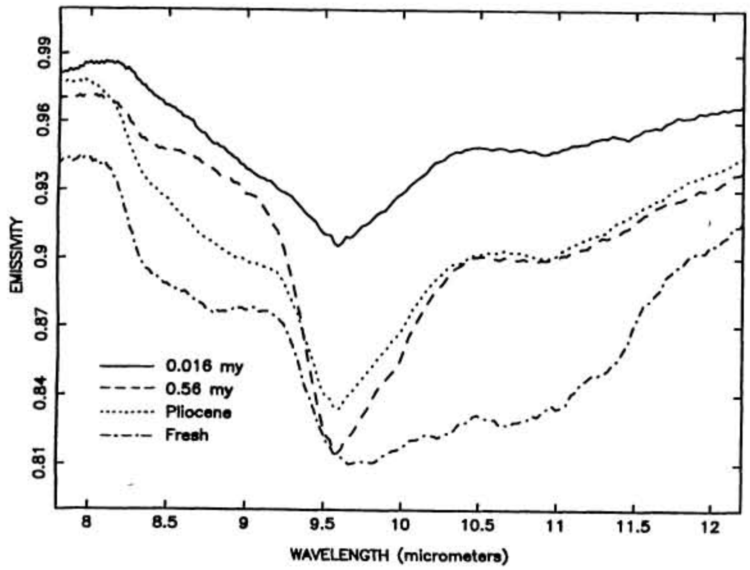

Fig 1. Emissivity spectra calculated from FTIR reflectance spectra of three different age basalt rocks. The fresh spectra was taken from the 0.56 my old rock after it had been broken in half to expose the unvarnished surface. Note the development of the shoulder between 8.4-9.3 µm in the older rocks, which matches the shoulder in the fresh spectra.

Fig.2 CIMA VOLCANIC FIELD: TIMS SPECTRA

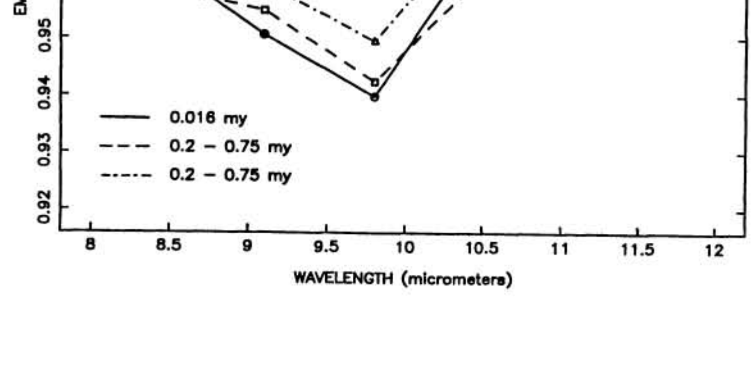

Fig 2. Emissivity spectra extracted from TIMS images of three different age lava flows. All spectra begin at the same emissivity (0.985) because the assumption was made that all emissivities in TIMS's channel 1 (0.83 µm) equalled 0.985 in order to solve for the emissivities in the remaining 5 channels. Note the development of a shoulder between channels 2 and 3 (8.6-9.1 µm) on the older flows, which is consistent with the FTIR spectra.