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SUMMARY OF RESEARCH 03/15/1998 through 03/14/2001
GROUND-BASED IR SPECTROSCOPY OF MERCURY FOR COMPOSITION
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Rosemary M. Killen, PI
Southwest Research Institute
6220 Culebra Road
P.O. Drawer 28510
San Antonio, Texas 78228-0510

Remote sensing measurements of the Moon and Mercury in the thermal infrared have been plagued with problems due to atmospheric absorption and other effects. Controversial results have been discussed by Nash *et al.* (1993) and by Salisbury *et al.* (1995). We have developed a technique to obtain thermal IR spectra of Mercury together with solar and sky spectra in the 8-13 μm region suitable for determining the presence or absence of mineralogical features. High-resolution (0.05 cm^{-1} between data points) spectra were obtained during daylight using the Fourier Transform Spectrograph (FTS) at the McMath-Pierce Solar Telescope Facility at Kitt Peak National Observatory, Arizona. The reduced data were independent of any model of the transmission of the Earth's atmosphere and rest on a calibration using sky spectra along the same line-of-sight through the atmosphere as the actual Mercury raw spectrum. This method can be applied at all solar elongation angles including small elongation angles (5 degrees or less). The basic sequence and the technique are robust.

Our infrared spectra of Mercury are nearly devoid of features in the 8 – 12 μm region except for a possible emission maximum at 8 μm, shallow maxima at 9.2 and 10.7 μm, and a shallow minimum at 12μm (Mercurian longitudes 10°, 80°, 256°, and 266°) or 12.5 μm (229°). The general lack of features is characteristic of Apollo 16 soil samples (Salisbury *et al.* 1997), and it is also characteristic of the spectra of many powdered rocks and minerals, including labradorite. A featureless spectrum would be expected from a weathered or vitrified surface having no exposed crystalline surfaces (e.g. Clark *et al.*, 1992) and could be explained by the fact that Mercury's surface is heavily modified by both a large meteoroid flux and a high solar wind flux. Glass formation reduces spectral features by eliminating lattice vibrations (Nash and Salisbury, 1991). Salisbury *et al.* (1997) argue that the dominant effect of space weathering in the 8-12 μm region is the production of fines. Although the process of agglutination, a welding of particles by the glass produced by impact melting, produces larger particles, the comminution of particles to produce fines continues due to influx of micrometeorites. Even for mature soil, the fines coat the larger agglutinates and dominate the spectrum through scattering (Lindsay 1973; Logan *et al.* 1973; McKay *et al.* 1974).

In order to determine whether these spectra can be used to characterize mineralogy, we reexamined spectra of a well characterized (both in regard to mineralogy and chemistry) suite of igneous rocks and their powdered counterparts. The ASTER spectral library (http://speclib.jpl.nasa.gov/) includes spectra of both solids and powders for 8 felsic rocks, 10 intermediate rocks, 13 mafic rocks, and 4 ultramafic rocks—70 spectra altogether; 35 of solids and 35 of powders. Although additional igneous rock samples are available in the library, we only used the samples for which there were spectra of both powdered and solid forms of the same sample. The spectra of most of the powdered samples for the intermediate, mafic and ultramafic rocks have low spectral contrast, with Christiansen Features (CFs) and Transmission Features (TFs) being the only prominent features. The only useful way to categorize them would be on the basis of the combination of CF and TF position. The powdered felsic samples have more pronounced reststrahlen features than do most of the other powdered samples. In the case of the felsic rocks, this is likely due to the unusual persistence of quartz reststrahlen bands at fine particle size (c.f. Salisbury and Wald, 1992; Mustard and Hays, 1997). There is a fairly systematic decrease in the spectral contrast of the TF, as well as a shift in TF to longer wavelengths, from felsic to ultramafic rock type. The decrease in spectral contrast in spectra of igneous rocks as they become more mafic is apparently due to the increasing content of relatively opaque metal oxides. This opacity also causes the minimization of the Transparency Feature. Thus, mineralogy can affect the strength of the reststrahlen bands, but the presence of opaques affects both TF *and* reststrahlen bands. As pointed out in Salisbury and Walter (1989), olivine is another mineral with unusually strong and persistent reststrahlen bands, which partially accounts for the enhanced spectral contrast of dunite in comparison to other mafic and ultramafic rocks.

Based on the position of the Transparency Features, we conclude that our spectra are indicative of intermediate, mafic and ultramafic rock types. Low spectral contrast suggests a significant percentage of agglutinic material. Further specificity is not warranted by the data.

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