MERCURY: Mg-RICH MINERALOGY WITH K-SPAR AND GARNET. A. L. Sprague[1], K. L. Donaldson Hanna[1], R.W. H. Kozlowski[2], J. Helbert[3], A. Maturilli[3], N. R. Izenberg[4], [1]Lunar and Planetary Laboratory, Tucson, AZ 85721 (sprague@lpl.arizona.edu) [2]Susquehanna University, Selinsgrove, PA, 17870 [3]Institute for Planetary Research, DLR, Rutherfordstrasse 2, 12489 Berlin, Germany,[4]Johns Hopkins Applied Physics Laboratory, Laurel, MD 20723.

Introduction: We report the results of spectral unmixing at two distinct regions near the footprint of the 1st flyby of Mercury by the MESSENGER spacecraft. Results indicate that both regions have Mg-rich chemistry, K-spar, and the presence of minor Ca-and Mg-rich garnets. However, one region is more mafic (primarily enstatite) than the other (primarily labradorite). Labradorite, orthopyroxene [1], and clinopyroxene [2,3] have previously been identified at other locations on Mercury's surface. This is the first time that many spectra from the same locations on Mercury have been analyzed by spectral unmixing using a well-documented deconvolution algorithm [4,5].

Observations: Mid-infrared 2-D long-slit spectral imaging from 8.2 to 12.7 µm of Mercury was obtained during daytime observations 7-8 April 2006. At the time of the observations, Mercury was between ~7.8 arc seconds in diameter, 0.46 AU from the Sun, with the sub-Earth longitude varying from 172° to 196°W. longitude. We used MIRSI's 10-µm grism covering 8 - 14 µm with $\lambda/\Delta\lambda$ equal to 200 and a slit width of 0.6″ in chop/nod mode. The MIRSI detector is a 16-channel 320 x 240 Si:As IBC array developed by Raytheon; each channel measures 20 x 240 pixels [6]. To position the slit over the desired location, we obtained 7.7 µm filter images just prior to each spectral image. Spectral images of β Pegasus just prior to and following Mercury observations were used as our standard calibrator. Spectra were corrected for telluric effects and ratioed to rough surface thermal models computed for the time of observation to remove the blackbody continuum. Fig. 1 gives the locations of observations as regions within red rectangles and in proximity to the M1 flyby footprint.

Spectral Deconvolution and Mineral Identification: These data are the first Mercury data to be compositionally analyzed by a spectral deconvolution, or spectral unmixing, technique. Inputs into the spectral deconvolution algorithm [3] include the data spectrum to be unmixed and the end member spectral library of minerals measured at the same wavelengths as the unmixed data spectrum. Results of a blind retrieval test where spectral end members were known to be in the spectral library showed that for each mineral in the mixture differences between the unmix model abundance and the actual abundance was between 4 and 12%. More recently linear deconvolution of plagioclase feldspar sands using the same deconvolution algorithm demonstrated the success of determining the proper feldspar composition to within 5% modal anorthite for compositionally complex mixtures [4].

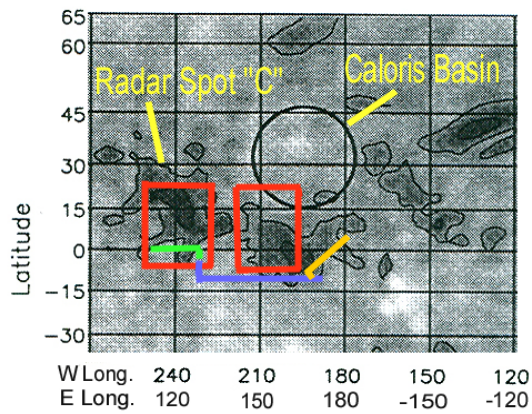

Fig. 1. A section of visible and radar map [7] is shown along with the footprint of ground-based spectroscopic images (red boxes) and the ground path of the M1 fly by. Colors: green, VIRS; blue, UVVS, VIRS; orange, VIRS.

Spectral libraries: In our case we do not have known end member spectra and uncertainties are not so well quantified. The quality of the spectral library is critically important and we have found that spectral libraries with a range of small grain sizes are essential for matching Mercury spectra. Thus, we have built mid-infrared spectral libraries using laboratory spectra from a wide range of sources (USGS, RELAB, BED, JHU, JPL, ASU). We used spectra of minerals typical in lunar soils and terrestrial basalts, trachytes, and other rocks of magmatic origin but were unable to find adequate compositional variety in clinopyroxenes. We added spectra of garnet to the end-member libraries because no good fit could be obtained until pyrope and grossular were available in the end member library for unmixing.

Results: Hundreds of unmixing models were run restricting endmember compositions until we had repeated good fits. To illustrate the uncertainty in the "best-fit" models we show alternative fits with high (sanadine) and low (orthoclase) temperature K-spar in Fig. 3 (122°E, 238°W) and Fig. 4 (150°E, 210°W). Also shown is the difference between a fit using forsterite, which gives the best fit, vs. fayalite for olivine (Fig. 3) and labradorite, which gives the best fit vs. bytownite (Fig. 4).

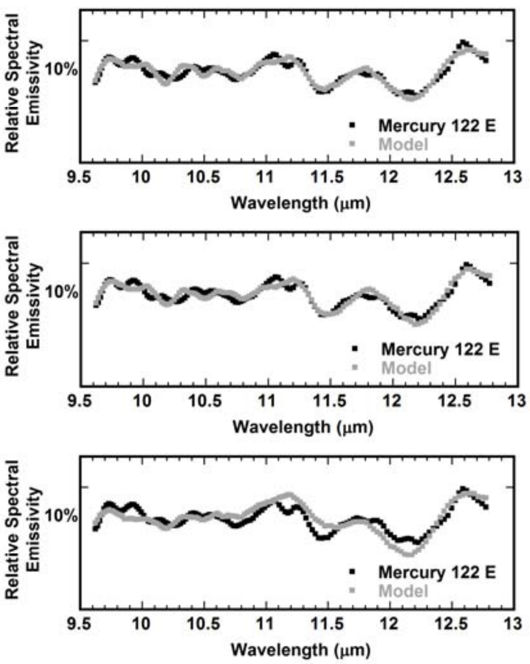

Fig. 3. (top) best fit with K-spar as sanadine (middle) with K-spar as orthoclase (bottom) Fe-rich (fo21) olivine substituted for Mg-rich (fo92), with sanadine.

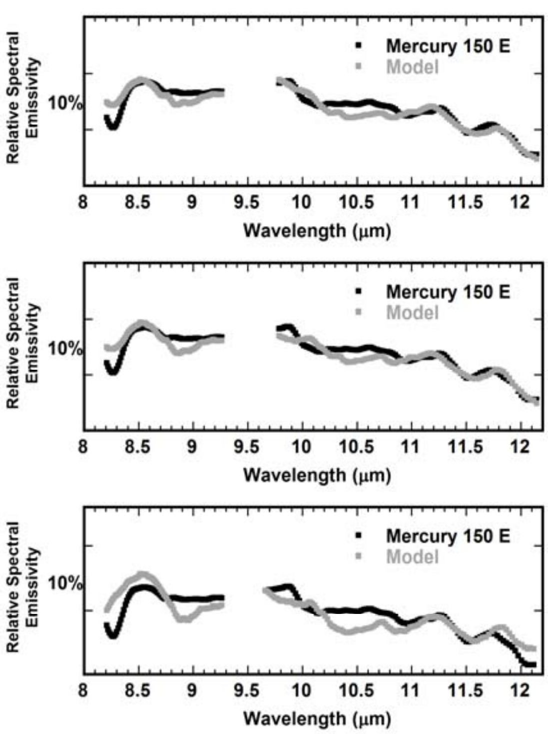

Fig. 4 (top) best fit with K-spar as sanadine and plagioclase as labradorite, (middle) K-spar as orthoclase and plagioclase as labradorite, (bottom) best fit with K-spar as orthoclase and plagioclase as bytownite.

Neither spectrum could be fit without either pyrope (Mg-rich) or grossular (Ca-rich), or both. However, Fe-rich garnet at any grain size was rejected in all deconvolutions. Table I gives the choices for the best fit unmixing models to date.

Table I. Best-fit compositions

Minerals	**East Longitude**	
	122°	**150°**
Major	enstatite	labradorite
	sanadine or orthoclase	hypersthene
	labradorite	diopside
Minor	forsterite	sanadine or orthoclase
	pyrope	pyrope
	grossular	

Discussion: While labradorite, bytownite, orthopyroxene, and clinopyroxene have been identified in other mid-infrared spectra of Mercury, this is the first time that a suite of high temperature and pressure minerals have been idicated in many spectra from the same region on Mercury. Eclogite, a dense rock having a similar chemical composition to basalt can be formed as a high temperature and pressure cumulate (*e.g.* ~12 kbar at 1110C) [8]. That the spectra are obtained at radar bright regions thought to be excavated material from impact craters [9] lends support to these interpretations. One example of the change from basalt to eclogite would be from the mineral assemblage ilmenite-clinopyroxene-plagioclase typical of the Apollo 11 and 17 lavas to one composed of garnet-rutile-clinopyroxene. In Mercury's case pyroxene and garnet are Mg and Ca rich. The addition of rutile spectra as an end member to our spectral library will enable us to explore this possibility. In these models it was not included. The established presence of eclogite would help to explain Mercury's high density.

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