LUNAR MARE BASALTS AS ANALOGUES FOR MARTIAN VOLCANIC COMPOSITIONS: EVIDENCE FROM VISIBLE, NEAR-IR, AND THERMAL EMISSION SPECTROSCOPY. T. G. Graff[1], R. V. Morris[2] and P. R. Christensen[1], [1]Department of Geological Sciences, Arizona State University, Tempe, AZ 85287 (tgraff@asu.edu), [2]Code SR, NASA Johnson Space Center, Houston, TX 77058.

Introduction: The lunar mare basalts potentially provide a unique sample suite for understanding the nature of basalts on the martian surface. Our current knowledge of the mineralogical and chemical composition of the basaltic material on Mars comes from studies of the basaltic martian meteorites and from orbital and surface remote sensing observations. Petrographic observations of basaltic martian meteorites (e.g., Shergotty, Zagami, and EETA79001) show that the dominant phases are pyroxene (primarily pigeonite and augite), maskelynite (a diaplectic glass formed from plagioclase by shock), and olivine [1,2]. Pigeonite, a low calcium pyroxene, is generally not found in abundance in terrestrial basalts, but does often occur on the Moon [3]. Lunar samples thus provide a means to examine a variety of pigeonite-rich basalts that also have bulk elemental compositions (particularly low-Ti Apollo 15 mare basalts) that are comparable to basaltic SNC meteorites [4,5]. Furthermore, lunar basalts may be mineralogically better suited as analogues of the martian surface basalts than the basaltic martian meteorites because the plagioclase feldspar in the basaltic Martian meteorites, but not in the lunar surface basalts, is largely present as maskelynite [1,2].

Analysis of lunar mare basalts my also lead to additional endmember spectra for spectral libraries. This is particularly important analysis of martian thermal emission spectra, because the spectral library apparently contains a single pigeonite spectrum derived from a synthetic sample [6].

Samples and Methods: We were allocated ~1.0 g of 15 lunar mare basalts. We concentrated our selection on large basaltic rocks (total initial mass > 40 g [5]) that are pigeonite-rich on the basis of petrographic observations and/or have spectral characteristics in the visible and near-IR that are similar to that are similar to Martian reflectivity spectra (i.e., a local reflectivity maxima near 760 nm and a ferrous iron band minimum near 950 nm).

The rock samples were crushed with an alumina mortar and pestle and the resulting powder was sieved to yield 500-1000 µm and <45 µm size separates fractions. The coarse size fraction was washed with ethanol to remove adhering particles. The <45 µm size fraction is used for analytical procedures where a fine powder is needed and to give a size fraction that is more representative of Martian dust.

Sample characterization was preformed by visible, near-IR spectroscopy (VNIR) from 0.35 to 2.10 µm, thermal emission spectroscopy (TES) from 5 to 50 µm, transmission Mössbauer spectroscopy, and X-ray diffraction (XRD) methods described in [7,8].

The multidisciplinary analytical approach for examining the samples maximize overlap with *in situ* datasets that have been or will be acquired for Martian surface materials during robotic exploration of the planet. Current and approved missions include the Mars Global Surveyor (MGS), Mars Odyssey, Mars Exploration Rover (MER), Mars Express (both an orbiter and the Beagle-2 lander), and Mars Reconnaissance Orbiter (MRO). MGS, Odyssey, and MER have thermal emission spectrometers, MER and Beagle-2 have Mössbauer spectrometers, and the Mars Express orbiter and MRO have VNIR instruments.

Results and Discussion: In Figures 1-3 we show the Mössbauer, thermal emission, and VNIR data for the lunar mare basalts, arranged with the high-Ti mare basalts at the top.

Mössbauer Spectra. As shown in Figure 1 and in agreement with previous Mössbauer studies of lunar samples [9, and references therein], the Mössbauer spectra of lunar rocks are dominated by the three doublets associated with Fe^{2+} in pyroxene, olivine, and ilmenite. As expected, the ilmenite doublet is the most intense in the three high-Ti mare basalts (10057, 70215 and 78598) and the least intense in the low-Ti mare basalts. Within each group of high- or low-Ti mare basalts, the spectra are arranged in decreasing relative intensity of the olivine doublet. The three basalts with the most Fe^{2+} in olivine relative to pyroxene are 12009, 12002, and 15555. Fe^{2+} in glass may also be present, and its doublet strongly overlaps with the pyroxene doublet [9]. The XRD results (not shown) are consistent with these three phases plus feldspar being the major crystalline phases.

Thermal Emission Spectra. Figure 2 shows the thermal emission spectra for the 500-1000 µm size fraction. These spectra demonstrate the mineralogical variance between samples in the restrahlen band region. Qualitatively, spectra for the more pyroxene-rich high-Ti mare basalts resemble those published by [10,11] for the basaltic martian meteorites. Olivine-rich samples 12002 and 12009 resemble MGS TES surface spectra of the Nili Fossae region on Mars as described by [11,12] to have spectral features of olivine-bearing material.

Visible Near-IR Spectra. The VNIR spectra (Figure 3) were obtained from the <45 µm size fraction, and they are consistent with previously published spectra for lunar samples [e.g., 13]. Except for the high-Ti mare basalts and 12009, the VNIR spectra are dominated by the spectral signature of Fe^{2+} in pyroxene [14]. The Fe^{2+} pyroxene band minimum near 950 nm is comparable to the minimum observed for basaltic martian meteorites, the martian surface by Phobos-2, and the Hubble Space Telescope [15-17]. Sample 12009 is the only sample that has a distinct olivine spectral signature.

Implication and Future Work: This on going research will directly further the current understanding of Mars by providing new data (especially TES) on a new class of Mars-relevant basaltic material. We anticipate that the pigeonite-rich lunar basalts will provide defining characteristics for that class of pyroxenes, which can then be used as endmembers for the current and future observational spectral datasets.

Future work will focus on quantitative spectral matching to the martian meteorites and surface types, as well as deconvolution results.

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