

LUNAR ROCK AND MINERAL CHARACTERIZATION CONSORTIUM (LRMCC): LINKS TO GLOBAL SCIENCE AND EXPLORATION. C. M. Pieters¹, P. J. Isaacson¹, R. L. Klima¹, T. Hiroi¹, A. B. Sarnadikari², Y. Liu² and L. A. Taylor², ¹Dept. Geological Sciences, Brown Univ., Providence RI, 02912 [Carle_Pieters@Brown.edu], ²Planetary Geoscience Inst., Dept. Earth & Planetary Science, Univ. Tennessee, 37996.

Introduction: The composition of the lunar crust will be probed and documented in unprecedented detail over the next few years. With the successful launch of SELENE-KAGUYA and Chang'E and the imminent launch of Chandrayaan-1 and LRO, the lunar science community enthusiastically prepares for the long-awaited global-scale remote sensing data of Earth's nearest neighbor from a host of sophisticated instruments. The highest spatial resolution compositional data are provided by optical instruments that allow the mineral character of the Moon to be explored in geologic context. Foremost among these are a suite of modern optical instruments that provide high spatial resolution, broad spectral coverage, and high spectral resolution across the surface (LISM on KAGUYA; M3, SIR2, HySI on Chandrayaan-1; LROC on LRO). Using craters and basins as probes to the interior, these combined imaging and spectroscopy data allow several long-standing issues about the compositional diversity, structure, and evolution of the crust to be addressed (nature and distribution of Magma Ocean components, character of the lower crust, composition and spatial extent of plutons, location of distinct mantle source regions for mare, etc.).

LRMCC Overview. Although the basis for diagnostic mineral absorption bands and their variation across the near-infrared is well understood and grounded in mineral physics [1], the diversity of forms and combinations of minerals found in a natural environment is large. In the lunar case, the products of space weathering (in particular, the presence of nanophase metallic iron) add complexity that is now better understood [2, 3, 4]. The Lunar Soil Characterization Consortium (LSCC) undertook detailed analyses of a suite of representative lunar soils with carefully coordinated mineralogy, petrology, and spectroscopy measurements [4, 5]. The goal of the LRMCC is to examine and document the unweathered mineral components of lunar rocks with a similar coordinated detailed analysis of representative lunar minerals and rocks. Results from the combined "ground truth" of LSCC and LRMCC provide a solid foundation of well-characterized materials for lunar science and exploration.

Sample Preparation and Measurement Plan. The LRMCC begins with a group of lunar basalts specially prepared for coordinated analyses. A thin section and neighboring slab were prepared for petrology and chemistry and are discussed in a coordinated abstract [6]. Bulk particulate samples and mineral separates prepared from the slab are used for spectroscopic measurements. Four basalts have been prepared for analysis: 15058, 15555,

70017, and 70035. Two bulk samples were prepared for each: coarse grain samples 125-250 μm and <125 μm . As described in [6], mineral separates were prepared from the 125-250 μm size fraction. RELAB spectroscopic measurements at Brown include bidirectional reflectance (BDR) 350 – 2600 nm (and soon down to 280 nm) and biconical FTIR measurements 1 to 50 μm . As coarse mineral separates are measured, all or some of each samples is gently crushed to pass through the smaller 125 μm sieve and remeasured.

Spectroscopy Data. Although measurements are not yet complete, initial spectra are presented here using basalt 15555 as an example. BDR spectra for the mineral separates sieved to <125 μm are shown in Figure 1. Spectra of a coarse grained bulk sample along with a very fine-grained (saw fines) sample acquired previously are shown in Figure 2.

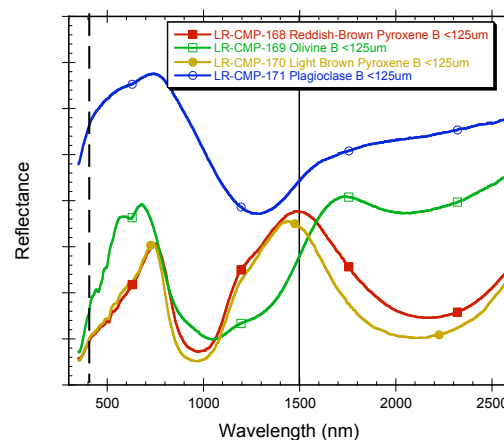


Figure 1. Bidirectional reflectance spectra of mineral separates from basalt sample 15555. Solid vertical line at 1500 nm is shown for reference in this and all other figures. Dashed vertical line is at 400 nm.

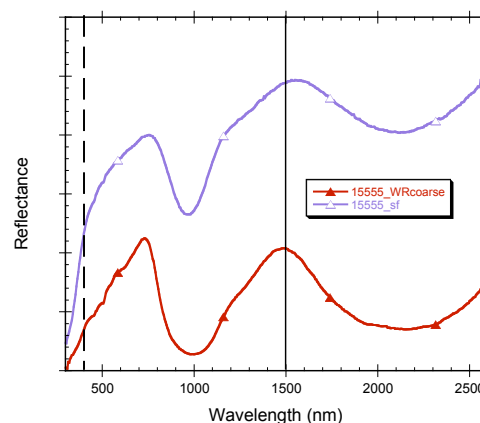


Figure 2. BDR spectra of particulate bulk 15555.

Shown in Figure 3 are spectra acquired with the FTIR system that allow overview comparisons. Near-infrared spectra of mineral separates and bulk sample size separates of the four basalts are shown over the spectral range of 1 to 3.3 μm (a,b,c,d,f) to allow examination of the presence or absence of adsorbed water (from processing). Mid-infrared spectra for the coarse grained mineral separates from 15555 are shown in Fig. 3e. For cross-comparison, the solid vertical line marks 1.5 μm in all spectra of Figs. 1, 2, & 3.

Discussion. The distinctive compositional trends of the pyroxenes in these basalts, which are documented in [6], are directly reflected in the band positions of the pyroxene spectra. Quantitative MGM analysis of the diagnostic bands that occur in the cores and rims of 15555 pyroxene spectra are discussed in [7], and MGM analysis of 15555 olivine bands is presented in [8]. All mineral separates appear to be >97% pure. Note, however, that trace amounts of absorbing Cr-spinel inclusions in olivine [6] result in an additional (non-olivine) asymmetric band near 2 μm (Figs 1 and 3c).

From Figs. 1, 2 and 3f, it is clear that pyroxene dominates the overall character of whole rock spectra and contributes greatly to understanding the mineral history [7]. However the 25-30% plagioclase present in these basalts has several subtle and distinctive optical effects. For an unexplained reason, plagioclase separates appear to be notably more susceptible to retaining adsorbed water (feature at ~ 3000 nm) than the mafic minerals. These anorthitic plagioclases [6] are also relatively iron-rich (0.3 to 0.5% FeO), and unshocked crystalline plagioclase exhibits a distorted crystal-field ferrous absorption near 1.3 μm [9]. Because such plagioclase is also relatively transparent, this feature is rarely observed directly in mixtures with pyroxene. Plagioclase typically simply increases the albedo of a plagioclase-bearing lithology. Nevertheless, two additional effects of the presence of plagioclase can be observed even in these raw spectra and in remote spectra of sufficient high precision and resolution. First, the 1.3 μm plagioclase ferrous absorption slightly suppresses a reflectance peak between the 1 and 2 μm pyroxene absorptions. This is detected in a longer reflectance peak in the <125 μm bulk sample spectra. More importantly, when plagioclase is fine grained (Fig 2), it flattens the visible spectrum between ~ 400 -700 nm, but strongly reddens the spectrum below 400 nm.

References: [1] R. G. Burns 1993 Cambridge Univ. Press [2] C. Pieters et al. 2000, *MaPS* 35 [3] B. Hapke 2001, *JGR* 106 E5 [4] Taylor et al. (2001) *JGR* 106 [5] Pieters and Taylor 2003 *GRL* v30 n20 [6] Sarbadhikari et al., 2008 these volumes [7] Klima and Pieters 2008 these volumes [8] Isaacson and Pieters 2008 these volumes [9] Adams and Goulaud (1978) *PLPSC* 9th.

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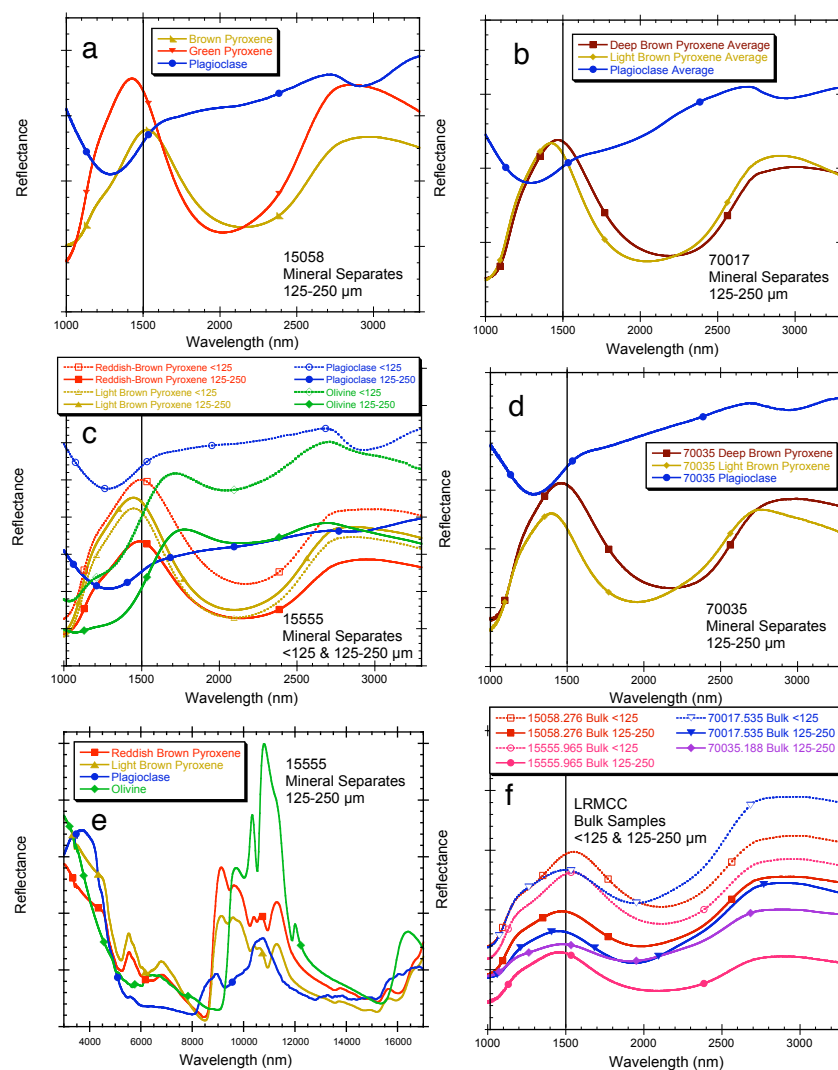


Figure 3. Reflectance spectral of basalt mineral separates (a – e) and whole rock size separates (f) measured with the RELAB FTIR system. Vertical line is placed at 1500 nm to allow cross comparisons.