MAPPING THE COMPOSITION OF THE MOON USING THERMAL INFRARED SPECTROSCOPY: CURRENT AND FUTURE OBSERVATIONS FROM ORBITAL AND LANDED MISSIONS. K. L. Donaldson Hanna[1,2], N. E. Bowles[2], B. L. Ehlmann[3], B. T. Greenhagen[4], P. O. Hayne[5], R. L. Klima[4], P. G. Lucey[6], D. P. Osterman[7], D. A. Paige[8], and C. M. Pieters[9], [1]University of Central Florida, (Kerri.DonaldsonHanna@ucf.edu), [2]University of Oxford, [3]California Institute of Technology, [4]Johns Hopkins Applied Physics Laboratory, [5]University of Colorado Boulder, [6]University of Hawaii, [7]Ball Aerospace, [8]University of California Los Angeles, [9]Brown University.

Introduction: Much of what we know today about the Moon's composition comes from orbital spacecraft mapping its upmost surface. Instruments used to probe the composition of the crust have included multispectral imaging systems (NASA's Clementine Ultraviolet/Visible Camera and the Lunar Reconnaissance Orbiter Wide Angle Camera), spectrometers (NASA's Lunar Prospector Gamma Ray and Neutron Spectrometers, ISRO's Chandrayaan-1 Moon Mineralogy Mapper, and JAXA's Kaguya Multiband Imager and Spectral Profiler), and radiometers (NASA's Lunar Reconnaissance Orbiter (LRO) Diviner Lunar Radiometer). Particularly, visible to near infrared (VNIR) and thermal infrared (TIR) remote sensing measurements have been used to identify and characterize the mineralogical diversity of the lunar crust by comparing observations with analog materials measured in the laboratory. Highlights from these observations include the identifications of: (1) regions of the primary anorthositic crust [e.g., 1-3], (2) a limited number of olivine-rich regions (possibly indicative of the mantle) [e.g., 4-5], (3) regions of silicic volcanism [e.g., 6-7], (4) a new lunar-rock type dominated by Mg-rich spinel [e.g., 8], and (5) the effects of space weathering on TIR measurements [e.g., 9].

With NASA's Moon to Mars exploration program, new observations of the lunar surface are expected, which should further enable our understanding of the composition. In this presentation we will discuss the current understanding of the Moon's composition, based on thermal infrared observations from Diviner; how Diviner TIR observations combined with VNIR spectral measurements place important constraints on the composition of the crust; and what we will learn from thermal infrared observations of the Moon at the surface (Lunar Compact Infrared Imaging System) and from orbit at higher spatial resolutions (Lunar Trailblazer).

Current TIR Spacecraft Observations of the Moon: The Moon is one of the most well studied Solar System airless bodies at TIR wavelengths in large part due to a decade of observations from the Diviner [e.g., 10-11]. Diviner is a nine band TIR radiometer launched on board LRO in June 2009. Three narrow bands near 8 μm were specifically chosen to globally and locally map composition.

Upcoming TIR Spacecraft Observations of the Moon: The Lunar Compact Infrared Imaging System (L-CIRiS) is a multi-spectral imaging radiometer based on Ball Aerospace's Compact Infrared Radiometer in Space (CIRiS) cubesat [12]. In July 2019, L-CIRiS was selected by NASA to go to the lunar surface on board a Commercial Lunar Payload Services (CLPS) mission where it will map the compositional and thermophysical properties of the surface in a polar environment. Radiometric imaging will be accomplished in four infrared bands between 7 and 14 μm at a spatial resolution of < 1cm near the lander and ~40 cm at 100 m from the lander. New observations from L-CIRiS will be critical for ground-truthing orbital observations, as its in situ measurements will be compared to Diviner measurements of the landing site.

In June 2019, NASA selected the SIMPLEx mission Lunar Trailblazer for Phase A/B development, with a Preliminary Design Review in fall 2020 on the path to flight [13]. Lunar Trailblazer includes the High-resolution Volatiles and Minerals Moon Mapper (HVM^3), an imaging VNIR spectrometer (0.6 – 3.6 μm), and Lunar Thermal Mapper (LTM), a TIR imaging radiometer. LTM will radiometrically image the lunar surface using eleven infrared bands between 7 and 10 μm at a spatial resolution of < 35 m [14]. New observations from LTM would also be critical for linking higher spatial resolution orbital observations with L-CIRiS in situ observations of the surface and with orbital observations from Diviner.

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