OVERVIEW OF THE 2009 LRO DIVINER LUNAR RADIOMETER COMPOSITIONAL INVESTIGATION.

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Introduction: The Diviner Lunar Radiometer Compositional Investigation will use multichannel (0.3 – 300 µm) spectral observations to constrain the composition of the lunar surface. Diviner will be the first lunar orbiting instrument capable of identifying the Christiansen feature (mid-infrared emissivity maximum), which is a good compositional identifier [1]. Diviner will also be the first instrument to measure lunar thermal emission between 13 and 300 µm using multiple channels. These unique data, along with Diviner broadband solar reflectance measurements, are sensitive to different aspects of composition. Ongoing laboratory investigations by members of the Diviner Science Team will measure lunar samples and lunar analog minerals. The Diviner Compositional Investigation's multispectral approach has the potential to significantly improve our understanding of lunar surface composition.

Diviner Lunar Radiometer: Diviner (Figure 1) is scheduled to launch in 2009 on the Lunar Reconnaissance Orbiter. Diviner will map surface temperatures to investigate the Moon's three thermal environments (daytime, nighttime, and polar) through diurnal and seasonal changes. The temperature data and data from thermal models will be fit to determine thermal-physical properties (e.g. thermal inertia, rock abundance). The Compositional Investigation will use solar reflectance and temperature derived infrared emissivity to determine aspects of lunar surface composition.

Diviner Spectral Channels. Diviner has nine spectral channels spread unevenly between 0.3 and 300 µm (Table 1). Two solar channels broadly measure reflected solar radiation with high (channel 1) and low sensitivity (channel 2). Diviner has three narrow-band 8-µm channels to identify the location of the mid-infrared Christiansen feature. Diviner's thermal channels measure emission in four roughly defined octaves of the far-infrared.

Diviner Observations. Diviner will primarily employ continuous pushbroom nadir mapping. Diviner's mapping resolution will be 320 m in track and 160 m cross track at 50 km altitude (6.7 x 3.4 mrad pixel size) with a swatch width of 3.4 km (71 mrad). Diviner's spatial coverage for any given four lunar-hour period (e.g. pre-sunrise, midday) is expected to be ~40% at the equator, generally increasing to 100% at the poles for the scheduled 1 year mapping orbit. This coverage increases to 80% at the equator for the proposed one year extended mission (90% for two years).

Figure 1: Diviner Lunar Radiometer. Diviner's optics are contained in the central drum behind the apertures. The azimuth and elevation actuators can each rotate 270°. The white surface is the solar calibration target, which is used for photometric calibrations. Blackbody calibration targets, used for radiometric calibrations, are located in the yoke.

Table 1: Diviner Spectral Channels.

Channel Type	Channel Number	Passband (µm)
Solar	1	0.3 – 2.8
	2	0.3 – 2.8
8-µm	3	7.55 – 8.05
	4	8.1 – 8.4
	5	8.4 – 8.7
Thermal	6	13 – 23
	7	25 – 41
	8	50 – 100
	9	100 – 300

Compositional Investigation: The Diviner Compositional Investigation will determine compositional constraints by analyzing data from all three types of Diviner spectral channels (solar, 8-µm, and thermal). The core of the Compositional Investigation is our ability to identify the Christiansen feature location using the 8-µm channels [1]. The Christiansen feature is diagnostic of silicate composition (Figure 2) and has long been proposed as a principle spectral feature on airless, particulate bodies [e.g. 2, 3]. Secondly, the Compositional Investigation will analyze spectral emissivity variations in thermal channel data, which may be particularly useful in identifying non-silicates such as ilmenite. We will also analyze albedo variations in the solar channel data, which overlaps regions measured by near-infrared lunar remote sensing instruments.

Christiansen Feature: In the lunar environment (particulate surface, vacuum, high thermal gradients), the Christiansen feature has significantly enhanced spectral contrast compared to other mid-infrared features (Figure 3). The Christiansen feature occurs when the refractive index (real part) of a material approaches the refractive index of the surrounding medium AND absorption is relatively low (n ≈ 1, k ≈ 0). The Christiansen feature is tied to the fundamental vibrational band and shifts to shorter wavelengths with increasing polymerization of the SiO_4 tetrahedra.

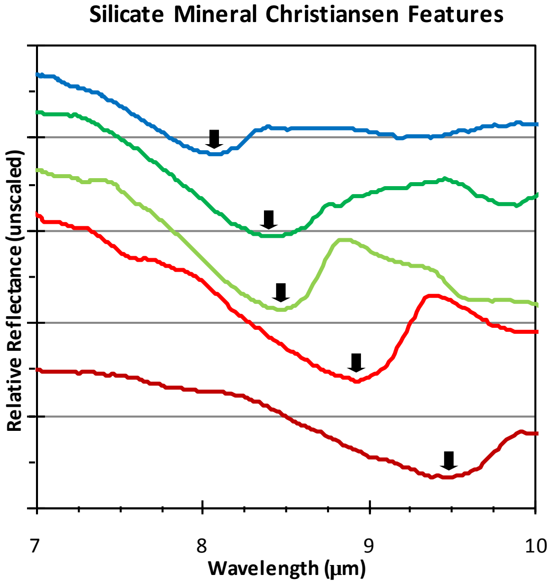

Figure 2: Christiansen Feature of Silicates in Reflectance. The location of the Christiansen feature (black arrows) shifts with composition: anorthite (blue), enstatite (green), augite (light green), forsterite (red) and fayalite (dark red) [4]. The Christiansen feature shifts to shorter wavelengths when measured in a simulated lunar environment.

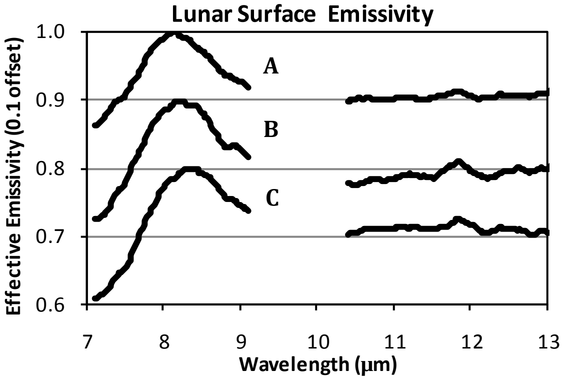

Figure 3: Lunar Balloon-borne Telescopic Observations. Emission observations at 32 km altitude with 300 km circular spot size. Copernicus (A), Central Highlands (B), and Mare Serenetatis (C). Data from [5].

Diviner's 8-µm channels span the Christiansen features locations of lunar soils measured in simulated lunar environments reported in the literature, 7.95 to 8.50 µm [6]. Measuring the Christiansen feature requires high signal-to-noise which corresponds to warm surface temperatures (>250 K). We expect to make the measurement for latitudes up to 80° N/S at noon local time and between 6:30 am and 5:30 pm at the equator.

Spectral Emissivity: The Compositional Investigation will derive spectral emissivity from surface temperature data. Both surface roughness and rock abundance cause anisothermalities that induce slopes in infrared spectral emissivity. Our calculations will initially concentrate on low latitude regions near midday when surface roughness effects are minimal. Rock abundance effects can then be removed using diurnal temperature data. Finally, we will use 8-µm channel derived brightness temperatures (near unit emissivity) to calculate spectral emissivity in the thermal channels.

Ongoing Laboratory Investigations: Diviner Science Team members have begun complementary laboratory investigations [e.g. 4, 7]. Most investigations are measuring lunar samples and/or lunar analog minerals across Diviner's spectral range in relevant conditions, especially simulated lunar environments. Other investigations are revisiting data in the literature and existing laboratory datasets. These investigations are key to interpreting Diviner's compositional dataset.

Conclusions: Diviner was designed, in part, to produce a unique compositional dataset that can be used to constrain observed lunar surface composition. The compositional uncertainties will be smallest when Diviner data is correlated with other lunar compositional investigations (e.g. LRO Lunar Reconnaissance Orbiter Camera, Chandraayan-1 Moon Mineralogy Mapper). While near-infrared instruments are more capable of identifying most iron-bearing minerals, Diviner should be relatively sensitive to anorthite (plagioclase feldspar) and the 8-µm and thermal channels may be relatively insensitive to soil maturity. Thus Diviner and other instruments can provide critical complementary information.

References: [1] Greenhagen B.T. and Paige D.A. (2006) *LPS XXXVII*, Abstr. 2406. [2] Logan L.M. et al. (1973) *JGR, 78*, 4983-5003. [3] Nash D.B. et al. (1993) *JGR., 98,* 23535-23552. [4] Greenhagen B.T. et al. (2008) *AGU Fall Meeting*, Abstr. P31B-1420. [5] Murcray F.H. et al. (1970) *JGR., 75,* 2662-2669. [6] Salisbury J.W. et al. (1973) *LPS IV,* 3191-3196. [7] Thomas I.R. et al. (2009) *LPS XL*, Abstr. 2110.