

OVERVIEW OF SILICIC MAGMATIC ACTIVITY ON THE MOON. T. D. Glotch¹, C. M. Elder², P. O. Hayne², B. T. Greenhagen³, D. Dhingra⁴, and W. S. Kiefer⁵, ¹Department of Geosciences, Stony Brook University (timothy.glotch@stonybrook.edu), ²Jet Propulsion Laboratory, ³Applied Physics Laboratory, ⁴University of Idaho, ⁵Lunar and Planetary Institute

Introduction: Lunar “red spots,” originally recognized in the Apollo and post-Apollo era of lunar exploration, were thought to be examples of non-mare volcanism. This interpretation was based on the often rugged morphology associated with these features and characteristic featureless red slopes in visible and near-infrared (VNIR) spectra. The Diviner Lunar Radiometer Experiment onboard the Lunar Reconnaissance Orbiter has confirmed the hypothesis that at least some of the red spots are the product of silicic magmatic activity. Notable silicic regions on the Moon include the Gruithuisen domes, the Mairan domes, Hansteen Alpha, Lassell Massif, and Compton Belkovich. In addition, the detection of silicic material in the central peak and ejecta blanket of Aristarchus suggests the excavation of a silicic pluton. Some reported red spots, most notably the Helmet, apparently do not have silicic compositions.

Diviner Data: Diviner is an infrared radiometer that includes three narrow band channels centered at 7.8, 8.25, and 8.55 μm that are used to characterize the silicate Christiansen feature (CF), an emissivity maximum that is indicative of bulk silicate composition. The emissivities of these three “8 μm channels” are used to model the emissivity maximum as a parabola, the maximum of which is taken to be the CF position. Materials with high silica contents including SiO_2 polymorphs and alkali feldspars have CF positions outside of the region that can be characterized by the Diviner CF channels. Instead of defining a concave down parabola, the 8 μm channels display a concave-up spectral shape. Because the concave-up spectral shape is unique to highly silicic materials (with the notable exception of fayalitic olivine), we have defined an index to map the concavity of the Diviner 8 μm channels. So far, this work has focused on high spatial resolution (128-256 pixels per degree) analysis of known red spots, but current and future work is extending our range of analyses to global scales in an effort to identify additional compositionally unique lithologies.

In addition to the compositional information provided by daytime Diviner infrared measurements, Diviner nighttime temperature observations can be used to derive regolith properties including density and vertical variation. We assume regolith density follows an exponential vertical profile which increases with depth over a characteristic length scale, H . This H -parameter is representative of the thermophysical properties of the upper ~30 cm of regolith including rocks smaller

than 1 m. Higher H -parameter values correspond to lower thermal inertia (lower density) of the uppermost regolith. Variations in H -parameter could correlate with variations in small rock fragment abundance, regolith porosity, or the crystallinity of the material.

Silicic regions on the Moon tend to be associated with a high H -parameter values, which correspond to a low thermal inertias. Previous work has shown that no clear relationship exists between thermal inertia and composition, so the low thermal inertia material at silicic regions may suggest pyroclastic deposits (containing small glass beads and fewer rock fragments than regolith) or a low-density material such as pumice.

GRAIL Data: Interestingly, Diviner H -parameter measurements at the silicic regions appear to correlate with low bulk densities based on models of Gravity Recovery and Interior Laboratory (GRAIL) data. Recent models of the Gruithuisen Delta dome suggest a bulk density of $2150 \pm 150 \text{ kg m}^{-3}$. This is less than typical felsic materials, suggesting a high porosity. While a high primary porosity rock such as pumice is a reasonable candidate to explain the observations, secondary porosity between rhyolitic (or similar composition) rocks formed as materials are pushed away from the vent could also explain the observations. Diviner H -parameter and rock abundance data may help to distinguish between these two scenarios.

M³ Data: Mg-spinel exposures are most commonly associated with iron-poor feldspathic lithologies and no detectable mafic minerals. The exposures of Mg-spinel at Hansteen Alpha are unique in terms of their association with a highly silicic lithology. Representative Mg-spinel spectra from the region show the typical absence of absorption band at 1 micron which is contrasted by a strong absorption near 2 micron. Work is ongoing to correlate M³-derived Mg-spinel spectra with variability in mid-IR Diviner thermal emission spectra. This may shed more light on the provenance of the unique Mg-spinel lithology.

Summary: Data from the Diviner Lunar Radiometer, GRAIL, and M³ all point to unique compositions for many previously recognized red spots. Work is ongoing to correlate these datasets and place additional constraints on the composition of these features. This work, combined with analysis of high resolution imagery and topography and crater counting can place these features in the broader context of lunar magmatic and volcanic history.