PHOTOGEOLOGIC ANALYSIS OF IMPACT MELT-RICH LITHOLOGIES IN THE LUNAR CRATER KEPLER USING LROC AND KAGUYA DATA. T. Öhman[1,2] and D. A. Kring[1,2], [1]Center for Lunar Science and Exploration, Lunar and Planetary Institute, Universities Space Research Association, 3600 Bay Area Blvd., Houston, TX 77058, USA (ohman@lpi.usra.edu), [2]NASA Lunar Science Institute.

Introduction: Kepler (D=31 km, d=~2.7 km) is a Copernican complex impact crater situated between Mare Insularum and Oceanus Procellarum at 8.1ºN 322ºE on the lunar nearside. It overlies Imbrium basin ejecta [1] and the Upper Imbrian and Eratosthenian high-iron mare basalts of Procellarum KREEP Terrane (PKT) [2, 3]. Stratigraphically it is younger than Copernicus (~540 km to E), but older than Aristarchus (~540 km to NW) [4]. The impact excavated high-thorium and moderately high-iron material beneath the mare [2] and, based on Clementine data, the composition of Kepler's rim is interpreted to be noritic [5]. However, photogeologically Kepler remains relatively poorly studied [1]. This work, addressing two key lunar science concepts outlined by the NRC [6], aims to characterize the distribution, properties, and possible sampling locations of impact melt-rich lithologies within and around Kepler by an integrated analysis of different image data sets.

Data and methods: The main data sets are images from the Kaguya Terrain Camera (TC evening and morning mosaics; resolution ~7 m/pixel), the Lunar Reconnaissance Orbiter Narrow and Wide Angle Cameras (NAC, ~0.5–1.2 m/px; WAC, ~60 m/px), and the Kaguya Multiband Imager (MI, ~20 m/px). In addition, Lunar Orbiter (~60 m/px), Clementine UVVIS (~100 m/px), and SMART-1 AMIE (~150 m/px) mosaics and Lunar Orbiter Laser Altimeter (LOLA) data were utilized. NACs and WACs were calibrated and projected with USGS Integrated Software for Imagers and Spectrometers (ISIS), and mosaicked and analyzed with Adobe Photoshop. Area calculations were carried out with ImageJ. Identification of impact melt-rich lithologies was based on established morphological and textural criteria, such as cooling cracks in smooth, level deposits filling depressions and having generally lower albedo, tension cracks in veneer draped over irregular surfaces, leveed channels, and smooth lobes [e.g., 7–9].

Distribution and characterization of impact melt-rich lithologies: Figure 1 is a geologic sketch map of Kepler, with an emphasis on units interpreted to include a substantial proportion of impact melt. *Smooth floor* (~35 km^2) forms a fairly level, fissured unit with generally lower albedo than the surroundings. It is mainly found on the N part of the floor of Kepler. It grades into the more extensive (~78 km^2) *hummocky floor* unit, which is characterized by bright hummocks with darker fissured material (similar to smooth floor) between the hummocks. Where stereo NAC imagery is available, hummocky floor material can also be seen to have longer wavelength topographic irregularities distinct from the generally flat smooth floor unit. In addition, stereo imagery reveals that the fissures tend to be located on topographic highs or slopes. Hence, they are interpreted as tension rather than cooling cracks.

Terrace ponds are found as fairly small (typically ~0.1–0.8 km^2 each) isolated level patches of darker, sometimes fissured material filling depressions in the terrace and talus zone of the crater. Sometimes terrace ponds on different levels are connected by channels. In morphology and texture, terrace and *exterior ponds* are quite similar. Numerous exterior ponds are concentrated on the N and NW sides of the crater. The exterior ponds are sometimes very closely related to a typically cracked *rim veneer* that covers most of the topographically irregular rim crest. Rim veneer occasionally covers larger areas, typified by cracks, small smooth surfaces, and indistinct flow features. Rim veneer can also form more pronounced leveed flows that grade into exterior ponds.

Wall lobes cover much of the upper part of the crater wall. They form dark, smooth, lobate deposits overlapping each other, clearly different from the extensive digitate clastic debris flows on the crater's exposed wall. The exposed wall also displays distinct dark layers that can be traced over much of the crater wall, apparently on a fairly constant elevation. Based on shadow measurements and slope estimates from interpolated LOLA data, thicknesses of the wall lobes are on the order of 1–5 m, and together they contain ~0.1 km^3 of impact melt. Assuming a noritic composition for the melt, viscosity of the lobes is ~5 Poise, and yield strength ~4500 Pa. This is within the range found in earlier studies of lunar impact melt properties [10].

Discussion and conclusions: The floor of Kepler around the bright central uplift is covered by smooth and hummocky units, interpreted to contain the majority of the melt produced. The hummocky floor unit includes large blocks of excavated rock and is topographically irregular also at longer wavelengths. It is interpreted as having a higher clast content and viscosity than the smooth floor material, which may be analogous to clast poor impact melt breccias found in terrestrial impact structures. A new scaling law [11] predicts ~14 km^3 of impact melt produced in Kepler, most of it retained within the crater. Our future work aims to test this scaling law using the Kepler melt mapping and studies of other fresh complex craters.

Flow features in melt-rich lithologies can be observed in ponds on the terrace zone, the upper crater wall with overlapping melt lobes, and in an apparently thin rim veneer which grades into exterior ponds, sometimes by leveed flows. The exterior ponds are not observed symmetrically around the crater, but are concentrated on the N and NW sides. Asymmetry can also be seen in the interior deposits, as the smooth floor unit is mainly found in the N half of the floor, while the hummocky floor unit dominates the S part.

Potential as an exploration site: Kepler has been recognized as an important site for obtaining well-documented impact melt samples to refine the impact flux during the Copernican Period [12]. The mare units surrounding Kepler have model ages spanning from 3.57 to 1.87 Ga [3]. Hence, samples from Kepler would provide insight into the long and complex history of endogenic activity in the Procellarum–Insularum area as well. In addition, with a maximum depth of excavation of ~3 km and a stratigraphic uplift of ~3 km, Kepler presents a direct view into the heart of PKT, one of the three major lunar terranes [2]. The impact also likely excavated Imbrium basin ejecta. An almost equatorial nearside location makes mission planning fairly straightforward. Therefore, Kepler has a wealth of scientific and practical benefits for being considered as a possible site for future robotic or manned exploration.

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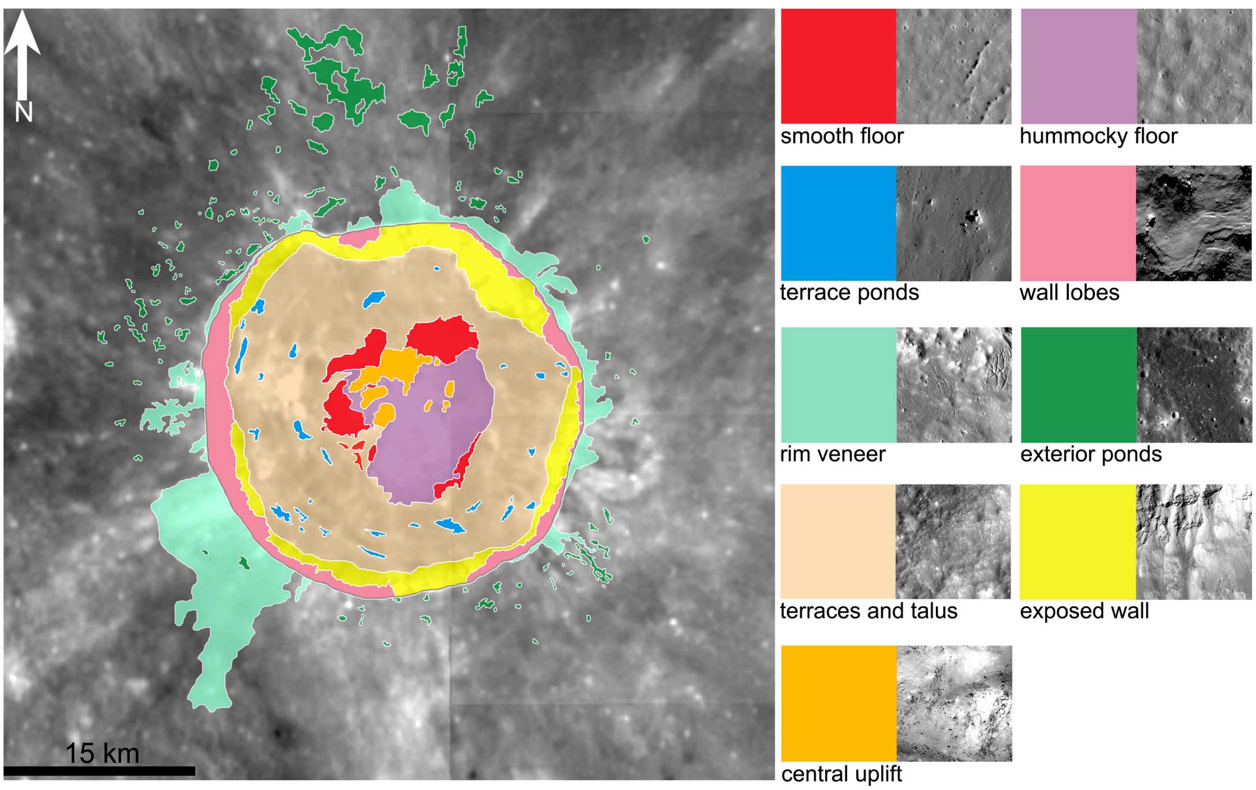

Figure 1. Geologic sketch map of the lunar crater Kepler. The legend shows typical morphologic expressions (in varying scales and orientations) of the different units in NACs. It should be noted, however, that many of the units grade into each other, particularly the smooth and hummocky floor units, and the wall lobes, rim veneer, and exterior ponds. In the legend, estimated melt content decreases downwards, and in wall lobes, terraces and talus, exposed wall, and central uplift, "downwards" is to the bottom of the page. The base map is Clementine UVVIS 950 nm mosaic in simple cylindrical projection centered at 322.5ºE.