

HEAT FLOW MEASUREMENTS PLANNED FOR THE UPCOMING ROBOTIC MISSIONS TO MARE CRISIUM AND THE SCHRÖDINGER BASIN. S. Nagihara¹, K. Zacny², R. E. Grimm³, M. A. Siegler⁴, M. E. Banks⁵, W. B. Garry⁵, and the Honeybee Robotics LISTER Team², ¹Department of Geosciences, Texas Tech University, Lubbock, TX 79409 (seiichi.nagihara@ttu.edu), ²Honeybee Robotics, Altadena, CA 91001, ³Southwest Research Institute, Boulder, CO 80302, ⁴Planetary Science Institute, Tucson, AZ 85719, ⁵Goddard Space Flight Center, Greenbelt, MD 20771.

Introduction: The heat flow measurements made on Apollo 15 and 17 (Fig. 1) [1] and the subsequent orbital observations of radionuclides (U, Th, K) distribution [2, 3] led to the present hypothesis that the crust of the so-called Procellarum KREEP Terrane (PKT) contains higher concentrations of radionuclides than the outer crustal terranes, and that surface heat flow in the PKT is elevated as a result [4]. Two of the upcoming robotic lunar lander missions supported by NASA's Commercial Lunar Payload Services (CLPS) present opportunities to further test this hypothesis. The first one (Task Order (TO) 19D) is scheduled to land in Mare Crisium (MC) in 2024. The other is destined to the Schrödinger basin (SB) in 2024-2025 (TO CP12). The two CLPS deliveries will have identical heat flow probes: the Lunar Instrumentation for Sub-surface Thermal Exploration with Rapidity (LISTER) [5]. The payloads for these missions also include the Lunar Magnetotelluric Sounder (LMS), which will provide independent estimates of mantle temperature [6].

Objectives of the Heat Flow Measurements: The outward flow of heat originating from the interior of the Moon can be measured as it travels through shallow subsurface rock (or regolith) by conduction before it is released into space. LISTER is designed to penetrate 2 to 3 m into the lunar regolith and measure its thermal gradient and thermal conductivity. The conductive heat flow is obtained as a product of these two measurements. Based on the Apollo data [1], we believe that the regolith temperature below ~1.5-m depth is unaffected by the insolation cycles and is controlled by the heat flow from the deeper interior.

The lunar crust in general has higher radiogenic heat production rates than the underlying mantle [7]. Heat generated within the crust adds to the heat flow from the deeper interior. The PKT has the highest concentration of radionuclides in its crust [8] and possibly the underlying mantle as well [9]. Therefore, surface heat flow is expected to be highest in the PKT.

The collective objective of the two planned measurements at MC and SB is to determine the heat flow out of the mantle under these basins and the heat production rate of the non-PKT crust. Unlike the Apollo sites, MC and SB are completely outside of the PKT. These basins are similar in their very low Th values (~0.5-ppm). However, if a thick crust cumulatively produces more radiogenic heat than a thin crust, SB

would yield a higher surface heat flow value than MC, because the crust of the SB landing site is almost 4 times thicker (~33 km vs. <10 km, [10]). Comparison of these two surface heat flow observations will help us determine the heat production rate of the non-PKT crust. MC, because of its very thin crust and being outside of the PKT, is expected to yield the lowest surface heat flow and should approximate the heat flow solely from the mantle.

References: [1] Langseth M. G. et al. (1976) *LSC*, 7, 3143-3171. [2] Lawrence D. J. et al. (2000) *JGR*, 105, 20307-20331. [3] Kobayashi, S. et al. (2010) *Space Sc. Rev.*, 154, 193-218. [4] Wieczorek, M. A. and Phillips, R. J. (2000) *JGR*, 105, 20417-20430. [5] Nagihara, S. et al. (2020) *LPSC LI*, Abstract#1432. [6] Grimm, R. E. et al. (2021) AGU Fall Mtg., Abstract #P54C-02, [7] Shearer, C. K. (2006) *Rev. Mineral. Geochem.*, 60, 365-518. [8] Jolliff, B. L. (2000) *JGR*, 105, 4197-4216. [9] Grimm, R. E., (2013) *JGR*, 118, 1-20. [10] Wieczorek M. A. et al. (2013) *Science*, 339, 671-675.

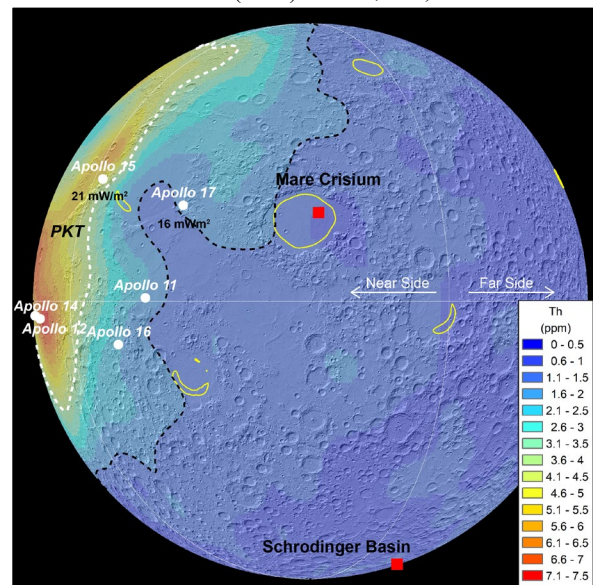


Figure 1. A map of surface Thorium concentration obtained by the Kaguya mission [3]. The white dashed line is the 3.5-ppm contour, which roughly delineates the geographic extent of the PKT. The black dashed line is the 1-ppm contour. The Apollo landing sites are indicated by white dots. The previously obtained heat flow values obtained [1] are also shown (Apollo 15 and 17). The MC and SB landing sites are shown as red squares. The areas with thin (<10 km) crust are delineated by the yellow solid lines [10].