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ALRAD - AN INFRARED RADIOMETER TO EXPLORE LUNAR MARE PITS

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Circular depressions in the lunar mare were observed by SELENE and LRO and are potential openings to lava tubes [1,2,3]. The walls of these pits show layers of exposed lunar bedrock, potentially lava flows. The pits are furthermore potential habitats for long-term astronomical bases. Mission concepts like Arne [4] aim at investigating these pits by flying in and out with a reconnaissance vehicle. Here we describe the Arne Lunar RADiometer (ALRAD) as an infrared payload to such a mission. ALRAD uses thermopile sensors to measure the net radiative flux in the thermal infrared wavelength range. Its sensor head carries six thermopile sensors, equipped with individual IR-filters. The instrument design is based on the miniRAD [5] and LRAD [6] radiometers of the MMX IDEFIX rover and the Intuitive Machines Athena (IM-2) hopper, respectively. ALRAD addresses three science objectives:

1. Determination of surface brightness temperature in the pit wall
2. Determination of surface thermal inertia in the pit wall
3. Determination of the location of the Christiansen Feature in the pit wall

To derive thermal inertia, ALRAD measures the surface brightness temperature using broad-band filters. Observing the pit walls at different local times during descending and ascending flights then allows determining thermal inertia, which is expected to vary between layers depending on the porosity of the bedrock and regolith grain size. To constrain mineralogical variations across the pit, the position of the Christiansen feature will be determined using three narrow bandpass filters in the 7.5 to 9 μm spectral range, a method previously demonstrated using the LRO Diviner instrument [7]. With ALRAD, we will attempt to determine variations in olivine content across the pit wall layers. The ALRAD payload offers a unique opportunity to characterize the thermal environment within a lunar pit, enabling a comprehensive characterization of the thermophysical properties of the regolith exposed in the funnel. Further, we will identify potential layering and detect compositional variations between lava flows.

References: [1]Haruyama, J., et al. (2009), GRL., 36, L21206, doi:10.1029/2009GL040635, [2] Robinson et al. (2012) PSS, 69, doi:10.1016/j.pss.2012.05.008, [3] Wagner and Robinson (2014) Icarus, doi:10.1016/j.icarus.2014.04.002, [4] Martin, T., et al. (2022), ELS 2022, [5] Knollenberg, J. et al. (2025) Prog Earth Planet Sci 12, 53. doi:10.1186/s40645-025-00717-3, [6] Knollenberg, J. et al., (2024) EPSC 2024, doi: 10.5194/epsc2024-837, [7] B. T. Greenhagen et al., (2010) Science, 329, 5998,1507–1509, doi:10.1126/science.1192196