LUNAR NEARSIDE OLIVINE EXPOSURES AS TARGETS FOR HUMAN EXPLORATION. P. J. McGovern[1], G. Y. Kramer[1], L. Corley[2], J. Kalynn[3], K. E. Powell[4], [1]Lunar and Planetary Institute, USRA, 3600 Bay Area Blvd., Houston, TX 77058 (mcgovern@lpi.usra.edu); [2]HIGP, University of Hawaii at Manoa, Honolulu, HI, 96822; [3]Department of Earth and Ocean Sciences, University of British Columbia, Vancouver, BC, V6T 1Z4, Canada; [4]Dept. of Physics and Astronomy, Rice University, Houston, TX 77005.

Introduction: The mineral olivine is a major constituent of the lunar interior. Recently, spectral observations from several spacecraft have revealed the presence of olivine in and around large lunar impact basins [1, 2]. While the prevailing hypothesis for these exposures is excavation of deep material via basin impact [1], several settings are consistent with magmatic transport of olivine to the near surface [2]. Given that remote detections of olivine require a substantial fraction of the exposed surface material to consist of this mineral [3], and being mindful of the vital importance of obtaining samples of the deep lunar interior, we find that these exposures make appealing targets for selection and return of samples by the type of human-landed missions planned by Golden Spike Company [4].

Spectral Detection of Olivine: While spectral evidence for lunar olivine has been gathered by ground-based observations [5], orbiting spectrometers have greatly increased the sensitivity and resolution of observations. Kaguya's Spectral Profiler (SP) detected olivine exposures in and around a number of large impact basins [1]. While some of these detections occurred in basin interiors, most were located in basin rims. The favored explanation for the setting of these detections is exposure of mantle material by the basin-creating impact [1], although exposure of a lower crustal pluton is acknowledged as an alternative. We independently assess the distribution of olivine exposures on the Moon using spectra from the Moon Mineralogy Mapper (M^3) [6]. M^3 is an imaging spectrometer that provides visual context to directly link spectra to geologic features, enabling comprehensive exploration.

Results: At Crisium basin we found 42 spectra with signatures indicating olivine or olivine-pyroxene mixtures. Several of these are located within the basin on mare basalts, including on the rim and in the ejecta of Picard crater. This crater is large enough to have penetrated the thin crust predicted at this site from measurements of gravity by the Gravity Recovery and Interior Laboratory (GRAIL) mission [7], thereby directly exposing lunar mantle. Several sites in eastern Crisium span the boundary between low-lying mare and elevated rim materials. Another site is located within a small mare inlier amidst rim material at Lacus Perseverantiae [2]. At Nectaris basin, at least 35 spectra show olivine or olivine-pyroxene signatures, with most of them located within the basin on mare flows.

Discussion: Olivines are relatively rare in the lunar sample collection: for example, only one hand sample-sized dunite (fragments in samples 72415-8) was collected from the Moon [8]. Fragments from this dunite have been labeled primary (i.e., mantle) in origin [9], although subsequent analysis suggests a shallow intrusive origin [8]. In any event, to date, no samples of the lunar mantle have been unambiguously identified in the lunar sample collection. Obtaining such a sample would be a major accomplishment, yielding fundamental new insights into the structure and evolution of the lunar interior. However, olivines may also arise from magmatic processes within the lunar crust [1-2, 8], and such samples would provide valuable constraints on magma chamber and dike dynamics, magma and source rock compositions, and process rates. Olivine exposures on mare units that are not associated with craters large enough to completely penetrate the crust are likely to have been transported to the (near) surface by magmatic processes [e.g., 2]. Magmatic processes can transport olivine through the crust, either as entrained xenoliths of mantle rock or as products of magmatic evolution (cumulates).

Sites in the relatively flat, smooth mare are attractive for meeting landing safety requirements. At Crisium, Picard crater is an appealing site, both for the prospect of direct sampling of the mantle and for understanding impact processes. A landing site in eastern Crisium has the advantage of access to olivines in both mare and highland settings, possibly spanning a range of transport mechanisms (impact and magmatic) and origins (mantle or cumulates). At any site, the ability of humans to recognize and select appropriate samples [10] will be crucial to mission success.

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