PROLONGED ROCK EXHUMATION AT THE RIMS OF LUNAR CRATERS: IDEAL LOCATIONS FOR LUNAR SURFACE SAMPLING.
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Introduction: Rock fragments contained in the lunar regolith are primarily mobilized by impact cratering and mass wasting, with the former being capable of transporting lunar materials thousands of kilometers across the surface [1]. These mixing processes pose a challenge to lunar surface sampling initiatives in that only a small percentage of hand-sample-sized lunar rock fragments are locally derived [2]. The accuracy of temporal and geologic interpretations drawn from analyses of those samples hinge on the assumption that petrogenesis occurred geographically close to where the samples were collected.

In the work presented here, we use a combination of radar and thermal infrared data to show that boulders present at the rims of lunar impact craters are continually being exhumed from the subsurface by the downslope motion of the overlying regolith [3]. Those results indicate that exhumed boulders at crater rims are less likely to have undergone distal transport from other areas of the lunar surface.

Data and Methods: Our analysis utilizes Circular Polarization Ratio (CPR) radar data from the Lunar Reconnaissance Orbiter (LRO) Mini-RF instrument [4]. These data are sensitive to lunar rock fragments on the scale of the S-band wavelength (~12.6 cm) at the surface and subsurface to a depth of ~1.0 m [5]. We also utilize Rock Abundance (RA) data derived from LRO Diviner thermal infrared data [6]. The RA dataset provides the areal coverage of meter-scale rocks present at the lunar surface by minimizing the RMS error between nighttime surface radiance and a modelled radiance for surface rocks and regolith.

Using ESRI's ArcGIS Pro software, we georeferenced the aforementioned data with the center points of 6,240 km-scale impact craters on the lunar maria; age dates for these craters were inferred from prior topographic diffusion modelling [7]. We collected mean and median values of CPR and RA over the rim (1.0–1.5 crater radii) and ejecta (1.5–4.0 crater radii) of each crater in our database. Those mean and median values were then binned by model age of the associated crater for comparison (**Fig. 1**).

Results: The CPR and RA data associated with the rims of our age-modelled craters remain elevated above the ejecta deposits for the lifetime of most craters in our database. The decreasing trends of the rim and ejecta RA data values are more qualitatively separable than that of the radar data. Statistically, the decreasing rates of ejecta and rim values in each dataset are separable using the York method [8].

Discussion: The elevated radar and RA data values at the rims of the oldest craters in our dataset (**Fig. 1**) cannot be explained by prior estimates of lunar space weathering which predict maximum boulder lifetimes of ~300 Myr [9]. Therefore, we infer that the rocks present at the rims of km-scale craters on the lunar maria are being exhumed from the subsurface due to the downslope creep of the overlying regolith into the crater interior and exterior. This process must be occurring at a rate that outpaces the rate of surface rock destruction in order to explain our results and observations.

Our inference of rock exhumation necessitates that the rocks being exhumed have spent some amount of time in the subsurface where they are less susceptible to mixing processes and less likely to have been transported from some other area of the Moon. We can therefore conclude that topographically raised crater rims are ideal places to collect lunar samples that are less likely to have undergone distal transport. This process of rock exhumation is also likely to occur at other topographic features (i.e., wrinkle ridges and other scarps) on the lunar surface. Based on our findings, the selection of a lunar landing site near a crater rim or another topographic feature is likely to be scientifically beneficial for a variety of geological subdisciplines.

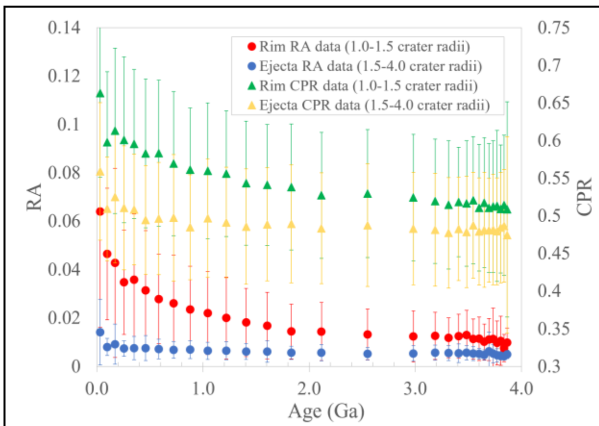

Figure 1: Rates of evolution for crater rim/ejecta CPR (green/yellow triangles) and rim/ejecta RA (red/blue circles). Rim values in each dataset are elevated above the ejecta indicating that rocks are continually exhumed at crater rims.

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