BULLIALDUS CRATER: EXCAVATION AND EXPOSURE OF AN MG- OR ALKALI- SUITE PLUTON?

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Introduction: The central peak of Bullialdus Crater has long been recognized as having a reflectance spectrum dominated by a strong noritic signature (e.g., 1-4). Results of spectral fits to the central peak of Bullialdus suggest a relatively high Mg# (>Mg_{75}) in the low-Ca pyroxenes (5), within the range of values observed for Mg-suite lunar samples (e.g., 5). Centered at -20.7°, 337.5° in Mare Nubium, Bullialdus Crater lies within the high-thorium Procellarum KREEP Terrane (e.g., 6). In fact, based on orbital gamma-ray data, Bullialdus is the location of a clear thorium (Th) enhancement, which is important because Th commonly serves as a proxy for detecting KREEP-rich materials on the lunar surface (e.g., 6-8). We examine the mineralogy of Bullialdus crater and the spatial distribution of the Th signature associated with it to investigate the character and composition of the excavated pluton.

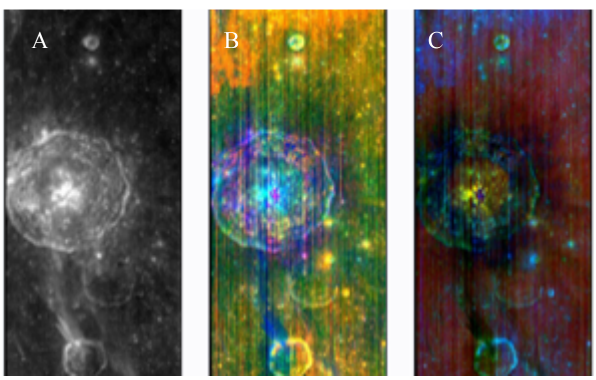

Fig. 1. Mineral diversity in Bullialdus crater. (A) 0.75 µm albedo map. (B) Mafic mineralogy depicted using an RGB composite where R=integrated 1 µm band depth; G=integrated 2 µm band depth, and B=reflectance at 1.5 µm. In this color scheme, fresh material appears bright, with deep blue generally indicating feldspathic material, red indicating an enhancement in olivine, and orange and yellow indicating pyroxenes. Low-Ca pyroxene often appears as cyan, due to the overall brightness and narrow 1 µm band. (C) Pyroxene diversity map depicted using an RGB composite where R = 1.9 µm band depth, G = integrated 2 µm band depth, and B = integrated 1µm band depth. This color scheme highlights low-Ca pyroxene as yellow, and fresh high-Ca pyroxene as cyan. Anorthositic material and highly space-weathered material appear as black.

Bullialdus Region Mineralogy: Bullialdus crater and the local mineralogy are shown in Fig. 1, and representative spectra from Bullialdus and the surrounding region are shown in Fig. 2. Strong pyroxene bands indicative of a noritic composition dominate the central peak. Anorthositic material, excavated by Bullialdus, is exposed in the crater rim and proximal ejecta (Fig. 1). Portions of the walls exhibit a gabbroic signature, potentially olivine-bearing. Fresh craters in Mare Nubium exhibit a typical basaltic spectral signature, while both mare and highland soils in the region are generally spectrally featureless.

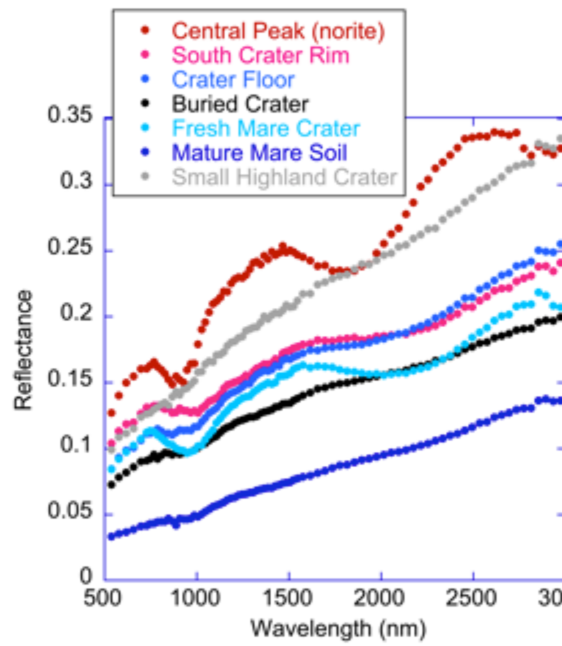

Fig. 2. Representative spectra from within and around Bullialdus crater.

Bullialdus Crater, KREEP and Hydroxyl: Shown in Fig. 3 is the deconvolved Lunar Prospector Th content around Bullialdus crater. There is a clear Th enhancement (~6-7 ppm Th) centered on Bullialdus crater and its northern wall outer flanks (9). However, if the source of the Th is only the material excavated in the central peak, the Th content is higher, and closer to the range of Alkali suite norites (10).

In addition to providing a window into the complex petrology of the lunar crust, Bullialdus crater may also provide insight into the distribution of native lunar volatiles and the minerals that bear them. Multiple lunar data sets have demonstrated that some lunar surface materials exhibit a 2.8 – 3.0 μm absorption band, indicative of a hydroxyl or water component (e.g., 11-13). An increasing number of studies also suggest that the lunar mantle may have contained more water than originally assumed (14-16) and some of this water may be related to KREEP materials (17). Observations of the central peak of Bullialdus crater indicate that the pyroxenes exhibit a distinctive 2.8 μm band absorption that is significantly stronger than the immediate surroundings, possibly indicating the presence of a hydroxyl component, as illustrated in Fig. 4. The hydroxyl signature persists through multiple viewing geometries and illumination conditions, suggesting that it is not transient, like the lunar surface water previously observed (11-13).

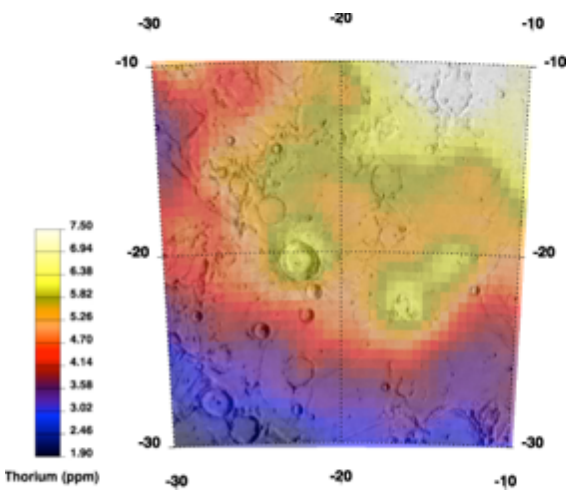

Fig. 3. Lunar Prospector Th, spatially deconvolved and overlain on the regional topography.

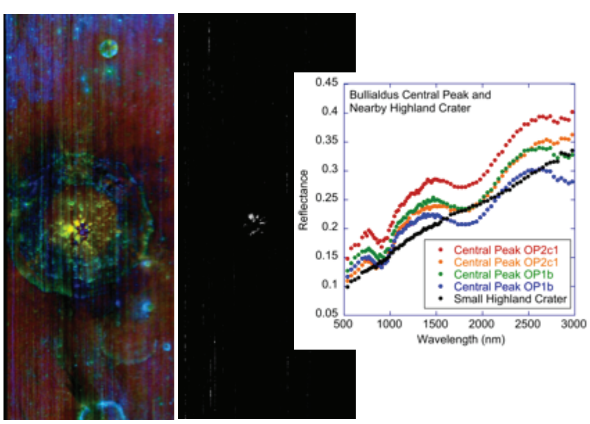

Fig. 4. Bullialdus crater pyroxenes (left) and 2.8 μm band depth (middle). (Right) Example spectra for the central peak taken during different optical periods with different illumination and viewing geometry are provided. A small, fresh highland crater from a similar latitude is provided for comparison.

We will explore the geology in and around Bullialdus in more detail, examining relationships between lithology, Th content, and hydroxylated material. In particular, we investigate the specific compositions and spectral properties of the pyroxenes in these exposures to determine whether they can provide further information about the crustal source region and distribution and character of KREEP within the lunar crust.

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