SPALL AT LONAR CRATER, INDIA: FIELD IMAGES, PETROGRAPHY, AND MODELING

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Introduction: Spall is defined as "a chip of a material broken off a larger solid body, and can be produced by projectile impact". In planetary science, spall is often cited as the likely mechanism that delivers meteorites from their parent bodies to Earth [1]. Spall can generally be seen as discontinuous ejecta lobes emplaced balistically circum the continuous ejecta blanket. Here, a case is made for terrestrial spall.

Field Observations: Three piles of ~5 cm-sized basalt cobbles and one boulder with a visibly fractured appearance and totaling an area of ~5-10 m^2 were found ~140 m south of the southern edge of the continuous ejecta blanket at Lonar Crater, India [2]. They appear as if one to three much larger (~1-2 m diameter) boulders were broken up in place (**Figure 1**). These materials are off of the continuous ejecta blanket defined by several authors [2] and overlie an black paleosol older than all ejecta deposits.

Petrographic Observations: Samples were collected and two were sent for petrography. Petrography of both revealed a fractured texture at the microscopic level corresponding to Class 1 shocked basalt classified by Kieffer et al., 1976 [3] (**Figure 2**). This shock level Class 1 has fractured grains, including laths of labradorite and groundmass augite and labradorite grains, suggesting a shock pressure less than 20 GPa [3]. Twinning in labradorite laths is highly disturbed.

Interpretations and Modeling: The interpretation is that these three piles were one to three masses spalled from at or near the initial impact point, and were jettisoned to their current position in a parabolic path. The spalled fragment was found 1560 m from the crater center (from GPS measurements). Because the fragment is outside of continuous ejecta blanket, it was likely ejected from a location near the point of impact. Assuming a typical 45 degree ejection angle the velocity of material ejected to a range, R, is given by $v_{ej}=\sqrt{Rg}$. Thus, the spall fragment was ejected at ~124 m/s. According to the Hugoniot of basalt [4], material experiencing a particle velocity of 124 m/s would be shocked to a pressure of 1.8 GPa. Spall may be ejected at velocities exceeding the particle velocity implied by the hugoniot [1]. This means spall may be ejected at a velocity of 124 m/s while experiencing peak shock pressures much lower than 1.8 GPa. The modeled 1.8 GPa fits the range of Class 1 [3] (**Figure 2**).

Implications: Whereas there were likely many more spall created at the time of the Lonar impact event, the emplacement and flow of the lithic layer of the ejecta blanket likely incorporated and "covered" initial spall that was closer to the rim at the time of the impact. These won't likely be found as they would be indistinguishable from Class 1 shocked basalt in the lithic ejecta layer. The interpretation of spall is supported by their location ~140 m past the distal edge of the continuous ejecta blanket, and their classification as Class 1 shocked basalt [3]. This key location has been noted for future investigations and petrography of other samples is underway.

Figure 1. From left to right, a boulder in the first pile is shown with the entire 2nd and 3rd piles. Inset: Note "fractured" texture of most samples.

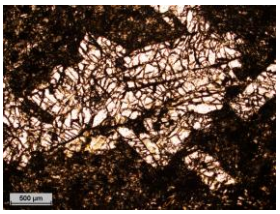
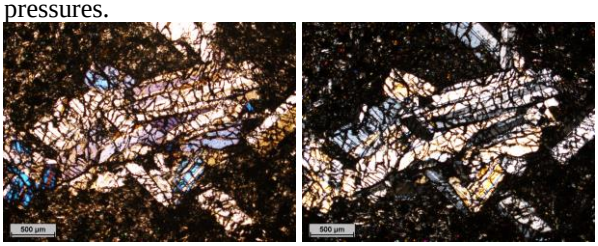


Figure 2. Petrography of sample collected in PPL (right) and two orientations of CPL (below) show intense fracturing of labradorite and loss of twinning indicative of Class 1 shock pressures.



References: [1] Melosh (1984) *Icarus*; Melosh (1985) *Geology;* Melosh and Vickery (1987) *Science* [2] Maloof et al. (2010) *GSA Bulletin*; Fudali et al. (1971) *Earth, Moon, and Planets*; Milton (1979) *LPSC* [3] Kieffer et al. (1976) *LPSC* [4] Pierazzo et al. (2005) *GSA Special Papers 384*, 443-459.