**FORMATION OF SOUTH POLE-AITKEN BASIN AS THE RESULT OF AN OBLIQUE IMPACT: IMPLICATIONS FOR MELT VOLUME AND SOURCE OF EXPOSED MATERIALS.** N. E. Petro [1]
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**Introduction:** The South Pole-Aitken Basin (SPA) is the largest, deepest, and oldest identified basin on the Moon and contains surfaces that are unique due to their age, composition, and depth of origin in the lunar crust [1-3] (Figure 1). SPA has been a target of interest as an area for robotic sample return in order to determine the age of the basin and the composition and origin of its interior [3-6]. As part of the investigation into the origin of SPA materials there have been several efforts to estimate the likely provenance of regolith material in central SPA [5, 6]. These model estimates suggest that, despite the formation of basins and craters following SPA, the regolith within SPA is dominated by locally derived material. An assumption inherent in these models has been that the locally derived material is primarily SPA impact-melt as opposed to local basement material (*e.g.* unmelted lower crust). However, the definitive identification of SPA derived impact melt on the basin floor, either by remote sensing [2, 7] or via photogeology [8] is extremely difficult due to the number of subsequent impacts and volcanic activity [3, 4].

In order to identify where SPA produced impact melt may be located, it is important to constrain both how much melt would have been produced in a basin forming impact and the likely source of such melted material. Models of crater and basin formation [9, 10] present clear rationale for estimating the possible volumes and sources of impact melt produced during SPA formation. However, if SPA formed as the result of an oblique impact [11, 12], the volume and depth of origin of melted material could be distinct from similar material in a vertical impact [13].

**Volume of Melt Produced by SPA:** Prior studies of the production of SPA impact melt [10] focused on the depth of melting and the possible amount of mantle melted during basin formation. Warren et al. [10] concluded that, assuming a transient cavity diameter of 1,170 km, melt produced by SPA would be nearly completely of mantle origin, and such melt (from both crust and mantle) would comprise approximately one-third of the total ejecta volume.

Cintala and Grieve [9] state that "…the relative volume of impact melt remaining inside the final crater increases with crater size." Subsequently, they show that, for craters larger than 10 km in diameter, the volume of melt retained within the crater is larger than 40% of the total melt. Extrapolating their data out to a basin the size of SPA and assuming a transient cavity diameter of 2,099 km [14] suggests that nearly 80% of the impact melt that is produced during basin formation is retained within SPA. Clearly such models, applied to a basin as unusual as SPA, should be treated carefully. Even in this extreme case, a significant volume of the roughly $8 \times 10^8$ $km^3$ of melt would still be retained.

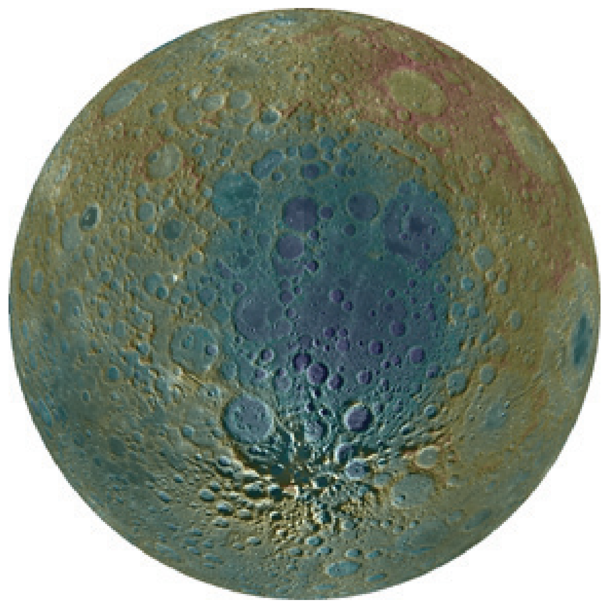

**Figure 1**. Orthographic projection about the center of SPA (-180º E, -56ºS) of LRO WAC mosaic with LOLA topography draped on top. Interior of SPA contains several smooth, flat regions, interpreted to contain either ancient mare basalts or SPA melt. Models of impact melt generation [9] predict that the deepest, central portion of the basin is almost completely covered by melt produced by SPA's formation.

**Implications of Oblique Impact:** Several authors have identified evidence for an oblique impact origin of SPA [11, 12, 15]. These lines include an elongation of the main rim of the basin, an offset in the location of highest Thorium concentrations from the center of the basin, and an offset between the center of possible damage to the nearside and the antipode of SPA. If SPA did indeed form as the result of an oblique impact, there are several implications for the volume and origin of SPA impact melt.

Pierazzo and Melosh [13], using computational simulations, modeled the effects of oblique impact on the volume and source of shocked material. They noted that, in general, with increasing obliquity a decrease in the volume of shocked (or melted) material and a shallowing in the source of melted material (Figure 2). Numerically, Pierazzo and Melosh state that in the 45º impact case, 80% less melt is produced relative to 90º impact, 50% of the volume of melt is produced in the 30º case. It should be noted, however, that the modeling was assuming a target attempting to recreate the Chicxulub impact, which incorporated target materials that would not be found on the Moon. Even in this "worst case" scenario (a highly oblique impact), a large volume of melt is produced. Certainly some portion of the melted material is ejected from the basin, and additional work in modeling the amount retained within such a large transient cavity is necessary, however given the large volume of material melted, there is certainly ample source material to coat a significant portion of the resulting transient cavity.

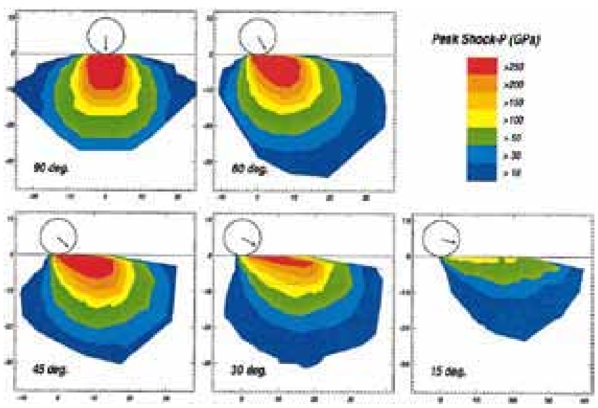


**Figure 2.** Effects of increasing obliquity (from 90º to 15º on the volume of shocked/melted material and the depth of melting (Figure 3 of [13]).

**Implications for Location of SPA Melt:** Schultz and Crawford [12] predict that the location of first contact between the impactor and the Moon is located near the Ingenii Basin (black circle in Figure 3). In their model, the trajectory of the impactor is roughly following a northwest to southeast path. In the Pierazzo and Melosh [13] model, the enhanced melting occurs downrange (and symmetrically) from the impact point. Could the enhanced iron as measured by Lunar Prospector (and others, Figure 3) be a signature of SPA impact melt. Certainly there are a number of medium to small sized mare basalts scattered across SPA [16], but there are large areas of non-mare that are also enhanced in iron. Recent results from the Moon Mineralogy Mapper also suggest a distinct high Calcium pyroxene region near the center of SPA [17, 18] which may represent either a unique composition of melt (relative to the noritic enhancement seen elsewhere in the basin).

**Conclusions:** A large volume of material was melted during the formation of SPA regarless of the impact's obliquity. The origin of melt, likely lower crust or upper mantle, is a source for the iron enhancement across the basin and possibly the compositional variability seen in the surface pyroxenes. Given the relatively minor contamination by subsequent events [5, 6], it is very likely that the regolith inside SPA, in many areas, is dominated by melt from the SPA event.

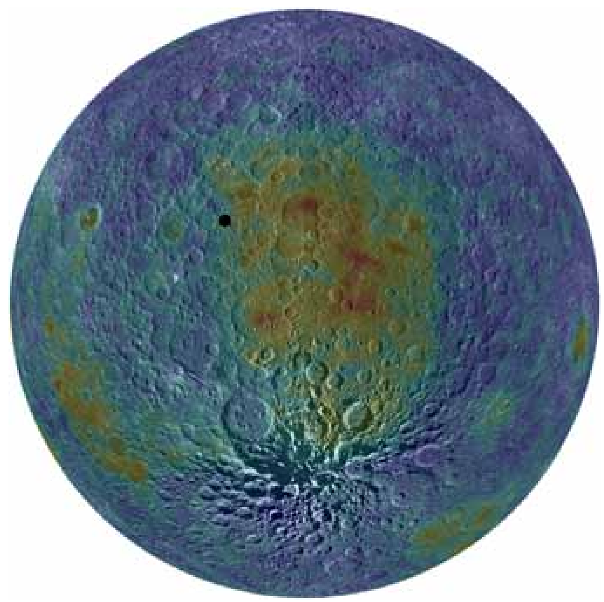

**Figure 3.** In the same view as Figure 1 instead with Lunar Prospector Iron overlain. The impact point predicted by [12] is marked with a black circle.

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