EASTERN BASIN TERRANE AND SOUTH POLE-AITKEN BASIN EJECTA: MID-LEVEL CRUST?  
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Despite its great age and the fact that numerous smaller basin impacts are superposed on it, the South Pole-Aitken (SPA) basin preserves a recognizable annulus of ejected material for which FeO concentrations, although lower than the basin interior, are greater than that of much of the feldspathic highlands. Previously, we compared the average composition of this material to highlands that occur between the Procellarum KREEP Terrane and the anorthositic regions of the Feldspathic Highlands Terrane (FHT) [1]. Comparing FeO (Clementine spectral reflectance or CSR) and Th (Lunar Prospector gamma-ray spectrometer or LPGRS), we inferred that the compositions are broadly similar between these two kinds of terrane and significantly more mafic than the bulk of the feldspathic highlands, which are most extensive in the northern far-side quadrant. That these compositions are associated with the ejecta from large basins indicates a more mafic composition at some depth within the crust than the presently exposed upper crust, although the MgO content remains an important unknown. This idea is not new [e.g., 2]; however, recent global compositional data allow us to test the idea with higher resolution and more accuracy.

The composition of materials associated with South Pole-Aitken basin remains enigmatic in part because no obvious analogues for the mafic nonmare rock components occur among the lunar samples and in part because compositional information derived from CSR data, i.e., FeO concentrations, differs significantly from that derived from LPGRS data. In many other locations, the data sets are in fairly close agreement [3,4], but in the SPA basin, CSR data suggest significantly higher FeO concentrations than the LPGRS data. On the basis of CSR-derived data, [5,6] concluded that the basin floor could be a mixture of upper mantle and lower crust.

Recent investigation of SPA basin rock types using combined remotely sensed mineralogy and compositions (especially LPGRS FeO [7]), however, indicate that the basin, despite its great size, probably penetrated only into the lower crust and not the mantle [8,9]. Questions remain as to the nature of this lower crust – and to the nature of the middle and upper crust for that matter – and to how representative they may be of lunar crust in general. Clearly this region of the crust is different from the Th-rich PKT, but is the crust in this area essentially similar to the FHT, just excavated to different depths, or is it fundamentally different crust? Here, we compare compositions between material outside the topographic depression of SPA basin to materials surrounding basins in the vicinity of Crisium eastward to about 120°E as representing the region we refer to as the Eastern Basin Terrane (EBT, Fig. 1). These regions are surfaced by deposits built up largely of ejecta from numerous basin impacts.

**Figure 1.** Images of FeO (CSR) showing location of Eastern Basin Terrane and annulus of elevated FeO material surrounding SPA (light blue & green), and regions of interest discussed in the text.
were selected for SPA in order to assess the effects of potentially thick antipodal deposits from Imbrium [16] or Serenitatis [12] and two locations are likewise selected for circum-Crisium deposits.

Histograms are shown in Fig. 2 for FeO and Th for the regions of interest. Highlands surrounding Crisium and in the area east of Smythii typically have FeO concentrations of 6–7%, greater than the 3–5% typical of the anorthositic part of the FHT (Fig. 1), but less than the interior of SPA. These values are typical of granulitic breccias and of anorthositic norite or troctolite compositions. Regions west and northwest of SPA also have FeO typically in the range 6–7%, but east-northeast of the basin, FeO is lower, possibly as a result of mixing of more feldspathic material from the Orientale basin.

Concentrations of Th are low, averaging 0.6–0.8 ppm in areas least affected by ejecta from the late, large near-side impacts into the Procellarum KREEP Terrane, especially Imbrium [17]. From deposits west of Crisium to the east, Th decreases from an average of 1.8 to 0.7 ppm, consistent with increasing distance from Imbrium and Serenitatis. Deposits west-northwest of SPA have on average 1.2 ppm Th, but this may in part result from proximity to antipodal ejecta from Imbrium and Serenitatis [16,12]. Deposits northeast of the basin have 0.7 ppm on average, compared to a general “background” value within the basin of about 2.2 ppm.

Crustal sources of Thorium. Recent investigation of spectral properties of freshest nonmare rock exposures in SPA indicates a predominance of norite, which, coupled with mafic composition, is consistent with exposure of lower crust or impact melt derived therefrom [9]. We may therefore take the background Th concentration as typical of lower crust in that part of the Moon. Ejecta in the annulus of moderately mafic basin exterior deposits, however, indicate only about 0.7 to 1.2 ppm Th in mid-crustal levels. Typical FHT Th concentrations of 0.6 ppm and even lower values (<0.5 ppm) for the feldspathic lunar meteorites probably characterize the upper 20 km. Concentrations of Th in the Eastern Basin Terrane, which derive from accumulation of ejecta from many basins such as Crisium, appear to be slightly less than 1 ppm and probably also reflect mid-crustal levels, e.g., 20–40 km, although Crisium may have penetrated deeper.

Compositions of Luna 20 materials are similar for FeO and Th to the average remotely sensed compositions of circum-Crisium highlands, i.e., 7 % and 1.2 ppm, respectively, but containing no obvious KREEP-like (e.g., Imbrium) components [18]. This similarity indicates that we have adequately accounted for the presence and effects of cryptomare, which contribute high FeO and slightly higher Th than associated highlands to the remotely sensed data.

These results support the estimates of Th concentrations for the lower and middle crust outside of the PKT used by [1] in their crustal and global Th mass-balance calculations. Whether the modestly elevated Th concentrations of the SPA basin interior are representative of lower lunar crust away from the Procellarum KREEP Terrane remains unknown.

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