DO WE HAVE A METEORITE FROM THE SOUTH POLE-AITKEN BASIN OF THE MOON?

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The SPA (South Pole-Aitken) basin, the largest impact structure in the solar system, encompasses about 5% of the lunar surface ([1] "inner"). Samples from SPA will help us better understand the impact history and crustal evolution of the Moon [2]. The ~50 lunar meteorites probably represent 35–40 source craters. Thus it is likely that 1 or 2 meteorites originate from within the basin. How would we recognize such a meteorite? Data obtained from orbit show the nonmare material of SPA to be more mafic (~10% FeO) than materials of the FHT (Feldspathic Highlands Terrane, 4–5% FeO). SPA material is also richer in Th (1–2 ppm, with a few "hot spots" up to 4 ppm) than the FHT (<1 ppm), but not as rich as the PKT (Procellarum KREEP Terrane) (>4 ppm) [1].

Several lunar meteorites, all breccias, are intermediate to anorthosite and basalt in composition (FeO, Al_2O_3) and richer in Th than mixtures of basalt and anorthosite: NWA 2995 (2 ppm Th), Yamato 983885 (2 ppm), Dhofar 961 (3 ppm), Calcalong Creek (4 ppm), NWA 4472/4485 (7 ppm), and SaU 169 (10 ppm, regolith breccia). SaU 169 and NWA 4472/4485 are likely from the PKT [3,4]. Of the others, Dhofar 961, an impact-melt breccia [5] with the composition of gabbronorite (18% Al_2O_3, 11% FeO; $Mg' = 63$), has some unusual geochemical properties. Concentrations of incompatible elements are moderately high, e.g., 7 ppm Sm, and would require 10% high-K KREEP [6], if an Apollo breccia. Polymict nonmare materials in the Apollo collection with this level of Sm typically contain 1.2 ppm Eu, and never <1 ppm. Yet Dhofar 961 contains only 0.8 ppm Eu. In essence, the composition of Dhofar 961 does not correspond (as do those of most other "mingled" meteorites [7]) to a mixture of feldspathic material as represented by the feldspathic lunar meteorites, mare basalt, and any form of KREEP as it is known in Apollo samples. Our working hypothesis is that Dhofar 961 derives from ferroan mafic rocks, possibly including basalt, with an intercumulus component that is not KREEP in the additive, polymict sense.

Dhofar 961 may originate from the PKT, but from a point distant from the Apollo samples as no Apollo sample shares its lithophile-element signature. Curiously, Dhofar 961 does share a feature with impact-melt breccias of Apollo 16 – high abundance (~1%) of FeNi metal likely derived from an iron meteorite with nonchondritic Ir/Au (1.5) [7,8]. Alternatively, it may originate from a place where magma-ocean differentiation led to a different flavor of "KREEP" – a place such as the South Pole-Aitken basin. It will be important to obtain a crystallization age of the Dhofar 961 impact-melt component. The stone and its probable pairs, Dhofar 925 and 960, are difficult to obtain, however.

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