IS LUNAR METEORITE KALAHARI 009 BRECCIATED NONMARE BASALT OR IMPACT MELT?

R. L. Korotev, Department of Earth & Planetary Sciences Washington University, Saint Louis MO 63130 (korotev@wustl.edu)

Introduction: Sokol et al [1] identify lunar meteorite Kalahari 009 as "a monomict breccia with basaltic composition and mineralogy." The protolith is a "VLT (very-low-Ti) mare basalt with extremely low contents of incompatible elements" [1]. "Lu–Hf data define an age of 4286 ± 95 Ma indicating that Kalahari 009 is one of the oldest known basalt samples from the Moon" [1]. Warren and Taylor [2], however, note that Kalahari 009 is an "ancient monomict-brecciated Ti-poor basalt …which is generally interpreted as a mare material [2] despite its position on this diagram," a figure such as Fig. 1. Kalahari 009 [symbols K] has lower Ca/Al than mare basalts, in the direction of material from the feldspathic highlands (Fig. 1).

In other respects, the composition of Kalahari 009 is not like that of any known mare basalt in that it has some nonmare characteristics. With 12.8% [1] to 14.9% [3] Al_2O_3, Kalahari 009 is more aluminous than any mare basalt except those of Luna 16 (13.5%, but which plots off scale of Fig. 2 at 3.3 µg/g Eu). Kalahari 009 is also more like nonmare rocks in terms of Eu/Na ratio (Fig. 2). Both Kalahari 009 and its feldspathic pair Kalahari 008 [1] are richer in Na than other lunar meteorites of otherwise similar composition (Fig. 2). Most plagioclase analyses in Kalahari 009 are in the An_{88-95} range [1], greater than is typical of mare basalt. If Kalahari 009 represents a magma, then it is very unusual one.

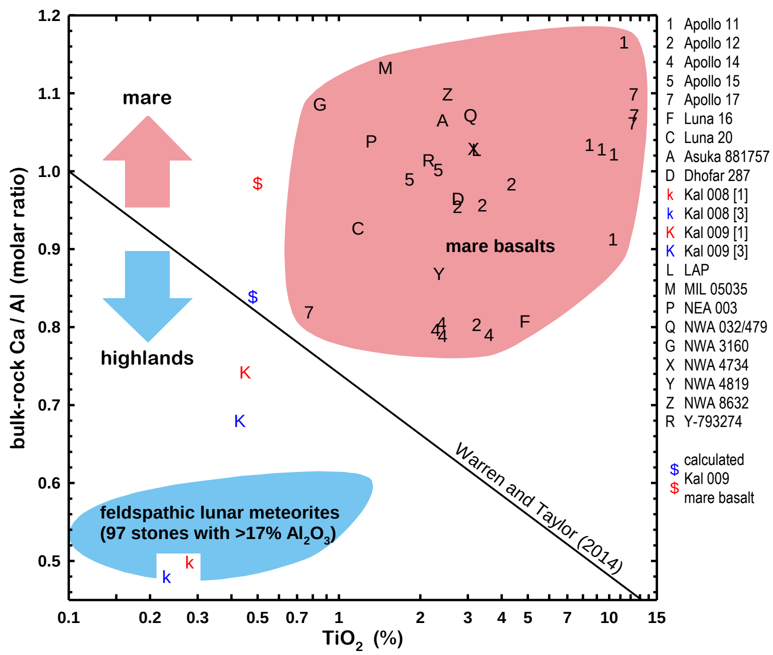

Figure 1. After Fig. 2 of [2]; see note [5]. The two points each for Kal 008 (k) and Kal 009 (K) are from the data of [1] and [3]. The $ symbols are calculated mare bas compositions assuming that the K points are mixtures of 77% $ and 23% k.

The composition of Kalahari 009 could in part be reconciled in terms of more typical mare basalt (but one with very low incompatible element abundances) if it were an impact mixture of ~77% low-Ti basalt with ~20% FeO and ~10% Al_2O_3 and ~23% Kalahari 008 (Figs. 1,2). The two Kalahari lithologies were clearly in the same target area on the Moon if the meteorites are paired. Ni and Ir concentrations in Kalahari 009 are low for melt breccias, however (<150 µg/g and <8 ng/g), and clasts of feldspathic material are not reported as occurring in Kalahari 009 [1]. Also, the impact mixing scenario this drives the Eu concentration of the inferred basalt component to very low concentrations, equivalent only to that of the olivine gabbro in NWA 773 (Fig. 2, [4]). Thus, the impact-mixture hypothesis is also ambiguous. Kalahari 009 is unique and has an untold story that needs telling.

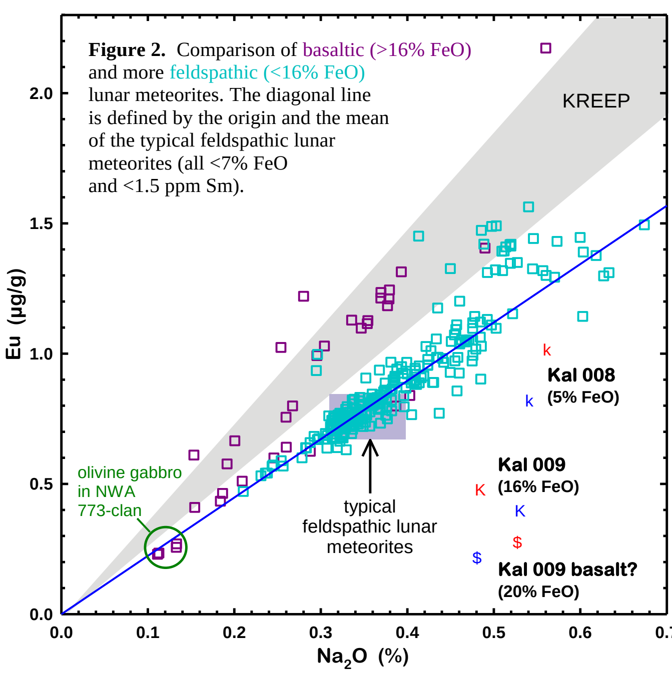

Figure 2. Comparison of basaltic (>16% FeO) and more feldspathic (<16% FeO) lunar meteorites. The diagonal line is defined by the origin and the mean of the typical feldspathic lunar meteorites (all <7% FeO and <1.5 ppm Sm).

References [1] Sokol A. K et al. (2008) *GCA* 72:4845–4873. [2] Warren P. H. & Taylor G. J. (2014) Ch. 2.9, *Treatise on Geochemistry (2nd Edition)* A. M. Davis, ed., pp. 213–250. [3] Korotev R. L. et al., *M&PS* 44: 1287–1322. [4] Jolliff B/ L. (2003) *GCA* 67:4857–4879. [5] TiO_2 values were incorrectly reported in [3]. Correct values are Kalahari 008: 0.26% and Kalahari 009: 0.43%.