HIGHLY-SIDEROPHILE ELEMENT ABUNDANCES AND RE-OS ISOTOPIC SYSTEMATICS OF LHERZOLITIC SHERGOTTITE YAMATO 984028.
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Introduction: Shergottites are rare basaltic achondrites, which represent magmatic rocks from Mars [e.g., 1-3]. These samples present an opportunity to constrain the nature and timing of igneous processes that operated on the red planet. In the absence of direct samples of the martian mantle, previous studies have utilized the highly-siderophile element (HSE; Os, Ir, Ru Pt, Pd, Re) abundances and osmium isotopic characteristics of the shergottite suite to constrain the martian mantle HSE composition [e.g., 4,5]. In addition, the HSE compositions of shergottites have been employed to infer the processes and timing of core formation, and the development of depleted and enriched reservoirs during the early evolution of Mars [6]. Lherzolitic shergottites consist of cumulative olivine and pyroxene crystallized from primitive mantle-derived melts. These samples may represent the closest analogues of martian mantle composition(s) available for investigation.

Detailed studies on the petrographic, mineralogical, and geochemical characteristics of a newly recognized lherzolitic shergottite, Yamato (Y) 984028, have been conducted [8,9]. Here, the petrogenetic constraints provided by HSE abundances and Re-Os isotopic compositions of Y-984028 are explored.

Petrography, Mineralogy and Bulk Chemistry: Detailed petrographic observations, mineralogy, and bulk chemistry (major- and trace-elements) are reported elsewhere [8,9]. Yamato 984028 consists of three coarse-grained textural zones and a partially devitrified fusion crust (Fig. 1). Zones A (poikilitic) and B (non-poikilitic) are magmatic, Zone C is a breccia, and Zone D corresponds to the fusion crust. Zone A and Zone B are similar to magmatic textures identified in other lherzolitic shergottites [e.g., 10,11]. Cross-cutting relationships between the magmatic textural zones, the breccia zone, and the fusion crust show that Zone C formed after magmatic crystallization, but prior to terrestrial atmospheric entry.

HSE Abundances and Re-Os Isotopic Systematics: Osmium, Ir, Ru, Pt, Pd, and Re contents measured in Y-984028 (Fig. 2A) are within the range of other lherzolitic shergottites [6, 12]. As with other lherzolitic shergottites, the bulk-rock Re/Os ratio of this meteorite is low, so age correction to the time of crystallization [~170 Ma; 13] is minor, and the calculated initial $^{187}Os/^{188}Os$ of Y-984028 (0.1281 ± 0.0002) is within the range of chondritic meteorites. The range of Os, Ir, and Ru (I-PGE) concentrations in terrestrial picrites and komatiites overlap measured I-PGE abundances in lherzolitic shergottites (Fig. 2A).

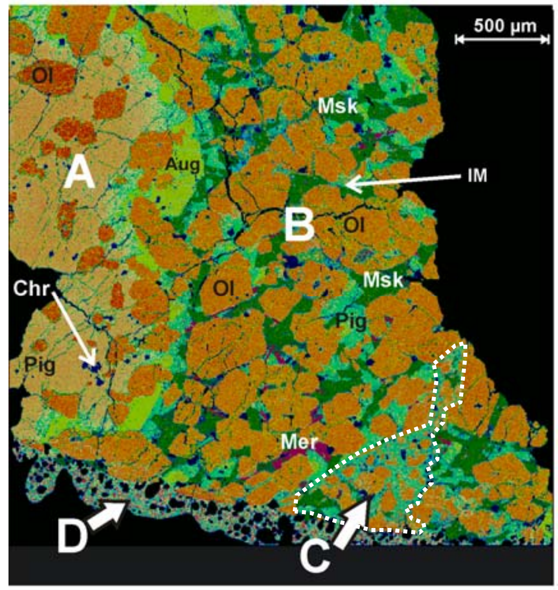

Figure 1: *Combined MgKα-CaKα map of Y-984028 ,51-3. Different lithologies (A, B, C) are labeled. A = poikilitic zone; B = non-poikiltic zone; C = breccia zone; and D = fusion crust. Aug = augite. Chr = chromite. Msk = maskelynite. Mer = merrillite. IM = impact melt. Ol = olivine (dark red olivine has high Mg). Pig = pigeonite.*

Effects of Assimilation of Martian Crust and Regolith: The fractionated HSE patterns of lherzolitic shergottites reflect magmatic processes and cannot be accounted for by meteoritic contamination linked to impact processing of the martian surface. Furthermore, contributions of small amounts of martian crust with low Os-Ir-Ru contents (i.e., analogous, perhaps to the HSE inventory of terrestrial continental crust [e.g., 14]) during fractional crystallization accompanied by crustal assimilation, will lead to purely dilutional effects on the HSE composition of lherzolitic shergottite parental magmas. Thus, HSE abundances and Os isotope systematics of lherzolitic shergottites are probably highly resilient to contamination processes and preserve magmatic compositions. Given the different geochemical behaviour of lithophile and siderophile elements, these observations do not preclude resolvable modification of lithophile elements and their isotopic systems during open-system fractional crystallization [e.g., 15].

Petrogenesis of Y-984028; Implication for Martian Magmatism and Mantle Processes: Bulk-rock Os abundances determined from interior portions of lherzolitic shergottites (Fig. 2A) vary over a similar order of magnitude when compared to basaltic rocks of similar MgO-content on Earth [5], suggesting that HSE partitioning in lherzolitic shergottites may approximate that of basaltic magmatism on Earth.

Elevated I-PGE contents (Fig. 2B) may have been imparted by high-degrees of melting (conservatively estimated to be >10%) capable of liberating the I-PGE beyond the point of sulfur saturation in the melt. As such, lherzolitic shergotites may share some similarities with high-MgO terrestrial picrites with high I-PGE concentrations and chondritic osmium isotopic compositions. A sulfur-under-saturated melt may carry a significant portion of the HSE inventory of the mantle source, and could precipitate HSE as Os-Ru ± Ir (Pt, Rh) sulfides and platinum-group micro-minerals conceivably associated with early-crystallizing olivine and chromite under appropriate f_{S2} and f_{O2} conditions [16]. This information suggests that the HSE inventory and Os-isotopic composition of lherzolitic shergottites can be used to constrain the composition of their mantle source(s). The ~170 Ma crystallization ages of lherzolitic shergottites and their low Re/Os ratios indicate the martian mantle source for these rocks may have evolved with an average Re/Os ratio within the range of chondrites. Moreover, elevated HSE abundances in lherzolitic shergottites (1-10s ng/g) indicate that the martian mantle contains HSE abundances in excess of those predicted from models of low-pressure core-mantle segregation (<0.001 pg/g [5]).

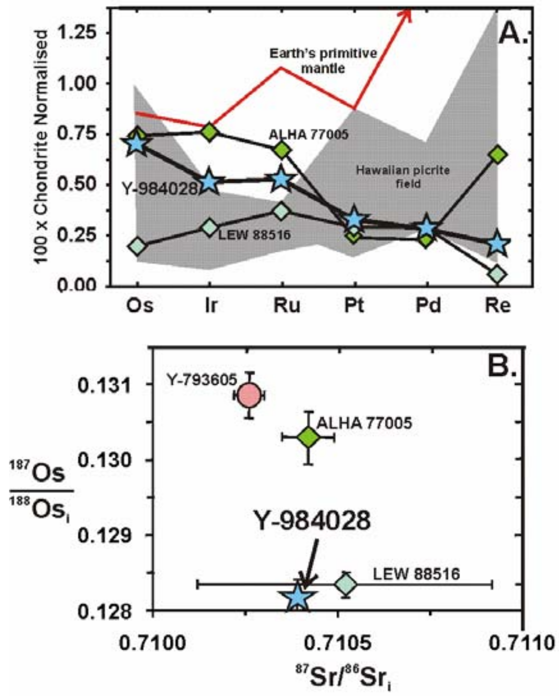

Figure 2: A: *Bulk-rock HSE-element abundances of Y-984028 and other lherzolitic shergottites [12] normalized to the composition of Orgueil [18]. The field of hawaiin picrites is taken from [19] The primitive mantle composition of [20] is shown for refence, and the Pd and Re concentrations of this estimate plot off the diagram at this scale.* ***B:*** *Initial $^{187}Os/^{188}Os$ and $^{87}Sr/^{86}Sr$ values of lherzolitic shergottites at the time of their crystallization [21 and references therein].*

References: [1] Bogard, D.D. & Johnson, P. (1983) *Science*, **221**, 651-654. [2] McSween, H.Y. & Treiman, A.H. (1998) *Planet. Mat.*, **36**, F1-F53. [3] McSween, H.Y. (2002) *MAPS*, **37**, 7-25. [4] Warren, P.H. et al. (1999) *Geochimica Et Cosmochimica Acta,* **63**, 2105-2122. [5] Walker, R.J. (2009) *Chemie der Erde*, **69**, 101-125. [6] Brandon, A.D. et al. (2000). *Geochimica Et Cosmochimic Acta,* **64**, 2093-2103. [7] Goodrich, C.A. (2002) *MAPS*, **40**, 1175-1184. [8] Riches, A. J. V. et al., (2010) *Polar Science,* in revision [9] Riches, A.J.V. et al. (2009) *32nd Symp. on Antarctic Meteorites* [10] Mikouchi, T. & Kurihara, T. (2008) *Polar Science,* **2**, 175-194. [11] Treiman, A.H. et al. (1994) *Meteoritics,* **29**, 581-592. [12] Puchtel, I.S. et al., (2008) *LPSC* **39th***,* Abstract #1650. [13] Shih, C.-Y. et al., (2009) *32nd Symp. on Antarctic Meteorites* [14] Peucker-Ehrenbrink, B. & Jahn, B-M. (2001) G^3, 210, 1061-1083. [15] Herd, C. et al., (2002) *GCA* **66**: 2025-2036. [16] Jones, J.H. et al., (2003) *Chemical Geology,* **196**, 21-41. [18] Horan, M. F., *et al*. (2003) *Chemical Geology,* **196** (1-4), 27-42. [19] Ireland, T. J. et al. (2009) *Chemical Geology* **260**: 112-128. [20] Becker, H. et al. (2006) *Geochimica Et Cosmochimica Acta ,* **70**, 4528-4550 [21] Meyer, C (2009) http://www-curator.jsc.nasa.gov/antmet/mmc/.