Rb-Sr AND Sm-Nd STUDIES OF OLIVINE-PHYRIC SHERGOTTITES RBT 04262 AND LAR 06319: ISOTOPIC EVIDENCE FOR RELATIONSHIP TO ENRICHED BASALTIC SHERGOTTITES.

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Introduction: RBT 04262 and LAR 06319 are two Martian meteorites recently discovered in Antarctica. Both contain abundant olivines, and were classified as olivine-phyric shergottites [1]. A detailed petrographic study of RBT 04262 by [2] suggested it should be reclassified as a lherzolitic shergottite. However, the moderately LREE-depleted REE distribution pattern [3] indicated that it is closely related to enriched basaltic shergottites like Shergotty, Zagami, Los Angeles, etc. In earlier studies of a similarly olivine-phyric shergottite NWA 1068 which contains 21% modal olivine, it was shown that it probably was produced from an enriched basaltic shergottite magma by olivine accumulation [4, 5]. As for LAR 06319, recent petrographic studies suggested that it is different from either lherzolitic shergottites or the highly LREE-depleted olivine-phyric shergottites [6]. We performed Rb-Sr and Sm-Nd isotopic analyses on RBT 04262 and LAR 06319 to determine their crystallization ages and Sr and Nd isotopic signatures, and to better understand the petrogenetic relationships between them and other basaltic, lherzolitic and depleted olivine-phyric shergottites.

Samples: Aliquant samples of RBT 04262 weighing 3.1 g and of LAR 06319 weighing 1.4 g were allocated to us for isotopic studies. The bulk rock samples (WR) were taken after the samples were coarsely crushed to <149µm. Then, the sample was further crushed and sieved into finer 74-149µm and <74µm splits. The mineral separates – pyroxene (Px), olivine (Ol) and plagioclase (Plag) - were obtained from these finer size fractions by magnetic and heavy-liquid density separations. Most samples were washed with weak HCl (1-2N) to remove possible surface contaminants. This procedure was especially important for the Rb-Sr isochron study of RBT 04262 (see Fig.1). Both acid-residue (r) and combined mineral leachates (Leach) were analyzed.

Rb-Sr results: The Rb-Sr isotopic system for RBT 04262 is highly disturbed (Fig. 1). Five acid-washed samples and one unwashed plagioclase sample (solid circles) form a linear array corresponding to an age of 167±6 Ma for $\lambda(^{87}Rb)$ =0.01402 Ga^{-1} and the initial $^{87}Sr/^{86}Sr$ =0.722745±19. However, two acid leachates and three unwashed bulk rock and pyroxene and olivine samples (open circles) lie considerably below the isochron, and were probably contaminated. In contrast, the Rb-Sr isotopic system for LAR 06319 is not significantly disturbed (Fig. 2). All nine bulk rock and mineral samples including two acid leachates form an isochron with an age of 207±14 Ma and an initial $^{87}Sr/^{86}Sr$ =0.722509±69. The RBT 04262 age is within the range of Rb-Sr ages of olivine-free enriched basaltic shergottites (161-177 Ma) as well as previously reported ages for lherzolitic shergottites (148-185 Ma). It is also in agreement with the Rb-Sr age of olivine-bearing basaltic shergottite NWA 1068 (166±37 Ma). However, LAR 06319 is apparently older by 40±15 Ma.

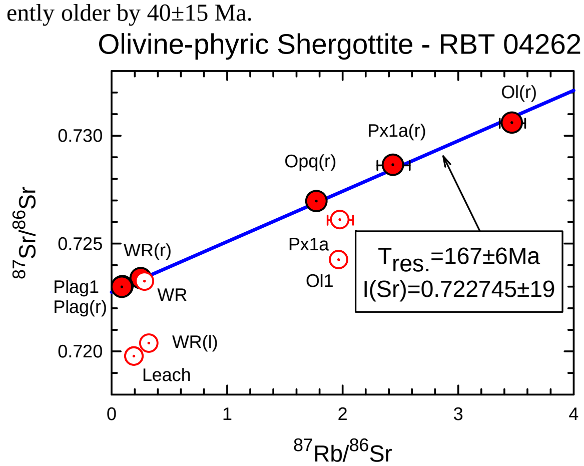

Figure 1. Rb-Sr isochron of RBT 04262.

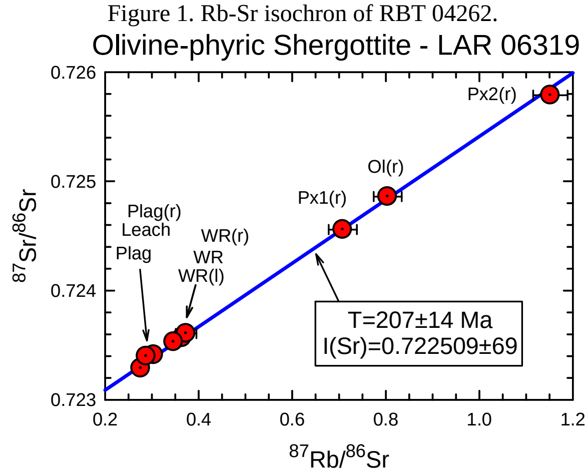

Figure 2. Rb-Sr isochron of LAR 06319.

More importantly, the initial $^{87}Sr/^{86}Sr$ ratios for RBT 04262, LAR 06319 and NWA 1068 are all well within the range (0.7208-0.7228) previously reported for olivine-free basaltic shergottites, but much more radiogenic than those previously known for lherzolitic shergottites (0.7102-0.7105). Thus, the source regions for these three olivine-phyric shergottites are distinctly different from those of previously known lherzolitic shergottites.

Sm-Nd results: Sm-Nd isotopic results for RBT 04262 are shown in Fig. 3. Eleven samples of acid-washed and unwashed bulk rocks, minerals, and acid-leachates form a linear array yielding an age of 174±14 Ma for $\lambda(^{147}Sm)=0.00654\ Ga^{-1}$ and an initial ε_{Nd} =-6.7±0.2 relative to CHUR [7]. This age is in good agreement with the Rb-Sr isochron age, but does not agree with the older Lu-Hf isochron age of 225±21 Ma [8]. The Sm-Nd isochron for LAR 06319 is shown in Fig. 4. A total of nine samples, including acid-washed and unwashed bulk rock, minerals, and acid leachates define an isochron age of 190±26 Ma and an initial ε_{Nd}=-6.9±0.4. The Sm-Nd ages indicate LAR 06319 is older than RBT 04262 by 16±30 Ma. The older age of LAR 06319 is more clearly resolved by the Rb-Sr ages. Again, similarly young Sm-Nd ages (160-200 Ma) are found for three olivine-phyric shergottites, RBT 04262, LAR 06319 and NWA 1068, six olivine-free basaltic shergottites, and four lherzolitic shergottites, but their initial ε_{Nd} values are very different. Previously known lherzolitic shergottites have initial ε_{Nd} values of +8 to +12, while the three olivine-phyric enriched shergottites and six basaltic enriched shergottites have consistently low ε_{Nd} values within the narrow range from -6.2 to -6.9. Two-stage evolution models imply that the former came from source regions depleted in LREE, the latter from LREE-enriched sources.

Initial ε_{Nd} and mg-values of shergottites: Fig. 5 summarizes mg-values and initial ε_{Nd} values calculated at 173 Ma ago for basaltic (circles), olivine-phyric (squares) and lherzolitic (triangles) shergottites. The ε_{Nd} values suggest that these shergottites came from at least three distinct mantle reservoirs. Olivine-free shergottite QUE94201 and olivine-phyric shergottites Dho019, DaG476 and SaU005 were derived from highly LREE-depleted mantle sources with ε_{Nd} values ~+40~+50. Olivine-phyric shergottites NWA 1068, RBT 04262, and LAR 06319 (not shown) along with olivine-free shergottites Shergotty, Zagami and Los Angeles, could have come from an LREE-enriched mantle reservoir with distinct negative initial ε_{Nd} values of ~-6 to -7. The lherzolitic shergottites ALHA 77005, LEW 88516 and Y793605 and olivine-phyric shergottite EETA 79001 lith A (EA) & olivine-free shergottite lith B (EB) could have come from moderately LREE-depleted mantle sources.

Conclusions: The large variations among mg-values found within each shergottite group probably are due to either crystal fractionation or pyroxene- and olivine-accumulation during the crystallization of their respective parental magmas near the Martian surface (see Fig. 5). Our isotopic data are consistent with the formation of olivine-phyric shergottites NWA 1068, RBT 06242 and LAR 06319 by olivine accumulation in an enriched shergottite (Shergotty-type) basaltic magma [3-5]. These olivines were probably early phenocrysts from the magma since their Rb-Sr and Sm-Nd isotopic data are in isotopic equilibrium with other mineral phases. The cosmic-ray exposure ages of NWA 1068, RBT 04262 and LAR 06319 [9] suggest that they were in the close vicinity of Shergotty-type basaltic shergottites when they were ejected from Mars by the same impact.

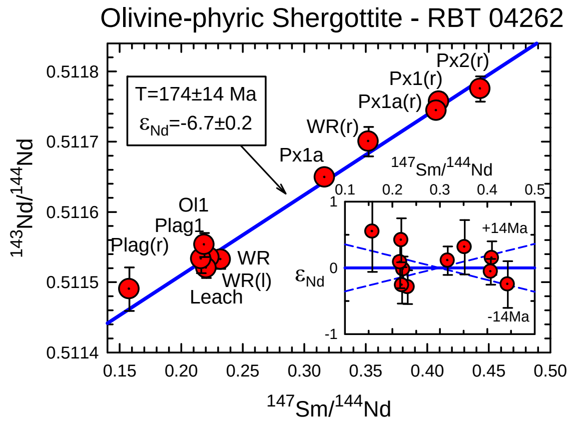

Figure 3. Sm-Nd isochron of RBT 04262.

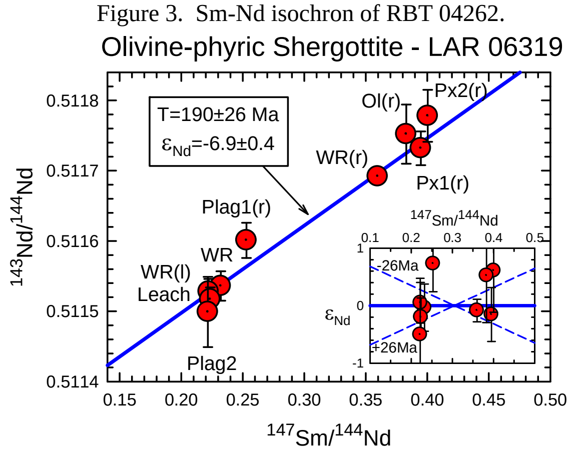

Figure 4. Sm-Nd isochron of LAR 06319.

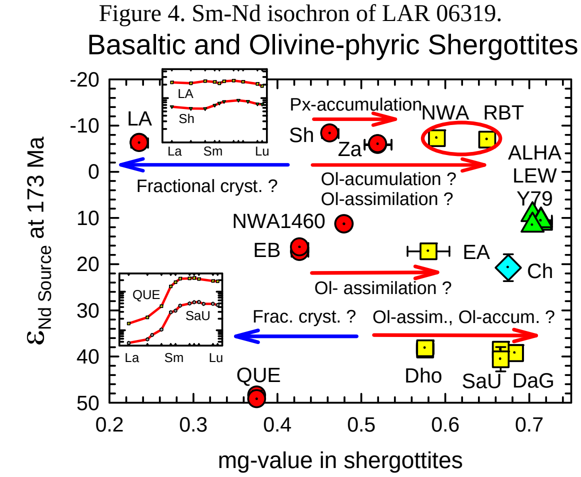

Figure 5. mg- vs. ε_{Nd}-values for Martian meteorites.

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