Uranium-Thorium-Lead Isotope Systematics in Depleted Shergottites: Implications for the Heterogeneous Shergottite Source Mantle

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The parental magmas of shergottites (Martian basalts) reflect geochemical source reservoirs in the Martian mantle. Recent studies have attempted to identify these geochemical source reservoirs based on the Rb-Sr, Sm-Nd and Lu-Hf isotope systematics of shergottites [e.g., 1]. On the other hand, the U-Th-Pb isotope systematics, one of the most diagnostic geochemical tracers for examining the Earth's crust-mantle evolution, has been used to a limited extent for the shergottite petrogenesis. This study determines Pb isotopic compositions and concentrations of U, Th, and Pb in a depleted olivine-phyric shergottite Tissint. The results are used for identification of the origin of depleted shergottite source mantle by combining with dataset from previous studies [e.g., 2]

Tissint has an initial Pb isotopic composition of $^{206}Pb/^{204}Pb$ = 10.819 and $^{208}Pb/^{204}Pb$ = 30.103 at the time of crystallization 574 Ma [3]. A calculated time-integrated κ-value ($^{232}Th/^{238}U$ = 1.2) of Tissint source mantle at 574 Ma is the lowest among the depleted shergottites ($^{232}Th/^{238}U$ = ~4) except for Dar al Gani 476 ($^{232}Th/^{238}U$ = 0.2) [2]. These κ-values are not interpreted to result from either terrestrial weathering or alteration on the Martian surface, but reflect the heterogeneity in the Martian mantle. The geochemical heterogeneity of the depleted shergottite source mantle is also observed by the Nd and Hf isotope systematics [4], which is indicative of garnet fractionation in the deep mantle. An experimental study shows that U, Th and Pb can be fractionated by crystallization of garnet [e.g., 5]. Therefore, we propose that the various κ-values observed in the depleted shergottites would have also reflected different degrees of garnet fractionation during the Martian magma ocean.

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