Re-Os ISOTOPIC CONSTRAINTS ON THE CHEMICAL EVOLUTION AND DIFFERENTIATION OF THE MARTIAN MANTLE

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The ^{187}Re-^{187}Os isotopic systematics of SNC meteorites, thought to be from Mars, provide valuable information regarding the chemical processes that affected the Martian mantle, particularly with regard to the relative abundances of highly siderophile elements (HSE). Previously published data (Birck and Allegre 1994, Brandon et al. 2000), and new data obtained since these studies, indicate that the HSE and Os isotopic composition of the Martian mantle was primarily set in its earliest differentiation history. If so, then these meteorites provide key constraints on the processes that lead to variation in HSE observed in not only Mars, but also Earth, the Moon and other rocky bodies in the Solar System. Processes that likely have an effect on the HSE budgets of terrestrial mantles include core formation, magma ocean crystallization, development of juvenile crust, and the addition of a late veneer. Each of these processes will result in different HSE variation and the isotopic composition of mantle materials and mantle-derived lavas. Two observations on the SNC data to present provide a framework for which to test the importance of each of these processes. First, the concentrations of Re and Os in SNC meteorites indicate that they are derived from a mantle that has similar concentrations to the Earth's mantle. Such an observation is consistent with a model where a chondritic late veneer replenished the Earth and Martian mantles subsequent to core formation on each planet. Alternative models to explain this observation do exist, but will require additional data to test the limitations of each. Second, Re-Os isotopic results from Brandon et al. (2000) and new data presented here, show that initial γ_{Os} correlates with variations in the short-lived systems of ^{182}Hf-^{182}W and ^{146}Sm-^{142}Nd in the SNC meteorites (ε_W and ε_{142Nd}). These systematics require an isolation of mantle reservoirs during the earliest differentiation history of Mars, and subsequent inefficient mixing between these reservoirs. These data show that models for the origin of isotopic variation for SNC meteorites require at least two long-lived mantle reservoirs, and possibly three. The range in the projected present day γ_{Os} of these reservoirs is from -5.4 ± 2.6, to $+4\pm1$. The isotopic systematics of these reservoirs may be linked to development of cumulate crystal piles in a Martian magma ocean and variable amounts of late stage intercumulus melt. In this model, fractional crystallization of olivine and possibly other phases with slightly subchondritic Re/Os, from a solidifying magma ocean, resulted in a lower Re/Os ratio early cumulates, and a resultant low γ_{Os}. Later cumulates or evolved melts crystallized with higher Re/Os ratios to produce the mantle reservoir(s) with consequent higher γ_{Os}. Crystallization of the Martian magma ocean followed earliest core formation, as indicated by the correlation of ε_W with ε_{142Nd} and initial γ_{Os}.

Birck J. L. and Allègre C. L. (1994). *Earth Planet. Sci. Lett.* 124, 139-148.

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