

Nd isotopic constraints on the relative sizes of Martian reservoirs

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There are three known Martian reservoirs that have been deduced from the isotopic analysis of Martian meteorites: (i) a mantle source region for the shergottites; (ii) a mantle source region for the nakhlites and chassignites; and (iii) an enriched reservoir that is presumed to be crust. From the analysis of the most LREE-depleted shergottites (e.g., QUE94201), the shergottite mantle must have a present-day $\epsilon(^{143}\text{Nd})$ of about +50 [1]. Extrapolations of measured nakhlite source regions from 1.3 b.y. to the present indicate that this mantle has an $\epsilon(^{143}\text{Nd})$ of about +20 [2]. Calculations by Longhi [3] yield a crustal $\epsilon(^{143}\text{Nd})$ of about -20. On the assumption that (i) bulk silicate Mars (BSM) has an $\epsilon(^{143}\text{Nd})$ of zero and that (ii) these three reservoirs are the only ones of importance, Nd mass balance calculations tightly constrain how much Nd resides in the enriched crust. The relative proportions of the nakhlite and shergottite mantles are largely unconstrained.

Following Norman [4], I initially assumed that 50% of Martian Nd was sequestered in the crust. As it turns out, this is the *minimum* amount of Nd that can be in the crust. Lower concentrations of crustal Nd result in non-physical solutions for the mass balance equation. For this endmember solution, the remaining Nd resides in the nakhlite mantle and any Nd in the shergottite mantle is negligible.

Non-physical solutions also arise for models where more than 71% of Martian Nd is in the crust. Therefore, the amount of Nd in the crust is rather tightly constrained to be $60\pm 10\%$ of BSM. For this endmember solution, the remaining Nd is in the shergottite mantle and any Nd in the nakhlite mantle is negligible.

Because mass-balance solutions exist where both the nakhlite and shergottite sources range from dominant to negligible, the volumes of these sources are totally unconstrained. However, if concentrations of Nd in these mantle reservoirs were known [e.g., 5], then their mass fractions and volumes could be calculated.

Because Nd is more compatible than most heat producing elements, $>60\%$ of these elements (U, Th, K) should also be in the crust.

[1] Borg *et al.* (1997) *GCA* **61**, 4915-4913. [2] Jones J.H. (1989) *Proc. Lunar Planet. Sci. Conf. 19th*, 465-474. [3] Longhi J. (1991) *Proc. Lunar Planet. Sci. Conf. 21st*, 695-709. [4] Norman M.D. (1999) **34**, 439-449. [5] Jones J.H. (2003) *MAPS* **38**, 1807-1814.

Reactive gases and inert gas tracers in vadose zone environmental applications

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Reactive gas transport in the vadose zone significantly affects the attenuation of organic contaminants and mineral weathering in mine waste. For example, sulfide mineral oxidation in waste rock piles may be limited by the ingress of atmospheric O₂, while weathering of carbonate minerals contained in the waste rock releases CO₂. At sites contaminated with petroleum hydrocarbons, aerobic degradation yields to the consumption of O₂, while degradation under methanogenic conditions will produce CH₄ and CO₂. The production and consumption of gases drives transport of both reactive and non-reactive gases and profoundly alters the gas composition in the vadose zone. In this presentation, we evaluate the use of gas analysis by chromatography and mass spectrometry to characterize interactions between transport and reaction processes and to delineate weathering and contaminant attenuation rates in the vadose zone. Data for this analysis was obtained from experimental waste rock piles at the Antamina mine, Peru and a crude oil spill site near Bemidji, MN. Reactive gases such as O₂, CO₂, CH₄, and noble gases with an emphasis on Ar are considered. It can be shown that accumulation or depletion of inert gases relative to atmospheric conditions can be correlated to zones of gas production and consumption and can be used as an indicator for advective gas transport. Multi-component gas transport was implemented into a reactive transport code and this model is used to quantify reaction-induced fluxes of both reactive and inert gases.