VOLATILES IN SNC PETROGENESIS: A SR SIGNAL? J. Longhi, Lamont-Doherty Geological Observatory, Palisades, NY 10964

A recent experimental study (1) has confirmed a significant concentration of H2O (-1 wt%) in the parent magma of Chassigny. This work was based upon the presence of a hydrous amphibole in a silicate melt inclusion and suggests that similar inclusions in Shergotty (2) record significant magmatic H2O concentrations as well. Speculations on the unusually high normative wollastonite component (high Ca/Al) calculated for the Nakhl parent magma (3,4) point to a role for CO2 as well in the genesis of the nakhlite magmas (4,5). It should be instructive, therefore, to compare the compositions of the SNC parent magmas with basaltic rocks from other planets to see if there are any similarities between the SNC magmas and those for whom fluids play an important petrogenetic role. A previous survey of the non-volatile incompatible element patterns of eucritic, lunar, and terrestrial basalts showed that the SNC had patterns of rare earth (REE) and high-field strength (HFSE) element abundances distinct from any other common solar system basalts, but sharing some interesting parallels with volcanic rocks from terrestrial convergent plate margins (5), for which a petrogenetic role for fluids is generally accepted. One element omitted from that study that does have a significant susceptibility to fluid transport is Sr. So the present work attempts to fill in that gap.

Fig. 1 illustrates the measured (6) and calculated (5,7) concentrations of the non-volatile incompatible elements in the SNC parent magmas plotted in order of decreasing incompatibility (left to right). The order is taken from (8). Previous work pointed out the generally reciprocal patterns of the Nakhl and 79001A patterns both in terms of REE and HFSE. Unlike the Antarctic shergottite, 79001A, the Shergotty parent is only weakly depleted in the light REE, but nevertheless has positive anomalies of the HFSE. The similarity of the major element compositions of Shergotty and 79001A (5), coupled with differences in the light REE and Nd-isotope ratios (9), suggest a crustal(?) assimilation event for Shergotty (5,9). There is a prominent positive Sr anomaly for 79001A relative to the adjacent REE; this pattern is based on a direct chemical analysis (6) and is, therefore, presumably real. The calculated Shergotty pattern shows a negligible Sr anomaly. The Nakhl pattern has either a positive or negative Sr anomaly depending on the type of calculation: the 50 ICM pattern is calculated from the bulk rock composition and an inferred amount of trapped intercumulus liquid (5); the Px pattern is calculated directly from the composition of a separate of augite cores (10). The ICM calculation presumes that the rock solidified as a closed system; the Px calculation presumes that the separate is pure. In situ measurements of Sr in the augite cores need to be made, but given that plagioclase was a late crystallizing phase in Nakhl (3), the Px calculation seems less likely to be in error. Therefore, a small positive Sr anomaly is inferred for the Nakhl parent magma.

Examination of the incompatible element patterns (including Sr) of solar system basalts in whose petrogenesis volatiles play a minor or negligible role (lunar, eucritic, MORB, basaltic komatiites, continental flood basalts) shows that there are prominent Sr anomalies only for lunar basalts (Fig. 2) and these anomalies are paralleled by Eu anomalies indicating remelting of a source region depleted by the formation of an early plagioclase-rich crust (e.g., 11). Juvinas lacks a Sr anomaly (Fig. 2), as do common depleted (MORB I) and enriched (MORB II) mid-ocean ridge basalts (Fig. 3a) and typical basaltic komatiites (BK II, also Fig. 3a). The most typical flood basalts (FB D[ecan], Fig. 3b) show weak Sr anomalies, but the prominent HFSE/REE fractionations of the SNC. Prominent Ta-Nb anomalies are present in the less common picrites associated with flood basalts, but not the strong Hf-Zr anomalies characteristic of the SNC. Strong positive Sr anomalies are common in ocean island basalts (OIB, Fig. 3a), in island arc basalts (IAB, Fig. 3c), boninites (BN, Fig. 3c), and high-Al basalts (HAB, Fig. 3c). These anomalies are present even in aphyric lavas (e.g., 12). Fluids may play a role in the low degrees of melting typically inferred for OIB petrogenesis (13), however, these lavas do not have the strong Hf-Zr anomalies of the SNC. On the other hand not only do the convergent margin lavas have strong Hf-Zr anomalies, but these anomalies are both positive and negative with the positive anomalies being found in rocks with lower REE concentrations and negative Hf-Zr anomalies in rocks with higher REE. The analogy between the SNC and convergent plate margin lavas breaks down when the Ta-Nb anomalies are considered (compare Figs. 1 and 3c), however, we should expect an exact analogy because there is no evidence of plate tectonics on Mars. Nonetheless the variations in the concentrations of REE, HFSE, and Sr in convergent margin lavas are frequently attributed to fluid transport, with Sr being more mobile than the REE, which in turn are more mobile than the HFSE. Although the planet-wide differentiation on Mars is certain to be different than that observed in terrestrial convergent plate margins, it seems worthwhile to anticipate an important role for fluids in martian petrogenesis.

REFERENCES