Volatility trends of the inner planets revealed by Ge/Si and Zn/Mn variations in solar system materials

V. LE ROUX AND C.-T.A. LEE

Department of Earth Sciences, Rice University, MS-126, 6100 Main Street, Houston, TX, 77005, USA

The goal of this study is to constrain the origin of volatility trends observed in planetary materials. Planetary evolution includes various processes like early volatile loss, core segregation and silicate differentiation that redistribute the volatile elements in the planet. It is thus necessary to consider geochemical indices able to discriminate between these processes. Here we propose that Ge/Si and Zn/Mn ratios, because of their consistency during silicate differentiation processes, may be reliable candidates as tracers for volatility trends. Ge is a siderophile element, but is also known to substitute for Si in silicates. Importantly, during volatilization, Ge's moderately volatile nature causes it to fractionate from Si. Similarly, Zn is a lithophile, highly volatile element likely to fractionate from Mn (moderately volatile) during volatilization.

Here we provide new LA-ICPMS measurements of Ge concentrations in olivine (~0.6 ppm), pyroxenes (~1.3 ppm) and garnet (~2 ppm) in various mantle peridotites. Ge/Si and Zn/Mn ratios show a narrow range of variations in Earth mantle minerals suggesting that primary silicate differentiation processes cannot account for the whole range of Ge/Si vs Zn/Mn variations observed in solar system materials. On the other hand, Ge/Si vs Zn/Mn ratios display a well-defined positive correlation throughout the whole range of solar system materials, ranging from low Ge/Si – Zn/Mn ratios in HED meteorites to high Ge/Si – Zn/Mn ratios in chondrites. Assuming that these variations, to first order, are not related to differentiation processes and that Zn is not siderophile, the Ge/Si vs Zn/Mn positive correlation observed in solar system materials could be related to early volatile loss. However, Ge sequestration in planetary cores may affect the overall trend.

These preliminary results show, as expected, that small achondrites parent bodies are the most volatile-depleted while Earth and Mars show intermediate depletions. However, Ge/Si and Zn/Mn of Earth mantle, SNC meteorites (Mars) and Lunar meteorites with the highest Zn/Mn-Ge/Si are suprisingly similar. This suggests that for the large rocky planets, there is no obvious correlation between degree of volatilization and size and that thick atmospheres may have been important on some planetary bodies in their earliest histories.

Uranium partitioning to nanoparticulate phases: Measurements with Fl FFF-ICP-MS

EMILY K. LESHER*, JAMES F. RANVILLE AND BRUCE D. HONEYMAN

Colorado School of Mines, Golden, CO 80401 (*correspondence: elesher@mines.edu)

Flow field flow fractionation (Fl FFF) hyphenated with inductively coupled plasma-mass spectrometry (ICP-MS) is shown to quantitatively measure partitioning of uranium to nanoparticulate hematite and natural organic matter. Nanoparticles, engineered and naturally occurring, can bind metals and radionuclides in aqueous systems through surface complexation reactions. Particles in this size range have often been classified as 'dissolved,' due to their ability to pass through a filter. In reality, the nanoparticulate phase may act very differently from the dissolved phase, and because of high specific surface area, may significantly contribute to metal transport.

As an analytical tool Fl FFF-ICP-MS is flexible: during a single run it can separate particles within a 10-20 fold size range. By varying flow rates and operating conditions, the absolute separation range is a few nm to approximately 10 μm. A general approach to optimizing the method will be discussed.

Initial results indicate that Fl FFF-ICP-MS can separate nanoparticulate phases and quantify uranium adsorption. In simple systems, the method was run in parallel to traditional methods of separation and measurement, and pH dependent sorption edges created and compared. Close agreement was found.

The method is promising for use in transport studies because it requires little volume, maintains sample integrity, and is able to separate polydisperse nanoparticulate mixtures. Detection limits and relevance to environmental systems will be discussed.