Using Stable Isotopes to Probe the Differentiation and Evolution of Planetesimals

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As increasing knowledge points to the Earth and other terrestrial bodies being formed from already differentiated planetesimals it is essential that we understand what these planetesimals looked like in order to fully understand how the Earth and other terrestrial planets formed.

A wide range of non-traditional stable isotope systems have been measured in differentiated materials from our solar system. Each study begins with measurements to establish a chondritic reference frame, the starting isotopic ratio for the element of interest. Next, the isotopic ratios are measured in natural samples or experiments. Then an argument is made about the physical and chemical conditions that existed on the planetesimal that the stable isotopes are tracing. In many of these cases, there is still considerable debate over interpretation of the data and/or if the isotope variations are definitively linked to planetary differentiation/evolution processes.

To fully understand how stable isotopes can probe planetary differentiation and evolution, we have conducted experiments in a 1 atmosphere furnace, piston cylinder press, and diamond anvil cells, calculated theoretical fractionation factors, analyzed meteorite samples, and calculated the effects of volatilization on isotope ratios. We have begun by focusing on the major elements: Fe, Mg and Si. Our experimental results and calculations suggest that there is an isotopic fractionation factor associated with equilibrium metal-silicate fractionation, with evaporation from the surface of a molten planetesimal, as well as with the crystallization of a metallic body.

This talk will focus on how stable isotope ratios can inform us about the differentiation and evolution of planetesimals. There are many processes which will fractionate stable isotopes so it is imperative that experiments be conducted to determine fractionation factors at a range of conditions applicable to planetary formation scenarios. By conducting experiments, analyzing natural samples, and then modeling the results, we can begin to unravel the conditions under which these bodies evolved.