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Combining Theory, Experiment, and Natural Samples to Understand the Evolution of Iron Stable Isotopes Throughout Planetary Evolution

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The stable isotopes of heavy elements can be used to trace the accretion, differentiation and evolution of terrestrial planets. There are many processes which will fractionate stable isotopes throughout the evolution of a planet so it is imperative to consider all possible mechanisms including: core formation, evaporation, melting/crystallization, as well as low temperature processes on the surface. The combination of experiments, theory, and analysis of natural samples is particularly powerful in understanding the isotopic ratios measured. Iron is a ubiquitous element in terrestrial and extra-terrestrial settings as well as an element with multiple oxidation states, making it particularly interesting to trace processes occurring at varying conditions during a planet's evolution. In this presentation, we will focus on iron isotopes and their evolution throughout the several billion-year history of a planet from core formation to evaporation on planetesimals, to partial melting, and finally to recycling during subduction.

Here we present the results of several recent studies aimed at understanding how the iron isotopic ratio of the silicate mantle of the Earth has evolved throughout history. Pyrolitic samples formed by a laser levitation furnace at varying oxygen fugacity conditions have been probed by NRIXS at APS. Natural mantle minerals have also been analyzed by NRIXS to investigate their equilibrium fractionation factors. Evaporation modeling was conducted to determine if any iron isotopic fractionation could occur early in solar system history. And lastly, metallic inclusions in superdeep diamonds were analyzed for their iron isotopic ratios. By combining theoretical, experimental and natural data, we will discuss how iron isotopes can be used to trace processes occurring throughout planetary evolution.