Isotope Fractionation in High Pressure and Temperature Experiments

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There has been enormous progress in the non-traditional stable isotope community in the past 15 years. Natural samples from almost every setting imaginable have been analysed, along with extra-terrestrial samples, biological samples, and experiments. An ever-increasing database has emerged. However, what is missing is a more systematic understanding of how and why these seen fractionations are formed. Experiments are key to understanding the mechansims behind the fractionations seen in nature and calculated in models. While the experiments are technically challenging as equilibrium and kinetic processes are hard to disentangle in such small samples, an enormous amount has been learned in the past few years. To date, experiments have been conducted to probe the Fe, Si, Mo, Mg, S, Ni, C, V and Ag isotope systems. While some of the results are contradictory, it is clear that stable isotopes can and do fractionate at high pressure and temperature and that experiments are central to figuring out why.

In this study, we aim to study the mechanisms responsible for Fe stable isotope fractionation at high pressure and temperature in order to understand more about the formation of the Earth and its differentiation. The motivation for this work is two-fold. Fundamentally, it is important to understand what mechanisms are responsible for the iron isotope fractionations found in nature. On the other hand, we will also be able to start to systematically independently determine the identity of the light elements in the core and the physical conditions and mechanisms of Earth's differentiation.

All of our experiments are conducted in a piston cyinder apparatus at temperatures ranging between 1600 – 1900°C and utilize the three-isotope technique as a means of demonstrating equilibrium conditions. Our new data present evidence that the composition of the metallic alloy influences the iron isotope fractionation between metal and silicate in the Fe - C, Si or S system. This result implies that the amount of light elements in a core should influence the extent of equilibrium iron isotope fractionation measured in samples of the mantle. We also present experimental evidence for the fractionation between olivine and metal in order to better understand the formation and thermal history of pallasite meteorites.