Iron isotopes as tracers of core composition

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Iron isotopes have the potential to provide information on high pressure and temperature processes that occurred on Earth and other planetary bodies. In the past two decades, natural samples have been analysed for their iron isotopic ratios, along with extra-terrestrial samples and biological samples, and an ever-increasing database has emerged. However, what is missing is a more methodical 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 as the pressure, temperature and compositional space can be interrogated systematically.

In this study we present how pressure, temperature and composition affect the partitioning of iron isotopes between metal and silicate. In particular we focus on whether high pressure experiments can explain the enrichment found in basalts on Earth and if the light element in the core has left a fingerprint on the iron isotopic ratios in the mantle.

We report new high presure ^{57}Fe NRIXS spectra obtained at beamline 16 ID-D (HPCAT) of the Advanced Photon Source, in order to better understand the effect that pressure has on iron isotope fractionation. We conducted experiments in a panaromic-type diamond anvil cell using 100% ^{57}Fe enriched samples. NRIXS spectra were collected by tuning the x-ray energy range within ± 120 meV around the ^{57}Fe nuclear transition energy. We will present the force constants and calculated beta factors for Fe in FeO, Fe_3C and FeH_x. We find that extreme pressure conditions do in fact have an effect on the iron isotope fractionation factors and should be considered in models used to understand planetary scale iron isotope ratios.

We will also present work conducted in the piston cylinder apparatus at 1 GPa focusing on how temperature and composition affect iron isotopic ratios. Our new data demonstrate 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.

Our goal is to build up enough of a database so as to be able to independently determine the identity of the light elements in the core and the physical conditions and mechanisms of Earth's differentiation.