Metal-silicate isotope fractionation experiments to constrain planetesimals differentiation

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Planetesimals are small objects (10 to 1000 km in size) that accreted early in the history of the solar system and show a wide variety of thermal histories, ranging from simple metamorphism to complete metal-silicate differentiation. Moreover, stable isotope compositions of siderophile elements, e.g. Fe, Ni, and W in meteorites spread over a range that can be explained by fractionation related to the process of core-mantle segregation. The present experimental study aims at determining metal-silicate isotope fractionation of these three elements at temperature and oxygen fugacity conditions relevant to planetesimals.

Different types of experiments have been performed in order to quantify kinetic and equilibrium fractionation factors between metal and silicate. For Ni and Fe, experiments have been run in a gas-mixing vertical furnace under different conditions of temperature (1300-1600°C) and oxygen fugacity (IW+2 to IW-2). For W, sealed quartz tubes have been used, under oxidizing conditions, to avoid W loss by volatility. After experiments, phases were mechanically separated, the element of interest was separated and purified using column chromatography, and isotopes analysed using a high resolution MC-ICP-MS.

Results show evidence of strong kinetic fractionation during the first annealing times with a faster diffusion of the lightest isotopes. At equilibrium, no significant fractionation of neither Ni nor Fe has been observed. Overall, our experimental results are in agreement with previous stable Fe and Ni isotope results obtained on meteorites.