

Iron isotope systematics of the lithospheric mantle investigated by a magnesiochromite inclusion in diamond

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Iron isotopes are a powerful geochemical tool that can be used to elucidate processes controlling the formation and evolution of terrestrial planets, including core-formation and magmatic chemical differentiation. Previous studies have attempted to constrain the Fe isotopic composition of the Earth mantle, mainly focusing on mantle xenoliths or basaltic melts that form in different geodynamic settings and mantle environments. However, such specimens, particularly mantle xenoliths, show large variations in Fe isotopic signatures, which has been attributed to variable genesis conditions (such as different sources, pressures, temperatures and/or oxygen fugacity conditions), partial melting or alteration by metasomatic agents. Mineral inclusions in diamonds represent a robust alternative to mantle xenoliths as inclusions sampled from the deep mantle are protected from secondary alteration by their physically robust and chemically inert diamond hosts.

The aim of this study is to shed light on the Fe isotopic composition of the lithospheric mantle by investigating, for the first time, the Fe isotopic composition of a magnesiochromite inclusion in a diamond from the Panda kimberlite (Ekati Mine, Northwest Territories, Canada). Magnesiochromite is a common inclusion in natural diamonds and X-ray diffraction and Fourier Transform Infrared spectroscopic analyses of the inclusion and the diamond host, respectively, suggest a lithospheric origin. After preliminary analysis, the magnesiochromite inclusion was extracted and the major, minor and trace element composition was determined. Finally, most of the inclusion was digested to isolate Fe and determine its isotopic composition using novel multicollector inductively coupled plasma mass spectrometry protocols developed to measure the Fe isotopic composition of very small amounts of material (few μg), typical of inclusions in diamonds.

These unprecedented results will be framed in the context of lithospheric mantle Fe isotopic variation observed particularly in mantle xenoliths. Fractionation models will be discussed to investigate the role of partial melting and inter-mineral isotopic exchange to explain the Fe isotopic composition of the magnesiochromite inclusion in diamond.