Metamorphism of the Solar System's Earliest Metals

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Context

Isotopes within ancient meteorites offer a powerful tool to study whether the early Solar System incorporated products of stellar nucleosynthesis ejected from nearby stars during the early stages of the solar nebula, or if these materials were derived in equilibrium with the galactic background[1]. Carbonaceous chondrites contain abundant Fe-Ni metals, which are thought to be direct condensates from the primitive solar nebula. Two subcategories of carbonaceous chondrites, the CH- and CB-carbonaceous chondrites, contain a particularly high abundance of these metals. Furthermore, while the Fe-Ni metals within the CB-chondrites appear homogenous within the resolution of electron microprobe, metals within CH-chondrites are strongly zoned[2]. This difference in zoning, coupled with major element chemistry and the fact that metals within CB-chondrites are approximately 6 million years younger than those within CH-chondrites, has been suggested to reflect a widespread metasomatic event on the CB-parent body, while metals within the CH-chondrites remain pristine condensates from the primitive solar nebula. Using both local electrode atom probe tomography and secondary ion mass spectrometry, it should be possible view details of the isotopic distribution of Fe and Ni isotopes within these metals that have not been accessible in the past. Such a high-resolution study of isotopes within these metals may shed light on the processes responsible for these observations[3].

Objectives and Methods

Analysis of metals from CH- and CB- chondrites by both local electrode atom probe tomography and secondary ion mass spectrometry will be used to study the processes responsible for isotopic distributions within these samples. This will involve several days working on the secondary ion mass spectrometer at UNIL, and a week or two working on the atom probe at ETH Zürich. Samples have already been acquired, and funding for the machine time has been secured. This project will suit a student who is interested in igneous and metamorphic petrology, isotope geochemistry and planetary petrology. Interpretation of the results may require some mathematical modeling, so a desire to learn the modeling side of petrology would be advantageous.

Literature

[1]Tang, H., Dauphas, N. (2012) Abundance, distribution, and origin of 60Fe in the solar protoplanetary disc. Earth Planet. Sci. Lett. 359-360, 248-263.
[2]Petaev, M., Wood, J., Meibom, A. (2001) The condensation origin of zoned metal grains in Queen Alexandra Range 94411: Implications for the formation of the Bencubbin-like chondrites. Met. Planet. Sci. 36, 93-106.
[3]Sio, C.K.I., Dauphas, N. (2016) Thermal and crystallization histories of magmatic bodies by Monte Carlo inversion of Mg-Fe isotopic profiles in olivine. Geology G38056-1.

Choice of orientation :

2) GATO