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Nanoscale analysis of siderites: insights into the low temperature FeNi phase diagram

FREDERIC DANOIX[1], RAPHAELE DANOIX[2], FABIEN CUVILLY[2], JÉRÔME GATTACCECA[3], CLARA MAUREL[4], MATHIEU ROSKOSZ[5] AND MATTHIEU GOUNELLE[6]

[1]CNRS - GPM - UMR 6634
[2]GPM
[3]CNRS, Aix-Marseille Univ, IRD, INRAE, CEREGE
[4]CEREGE, UMR 7330
[5]Muséum National d'Histoire Naturelle
[6]Muséum national d'histoire naturelle

Presenting Author: frederic.danoix@univ-rouen.fr

Metal matrix in siderites are iron based alloys containing up to 35at%Ni as well as other minor elements such as Co and P, at levels lower than 1at%, the microstructure of which keeps records of their thermal and mechanical history. The initial alloy was once melted in planetesimal cores before exhumation during catastrophic disruption of the parent body. These samples are arguably the closest natural analogues of alloys making up planetary cores (pressure effects left behind). In this respect, they are frequently used to better apprehend element partitioning during metal-silicate differentiation. However, during cooling down of the parent body, it solidified as FCC taenite, and underwent several solid-state transformations that may modify the distribution of minor, trace and volatile elements trapped in the initial alloy. When the Ni content is lower than about 12at%, the first, and main, transformation is the precipitation of Widmanstätten kamacite from taenite, developing the iconic microstructures of octahedrites [1]. As it develops, kamacite rejects nickel towards taenite, creating a Ni composition gradient that extends over several hundred microns, from more than 50% Ni at the interface with the kamacite, down to the initial Ni content. This naturally graded material makes it possible to explore the Fe rich part of the low temperature FeNi phase diagram [2].

In this work, we used cutting edge nanometer scale microscopies: atom probe tomography (APT), electron backscattered diffraction (EBSD) and transmission Kikushi diffraction (TKD) on focused ion beam (FIB) lift outs to investigate the compositional and microstructural features of this gradient material. The fine scale complexity of the final microstructures revealed in octaedrites and ataxites is discussed in the framework of the FeNi phase diagram. Of particular interest is the low temperature (» 300°C) FeNi spinodal domain, and tetrataenite, the $L1_0$ ordered form of equiatomic FeNi taenite, an attractive natural mineral with remarkable magnetic properties. The distribution of minor and volatile elements within these low-temperature phases will also be discussed.

References:

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