MICROSCALE TO NANOSCALE ANALYSIS OF Ni-RICH IRON METEORITES.

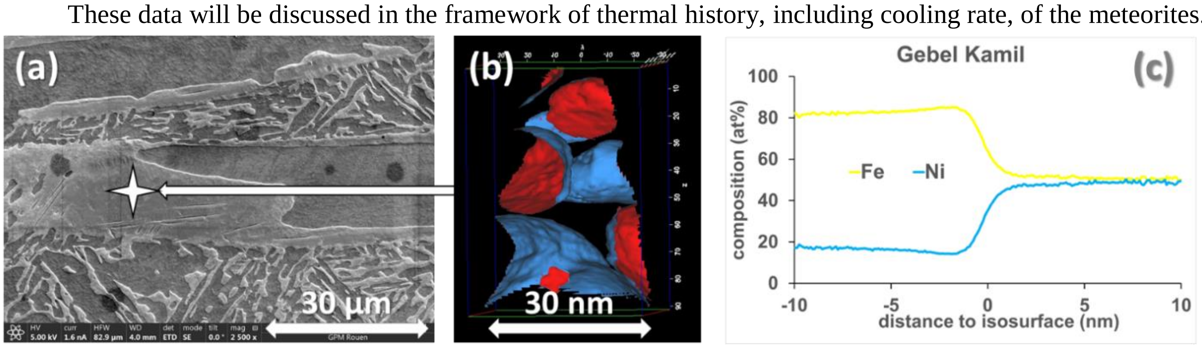
F. Danoix[1], R. Danoix[1], F. Cuvilly[1] , J. Gattacceca[2], C. Maurel[2], B. Devouard[2], M. Roskosz[3] and M. Gounelle[3], [1]Groupe de Physique des Matériaux – UMR CNRS 6634 – Faculté des Sciences de Rouen - Avenue de l'Université – 76801 Saint Etienne du Rouvray Cedex – France – frederic.danoix@univ-rouen.fr. [2]CEREGE, Technopole Environnement Arbois-Méditerranée BP80 - 13545 Aix en Provence Cedex 04 – France. [3]Institut de Minéralogie - Physique des Matériaux et Cosmochimie - Muséum National d'Histoire Naturelle - CP 52 - 57 rue Cuvier -75231 Paris Cedex 05 France..

Introduction: Since the pioneering work of Goldstein and Williams (e.g.,[1,2]) and Miller (e.g., [3,4]), very few investigations of the nanoscale structure of iron meteorites have been conducted. The most recent studies were conducted on selected moderately- to highly-Ni-enriched meteorites, and focused on the strongly-magnetic phase tetratenite (namely Bristol IVA, fine octaedrite by Rout et al [5], Tazewell IAB sLH fine octaedrite by Einsle et al [6], NWA 6259 Iron Ungr. ataxite by Kovacs et al [7]).

In this work, we propose a detailed survey of the microstructures found in a series of iron meteorites, conducted down to the nanometer scale. The objective is to shed light on the thermal histories of these Ni rich iron meteorites and the formation mechanisms of the different microsctructures. We selected ungrouped iron ataxites (Dronino, Gebel Kamil, Chinga, NWA 6259 and NWA 859), as well as a IVB ataxite (NWA 12769). We characterized the structure of these sample using optical microscopy, scanning electron microscopy (SEM) combined with electron backscattered diffraction (EBSD) and transmission Kikuchi diffraction (TKD). We also analyzed quantitatively their chemical composition using energy-dispersice X-ray spectroscopy (EDS) and atom probe tomography (APT). All chemical and structural analyses were therefore conducetd with resolution down to the nm scale.

The main minerals of these meteorites, apart from mm-size sulphide and phosphide inclusions, are a mixture of face centered cubic (FCC) and body centered cubic (BCC) phases, themselves containing various microstructures, with typical length scales varying from µm to nm. The vast majority of the FCC phases have original taenite orientation, and can thus be considered as retained taenite. Their composition varies from 10 to 50 at.% Ni, with the most Ni-rich phase likely corresponding to tetrateanite, showing an ordered $L1_0$ long range order superstructure responsible for its outstanding magnetic properties. On the other hand, BCC regions are shown to be either kamacite or martensite, with Ni content systematically < 7 at.%, reaching down to 3 at.%. Martensite is very similar to the so called 'plate martensite', common in steels that have martensite start temperatures below room temperature. Some FCC precipitates with different orientations have also been observed in the kamacite/martensite, and are the result of the reversed-precipitation in Ni supersaturated BCC phase.

These data will be discussed in the framework of thermal history, including cooling rate, of the meteorites.



Microstructure of the Gebel Kamil meteorite: (a) SEM view showing FCC (taenite and/or tetrataenite) in light grey and BCC ((kamacite and/or martensite) in dark grey (b) APT reconstruction within the teanite region highlighted by a star. Isosurfaces delineating regions containing exactly 30at%Ni: inside the red (resp blue) region, Ni content is higher (resp. lower than 30at% (c) Iron and Nickel variations across the isosurface from Fe enriched taenite matrix to Ni enriched tetrataenite (from left to right)

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