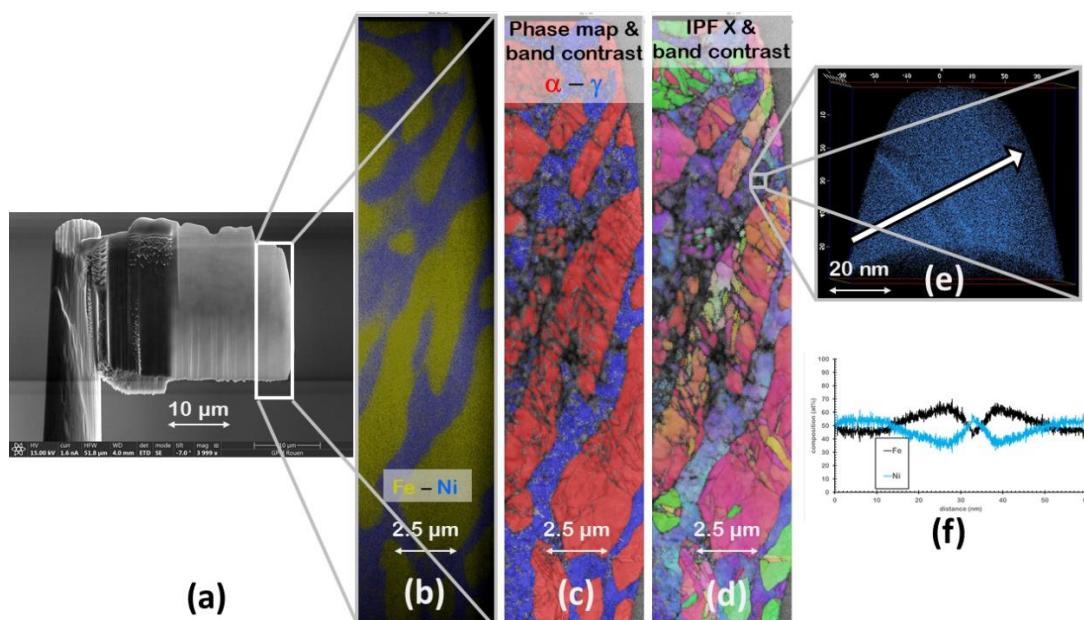


NANOSTRUCTURE AND NANO-CHEMISTRY OF SELECTED IRON METEORITES OBSERVED AT THE NANOMETRIC SCALE

F. Danoix¹, E. Cadel¹, F. Cuvilly¹, R. Danoix¹, M. Gounelle², L. Kern², M. Roskosz², ¹Groupe de Physique des Matériaux, UMR CNRS 6634, Faculté des Sciences de Rouen, Avenue de l'Université, F-76801 Saint Etienne du Rouvray, France (frederic.danoix@univ-rouen.fr), ²Institut de Minéralogie, Physique des Matériaux et Cosmochimie, Muséum National d'Histoire Naturelle, CP 52, 57 rue Cuvier, F-75231 Paris Cedex 05, France.

Introduction: Ataxite refers to iron meteorites that do not show any obvious structural feature when observed by naked eyes, even after etching. However, it is recognized that after microscopic investigation, they often exhibit a dual phase microstructure, mostly consisting of micrometer size intermixed kamacite and taenite domains, with some schreibersite inclusions. In this work, we report an investigation of these domains at an even smaller scale, namely the nanometric scale, using the latest generation of microscopes, including scanning electron microscope (SEM) equipped with Plasma Focussed Ion Beam (PFIB) and Energy Dispersive Spectroscopy (EDS)/Electron BackScattered Diffraction (EBSD) and Transmission Kikuchi Diffraction (TKD), combined with Atom Probe Tomography (APT). To illustrate the potential of such a correlative microscopy approach, we investigated selected Ni rich ataxites (Chinga and Gebel Kamil in this work), where the combination of structural and chemical characterization down to the nanometric scale provides unrevealed information related to the intimate nanostructure of both kamacite and taenite, which are shown to be everything but homogeneous at this scale. It is obvious that these original observations will bring new elements to better understand their thermo-mechanical history, which to our knowledge, hasn't yet been investigated.

The analytical capabilities of APT offers unique unique opportunities for the analysis of meteorites, as shown in [1][2]. Recent developments in detection systems open new possibilities for local isotopic analysis applied to cosmochemistry, and when used in combination with Secondary Ions Mass Spectrometry, will greatly contribute to increase our knowledge of the origin and formation mechanisms of stony and iron meteorites.



Micro to nanostructure of Gebel Kamil ataxite: (a) thin foil extracted by PFIB lift out – (b) EDS chemical map exhibiting the mixture of Ni and Fe rich domains - (c) TKD phase map showing α -bcc-kamacite in red and γ -fcc-taenite in blue (note that taenite corresponds to Ni rich domains in (b) – (d) TKD inverse pole figure showing the sub structure of both kamacite and taenite - (e) APT reconstruction of a small volume of taenite, showing a nanometric internal defect (note that only Ni atoms are represented) – (f) APT concentration profile showing the Fe and Ni composition variations across this planar defect, along the white arrow in (e) (note that taenite contains approx. 50at%Fe and 50at%Ni, indicating that it is most likely $L1_0$ ordered tetraetaenite)

References: [1] Rout S.S., Heck P.R., Isheim D., Stephan T., Zaluzec N.J., Miller D.J., Davis A.M., Seidman D.N. (2017) *Meteoritics and Planetary Science* 52:1707-2729, [2] Einsle J.F., Eggeman A.S., Martineau B.H. Saghi Z., Collins S.M. Blukis R., Bagot P.A.J., Midgley P.A. and Harrison R.J. (2018) *PNAS* 115-49:E11436-E11445