Atom probe tomography: (almost) ideal tool for the investigation of nanometer scale composition heterogeneities in (geological) materials

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Atom probe tomography (APT) is an analytical microscopy, allowing sub nanometer scale investigation of composition heterogeneities in material. It initially derived from the combination of a field ion microscope – the first ever microscope to image individual atoms – with a time of flight (ToF) mass spectrometer. The outcome of the latest generation of instruments is an atomic scale 3D reconstruction of a sub-volume of the analyzed material (typically 50x50x500 nm^3) located at the apex of a sharply pointed needle tip. With a detection efficiency reaching 80%, several tens, or even hundreds, of millions of atoms are chemically identified by their ToFs, with a mass resolution $m/\Delta m \approx 1000$. As the detection efficiency is the same for all chemical species from hydrogen to actinides, the analysis is quantitative, without prior calibration, and sensitivity can reach several ppm.
For physical reasons, the technique has long been restricted to conductive materials, almost exclusively metals. But at the turn of the century, the development of femto-second laser pulsing allowed its extension to semi-conductors and insulators. It is only in the last decade that its potential for geological materials has been recognized, and that seminal experiments made it essential when a combination of both elemental (or even isotopic) sensitivity and spatial resolution are required.
The preparation of non-conductive specimens suitable for APT analysis was only made possible by the concomitant development focused ion beams (FIBs) columns and lift out techniques in scanning electron microscopes, allowing positioning the region of interest within the extreme apex region of APT tips.
It is clear that the combined use of APT and FIB in geological science is still in its infancy, and that much is yet to come. This presentation mainly aims at introducing the technique to a new community, and illustrating its potential on the basis of some selected experiments obtained by pioneer groups over the world.

Mots-Clés : 3D reconstruction; subnanometric scale resolution; elemental and isotopic analysis,

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