Recent instrumental development on the NanoSIMS ion microprobe

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We present recent instrumental developments performed on the NanoSIMS [1], ion microprobe optimized for isotopic and element measurements with sub-micron lateral resolution.

The two main characteristics of the NanoSIMS are:
- a coaxial, normal incidence objective and collecting immersion lens with a short working distance,
- a magnetic sector mass spectrometer with parallel collection (up to seven detectors, FCs or/and EMs) offering high transmission even at high mass resolution.

The new developments include:

1) A prototype of cold stage. Using a liquid nitrogen dewar, cold finger and heater it allows to regulate the sample temperature at -130°C ±1°C. Two applications are pursued: a) analysis of frozen liquid inclusions, b) the analysis of frozen-hydrated biological sample without the need of fixation/resin substitution/microtoming.

2) A partial redesign of the primary column, originally designed for small spots (50nm) / small currents (pA range). While keeping the small spot performance, it is designed to obtain 10-20nA in a spot of a few μm. This will improve the performance and throughput of high precision isotopic measurements when coupled with multiple FCs.

3) Ultra Low Energy reactive species incorporation into the sample surface prior the analysis. Achieved in quasi-mirror mode, this reduces the transient sputtering regime and thus optimizes the sensitivity for analyzing the top surface of ultra-thin samples as biological membranes or coatings.

4) Two new software features in the new control software under PC/Microsoft Windows OS:
- Stage rastering mode for mm size imaging and
- Point Logger mode allowing navigation directly on an external image (SEM, optical) after initial referencing.

[1] Slodzian, Daigne, Girard & Hillion (1991) *Proceedings of the VIIIth SIMS Conference, Amsterdam, 1991*

Uranium biomineralization through the activities of microbial phytases

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The need for cost effective *in situ* U (VI) remediation strategies remains a pressing issue at radionuclide-contaminated sites across the United States. As they are cost effective and non-invasive, bioremediation techniques have recently gained popularity over conventional ex situ remediation techniques. Bioreduction is the most studied bioremediation technique for U (VI) immobilization; however, uraninite, the insoluble byproduct of U (VI) reduction, is readily reoxidized by O_2, MnO_2, NO_2^-, or Fe^{3+}. The instability of uraninite has promted studies on the biomineralization of insoluble U (VI)-phosphate minerals through stimulation of microbial metabolism as a complementary strategy to bioreduction. Although the impetus for microbial hydrolysis of organophosphates is unclear, it is known that biological hydrolysis is catalyzed by non-specific phosphatase enzymes which hydrolyze inorganic phosphate from organophosphates to precipitate U (VI) phosphate minerals over a wide pH range. Previous biomineralization studies have focused on the addition of an exogenous organophosphate source to subsurface environments. In this study, we investigate the potential of exploiting phytic acid, the dominant natural organophosphate in soils, as a phosphorus source for the biomineralization of U (VI)-phosphate minerals. Phytic acid is unique as it can only be hydolyzed by the phytase enzyme, a specific phosphatase only carried by a subset of prokaryotes.

To determine if phytic acid can be used as an organophosphate source for biomineralization, U (VI)-phosphate mineral formation was investigated with heavy-metal resistant bacteria. In the presence of an external carbon source, organophosphate hydrolysis was observed in various pH conditions and lead to the biomineralization of U (VI) phosphate minerals. This is one of the first studies to investigate phytic acid as natural organophosphorus source for the biomineralization of U (VI) phosphate minerals.