Japan Geoscience Union Meeting 2014
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SMP49-01 Room:314 Time:May 1 16:15-16:30

Introduction of NANO-EPS

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Nano, a prefix for 10^-9, represents vast frontiers for both Earth and Planetary Solid Sciences. Conventional tools such as Electron Probe MicroAnalysis (EPMA) for ppm-level quantification at the micrometer scale and Power X-Ray Diffraction analysis (XRD) for the identification of submicron minerals are being transformed into the next generation instruments. In addition, it is possible to reveal the heterogeneity and oscillation of chemical and isotopic compositions at nano-spatial resolutions. It is becoming more aware that nano-sized solids with extremely large surface areas and distorted structures are ubiquitous in planetary materials and intimately relevant to many issues such as soil and groundwater contamination with metals and radionuclides, mineral resources exploitation, carbon sequestration and so on. In my presentation, nano-frontiers from various fields of Earth and Planetary Sciences and key technological advancements will be overviewed as the introduction of this session.

Keywords: nano

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SMP49-02 Room:314 Time:May 1 16:30-16:45

Properties and depositional process of sub-micron scale manganese oxide minerals in the aqueous surface enviromnent

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A large variety of minerals form submicron compounds or minerals in the surface aqueous environments (sea waters, rivers, soils, underground waters, organisms etc.) Especially iron and manganese oxide are most mobile elements among others in such environments. The iron and manganese oxides often scavenge numbers of metallic elements and play significant role in material cycling and geochemical cycles. In this paper, we attempt to introduce several types of occurrences of manganese oxide in the diverse environments. For example a phyllo-manganate minerals, nano-scale aggregate are shown in the paper.

Keywords: manganese oxide mineral, manganese crust, manganese nodule, low-temperature hydrothermal activity, phyllomanganate, redox condition

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SMP49-03 Room:314 Time:May 1 16:45-17:00

Development of PF-STXM and its application to environmental geochemistry

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Scanning transmission X-ray microscopy (STXM) has been applied to various fields in earth and environmental sciences such as aerosol chemistry, geomicrobiology, soil science, and nanomineral sciences. In particular, the technique has been used in the world because of its great importance in imaging distribution of carbon, or in particular carbon functional group, with about 50 nm spatial resolution. However, STXM that can be used to measure NEXAFS at carbon K-edge has not been in use in Japan. We have constructed STXM in Photon Factory (PF-STXM) from 2012 and started to use it for various topics in earth and environmental sciences.

In the PF-STXM, soft X-rays from the undulator are monochromatized by the grating and focused at the four-way aperture slit. The FZP with the outermost zone width of 30 nm is placed at 1 m distant from the aperture slit. First order diffraction selected through an order sorting aperture (OSA) is focused onto the sample with the focal distance of 0.7-5 mm, and then the transmitted X-rays are detected. The PF-STXM at present is mainly operated at BL-13A in Photon Factor, where the energy range available is from 250 eV to 1600 eV, which covers K-edges of carbon, nitrogen, oxygen, potassium, and aluminum. The beamize of the STXM was around 50 nm focused with Fresnel zone plates (FZP). The intensity of focused X-rays at the sample was expected to be up to 10^7 photons/s. Instead of a photomul-tiplier tube (PMT) which is commonly used in STXM, a silicon avalanche photodiode (APD) is utilized to detect the transmitted X-rays in PF-STXM. Compared with other STXM system in the world, our STXM is made so compact and light that it is easily connected to and removed from the multi-purpose beamlines. The experiments reported below are performed at BL-13A and BL-16A of Photon Factory.

The PF-STXM has been used for various applications. Among them, we would like to present recent results on (i) speciation of calcium in mineral dust with 50 nm spatial resolution, (ii) characterization of carbon adsorbed on particulate matter in river water, and (iii) spatial distribution of rare earth elements in bacterial cell.

Keywords: STXM, PF, Aerosol, Particulate matter, Bacteria

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SMP49-04 Room:314 Time:May 1 17:00-17:15

Nano-scale investigation of the microbe-mineral interaction by scanning transmission X-ray microscopy

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Microorganisms in the environment critically impact global geochemical cycles and redox reactions of various elements. Many geochemically important redox reactions (e.g., sulfate reduction, Fe(II) oxidation) are largely associated with microbial activity. In addition, microbes can mediate both mineral formation (biomineralization) and mineral dissolution (bioleaching). Recent studies suggest a significant relationship between Fe(II)-oxidizing bacteria and ancient Banded Iron Formation, one of the large geochemical events in Earth's history. The general ecological importance of environmental microbial reaction has been well recognized; however, the specific mechanisms of the reactions in the environments such as the reaction rate and spatial dynamics are poorly understood. In the environment such as sediments, microbial reactions and habitability vary locally and form complicated geochemical networks, which makes it difficult to characterize the specific biogenic reactions in detail.

Scanning transmission X-ray microscopy (STXM), which uses near-edge X-ray absorption spectroscopy (NEXAFS) is a powerful new tool that can be applied to hydrated biological materials with high spatial resolution. The STXM provides spatial resolution of better than 50 nm, which is suitable for imaging bacteria and bacterial biofilms.

In the present study, we applied the STXM into the bioleaching of sulfide mineral (pyrite) to determine carbon, oxygen, and iron species in nano-scale. Both metal and biogenic organic materials in pyrite-microbe interface were investigated in the single cell level. Our study shows that the STXM could be a potential technique to provide direct information on specific biogenic reaction microorganism.

Keywords: STXM, pyrite, bioleaching

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In-situ trace element quantification of geological samples using LA-ICPM

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Laser-Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICPMS) is a type of mass spectrometry which is capable of in-situ trace element quantification of a solid sample. We introduce an typical application to characterize sub-micron scale particles based on the variation of their geochemical compositions.

Keywords: LA-ICPMS, femtosecond laser, in-situ analyses, trace-element quantification