

**Experiment title:**

Study of the oxidation products of naturally arsenic enriched Bangladesh ground waters.

**Experiment number:**  
**ME 513**

**Beamline:**

BM30B  
FAME

**Date of experiment:**

from: September 4<sup>th</sup> to 9<sup>th</sup>, 2002

**Date of report:**

23-09-02

**Shifts:**

9

**Local contact(s):**

Jean-Louis Hazemann

*Received at ESRF:*

**Names and affiliations of applicants** (\* indicates experimentalists):

Jerôme ROSE\*<sup>1</sup>, Sophie THORAL\*<sup>1</sup>, Thierry HEULIN<sup>2</sup>, Jean-marie GARNIER<sup>1</sup>, Alexander VAN GEEN<sup>3</sup>/

<sup>1</sup>CEREGE, Physico-chimie des interfaces Européole de l'Arbois BP 80 13545 Aix-en-Provence France;

<sup>2</sup>Laboratoire d'Ecologie Microbienne de la Rhizosphere - U.M.R. 163, C.M.R.S.-C.E.A., F-13108 Saint-Paul-lez-Durance Cedex, <sup>3</sup>Lamont Doherty Earth Observatory, University of Columbia, Palisades, NY 10964-USA

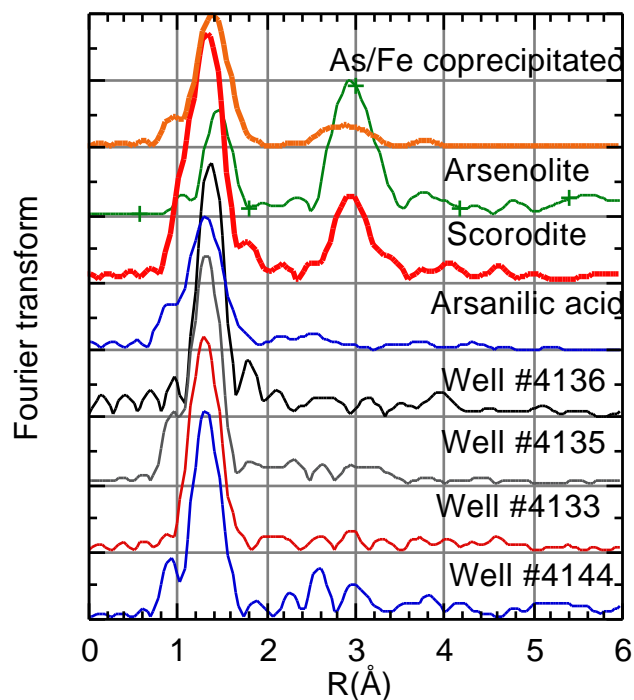
**Report:**

Arsenic poses a grave threat to human health in the southern portions of Bangladesh and West Bengal, where millions of people are drinking groundwater with naturally elevated concentrations of arsenic, a highly toxic and carcinogenic substance. As concentrations above 10 µg/l (the World Health Organization (WHO) Maximum Contamination Level in Bangladesh), are found in over 50% of the wells, placing an estimated 20 million people at risk of developing neurological, skin diseases and cancer. An international research project between Columbia University (New York), the CEREGE (Aix-en-P<sup>ce</sup>), and the LEMIR (CEA, Cadarache) started year 2000. The aim of that project is to characterize biologically, physically and chemically this complex system and then propose simple and efficient water treatment procedures. Previous results indicate the great importance of iron in controlling As concentrations in waters. Then the logical way for As removal should be to oxidize these waters and thus favor As-Fe precipitation. However, due to highly variable physico-chemical conditions, As removal is unpredictable. The aim of our experiments was to determine As speciation in powder resulting from freeze-dried oxidized waters from Bangladesh wells, to better understand the coprecipitation of Fe and As in such a complex system and to improve the As immobilization during the oxidation of groundwater.

As K-edge XAS experiments have been carried out on the new XAS CRG French beamline (FAME). The Si(111) monochromator was used and the samples were recorded in the fluorescence mode due to the low As concentration in the freeze dried samples, with a multi-channel fluorescence detector. The sensitivity of the beamline allowed us to scan even the lowest As concentrations samples. But one difficulty was encountered that was related to the stability of the beam. The cooling of the first crystal of the monochromator realized with liquid nitrogen lead to beam vibrations, due to N<sub>2</sub> pressure modifications in the ESRF network. These vibrations resulted in a decrease of the signal to noise ratio.

Thus the scanning time for each sample was relatively high. The N<sub>2</sub> phase separator that will be installed before the first crystal of the monochromator will highly increase the stability of the beam

The XANES results indicate that As is at the 5+ oxidation state for all freeze-dried water samples. The XAS results are presented in the following figure. The Fourier transforms (FT) of the natural samples spectra are compared with spectra of reference compounds : Arsanilic acid (H<sub>2</sub>NC<sub>6</sub>H<sub>4</sub>AsO<sub>3</sub>H<sub>2</sub>), Scorodite (FeAsO<sub>4</sub>) and Arsenolite (As<sub>2</sub>O<sub>3</sub>) and the spectrum of a As/Fe coprecipitated sample. The Fourier transforms of the natural samples



**Figure 1 : Fourier transforms of the EXAFS spectra of natural samples compared with spectra of reference compounds**

are really different from that of reference compounds. The position as well as the intensity of the first peak tend to indicate that As is under the 5+ form i. e. surrounded by 4 oxygen atoms. Peak at larger distances do not correspond to the position and intensity of the Fourier transform of the reference compounds. Especially the FT of As-Fe coprecipitated is really different from that of natural samples. Thus even if the [As]/[Fe] ratio and pH were similar to the well #4144, the coprecipitation in natural conditions versus synthetic solutions does not lead to same atomic structure of the precipitated compounds.

The result confirms water oxidation kinetics that were realized on field which highlight that phosphates, silicates and natural organic matter may inhibit As-Fe complexation. The low intensity of the peaks in the 2-4 Å range for the natural samples strongly suggests that the As-Fe interaction is not that important and that the As behavior is not totally controlled by Fe at the atomic level. The modeling of the EXAFS spectra is under progress.