EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

ESRF

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** Tellurium cycling at the nanoscale: the complex environmental dispersion and bioavailability of a rare critical metal	**Experiment number**: EV-447
Beamline: ID21	**Date of experiment**: from: 23 Sep 21 to: 28 Sep 21	**Date of report**: 31 Aug 22
Shifts: 12	**Local contact(s)**: Edgar Eduardo Villalobos Portillo Hiram Castillo Michel	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Joel Brugger*, Barbara Etschmann*, Monash University

Owen Missen*, Monash University; Stuart Mills, Museums Victoria

Aim

By characterizing the dispersion and speciation (oxidation state and association with main soil phases) of Te in rocks and soils around relatively undisturbed natural anomalies, we aim to produce a model of the controls on Te mobility and toxicity in soils. Mineralogical changes are likely to influence – and be influenced by – microbes living within Te-enriched areas. This natural analogue study aims to improve our ability to predict the long-term fate of Te introduced in the environment as a result of expanding anthropogenic uses, in particular by examining the fate of environmental Te nanoparticles.

Experimental

Due to covid, we were in Australia during this experiment and Eduardo and Hiram were miracle workers, going above and beyond the call of duty to help make this experiment an extraordinary success.
We are always grateful to the local contact, but in this case, we really really wish to thank them for everything!

General observations & Impact

Paper published:
Owen P. Missen, Ella R. Lausberg, Joël Brugger, Barbara Etschmann, Stuart J. Mills, Koichi Momma, Rahul Ram, Mihoko Maruyama, Xi-Ya Fang, Erik Melchiorre, Christopher G. Ryan, Edgar E. Villalobos-Portillo, Hiram Castillo-Michel, Kiyofumi Nitta, Oki Sekizawa, Jeremiah Shuster, Santonu K. Sanyal, Andrew Frierdich, Steve Hunt, Yuka Tsuri, Yuriko Takahashi, Uta Michibata, Sahil Dwivedi, Maria A.D. Rea (2022) Natural nanoparticles of the critical element tellurium, *Journal of Hazardous Materials Letters*, 3,100053 (https://doi.org/10.1016/j.hazl.2022.100053).

The discovery of Te nanoparticles in natural environments has significant implications for the toxicity of Te in soils, as it requires an active biogeochemical process and suggests greater bioavailability than previously assessed. This is significant as anthropogenic uses of Te are increases (e.g. solar panels).

Abstract

Tellurium (Te) is a Critical Element that is toxic to microorganisms and humans alike, most notably in its soluble oxyanionic forms. To date, the biogeochemical behaviour of Te in Earth's surface environment is largely unknown. Here, we report the discovery of elemental Te nanoparticles (Te NPs) in regolith samples using Single-Particle Inductively Coupled Plasma Mass Spectroscopy. Tellurium NPs were detected in both proximal and distal locations (bulk concentrations >4 ppm) relative to weathering Te ores. Synchrotron X-ray Fluorescence Mapping and X-ray Absorption Spectroscopy showed that bulk Te in the regolith is generally associated with Fe (oxyhydr)oxides and clay minerals, and mostly found in the oxidation states +IV and +VI. Although Te NPs account for less than 2 mol‰ of Te in our samples, their detection provides evidence for the active biogeochemical cycling of Te in surface environments. Te NPs are

reactive and are likely to have formed in situ in distal samples, most likely via microbially-mediated reduction. Hence, the presence of Te NPs indicates the potential for release of toxic soluble forms of Te even in environments where most Te is “fixed” in forms such as Fe (oxyhydr)oxides that have low solubility and poor bioavailability.

Graphical Abstract