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:** REE transport in alkaline fluids at high P-T: Implications for the remobilization of REE by hydrothermal fluids and the formation of rare metals deposits	**Experiment number**: 30-02-1139
Beamline: BM-30	**Date of experiment**: from: 22 Nov 18 to: 30 Nov 18	**Date of report**: 08 Sep 23
Shifts: 21	**Local contact(s)**: Denis Testemale	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Joel Brugger*, Barbara Etschmann*, Monash University

Marion Louvel*, Munster University.

This exp was the last needed for the paper

*Louvel, M., Etschmann, B., Guan, Q., Testemale, D. and Brugger, J. (2022) Carbonate complexation enhances hydrothermal transport of rare earth elements in alkaline fluids. Nature Communications 13, 1-11.

Abstract

Rare earth elements (REE), essential metals for the transition to a zero-emission economy, are mostly extracted from REE-fluorcarbonate minerals in deposits associated with carbonatitic and/or peralkaline magmatism. While the role of high-temperature fluids ($100 < T < 500$ °C) in the development of economic concentrations of REE is well-established, the mechanisms of element transport, ore precipitation, and light (L)REE/heavy (H)REE fractionation remain a matter of debate. Here, we provide direct evidence from in-situ X-ray Absorption Spectroscopy (XAS) that the formation of hydroxyl-carbonate complexes in alkaline fluids enhances hydrothermal mobilization of LREE at $T \geq 400$ °C and HREE at $T \leq 200$ °C, even in the presence of fluorine. These results not only reveal that the modes of REE transport in alkaline fluids differ fundamentally from those in acidic fluids, but further underline that alkaline fluids may be key to the mineralization of hydrothermal REE-fluorcarbonates by promoting the simultaneous transport of (L)REE, fluoride and carbonate, especially in carbonatitic systems.

Previous work on critical metals, with data collected at ESRF.

* Guan, Q.S., Mei, Y., Etschmann, B., Testemale, D., Louvel, M. and Brugger, J. (2020) Yttrium complexation and hydration in chloride-rich hydrothermal fluids: A combined ab initio molecular dynamics and in situ X-ray absorption spectroscopy study. *Geochimica Et Cosmochimica Acta* 281, 168-189.

*Guan, Q., Mei, Y., Etschmann, B., Louvel, M., Testemale, D., Bastrakov, E. and Brugger, J. (2022) Yttrium speciation in sulfate-rich hydrothermal ore-forming fluids. *Geochimica et Cosmochimica Acta* 325, 278-295

*Guan, Q., Mei, Y., Etschmann, B., Louvel, M., Testemale, D., Spezia, R. and Brugger, J. (2022b) Speciation and thermodynamic properties of La (III)-Cl complexes in hydrothermal fluids: a combined molecular dynamics and in situ X-ray absorption spectroscopy study. *Geochimica et Cosmochimica Acta*, 330, 27-46.

*Liu, Etschmann, Hazemann, Testemale, Migdisov and Brugger, 2017. Revisiting the hydrothermal geochemistry of europium(II/III) in light of new in-situ XAS spectroscopy results. *Chemical Geology*, 459, 61–74.