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 via the User Portal: *https://wwws.esrf.fr/misapps/SMISWebClient/protected/welcome.do*

Deadlines for submission of Experimental Reports

Experimental reports must be submitted within the period of 3 months after the end of the experiment.

Experiment Report supporting a new proposal ("relevant report")

If you are submitting a proposal for a new project, or to continue a project for which you have previously been allocated beam time, you must submit a report on each of your previous measurement(s):

- even on those carried out close to the proposal submission deadline (it can be a *"preliminary report"),*
- even for experiments whose scientific area is different form the scientific area of the new proposal,
- carried out on CRG beamlines.

You must then register the report(s) as "relevant report(s)" in the new application form for beam time.

Deadlines for submitting a report supporting a new proposal

- 1st March Proposal Round - **5th March**
- 10th September Proposal Round - **13th September**

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.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report in English.
- include the experiment number 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: Isolating the factors governing strain localization and fracture coalescence leading to dynamic rupture	**Experiment number**: **ES-927**
Beamline:	**Date of experiment**: from: 13 Sept, 2020; 19 Feb, 2021 to: 18 Sept, 2020; 21 Feb, 2021	**Date of report**: 21 Sept 2021
Shifts:	**Local contact(s)**: Benoit Cordonnier, Bratislav Lukic, Alexander Rach	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Jessica McBeck

Benoit Cordonnier*

Report: Firstly, I apologize for the lateness of this report, I was not aware of the deadline.

In the round of beamtime in September 2020, the onsite experimentalist (Benoit) performed six experiments that studied the influence of preexisting fracture density and pore fluid on fracture network growth and subsequent failure. The experiments were performed on Westerly granite. Some of the experiments used granite cores that were precracked, and the other two experiments were not precracked. The experiments varied in the applied confining stress and pore fluid pressure. In the round of beamtime in February 2021, Benoit performed three additional experiments that included more end members of the parameter space. Through collaboration with project ES-930, the present project (ES-927) plans to compare fracture development in these granite cores with the sandstone cores deformed for project ES-930. The tables below describe the applied loading conditions, pore pressure, and sample treatment for the experiments relevant for this work.

These experiments were acquired with the new HDF5 format. At the time of acquisition no reconstruction was yet possible, and no correction or adjustment during acquisition could be accomplished. Following these experiments, the computing cluster at ESRF underwent some maintenance that slowed the reconstruction process. Much effort has been expended in developing the reconstruction software, but we are not yet at the capacities, functionalities and quality available before the shutdown. Thus, at this time, we are continuing to post-process the experimental data, and have not yet begun the scientific analysis.

In the meantime, we have been developing new post-processing scripts that will help automatize the process of denoising, fracture and pore segmentation, and digital image correlation that we will perform for these experiments. Thus, when we acquire the reconstructed scans we will be able to apply our post-processing steps as efficiently as possible.

In the past two years, we have published several papers using previous experiments performed on beamline ID19 (see citations below). We also have several papers under review that use synchrotron data from beamline ID19. Two papers (submitted to the International Journal of Rock Mechanics and Mining Sciences) study the influence of segmentation method and spatial resolution on the fracture network characteristics calculated from tomograms. Another manuscript under review (submitted to Pure and Applied Geophysics) uses fracture characteristics to predict fracture network development using machine learning. Another manuscript (submitted to Tectonophysics) quantifies the localization of local strains calculated from digital image correlation of tomograms. Another manuscript (submitted to Frontiers in Earth Science) quantifies the localization of the fracture networks extracted from X-ray tomography triaxial compression experiments.

McBeck, J. A., Zhu, W., & Renard, F. (2021). The competition between fracture nucleation, propagation, and coalescence in dry and water-saturated crystalline rock. *Solid Earth*, *12*(2), 375-387.

McBeck, J. A., Aiken, J. M., Mathiesen, J., Ben-Zion, Y., & Renard, F. (2020). Deformation precursors to catastrophic failure in rocks. *Geophysical Research Letters*, *47*(24), e2020GL090255.

Renard, F., Kandula, N., McBeck, J., & Cordonnier, B. (2020). Creep burst coincident with faulting in marble observed in 4-D synchrotron X-ray imaging triaxial compression experiments. *Journal of Geophysical Research: Solid Earth*, *125*(9), e2020JB020354.

McBeck, J., Aiken, J. M., Ben-Zion, Y., & Renard, F. (2020). Predicting the proximity to macroscopic failure using local strain populations from dynamic in situ X-ray tomography triaxial compression experiments on rocks. *Earth and Planetary Science Letters*, *543*, 116344.

McBeck, J., Ben-Zion, Y., & Renard, F. (2020). The mixology of precursory strain partitioning approaching brittle failure in rocks. *Geophysical Journal International*, *221*(3), 1856-1872.

Renard, F., McBeck, J., & Cordonnier, B. (2020). Competition between slow slip and damage on and off faults revealed in 4D synchrotron imaging experiments. *Tectonophysics*, *782*, 228437.

Experiments completed in February 2021

Project Number	Exp. name	sample diameter	Pconf (MPa)	Ppore (MPa)	Peffective (MPa)	Sample Treatment	Axial stress at yielding (MPa)	Axial stress at failure (MPa)
ES-927	WG18-14	4	15	10	5	Precrack and saturate	92, 108	115
ES-927	WG19_18	4	10	5	5	No treatment and saturate	154	161
ES-927	WG20	4	15	10	5	No treatment and saturate	140	153
ES-930	DD4-10	5	12	2	10	saturate the sandstone	??	95
ES-930	DD5-05	5	50	40	10	saturate the sandstone	110	134

Experiments completed in September 2020

Project Number	Exp. Name	sample diameter	Pconf (MPa)	Ppore (MPa)	Peffective (MPa)	sample treatment	axial stress at failure (MPa)	number of scans
ES-927	WG05_07	4	5	0	5	precrack	135.27	90
ES-927	WG09_05	4	20	15	5	No treatment	circa 95	21
ES-927	WG09_06	4	20	15	5	No treatment	139.94	90
ES-930	WG14_01	4	20	10	10	No treatment	190	181
ES-927	WG06_02	4	10	5	5	precrack and saturate	148.95	86
ES-930	WG15_04	4	5	4	1	Precrack and saturate	65	16
ES-930	DD1	5	20	10	10	saturate	105.711	287
ES-927	WG10	4	5	0	5	No treatment	131.45	???
ES-930	DD3	5	10	0	10	No treatment	101.6	45
ES-927	WG13	4	20	15	5	No treatment and saturate	134	74