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:** Effects of Differential Stress on Phase Equilibrium at Deep Earth Conditions	**Experiment number**: ES-910
Beamline:	**Date of experiment**: from: 17/02/2021 to: 23/02/2021	**Date of report**:
Shifts: 18	**Local contact(s)**: Wilson CRICHTON	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Julien GASC

Arefeh MOAREFVAND

Report:

The end goal of this beamtime proposal was to assess the relations between non-hydrostatic stresses, phase change and seismic velocities. As a first step, it was decided to focus on the quartz α-β transition, a second order transition that has major geophysical implications [1]. This transition was chosen because the temperature at which it occurs at high pressure and its physical properties are still poorly constrained [2]. Notably, thermodynamics databases predict a dramatic increase in compression wave velocity, V_p in the β field with depth, which results in the attribution of high velocity zones in seismic tomography data to the α-β transition [3]. However, the predicted V_p increase in the β field is not observed in preliminary experiments performed off-line at our home institution [4]. This discrepancy may reflect either a fading of mechanical contrast between α and β quartz with increasing pressure (resulting in a smoother transition) or a partial transformation. However, since β quartz cannot be quenched, it is impossible to observe the actual amount of reaction in recovered samples.

Therefore, it was chosen to first use the ESRF beam to characterize the transition at high pressure before eventually measuring the associated velocity changes. These experiments are performed without direct temperature (i.e., thermocouple) and pressure measurement. One of the main goals during this first beamtime was therefore to calibrate the press load and furnace output needed to reach the PT conditions of the transition. The data collected over 4 experiment during ES-910 achieved that goal through sevral heating-cooling cycles at increasingly higher loads until coesite (the high pressure phase) was observed at ~ 3 GPa. Furthemore the data revealed that the full transition is sharp (it takes place over a temperature interval < 10°C), even at pressures of several GPa's (figure 1), which had never been observed before. In addition, they suggest that the transition becomes indeed smoother toward high pressure, which may explain the lower V_p contrast observed in our previous experiments.

In future experiments, the P-wave travel time inside the sample will be retrieved using a pulse-echo technique and by identifying the top and bottom sample reflections in the waveforms obtained. The evolution of V_p across the transition will then be retrieved by monitoring the sample length in x-ray absorption images. These data can be directly used for the interpretation of seismic tomography profiles.

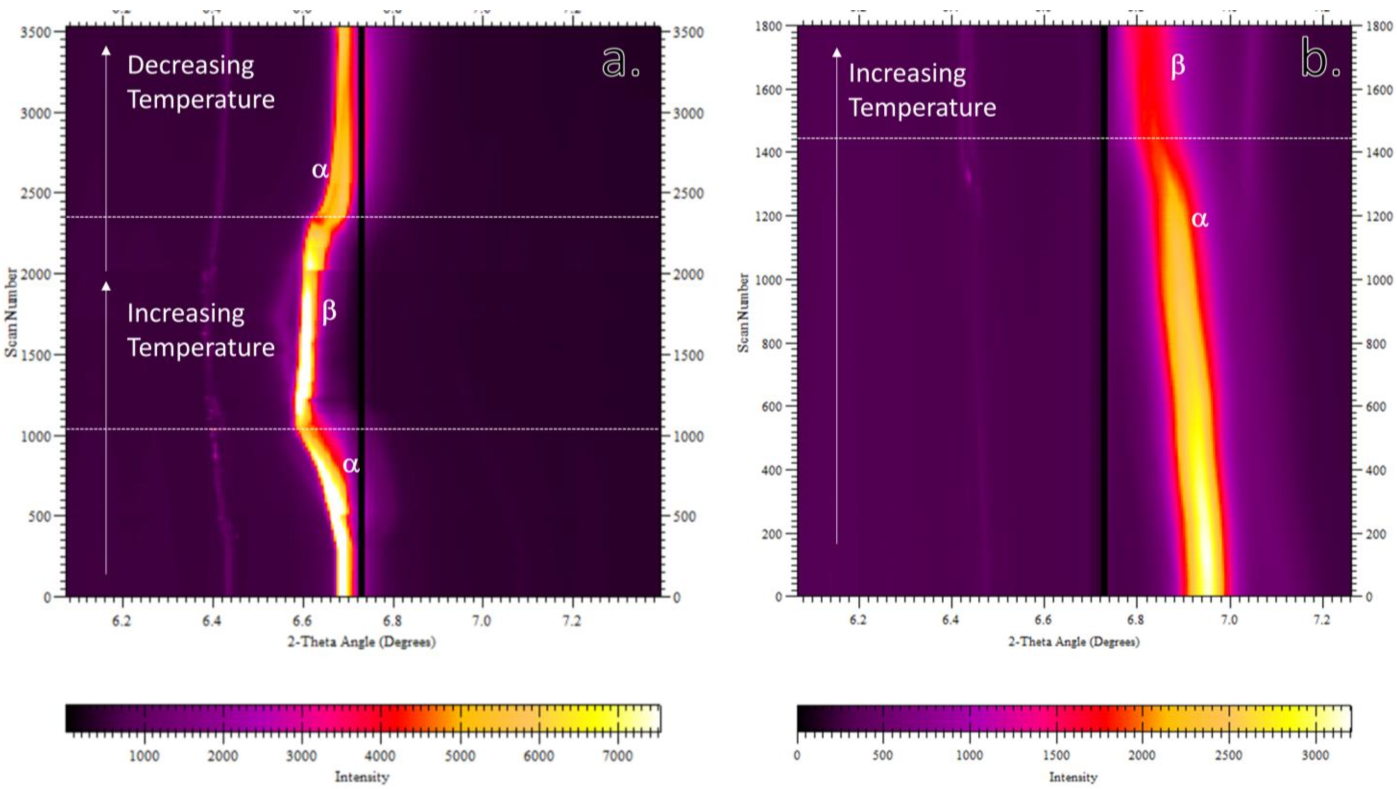

Figure 1. Results from ES-910. The main reflection of quartz (011) is observed as a function of scan number while the temperature was ramped up or down at constant rates. (a) shows a full temperature cycle at low pressure (~1 GPa). The transition is clearly identified (dashed lines) both on the up- and down-temperature paths by pronounced changes in peak position shifts. (b) shows a similar behavior at higher pressure (~2 GPa) during temperature ramping. In this case, however, the smoother nature of the transition may reflect a smaller contrast of cell parameters between the two phases at higher pressures.

1. Angel, R.J., et al., *A simple and generalised P-T-V EoS for continuous phase transitions, implemented in EosFit and applied to quartz.* Contributions to Mineralogy and Petrology, 2017. **172**(5).
2. Coe, R.S. and M.S. Paterson, *ALPHA-BETA INVERSION IN QUARTZ - A COHERENT PHASE TRANSITION UNDER NONHYDROSTATIC STRESS.* Journal of Geophysical Research, 1969. **74**(20): p. 4921-&.
3. Sheehan, A.F., et al., *Physical state of Himalayan crust and uppermost mantle: Constraints from seismic attenuation and velocity tomography.* Journal of Geophysical Research-Solid Earth, 2014. **119**(1): p. 567-580.
4. Moarefvand, A., et al., *A new generation Griggs apparatus with active acoustic monitoring.* Tectonophysics, 2021. **816**: p. 229032.