Characterizing Albite Melt Under Pressure: "Quasi-Simultaneous" Density, Tomography, and Structure Measurements

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Introduction

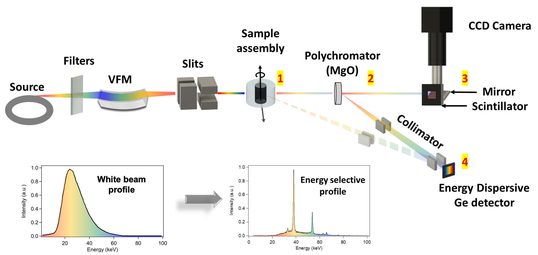
❖ Here we report experimental results utilizing white synchrotron radiation with a Paris-Edingburgh press to study the structure and physical properties of albite liquid up to 3 GPa and 2000 K at the PSICHÉ beamline at the SOLEIL Synchrotron. This beamline has a unique setup that allows users to measure high-pressure densities, collect X-ray tomographic images, and acquire structure data of an amorphous sample in a single experiment. The ability to directly correlate density information with the liquid structure will help us better understand and constrain the evolution of the structure under high pressure.

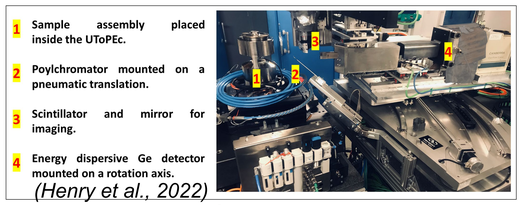
Experimental Setup

Imaging
-- fast tomography
(volume measurement)
-- radiography

Diffraction
-- energy dispersive
-- CAESAR
(amorphous structure measurement)

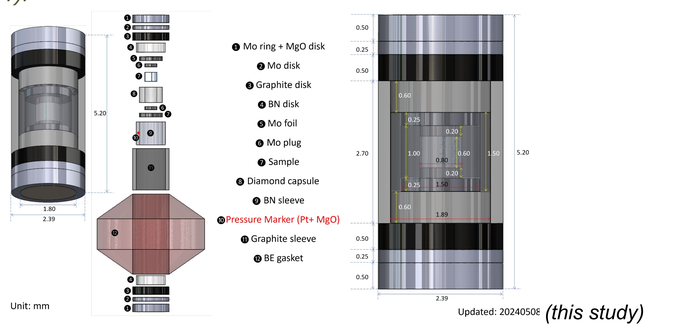
Absorption
(density measurement)





(Henry et al., 2022)

*Fig. 1) White beam station layout of the PSICHÉ beamline at the SOLEIL Synchrotron. For detailed beamline setup information, please visit Poster: **MR31B-2983** by Dr. Nicolas Guinot (just 4 poster boards away!).*

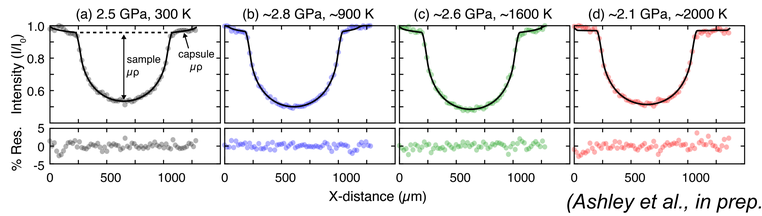


(this study)

Fig. 2) Cell assembly for the experiments. Pressures up to 3 GPa and temperatures up to 2000 K were reached using the Ultrafast Tomography Paris Edinburgh Cell (UToPEc).

Density Measurement

- X-ray absorption method was applied due to the lack of long-range order in amorphous materials.
- Single crystal diamond capsules were used to maintain the melt sample geometry at HP&HT.
- The X-ray diffraction pattern of MgO shows an energy-selective profile acting as a polychromator. The diffraction peak intensities are directly related to the transmitted beam intensity at specific energies.
- Absorption profiles were fitted based on the Beer-Lambert Law to extract density information.

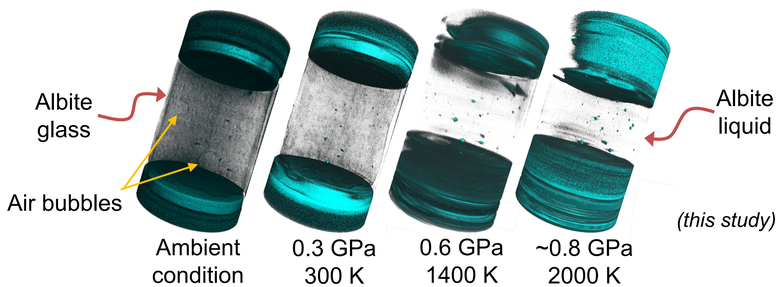


(Ashley et al., in prep.)

Fig. 3) The absorption profiles at 17 keV and the fitted results of high-pressure albite melts at various temperatures.

Tomography Imaging

- Throughout the compression and heating process, we performed pink beam microtomography to measure the volume of the melt and investigate internal features in 3D by converting 2D radiograph images collected by a CCD camera into 3D tomographic images.
- The starting material was albite glass, which contained numerous small "bubbles". Upon compression and heating, the bubbles gradually disappeared. Melting was confirmed by XRD after recrystallized peaks were gone.

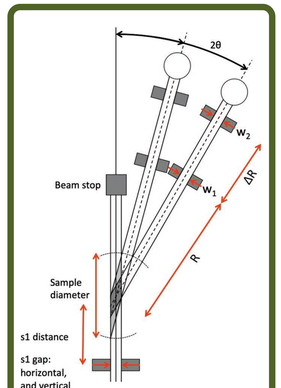


(this study)

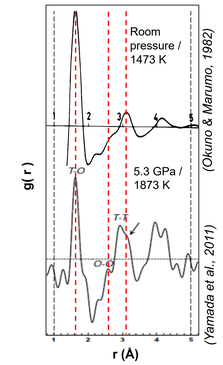
Fig. 4) Reconstructed images of the sample (center) and the top & bottom molybdenum plugs (cyan) at various PT conditions. The volume of the sample can be determined by a careful thresholding process.

Structure Measurement

- Combined angle- and energy-dispersive X-ray diffraction (CAESAR scan; King et al., 2022) is setup for structure measurement of amorphous material.
- A single element solid state germanium point detector is used to collect diffraction signal. The detector is mounted on a rotation stage to change the diffraction angle.
- T-O and T-T peaks are distinguishable in the pair distribution function analysis, Na-O and O-O are hard to resolve.

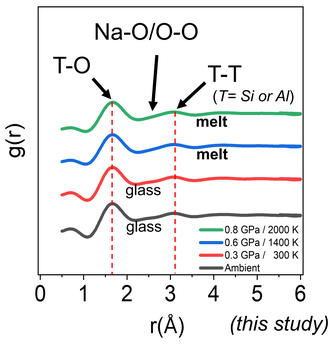


(King et al., 2022)



(Okuno & Marumo, 1982)

(Yamada et al., 2011)



(this study)

Fig. 5) Preliminary structure analysis of albite glass and melt from data collected at PSICHÉ. T-O and T-T peak positions agree with previous X-ray total scattering studies of albite melts.

Summary

- Density, tomographic images, and structures of albite glasses and melts have been measured "quasi-simultaneously" in the same run using the unique setup at the PSICHÉ beamline at the SOLEIL Synchrotron.
- Structures and physical properties of albite melts up to 3 GPa and 2000 K have been studied.

For detailed experimental results of this study, please visit Dr. Aaron Ashley's poster (online) from 13:00- 15:00 (Wednesday and Thursday).

The link to Dr. Ashley's iposter presentation

Acknowledgments

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