The Large-Volume Press Facility at GSECARS

Yanbin Wang and Tony Yu, The University of Chicago

The GSECARS Large Volume Press (LVP) facilities run part-time in three stations at Sector 13 of the APS: a 250-ton press in 13-BM-D, a 180-ton Paris-Edinburgh press (PEP) in 13-ID-C, and a 1000-ton press in 13-ID-D. Between 2017 and 2021, the program generated 49 publications, with 43 being ESS publications. This includes 1 Masters thesis and 9 Ph.D. theses. For the same period, we have developed a range of new techniques, including:

1. Double-stage (6/8) configuration in the DDIA-30 module for experiments up to 50 GPa and 1800 K.
2. Large cell assembly for deforming rock samples up to 12 mm in length in the DDIA-30, with acoustic emission (AE) monitoring.
3. Ultrasonic velocity measurements on silicate liquids in the T-25 module.
4. Simultaneous measurements on viscosity and electrical conductivity of liquids in the T-25.
5. A Paris-Edinburgh press (PEP) system for studying structures of liquid silicates at high pressure.
6. Machine-learning algorithms for acoustic emission experiments.
7. High-energy diffraction microscope (HEDM) in the high-pressure x-ray tomography module (HPXTM).

We propose to capitalize on these developments for our LVP program in the new organization. While ontinuing our support for the mineral physics community, we will expand the scope to include new techniques serving a broader earth science user base. Many of the above techniques can directly benefit the rock mechanics community for their scientific research (e.g., items 2, 4, 6, and 7). The following is a highly condensed technical development plan:

- Petrology and equations of state studies under lower mantle conditions (double-stage DDIA-30)
- Structure and physical properties (density, elasticity, viscosity) of geoliquids and geofluids under deep upper-mantle conditions (PEP and HPXTM)
- Oscillating deformation of complex rocks at seismic frequencies (DDIA-30, DDIA-6)
- Physical mechanisms of earthquakes with acoustic emission monitoring (DDIA-30, DDIA-6)
- Grain-level stress distribution in poly-phase rocks during deformation (HEDM in HPXTM)
- Ice rheology to 10 GPa (DDIA-30, DDIA-6)
- 4D imaging of frictional faulting (HPXTM) and stress mapping across fault planes under crustal conditions (DDIA-30)

To accomplish the above goals, we propose the following instrument upgrades and new developments:

- Upgrade the vertical positioning mechanism of the 1000-ton press, to improve accuracy and increase motion speed
- Upgrade the multichannel collimator for PEP, to improve beam collimation on smaller sized samples, for liquid structure studies to ~20 GPa.
- Upgrade the HPXTM to reduce rotation run-out error and increase rotation speed to reduce data collection time.
- Develop a shared dual booster pump system for high frequency oscillation deformation for both DDIA-30 and DDIA-6
- Develop compound refractive lenses (CRLs) in 13-BM-D, to increase beam flux by ~150x, reducing monochromatic diffraction data collection time to ~1 s.
- Purchase a micro laser welder to seal fluid in metal capsules, to enable a new class of experiments on properties of geofluids (density, equation of state, viscosity) to pressure and temperature conditions to >300 km depth.

We request financial support for two beamline scientists and one post-doc for the LVP program.