The High-pressure Large Volume Press Program at GSECARS

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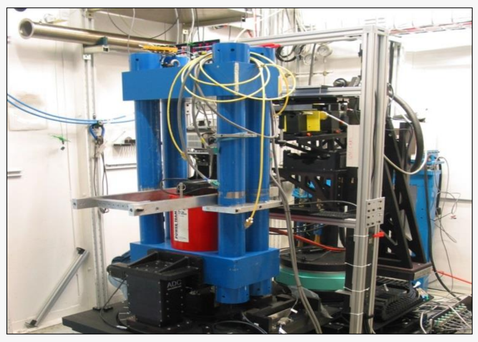
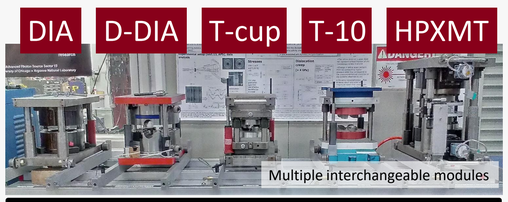
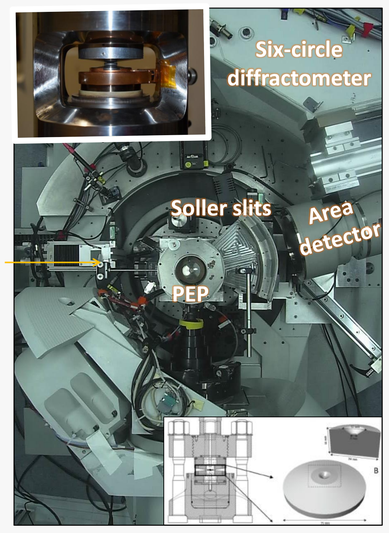
13-BM-D: 250 t press



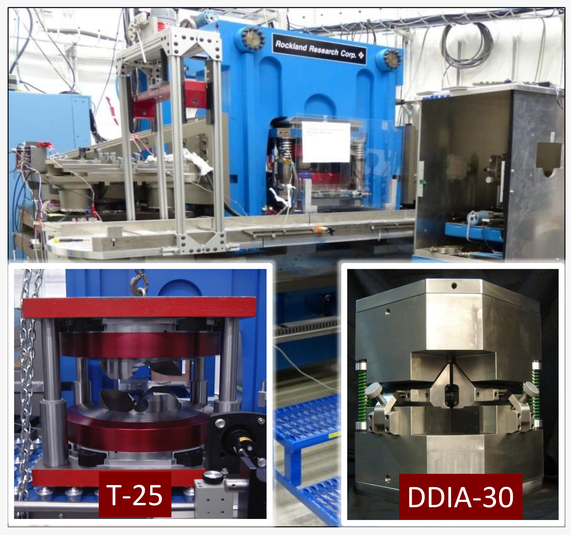


"Swiss-army knife" approach

13-ID-C: Paris-Edinburgh press



13-ID-D: 1000 t press

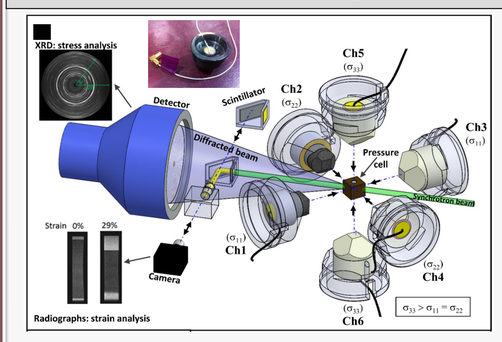


All can be interfaced with ultrasonic, acoustic emission, and conductivity equipment

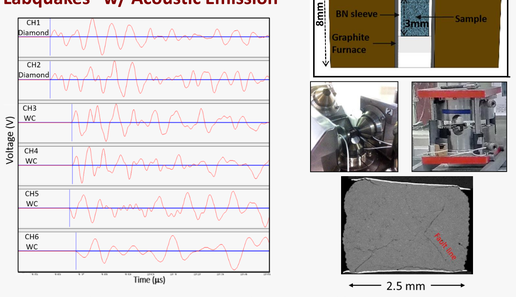
Timeline of development

Feb. 1996	Design work begins	In consultation with **design team** (till ~2001)
Nov. 1998	250 t LVP commissioned in **13-BM-D**	DIA from U. Hawaii, T-10 built by Stony Brook
Oct. 1999	1000 t LVP installed in **13-ID-D**	Designed in-house, built by Rockland (delayed 1 year)
May 2000	1000 t press commissioned with T-25 in **13-ID-D**	Module designed in-house, built by Rockland
Aug. 2002	D-DIA experiment w/ mono XRD, **13-BM-D** (deformation)	D-DIA module from LLNL (Bill Durham)
Jun. 2003	GSE small D-DIA commissioned in **13-BM-D**	Built by Rockland
July 2004	High-P tomography apparatus commissioned in **13-BM-D**	Similar technique later available at other synchrotrons
Feb. 2005	CAESAR diffraction at **13-ID-D** (white beam crystallography)	Permanent setup now available at SOLEIL (PSICHE)
Oct. 2008	280 t PE (EDXD) commissioned in **16-BM-B** (liquid structure)	Operation partial support from COMPRES and HPCAT
Dec. 2009	DDIA-30 commissioned at **13-ID-D** (large sample)	Partial support from COMPRES, designed in-house
Jun. 2011	Acoustic emission system commissioned (transportable)	Purchased from Adv. Seismolog. Consulting, Ltd
Feb. 2013	250 t LVP control system at **13-BM-D** upgraded	Co-designed with ADC, built by ADC
July 2013	Tony Joins GSE staff	Leads PE and high-P tomo user support
Jun. 2014	130 t PE (ADXD with Soller slits) at **13-ID-C** (liquid structure)	Soller slits designed by ESRF (ID27)
Nov. 2016	Double-stage DDIA-30 open to users in **13-ID-D** (to 50 GPa)	COMPRES DELVE project supported user travels
July 2018	Electrical conductivity implemented with T-25 in **13-ID-D**	Instrument from Anne Pommier (UC San Diego)

DDIA (brittle & ductile deformation)

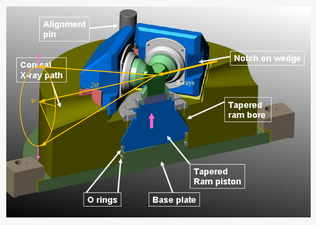


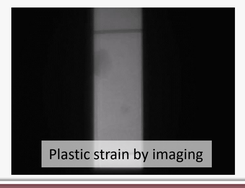
"Labquakes" w/ Acoustic Emission

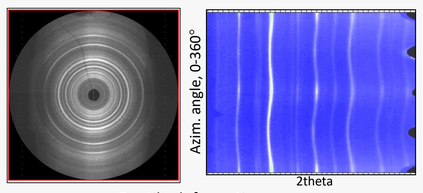


The Acoustic emission work is supported by EAR-1661489, 1925920.

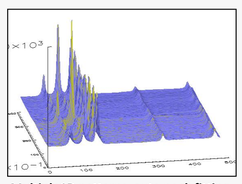
Rheology & flow laws



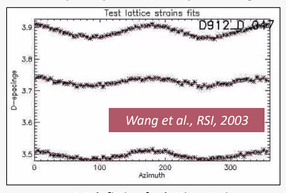




Ductile deformation:
Flow laws
Lattice preferred orientation
Deformation mechanisms
Cement mechanics
(>20 publications)
Brittle deformation w/ AE monitoring:
Transformational faulting
Metamorphism-induced faulting
With automated deformation loop control



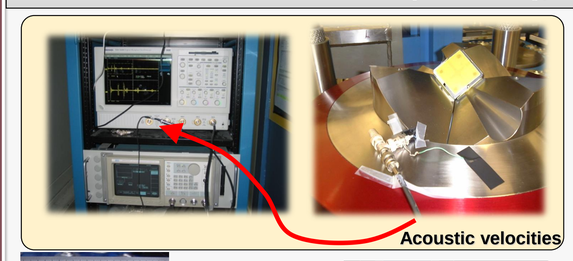
Multiple1D patterns, auto peak fitting

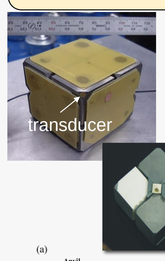


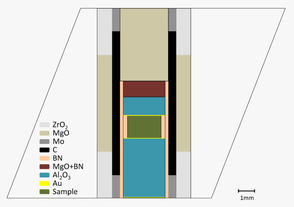
Batch fitting for lattice strain

The rheology work is supported by EAR-0652574, 0968456, 1361276.

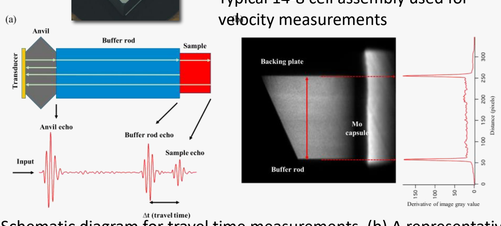
T25 (viscosity, P-Vp-Vs-Vol-T equations of state)





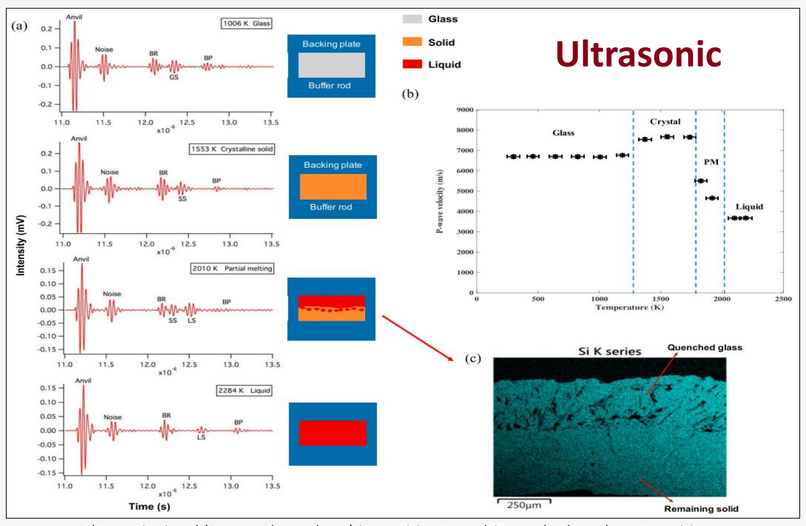


Typical 14-8 cell assembly used for velocity measurements



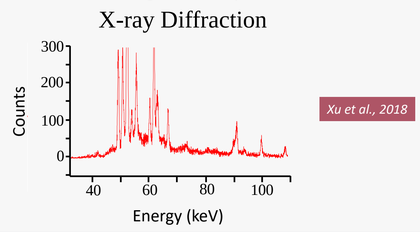
(a) Schematic diagram for travel time measurements. (b) A representative radiographic image of the sample. The sample length can be measured by plotting the derivative of image gray values versus pixel distances

Ultrasonic



Ultrasonic signal (P wave shown here) is sensitive to melting and other phase transitions

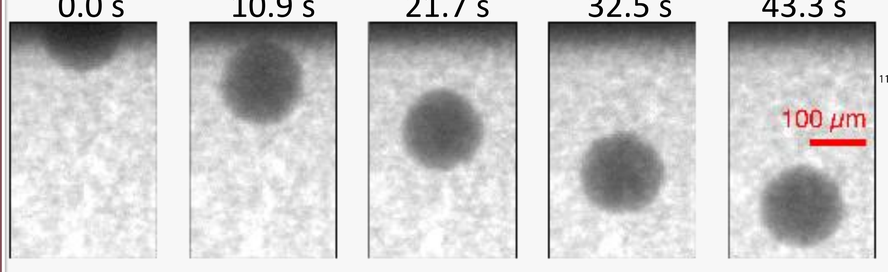
Unit cell volume at high-pressure and high-temperature can be determined via X-ray diffraction

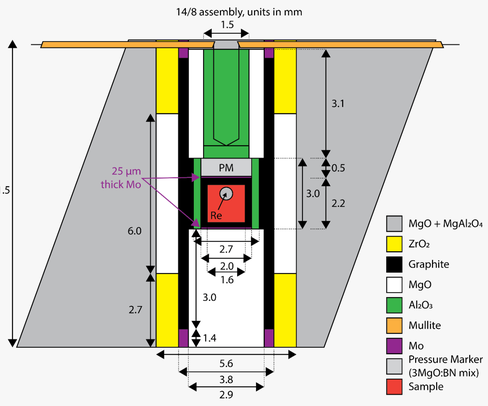


Xu et al., 2018

The ultrasonic work is supported by EAR 0711057, 1214376, 1620548, 2246803, NASA 13-PGG13-0026

Viscosity of silicate and metallic melts



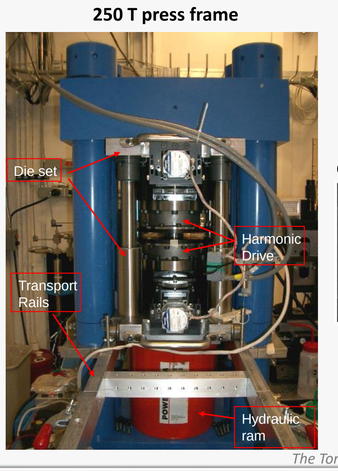


Ashley et al., submitted

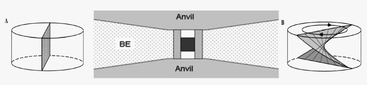
The Viscosity work is supported by EAR-0711057, 1214376, 1620548, 2246803, NASA 13-PGG13-0026.

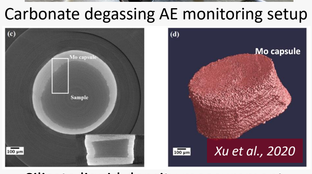
HP Tomography

250 T press frame

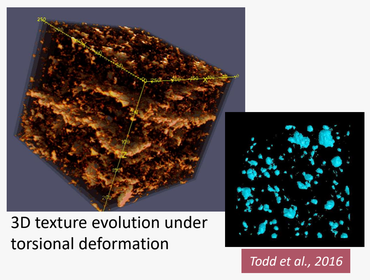


Carbonate degassing AE monitoring setup





Silicate liquid density measurement



3D texture evolution under torsional deformation

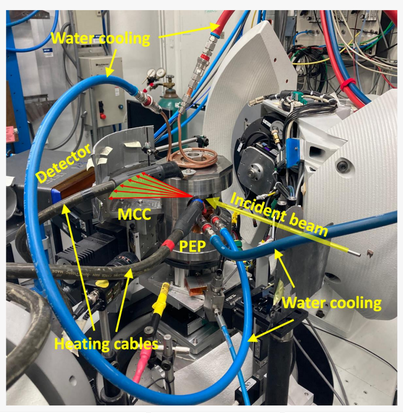
Todd et al., 2016

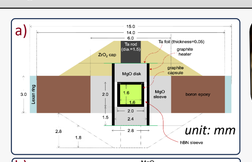
Third-order Birch-Murnaghan EOS:

$$P = \frac{3KT_0}{2}\left[\left(\frac{\rho}{\rho_0}\right)^{\frac{7}{3}} - \left(\frac{\rho}{\rho_0}\right)^{\frac{5}{3}}\right]\left\{1 + \frac{3}{4}(K'_T - 4)\left[\left(\frac{\rho}{\rho_0}\right)^{\frac{2}{3}} - 1\right]\right\}$$

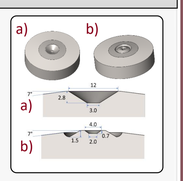
The Tomography work is supported by EAR-0001088, 0711057, 1214376, 1620548, 2246803, NASA 13-PGG13-0026.

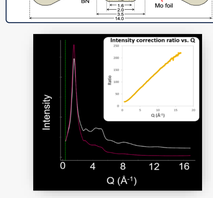
PE (amorphous structure)

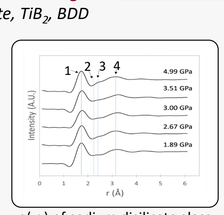




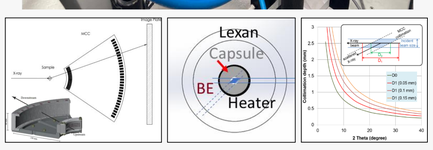
Max P: 12 GPa
Max T: 3000 K
Resistive heating:
graphite, TiB_2, BDD





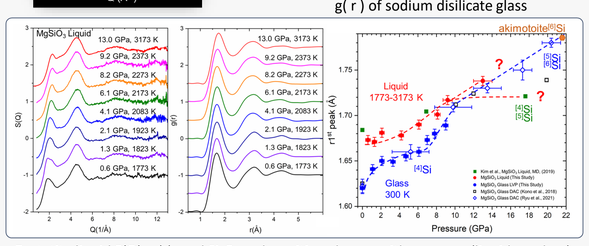


g(r) of sodium disilicate glass



Sample diameter= 0.5mm; clean sample signal at 2theta> 10°
(0.05mm incident beam)

Yu et al., 2019



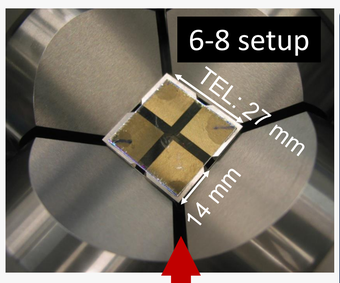
Enstatite liquid S(Q), g(r), and Si-O peak position change with pressure (liquid vs. glass)

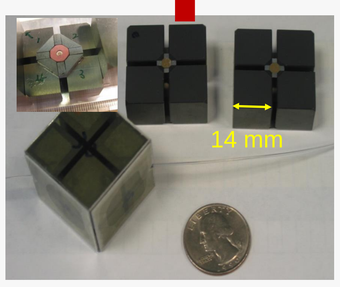
Ryu et al., in prep.

The PE Press work is supported by EAR-0711057, 1214376, 1620548, 2246803, COMPRES.

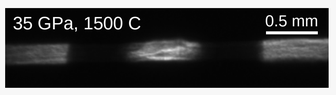
DDIA-30 (rheology, AE, high pressure)

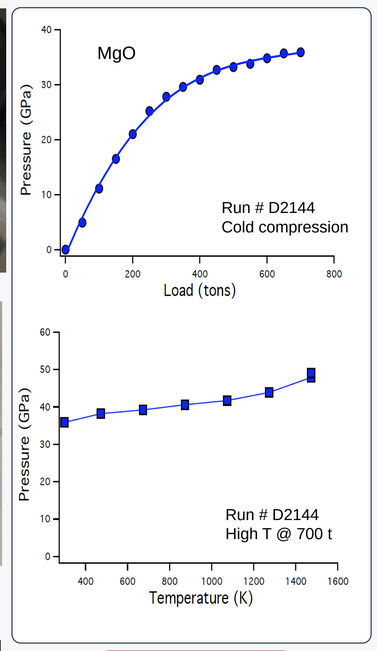
High pressure





Co binded sintered diamond anvils with 1.5 mm TELs

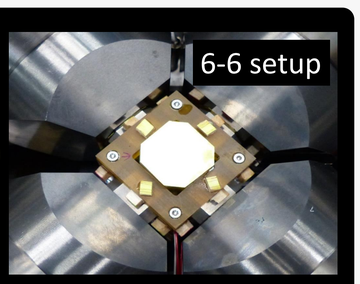




Z. Jing (SUSTech)
B. Chen (Hawaii)

Rheology; AE

Large samples
Length = 12 mm
Diameter = 6 mm
Volume = 340 mm^3
(~35x the sample volume in small DDIA)



Mg_2GeO_4 samples from Harry Green's lab

Also applicable to studying rheology of complex rocks

Officer et al., in prep.

The Acoustic emission work is supported by EAR-0652574, 0968456, 1361276, COMPRES; The High-pressure work is supported by COMPRES

Acknowledgments:

GeoSoilEnviroCARS is supported by the National Science Foundation – Earth Sciences via SEES: Synchrotron Earth and Environmental Science (EAR –2223273). This research used resources of the Advanced Photon Source, a U.S. Department of Energy (DOE) Office of Science User Facility operated for the DOE Office of Science by Argonne National Laboratory under Contract No. DE-AC02-06CH11357.