Dynamic compression response of SiO_2 at different strain rates

Karen Appel

HED instrument at European XFEL
3rd DyCoMax Workshop,
January 14th -- 15th, Grenoble, France and online

Acknowledgements

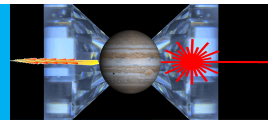
XFEL team: Markus Schoelmerich, Nicole Biedermann, Christian Plückthun, Lennart Wollenweber, Thomas Preston, Ulf Zastrau, Thomas Tschentscher (all experiments)

dDAC work: Hanns-Peter Liermann, Alba Mendez

Optical laser dynamic compression: Cindy Bolme, Arianna Gleason, Sally Tracy, Ray Smith, B. Nagler, E. Galtier, E. Cunningham (LCLS experiments), Marion Harmand, Norimasa Ozaki, Srikant Baht, Robert Farla, Yuishi Inubushi, Kento Kantagiri, Kohei Miyanishi, Tsubasa Tobase, Tadashi Togashi, Yuhei Umeda, Toshinori Yabuuchi (SACLA experiments)

Ronald Redmer, Rostock

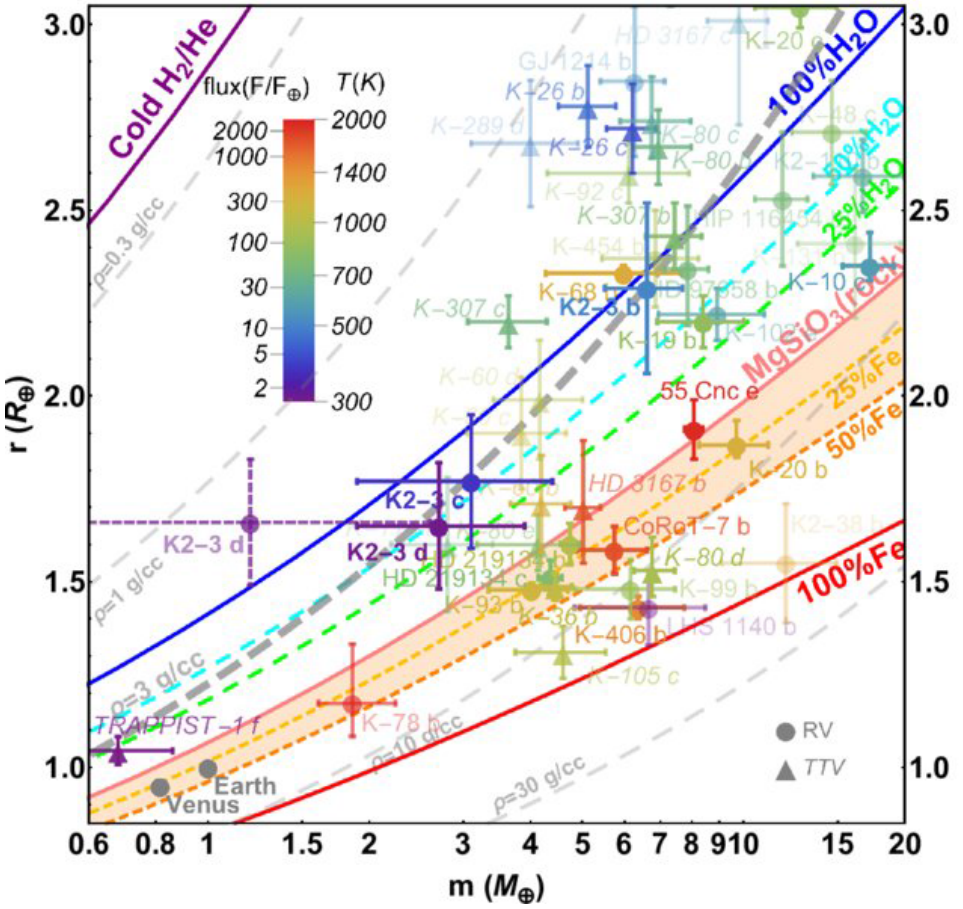
DFG Research Unit „Matter Under Planetary Interior Conditions“



DFG Deutsche Forschungsgemeinschaft

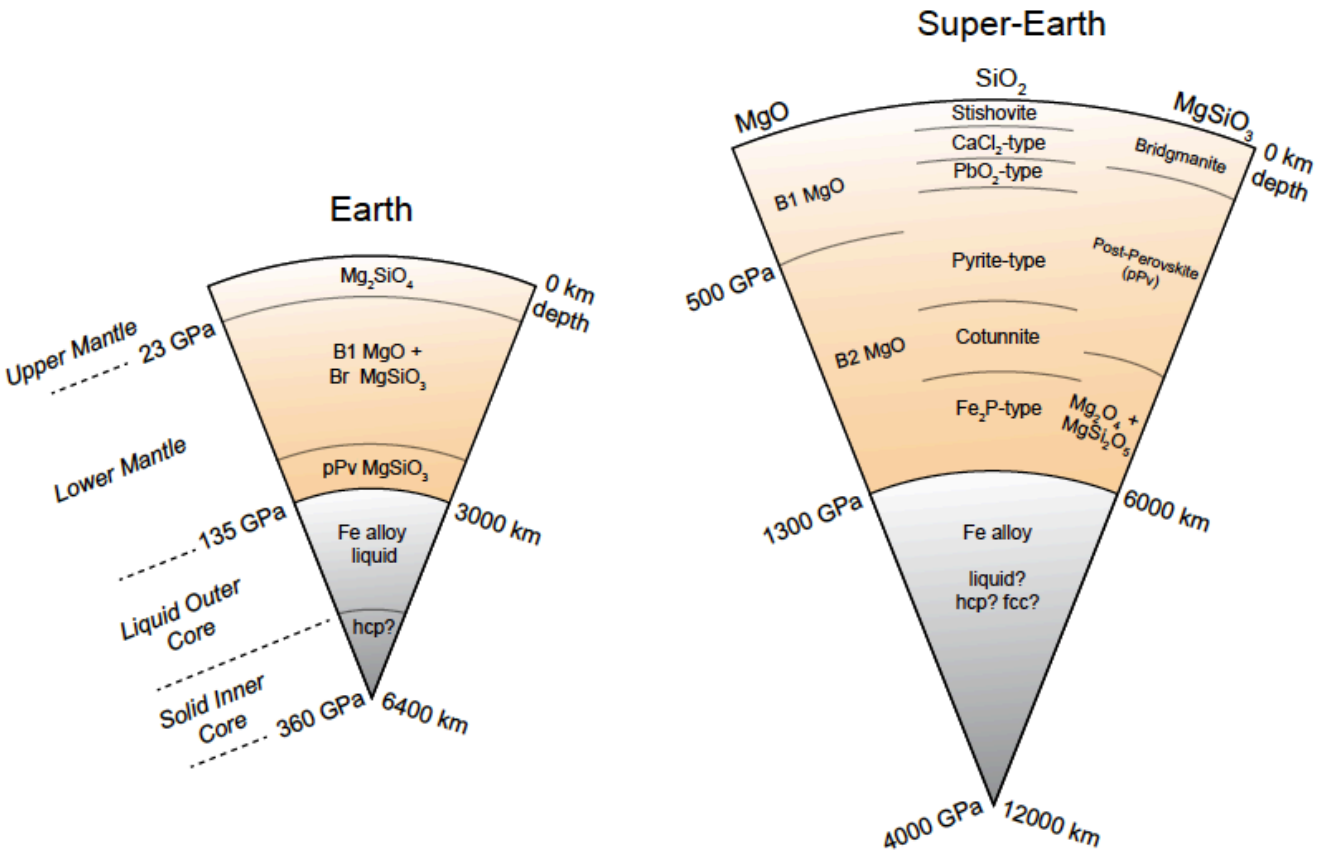
The HED science within planets and exoplanets

- Phase relations
- Crystal chemistry
- Physical properties (viscosity, density, heat transport, plasticity..)
- Reactions of phases at relevant conditions
- Evolution of the Earth and planets



Modified after Damasso et al., 2018; Zeng & Sasselov, 2013

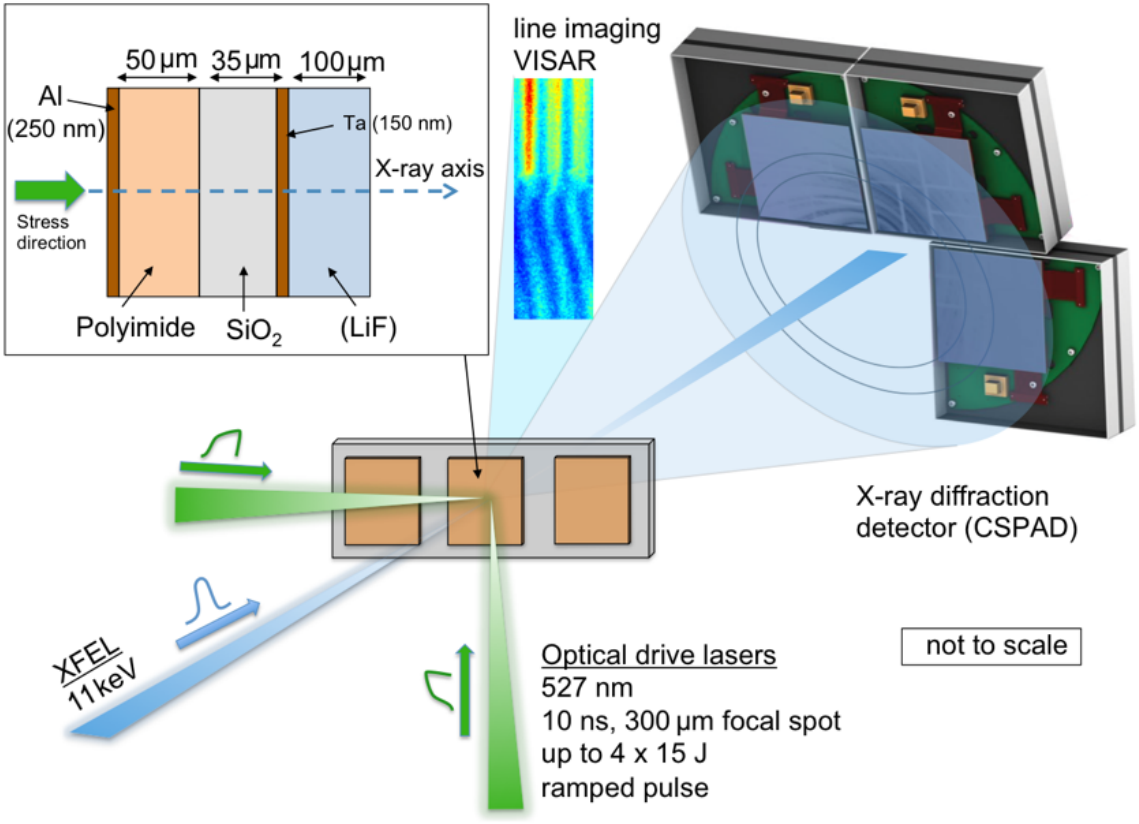
Structural properties and phase stabilities of rock-forming minerals at PT regime relevant for deep planetary interiors

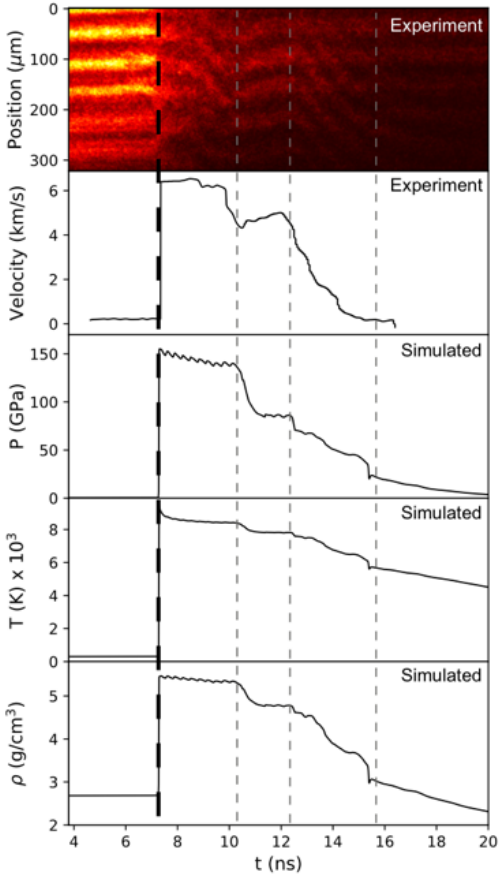


- Dynamic optical laser compression experiments (quartz, fused silica, stishovite, cristobalite, GeO_2)
- Target design and experimental condition control with hydrodynamic simulations
- Obtain EoS data, identification of phase boundaries, derive melt structure

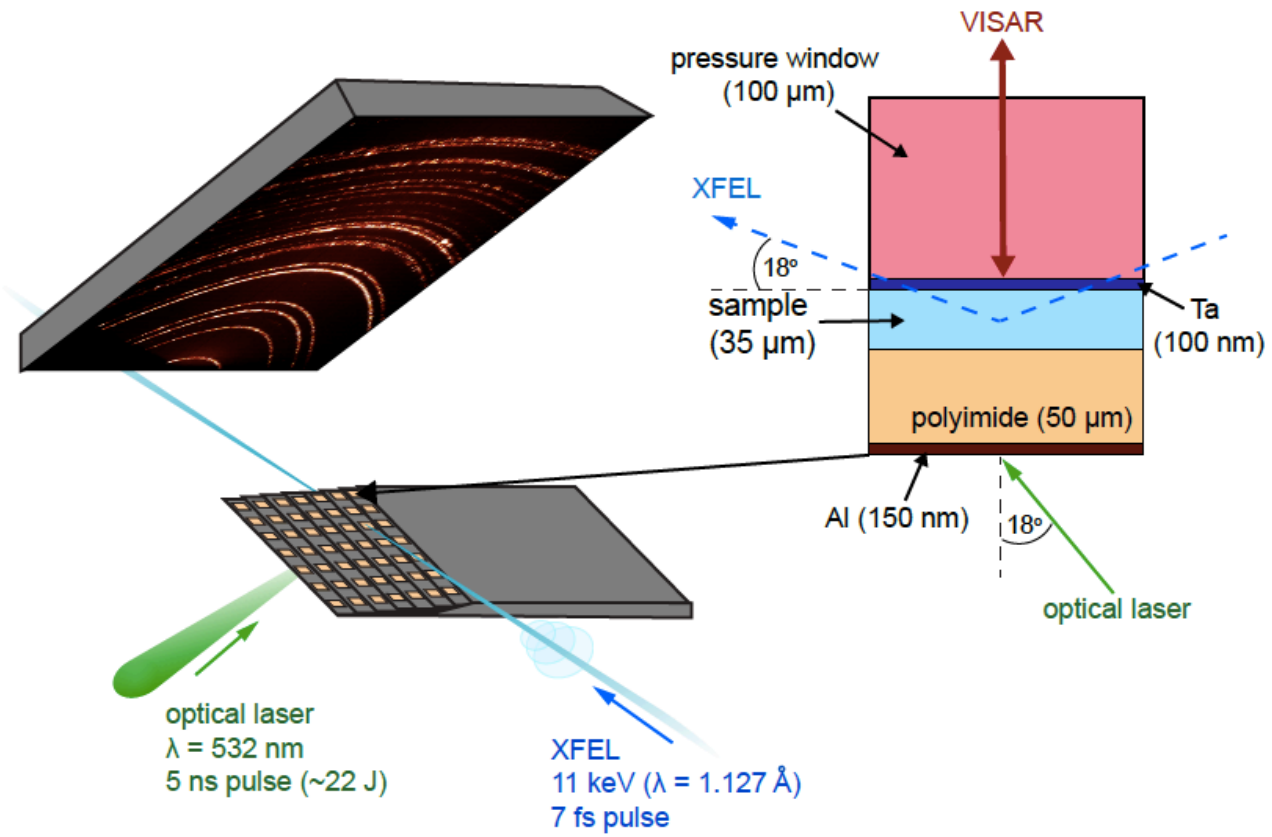
Schoelmerich PhD thesis, 2020

Set-up dynamic compression at MEC, LCLS, LS84



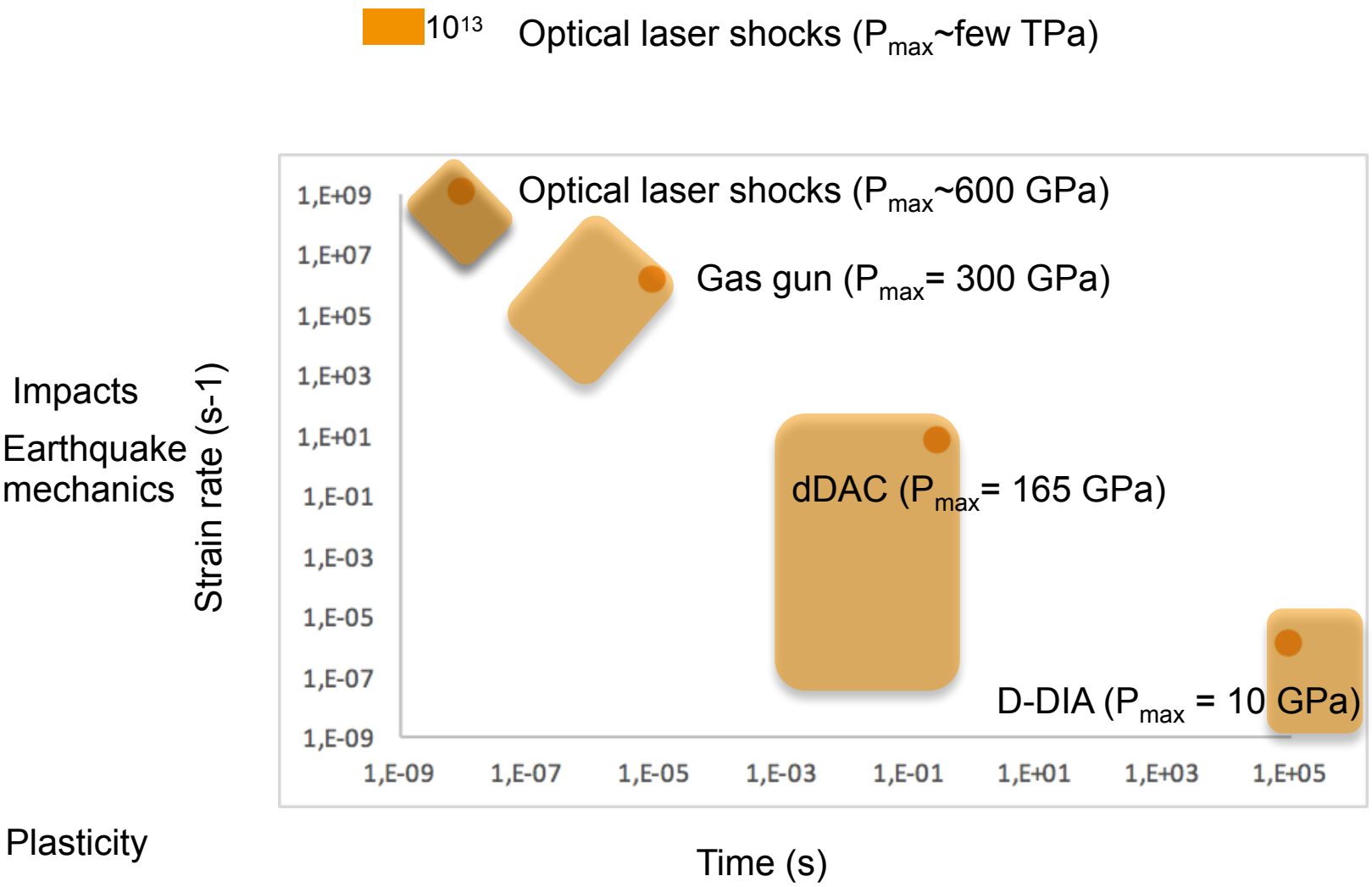


Set-up dynamic compression at EH3, SACLA



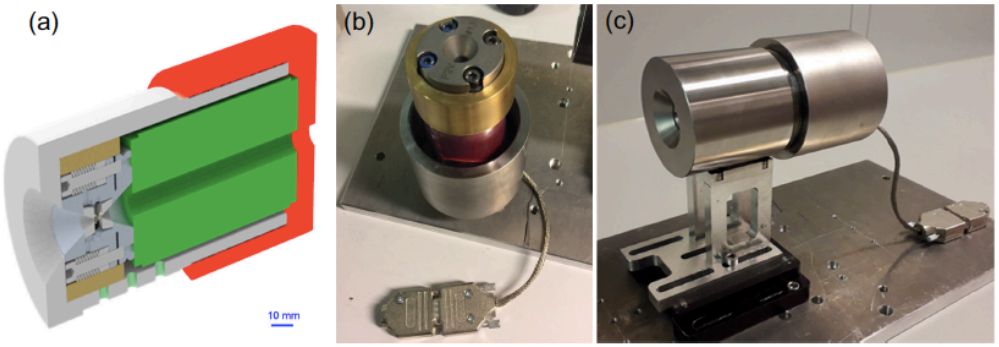
Schoelmerich et al., Sci.Rep., 2020

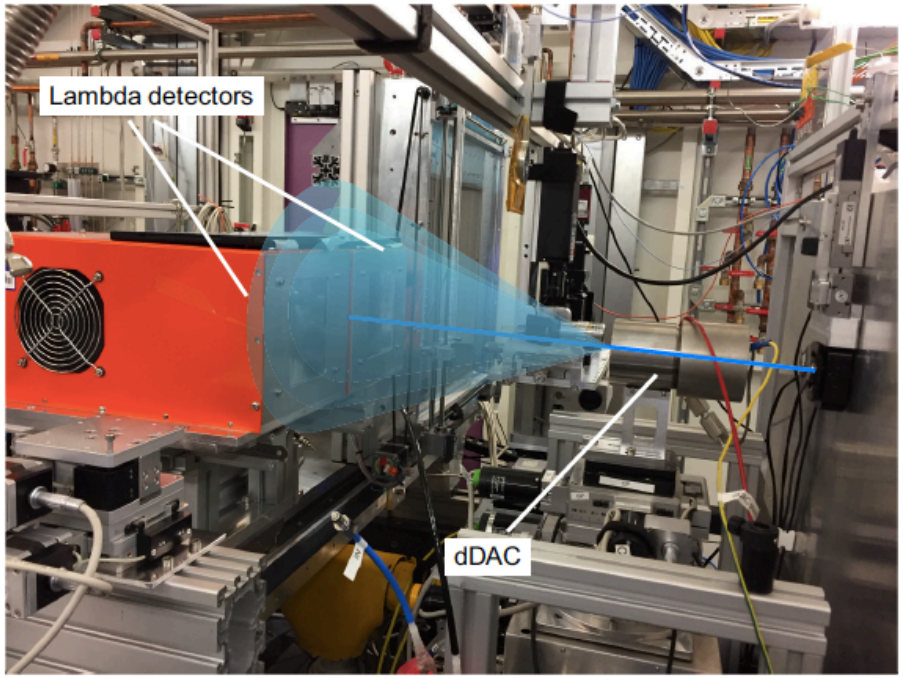
Strain rates and duration of experimental HP techniques

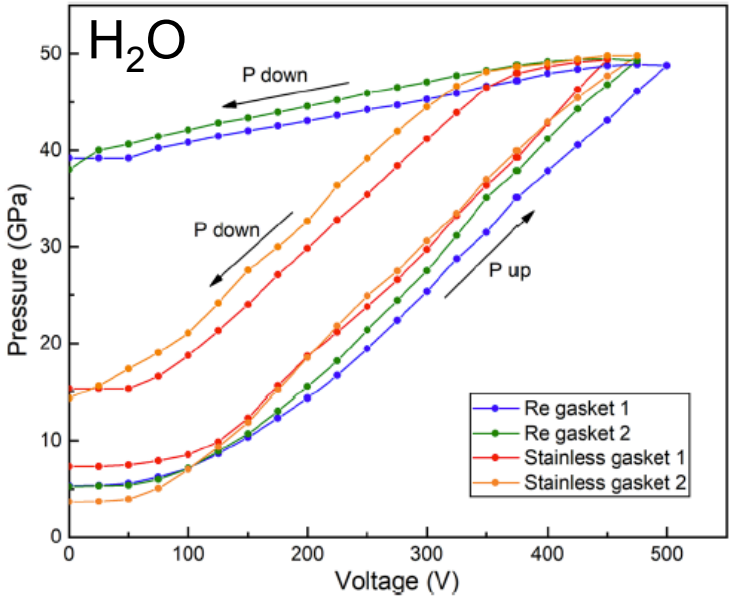


Set-up dynamic compression in a DAC at P02.2

- Up to 160 GPa
- Up to 160 TPa/sec
- 4 kHz repetition rate



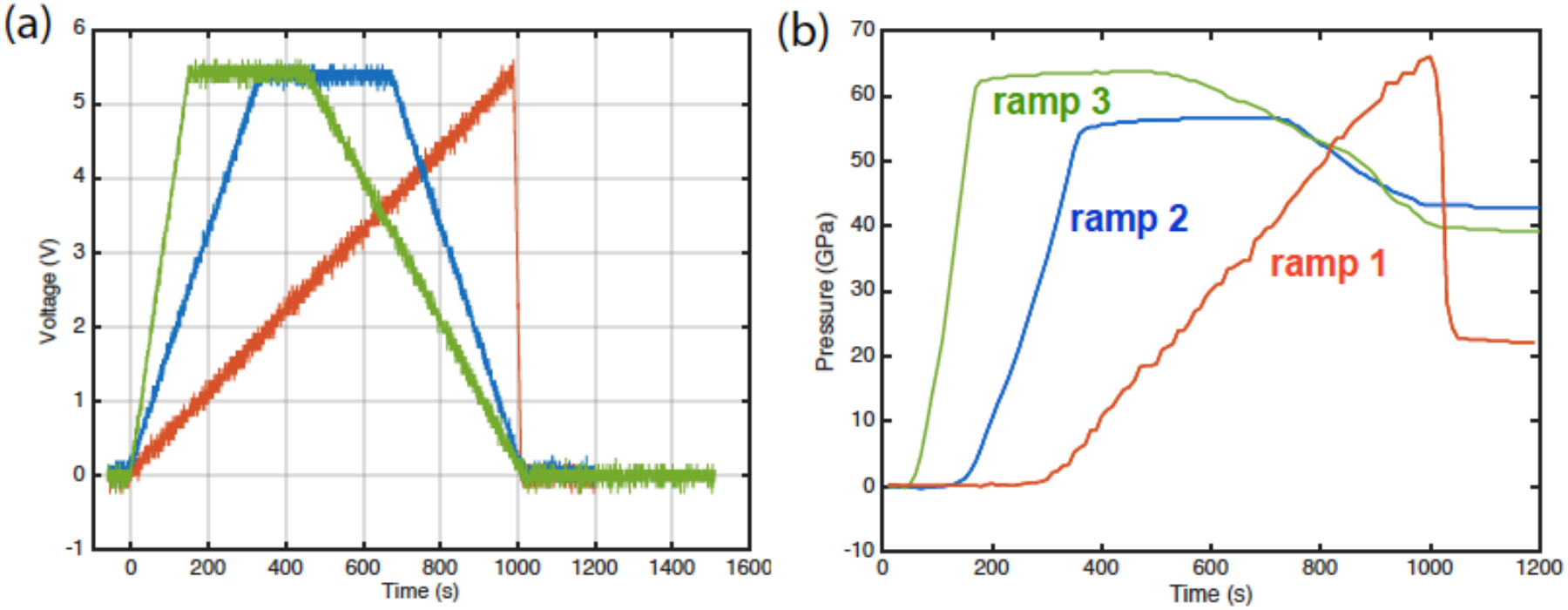




Jenei et al., 2019

Schoelmerich, PhD thesis, 2020

Dynamic compression pathways in a dDAC

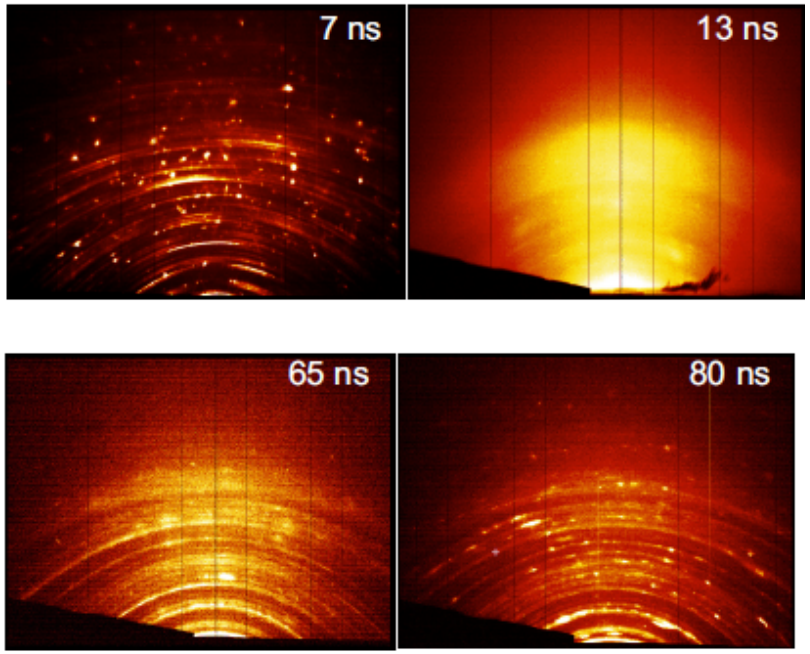


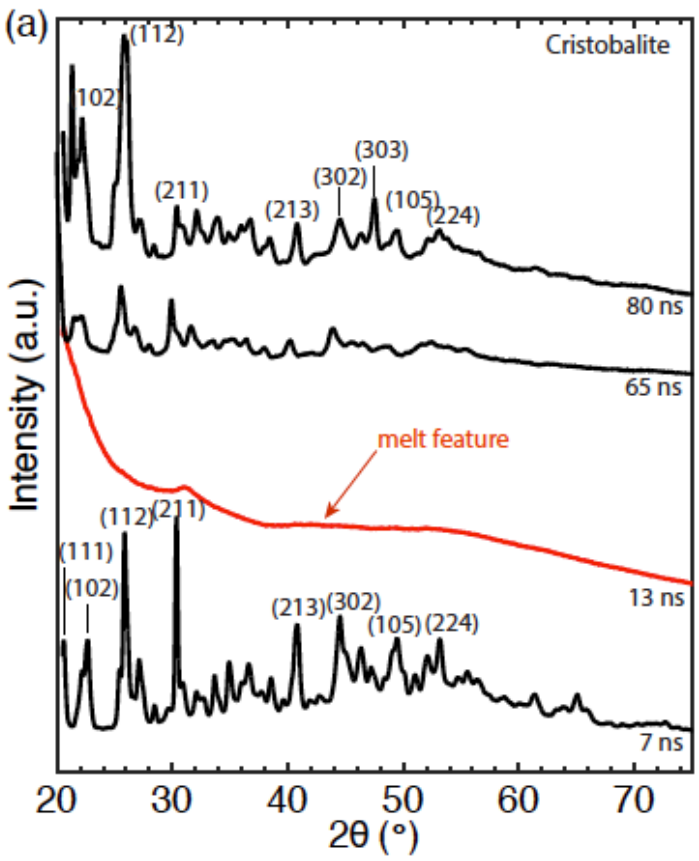
Schoelmerich, PhD thesis, 2020

Results

Optical laser induced dynamic compression

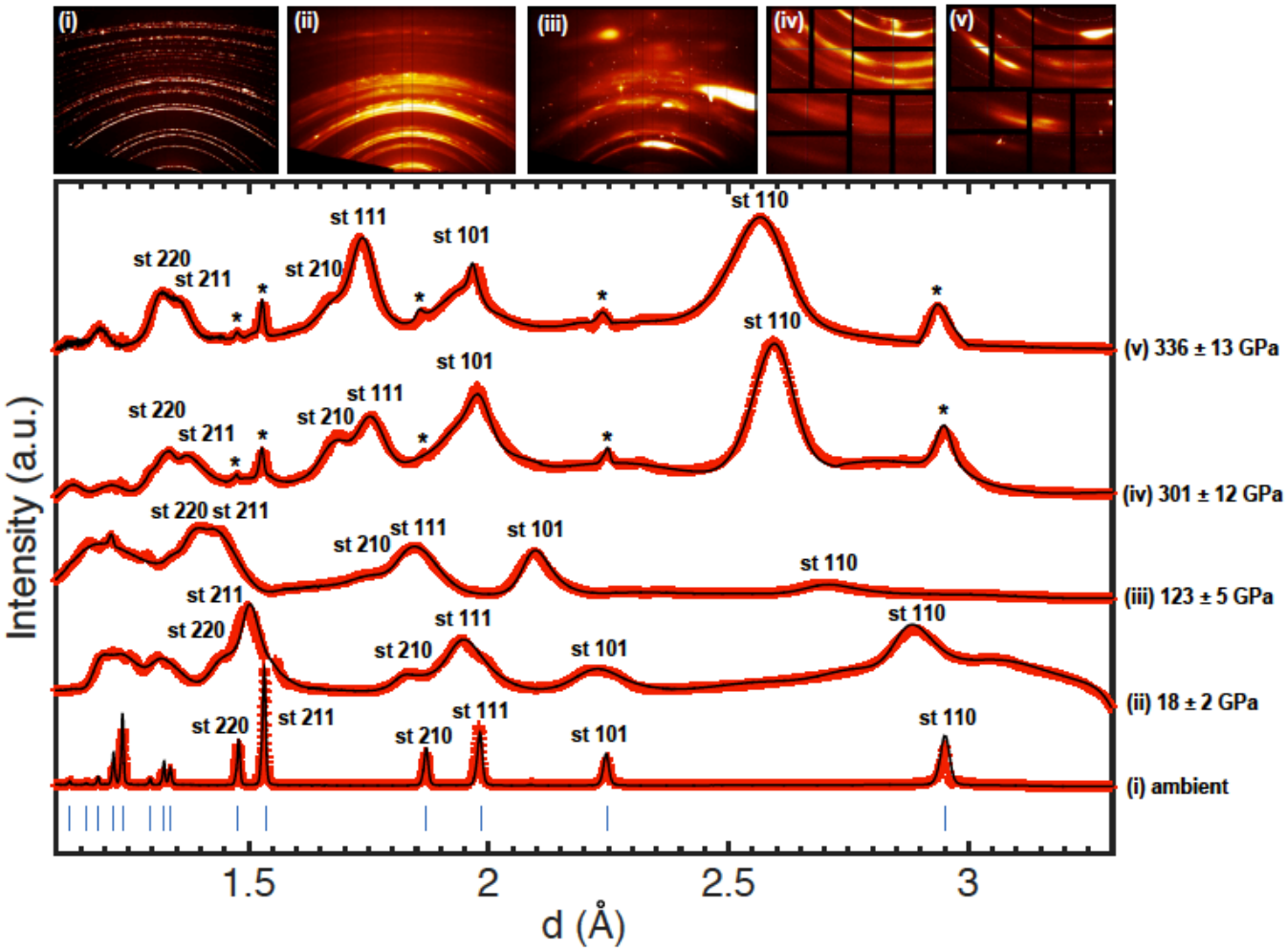
α-cristobalite during optical laser induced dynamic compression





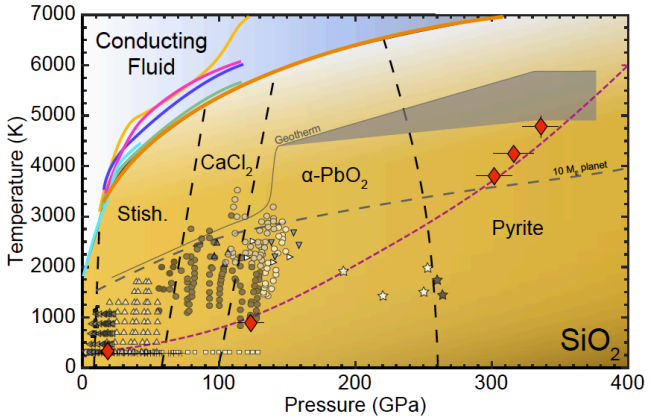
Schoelmerich, PhD thesis, 2020

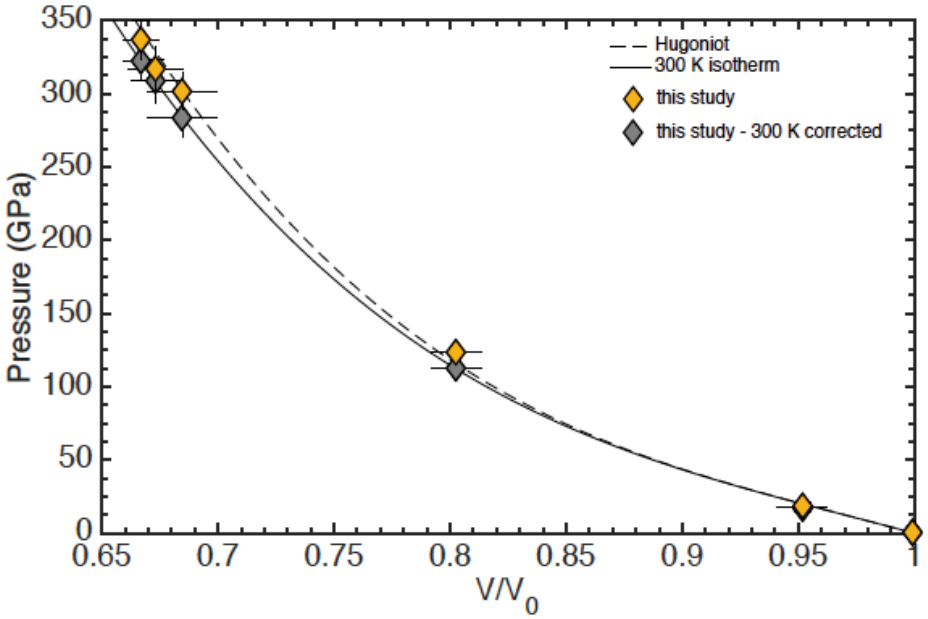
Response of stishovite during dynamic compression

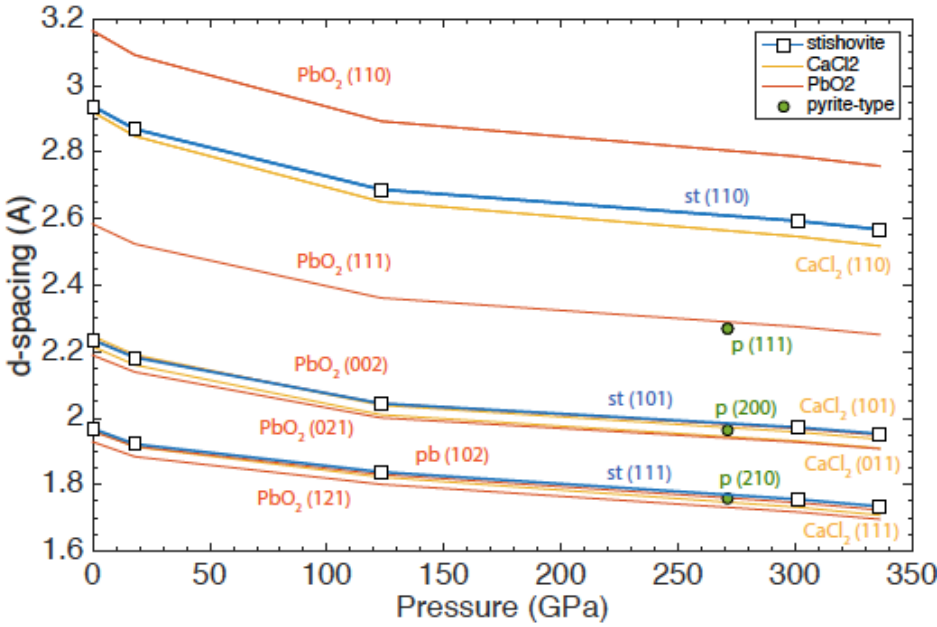


Schoelmerich et al., 2020

Relative volume change of shock compressed stishovite vs pressure and comparison to other polymorphs

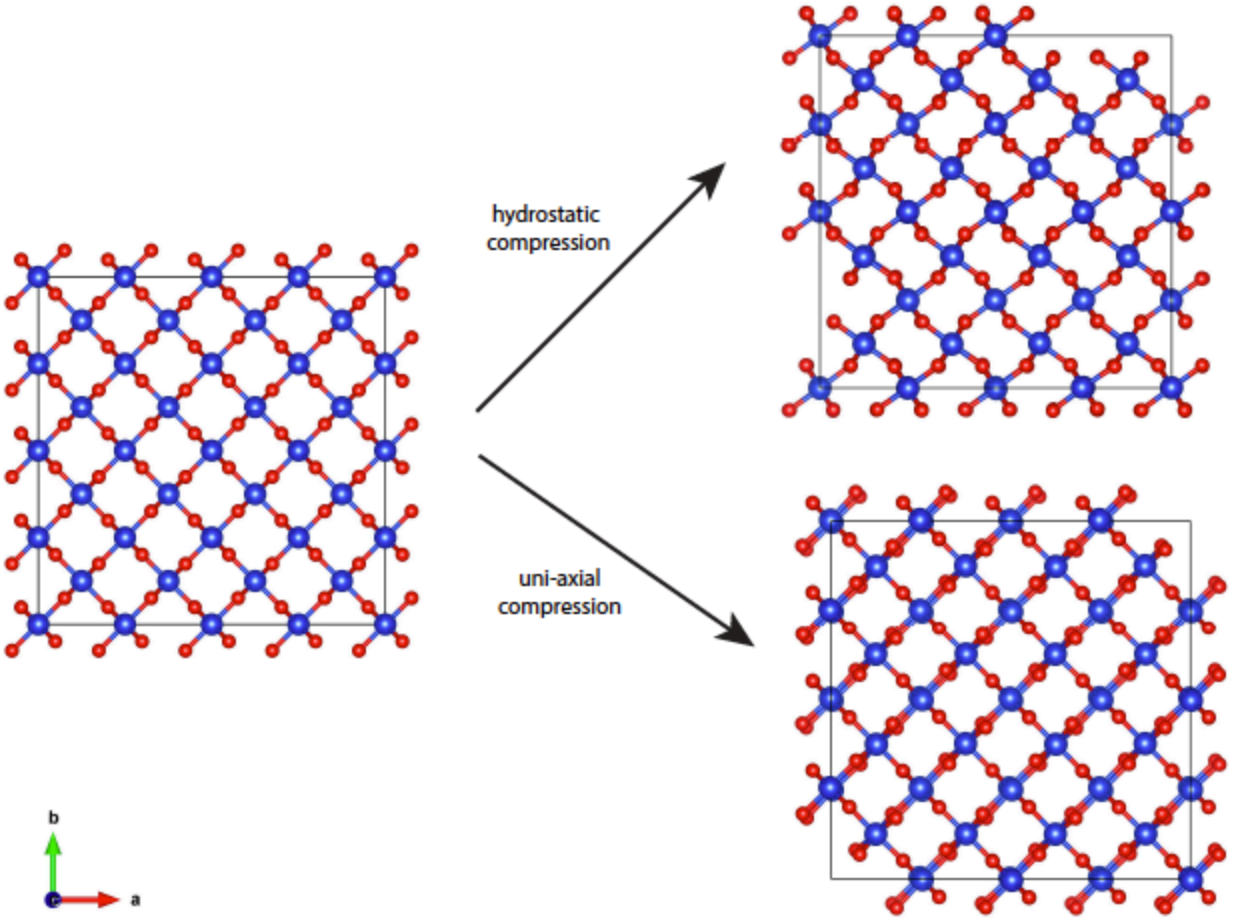






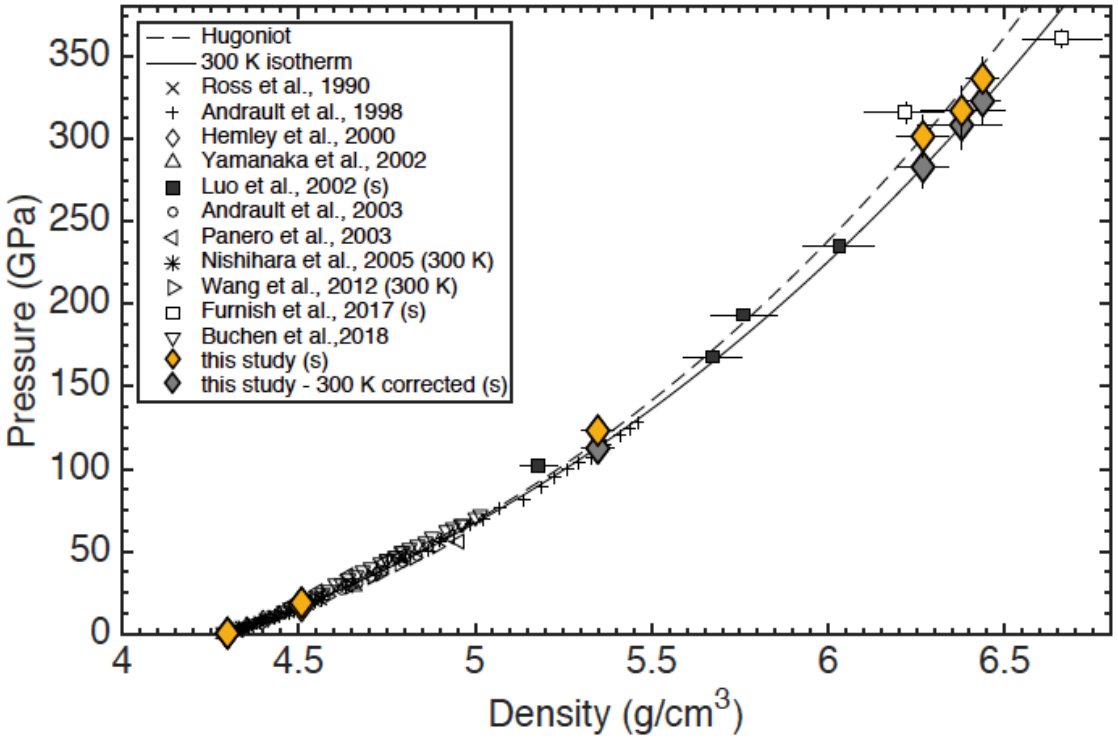
Schoelmerich et al., 2020

DFT-MD simulation for stishovite



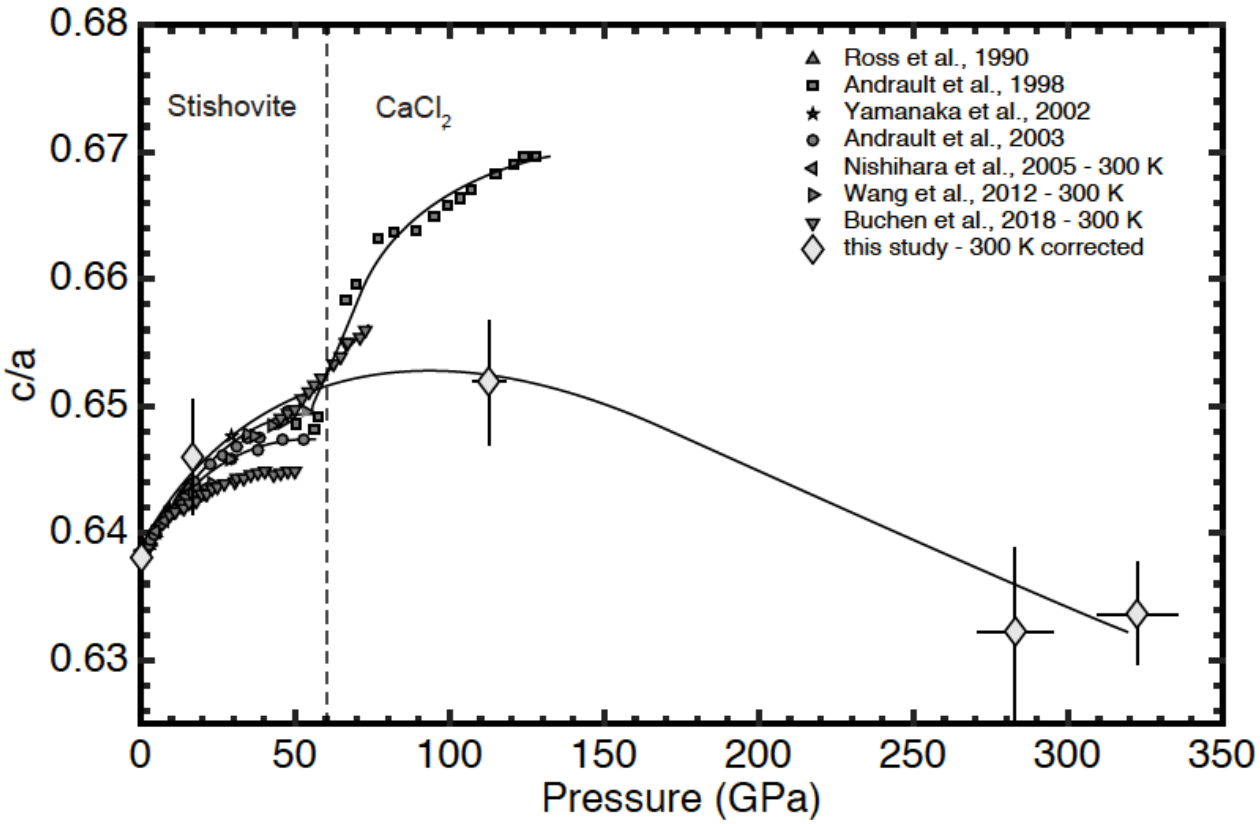
Schoelmerich, PhD thesis, 2020

Pressure – density data of stishovite



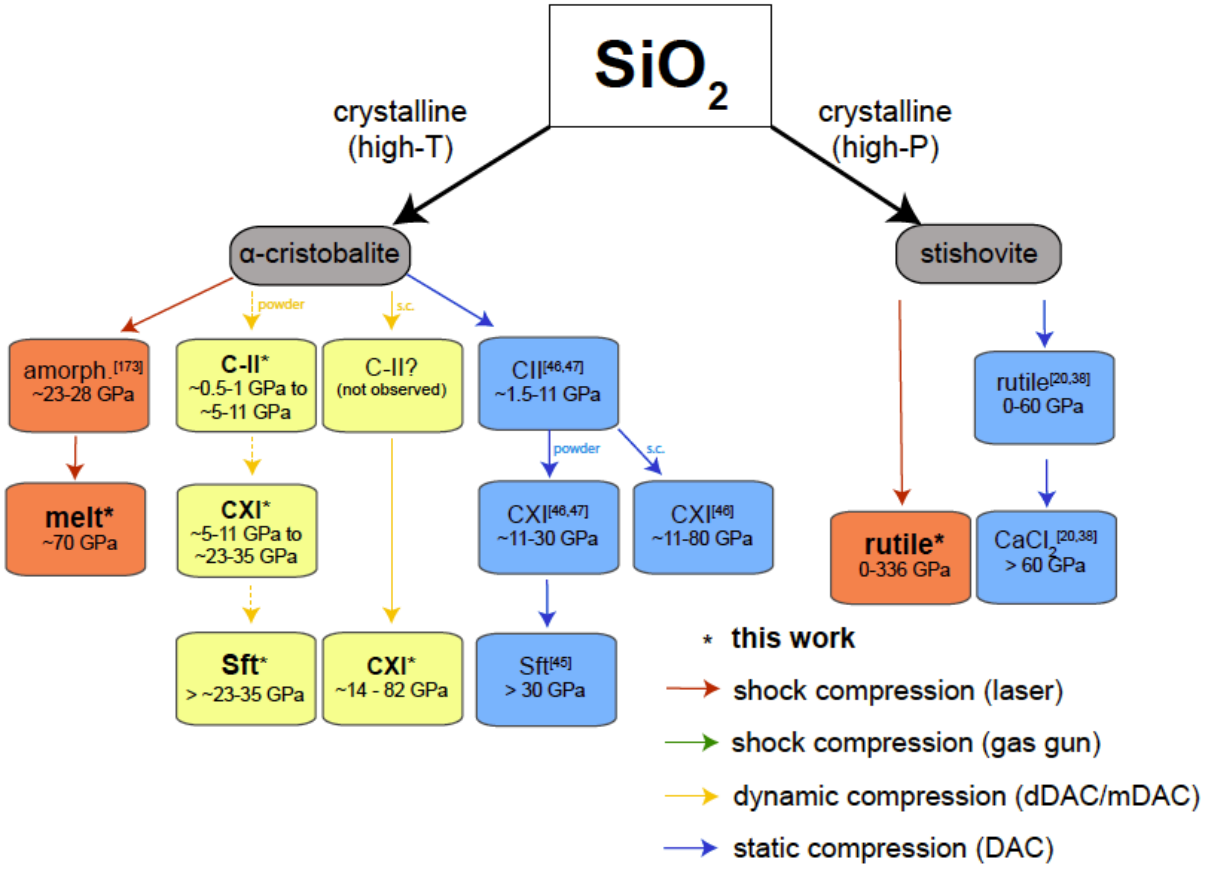
Schoelmerich et al., 2020

Effect of hydrostacity on the structural transition pathway



Schoelmerich et al., 2020

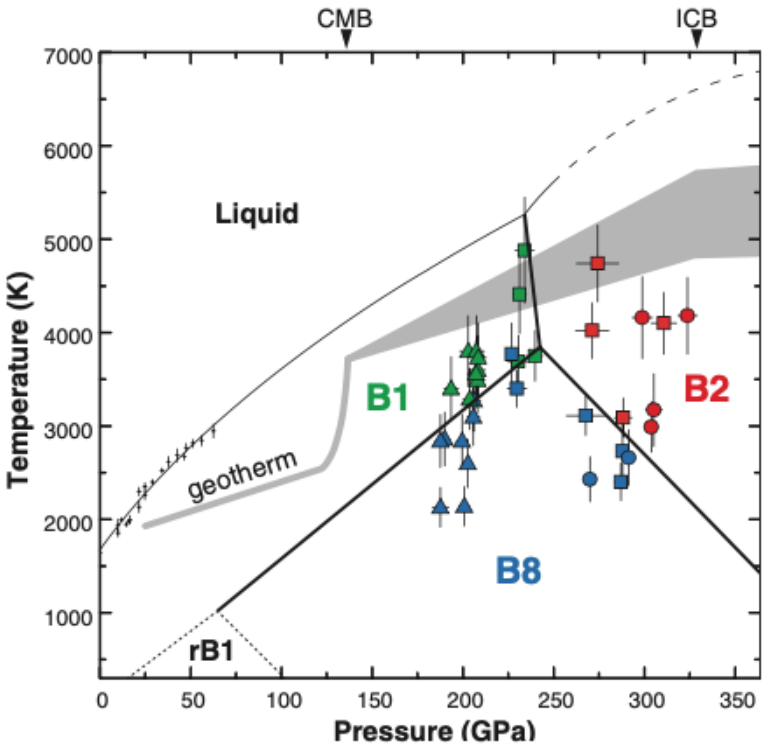
Summary on structural transformation pathways in SiO_2 polymorphs



Schoelmerich, PhD thesis, 2020

Interest in experiments at dynamic compression facility at ESRF

FeO



Ozawa et al, 2011

- Further development of dynamic compression technique
  - Sample preparation
  - Data analysis
  - X-ray techniques
- Study well-known rock-forming systems at ultrahigh pressures and high temperatures
- Apply XANES to study phase relations, electronic and thermo-elastic properties of phases in the binary system Fe-O, to prepare ternary systems (Fe-Mg-O), and quaternary (Fe-Mg-Si-O).
- XRD experiments planned within a DFG funded project at HED (PhD student starts in mid-Feb)