2025 Users' Meeting

Electronic properties of ferropericlase (Fe,Mg)O obtained from dynamic compression experiments using DiPOLE100-X at European XFEL.

C. Camarda[1,2], K. Appel[1], Buakor. K[1,3], Amoureti. A[4], Crepisson. C[5], Harmand. M[6], Pennacchioni. L[7], Sieber. M[7], Sternemann. C[2] and on behalf of DiPOLE Community (proposal 6656)

1 European X-ray Free Electron Laser (Eu.XFEL); 2 Technische Universitat Dortmund; 3 Rostock University; 4 SACLA-Japanese XFEL; 5 Processes and Engineering in Mechanics and Materials (PIMM); 6 University of Oxford; 7 Potsdam University.)

Abstract

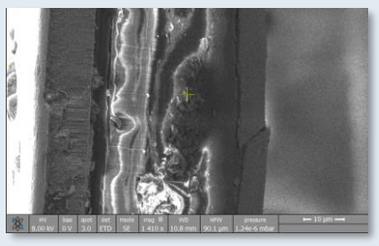
This study focuses on the behavior of ferropericlase under extreme conditions that simulate the environment near the core-mantle boundary (CMB) and within the outer core, at pressures around 130 GPa and temperatures of about 3500 K related to a depth of approximately 2800 km by using shock compression experiments. This study aims at deepening understanding of ferropericlase's role in geophysical processes occurring at extreme conditions within Earth's interior, ultimately contributing valuable insights into core formation theories and mantle dynamics. To investigate these properties, we synthesized ferropericlase ($Fe_{0.15}Mg_{0.85}O$) samples resembling pyrolytic mantle composition suitable for dynamic compression experiments.

Motivation

- (Fe,Mg)O is the second most abundant mineral in Earth mantle.
- Spin transition information with shock experiments are still lacking.
- Information for FeMgO in conditions close to the CMB are still incomplete.

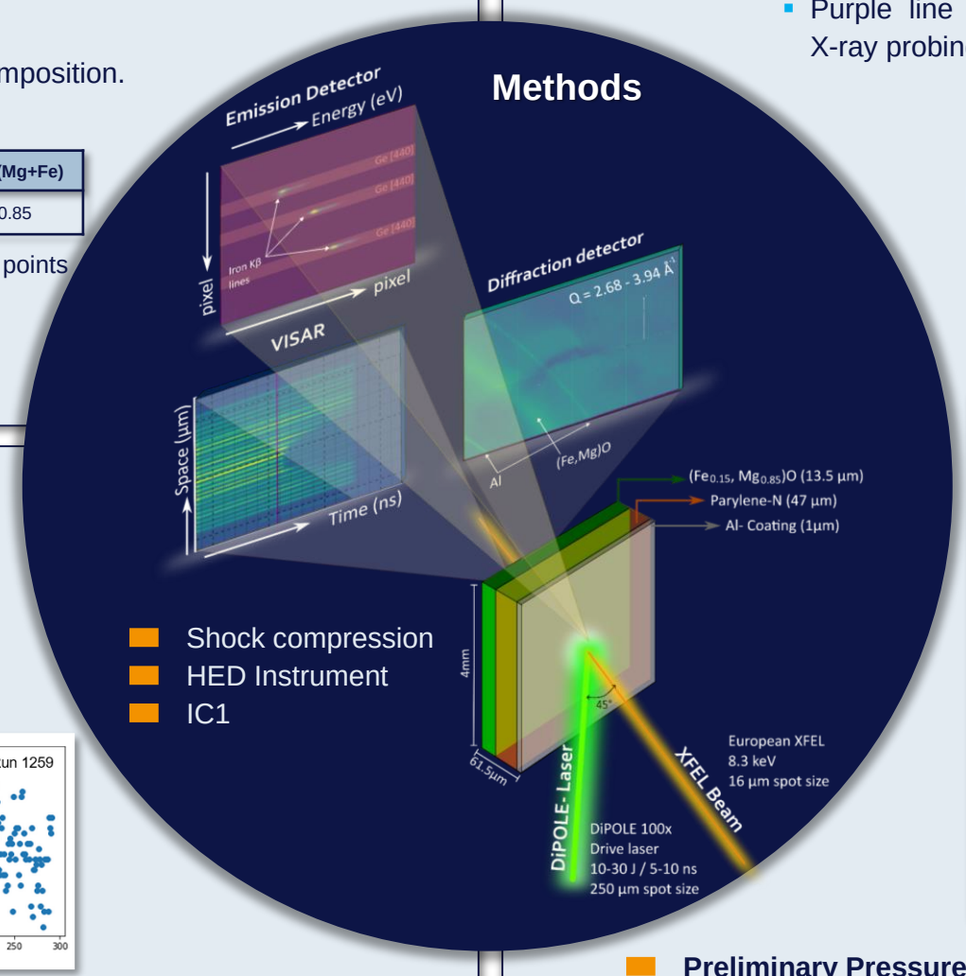
Sample Characterization

- Synthesized using physical vapor deposition.
- e-SEM (FEI Quanta 450) analysis to get the composition.



*#atom%			
O	Mg	Fe	Mg/(Mg+Fe)
31.9	58.3	10.6	0.85

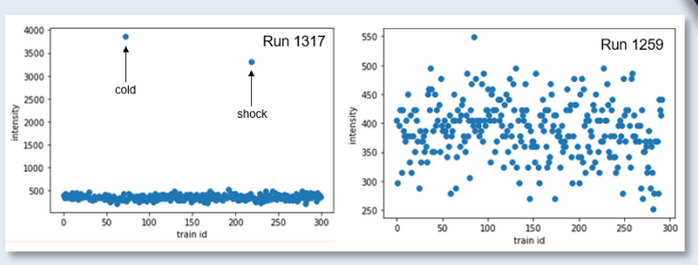
*Average of 50 analyzed points



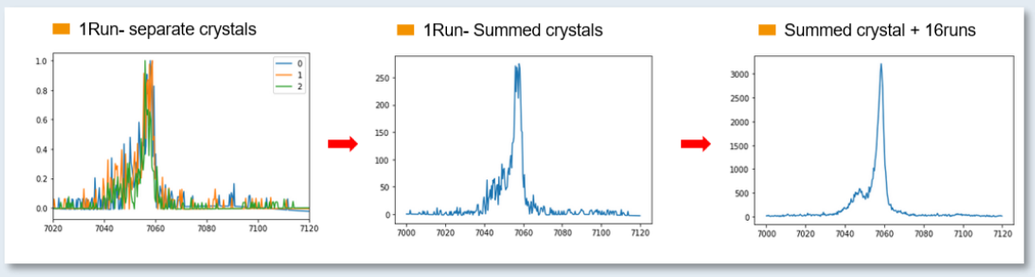
Data Processing

XES

- Calibrate ROIs and align Kβ lines.
- Check the train ID, and use the values. when the X-rays arrived.
- Sum-ups



- Fe-standard

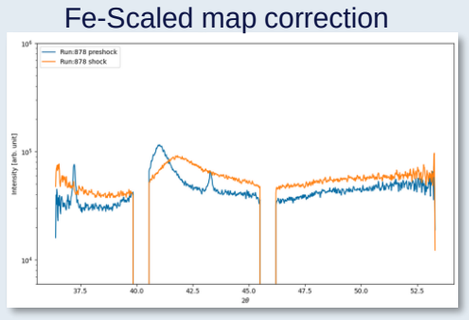


XRD

- Apply flat fielding correction.
- Sum-up the XRDs patterns.
- Calcalculate the unit cell for ferropericlase.

No Correction

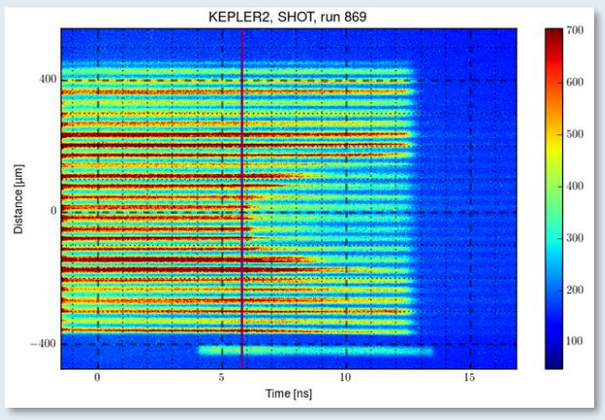
Fe-Scaled map correction



Results

VISAR

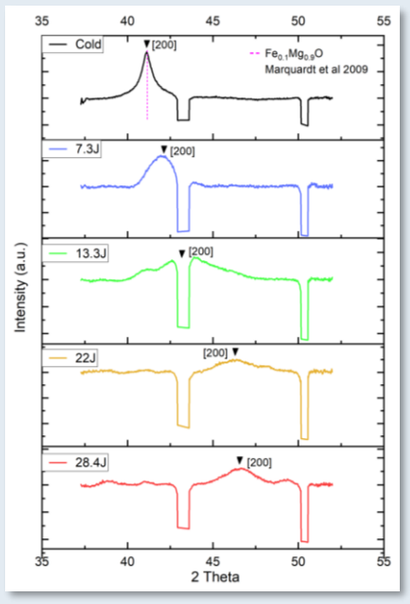
- Used to calculate the breakout, shock and particle velocity, to get the pressure and the density along the Hugoniot



- Purple line is the FEL X-ray probing time

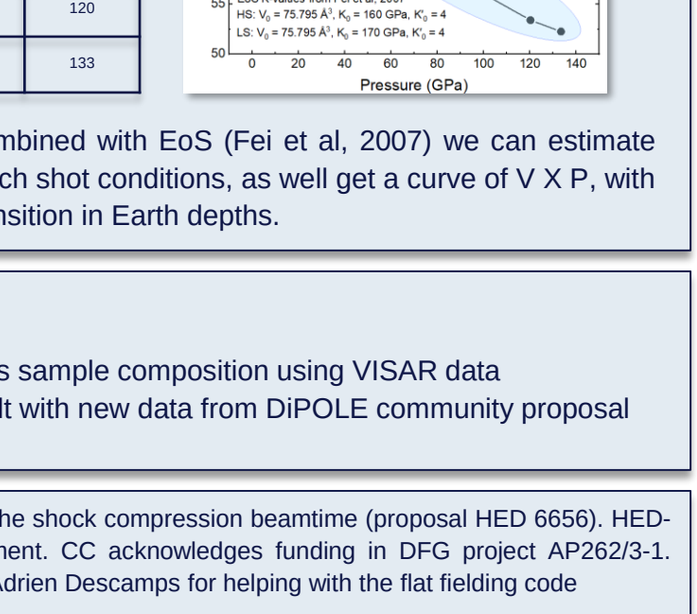
XRD

- Fe-Scaled map Correction
- B1- Cubic Cell
- Used to calculate the Unit Cell Volume based on reflection [200]



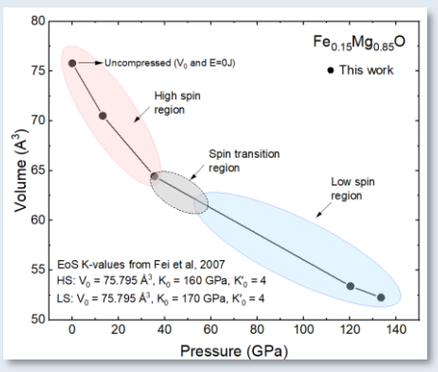
XES

- Crossed the boundry from High Spin to Low Spin.
- Energy shift = 2eV
- 13.3J start of the transition (?)



Preliminary Pressure Evaluation

Laser conditions	Relative time B.O (ns)	Number of runs	V (Å³)	Estimated pressure from unit-cell volume (GPa)
No laser	-	> 50	75.8	0
7.3 J	0.6ns after	7	70.5	13
13.3 J	1.2ns before	14	64.4	35
22 J	0.6ns before	11	53.4	120
28.4 J	0.8ns before	13	52.2	133



- Based on our first results combined with EoS (Fei et al, 2007) we can estimate the pressure that we got in each shot conditions, as well get a curve of V X P, with information about the spin transition in Earth depths.

Next Steps

- Establish the Hugoniot for this sample composition using VISAR data
- Study the structure of the melt with new data from DiPOLE community proposal 6659 experiment.

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. **Reference:** Fei et al. Spin transition and equations of state of (Mg, Fe)O solid solutions. Geophys. Res. Lett., 34, L17307 (2007) 10.1029/2007GL030712

European XFEL GmbH, Carolina Camarda, Holzkoppel 4, 22869 Schenefeld, Germany, Carolina.camarda@xfel.eu
www.xfel.eu

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