Phase stabilities and Fe/Sr/La partitioning between magnesite and mantle silicate at lower mantle conditions.

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Aims:

1. Determination of the stability of magnesite ($MgCO_3$) in presence of Mg,Fe-rich mantle silicate (bridgmanite)

2. Investigation of the trace elements partitioning in the reaction products.

Studied reaction :

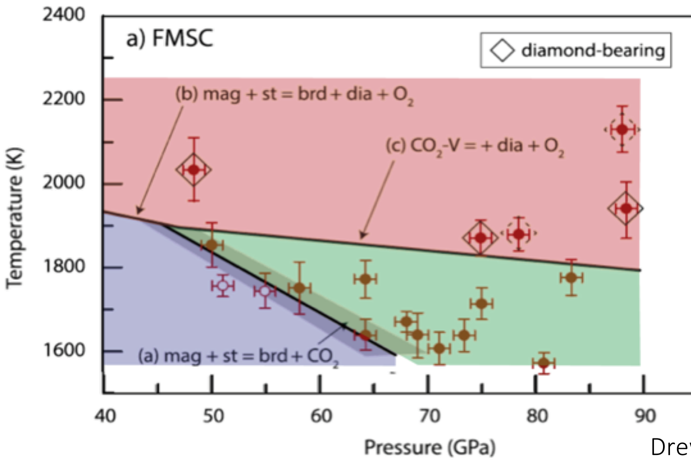
$MgCO_3 + (Mg_{0.8}Fe_{0.2})SiO_3$-glass doped with Sr or La

By using high-pressure and high-temperature experiments

- Multi-anvil press experiments for 25 to 30 GPa
- Laser-heated diamond anvil cell for >30 GPa

Previous studies

- The $MgCO_3$ + SiO_2 system has been intensively studied in experiments and by *ab-initio* simulations [1]. This system shows the decomposition of magnesite at lower mantle conditions into CO_2 or diamond



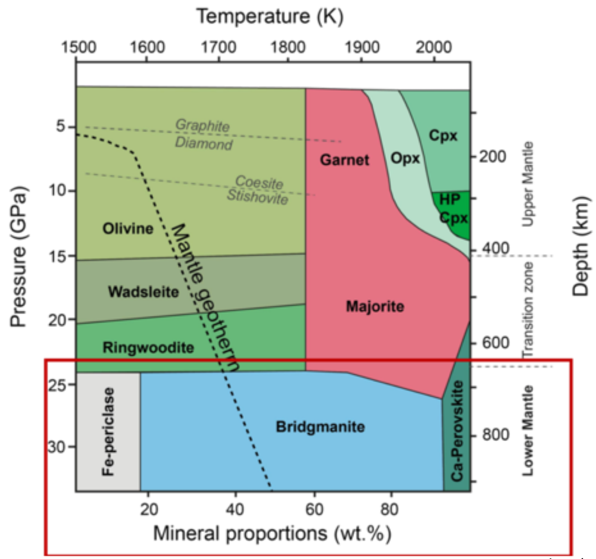
Drewitt (2019)

$MgCO_3 + SiO_2$ –> $MgSiO_3 + CO_2$ (solid)
$MgCO_3 + SiO_2$ –> $MgSiO_3$ + C (diamond) + O_2

[1] Oganov (2008) ; Seto (2008) ; Maeda (2017) Litasov (2008a) & Drewitt (2019)

- Determination of the melting curve in the $MgCO_3$ – $MgSiO_3$ system by Thomson et al. (2014) in an iron-free system.

- We investigate the reaction in a system closer to the natural system. In contrast to previous studies, we are considering that the composition of the lower mantle is described by the pyrolite model. It implies that the major mineral present in the lower mantle is bridgmanite $(Mg,Fe)SiO_3$.



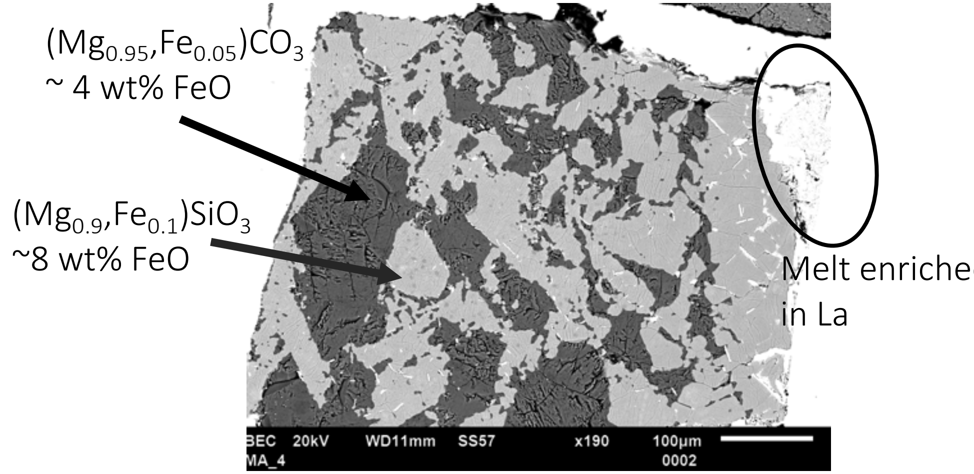
Kaminsky (2011)

High-pressure and high-temperature experiments

- **Multi-anvil press** (MAP) experiment

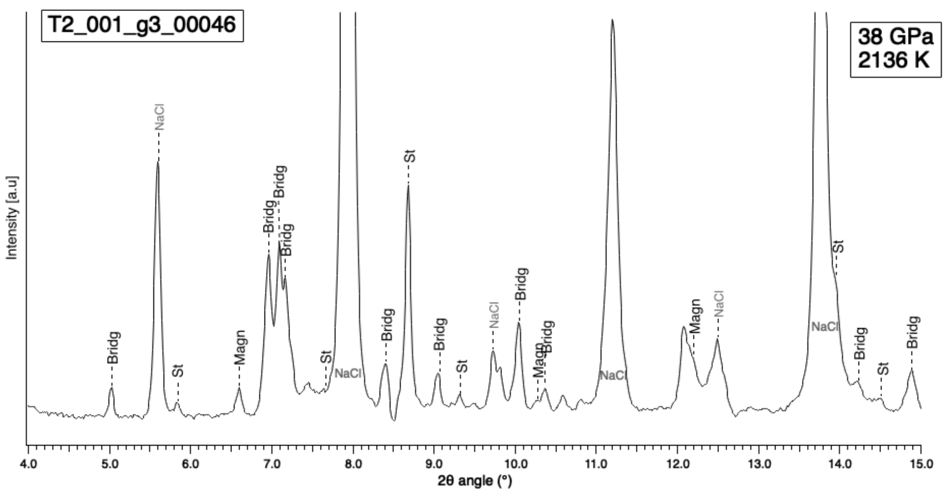
25 GPa – 2000 K – EPMA analyses

The MAP data show some melting that is consistent with the melting curve of Thomson et al (2014) (see next slide). The Fe partitioned between the bridgmanite and magnesite with a partitioning coefficient of 2.



Back-scattered electron image of the multi-anvil press capsule (Re) after experiment.

- **Laser-heated diamond anvil cell** (LH-DAC)

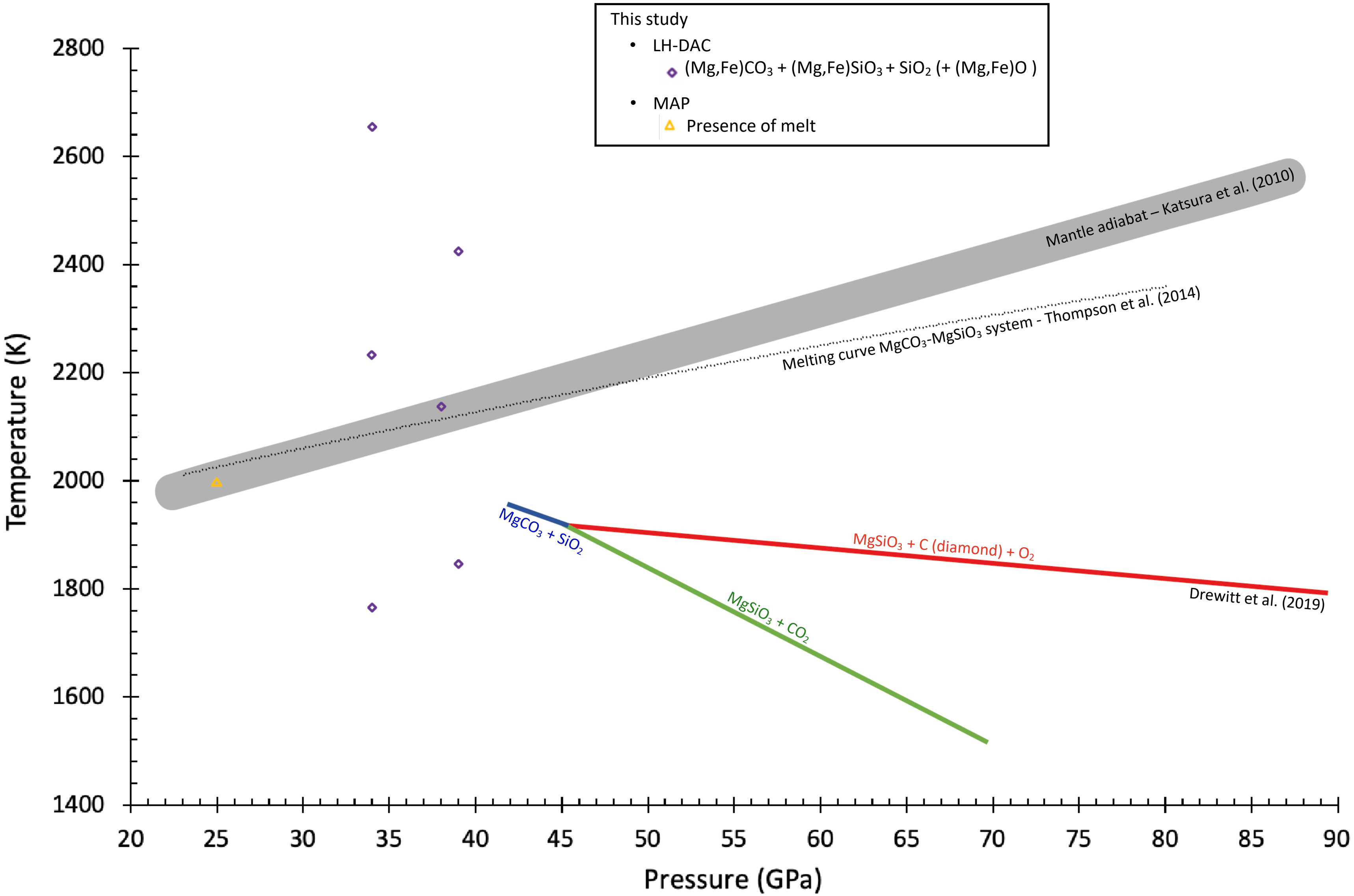


XRD pattern on quenched reaction products still at high-pressure indicating the presence of bridgmanite, magnesite and stishovite.

Offline LH-DAC have been performed at an pressure of 34, 38 and 39 GPa and the pressurized cells were analysed using XRD at the P02.2 beamline at PETRA III (DESY -Hamburg).

All XRD patterns show the presence of magnesite, bridgmanite and stishovite (SiO_2). TEM analyses were performed on a few hotspots and show the presence of bridgmanite, iron-magnesite and magnesiowüstite. This last phase is not detected by *in-situ* XRD.

Pressure – temperature plot



P-T diagram showing the location of the $(Mg,Fe)CO_3$ + $(Mg,Fe)SiO_3$ reaction from multi-anvil press (MAP) and laser-heated diamond anvil cell (LH-DAC) experiments. All in-situ patterns confirm the presence of stishovite (SiO_2) in LH-DAC.

Discussion

The first insight of this study suggests that the magnesite + iron rich-bridgmanite systems is not stable in the lower mantle considering the mantle adiabat by Katsura et al. (2010). The stishovite 's presence can be interpreted in two ways :

1) Sub-solidus interpretation: Iron-bridgmanite coexists, at 25 GPa and 2000 K, with 2 other phases: stishovite + magnesiowüstite (Mg,Fe)O. This interpretation implies that the stability of fe-bridgmanite + stishovite + magnesiowüstite is larger as presented by Dorfmann (2016).

2) Supra-solidus interpretation: Presence of stishovite is an indicator of the existence of melting in the system $(Mg,Fe)CO_3$ - $(Mg,Fe)SiO_3$. Therefore, stishovite is coexisting with the melt.

If the production of melt is confirmed, the presence of iron in the $(Mg,Fe)CO_3$ - $(Mg,Fe)SiO_3$ system lowers the melting curve compared to the iron-free system studied by Thompson et al. (2014) and that magnesite melts in the upper part of the lower mantle (25 GPa to 40 GPa – ~2000 K).

To evaluate the presence of melt, we have to identify melt *in-situ* in the LH-DAC experiments. For that, it is necessary to use multiple criteria, such as temperature plateau (temperature vs laser power curves) supported by *ex-situ* TEM analyses, allowing semi-quantitative analyses and comparison of textures between sub-solidus and melting runs. Further, we anticipate to continue the investigation at lower pressure with multi-anvil press experiments.

Acknowledgments

Universität Potsdam

Christina Günter, Christine Fisher, Rico Fuchs for sample preparation.

GFZ Helmholtz-Zentrum Potsdam

Anja Schreiber, Richard Wirth, Vladimir Roddatis for FIB and TEM analyses.

BGI Bayerisches Geoinstitut

Serena Dominijanni, Catherine McCammon, Svyatoslav Shcheka, Tomoo Katsura, Dan Frost for the multi-anvil press experiments.