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.

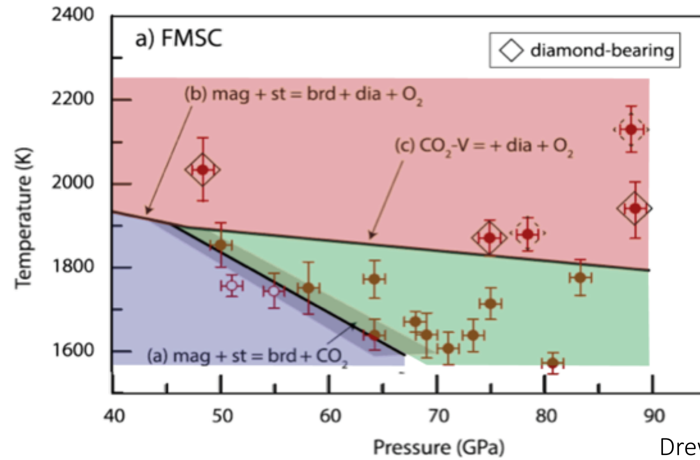
Studied reaction :

$MgCO_3$ + $(Mg_{0.8}Fe_{0.2})SiO_3$-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

- 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



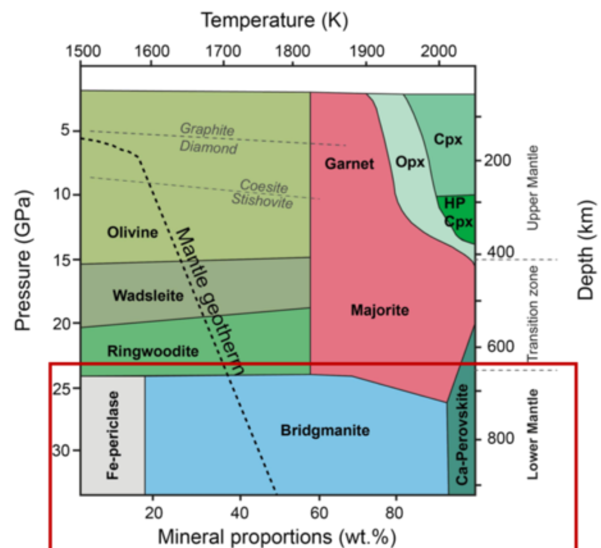
Drewitt (2019)

$MgCO_3 + SiO_2$ –> $MgSiO_3 + CO_2$ (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 fe-bearing natural system. In contrast to previous work, we study the stability of magnesite in presence of bridgmanite $(Mg,Fe)SiO_3$.

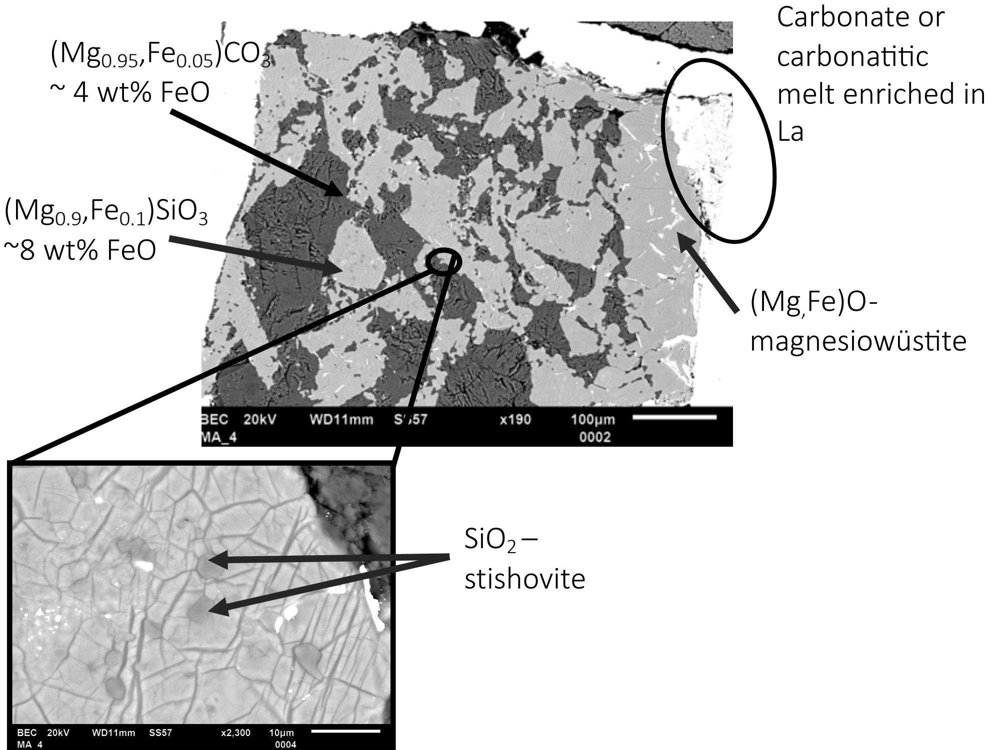


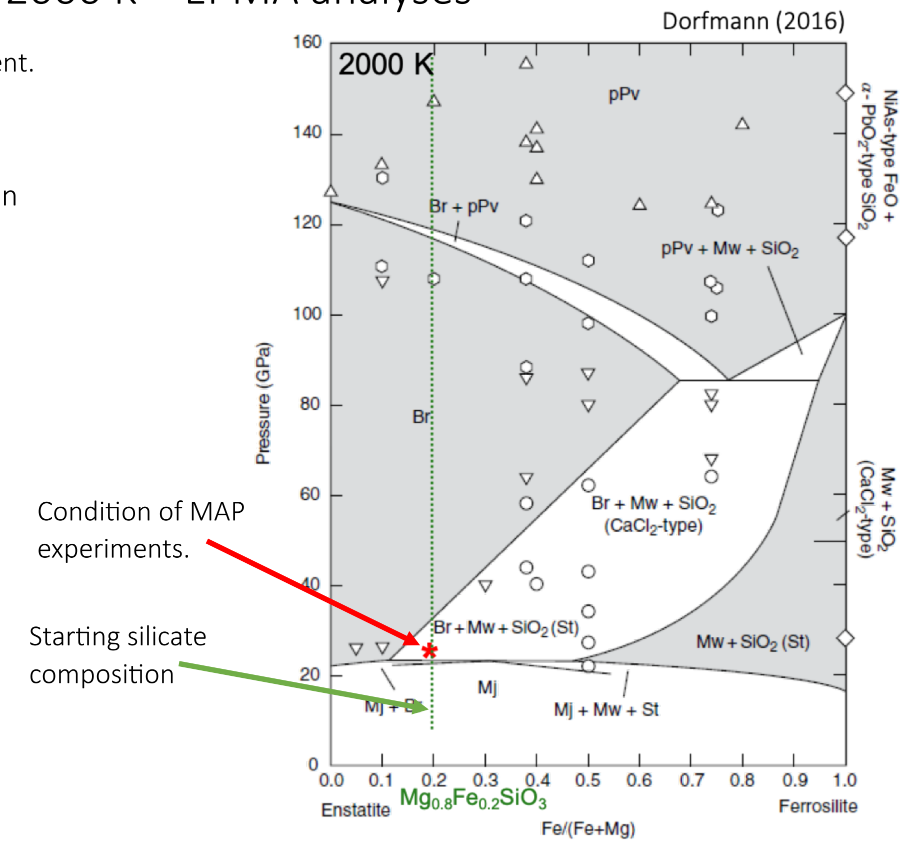
Kaminsky (2011)

High-pressure and high-temperature experiments

- **Multi-anvil press** (MAP) experiment at 25 GPa – 2000 K – EPMA analyses

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



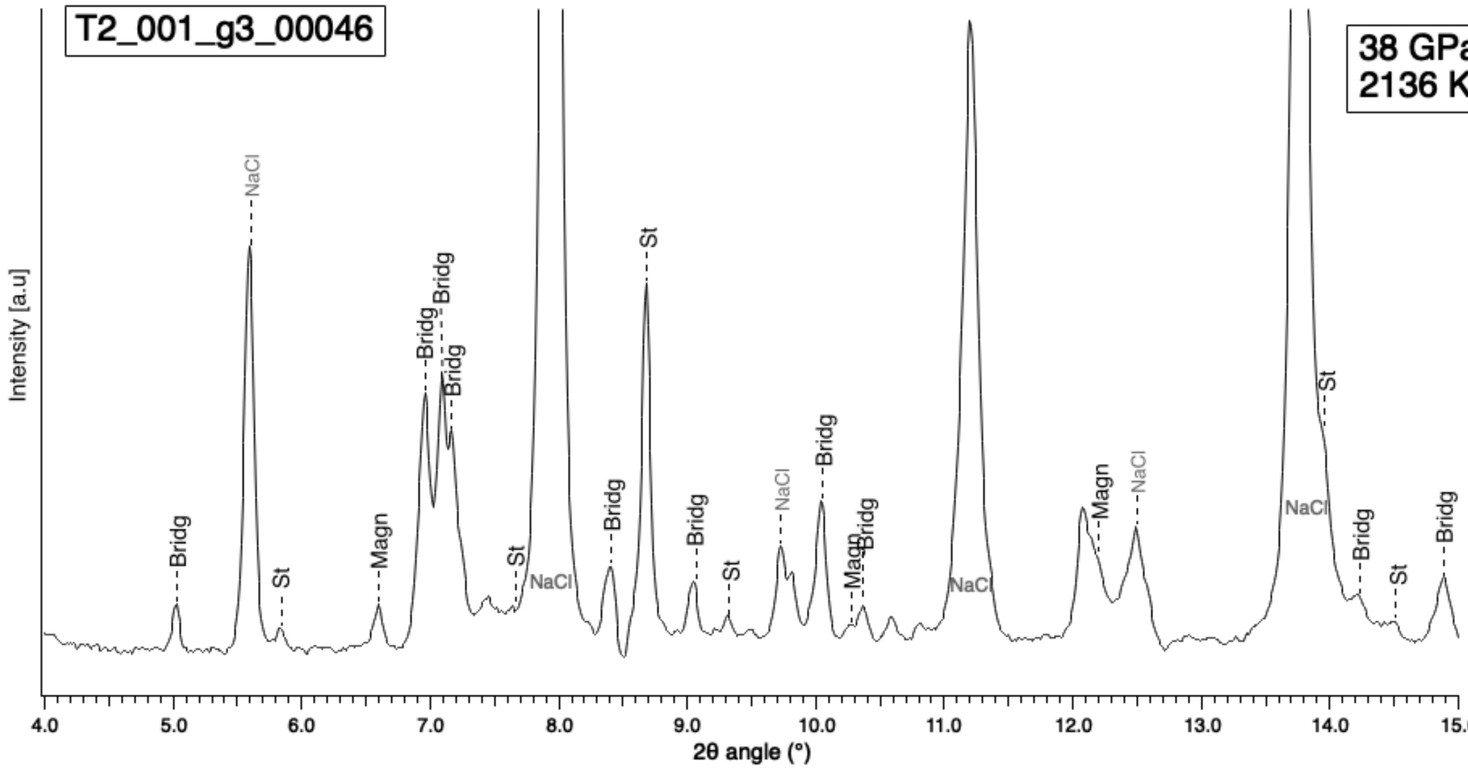


Phase diagram of MgSiO3-FeSiO3 (enstatite-ferrosilite) at lower mantle pressures and ~2000 K according to Dorfman (2016). Majorite (Mj), magnesiowüstite (Mw), stishovite (St), bridgmanite (Br), and postperovskite (pPv).

The MAP experiment shows formation of a carbonate/carbonatitic melt 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. The presence of stishovite and magnesiowüstite in the run product could be formed as by product of the Fe-bridgmanite composition used in as starting material as shown in the enstatite-ferrosilite phase diagram.

High-pressure and high-temperature experiments

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

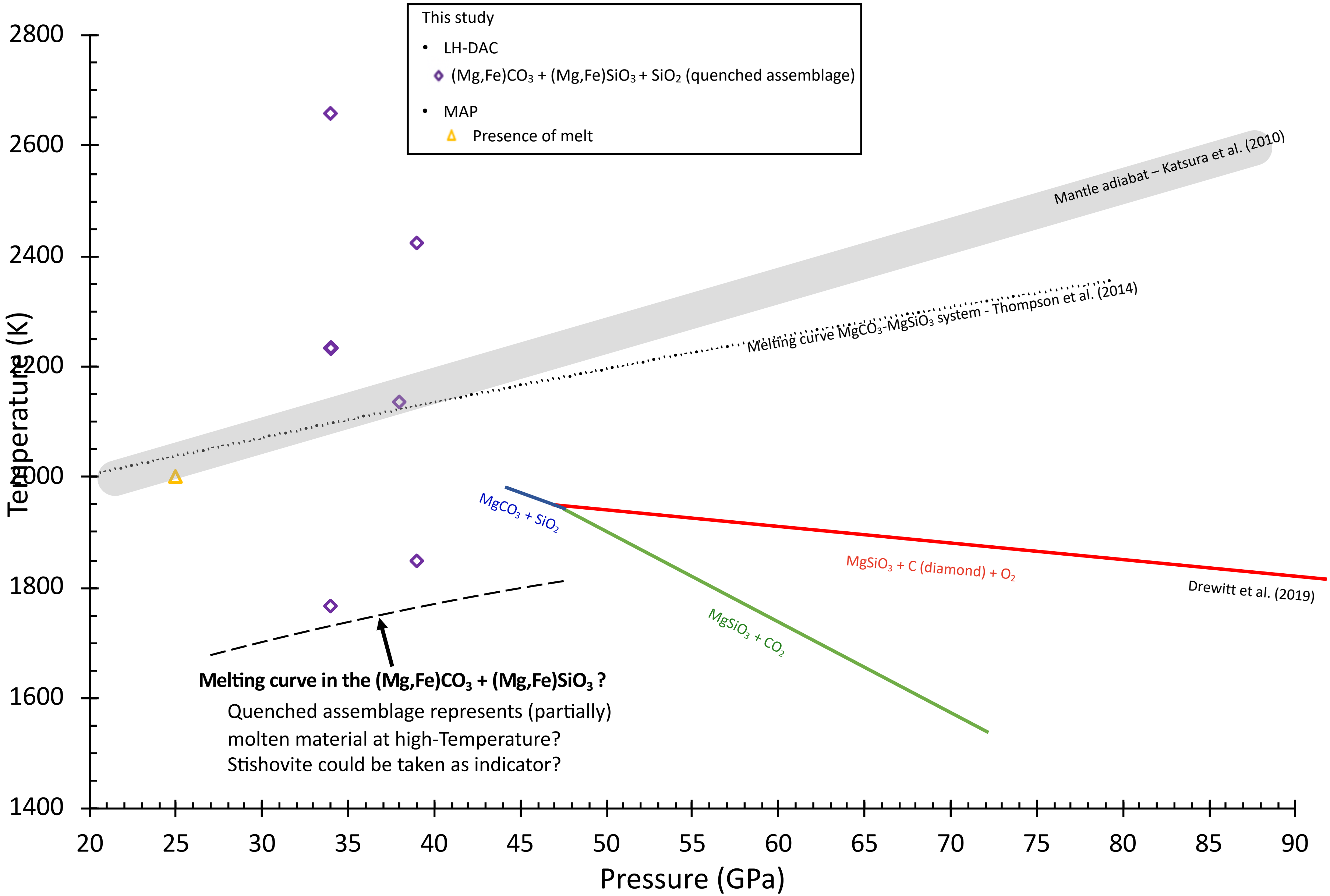


XRD pattern on quenched reaction products still at high-pressure indicating the presence of bridgmanite, magnesite and stishovite.

Offline LH-DAC experiments have been performed at an pressure of 34, 38 and 39 GPa and the pressurized quench products 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 on the (Mg,Fe)CO_3- (Mg,Fe)SiO_3 system suggests

1) Melting occurs already below 2000 K at 25 GPa as suggested by the MAP experiment and in consistent with data on the iron-free systems studied by Thompson et al. (2014).

2) The assemblage observed in LH-DAC experiments quenched from T > 1750 K and 34-38 GPa could represent (partially) molten materials and stishovite is thus a marker of the quenched melt.

3) The stability of Fe-bearing bridgmanite + stishovite + magnesiowüstite below 2000K and at pressures of 25-38 GPa is larger as presented by Dorfmann (2016) (Fig. in slide 3).

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). Considering the adiabat of Katsura et al.(2010) magnesite would not be stable with a lower mantle mineral assemblage.

To evaluate the presence of melt, we have to identify melt *in-situ* in the LH-DAC experiments at high temperature. For that, it is necessary to use multiple criteria: temperature plateau (temperature vs laser power curves), *in-situ* high-temperature XRD, and *ex-situ* TEM analyses comparing sub-solidus and super-solidus run. Further, we anticipate to continue the investigation at lower pressure with multi-anvil press experiments.

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