# MINERALOGY OF THE SILICON-RICH MANTLE: IMPLICATIONS FOR MARS AND EXOPLANETS.

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**Introduction:** With the InSight mission deploying a seismometer, Martian bulk chemical compositional models are more important than ever. Three classes of models have been developed in the literature over the past four decades [1]: Isotopic, geochemical, and geophysical. Of these three, the isotopic models have the systematically lowest divalent cation to silicon ratios. However, the impact of such a low Mg/Si ratio on mineralogy has not been experimentally investigated. We have measured the mineralogy of an isotopic compositional model, EH70 [2], through in-situ laser-heated diamond anvil cell (LHDAC) and large volume multi-anvil apparatus (MAP). The observed mineralogy is significantly different from pyrolite mineralogy which is dominated by wadsleyite and ringwoodite. Such differences are important to estimate the velocity profiles and to model the dynamics of the Martian mantle as well as exoplanets with stellar Mg/Si ratios that are lower than the pyrolitic model [3].

**Method:** We conducted two different types of high pressure experiments: in-situ laser-heated diamond anvil cell (DAC) and large volume press (LVP).

For DAC data, a powdered glass starting material was compressed to pressures up to 35 GPa. Infra-red lasers are focused on both sides of the sample for heating up to 2500 K. While under high temperature and pressure, we measured powder x-ray diffraction (XRD) of the sample to determine mineralogy at specific temperature and pressure. The LVP data used the same starting material. The sample was loaded in a Re capsule and compressed in-between 8 truncated silicon carbide cubes in LVP up to 26 GPa and ~2000 K. The sample is then examined ex-situ using Raman, electron microprobe, and x-ray diffraction. We also conducted calculation of phase diagram for the same composition in Perple_X [7].

**Results and Discussion:** Below 22 GPa and 2400 K, the mineralogy is dominated by majorite with ~10 vol% of ringwoodite. Between 19.5 and 21 GPa and below 1800 K, majorite, calcium perovskite, and stishovite are stable but majorite still dominates making up >90 vol%. Between 21.5 and 22.5 GPa and below 1800 K, akimotoite and majorite mixed phases are stable. Above 22.5 GPa, bridgmanite forms as a mixed phase region with majorite. Bridgmanite vol% increases with pressure. Above 27.5 GPa, all the majorite has been transformed to bridgmanite and only bridgmanite and calcium perovskite remain with ~5 vol% calcium perovskite. Initial results show that in a silicon-rich mantle at temperatures above 1900 K, bridgmanite forms at 23 GPa and thus is expected to form a thicker bridgmanite layer at the core-mantle boundary of Mars as compared to other models that have Mg/Si ratios >1 [5], if the Martian core is sufficiently small. In addition, the mixed phase bridgmanite and majorite stability field is more extensive and reaches higher pressures, up to 27 GPa, than in the pyrolitic mineralogy [6] expected for the Earth.

An important use of this study is comparing with mineralogies calculated by the Perple_X [7] software, which will be utilized for mineralogy calculations by the InSight mission team. We found overall a good agreement between our experimental data and the results from Perple_X. However, there are a few important differences. The akimotoite stability field is stable up to 1800 K and between 21.5 and 23 GPa. However, Perple_X predicts akimotoite to be stable only up to 1500 K and between 23 and 24 GPa. Perple_X predicts bridgmanite to first begin forming at 23.5 GPa while we found that bridgmanite first appears at 22.5 GPa. Such differences should be resolved before the model calculation method is applied to the mission data.

**References:**

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