Forsterite, 𝑀𝑔2𝑆𝑖𝑂4, is expected to be a major component of the mantles of rocky exoplanets and it has many implications in the field of planetary science. In the mantle, it creates and drives convection currents, which influence place tectonics and magnetosphere production, both very important to surface conditions than can support life. Experimentally proving the predicted phase changes of forsterite is extremely important because it provides insight into the formation, evolution, and habitability of rocky planets. It is theorized to undergo the process of incongruent melting and form a liquid silicate, 𝑀𝑔𝑆𝑖𝑂3, and crystal magnesium oxide, MgO, at high pressures.

In this experiment, we used laser shock compression to achieve the necessary pressures (150 GPa and 260 GPa) on the samples of polycrystalline forsterite. To determine the crystal structure of the laser compressed forsterite, we used x-ray diffraction. Because the x-rays will scatter differently according to the composition of the sample, each diffraction peak (where the x-rays are concentrated), can show the presence of a certain substance. This is done by translating everything into d-spacing (inter-atomic spacing in the lattice). At 150 GPa, all the diffraction peaks can be attributed to forsterite or forsterite III (solid polymorph of forsterite), but at 260 GPa, most of the peaks can be attributed to forsterite or forsterite III, except for one that might be MgO. This is further supported when looking at the x-ray diffraction data. At 260 GPa, the forsterite peaks are much fuzzier and broader than at 150 GPa, which is characteristic of diffraction from a liquid. The suspected MgO peak that appears at 260 GPa is much clearer, signifying a definite crystal structure.

Therefore, there is evidence of incongruent melting occurring at 260 GPa due to the appearance of crystal MgO and melted forsterite peaks. These results indicate complex changes to the physical and chemical properties of forsterite at high pressures and affect our understanding of the interiors of rocky exoplanets.