Forsterite, 𝑀𝑔2𝑆𝑖𝑂4, is expected to be a major component of the mantles of rocky exoplanets and the study of forsterite has many implications in the field of planetary science. Experimentally proving the predicted phase changes of forsterite is extremely important because it provides insight into the formation, evolution, and habitability of rocky exoplanets. Forsterite is theorized to undergo the process of incongruent melting and form a liquid silicate, like 𝑀𝑔𝑆𝑖𝑂3, and crystal magnesium oxide, MgO, at high pressures.

In this experiment, laser shock compression is used to achieve the necessary pressures (150 GPa and 260 GPa) on samples of polycrystalline forsterite. Analyses of x-ray diffraction patterns are used to determine the crystal structure of the laser compressed forsterite. Since the x-rays scatter differently depending on the composition of the sample, each x-ray diffraction peak (where the x-rays are concentrated) can be interpreted as d-spacing (inter-atomic spacing in the lattice). Each substance can be identified by its unique combination of d-spacing patterns. This method is used to identify forsterite, forsterite III (solid polymorph of forsterite), and MgO in the experiments. At 150 GPa, all the diffraction peaks can be attributed to only forsterite or forsterite III, but at 260 GPa, a new diffraction peak corresponding to MgO appears. The presence of MgO implies that incongruent melting occurs at 260 GPa, which can be further confirmed by looking at the x-ray diffraction images. At 260 GPa, the forsterite peaks are much fuzzier and broader than at 150 GPa, indicating that forsterite remains crystalized at 150 GPa but it is partially liquified at 260 GPa. In addition, the MgO diffraction peak at 260 GPa is sharper, signifying a definite crystalline structure.

These results show that incongruent melting of forsterite occurs at 260 GPa (but not at 150 GPa) due to the appearance of crystalline MgO and melted forsterite diffraction peaks. These results indicate complex changes to the physical and chemical properties of forsterite at different high pressures and this can affect the understanding of rocky exoplanets interior.