Single crystal discs of forsterite (MgSiO₃) cut parallel to (001) were experimentally shock-loaded to a peak pressure of 69 GPa with the shock-wave direction parallel to the crystallographic c-axis. Experimental procedures have been described by Schneider et al., Phys. Chem. Minerals, 1984, 10, 142-147. The shock-induced deformation effects of forsterite were analysed by single crystal X-ray techniques. No significant changes of lattice constants do occur in the shocked crystals, although slight broadening of X-ray reflections indicates some lattice strain. The streaking of X-ray reflections is strong in the b* c-plane, for h01 and k00 reflections it is much weaker. This indicates a shock-induced structural deformation caused by rotational movements of relatively large domains around the a-axis in (001), the plane of the approximate close packing of oxygen atoms in forsterite. Each 001 reflection streak exhibits two intensity maxima which shows that the domains are preferably arranged in two different directions with the a-axis in common but rotated against each other by an angle of about 14°.

While the Laus group mm of olivine is apparently not changed by the shock-wave, additional h01 reflections with h=2n+1 violate the extinction conditions for the space group of olivine (Pbnm) and lead to space group Pb2/m. Crystal structure determinations of forsterite at elevated pressures (e.g. Hazen, Amer. Min., 1976, 61, 1280-1293) have shown that the geometries of SiO₄ tetrahedra are practically insensitive to pressure. Therefore the reduction of symmetry is probably not caused by tetrahedral distortions. Possible mechanisms in correspondence with the observed symmetry are small rotations of SiO₄ tetrahedra against each other around the c axis or small displacements along the c axis with no principal changes in the distorted close-packed arrangement of oxygen atoms.

The streaking of X-ray reflections is strong while the Laue group mmm of olivine is apparently different orientations with the a-axis in the direction of planes of parallel (SiO₄)-chains: +++++.--(oe), +++++.----(oe) and +++++...-.(pe), where + - refers to a shift in c-direction.

All investigations were carried out on natural crystals from Bamble, Norway (~25 Fe). At all temperatures X-ray photographs show diffuse streaks in a-direction, which are of static origin as deduced from elastic neutron scattering experiments at the UNIDAS (KFA Jülich). The number of the corresponding stacking faults increases slightly near the pe-co transition becoming constant below it.

In order to look for possible precursor effects the initial dispersion branches of the transformed acoustic modes along [001] and [010] have been determined near the p point in the transformation region. Both correspond to the 055 elastic constant, which is connected with a shear in the a-c-plane necessary for the transformation. Whereas no anomaly was found along [0001], the slope of the dispersion branch along [001] increases slightly several degrees above the transition and becomes normal below it again. This anomalous stiffening of the force constant can be correlated with the simultaneous increase of the number of stacking faults (the eigenvector of this mode is parallel to a) and has thus to be regarded as a secondary effect, i.e. the transformation is triggered by some other mechanism possibly nucleation at the stacking faults.

The kinetics of the transformation and the variation of the structural details have been studied by neutron powder diffractometry on the instruments D1A and D1B at the ILL/Grenoble. Reliable structural parameters have been determined just above and below the transition with the high resolution instrument D1A. In pe analysis of the anisotropic thermal parameters revealed large amplitude motions of the SiO₄-tetrahedra around axes being roughly parallel to the chains. Especially large displacements result for the oxygen linkages to the tetrahedra. A series of experiments has been done on the high intensity instrument D1B with different time – temperature gradients (10 min measuring time per pattern). No discontinuous changes of relative intensities have been observed at a rate 10 K/10 min, whereas a distinct transformation takes place at 80 K/15 min and higher rates. Measurements at constant temperatures within the transition region show the athermal behaviour. Starting from the D1A structural parameters the temperature dependence of the most sensitive parameters has been evaluated. Parameters and the volume ratios of the different phases will be reported.

The work has been supported by funds of the BMFT.