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Superplasticity in forsterite system

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For understanding the structure and physical properties of the earth interior it is useful to measure creep characteristic by deforming the mineral at high temperature. In the earth science, superplastic deformation in the earth interior is estimated in experimental and observed natural products. In materials science, superplasticity is a phenomenon to exhibit tensile strain up to several hundred % at the unaxial tension test. On the other hand, in the earth science, superplasticity is often used to describe deformation mechanism that should operate during superplastic deformation.
In this study, we developed a technique to deform mineral aggregates by uniaxial compression and tension tests under atmospheric pressure. With this technique, we could obtain high-resolution mechanical data during the creep tests of polycrystalline forsterite aggregates. Combined with the results of microstructural observations of the samples, we could estimate deformation mechanism during the creep.
We could develop a technique to synthesize pore-free polycrystalline forsterite aggregates with an average grain size of < 1 micrometer. In a uniaxial compression and a tension tests, the samples with the shape of pillar-type and array-type, respectively.
We succeeded in deforming such materials plastically under atmospheric pressure.
Four different samples of forsterite, forsterite + enstatite, forsterite + periclase, forsterite + enstatite + diopside were used for uniaxial compression and tension tests. By changing the strain rate and temperature conditions, flow laws of the creep were obtained. At uniaxial tension test, superplasticity of the materials was observed. Tensile strain up to 500 and 300 % were achieved in the samples of forsterite + periclase and forsterite + enstatite + diopside, respectively. Stress exponent of 2 and grain size exponent of 1.5 and activation energy of 340 (kJ/mol) were obtained for the superplasticity in the former assembly.