

SIT039-P11

会場:コンベンションホール

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H₂O 氷と CO₂ 氷の 2 相多結晶体の塑性変形実験 Deformation experiments of two-phase aggregates of H₂O and CO₂ ices

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We have conducted creep experiments on two-phase mixtures of dry ice (CO₂) and H₂O ices at CO₂:H₂O volume ratios of 4:96, 8:92, 21:79, 46:54, 75:25, under confining pressures of 20-100 MPa and temperatures of 170-190 K using a gas-medium triaxial deformation apparatus. Two-phase aggregates of CO₂ and H₂O ices were mixed as powders, hydrostatically compacted. Hydrostatic compression pressures to reach zero porosity were between 60 MPa and 140 MPa and were generally lower for samples with higher CO₂ content. The compacted two-phase aggregates were then deformed at constant strain rates from 3e-7 to 1e-5/s. The measured flow stress is in the range of 2-25 MPa.

The creep experiments revealed that the flow strength of the two-phase aggregate decreases drastically with increasing CO₂ content. The range of the stress exponents and the activation energies in the aggregate flow law are 3.6-7.0 and 51-41kJ/mol, respectively. These values gradually change from those of one end member to those of the other. The rheology of the two-phase aggregate roughly matches an average of isostress and isostrain models. The flow strength in the 4 vol.% CO₂ aggregate is almost half of that in pure H₂O ice at the strain rate of 1e-6/s. The presence of 4 vol.% CO₂ ice in H₂O ice decreases viscosity by more than one order of magnitude at a differential stress of 0.1 MPa. Microstructural observations of the deformed samples are important future studies.

CO₂ ice has been observed on the surface of Mars's residual south polar ice cap and is likely to be present on most icy bodies in outer solar system. The present study clearly demonstrates that presence of small amounts of CO₂ ice can drastically decrease the flow strength of the two-phase aggregate. It is important to consider the influence of the rheological behavior of two-phase aggregates of CO₂ and H₂O ices on tectonics and internal dynamics of icy bodies, as well as the stability of the Mars polar cap. Present results can be used to constrain allowable concentrations of CO₂ ice to support the Martian south polar ice cap, and suggest that the presence of small amounts of weak non-water ices such as CH₄, N₂, and CO₂ possibly has important roles on viscous relaxation of craters, surface tectonics, and internal convection of icy bodies of outer solar system.

キーワード: H₂O 氷, CO₂ 氷, 2 相系, レオロジー, 氷天体

Keywords: H₂O ice, CO₂ ice, two-phase aggregate, rheology, icy body