

Rheology of non-water ices inferred from diffusion coefficients: A compilation study

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Non-water ices such as solid N₂, CO, CO₂, CH₄, and clathrate hydrates are a main constituent of the surfaces and crusts of the icy bodies. Understanding rheological properties of them are essential to understanding the dynamics including thermal convection, flow of glacier, and relaxation of topography. Several researchers investigated the rheological properties of them directly by low-temperature deformation experiments: solid N₂, CH₄ (Yamashita et al. 2010), CO₂ (Yamashita and Kato 1997, Durham et al. 1999), and CH₄ clathrate hydrate (Durham et al. 2003). They revealed the viscosities and plastic deformation mechanisms with a stress exponent of $n > 2$ in the range of 0.1 –100 MPa. However, the deformation experiment at low-stress conditions below 0.1 MPa is technically very difficult. The extrapolation of the plastic-flow law under their mechanisms to the low stress conditions may give an overestimate for the viscosity, because the diffusion creep can dominate in the low stress conditions below 0.1 MPa. Under the diffusion creep regime, the viscosity behaves as Newtonian fluid, and is sensitive to the grain size. Although the viscosity under the diffusion creep regime cannot be measured directly, it can be estimated from diffusion coefficients based on the theories of diffusion creep (Frost and Ashby 1982). I will discuss the rheological properties of non-water ices inferred from the diffusion coefficients. There are many non-water ices whose diffusion coefficients have not determined yet by experiments. This substance includes solid CO and clathrate hydrates. In the case of molecular solids, the diffusion enthalpy has a correlation with the sublimation enthalpy (Chadwick and Sherwood 1971). I estimated the diffusion coefficients using the correlation in order to infer the rheological property.

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