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Preliminary experiments on mechanical properties of the Martian south polar cap

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It is known that there are layered deposits on the south polar cap on Mars, which is composed of unknown proportions of CO_2 ice, H_2O ice, and dust. The recent studies have revealed that the density of the south polar cap is about 1.2 g/cm^3 based on the gravity and topography analysis (Wieczorek, 2007). This indicates that the ratio of H_2O ice (density 0.92g/cm^3) to CO_2 (1.6g/cm^3) ice is about 45 to 55 % by volume in the case of no dust (about 3g/cm^3), and H_2O ice to dust is 72-86 to 14-28 % by volume in the case of no CO_2 ice. On the other hand, it has been suggested that CO_2 ice is unlikely to be predominant for the south polar cap on Mars because CO_2 ice is markedly weaker than H_2O ice (Durham et al., 1999) and cannot support the polar cap for the geological time scales (Nye et al., 2000). Therefore rheological properties of the mixture of CO_2 and H_2O ices are important to understand the composition and the stability of the Martian south polar cap. In this study, we have performed preliminary experiments on mechanical properties of the mixture of CO_2 and H_2O ices.

At first, we have conducted compaction experiments using mixtures of CO_2 and H_2O ices at 173-203 K up to 40.9 MPa. The starting powdered ices were put in a piston cylinder apparatus, and compressed to make the cylindrical sintered sample with having low porosities. Following the compaction experiment, we have carried out uniaxial deformation experiments using the sintered sample at 0.1 MPa and about 163 K.

Results of the compaction experiments indicate that porosities of the sintered ice samples decrease with increasing CO_2 contents. The porosities of pure CO_2 ice and the mixture for CO_2 fraction of 0.8 are 1.23% and 9.1% at 40.9 MPa and 173-203 K, respectively. Preliminary results of the deformation experiments suggest that flow strength of the sintered ice samples decreases with increasing CO_2 contents. Strain rates of pure CO_2 ice and the mixture for CO_2 fraction of 0.8 are $7.2*10^{-6}$ s^{-1} and $1.6*10^{-6}$ s^{-1} at the stress of 0.66 MPa. However the strain rate for pure CO_2 ice obtained in the present study is larger than that in the previous study (Durham et al., 1999) by two orders of magnitudes. It is necessary to use the sintered samples with lower porosities and decrease thermal gradients of the sample during the deformation experiment. Also, we have to deform the sample to larger strain than the present study.