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Deformation test of icy materials using the indentation method: New approach for the measurement of deformation strength

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The deformation strength of ice-rock mixture is a very important property to study the flow process of glaciers on Earth and Mars, and the tectonics of icy satellites, so many researchers such as Yasui and Arakawa [2008] examined the strength with various rock contents. We found that the strength was almost same or weaker in the case of small rock contents compared to pure ice while it increased with increasing the rock content in the case of high rock contents. However, it is necessary to study the deformation mechanism of icy material on the laboratory scale in order to apply the experimental results to the flow process of glaciers because it is suggested that the deformation mechanism and the strain rate of icy material changes with geological . For the first step to study the deformation mechanism, we should identify the local area where the bulk deformation is controlled dominantly when the ice-rock mixture has a specific macroscopic structure. That is, the bulk deformation strength could be related to the macroscopic internal structure, thus it is important to measure the local viscosity of each area which constructs the macroscopic structure because each area has a different viscosity. The strength changes with the rock content, so we can speculate that the area controlling the bulk deformation also changes with the rock content. We can measure the bulk strength of ice-rock mixtures with the size of cm by using the commercial deformation machine, but we cannot use this to examine the strength of a local area of the sample. Thus we propose a new method to examine the deformation strength of ice-rock mixture of a local area by using an indentation method.

Indentation method is used for the measurement of yield strength and brittle strength of nano-scale ceramic film in engineering fields and it is very useful method to examine the deformation strength at a local area. Furthermore, the contact area between the indenter and the sample changes with the deformation time under a constant load, so the stress changes with the strain and we can obtain a wide range of the relationship between stress and strain rate by one test. In this study, we evaluated whether this indentation method was appropriate for studying the deformation strength of a local area for icy material or not. We used the silica beads with the diameter of 1 micron for the ice-silica mixtures, and the silica content was changed from 0 to 50 wt.%. The indentation tests were made in a large cold room of Hokkaido University and a small freezer of Nagoya University. The temperature was set at -10 ℃ in the cold room, and -22 to -25 ℃ in the freezer.

Reference: Yasui and Arakawa, GRL, 35, doi:10.1029/2008GL033787, 2008

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