

Limit of the ice-sheet thickness and the subglacial lake

Yutaka Narita^{1*}

¹OYO Corporation

It is said that there is the water at the bottom of thick ice-sheet, there is a water cycle of freezing and melting and re-freezing in there. In this study, I explored basic structure of the ice under high pressure at the bottom of the ice-sheet, and I discussed the limits of the ice-sheet thickness.

1) Formation of the subglacial lake

The subglacial lakes were found over a wide range under East Antarctica ice-sheet by the permeable radar on ICESat satellite, and to be confirmed the water is present. It is considered that the water temperature of the subglacial lakes are about -2~-3°C. The subglacial lakes have keeping the liquid for high pressure by the ice load, and that is the temperature at which melting point of the ice and temperature gradient crosses. Lake Vostok is largest the subglacial lake in the Antarctica, there are about 3,800m under the ice-sheet, total area is 14,000km², and average depth of the lake is 125m.

2) Ice transition under high pressure

Inside pressure of the ice-sheet is going to increase gradually due to snow load. This pressure reaches about 30MPa at the bottom of the Antarctica ice-sheet. The air of the earth's surface is captured between the snow particles in this consolidation course, and the air bubbles isolate about 200m depth (Ice-Gas phase region). Reaches about 1,000m depth, this high-pressure air bubbles constitute a new crystal due to reacts with the ice, and Clathrate-hydrate is generated (Ice-Hydrate phase region). In addition, going to the higher pressure into the ice sheet, reach the region where Hydrate-water is produced by melting ice (Water-Hydrate phase region). Thereby, I think the water of the ice-sheet bottom is generated in the state of pressure melting under the ice-sheet.

3) Fracture strength of the ice and limit of the ice-sheet thickness

According to pressurization experiments of the ice under hydrostatic pressure, hydrostatic pressure was increased, which increased fracture strength. But, to compare hydrostatic pressure of 55MPa and 30MPa, fracture strength was reversed, because 30MPa was higher than 55MPa. From this fact, maximum fracture strength is expected to be about 35MPa (Thick of ice-sheet is 4,100m). Therefore, in high-pressure portion under the ice-sheet over about 4,000m occurs ductile fracture that continued plastic deformation without brittle fracture beyond the yield point. And, the state of pressure melting under the ice-sheet increase liquidity by the generated water, further, the strength is reduced

It is said that thickness of the Antarctic ice-sheet is maximum 4,000m for the ice-snow. Maximum depth of digging in the Antarctic ice-sheet is 3,800m at Vostok base, by adding depth of the subglacial lake under the ice-sheet, it will be about 4,000m. Therefore, limit of the ice-sheet thickness is about 4,000m, and by exceeding the limit thickness, the water is generated by plastic flow occurs under the ice-sheet. I think that a space to generated water has become the subglacial lake.

Keywords: Ice-sheet thickness, Subglacial lake, Pressure melting