P071-017 Room: C501 Time: May 28 15:49-16:06

Ice on ice friction experiments related to the motion of strike-slip faults on Europa

Masahiko Arakawa[1], Shigeki Kanazawa[2], Norikazu Maeno[3]

[1] Inst. Low Temp. Sci., Hokkaido Univ., [2] ILST, Hokkaido Univ., [3] ILTS,Hookaido Univ.

http://risu.lowtem.hokudai.ac.jp/~arak

Europa is a large icy satellite that shows apparent features of recent geological activities. The spacecraft exploration revealed that the surface covered with quite a lot of faults and ridges. Their origin has been discussed in relation to the tidal force excited in the icy crust by Jupiter. Hoppa et al. (1999) found that the strike-slip faults observed on the surface had a spatial distribution closely related to the tidal stress distribution in the crust. Based on this result, they proposed a mechanism to drive the strike-slip faults and pull-apart bands. This mechanism is called walking process because it is similar to the way of human walking on the ground. In order to work this mechanism, the friction force excited between fault planes should be larger than the tidal force during the normal stress is compression. This means that the friction coefficient between ice planes should be larger than 1 at the sliding speed corresponding to the tidal deformation smaller than 10^-5 m/s.

The ice friction experiments have been conducted at the sliding speed higher than 10^-2m/s, and the ice friction coefficient had been revealed to be smaller than 0.1. Then it is not certain whether the friction coefficient is smaller than 1 or not at the slow sliding speed. Therefore, we constructed an apparatus to conduct the ice on ice friction test at very slow speed and at variable low temperatures.

We used a mechanical testing machine to pull up a slider. This machine can regulate the sling speed very accurately from 10^-3 to 10^-7m/s. The normal force was applied to the slider by using a strong spring; the length of the spring was changed according to the normal force from 5 to 15 kgf. Polycrystalline ice plates were attached on the slider and a base steel plate. These ice samples can be cooled down below -100 C with an attached cryostat. The friction test devises are installed in a vacuum chamber for the thermal insulation in the low temperature test. However, in this presentation, we only describe the results at the constant temperature of -10 C. All the set up was installed in a large cold room regulated at -10 C.

We found that a type of the slider motion was dependent on the sliding speed. At the slider speed from 10^-4 to 10^-5 m/s, the slider shows a stick and slip feature, and from 10^-6 to 10^-7 m/s, the slider moves very smoothly without sticking on the surface. The friction coefficient (m) monotonically increases from 0.1 to 1 with the decrease of the sliding speed irrespective of the type of the slider motion. This simple dependence is written as m = m0 v^-0.28. This negative dependence on the sliding speed (v) seems to be inconsistent with previous studies. Because the ice friction at slow sliding speed is usually accepted to be excited by the ductile deformation of ice, and the flow law of polycrystalline ice clearly shows that the stress necessary for the constant strain rate has a positive dependence on the deformation rate. Therefore we should take into account a new mechanism to increase the friction coefficient at slow sliding speed. We propose an idea to cause this increase of the friction coefficient: the real contact area increases with time because of the deformation of asperities and sintering of ice on the contact surfaces. The simple model including this mechanism can explain the observed negative dependence very well.

Finally, it is noted that the physical condition to show the friction coefficient larger than 1 was found at the sliding speed as slow as 10^-7m/s between ice planes. This result supports that the walking process proposed by Hoppa et al. (1999) can work in Europa to form strike-slip faults.

Hoppa et al. (1999) Icarus, 141, 287-298.