S040-001 Room: C417 Time: May 31 9:00-9:15

Dynamics of Asperity Contacts 6. Velocity-dependency of Adhesive Friction

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1. Introduction

We have so far 5 times reported the results of indentation scratch tests. We here present a recent finding that the adhesive friction is dependent on sliding velocity and discuss about its implication to geophysical problems.

2. Experiment

The indentation scratch test is very simple: a metal sample is forced to horizontally move with a constant velocity, with a diamond conical indenter (apex angle, 136 degrees) being pressed onto its surface with a constant gravitational force.We measured the horizontal and vertical displacements of the indenter and the friction force. Since the measured friction includes the friction force between the sample table and its guide rail, we subtracted the friction force measured without scratching from that observed in scratching test.The velocity of the sample ranges from 1 micron/s to 2 mm/s.

3. Experimental Results

As so far reported, it has been observed that when the sample begins to horizontally move, the indenter begins to sink deeper into the sample. And then it begins to climb up and finally stabilizes.

In this report, we focus on the friction force as well as the locus of the indenter.The friction force rapidly increases when the sample begins to move, then reaches a maximum, slightly decreases and finally stabilizes.

The velocity of the sample was changed. Beginning with 1 micron/s, we measured the friction force under 10 times, 100 times, and 1000 times faster velocity conditions. We found that the friction force increases with the sliding velocity, being proportional to the logarithm of the velocity.

4. Comparison with model calculation

We have constructed a model which assumes that the flow pressure and adhesive friction act on the indenter surface (see C30, Abstract of Autumn Meeting, SSJ, 2000). The parameters of the model was determined by best-fitting both the locus of the indenter and the friction force observed in the experiment.

The result shows that (1) it is necessary to introduce dynamic flow pressure which is about 20% larger than the static flow pressure which is determined by a static indentation, and (2) only the increase in adhesive friction can explain the increase in friction force due to increase in sliding velocity.The friction force is found to be proportional to the logarithm of the velocity.

5. Discussion

Friction seems to include a variety of complex mechanism at individual asperity contacts, such as riding-up (elastic deformation), ploughing which inevitably includes plastic deformation, interlocking and brittle fracture, and so on. The experiment presented in this report is aimed to elucidate the mechanism of ploughing. However, the mechanism of adhesive friction is included in ploughing and other mechanisms where the surfaces are in direct contact. The experimental observation and the model calculation reveal the velocity-dependency of the adhesive friction.

Since it has been shown that the direct-effect of Dieterich-Ruina's friction law is proportional to the logarithm of velocity, it may be possible that the underlying mechanism of the direct-effect is the velocity-dependent adhesive friction.