Fault Vibration during Frictional Melting

Kazuo Mizoguchi[1]; Eiichi Fukuyama[1]; Takehiro Hirose[2]

[1] NIED; [2] JAMSTEC

We examined the property of vibration on the slipping fault under melting condition in the laboratory using high-speed servo-controlled rotary-shear apparatus [Mizoguchi and Fukuyama, 2008]. The purpose of this study is to investigate whether the vibration observed during the experiment couples with the mechanical behavior and physical process inside the fault. We conducted friction experiments on bare India gabbro rock samples under a constant normal stress of 2 MPa with a constant slip rate of 0.8 m/s, where frictional melting occurs. We employed a pair of solid cylindrical specimens (diameter, 25 mm) made from the same rock as used by Hirose and Shimamoto [2005]. One specimen rotates with respect to the other by contacting two end surfaces, which made up of a fault. We installed two sets of triaxial (x,y,z) accelerometers (SA11ZSC-TI, Fuji Ceramics Co., Ltd) inside the sample holder at the stationary side. One sensor is located at 60 mm below the fault plane on the rotation axis of the stationary column (we call this sensor A1). The other one (we call A2) is located 36 mm off the rotation axis and 60mm below the fault. We calculated the velocity Fourier amplitude spectrograms from the acceleration data, using MATLAB software.

In our experiments we measured torque and rotation speed of the sample, which correspond to shear traction and slip rate on the fault, respectively. From the traction behavior, we observed that after an initial weakening without visible melting, the friction recovered to the initial level and produced a second peak where visible melting began to occur. After that, a gradual decay in the friction was observed to a constant level of 0.4 with slip (second weakening). This behavior is consistent with the results of previous experiments [Tsutsumi and Shimamoto, 1997; Hirose and Shimamoto, 2005]. The slip displacement where the second weakening begins was different among the runs. There are some cases where no first weakening was observed because the initial weakening displacement was too small and visible melting started immediately after the start of the experiment.

In this study, we focus on fault vibration in the second weakening stage associated with visible melting to examine the relationship between frictional melting and fault vibration. The velocity spectrogram shows that the fault vibrations parallel and perpendicular to the fault plane during the experiments were characterized by the predominant frequency bands of 80-100 Hz and 200-250 Hz, respectively. There are no obvious differences in the parallel vibration data of two fault parallel components of A1 and A2 sensors. The amplitude of the fault parallel vibration of 80-100 Hz was constant during the second weakening, and it decreased by one order of magnitude when the friction became steady state. In contrast, the amplitude of fault perpendicular vibration was one order of magnitude lower at the second weakening than at the steady state. A common feature for the parallel and perpendicular vibration is that the vibration amplitude became lowest at the transition from the weakening to the steady state during the experiments.

It should be noted that although the predominant frequency of the vibration is rather low comparing to the size of the fault zone, the observed vibration should be reflected by certain aspects of the friction behavior because its generation correlates to the frictional behavior of the fault. To investigate in more detail, we are planning to conduct multichannel accelerometer array measurements of the fault vibration along the stationary column, that will help understand what determine the characteristic frequencies and the mode of vibration.