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Friction-Induced Decomposition of Siderite and Dolomite and their Weakening Effect on Simulated Faults at Seismic Slip-Rates

RAEHEE HAN[1], TOSHIHIKO SHIMAMOTO[2], JIN-HAN REE[1]

[1] *Department of Earth and Environmental Sciences, Korea University, Seoul, Korea*

[2] *Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, Kyoto, Japan*

We have shown in our high-velocity friction experiments that simulated faults in Carrara marble dramatically weakened in association with calcite decomposition due to frictional heating [1]. We show herein that similar decomposition occurs for siderite [FeCO3] and dolomite [CaMg(CO3)2] and is accompanied by marked weakening of faults with gouge composed of these carbonates. Quite interestingly, Li et al. [2] report that siderite is missing, but calcite is present in black fault gouge from a shallow northern drill hole penetrating the Chelungpu Fault that caused 1999 Taiwan Chi-Chi earthquake. They suggested that evaporation of siderite occurred, but in view of our results it is more likely that decomposition of siderite, not calcite, occurred in the gouge. Decomposition temperature is different for the three carbonates; i.e., about 580^{c}ircC for siderite, about 800^{c}ircC for dolomite and about 900^{c}ircC for calcite. Thus carbonate decomposition not only can cause weakening of faults at seismic slip rate, but can provide a useful indicator of temperature rise within a fault zone during earthquakes. Information on temperature rise within a slipping zone leads to strength estimate of faults which is very difficult to estimate for natural faults. Here are more details. For siderite, powder samples were deformed between gabbro cylinders in a rotary shear apparatus at a seismic slip rate of 1.28 m/s and under a normal stress of 0.62 to 1.26 MPa. When starting the runs, the friction coefficient (increased to a peak value of 1.2 to 1.55 and then decreased to a steady-state value of 0.25 to 0.4, indicating significant slip weakening. Thermal decomposition of siderite was synchronous with the slip weakening, which was confirmed by the measurement of CO2 gas emitted form the gouge during the runs as in our Carrara marble experiments [1]. The originally brown color of the siderite powder turned black due to magnetite generated by the thermal decomposition of siderite during shearing. For dolomite, we used a pair of solid cylindrical specimens (22.5 mm in diameter) jacketed with aluminum tubes ($\sim$1.3 mm thick) and narrow gap was left between the two aluminum tubes to avoid metal-to-metal friction. One run was done at 12.2 MPa and 1.18 m/s. The dynamic friction coefficient decreased from the peak value of 0.57 to the steady-state value of 0.08 and this weakening is due to thermal decomposition of dolomite. These preliminary experimental results together with those

of Carrara marble experiments consistently indicate that dramatic slip weakening is triggered by the friction-induced decomposition of carbonate minerals. Further detailed works will be conducted to check what physical properties (e.g., magnetic property) of fault zones can be changed during thermal decomposition and to test if these changes can be used for temperature estimation and identification of seismic slip zones. [1] Han, R. Shimamoto, T., Hirose, T. and Ree, J.-H., 2005, Dramatic decomposition weakening of simulated faults in Carrara marble at seismic slip-rates. EOS Transactons, American Geophysical Union 86 (52), Fall Meeting Supplement, Abstract T13E-01. [2] Li, W.-H., Wu, S.-Y., Hung, J.-H. and Tsai, Y. B., 2005, Nanometric Characteristics of fault gouge in the slip zone from FengYuan borehole of the 1999 ChiChi earthquake in Taiwan. AOGS Meeting Abstract.