Friction-induced Thermal Decarbonation of Siderite and Dolomite

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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.

For siderite, powder samples were deformed between gabbro cylinders in a rotary shear apparatus at a seismic slip rate (V) 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 from 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 (˜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 a normal stress of 12.2 MPa and a slip-rate of 1.18 m/s. The dynamic friction coefficient decreased from the peak value of 0.57 to the steady-state value of 0.08.

These preliminary experimental results together with those of Carrara marble experiments consistently indicate that dramatic slip weakening occurs due to the friction-induced decomposition of carbonate minerals. Furthermore, the formation of magnetite as a decomposition product in the siderite gouge during seismic slip may result in a remarkable change in magnetic property of the gouge, which can be used as an indicator of paleoseismic event.

[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.