Rock magnetic properties of fault rocks from the rupture of the 2008 Wenchuan earthquake, China and their implications for seismic faulting

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Abstract: Rock magnetic measurements were conducted on bulk fault rocks and fragments and matrix of six breccias from the Zhaojiagou outcrop at Leigu Town, Beichuan County, Sichuan Province (China), located on the Yingxiu-Beichuan Fault, the main fault ruptured in the 2008 Wenchuan Ms 8.0 earthquake. The matrix has much higher low-field magnetic susceptibility and magnetization, and lower coecivity in comparison with fragments and bulk samples. Magnetic behavior of the bulk samples and fragments is dominated by dia-/para-magnetic components, in contrast, small amounts of magnetite and lepidocrocite is present in the matrix. A simple conceptual model associated fault-related effects was proposed to explain these significant differences in magnetic properties of fragments and the matrix. During coseismic slip, intense shear crush pre-exist magnetic grains in fault rocks into finer ones; meanwhile the frictional heat would induce thermochemical alterations of magnetic mineralogy in fault breccias. During interseismic periods, meteoric fluids would infiltrate and percolate into fault zone and cause dissolution, precipitation and recrystallization of Fe-bearing minerals. As the diverse permeability structure and grain size of fragments and matrix, these alteration effects would change their magnetic mineralogy at various levels, and thus result in the observed different magnetic properties in fragments and matrix. It further proposed that magnetic studies of fault breccias would provide clues to help understand faulting and history of fault activity.

Meanwhile, temperature-dependent magnetic susceptibility of fault gouges increased significantly above 400 °C in the heating run. Magnetic behavior reveals the presence of siderite, lepidocrocite, chlorite and smectite as the possible major Fe-bearing minerals in fault gouges. Their thermal decomposition to ferrimagnetic minerals (e.g., magnetite and/or maghemite) could be responsible for the high magnetic susceptibility during the thermal treatment. A kinetic model analysis indicates that frictional heating could increase the temperature within the fault zone up to 320-908 °C at depth of 590 m, and 335-952 °C at depth of 618.3 m, respectively, during the

seismic slip of the Wenchuan earthquake, depending on shear stress. Such high temperatures are enough to drive thermal decomposition of Fe-bearing minerals in fault rocks (in particularly, in fault gouge), to form ferrimagnetic magnetite and/or maghemite. This is the most likely mechanism for the reported high magnetic susceptibility anomalies within the fault zone in the pilot hole of Wenchuan Earthquake Fault Scientific Drilling Project (WFSD-1).

Keywords: (magnetic properties; fault rock; seismic faulting; frictional heating; Wenchuan earthquake)