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Mineral decomposition during seismic slip: slip-weakening of fault zones and temperature-limiting effects

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During an earthquake, the heat generated by fault friction may be large enough to activate the devolatilization of minerals forming the fault rocks. Since devolatilization consumes heat and minerals to release fluids in the shear plane, it is an important process to consider for a better understanding of fault mechanics. The mechanical effects of mineral thermal decomposition on the slip behavior of a fault zone during an earthquake can be modelled by introducing the coupled effects of solid volume loss, heat consumption in the endothermic chemical reaction and fluid production in the theoretical analysis of shear heating and fluid thermal pressurization (Sulem et al, 2007). We focus on the thermal decomposition of some common carbonates (Calcite, dolomite) and phyllosilicates (talc, kaolinite, muscovite) because these minerals are present in every fault zones from the ductile-brittle transition (Ĩ5 km) to the subsurface. There is growing evidence that decarbonation and dehydration occurs during seismic slip in crustal faults, active and/or exhumed. The equations that govern the evolution of pore pressure and temperature inside the band and the mass of emitted fluids are deduced from the mass and energy balance of the multi-phases saturated medium and from the kinetics of the chemical decomposition of calcite. In the case of a fault in carbonate rocks such as the Aigion fault (Gulf of Corinth), our numerical simulation of seismic slip at depths of 5 – 8 km shows that decarbonation limits the coseismic temperature increase to less than 8̃00 °C (due to the initiation of the endothermic chemical reaction) inside the shear band. The rapid emission of CO2 by decarbonation significantly increases the slip-weakening effect of thermal pressurization. The pore pressure reaches a maximum and then decreases due to the reduction of solid volume, causing a re-strengthening of the shear stress. This case is then compared with the example of a talc- and other phyllosilicate-bearing fault such as San Andreas, showing that the thermal decomposition of minerals is an important slip-weakening process, and that a large part of the frictional heat of earthquakes may go into endothermic devolatilization reactions.

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