Estimation of temperature rise during localized slip based on stretching of fluid inclusions in calcite

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The estimation of temperature rise during the localized slip is a key to understand whether thermal pressurization worked effectively during seismic slip (i.e., pore dilation is unimportant and negligible loss of heat and fluid). Fluid inclusions trapped in calcite tend to increase their volume (stretching) when heated to temperatures higher than those of initial entrapment. Stretching of fluid inclusion lower the density of the inclusion fluid and thus increase the homogenization temperature. The duplex-fault zone in the Shimanto accretionary complex developed at seismogenic depths (4-6 km). The fault zone structure suggests slip localization along the narrow (mostly a few centimeters thick) ultracataclasite layer. The homogenization temperatures of primary fluid inclusions in calcite were measured using samples taken from the ultracataclasite layer, the altered zone immediately below the ultracataclasite layer, and the host rocks. The frequency distributions of homogenization temperature values of fluid inclusions in the ultracataclasite layer are characterized by the pronounced skewness, with the frequency mode near the low-temperature end of the range (130-180 degreeC) and the tapering tail to higher temperatures (180-370 degreeC). These frequency distributions are consistent with fluid-inclusion stretching by increased heating. In contrast, the homogenization temperatures of fluid inclusions in the altered zone and host rocks are concentrated around the host rock temperatures (130-180 degreeC). Thus, fluid-inclusion stretching recorded in the ultracataclasite layer is neither inflow of hydrothermal fluid nor regional thermal imprint. Rather, it possibly caused by frictional heating during the localized slip. Overheating experiments on the fluid inclusions with homogenization temperatures close to the host rock temperatures demonstrated that 50-150 degreeC overheating could explain the skewed frequency distributions of stretched inclusions in the ultracataclasite layer. Laboratory experiments also indicated that stretching of fluid inclusions occurred instantaneously. Fluid inclusions in calcite have potential to record the small temperature rise (50-150 degreeC) during short-lived thermal events and thus may be useful to identify whether thermal pressurization was operative during earthquakes.