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Smectite to chlorite conversion by frictional heating along the subduction thrust

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Recent fault rock analyses on the ancient subduction thrusts have found several evidences of fluid-assisted weakening processes such as thermal pressurization (e.g., Okamoto et al., 2006; Ujiie et al., 2007). During earthquakes, a temperature rise associated with frictional heating may be suppressed by fluid pressurization. However, there have been limited indicators of past heating on faults. In order to identify past heating on the subduction thrust exhumed from seismogenic depths, we here focus on the diagenetic mineral reaction within the fault zone and found that the crystal-chemical features of clay minerals is potentially useful to a small temperature rise during frictional heating on faults.
The studied fault develops at the top of the oceanic crust (i.e. basalt) in the Shimanto accretionary complex. Previous studies suggest that this subduction thrust records thermal pressurization-induced fluidization during subduction earthquake (Ujiie et al., 2007; 2008). Crystal-chemical features of the basalt-derived fault rocks were analyzed by SEM, XRD, EMPA and TEM. The fault rock contains 30~40 wt% of clay matrix surrounding feldspar, quartz, calcite and accessory minerals. Clay matrix is characterized by formation of mixed-layer chlorite/corrensite. The ultracataclasite, which experienced localized slip, has selectively higher chlorite/corrensite ratio than the host rock, probably caused by local heat anomaly. Chemical composition of chlorite within the ultracataclasite is similar to those for low-temperature diagenetic origins, and their estimated formation temperatures are about 35~55 degrees higher than the background temperature of the surrounding melange (130~150 degrees), which is consistent with the previously estimated range (50~150 degrees) from the stretching of fluid inclusions in calcite (Ujiie et al., 2008). Crystal-chemical analyses of fault rocks shown here is potentially another way to detect small temperature rise by frictional heating.

References

Okamoto, S., Kimura1 G., Takizawa S., and Yamaguchi H. (2006) Earthquake fault rock indicating a coupled lubrication mechanism. eEarth, 1, 23?28.
Ujiie, K., Yamaguchi A, Kimura, G., Toh, S. (2007) Fluidization of granular material in a subduction thrust at seismogenic depths. Earth and Planetary Science Letters, 259, 307-318.
Ujiie, K., Yamaguchi, A., Taguchi, S. (2008) Stretching of fluid inclusions in calcite as an indicator of frictional heating on faults. Geology, 36, 111-114.