Tectono-geochemical characteristics of faults in the shallow portion of an accretionary prism

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To understand the tectono-geochemical evolution of faults in the shallow part of a subduction–accretion system, we examined major faults in a fossil Miocene accretionary prism, Boso Peninsula, Japan, by performing multiple structural, geochemical, and mineralogical analyses. Because the strata are relatively shallow (burial depth, 1–4 km), early stage deformation related to subduction, accretion, and uplifting processes is well preserved in three dominant fault zones.

Two faulting systems were observed in the strata. The slip-zone rocks of early-stage faulting showed weak shear foliation and jigsaw puzzle microstructure, indicating that high pore-fluid pressure was generated during slip. However, no marked high-temperature fluid signal was detected by geochemical analysis results (measurement of fluid-mobile element such as Sr, Li, Rb, and etc), so fluidization might have occurred at relatively low temperature (<200 °C) during slip. The XRD analysis indicated a high concentration of smectite in the slip zone, which was also supported by geochemical modeling. On the other hand, the slip-zone rocks of later stage faulting has a specific geochemical characteristics that Na_2O, K_2O, and Ba concentrations were remarkably higher and Li, Rb, and Cs concentrations lower than the regression lines fitted to the host rock values, indicating the interaction of the rock with aqueous fluids derived from sediment pore water at a temperature as high as 350 °C.

On the basis of both previous findings and these geochemical and mineralogical results, we inferred that early stage faulting in a near-trench setting under high pore fluid pressure generated very low frequency earthquakes; and during later stage faulting, probably in association with accretion and uplift processes, a high-temperature fluid, revealed by a geochemical temperature proxy, triggered fault weakening by a thermal pressurization mechanism, and potentially led to the generation of a tsunami.