Geological and geochemical characteristics of deeper extension of faults

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Integration of geophysical, geological and geochemical data on deep extension of fault is very important for understanding seismogenic processes. In this presentation, I would like to summarize geological and geochemical information on the two faults, the Nojima fault and the Hatagawa fault zone. The Nojima fault was an active fault which slipped at 1995 Hyogoken-nanbu (Kobe) earthquake and the Hatagawa fault is an exhumed fault that was active in Cretaceous age. These two examples help us to image the fault zone at different depth of the granitic crust, the brittle zone for the Nojima fault and the brittle-plastic transition zone for the Hatagawa fault.

Nojima fault

The active fault drilling at Nojima Hirabayashi after the 1995 Hyogoken-nanbu (Kobe) earthquake provides us a unique opportunity to investigate subsurface fault structure and in-situ properties of the fault. The borehole (747m deep) is situated at Nojima Hirabayashi, on the northwestern coast of the Awaji Island, Japan, where the surface displacement at the 1995 Kobe earthquake was at maximum. We identified the fault core at about 623m to 625m depth interval based on both geophysical logging data and core lithology. The core lithology is mostly Cretaceous granodiorite with some porphyry dikes. The rocks above 426m depth are nearly intact granodiorite. The borehole enters into the fault zone at 426m depth and the rocks are affected by the fault even at the bottom of the borehole. Characteristic alteration minerals in the fault zone are smectite, zeolites (laumontite, stilbite) and carbonate minerals (calcite, siderite, and dolomite). The fault core of the Nojima Fault is investigated from structural and mineralogical point of view to elucidate the environment of the gouge formation. The fault core is about 30 cm thickness and deformation is intensively localized there. Geochemical data such as bulk rock composition and oxygen and carbon isotope data also show anomaly at the fault core probably due to high fluid flux at both post seismic and interseismic stages. Three types of fault gouge are identified and they are considered to represent different age and depth of Nojima fault activity.

Hatagawa fault

The Hatagawa fault zone is located in the eastern part of the Abukuma Mountains. It is extended in the direction of NNW-SSE up to 100km in length. It is a tectonic boundary between Abukuma belt in the west and South Kitakami belt in the east (Kubo et al., 1990). Various kinds of fault rocks of mostly Cretaceous granitoids origin are distributed and plastic deformation and brittle deformation are closely associated (Takagi et al., 2000). Main cataclasite zone, which is considered core of the Hatagawa fault zone is extended continuously in the direction of almost N-S with about 100m width. Mylonite zones with a sinistral sense of shear partially surrounds the cataclasite zone with a maximum width of 1 km. Small scale shear zones, of which width ranges from a few mm to a few m, are distributed in the surrounding granitoids. Deformation structure is well preserved in these small shear zones and pseudotachylyte bands sometimes occur (Kubo and Takagi, 1997). Shigematsu and Yamagishi (2002) categorized mylonite into two types based on microstructure. One was deformed under higher temperature (higher than 400C) and the other was deformed under lower temperature (about 300C). The cataclasite is formed at the temperature condition about 250~300C based on the alteration mineral assemblages. These temperature ranges cover the temperature of inland earthquake source region. The Hatagawa fault zone is, therefore, considered to have been a Cretaceous seismogenic zone of large earthquake (M7 class), inferred from the extension of the cataclasite zone.