Faults and geothermal system

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Most of large inland earthquakes start to rupture at the base of the brittle crust. Recent results of magnetoterullic survey and analysis of seismic waves indicate the existence of fluid phase at the deeper extension of the seismogenic faults. However, the characteristics of the fluid phase and transport properties have not been clearly understood. There are many active geothermal fields in Japan and geothermal explorations have clarified the nature of hydrothermal circulation system. The question is whether the nature and behavior of the fluid phase in the deeper extension of the seismogenic faults are analogous to those in active geothermal fields.

In the Kakkonda area, NE Japan, the Quaternary granites lies at the depth of about 3km and an active geothermal system is developed. A deep exploration borehole WD-1a, drilled by NEDO, reached the hot granites at the 3729 m depth and the bottom temperature exceeded 500 C. Hydrothermal system is developed above about 3km depth (350 C), whereas, heat conductive zone exists underneath. Meteoric origin water is dominant in the hydrothermal system, whereas, CO2 and H2S rich gas and brines rich in heavy metals were sampled from the heat conductive zone. They are derived from the cooling magma and there is no signature of meteoric water. The deep fluids probably fill the small pore space such as open grain boundary. Micro-earthquakes frequently occur in the hydrothermal system, whereas, no brittle failure is detected in the heat conductive zone. Fluid pressure is hydrostatic in the hydrothermal system and increases steeply in the heat conductive zone.

The base of the hydrothermal system is controlled by both rock properties (permeability, brittle-plastic transition) and fluid properties (critical point, chemical composition). Impermeable barrier could exist at the base of the hydrothermal system considering the solubility of silicate minerals. Discharge flow is focused in the faults or fractures and recharge flow is more slow and dispersive.

Intensive water-rock interaction is observed in the Nojima fault, which is activated at 1995 Kobe earthquake. Hydrothermal alteration is also exists in the Hatagawa fault zone, an exhumed seismogenic zone in the granitc crust. The nature and behavior of fluids mentioned above could be applicable to those in the fault zone, though the tectonic setting and geothermal gradient is different.