Heterogeneous localisation of plastic flow in the deepest part of a seismogenic faults: insight from the Hatagawa Fault Zone, NE Japan

Norio SHIGEMATSU (GSJ, AIST),

The hypocentres of inland earthquakes are generally located in the shallow part of the Earth's crust, and mainshocks usually occur in the deepest part of the seismogenic zone (e.g., Sibson, 1982, 1984; Nakamura and Ando, 1996). The temperature of the base of the seismogenic zone lies between 300 and 400 °C (Ito, 1999), which corresponds to the brittle–plastic transition in the Earth's crust (Sibson, 1982, 1984). These observations suggest the important role of plastic behaviour along the deep-level extensions of seismogenic faults in the generation of large inland earthquakes (Shimamoto, 1989; Scholz, 1990).

This study examines plastic flow in fault rocks exposed along the Hatagawa Fault Zone (HFZ) of NE Japan. The fault zone, developed in 110 Ma granitoids (Ohtani et al., 2004), ceased activity by 98.1±2.5 Ma (Tomita et al., 2002). Three different fault rocks (mylonites with microstructures A and B, and cataclasite) are exposed along the fault. Microstructure A formed at the brittle–plastic transition. The temperature conditions for microstructure B were higher than those for Microstructure A; those for the cataclasite were lowest. Microstructure A is exposed in limited regions (maximum length extent of approximately 6 km) along the HFZ. Many zones of localised deformation (also containing crush zones) developed within the outcrop extent of microstructure A.

The distribution of microstructure A is considered to represent the latest-stage localised zones of plastic flow, associated with strain weakening accompanied by dynamic recrystallization of feldspar (e.g. Shigematsu, 1999). This limited outcrop extent suggests the restriction of plastic displacement to certain intervals at depth ranges with P-T conditions of the brittle–plastic transition. Many localised deformation zones with crush zones are observed in rocks with microstructure A, suggesting that numerous fractures nucleated due to ductile fracture of highly deformed fine-grained feldspar in the outcrop extent of microstructure A (Shigematsu et al. 200; Rybacki et al., 2008). Interaction between fractures that nucleated by ductile fracture and stress concentrations associated with the restricted development of plastic displacement possibly promoted the nucleation of large earthquakes.

References

Sibson, R.H., 1982. B.S.S.A. 72, 151-163.
Sibson, R.H., 1984. J.G.R. 89B, 5791-5799.
Nakamura, M., Ando, M., 1996. J. Phys. Earth 33, 329-335.
Ito, K., 1999. Tectonophysics 306, 423-433.
Shimamoto, T., 1989. J. Struct. Geol. 11, 51-64.
Scholz, C.H., 1990. Cambridge University Press, Cambridge.
Ohtani, T., et. al., 2004. Earth Planets Space 56, 1201-1207.
Tomita, T., et al., 2002. Earth Planets Space 54, 1095-1102.
Shigematsu, N., 1999. Tectonophysics 305, 437-452.
Shigematsu, N., et. al., 2004. E.P.S.L. 222, 1007-1022.
Rybacki, E., et. al., 2008. G.R.L. 35, L04303, doi:10.1029/2007GL032478.