断層応力時間変化をいかに知るかー日本の活断層の事例研究

How can we learn on time variation of fault stress state: Case histories of Japan inland active faults

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It is an important factor to understand fault activities how the strength of a fault plane is recovered and how the stress on the fault plane accumulates during an earthquake cyclic interval. Recently, in-situ stresses associated with fault activities have been measured in and around the faults (e.g., Ikeda et al., 1996a; Ikeda et al., 1996b; Ikeda et al., 2001; Tsukahara et. al., 2001; Omura et al., 2004; Yamashita et al., 2004; Lin et al., 2007; Yabe et al., 2010; Yamashita et al., 2010; Yabe and Omura, 2011; Lin et al., 2013). However, it is difficult to make clear time variation of stress state in and around a particular fault in the field because the interval of an earthquake recurrence cycle is very long (about a thousand years or more as for cases of inland active faults in Japan). An alternative way is suggested to measure in-situ stress in and around different faults that are in different stages during the earthquake recurrence intervals, and that reflect different levels of the strength recovery and stress accumulation on the fault planes. In this presentation, examples of downhole in-situ stress measurements are introduced concerning time variations of stress state.

The hydraulic fracturing method is applied to estimate stress magnitudes, assuming that one of three principal stresses has vertical direction and is equal to the overburden pressure. Because the measuring system had large compliance (i. e., large volume of water is necessary to raise pressure in measuring borehole section), the tensile strength of the borehole rock is estimated and apply to next equations: SH = 3Sh - Pb + T - Pp, Sh = Ps; SH maximum horizontal principal stress; Sh minimum horizontal principal stress; Pb breakdown pressure; Pp pore water pressure; Ps shut-in pressure; T tensile strength of borehole rock. The directions of horizontal principal stresses were estimated by observations of borehole breakouts and/or drilling mud pressure induced tensile fractures due to borehole wall imaging logging tool (BHTV borehole televiewer).

Those examples suggested that the stress on the fault plane drops in association with the earthquake and increases toward the next earthquake. However, it is not clear whether the stress increase linearly with time, or change largely just after an earthquake, or increase rapidly just before the earthquake. It is necessary to measure repeatedly in-situ stress to detect effectively the time variation of stress state in and around a fault after an earthquake.

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