How can we Measure Time Variations of Fault Stress States: Case Studies of Japan Inland Active Faults

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It is an important factor to forecast earthquake mechanics 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]; Ito et al. [1997]; 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]; Kuwahara et al. [2012]; Ito et al. [2013]; Lin et al. [2013]). However, it is difficult to explore 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 at different faults those are in different stages during the earthquake recurrence intervals, and those 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 of Japan inland active faults. The faults are classified into three groups; Post-seismic faults [Nojima (1995 Kobe Eq.)], During-seismic faults [Atera (1586 Tensho Eq.), Atotsugawa (1858 Hietsu Eq.), Neodani (1891 Nobi Eq.)], and Pre-seismic faults [Gofukuji, Hagiwara].

The hydraulic fracturing method was applied to measure stress magnitudes, assuming that one of three principal stresses has vertical direction and is equal to the overburden pressure. The tensile strength of the core rock was estimated and applied to the 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 (BB) and/or drilling induced tensile fractures (DITF) by means of 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.

Ikeda, R, K.Omura and Y.Iio,.H. Tsukahara, 1996a, Proc. VIIIth Int’l. Symp. on the Observation of the Continental Crust through Drilling, 30-35.

Ikeda,R., Y.Iio and K.Omura, Y.Tanaka, 1996b, Proc. VIIIth Int’l. Symp. on the Observation of the Continental Crust through Drilling, 393-398.

Ikeda, R., Y. Iio and K. Omura, 2001, The Island arc Special Issue. 10, Issue 3/4, 252-260.

Ito, H., Y. Kuwahara and O. Nishizawa, 1997, Proc. Int’l. Symp. Rock Stress, Kumamoto, 351-354.

Ito, T., A. Funato, W. Lin, M. Doan, D. Boutt, Y. Kano, H. Ito, D. Saffer, L. McNeill, T. Byrne, and K. Moe, 2013, J. Geophy. Res., 118, 1-13, doi:10.1002/jgrb.50086.

Lin, W., E.-C. Yeh, H. Ito, J.-H. Hung, T. Hirono, W. Soh, K.-F. Ma, M. Kinoshita, C.-Y. Wang, and S.-R. Song, 2007, Geophys. Res. Lett., 34, L16307, doi:10.1029 2007GL030515.

Kuwahara, Y., T. Kiguchi, X. Lei, S. Ma, X. Wen, and S. Chen, 2012, Earth, Planets and Space, 64, 13-25.

Lin, W., M. Conin, J. Moore, F. Chester, Y. Nakamura, J. Mori, L. Anderson, E. Brodsky, N. Eguchi, and Expedition 343 Scientists, 2013, Science, 339, 687-690.

Omura, K., R. Ikeda, T. Matsuda, A. Chiba, and Y. Mizuochi, 2004, Earth Monthly, extra edition No.46, 127-134.

Tsukahara, H., Ikeda, R. and Yamamoto, K. , 2001, Island Arc, 10, 261-265.

Yabe, Y., K. Yamamoto, N. Sato, and K. Omura, 2010, Earth Planets Space, 62, 257-268.

Yabe, Yasuo and Kentaro Omura, 2011, Island Arc, 20, 160-173.

Yamashita, F., E. Fukuyama and K. Omura, 2004, Science, 306, 261-263.

Yamashita, F., K. Mizoguchi, E. Fukuyama, and K. Omura, 2010, J. Geophys. Res., 115, B04409, doi:10.1029 2009JB006287.