What happens in the Western Nagano Prefecture?

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It is not well known the generating process of intraplate earthquakes. How do stress concentration and/or strength reduction occur? What determines a recurrence interval, which is generally much longer than that of interplate earthquakes?

An ideal opportunity for the investigation of the generating process of intraplate earthquakes was offered by an intraplate earthquake occurred in the central part of the Japanese Island. The earthquake, the 1984 Western Nagano Prefecture, Japan earthquake (Ms6.8)(WNPE) occurred in the middle of a permanent seismic network. The hypocentral depth is very shallow and determined by Japan Meteorological Agency (JMA) as 2km. The maximum slip determined by an inversion method occurred at a depth of about 2 km [Yoshisa and Koketsu, 1992]. Since the focal region is very shallow, various kinds of data of high quality have been obtained by various observations in the Western Nagano Prefecture region.

A precise location of aftershocks [Horiuchi et al., 1992], 3D velocity tomography [Hirahara et al., 1992], Inversions of rupture process, a determination of the S-wave reflection points [Inamori et al., 1992], strong ground motions inferred from displaced boulders [Iio and Yoshioka, 1992], stress distribution around the focal region [Yamamoto et al, 1990] and etc. were reported.

One of the most important data is the stress distribution derived from core samples, which were obtained from four boreholes of a length of about 1 km drilled by NEDO. Data from the borehole located about 1 km from the earthquake fault indicate very small minimum compressional stress in a horizontal direction [Yamamoto et al., 1990]. It was found that the stresses obtained from the core samples well explain the focal mechanism of WNPE derived from first motion data. This implies that WNPE could be possibly generated by a strength reduction of a decreased fault normal stress.

The other important observation is a distribution of S-wave reflection points found by the Joint Research [Inamori et al., 1992]. It is found that the reflection points distribute adjacent to the lower margin of the fault. The points are scarcely found south of the lower margin. When the reflection points are assumed to constitute one plane, it is thought that the plane acts like a fault plane and slips occur on the plane, since the friction on the plane probably very small. Further, it is thought that the slips occur quasi-statically, since the plane is located below the seismogenic region. Here, the plane is regarded as a detachment.

The azimuth of the plane is almost the same as the direction of maximum compressional stress and earthquakes immediately above the plane are characterized by reverse faults [Yamazaki et al., 1992]. Then, the plane acts like a pure reverse fault and tensional stress field is produced around the southern edge of the plane, namely the lower margin of the earthquake fault of WNPE.

Thus, the generating process of WNPE is estimated as follows. Slow slips occurred on the detachment. The slips produced a tensional stress field around the lower margin of the fault. The tensional stress reduced the strength of the fault and quasi-static slips began to be generated on the fault plane just above the detachment. The quasi-static slips accelerate and the region where the slips had occurred extended upward and finally reached to the brittle region and dynamic rupture propagation occurred.