

Detection of aseismic slip below seismogenic zone in Atotsugawa fault using spatial variation of focal mechanism solution

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Aseismic slip such as creep and after-slip has been often observed by GPS network in recent years. In order to resolve the stress accumulation process in an earthquake cycle, it is important to detect aseismic slip region and investigate how it affects a surrounding stress field.

If a surrounding stress field changes due to aseismic slip, the influence should appear as spatial variation of focal mechanism solution of microearthquakes. This suggests a possibility that aseismic slip region is detected by the distributions of focal mechanism solutions.

We carried out dense seismic observations around the Atotsugawa fault from July through November 2002, and from May through November 2003. The spacing of the seismometers is about 5 km. Seismometers were fixed on hard rock surface with plaster of Paris. Using these data, we tried to determine focal mechanism solutions only with P polarities. However, it was difficult to obtain a unique solution for many earthquakes. Therefore, we added information of P and SH-wave amplitudes to obtain focal mechanism solutions stably, and we succeeded in determining focal mechanism solutions down to magnitude 0.5. The solutions show that the reverse fault earthquakes occur at depth shallower than brittle-ductile transition zone, while right lateral strike slip events occur only in and around the brittle-ductile transition zone. We suggested that the variation of focal mechanism solution with depth might be produced by aseismic slip below seismogenic zone (2003 SSJ fall meeting).

In this study, we tried to estimate aseismic slip below seismogenic zone which explains observed spatial variation of focal mechanism solutions. We considered a vertical fault with a length of 60km. We assume that the fault is locked less than 15km, and aseismic slip occurs at depth between 15 km and 30 km. The vertical stress is approximated by the overburden pressure ($S_v = \rho \cdot g \cdot z$). Two horizontal stresses (S_{max} and S_{min}) are assumed to be $S_{max} = S_{min} + 11.34 + 12.74 \cdot z$ [McGarr, 1980] and $S_{min} = A \cdot z$ ($A > 0$), respectively. The resulting stress field is obtained by adding the stress change by the aseismic slip to the above stresses. We consider that the strike slip events occur at the region where the stress field ($S_{max} > S_v > S_{min}$) is produced due to a reduction of S_{min} greater than 1MPa. We search a range of A and aseismic slip so that the region of the strike slip event occurrence does not exceed 3km. The range of A is limited around 24.5 ($= \rho \cdot g$), suggesting that S_{min} is almost equal to the overburden pressure. The estimated aseismic slip ranges from several cm to several m. However, the amount of aseismic slip of several m might be too large, because the lapsed time from the 1858 Ansei Hida earthquake is about 150 years. Therefore, the observed spatial variation of focal mechanism solutions can be explained by about 10cm aseismic slip below seismogenic zone.