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Aseismic fault slip and stress change before large intraplate earthquakes

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Aseismic deformation detected by geodetic survey before large intraplate earthquakes has been frequently reported. However, the relationship between geodetic deformation, aseismic fault slip, stress change, and intraplate earthquakes has not been fully investigated. In this study, we report significant deformation observed by geodetic survey before three large intraplate earthquakes (M=7.8, 1976, Tangshan; M=7.2, 1995, Kobe; and M=7.0, 1996, Lijiang). It is revealed that aseismic deformation occurred in areas around or nearby coseismic faults. Inversion analysis of the observed surface deformation indicates that aseismic slip occurred on active faults nearby the coseismic faults several years before the earthquakes. A common feature of the active fault models is that aseismic slip occurred at a depth of larger than 10 km, i.e., within the mid to lower crust. Such aseismic slip before earthquake on nearby geodetically active faults is not directly comparable with the geological slip-rates of the faults. A geological fault slip-rate represents the surface (fault) slip-rate, while aseismic slip on the active faults found in this study occurred at a deeper layer (10-30 km).

Results from laboratory experiments indicate that ductile deformation (dislocation creep) dominates in the lower crust. This implies that transient motion on nearyby faults about several or tens of years before a large intraplate earthquake could represent macroscopic fault activity within the semi-brittle regime.

A stress analysis shows that the Coulomb failure stress increased by about 4.5, 0.9 and 5.6 bar/yr at the hypocenters of the 1976 Tangshan, the 1996 Lijiang and the 1995 Kobe earthquakes about three, eight and five years before the earthquakes, respectively. These results demonstrate that these large intraplate earthquakes were possibly triggered or induced by aseismic movement of the nearby, geodetically active faults. This study suggests that aseismic fault slip beneath the seismogenic layer may play an important role in controlling regional stress concentration and inducing earthquakes on surrounding faults.