１９９９年イズミット地震破壊域における電気的状態の変化

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Changes in the electrical state of the 1999 Izmit earthquake rupture zone

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Crustal structure in the fault zones is often characterized by low resistivity that indicates crustal fluid and suggests a possible relation to earthquake generation. The North Anatolian Fault Zone (NAFZ), northwestern Turkey, is characterized by the low resistivity structure and electromagnetic studies there are expected to provide important information on the relation of crustal fluid with earthquake generation. When the Mw 7.6 Izmit earthquake occurred on 17 August 1999 along the NAFZ, five magnetotelluric (MT) sites (four along a profile crossing the NAFZ and one at a remote reference site approximately 40 km south) were recording the electromagnetic field in the area. Although these MT sites were aimed at investigating the resistivity structure of the NAFZ, they provide an extremely rare opportunity for studying pre- and co-seismic electromagnetic phenomena.

According to our recent detailed analyses, most estimates of apparent resistivity in the frequency range of 0.05 Hz to 2.0 Hz show abrupt co-seismic decreases on the order of tens of per cent. Data acquired at two sites one month after the Izmit earthquake indicate that the resistivity had already returned to pre-seismic levels. In addition, some data show pre-seismic changes seemingly in association with foreshocks and slow-slip events before the mainshock. We then searched for a plausible model to explain the co-seismic changes, using the 2D forward-modelling code. Our model is as follows. At 3-6 km depth, the resistivity is decreased by 50% in its shallow part (3-4 km) and by 80% in its deep part (4-6 km). Resistivity changes in additional local layers are 10% for 2-3 km and 50% for 1-2 km. This depth range is shallower than the hypocentre of the mainshock, which is estimated to be 10-15 km, but it is consistent with the distribution of major fault slip during the Izmit earthquake. The pre-seismic model is uncertain due to a very limited dataset, and it is supposed to be the same as the co-seismic stage except for a shallow layer between 1 and 2 km depth.

Conventionally, crustal resistivity is thought to change gradually, reflecting the diffusion of fluid. We propose an alternative model: a transition from the state of isolated fluids to the state of interconnected fluids. The crustal resistivity is primarily controlled by conductive crustal fluid and its interconnectivity at the microscopic level, such as on grain boundaries or along micro-cracks. Our conceptual model is as follows: before the earthquake, some fluids were partially in an isolated state, and the pore pressure changed immediately before and during the earthquake, connecting the fluids through a new fluid-path network. In this respect, the role of crustal fluids in the triggering of earthquakes has been discussed previously, and we propose that this transition may be triggered by the release of stress due to slow slip at the rupture initiation zone and during the earthquake rupture. The opposite can be considered for a possible relation to the slow slip; coupling at the fault interface is weakened by the fluid-filled network that is created by the increase in pressure, which results in increased fault slip. For details, visit http://www.nature.com/ncomms/2013/130703/ncomms3116/full/ncomms3116.html