Periodic variations in crustal resistivity and their relation to the 1999 Izmit earthquake

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The recent accumulation of seismic slow-slip events has provided an extremely useful tool to understand the process of fault rupture, particularly in subduction zones. However, how such events are generated remains to be studied, not only for subduction zones but also for inland active faults. One of the typical examples in the latter case is the North Anatolian Fault Zone, where the Mw 7.6 Izmit earthquake occurred on 17 August 1999 (UT) in the so-called seismic gap zone. Electromagnetic studies for this earthquake have provided some important information on the possibility of slow slip before the earthquake occurrence. In fact, Honkura et al. (2013) have reported the results of pre-, co- and post-seismic changes in apparent resistivity and impedance phase in magnetotellurics (MT). To assess the mechanism of resistivity decrease in relation to seismic slow-slip generation, we need more continuous estimates of MT parameters before and after the main shock.

However, we have found many electromagnetic noises with a short but large pulse-like waveform in urban areas near the observation sites; such noises are likely to affect a wide range of frequencies in spectral analyses. Therefore, we have manually removed these noises that occasionally occurred. This monotonous, but very significant procedure has generated extremely high-quality time-series data of the electric and magnetic fields before the main shock.

Here, we show the results of our recent detailed analyses of electromagnetic data acquired immediately before and after the Izmit earthquake. We could derive temporal evolutions of apparent resistivity and phase in the frequency range from 0.01 Hz to 2 Hz at each observation site. Most notable is the discovery of periodic variations in apparent resistivity and phase themselves. In view of the periods of approximately 12, 6 and 3 hours, these variations seem to be associated with the earth tide and its higher harmonic constituents. Hence, we propose that the earth tide acts as a driving force of the strain-induced transition between isolated and interconnected states of fluid, mostly corresponding to conducting water, in porous material within the crust. In view of the fact that the Izmit earthquake occurred during the fluid interconnected state, the possibility is inferred that such crustal fluid diffused into the fault zone and happened to lead to a fault slow slip.

Keywords: Magnetotellurics, Apparent resistivity and phase, Earthquake interaction, Seismic slow slip, Earth tide

