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Focal mechanism determinations along the North Anatolian fault, below the Sea of Marmara and the Aegean Sea

NAKANO, Masaru[1*] ; CITAK, Seckin ozgur[1] ; KALAFAT, Dogan[2]

[1]JAMSTEC, [2]KOERI, Bogazici Univ.

Rapid determinations of centroid moment tensor (CMT) of earthquakes, namely the source centroid location, focal mechanism, and magnitude is important for early disaster responses and issuing Tsunami warnings. Using the SWIFT system (Source parameter determinations based on Waveform Inversion of Fourier Transformed seismograms) developed by Nakano et al. (2008), we are developing earthquake monitoring system in Turkey. Also determinations of CMT solutions for background seismicity would reveal the tectonics in the target region, which contribute to develop scenarios for future disastrous earthquakes.

The North Anatolian fault (NAF) is one of most active fault in Turkey, which is a right-lateral fault system running in the East-West direction. NAF can be separated into a number of segments of which ruptures have propagated from east to west in the 20th century. The 1999 Izmit (Kocaeli) earthquake (Mw 7.4) is the westernmost activity along NAF in recent years, and next activity below the Sea of Marmara is anticipated. On 24 May 2014, an Mw 6.9 (USGS) earthquake occurred beneath the northern Aegean Sea, western extension of NAF. A seismic gap between these events still exists beneath the Sea of Marmara.

Using data from broad-band seismometers (Guralp CMG-3T, CMG-3ESP, or CMG-3ESPC) of the regional network in Turkey, we determined CMT solutions of earthquakes along the NAF beneath the Sea of Marmara and Aegean Sea. Seismic events are selected from the USGS ANSS Comprehensive Catalog (ComCat) with magnitude larger than 4 in the target area. We analyzed earthquakes that occurred between 2008 and 2014. We selected seismograms with good data quality. The seismograms are corrected for the seismometer response, band-pass filtered between 20-50 s, and integrated in time to obtain displacement seismograms. The Green functions are synthesized assuming the standard Earth model ak135. Assuming a double-couple source, waveforms are inverted in the frequency domain to obtain best-fit source location and mechanism.

Most events are outside the observation network and the azimuthal gap is larger than 180 and 270 degree for events beneath the Sea of Marmara and the Aegean Sea, respectively. However, for most events the obtained source location in our analysis were almost identical to, or different at most 0.1 degree from, the initial source location from the ANSS catalogue. Because of the large azimuthal gap, we also carefully checked the stability of the obtained focal mechanism.

For the 2014 event beneath the northern Aegean Sea, we obtained a right-lateral strike-slip focal mechanism (Mw=7.2), of which one of nodal planes was directing in ENE-WSW consistent with the slip on NAF. Most of other events represented similar focal mechanisms. Some normal faulting events were also observed several tens of kilometers east of the 2014 earthquake and beneath of the Sea of Marmara.

The Sea of Marmara is a pull-apart basin developed at a segment boundary of NAF, where the crust opens and extensional stress develops. The normal-fault earthquakes may represent such tectonic settings. Detailed descriptions of fault segments would help to estimate future earthquake magnitudes. Normal faulting earthquakes beneath the sea would cause tsunamis if large enough. Historical studies of earthquakes beneath the Sea of Marmara revealed that damaging tsunamis had been triggered due to large earthquakes. Therefore, mapping normal faults and evaluation of their seismic potential are important for disaster mitigation from tsunami in this region.

In the research project of SATREPS-Earthquake and tsunami disaster mitigation in the Marmara region and disaster education in Turkey, we will develop a CMT determination system and a CMT catalogue in Turkey.

Keywords: North Anatolian fault, pull-apart basin, centroid moment tensor