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Offshore seismicity in the western Marmara Sea, Turkey, revealed by ocean bottom observation

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The North Anatolian Fault (NAF) extends 1600 km westward from a junction with the East Anatolian Fault at the Karliova Triple Junction in eastern Turkey, across northern Turkey and into the Aegean Sea, accommodating about 25 mm/yr of right-lateral motion between Anatolia and the Eurasian plate. Since 1939, devastating earthquakes with magnitude greater than seven ruptured NAF westward, starting from 1939 Erzincan (Ms=7.9) at the eastern Turkey and including the latest 1999 Izmit-Golcuk (Ms=7.7) and the Duzce (Ms=7.4) earthquakes in the Marmara region. Considering the fault segments ruptured by the May 24th, 2014 Northern Aegean earthquake (Mw=6.9), the only un-ruptured segments left behind the 1600 km long NAF locate beneath the Marmara Sea and those segments keep their mystery due to their underwater location.

To obtain the detailed information about fault geometry and its stick-slip behavior beneath the western Marmara Sea, we started to operate a series of ocean bottom seismographic (OBS) observations. As a first step, we deployed 3 pop-up type OBSs on 20th of Mar. 2014 as a trial observation, and recovered them on 18th of Jun. 2014. Although one of the OBSs worked only 6 days from the start of the observation, other two OBSs functioned properly during the whole 3-month observation period.

We first searched for the microearthquakes missing by the land seismic network and estimated their precious location by using the initial 6 days data, i.e., using all the temporary OBS stations. Although there are only 3 earthquakes listed on the Kandilli Observatory and Earthquake Research Institute (KOERI) catalogue, we could identify 41 earthquakes with more than 5 picking data of P and S first arrivals, and two-third of them located within the OBS network. We found the earthquake cluster (cluster-A) along the main NAF and whose depth interval is 12-20 km, and some event pair within cluster-A has similar waveform. The location of cluster-A indicates that the dip angle of the main NAF is almost vertical.

Then, we relocated the KOERI-catalogued earthquakes in 3 months periods by combining the land and OBS data. The results indicated that some earthquakes occurred 5-10 km away from the main NAF, and the upper limit of seismicity along NAF seems to dip eastward. Besides, we calculated the correlation coefficient between the waveform data of cluster-A earthquakes and continuous 3-month OBS records to estimate the temporal change of cluster-A activity. The result indicates that the cluster-A became inactive on the end of March. Since the KOERI catalogue reported the active seismicity from 13th to 18th of Mar. near the cluster-A, there is a possibility that the duration of the cluster-A activity was about 2-3 weeks.

To obtain more information of the fault geometry beneath the Marmara Sea, we started a second step observation by using 10 OBSs from Sep. 2014 to Jun. 2015. In addition, we are planning to add 5 OBSs to this observation in Mar. 2015. All OBS observations are conducted as a part of the “Earthquake and Tsunami Disaster Mitigation in the Marmara Region and Disaster Education in Turkey” project, financially supported by Japan International Cooperation Agency (JICA), Japan Science and Technology Agency (JST), and the Ministry of Development in Turkey.

Keywords: The Marmara Sea, The North Anatolian Fault, Seismicity, Ocean bottom seismograph