
Seismic and aseismic fault slip during the inter-seismic period: observations from the Marmara region of the North Anatolian Fault

Patricia Martínez-Garzón^{*†1}, Dirk Becker², Durand Virginie², Grzegorz Kwiatek², Marco Bohnhoff², and Murat Nurlu²

¹Helmholtz-Centre Potsdam GFZ German Research Centre for Geosciences – Potsdam, Germany

²AFAD Turkish Disaster Management Presidency – Germany

Abstract

During the inter-seismic period, faults accumulate tectonic strain which is then released through slip transients of different duration from seismic to aseismic. Imaging creeping fault patches and constraining their depth extent could allow identifying fault segments with larger strain accumulation. The Marmara segment of the North Anatolian Fault (NAFZ) currently represents a seismic gap with a high probability for an $M > 7$ earthquake in direct proximity to Istanbul. In the eastern Sea of Marmara region of the NAFZ, the GONAF borehole observatory is fully operating since 2015, providing the means to monitor earthquake nucleation and crustal deformation over the entire frequency band. In this study, we investigate the spatio-temporal distribution of seismic and aseismic deformation in the Marmara region and the implications for the nucleation of a large earthquake compiling information derived from extended identification of earthquake repeaters and analysis of continuous strainmeter and geodetic recordings. At the eastern portion of the Marmara segment, a fully locked fault segment was identified from absence of microseismicity and from GPS data (Bohnhoff et al., 2013; Ergintav et al., 2014). Towards the western part, shallow fault creep was reported based on sea-floor geodesy (Yamamoto et al., 2018) and the occurrence of repeating earthquakes (Schmittbuhl et al., 2016; Bohnhoff et al., 2017) in specific areas. We generated a new 15-year homogenous seismicity catalog for the Marmara region (2006-2021) unifying the data from the main Turkish seismic agencies AFAD and KOERI and including the GONAF borehole network. A total of 13,876 events were of sufficient quality to obtain non-linear hypocenter locations. We utilized this catalog to search for earthquake repeaters along the entire Main Marmara fault segment as well as the southern Marmara and Armutlu fault segments. Centering at the Western High segment of the Main Marmara fault, a spatial transition eastward and westward from partially creeping to fully locked is observed based on the amount and magnitude of earthquake repeaters and the estimated creeping rate. No other sequence of repeaters is found in any other part of the Marmara region. Analysis of strainmeter continuous recordings revealed two slow slip events connected with the occurrence of two $M4+$ earthquakes in the region in 2016 and 2018 and lasting for at least 30 days. Coulomb forward modelling combined with seismicity analysis suggests that the fault source of these slip transients could be the shallower portion of a local normal fault structure in the Armutlu Peninsula favorably oriented with respect to the local stress field orientation. All

*Speaker

†Corresponding author: patricia@gfz-potsdam.de

together, these results suggest that aseismic slip is occurring in some segments and different depth extent within the Marmara section of the NAFZ and that aseismic slip has a role in earthquake triggering and nucleation in the region. Still, further studies combining seismological and geodetic data are needed to determine the exact amount of slip-partitioning, particularly with depth.