Submarine earthquake geology along the North Anatolia Fault in the Marmara Sea, Turkey: What we learnt about transform basins, earthquakes, and sedimentation

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The submerged portions of the North Anatolia Fault system beneath the Marmara Sea were studied with high-resolution multibeam bathymetry, subbottom profiling, and sediment cores. The major objectives were to learn about the seismic and tectonic history of the fault from the stratigraphic record at a scale similar to paleoseismic studies on land, and to develop tools for submarine earthquake geology that can be applied to fault-controlled basins in general. We focused on Holocene sediment in several Marmara Sea basins of different sizes. The approach was to test whether: 1) the depocenters of the larger basins contain a record of all historic Ms >7 earthquakes within the Marmara Sea region; 2) the small transform basins record earthquakes that rupture through them; 3) vertical and strike-slip Holocene deformation can be quantified; and 4) the effects of an earthquake generally includes both primary structural features due to rupture of the sea floor, such as strata offset, scarps, and tilting, as well as secondary effects due to shaking, such as mass-wasting and gravitational flows (McHugh et al., in press).

We found geologic evidence of earthquakes that we correlate with historic events in 181AD, 740AD, 1063AD, 1343AD, 1509AD, 1766AD, 1894AD, and 1912AD (Fig. 1). This evidence is primarily from those basins adjacent to the ruptures as inferred from historic data (Ambraseys 2002). This suggests that coseismic deformation of the sea floor in the vicinity the ruptures is a critical factor in the sedimentary record.

We propose a qualitative sedimentation model that relates this coseismic deformation to mass-wasting of the slope, scour of the basin floor, seiche motions and homogenite deposition. Frequent earthquake activity sheds sediments from the flanks, contributes sediment on the basin floor, and smoothes the sea floor while the basin infill typically tilts down towards the fault (Figs. 2 and 3). The surveying techniques and approaches used have therefore the potential of documenting earthquake ruptures of fault segments and to extend the earthquake record far before the known history, thus improving hazard evaluations and the fundamental understanding of earthquake process.

Results of this study indicate that submarine earthquake geology can be applied to transform basins of the San Andreas fault through a multi-step integrated approach: 1) It is critical to target the basin depocenter for maximum thickness of earthquake-related sediments, to avoid erosional discontinuities, and evaluate the extent to which pelagic sediments are reworked into the seismite. Long continuous sediment records can be obtained by using a drilling vessel such as the Joides Resolution of the Integrated Ocean Drilling Program. 2) High-resolution geophysics and understanding fault kinematics are prerequisites because the depocenters are generally much smaller than the basin's floor and typically shift along strike in these transform basins. 3) Closely spaced transects of precisely positioned cores are needed to ensure section completeness and to investigate lateral variations in the internal structure of each erosional-depositional event. Such '3D sampling' is also necessary to evaluate progressive vertical offset and tilting across a fault. Whether a basin preserves the record of every large rupture remains to be shown, but preliminary results suggest a close correspondence between geologic and historic record of large submarine ruptures. Our study also suggests that coseismic deformation of the seafloor plays an important role in generating seismites.

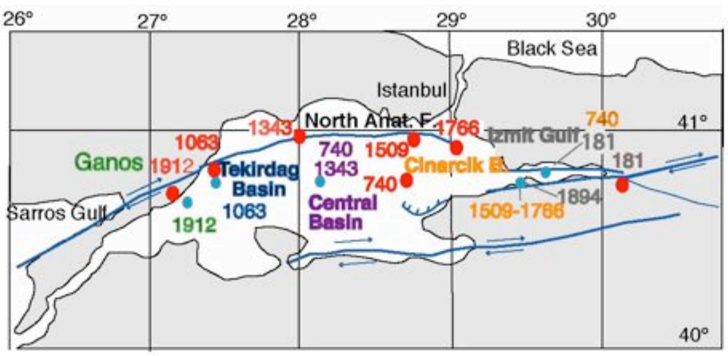


Fig. 1. Red dots are estimated locations of earthquake epicenters (Ambraseys 2002). Blue dots are our core locations (McHugh et al. in press).

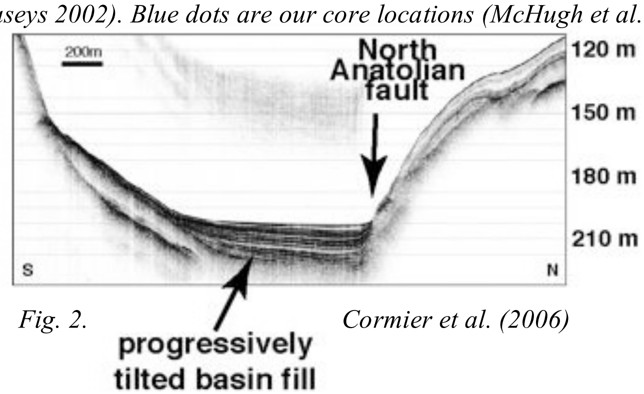
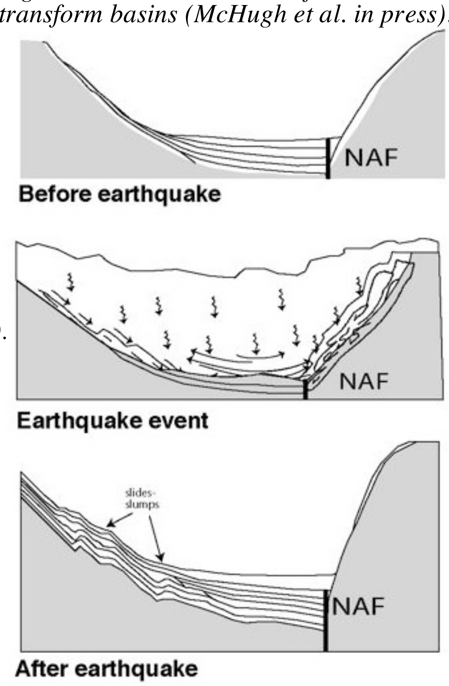


Fig. 2. *Cormier et al. (2006)*

Fig. 3. Sedimentation model for transform basins (McHugh et al. in press).



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