Annual Project Summary

Paleoearthquake History of the North Anatolian Fault, Western Turkey: An Investigation into the Nature of Earthquake Recurrence as Revealed by Precise Stratigraphic and Historical Records.

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Program element I
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Investigations Undertaken – Information on the size and timing of past earthquakes is important in understanding fault behavior, a key element in forecasting future seismic activity. The North Anatolian fault (NAF) in Turkey is an ideal candidate for understanding fault behavior over multiple earthquake cycles because there is a long and excellent historical record of large earthquakes going back over 2000 years. Furthermore, Like the San Andreas Fault of southern California, it is a fast-moving fault (23 mm/yr) resulting in many earthquakes for each fault segment during this long historical period. The work proposed for this year was to further quantify the earthquake history of the North Anatolian faults both east and west of the Marmara Sea. To the west, we planned to continue paleoseismic investigations and resolve slip for past large earthquakes, including the M7.4 1912 surface rupture. To the east, we planned to initiate paleoseismic studies along the fault zone near Izmit, which subsequently ruptured in August 1999. This report covers the two months of fieldwork undertaken this past summer.

Results – Twenty-six trenches were excavated at Kavakkoy near where the fault enters the Gulf of Saros, with the purpose of resolving slip. A sand channel dated to about A.D. 1600 crosses the fault and splays into a small alluvial fan(Figure 1) that fills a depression along the fault trace. We exposed the channel and fan in 20 trenches and collected over a thousand data on sand thickness and contour these data to develop information on slip (Figure 2). The results show that about 8.5 m of dextral slip has accrued on the NAF after formation of the sand channel. The many 2-D excavations across the fault were studied to resolve the number of events that produced this offset. In most exposures, there was evidence for only two large events, with both locally producing liquefaction. In one trench, however, where a remarkable stratigraphic record is preserved, a third event is recognized that produced relatively minor deformation to the sediments relative to the other two. We interpret the two large events as the August 1766 and November 1912 earthquakes, which are large regional events that are well known from their patterns of destruction. The 1912 rupture is also recorded by early photography. These are the only two large (M7.4-7.6) events along this fault segment during the period after about 1600.

The other, apparently minor event occurred between 1766 and 1912 and produced a small fissure in the fill alluvium resulting from the 1766 earthquake. The absence of major folding, liquefaction, and other indicators associated with the two larger events, along with the observation that this event is only recognized in one of the many trenches that crossed the fault

zone, all suggest that this event was considerably smaller, at least in terms of its effects at Saros. As there were no other large earthquakes known for this section of the NAF, we searched to the west and learned (from Nick Ambraseys) of the occurrence of a M6.9 event to the west in 1893, along the adjacent segment. The 1912 and 1893 segments are separated by a several km-wide releasing stepover, which has controlled the formation of the Gulf of Saros. We interpret the observed minor slip event at the Saros trenches to be the result of the 1893 earthquake, perhaps as bleed-over slip due to a primary rupture on the adjacent segment. If this is correct, then most of the observed 8.5m of slip can be attributed to the 1766 and 1912 events.

Six trenches were also excavated at two sites along the 1999 rupture, as proposed prior to the earthquake. At Kosekoy(Figure 3), we found evidence for two and possibly three earthquakes after A.D. 1630, one of which is 1999(Figure 4). At the Ottoman canal site, there appear to be only two large events that have occurred after its construction in 1591(Figure 5). These two sites, which are within 2 km of each other, should have essentially the same history yet there appears to be an additional event record at Kosekoy. Further work may be required here to sort this out, but these observations are consistent with rupture of this fault in 1719 (a well-recorded large event centered in this area) and possibly either 1754 or 1894.

Non-Technical Summary – Information on the size and timing of past earthquakes is important in understanding fault behavior, a key element in forecasting future seismic activity. The North Anatolian fault (NAF) in Turkey is an ideal candidate for understanding fault behavior over multiple earthquake cycles because there is a long and excellent historical record of large earthquakes going back over 2000 years. Furthermore, Like the San Andreas Fault of southern California, it is a fast-moving fault (23 mm/yr) resulting in many earthquakes for each fault segment during this long historical period. This past year, the amount of displacement for the 1766 and 1912 earthquakes was resolved at a site near the Gulf of Saros, providing important constraints on earthquake size west of the Marmara Sea. To the east, paleoseismic studies were conducted along the 1999 earthquake rupture where evidence for the 1719 and possibly one other event were found. These observations are being used to construct the earthquake history of the NAF and place constraints on fault recurrence models used to forecast earthquakes in the United States.