Macroseismic, Paleoseismic, and Archaeoseismic Data: Independent Records of Earthquake Recurrence

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A fundamental question in understanding earthquake recurrence is whether seismic rupture patterns observed in the 20th Century repeat or whether other rupture models are likely. Large earthquakes appear to occur infrequently (possibly periodically) and are generated by rupture of multiple segments along a fault length. Testing models of earthquake behavior requires records longer than the instrumental period–data that can only be provided from historical text (macroseismic data), stratigraphic sequences at archaeological sites (archaeoseismic data), and from geologic investigations (paleoseismic data). Comparison and correlation of faulting events or paleoearthquake intensity maps along similar and adjacent fault segments provide the necessary data for developing earthquake rupture scenarios and quantifying variables for probabilistic earthquake hazard assessments.

The California historical record is very short, with extensive written material covering only the past 200 years, and limited accounts covering the past four centuries. Data on past earthquake rupture of the San Andreas fault system are determined largely through paleoseismic studies at numerous research sites on the various fault segments. For example, our paleoseismic investigations at the Vedanta site located along a segment of San Andreas fault in Northern California that ruptured in the 1906 San Francisco earthquake yielded evidence for twelve earthquakes over the past 3000 years. Recurrence intervals between faulting events range from 50 to 600 years. A smaller (3m) coseismic slip in the penultimate event compared to slip in the 1906 earthquake suggests this segment has also ruptured in M~7 events. These data do not support the model that the northern San Andreas fault fails repeatedly in characteristic or 1906-like earthquakes. Paleoseismic data from the southern San Andreas fault have also failed to adequately constraint different earthquake rupture scenarios (Weldon *et al*. 2004).

Because of the longer cultural history recorded both in historical texts extending over 2000 years and in the archaeological record into the Neolithic period, the North Anatolian fault in Turkey provides a unique opportunity to document earthquake data over multiple cycles. Historical text collected in earthquake catalogues and archaeological and geological data are three independent sources that can all provide crucially needed data about the location, date, and intensity of ancient earthquakes. Whereas macro- and paleoseismic studies are well underway on the North Anatolian fault, the archaeological records have largely been under-utilized by the seismic hazard community. Archaeoseismology can constrain the date of past earthquakes by providing the age of fault rupture or of collapsed and seismically damaged features. The distribution area of archaeologically-stratified, earthquake damage from several sites can be used to develop an isosesimal map, define the epicentral location, and possibly the magnitude of past earthquakes. This type of data should be systematically explored for the Northern Anatolia fault.