The paleoseismic and neotectonic history of the North Frontal thrust system of the San Bernardino Mountains, southern California: Investigating complex fault interactions and possible implications for the San Andreas fault, while characterizing the seismic hazard of a major structure in the growing Inland Empire

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Technical Abstract

Investigations of the North Frontal thrust fault along the San Bernardino Mountains in southern California shed new light on regional seismic hazards and the behavior of intersecting fault systems. Using airphotos and field observations, we have mapped the tectonic geomorphology of the entire 80-km-length of the thrust system. Results show numerous fault scarps of youthful appearance on the western half of the fault zone. Field surveys of many of these scarps show that they are quite sharp and may be as young as late Pleistocene. Comparison of soil development along faulted alluvium with published soil chronosequences also suggests these scarps may be younger than previously considered. We speculate based on these soil comparisons that rates of uplift along the thrust fault may be as high as 0.25 mm/yr, about half of the long-term rate. This is much higher than previously predicted. Cosmogenic exposure age dating of fault scarps will add an independent measure to this rate estimate. In addition, we have found a very young rupture in an excavation across the thrust system. Near the center of the fault zone, we excavated a small ridge in younger alluvium situated between two 5-m-high scarps in late Pleistocene alluvium. The thrust fault was discovered, showing a simple, clean break of about 1.7 m thrust displacement. Based on estimates of soil development age (courtesy of M. Eppes, U. New Mexico), the entire stratigraphy of the exposure may represent ~20 Kyr. Given that the fault cuts most of these layers, the rupture event may be considerably younger. Radiocarbon dating will provide an independent test of this age estimate. Although we are not able to estimate the minimum age of this event, it does show that the fault has been active fairly recently (perhaps even in the Holocene). Future fault excavations may more tightly constrain the timing of this and earlier ruptures. In addition, our work suggests that the thrust system consists of several independent segments. Youthful scarps occur only along the western segment, which makes up half of the fault zone. In contrast, the eastern and central segments appear less-recently active. Estimates of scarp age based on soil development are consistent with this idea. This implies that the intersection of strike-slip faults (associated with the Eastern California shear zone) may create segment boundaries, that dissect the thrust system into independent reaches that fail in smaller events. This could have implications for the complex, analogous fault systems of the Los Angeles Basin. Cosmogenic exposure age results may add to

this comparison by providing slip rate along each thrust segment. In addition, future fault excavations may show whether the most recent rupture event affected these apparently less active thrust segments.

Non-technical Summary

Field and laboratory analyses of a major fault in San Bernardino County, California, have shed new light on regional earthquake hazards. This fault was previously considered extinct, but investigations of faulted soils suggests that it is active, albeit at a fraction (~50%) of its long-term rate. Investigations also show that the fault is broken into segments that may only break in moderate earthquakes. We have discovered the most rupture in an exacavation, which may have occurred in the past 10-20 thousand years. This rupture involved ~1.7 meters displacement and could have been associated with a M7 earthquake.