PALEOSEISMICITY OF QUATERNARY FAULTS NEAR ALBUQUERQUE, NEW MEXICO

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ABSTRACT

A prominent set of young faults displaces the West Mesa surface 10- 20 km west of downtown Albuquerque. These faults comprise the most likely sites of future moderate-to-large magnitude earthquakes that could cause damage in Albuquerque. In order to determine how large earthquake magnitude could be on these faults and when the latest (prehistoric) large earthquakes occurred, we trenched two strands of the Calabacillas fault on the western side of West Mesa at the City Soil Amendment facility. The eastern, 7 m-high trench exposed a thick calcareous soil that mantled the scarp and impregnated the entire colluvial wedge sequence, such that individual wedge components could not be identified. Rare cross-cutting relationships in tension fissures suggest that net displacement per event on this fault was <<0.5 m. On the western trench we recognize 4-6 paleoearthquake displacements, the latest 4 of which had vertical displacements of 15, 30, 55, and 20 cm. These values, and the inferred ages of soils offset by these events, are very similar to values derived from the County Dump fault in FY 1996, suggesting that the Calabacillas fault also experiences sub-meter displacements with a recurrence measured in 10s of thousand of years.

INTRODUCTION

The City of Albuquerque is located in the Rio Grande rift zone, a north-south-trending structural depression bounded by late Tertiary and Quaternary normal faults. Previous regional mapping of faults (Machette, 1982) identified two groups of faults with mid-late Pleistocene displacement. One group of faults, centered about the down-to-the-west Hubbel Springs fault, lies 12 km SE of downtown Albuquerque, on the east side of the rift. A second group of faults traverses the Llano de Albuquerque erosion surface (early Pleistocene) 10-20 km west of downtown Albuquerque. These down-to-the-east faults are the main focus of this investigation.

The Llano de Albuquerque faults trend N-S and are spaced a roughly uniform 2-3 km apart. Regional mapping by Chapin and Cather (1994), Russell and Snelson (1994a, b), and Hawley et. al (1997) indicates that these east-dipping faults are antithetic to the main master normal fault of the rift at this latitude (the "Rio Grande master fault" of Hawley et. al, 1997).

These faults were chosen for study for three reasons: 1) they are the closest Pleistocene faults to downtown Albuquerque, 2) they apparently dip east, toward the city, and 3) some paleoseismic work had been performed on one of the faults previously.

INVESTIGATIONS

A fault map was compiled for the Llano de Albuquerque based on previous mapping (e.g., Lambert, 1968; Lozinsky et al, 1991; Machette, 1982; Lozinsky, 1994; Hawley et al., 1997) and photogeologic interpretation. Although 5-6 faults offset the Llano de Albuquerque surface, the fault scarps are very broad and gently-sloping. A typical fault scarp is 800-1000 m wide and reaches a maximum scarp slope angle of only 3-4 degrees, attaining a height of 15-30 m. Thus, over the past 0.5-1 My, since the abandonment of the Llano de Albuquerque by the Rio Grande River, these faults have individually experienced displacements of only 15-30 m, yielding long term slip rates of 0.03-0.06 mm/yr.

The low slip rates, old faulted surface, and high eolian deposition rates on the Llano combine to create the broad, gentle appearance of the fault scarps. Previous study (Machette, 1978) showed that the colluvial wedge fronting one typical fault scarp was 17m thick, 700 m wide, and contained a sequence of eolian deposits and intercalated soils that dated back to ca. 500 ka.

These very thick, very broad, very old stacks of colluvia and soils pose a logistical challenge for a paleoseismic trenching study. We decided to excavate benched trenches composed of 1.5 m-high walls and intervening 1 m-wide benches.

The fault we chose to trench during June 1999 was the Calabacillas fault, recently described by Machette et al. (1998). This fault is located near the western margin of the Llano de Albuquerque and is expressed as a 1 km-wide, 30 m-high, degraded east-facing scarp fronted by a backtilted area or graben. The graben is best expressed at the City of Albuquerque Soil Amendment Facility, where it is ca. 100 m wide and 1 km long; the axis of the N-S topographic depression is now being used as a disposal area for sewage sludge. The main east-facing scarp lies farther west in the City Of Albuquerque Shooting Range Park. Between the scarp face and the axis of the graben is a 700 m-wide apron of slopewash that slopes 1-2 degrees east. The maximum scarp slope angle of the scarp face is generally 3-4 degrees, expect directly atop the fault trace where it steepens to 5 degrees.

RESULTS

We excavated 2 trenches, one across the eastern margin of the graben in the Soil Amendment Facility, where the scarp is 7 m high and 100 m wide (E. trench), and another across the base of main east-facing scarp (W. trench).

East Trench: The East trench was 130 m long, and up to 8 m wide and 6 m deep (Fig 1). The main normal fault zone was exactly centered beneath the scarp midpoint and consisted of 4 west-dipping normal faults with a cumulative throw of 3.3 m. The westernmost of these faults juxtaposes very loose sandy gravels of the uppermost Santa Fe Group against eolian-derived colluvium heavily impregnated with calcium carbonate.

The most striking feature of this trench is the strong Stage IV carbonate soil that underlies the ground surface across the entire scarp. On the upthrown block this soil is 2.5 m thick, but it thickens to engulf the entire 4.5 m-thick colluvial deposit abutted against the fault plane. Our preliminary interpretation is that individual faulting events here only averaged about 0.2-0.5 m throw distributed across several faults, and that amount of throw induced insufficient deposition on the downthrown block to keep the colluvium "out of reach" of carbonate accumulation from the surface. As a result, despite repeated surface-faulting events in the past 500 ka on the fault, the carbonate soil was cumulic on the colluvial wedge parent materials and welded itself into a 4.5 m-thick massive K horizon. Thus, we were not able to distinguish discrete colluvial wedges.

The main lesson at this trench is that fault displacement and scarp-derived colluvium must be thick enough to escape cumulic soil formation and welding. If it is, then individual colluvial parent materials and their soils can be distinguished within the colluvial section, as at the County Dump fault (FY96). If throws are <<0.5 m, as probably occurred on this minor antithetic fault, then soil overprinting prevents identification of individual colluvial wedge deposits.

West Trench: The West trench was 67 m long, and up to 8 m wide and 5.7 m deep (Fig 2). The main normal fault zone was exactly centered beneath the scarp midpoint and consisted of a single east-dipping normal faults with a throw of at least 1.2 m, with Santa Fe Group being juxtaposed against eolian-derived colluvium with calcareous soils. Five meters farther east, on the hanging wall, a second fault zone contained 4 apparent reverse faults in a zone 2 m wide; throw was >2m down-to-the-east (correlative units were faulted beneath the trench floor). These apparent reverse faults are probably domino-style faults bounding blocks that toppled eastward. Such faults were also observed in the 1997 trenches across the County Dump fault.

The entire scarp is mantled by a 1.5 m-thick blanket of eolian sand and associated soils that, at first glance, appears to drape over the fault and be unfaulted. However, detailed mapping shows that the fault has offset soil horizons by 10-15 cm as close as 0.5 m below the ground surface. Thus, there is evidence at this trench for a late Pleistocene small faulting event. This small young event is similar is displacement and timing to the youngest event interpreted for the County Dump fault. Based on differential displacements of soils across the main fault, the prior 3 faulting events had throws of 30, 55, and 20 cm across this fault. Further elucidation of the faulting chronology will have to await TL dating, which is in progress at Glen Berger's lab at the Desert Research Institute.

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Fig. 1. Photograph of the East trench on the Calabacillas fault, looking east from the western (toe) end of the trench. The excavator is deepening the central 1/3 of the trench to expose the Santa Fe Group in fault contact with eolian-derived colluvium. All the white material in the photograph is pedogenic calcium carbonate.

Fig. 2. Photograph of the West trench on the Calabacillas fault, looking east from the western (head) end of the trench. The eastern trench can be seen in the distance (upper left) as a thin line of white spoil on the eastern margin of the graben. At upper center (above the vehicle) several small basalt cones can be seen on the edge of the West Mesa; these are the Pleistocene Albuquerque Volcanoes. The large mountain range in the distance is the Sandia Mountains, which lie east of the City of Albuquerque on the eastern side of the Rio Grande rift. The City of Albuquerque is located in the valley of the Rio Grande River about 150 m below the surface of West Mesa, and thus cannot be seen in this photo. The main fault in this trench is located halfway down the trench, where the innermost bench surface changes color.