Paleoseismic Investigation of the Central Hubbell Spring Fault, Central New Mexico[1]
2001 Annual Project Summary

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INTRODUCTION

The Hubbell Spring fault (HSF) may be one of the most active faults in the Albuquerque-Belen basin in central New Mexico (Personius et al., 1999; Figure 1). It is the most significant seismic source to the southern Albuquerque area, particularly to the rapidly growing communities of Los Lunas and Belen (Wong et al., 2000). Recent mapping, geophysical and paleoseismic studies have shed some new light on this complex fault zone, but these studies also raise significant questions about its late Quaternary behavior and earthquake potential. These studies and questions are discussed further below. This project will address many aspects of these questions through a paleoseismic trench investigation of the previously untrenched central trace of the HSF. A trench site is selected just north of Carrizo Spring and fieldwork will be conducted next spring.

PREVIOUS STUDIES AND RESULTING QUESTIONS

Recent mapping of Neogene sediments along the northern HSF (e.g., Love et al., 1996; Maldonado et al., 1999) suggest that the fault geometry is more complex and some traces are much longer than previously mapped by Machette and McGimsey (1983; cf. Figures 1 and 2). In particular, Maldonado et al. (1999) map several anastomosing, discontinuous fault traces that form three dominant north-south trending fault splays (western, central and eastern), which merge together to the north (Figure 2). Machette and McGimsey (1983) showed the western and eastern traces dying out northeast of Los Lunas (Figure 1), whereas Maldonado et al. (1999) extend these traces at least another 15 kilometers to the south (Figure 2). Recent airborne aeromagnetic surveys (Grauch, 2001) support Maldonado et al.'s mapping and suggest that the eastern and western splays potentially extend even farther south, up to 45 kilometers total, and are as long as the central trace (Figure 3).

This raises questions about which is the most dominant and active fault splay of the HSF, or if the three splays all rupture coseismically. Based on available evidence, previous studies have suggested that the central HSF forms the active margin along this portion of the Rio Grande rift (Machette et al., 1998). The central HSF has the most prominent geomorphic expression on the Llano de Manzano, an early (?) Pleistocene surface formed along the piedmont of the Manzano Mountains that lie 5 to 12 km to the east (Maldonado et al., 1999). However, this may be partly due to the fact that the central splay is the only trace with bedrock (Tertiary sediments and Paleozoic sedimentary rocks) exposed in the footwall along much of its length, and thus it's prominent geomorphic expression may not necessarily be indicative of the greatest late Quaternary rate of activity. The central HSF is also most closely associated with a strong north-south trending gravity gradient along the Hubbell Bench (Figure 2). Although

[1] Revised from *Paleoseismic Investigation of the Rincon fault, Albuquerque, New Mexico*

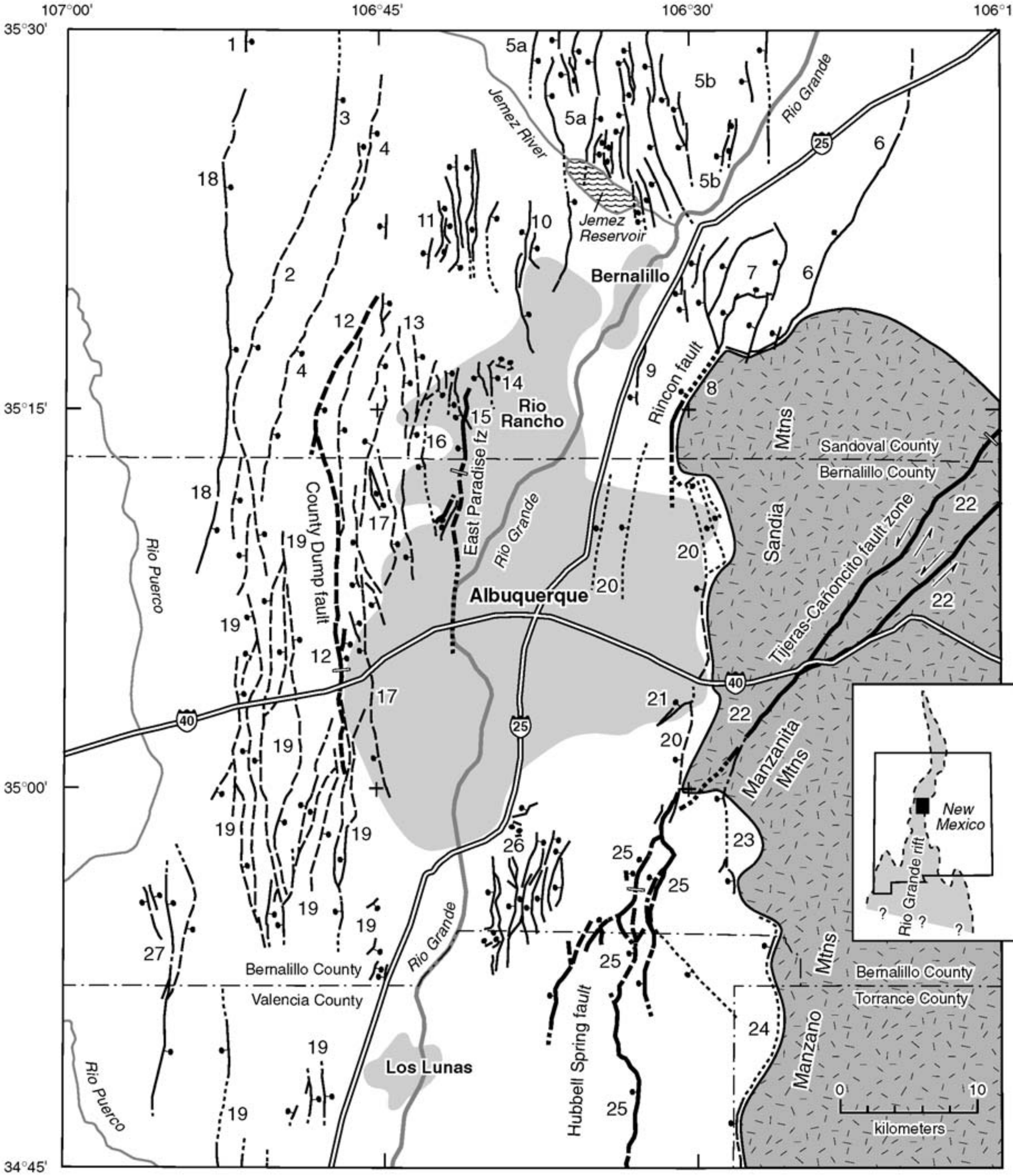

Figure 1. Known and suspected Quaternary faults near Albuquerque, New Mexico (from Personius et al., 1999). Faults with known displacements in late Quaternary deposits (<130 ka) are shown with heavier line weight. Note that traces of the Hubbell Spring fault (HSF) are primarily based on Machette and McGimsey (1983), with some modifications from GRAM Inc. and William Lettis & Associates, Inc. (1995), and Love et al. (1996).

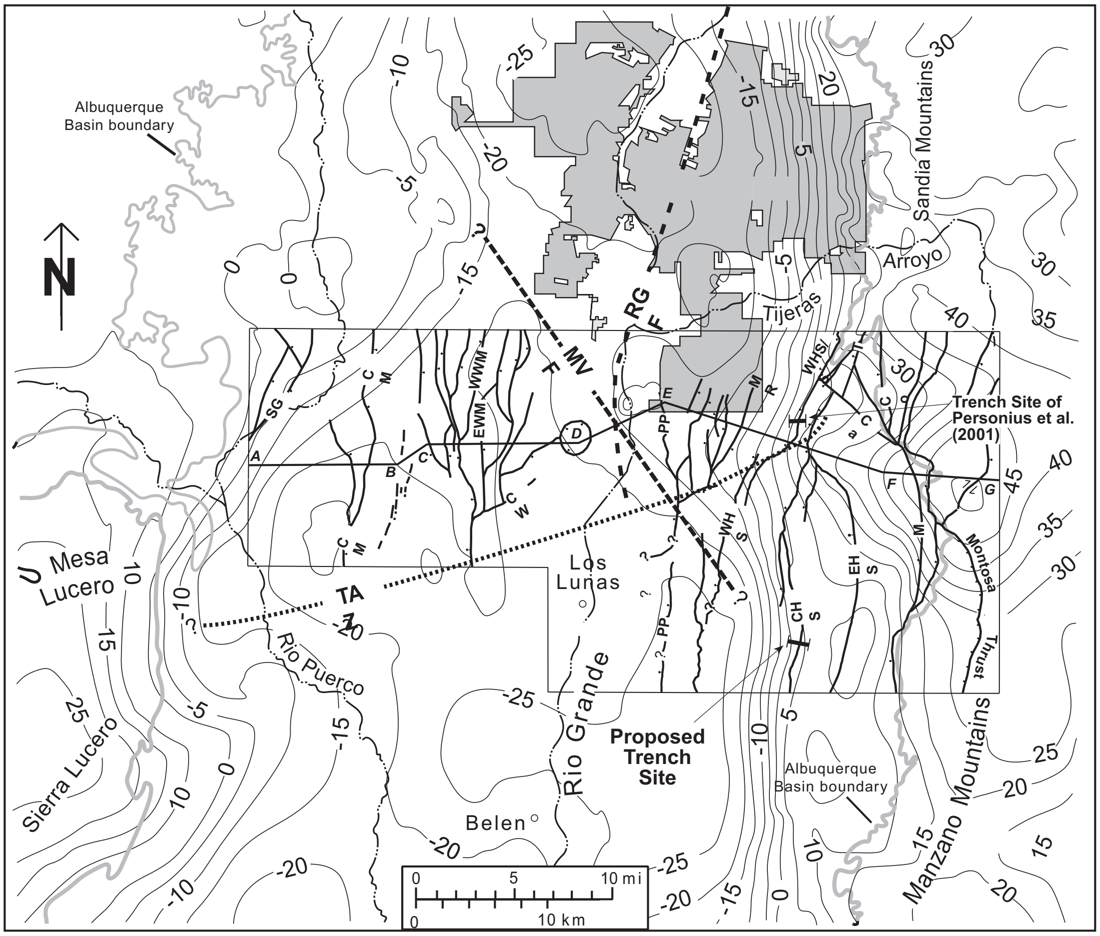

Figure 2. Isostatic residual gravity anomaly map (5 mgal contours) with faults and selected features in the study area of Maldonado et al., (1999). Line of cross-section A through G is keyed to their Figure 4. Abbreviation key: Ca-Colorado fault, **CHS-Central Hubbell Spring fault**, Co-Coyote fault, CM- Cat Mesa fault, CW-Cedar Wash fault, **EHS-Eastern Hubbell Spring fault**, EWM Eastern Wind Mesa fault, M-Manzano fault, MR-McCormick Ranch fault, MVF-inferred Mountain View fault, PP-Palace-Pipeline fault, S-Southern Sandia fault, SG South Garcia fault, T-Tijeras fault, TAZ-inferred Tijeras accommodation zone, **WHS-Western Hubbell Spring fault**, and WWM-Western Wind Mesa fault.

Machette and McGimsey (1983) measured scarp heights of 4 to 30 m on early to late Pleistocene deposits, primarily along the central HSF, very little is know about its paleoseismic behavior. Similarly, nothing is known about the Quaternary behavior of the eastern HSF. Despite its prominent aeromagnetic signature (Figure 3), it has a poor geomorphic expression, no associated gravity gradient (Figure 2), and may actually be a relict fault from a pre-Quaternary period of extension.

In comparison, the western HSF exhibits some of the highest scarps on the youngest deposits and may actually record the greatest late Quaternary activity. A recent paleoseismic investigation of a 7-m-high scarp on the western HSF near its northern end (Figure 1) revealed evidence for four surface-faulting events that post-date mid (?) Pleistocene fan deposits and resulted in 5 to 8 m of throw and average displacement per event of 1 to 2 m (Personius et al., 2001). Their preliminary luminescence ages of colluvial /eolian deposits associated with faulting suggest that at least 3 of these events are late Pleistocene and the youngest event occurred between about 11 and 16 ka. The penultimate event occurred shortly before circa 30 ka, and the antepenultimate event occurred about 10,000 to 40,000 years before that. The timing for the oldest event is poorly constrained. The relatively large per event displacements supports either longer rupture lengths for the western HSF, as mapped by Maldonado et al. (1999), or coseismic rupture with the central HSF, or both (a longer length for the western HSF and coseismic rupture with the central HSF).

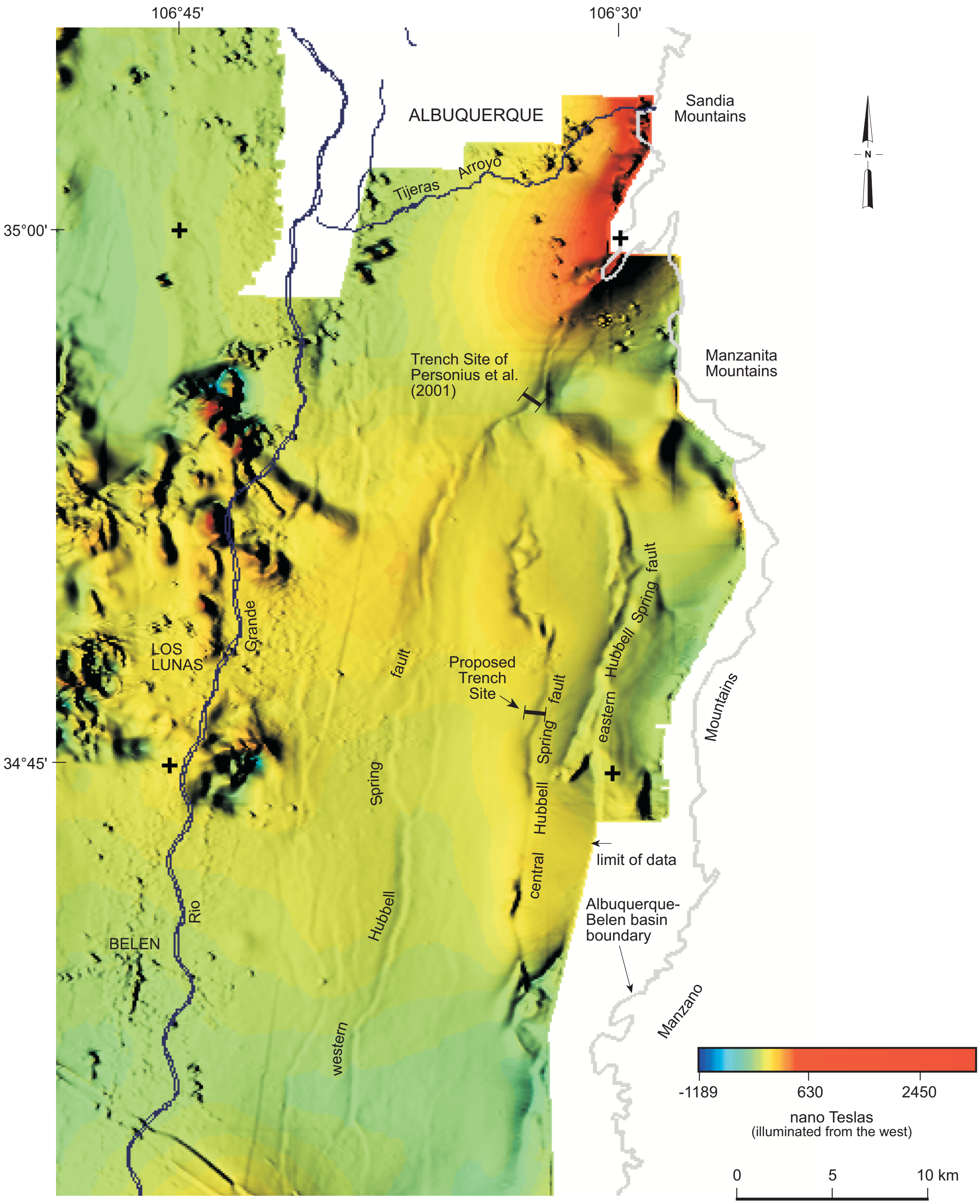

Figure 3. Color shaded-relief aeromagnetic image of the Hubbell Spring fault area, illuminated from the west (modified from Grauch, 2001).

In summary, recent studies raise several questions about the late Quaternary behavior and earthquake potential of the HSF, including: are all of the traces equally active, do they rupture coseismically, and were late Quaternary ruptures as long as suggested as by the aeromagnetic data? These questions are all important to assessing seismic hazards in the region (Wong et al., 2000).

PURPOSE AND SCOPE

The objectives of this study are to address these questions about the late Quaternary behavior and earthquake potential of the HSF. We will accomplish this by conducting a paleoseismic trench investigation of the central HSF to identify when, how big (displacements per event), and how often the youngest prehistoric earthquakes occurred. These data will not only be useful in directly characterizing the earthquake potential of the central HSF, but also in indirectly answering questions about fault linkages by comparing results to the previous investigation on the western HSF (Personius et al., 2001), to assess if the central and western splays ruptured coseismically or independently. Additionally, during our aerial photograph interpretation (of 1996 1:40,000 scale black and white stereo pairs) and field reconnaissance of potential trench sites, we observed little if any evidence for deformation of the Llano de Manzano along the eastern HSF south of Hells Canyon Wash, consistent with the original mapping of Machette and McGimsey (1983), and with recent mapping of Karlstrom et al. (2001). In contrast, we did observe sinuous, discontinuous fault scarps on the Llano de Manzano associated with some of the aeromagnetic anomalies of the western HSF as far south as 34° 45’ (cf. Figures 1 and 3). Ideally, a map of the Quaternary geology (including faults and deposits) of the entire Hubbell Bench needs to be done to better understand the relation of the HSF to the poorly understood Manzano fault to the east and the newly discovered Palace-Pipeline fault to the west (Figure 2). Although this is beyond the scope of this study, we will compile a map of Quaternary fault traces of the HSF that integrates recent data (e.g., GRAM Inc. and William Lettis & Associates, Inc., 1995; Maldonado et al., 1999; Love et al., 1996; Karlstrom et al., 2001; Grauch, 2001) and ongoing studies (e.g., unpublished Quaternary mapping of the Capilla Peak Quadrangle by S. D. Connell. This will be useful in further assessing the late Quaternary and seismogenic relation among the three splays of the HSF.

PROPOSED TRENCH SITE

The proposed trench site is near the along-strike midpoint of the central HSF, a couple of kilometers north of Carrizo Spring (Figure 2 and 3). Here the fault is marked by an alignment of springs along a single, simple scarp on the Llano de Manzano that is well-defined but broad. Scarp heights range from 3 to 15 meters, decreasing to the north as the fault splits into multiple scarps near the town of Meadow Lake. To the south the fault continues as a single scarp, increasing in height and becoming more dissected as it transects the Tome Land Grant, and eventually (roughly 5 km south) exposes Paleozoic sedimentary rocks in the footwall, becoming a bedrock-alluvium fault contact. Immediately to the north and south of the trench site, ephemeral drainages have incised 1 to 7 m into the Llano de Manzano, also incising the fault scarp but leaving no fault exposures in the loose, sandy deposits. Overall, the Llano de Manzano in the area is blanketed by a thin cover of eolian sand, creating a remarkably uniform surface (except for drainages and fault scarps) that slopes gently (2° to 4°) westward. This surface will provide a good datum on which to measure long term offsets (surface offsets and net vertical tectonic displacements) from topographic profiles. Locally, some eolian deposits have built up to form small dunes, particularly where deposits have banked up against fault scarps. These eolian deposits likely span a range of ages from late Pleistocene to modern. Although abundant organic material was found in an archeological excavation at Carrizo Spring (D. Love, NMBMMR, verbal comm.2001), we expect that material for radiocarbon dating will likely be sparse and have enlisted Steven Forman to assist with luminescence analyses to provide age constraints of fault-scarp slopewash colluvium and eolian deposits. We hope to excavate two shallow trenches to provide multiple exposures of the last few surface-faulting events recorded along the fault, but this will depend on the length and depth needed. Multiple exposures can be particularly useful when trying to distinguish faulting events in reworked eolian sands on the Llano de Manzano (S.F. Personius, US Geological Survey, written communication, 10-2001), however, the scarp is also broad and may require a trench longer than 200 m to fully expose the deformation zone.

PRODUCTS AND INFORMATION DISSEMINATION

We will compile a small-scale (≈1:250,000 scale) Quaternary fault map of the HSF, produce a detailed map of geology and measure scarp profiles at the trench site, log trenches at an appropriate scale (≈1:20), analyze radiocarbon and/or luminescence samples, and write-up results in a final report that will also be submitted for publication in a New Mexico Geological Society Guidebook. We will also conduct field reviews for local earth scientists and media. The resulting paleoseismic data can be used to better characterize the HSF in future seismic hazard evaluations of the Albuquerque metropolitan area. It will also provide key information for better understanding fault linkages and late Quaternary strain partitioning across this portion of the central Rio Grande rift.

NON-TECHNICAL SUMMARY

The Hubbell Spring fault is one of the most active faults and significant seismic sources in the southern Albuquerque area, particularly for the rapidly growing communities of Los Lunas and Belen. This trenching project is investigating when, how big and how often large prehistoric earthquakes occurred on the central Hubbell Spring fault. This information, along with mapping, will be used to better evaluate the earthquake potential of this important complex fault zone and improve hazard assessments in central New Mexico.

REFERENCES

GRAM Inc. and William Lettis & Associates, Inc., 1995, Conceptual geologic model of the Sandia National Laboratories and Kirtland Air Force Base: Technical report to Sandia National laboratories, Albuquerque, New Mexico, December 1995, various pagination.

Grauch, V.J.S., 2001, High-resolution aeromagnetic data, a new tool for mapping intrabasinal faults: Example from the Albuquerque basin, New Mexico: U.S. Geological Survey.

Karlstrom, K.E., Brown, C., Armour, J., Lewis, J., Connell, S., 2001, Geology of the Bosque Peak 7.5-minute quadrangle, Valencia and Torrance Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-File Digital Geologic Map DM 24, scale 1:12,000.

Love, D.W., Hitchcock, C., Thomas, E., Kelson, K., Van Hart, D., Cather, S., Chamberlin, R., Anderson, O., Hawley, J., Gillentine, J., White, W., Noler, J., Sawyer, T., Nyman, M., and Harrison, B., 1996, Geology of the Hubbell Spring 7.5-min quadrangle, Bernalillo and Valencia Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Digital Geologic Map 5, scale 1:12,000.

Machette, M.N. and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1º x 2º quadrangles, central New Mexico: U.S. Geological Survey, Miscellaneous Field Studies, Map MF-1465-A, scale 1:250,000.

Machette, M.N., Personius, S.F., Kelson, K.I, Haller, K.M., and Dart, R.L., 1998, Map and data for Quaternary faults and folds in New Mexico: U.S. Geological Survey, Open-File Report 98-521, 443 p.

Maldonado, F., Connell, S.D., Love, D.W., Grouch, V.J.S., Slate, J.L., McIntosh, W.C., Jackson, P.B., and Byers, F.M., Jr., 1999, Neogene geology of the Isleta Reservation and vicinity, Albuquerque basin, New Mexico, *in* Pazzaglia, F.J., and Lucas, S.G., eds., Albuquerque geology: New Mexico Geological Society Guidebook, v. 50, p. 175-188.

Personius, S.F., Machette, M.N., and Kelson, K.I, 1999, Quaternary faults in the Albuquerque area – An update, *in* Pazzaglia, F.J., and Lucas, S.G., eds., Albuquerque geology: New Mexico Geological Society Guidebook, v. 50, p. 189-200.

Personius, S.F., Eppes, M.C., Mahan, S.A., Love, D.W., Mitchell, D.K., and Murphy, A., 2001, Log and data from a trench across the Hubbell Spring fault zone, Bernalillo County, New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-2348, v. 1.1.

Wong I., Olig, S., Dober, M., Silva, W., Wright, D., Thomas, P., Gregor, N., Sanford, A., Lin, K.W., Love, D., and Naugler, W., 2000, A new generation of earthquake ground shaking hazard maps for three urban areas in the western U.S.: Part II Albuquerque-Belen-Santa Fe, New Mexico corridor, in Proceedings, Sixth International Conference on Seismic Zonation, v. I, p. 369-374.