Paleoseismologic Assessment of the Northern Tijeras- Cañoncito Fault System, Central New Mexico

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Investigations Undertaken

The objectives of this research are to (1) define the late Quaternary behavior of the Galisteo section of the Tijeras fault, through a program of Quaternary geomorphic mapping and (2) assess the segmentation of the fault system by comparing the late Quaternary deformation along the Galisteo section of the fault with the Canyon section of the fault to the south. Based on existing geologic data, aerial photography, and aerial reconnaissance, we developed a map of potentially active fault strands within a 2-km-wide swath along the fault on the Golden, Captain Davis Mountain, Picture Rock, and Galisteo USGS 7.5-minute quadrangles. We then performed field mapping along the fault and identified eight geomorphic units that constrain the late Quaternary activity on the northern Tijeras-Cañoncito fault system between the towns of Golden and Lamy, New Mexico (Figures 1 and 2).

Analysis of Aerial Photography

Our approach in mapping the northern Tijeras fault included analysis of aerial photography and imagery, aerial reconnaissance, and field mapping along critical sections of the fault. Because the fault traverses several large privately held land grants as well as land administered by the Bureau of Land Management and the U.S. Forest Service, there was no single set of imagery that covered the entire study area. In order to analyze the entire northern Tijeras fault, therefore, we used the following imagery to examine fault traces and geomorphic features on local and regional scales:

- Entire study area: 1:58,000-scale color-infrared images (USGS NHAP, 1981-82). These images provide a reconnaissance-level view of the fault, and help focus our activities on areas that will provide information on late Quaternary fault behavior.

- Golden quadrangle: 1:20,000-scale black-and-white photos (Soil Conservation Service, 1951). These photos pre-date much of the cultural modification of this area related to mineral extraction along the fault.
- Captain Davis Mountain and Galisteo quadrangles: 1:12,000-scale color photos (IntraSearch, Inc., 1970).
- Picture Rock and Galisteo quadrangles: 1:20,000-scale color photos (Bureau of Land Management, 1990)
- Galisteo, Bull Canyon, and Glorieta quadrangles : 1:15,840-scale color photos (U.S. Forest Service, 1973).

We acknowledge the assistance of Laura Gleasner of the Earth Data Analysis Center at the University of New Mexico, Albuquerque in obtaining these various sets of images. These photos were interpreted to identify surficial deposits and fault-related features for compilation onto the 1:24,000-scale strip map and field reconnaissance. We delineated tonal contrasts, lineaments, springs, ridge notches, and other potentially fault-related geomorphic features between the towns of Golden and Lamy (Figure 2). We also mapped late Quaternary surficial deposits that provide stratigraphic information on the late Quaternary behavior of the Galisteo section of the Tijeras fault.

Aerial Reconnaissance

Because the northern Tijeras-Cañoncito fault system crosses areas of rugged terrain that is difficult to access, aerial reconnaissance was necessary to examine the large field area efficiently and adequately, and to assist in directing subsequent field activities. During September 1999, we conducted an aerial reconnaissance along parts of the northern Tijeras fault to help identify and map late Quaternary fault strands. The aerial reconnaissance was performed during low-sun-angle illumination (early morning), when shadows highlight potentially fault-related features. The flight extended from our previous trench site on the southern Tijeras fault south of Golden (Kelson et al., 1999) to the central part of the Ortiz Mountains in the Golden quadrangle. North of Carache Canyon, however, low clouds precluded safe air travel and we postponed our reconnaissance of the northern parts of the fault. In addition, our aerial reconnaissance included review of the La Bajada-Rosario fault, which strikes northward from the Tijeras fault at Golden.

Field Reconnaissance

Based on our air-photo analysis and aerial reconnaissance, we conducted field mapping along the 51-km Galisteo section of the fault from Golden to Lamy. This section of the fault traverses private land and was accessed by permission of LAC Minerals and local land owners. The mapping was completed with local consulting geologist Stephen Maynard. Maynard currently is completing bedrock geologic mapping of the Golden quadrangle for the USGS STATEMAP program.

Results

Our analysis of aerial photography and aerial reconnaissance shows that fault strands within the Tijeras-Cañoncito fault system have surface expression in bedrock terrane and, in many cases,

are coincident with lineaments and other features in surficial deposits that potentially are related to surface rupture. To assess whether faults associated with the lineaments have had late Quaternary activity, we produced 1:24,00-scale surficial geologic maps along the Galisteo section of the Tijeras-Cañoncito fault system. We informally subdivide the maps into two geomorphic sub-provinces, the Ortiz Mountains geomorphic sub-province (Figure 2) and the Galisteo Basin geomorphic sub-province (Figure 2). Within these two sub-provinces, our field mapping identified eight different map units that range in age from Pliocene to Holocene.

The Ortiz Mountains geomorphic sub-province encompasses the area from Golden northeast to Arroyo Chorro and includes a part of the Galisteo section of the Tijeras-Cañoncito fault system (Figure 2). Northeast of Golden, large, middle to late Pleistocene, coalesced alluvial fans originating from canyons on the southeastern slope of the Ortiz Mountains cover the majority of the bedrock and dominate the area between the Ortiz Mountains and Arroyo Tuerto. Two distinct, low-relief erosion-cut bedrock pediments exist on the northeastern slope of the Ortiz Mountains. The Ortiz pediment, the topographically higher of the two, is capped by the Plio-Pleistocene Tuerto Formation gravel. The Tijeras fault traverses these alluvial fan and pediment surfaces along the southeastern margin of the Ortiz Mountains and continues to the northeast.

Our field mapping in the Ortiz Mountains geomorphic sub-province identified several lineaments across alluvial fan deposits that coincide with linear valleys developed in bedrock terrane. One of these lineaments is a 1.5-m-high scarp that trends N70E across the Buckeye Canyon fan. This scarp has fault-like morphology, however, it is only laterally continuous for a short distance and may represent cultural modification, a stream cut terrace edge, or the toe of an alluvial fan. Another lineament occurs as a topographic scarp across a high alluvial fan at the mouth of Carache Canyon. This lineament does not continue across a lower, inset fan surface, from which we infer that there may have been surface rupture along this reach of the fault during the middle Quaternary. Alternatively, this scarp may represent either original fan-surface irregularity, inset relations between two alluvial fans that are close in age, or dissection of the alluvial-fan surface.

Northeast of the Ortiz Mountains, Maynard (in prep.) maps a projection of the northern Tijeras fault underneath the Tuerto Formation gravel between Captain Davis Mountain and Peach Spring. At Peach Spring, along the eastern margin of the Tuerto Gravel, the fault is exposed in bedrock. Based on field inspection of this exposure at Peach Spring, the Tuerto Formation gravel is not deformed by the fault. These relations provide evidence against the occurrence of late Quaternary movement on the Galisteo section of the Tijeras fault.

The Galisteo Basin geomorphic sub-province extends from Arroyo Chorro to the vicinity of Lamy (Figure 2). Along the Tijeras-Cañoncito fault system the sub-province is characterized by two large arroyos separated by a low-relief, northeast-trending bedrock ridge. Remnants of the Plio-Pleistocene Ancha Formation exist in the northern part of the sub-province and occupy a similar stratigraphic position as the Tuerto Gravel within the Ortiz Mountains sub-province. The most prominent late Quaternary deposits in the province are broad fluvial fill terraces.

Our field mapping identified two fault strands in bedrock exposures in arroyo cuts previously documented by Lisenbee (1999). The western strand trends along the north side of Arroyo de los

Angeles from the vicinity of Kennedy to the vicinity of the Speiss railroad siding. The eastern strand trends along the south side of Arroyo de los Angeles from the vicinity of Thornton Ranch, across the alluvial fan at Speiss, and along Galisteo Creek to Lamy. In a few places these faults were associated with weak to moderate topographic features, linear valleys, and tonal and vegetation lineaments. However, none of the lineaments is associated with displacement of late Quaternary deposits. In particular, the well-preserved alluvial fan surface at Speiss contains no evidence of surface displacement along the fault strands. This relation, as well as an absence of fault-related features across late Quaternary surfaces and deposits elsewhere in the Galisteo Basin sub-province, suggests that the fault system in this area has not had movement within the past several hundred thousand years.

At the intersection of the two fault strands in the vicinity of Speiss, there is an early Pleistocene to Pliocene pediment remnant that has two north-facing scarps along fault strands mapped in bedrock. These scarps are developed on a surface that is probably a remnant of the upper surface of the Ancha Formation. The scarps are about 1- to 2- m high, broad and degraded, and project towards the unfaulted Speiss fan. Thus, we conclude that the Tijeras-Cañoncito fault system in this area may have had surface rupture in post-Ancha Formation time, but has not had late Quaternary surface rupture.

This research suggests that late Quaternary surface rupturing earthquakes that occurred south of the study area on the Canyon section of the fault, apparently did not occur on the Galisteo section. In addition to the timing of surface ruptures, a change in fault orientation and geometry between the two fault sections support the interpretation that a fault segment boundary along the Tijeras-Cañoncito fault system exists in the vicinity of Golden.

Non-technical Summary of Proposal

This investigation provides information that allows a better characterization of the Tijeras-Cañoncito fault system for seismic hazard assessments. The study identified the location of potentially active fault traces, through analysis of aerial photography, aerial reconnaissance, and field mapping at a scale of 1:24,000. Fault activity was then assessed by investigating Quaternary deposits along mapped fault traces. Our research provides strong evidence that the Galisteo section of the fault system has not experienced surface rupture during the middle and late Quaternary, and possibly since at least the Pliocene. This research also provides evidence that a fault segment boundary between the Canyon and Galisteo sections of the Tijeras-Cañoncito fault system exists near Golden. On the basis of the information developed during this study, we recommend that the Tijeras-Cañoncito fault system north of Golden no longer be considered as an independent, potentially active seismic source. Data from the study will help refine rupture scenarios for the Tijeras-Cañoncito fault system and help estimate the probability of future large earthquakes in the Albuquerque-Santa Fe corridor, New Mexico.

Reports Published

Because of the recent completion of this study, no reports have been published. However, we recently published two articles and one map database, and submitted two NEHRP Final Technical Reports, the southern and northern (this study) Tijeras fault .

Koehler, R.D. and K.I. Kelson, 2000, Paleoseismologic Assessment of the Northern Tijeras-Cañoncito Fault System, Central New Mexico: Final Technical Report submitted to the USGS National Earthquake Hazards Program, Award Number 99-HQ-GR-0107, 19 p.

Kelson, K.I., Hitchcock, C.S., and Harrison, J.B.J., 1998, Paleoseismologic assessment of the southern Tijeras fault, central New Mexico: Final Technical Report submitted to the USGS National Earthquake Hazards Program, Award Number 1434-HQ-97-GR-03012, 33 p.

Kelson, K.I., Hitchcock, C.S., and Harrison, J.B.J., 1999, Paleoseismology of the Tijeras fault near Golden, New Mexico: New Mexico Geological Society Guidebook, 50th Field Conference, Albuquerque Geology, p. 200-209.

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.

Personius, S.F., Machette, M.N., and Kelson, K.I., 1999, Quaternary faults in the Albuquerque area—An update: New Mexico Geological Society Guidebook, 50th Field Conference, Albuquerque Geology, p. 189-200.

Data Availability

The 2-km-wide swath map of the 51-km Galisteo section of the Tijeras-Cañoncito fault system from Golden to Lamy is available in Freehand version 9 format. This map is available at William Lettis & Associates for the cost of reproduction. Please contact Rich Koehler at (925) 256-6070 or email at Koehler@lettis.com.

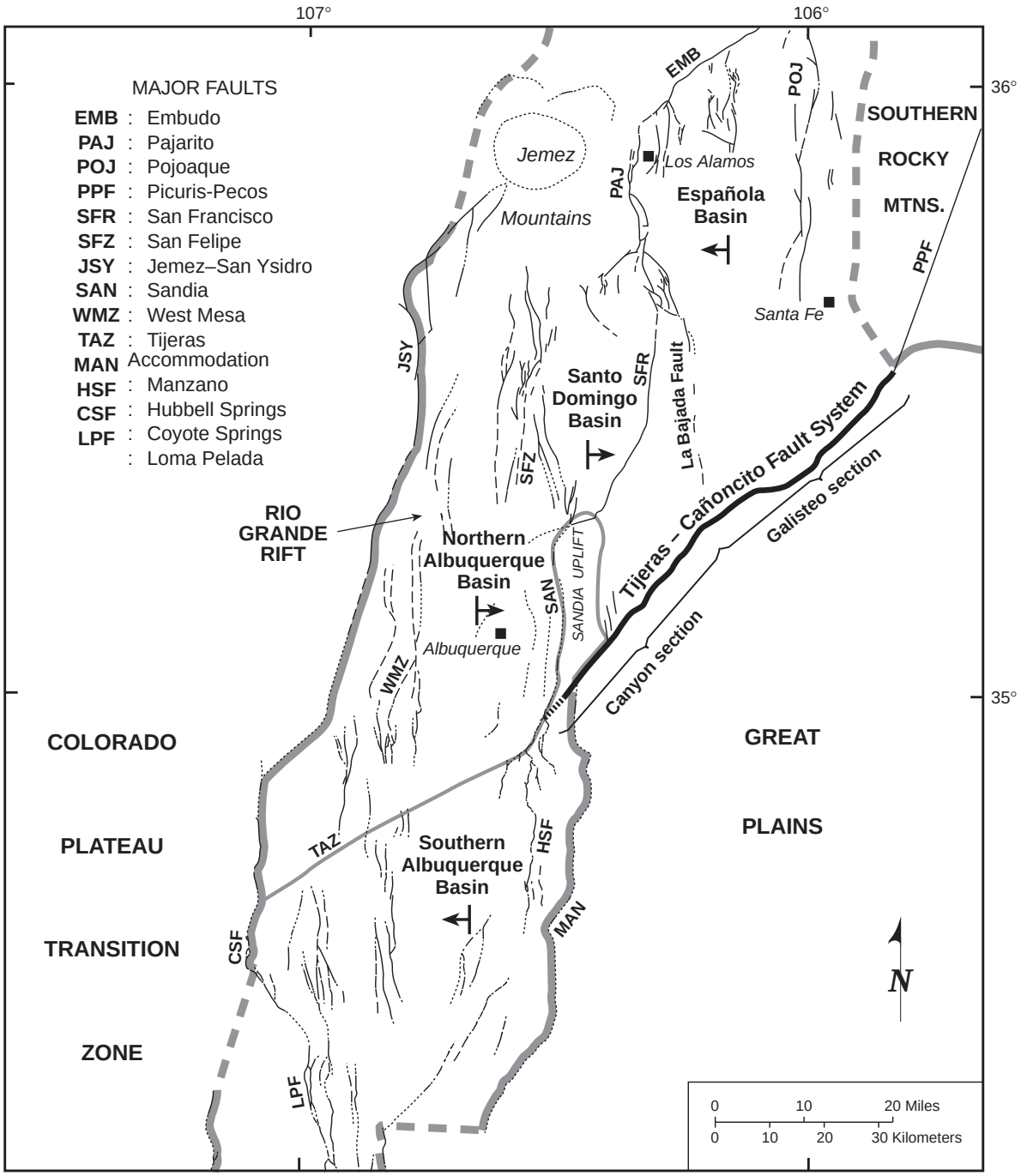

Figure 1. Generalized regional tectonic map of the Rio Grande rift near Santa Fe and Albuquerque. Arrows show tilt of major rift basins. Bold lines define seismotectonic provinces.

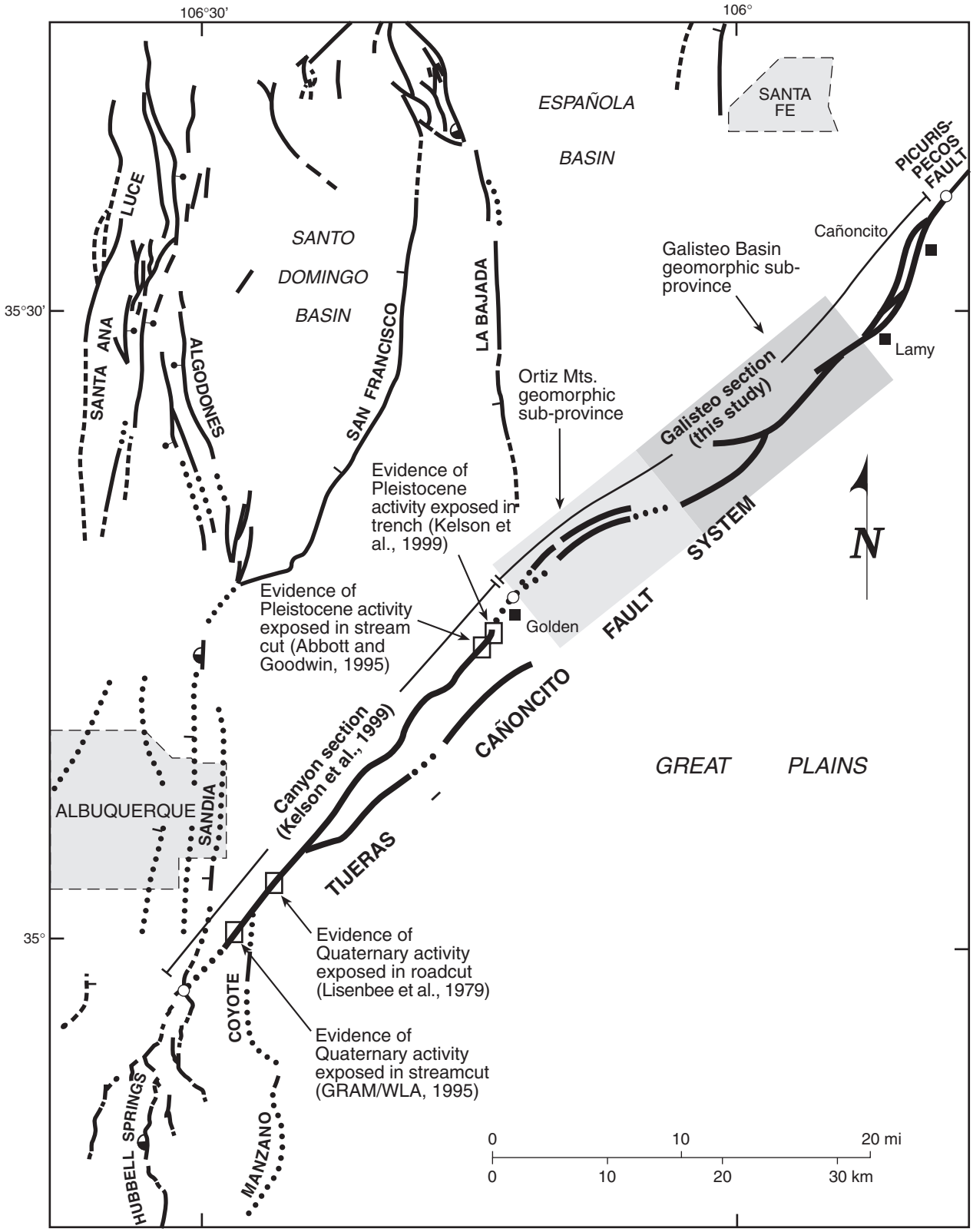

Figure 2. Regional fault map showing sections of the Tijeras–Cañoncito fault system and other major faults within the Rio Grande rift near Albuquerque and Santa Fe, New Mexico. Open circles show ends of fault sections identified by Machette et al. (1998).