Annual Project Summary

Neotectonic and paleoseismic study of the Pyramid Lake fault zone near Reno, Nevada

External Grant award number: 01-HQ-GR-0186

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Program Element: NI
Key words: neotectonics, trench investigations, paleseismology

Investigations undertaken

The Pyramid Lake fault zone is an active, northwest-trending, right-lateral strike-slip fault located in the northern Walker Lane (Bonham and Slemmons, 1968; Bell and Slemmons, 1979; Anderson and Hawkins, 1984) (Fig. 1). Recent GPS (global positioning system) geodetic measurements indicate 6±2mm/year of NW-directed right-lateral shear occurs across the northern Walker Lane, accounting for 10%-15% of Pacific-North America plate relative motion (Bennett et al. 1998, Thatcher et al. 1999). However, with the exception of the Honey Lake fault zone (Wills and Borchardt, 1993), Holocene slip rates have not been determined for faults of the northern Walker Lane. Richard Briggs, a Ph.D. graaduate student and I commenced a 1-year project on May 1, 2001 to map and conduct paleoseismic trenching studies along the Pyramid Lake fault to determine the Holocene fault slip rate and to better bracket the ages of Holocene earthquakes. Our results will provide a better understanding of the role of the Pyramid Lake fault zone in accommodating right-lateral shear within the northern Walker Lane and will improve seismic hazard analyses for northern Nevada and northeastern California.

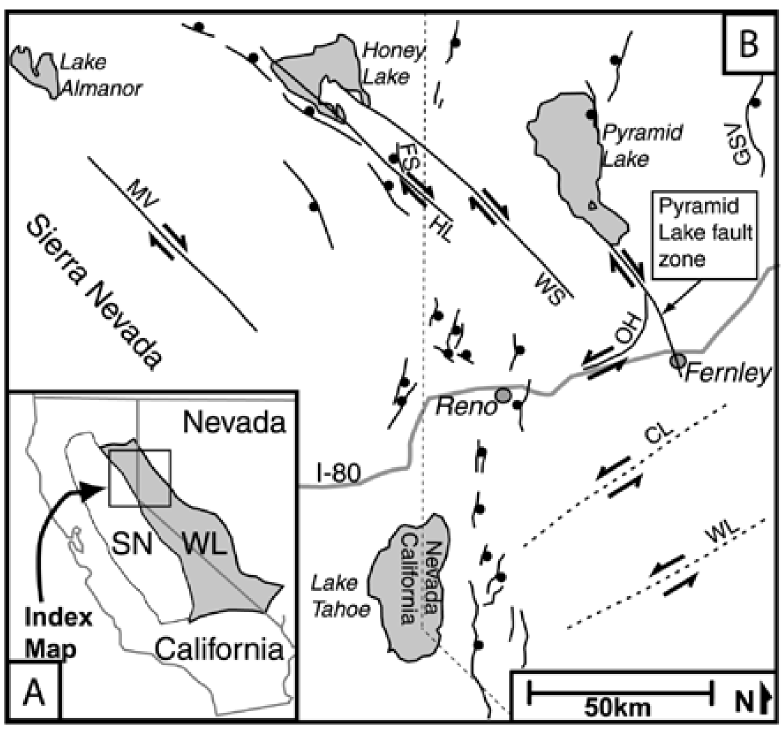

Figure 1. (A) Location of the northern Walker Lane (SN= Sierra Nevada; WL=Walker Lane). Geodetic studies show 4-8mm/year of NW-directed, right-lateral shear occurs across the northern Walker Lane. (B) Location of the Pyramid Lake fault zone. MV=Mohawk Valley fault zone, HL=Honey Lake fault zone, FS=Fort Sage Mountain fault, WS=Warm Springs fault zone, OH=Olinghouse fault zone, GSV= Granite Springs Valley fault, CL=Carson lineament, WL=Wabuska lineament. Circle is on hanging wall of normal faults, and arrows show relative motion across strike-slip faults.

Preliminary Results

Slip rate determination

We have thus far identified several locations where the Pyramid Lake fault offsets drainage channels which have developed since the highstand of pluvial Lake Lahontan about ~13ka (Adams and Wesnousky, 1999). The offsets provide an initial minimum bound of the fault slip rate of of 0.9-1.2 mm/year. Two of those sites have been surveyed and the resulting topographic maps of the features are presented here.

At site A, the northwest-striking fault forms a graben in a pluvially modified surface of an alluvial fan remnant. Here the fault offsets the well-defined northern bank of a channel orthogonal to fault strike right-laterally 12-15m (Fig. 2). Because the channel was formed subsequent to the dessication of Lake Lahontan (13ka), offset of the channel bank reflects a minimum amount of fault movement in the last 13,000 years, and is interpreted to indicate a minimum slip rate estimate of 0.9-1.1 mm/year. We await dates from detrital charcoal collected from a nearby lacustrine deposit which should better constrain the age of this offset feature and provide a more robust slip rate estimate.

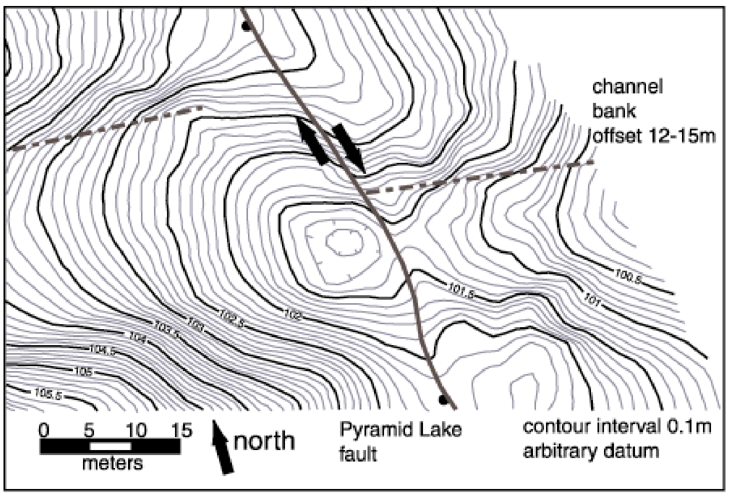

Figure 2. Site A: channel bank offset right-laterally 12-15 meters.

A second site, site B, provides a similar geomorphic constraint on fault slip rate as site A. A channel thalweg formed in post-Lahontan (13ka) alluvium is offset 13-15m right-laterally by the fault (Fig. 3). Again, because channel formation postdates Lake Lahontan (13ka), the offset is interpreted to record minimum bound on the fault slip rate in this location of 1.0-1.1 mm/year.

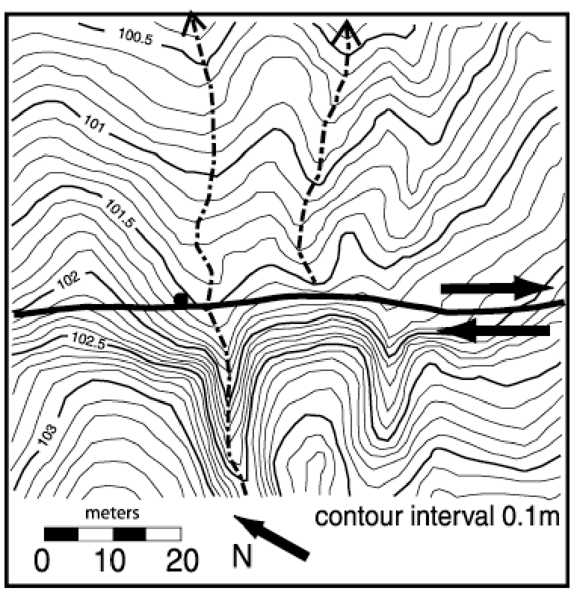

Figure 3. Site B: channel thalweg offset 13-15 meters right laterally.

Trench studies

We currently have open and are examining two trench exposures across the fault to place age constraints on individual Holocene earthquakes on the Pyramid Lake fault zone. The trenches are in locations previously identified as providing a full record of Holocene earthquakes in deposits containing datable material (Anderson and Hawkins, 1984). Our initial interpretation is that the trench exposures record evidence for four post-Lahontan (13ka) earthquakes on the Pyramid Lake fault, with two of these events occurring after deposition of the Mazama tephra (7627±150 cal. ypb; Zdanowicz et al., 1999).

Trench 1: *Stratigraphy and age control*

Trench 1 was emplaced across a sag pond and exposed well-bedded alluvial, lacustrine, and aeolian deposit. Structural and stratigraphic relationships exposed at the eastern edge of the graben illustrate the full faulting history exposed here, and we restrict the discussion for this report to this portion of the trench (Fig. 4). The structural material east of fault FE consists of well-rounded, well-sorted gravels showing shallowly dipping foresets (unit E1), overlain by poorly sorted debris flow deposits (units E2-E3) and capped by a poorly-sorted alluvium and debris flow deposit bearing disseminated Mazama tephra (unit W3). The tephra-bearing unit W3 appears continuously across the entire trench exposure. We interpret the basal gravels (unit E1) as post-Lahontan (13ka) lacustrine constructional beach or bar deposits on the basis of adjacent, unburied beach deposits and stratigraphic position relative to the overlying Mazama tephra. A weak soil characterized by a 20-30 cm thick Bt horizon and 2-5 cm thick vesicular A horizon is developed on the tephra-bearing unit and is truncated at fault FE (Fig. 4).

The central structural block occupies the graben between the two main fault zones. Continuous, poorly sorted alluvium and debris flow deposits (units W1-W5), including the tephra bearing unit (W3), form the basal portion of the central structural block. Each of the poorly-sorted basal coarse units W1-W5 is capped by thin (<20cm), discontinuous fine-grained sands and silts, possibly representing a short hiatus in deposition between graben-filling pulses. Well-sorted, fine-grained sandy and silty units W6 and W7 cap the central structural block. A thin vesicular A horizon and irregular, just-forming platy B horizon is developed on the aeolian sands of unit W6. Dark, distinctive organic-rich clay and silt of unit W7 forms a sharp, even continuous contact on unit W6.

Trench 1: *Evidence for faulting and intepretation of events*

The trench revealed two major fault strands bounding the sag pond edges, and additional splays distributed throughout the exposure. Facies and thickness mismatches of continuous units across faults and splays indicate a significant component of lateral motion. The main eastern strand (fault zone FE; Fig. 4) is a steeply west-dipping, narrow (0.5 m) zone of shear fabric and fissure fill. Minor fault splays (strand ***a***; Fig. 4) are manifest by shear fabric development and juxtaposition of dissimilar units or facies.

Trench T-1 exposes clear evidence for three post-Lahontan (13ka) earthquakes. The oldest event (event Z) is represented by a subtle, wedge-shaped package of poorly sorted silt to cobble with chaotic fabric (unit Zc) which sits on and is interfingered with the uppermost moderately sorted gravels of unit W1. This package, in turn, is covered conformably by the tephra-bearing unit W3. We interpret unit Zc as scarp derived colluvium associated with event Z. This event appears to narrowly predate the deposition of the Mazama tephra. Event Z is may also be recorded by fault splay **a**, which cuts Lahontan deposits and dies out below the tephra bearing unit W3.

The next two events postdate deposition of the Mazama tephra. Event Y, the penultimate event, is recorded by a roughly wedge-shaped package of chaotic, poorly sorted silts to small cobble (unit Yc) which sits on the coarse gravels of unit W5 at fault FE and is interfingered with the coarse sands and pebbles of unit W6. Colluvium associated with the oldest event Z (unit Zc) was faulted during this event.

A well-defined colluvial wedge associated with the most recent event (unit Xc) was deposited against the scarp produced during this event and is superposed on the penultimate colluvium (unit Yc) and capped by the dark organic unit W7. Colluvium associated with the penultimate event (unit Yc) is sheared along the fault, indicating that this deposit was faulted during the most recent earthquake (event X).

Trench 2: *Stratigraphy and age control*

Trench 2 was excavated across the oversteepened base of an uplifted linear ridge and exposeswell-bedded alluvial, lacustrine, and aeolian deposits. Exposed sediment may be divided into three structural blocks separated by strands FE and FW of the main fault zone (Fig. 5). The westernmost structural block consists of folded, interbedded sands and gravels with abundant gastropod remains (unit W1), overlain by thick flat-lying deposits of lacustrine clays and muds (units W2-W3) and aeolian sands and silts (units W4-W6). A distinctive light-toned unit with a thin (<2cm) discontinuous tephra layer (unit W6) is truncated at fault FW. A moderately well developed soil is developed in unit W6 and subsequently buried by channels of coarse pebbles interbedded with sand and silt (unit W7) which cap the western structural block. The uppermost silt cap is continuous (although not always exposed at the surface) across the trench exposure.

The central structural block occupies the position between the two main fault strands FW and FE (Fig. 5). Poorly sorted, altered and clay rich alluvial deposits (units C1-C3) are overlain by a thick deposit of moderately well sorted sand and silt (unit C4). The base of the eastern structural block consists of highly sheared, poorly sorted coarse alluvial deposits (units E1-E3) capped by a distinctive dark alluvial package (unit C2) and poorly sorted sands to small cobble (unit E4).

Primary age control is provided by the Mazama tephra (unit W5). We await dates for detrital charcoal collected from the trench exposure (Fig. 5) which will help to constrain individual earthquake ages.

Trench 2: *Evidence for faulting and intepretation of events*

Excavation of trench 2 revealed two major fault strands. The main western strand (FW; Fig. 5) is a moderately east-dipping planar fault with apparent thrust displacement. The eastern strand (FE; Fig. 5) opens upward into several splays and shows a significant extensional component, and incorporates a ~0.5m wide zone of fissure fill.

Trench 2 exposes evidence for four post-Lahontan (13ka) earthquakes. The oldest event (event Z) is represented by a wedge-shaped package of poorly sorted sand and angular small cobble and pebbles with chaotic fabric (unit Zc) which sits on the lacustrine sands and gravel of unit W1. If the sediments of unit W1 are due to receding Lake Lahontan (~13ka) they constrain the age of this event as < 13ka. We await dates on abundant gastropod shells of unit W1 to confirm this.

The next youngest event (event Y) is represented by a distinct package (unit Yc) of poorly sorted coarse pebbles and occasional small cobble interfingered with the sand and silt of unit W4. This package, in turn, is covered conformably by the tephra-bearing unit W5. We interpret unit Yc as scarp derived colluvium associated with event Y. Similar to trench 1, this event appears to narrowly predate the deposition of the Mazama tephra.

The next two events postdate deposition of the Mazama tephra. Event X, the penultimate event, is recorded by downwarping and thickening of the soil developed on unit W6 (unit Xc) and incorporation of a small portion of overlying unit W7 in a small fissure at the top of fault FW.

Event W, the most recent event, is recorded by warping along the surface at fault FE, resulting in a buried Av horizon with coarse slope debris (unit Wc) collected in a depression downslope of the upwarped surface.

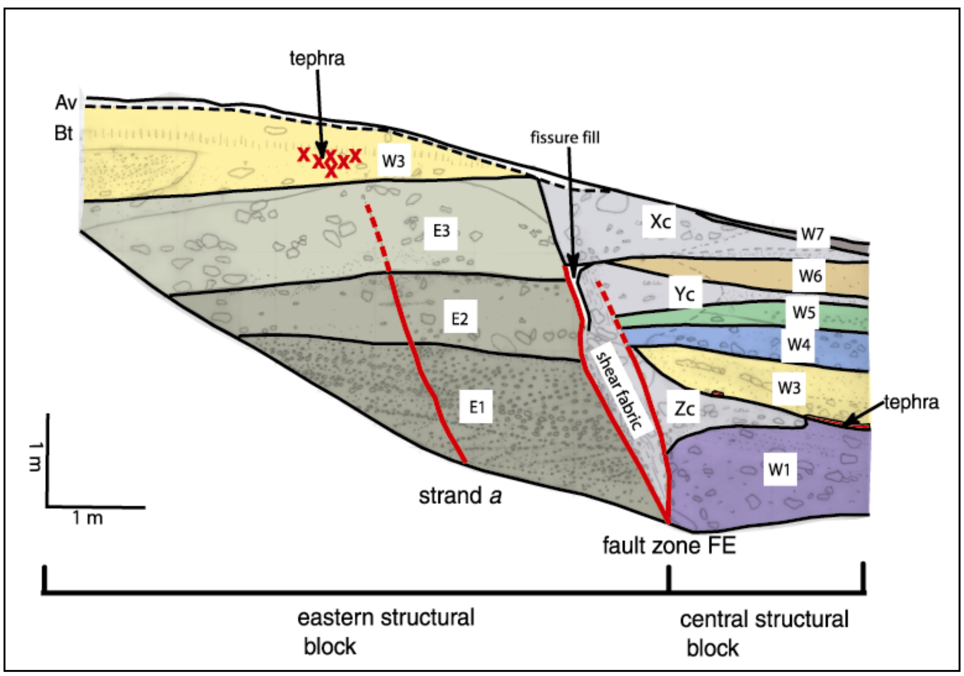

Figure 4. Portion of trench log for trench 1. Units and structural relations discussed in text.

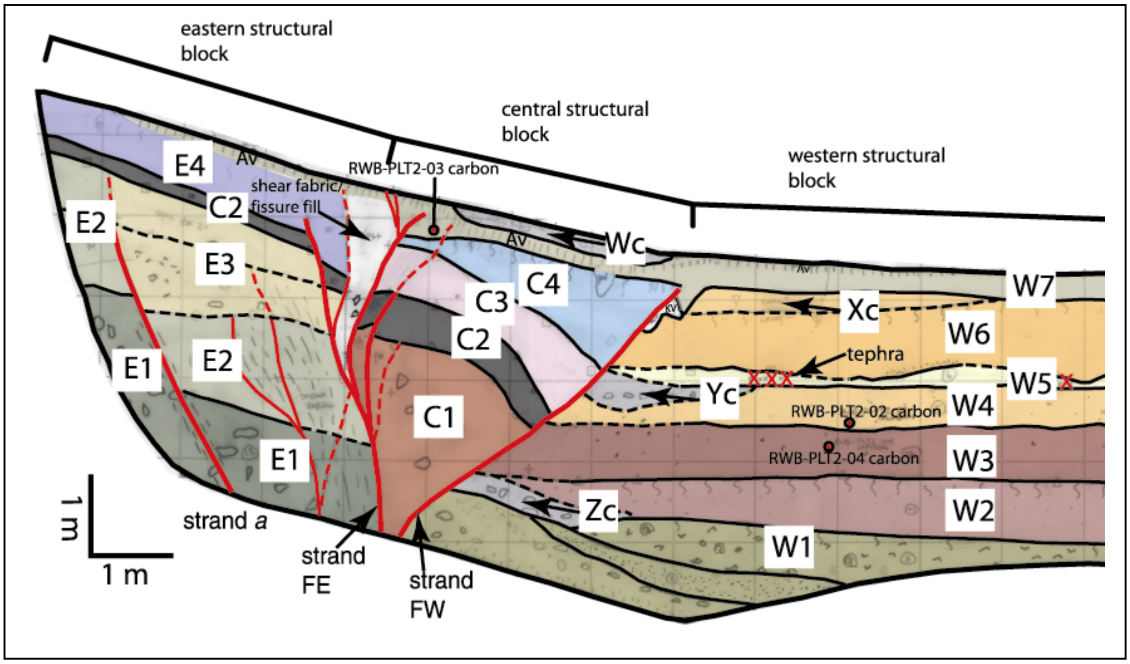

Figure 5. Portion of trench log for trench 2. Units and structural relations discussed in text.

Non-technical summary

The Pyramid Lake fault zone is an active strike-slip fault near Reno, Nevada. We are mapping the active fault trace and opened two trenches across the fault to better understand the earthquake history and tectonic activity of the Pyramid Lake fault zone. We estimate a minimum Holocene slip rate of 0.9 – 1.1 millimeters/year based on <13,000 year old channel features that have been offset right-laterally by the fault. Our trenches identify a minimum of 4 events since 13,000 years ago, with two of those events subsequent to deposition of the Mazama tephra (~7,600 cal. ypb). We are working to date these events individually.

Reports published

This work has resulted in three abstracts, and results are being written up for submission to a peer-reviewed journal:

Briggs, R.W. and S.G. Wesnousky, 2001, The Sierra Nevada – Basin and Range transition along the Northern Walker Lane: Geodesy vs. Geology. Seis. Res. Letters, Vol. 72, no. 2, March/April 2001.

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Briggs, R.W., Wesnousky, S.G., and G. Blewitt, 2000, A Reinvestigation of the Pyramid Lake and Olinghouse Fault Zones of the Northern Walker Lane: Geology and Geodesy: Geological Society of America, Annual Meeting, Abstracts with Programs, 2000.

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