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TRENCH LOGS AND SCARP DATA FROM AN INVESTIGATION OF THE STEENS FAULT ZONE, BOG HOT VALLEY AND PUEBLO VALLEY, HUMBOLDT COUNTY, NEVADA

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INTRODUCTION

This report contains field and laboratory data from a study of the Steens fault zone near Denio, Nev. The 200-km-long Steens fault zone (figs. 1 and 3) forms the longest, most topographically prominent fault-bounded escarpment in the Basin and Range of southern Oregon and northern Nevada. The down-to-the-east normal fault is marked by Holocene fault scarps along nearly half its length, including the southern one-third of the fault from the vicinity of Pueblo Mountain in southern Oregon to the southern margin of Bog Hot Valley (BHV) southwest of Denio, Nev. We studied this section of the fault to better constrain late Quaternary slip rates, which we hope to compare to deformation rates derived from a recently established geodetic network in the region (Hammond and Thatcher, 2005). We excavated a trench in May 2003 across one of a series of right-stepping fault scarps that extend south from the southern end of the Pueblo Mountains and traverse the floor of Bog Hot Valley, about 4 km south of Nevada State Highway 140 (fig. 3). This site was chosen because of the presence of well-preserved fault scarps, their development on lacustrine deposits thought to be suitable for luminescence dating, and the proximity of two geodetic stations that straddle the fault zone. We excavated a second trench in the southern BHV, but the fault zone in this trench collapsed during excavation and thus no information about fault history was documented from this site. We also excavated a soil pit (fig. 2) on a lacustrine barrier bar in the southern Pueblo Valley (PV) to better constrain the age of lacustrine deposits exposed in the trench. The purpose of this report is to present photomosaics and trench logs, scarp profiles and slip data, soils data, luminescence and radiocarbon ages, and unit descriptions obtained during this investigation. We do not attempt to use the data presented herein to construct a paleoseismic history of this part of the Steens fault zone; that history will be the subject of a future report.

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RADIOCARBON AND LUMINESCENCE AGE DATA

We obtained four radiocarbon samples from two burn layers in the youngest fault scarp colluvium (unit 7) in the trench (table 5). The samples yielded calibrated ages indicating these sediments were deposited about 4 ka.

We used luminescence dating techniques to determine the ages of lacustrine and colluvial sediments exposed in the trench and soil pits (see logs and table 2). TL (thermoluminescence), IRSL (infrared stimulated luminescence—a type of optically stimulated luminescence (OSL) unique to feldspars), and blue-light OSL techniques date the last time sediment is exposed to sunlight, presumably during deposition (Berger, 1988; Forman and others, 2000). Sampling was conducted with tubes of plastic electrical conduit driven into the freshly cleaned trench and pit walls; after extraction, sample tubes were sealed with plastic tape and stored in airtight plastic bags. Most dose rates were determined in situ with an Exploranium GR-256 gamma ray spectrometer placed in expanded sample holes drilled in the walls after sampling was completed. Field moisture contents of 1–20 percent by weight were determined for each sample in the laboratory. A polymineralic, fine-silt-size (4–11 mm) fraction was isolated for the TL and IRSL samples, and a fine-sand-size (90–250 mm) quartz fraction was isolated for OSL sample PV-T01. Samples were subjected to combinations of sunlight sensitivity tests, anomalous fading tests (Wintle, 1973), total bleach and partial bleach experiments for TL (Wintle and Huntley, 1980; Singhvi and others, 1982), and additive dose experiments for IRSL (Aitken, 1998) (table 2). Anomalous fading tests showed that the TL and IRSL samples exhibited varying amounts of fading, so ages were corrected using the anomalous fading correction technique of Huntley and Lamothe (2001). With three exceptions, our luminescence ages are generally consistent and in stratigraphic order. The colluvial sediments exposed in the trench were deposited about 4–11 ka. The lacustrine and fluvial sediments were deposited 16–20 ka.

REFERENCES

Adams, K.D., and Wesnousky, S.G., 1999, The Lake Lahontan highstand—Age, surficial characteristics, soil development, and regional shoreline correlation: Geomorphology, v. 30, p. 357–392.

Aitken, M.J., 1998, An introduction to optical dating—The dating of Quaternary sediments by the use of photon-stimulated luminescence: New York, Oxford University Press, 267 p.

Berger, G.W., 1988, Dating Quaternary events by luminescence, in Easterbrook, D.J., ed., Dating Quaternary sediments: Geological Society of America Special Paper 227, p. 13–50.

Birkeland, P.W., 1999, Soils and Geomorphology (3d ed.): New York, Oxford University Press, 430 p.

Bronk Ramsey, C., 1995, Radiocarbon calibration and analysis of stratigraphy—The OxCal program: Radiocarbon, v. 37, p. 425–430.

Bronk Ramsey, C., 2001, Development of the radiocarbon program OxCal: Radiocarbon, v. 43, p. 355–363.

Bucknam, R.C., and Anderson, R.E., 1979, Estimation of fault-scarp ages from a scarp-height-slope-angle relationship: Geology, v. 7, p. 11–14.

Carter, D.T., Ely, L.L., O'Connor, J.E., and Fenton, C.R., 2006, Late Pleistocene outburst flooding from pluvial Lake Alvord into the Owyhee River, Oregon: Geomorphology, v. 75, p. 346–367.

Caskey, S.J., 1995, Geometric relations of dip slip to a faulted ground surface—New nomograms for estimating components of fault displacement: Journal of Structural Geology, v. 17, p. 1197–1202.

Forman, S.L., Pierson, J., and Lepper, K., 2000, Luminescence geochronology, in Noller, J.S., Sowers, J.M., and Lettis, W.R., eds., Quaternary geochronology—Methods and applications: American Geophysical Union Reference Shelf 4, p. 157–176.

Hammond, W.C., and Thatcher, W., 2005, Northwest Basin and Range tectonic deformation observed with the Global Positioning System, 1999–2003: Journal of Geophysical Research, v. 110, B10405, doi: 10.1029/2005JB003678.

Hemphill-Haley, M.A., 1987, Quaternary stratigraphy and late Holocene faulting along the base of the eastern escarpment of Steens Mountain, southeastern Oregon: Arcata, Calif., Humboldt State University, M.S. thesis, 84 p.

Huntley, D.J., and Lamothe, M., 2001, Ubiquity of anomalous fading in K-feldspars and the measurement and correction for it in optical dating: Canadian Journal of Earth Sciences, v. 38, p. 1093–1106.

Machette, M.N., Haller, K.M., Dart, R.L., and Rhea, S.B., 2003, Quaternary fault and fold database of the United States: U.S. Geological Survey Open-File Report 03–417 (online database at http://earthquake.usgs.gov/regional/qfaults/).

Munsell Color, 1994, Munsell soil color charts: New Windsor, N.Y., Kollmorgen Corp., Macbeth Division.

Personius, S.F., Dart, R.L., Bradley, L.A., and Haller, K.M., 2003, Map and data for Quaternary faults and folds in Oregon: U.S. Geological Survey Open-File Report 03–095, 581 p., 1 sheet, scale 1:750,000.

Reheis, M., 1999, Extent of Pleistocene lakes in the western Great Basin: U.S. Geological Survey Miscellaneous Field Studies Map MF-2323, 1 sheet, scale 1:800,000.

Reimer, P.J., Baillie, M.G.L., Bard, E., Bayliss, A., Beck, J.W., Bertrand, C.J.H., Blackwell, P.G., Buck, C.E., Burr, G.S., Cutler, K.B., Damon, P.E., Edwards, R.L., Fairbanks, R.G., Friedrich, M., Guilderson, T.P., Hogg, A.G., Hughen, K.A., Kromer, B., McCormac, F.G., Manning, S.W., Bronk Ramsey, C., Reimer, R.W., Remmele, S., Southon, J.R., Stuiver, M., Talamo, S., Taylor, F.W., van der Plicht, J., and Weyhenmeyer, C.E., 2004, IntCal04 terrestrial radiocarbon age calibration, 26–0 ka BP: Radiocarbon v. 46, p. 1029–1058.

Singhvi, A.K., Sharma, Y.P., and Agrawal, D.P., 1982, TL dating of dune sands in Rajasthana, India: Nature, v. 295, p. 313–315.

Soil Survey Staff, 1999, Soil Taxonomy (2d ed.): U.S. Department of Agriculture Agricultural Handbook no. 436, 869 p.

Wintle, A.G., 1973, Anomalous fading of thermoluminescence in mineral samples: Nature, v. 245, p. 143–144.

Wintle, A.G., and Huntley, D.J., 1980, TL dating of ocean sediments: Canadian Journal of Earth Sciences, v. 17, p. 348–360.

Figure 1. Regional map of Quaternary faults. Faults in the northern part of the map are from Personius and others (2003); faults in the southern part of the map are from the Quaternary fault database of USGS (Machette and others, 2003).

Figure 2. Map of Quaternary faults and lacustrine shoreline features in southern Pueblo Valley. Faults and shoreline features (wave-cut shorelines and barrier bar) are from airphotographs and field reconnaissance during this study; note location of soil pit on crest of barrier bar.

Figure 3. Map of Quaternary faults and lacustrine shoreline features in Bog Hot Valley. Faults and shoreline features (shorelines and barrier bars) are from airphotographs and field reconnaissance during this study. Geodetic stations are from Hammond and Thatcher (2005).

Figure 4. Extent of pluvial lakes in the vicinity of Denio, Nev. (modified from Reheis, 1999). Note locations of Pueblo Valley (PV) and Bog Hot Valley (BHV) at southern end of Lake Alvord, which had no direct connection to Lake Lahontan during the late Pleistocene. Orange arrows on east side of Lake Alvord show route of probable late Pleistocene overflow flood into Lake Coyote and Owyhee River (Carter and others, 2006).

Figure 5. Elevation plot of selected pluvial Lake Alvord shoreline features in Bog Hot Valley, southern Pueblo Valley, and Alvord basin. The history of pluvial Lake Alvord is poorly known, but reconnaissance studies indicate an overflow flood event that lowered the lake level from an unknown elevation to about the

1,280-m level sometime in the late Pleistocene (Hemphill-Haley, 1987; Reheis, 1999; Carter and others, 2006). Assuming that Lakes Alvord and Lahontan had similar climatic responses, well-developed Lahontan-Sehoo-equivalent shoreline complexes at the 1,279- to 1,282-m level in the Bog Hot Valley and Alvord basin probably were abandoned in the latest Pleistocene (15,000–16,000 calibrated yr B.P.; Adams and Wesnousky, 1999). In Bog Hot Valley and southern Pueblo Valley, young shoreline features indicate Lake Alvord reached an elevation of 1,295–1,297 m, and perhaps higher, before the flood event reduced the lake (probably in stages) to 1,279–1,282 m. The Bog Hot Valley trench lies at an elevation of 1,292 m, so lacustrine sediments exposed in the trench predate the flood event and thus were deposited some time before 15–16 ka. Luminescence samples BHV-T02 and PV-T01 (table 2) indicate the flood probably occurred some time after 17–18 ka.

Figure 6. Topographic profile of fault scarp at Bog Hot Valley trench site (fig. 3). Note locations of trench and soil pit. Scarp nomenclature from Bucknam and Anderson (1979).

Figure 7. Fault scarp profiles in Bog Hot Valley. See figure 3 for profile locations and table 4 for additional slip data.

Photograph 1. View of Bog Hot Valley trench site, looking northwest (fig. 3).

Photograph 2. View (looking north along strike) of several right-stepping fault scarps (arrows) on floor of Bog Hot Valley (fig. 3). Hills in the distance are the southern end of the Pueblo Mountains (note west-tilted bedrock). Red line is generalized trace of the southern Steens fault zone along the Pueblo Mountains.

Photograph 3. View (looking southwest) of 4- to 5-m-high fault scarps (between arrows) on floor of Bog Hot Valley (fig. 3). Trench site is off left side of photograph.

Photograph 4. View (looking north) of 5-m-high basalt boulder on eastern flank of Pueblo Mountains (fig. 3). This and other large boulders probably were shaken loose from outcrops and rolled to their present positions as a result of strong ground motions from one or more recent large-magnitude earthquakes on the southern Steens fault zone.

Photograph 5. View (looking southeast) of several basalt boulders on floor of (dry) Continental Lake (fig. 3). Numerous large boulders such as these probably were shaken loose from outcrops and rolled down the steep eastern flank of the Pueblo Mountains (off right side of photo) as a result of strong ground motions from one or more recent large-magnitude earthquakes on the southern Steens fault zone.

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