U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

SCIENTIFIC INVESTIGATIONS MAP 2891
Version 1.0

GEOLOGIC EVIDENCE FOR LATE QUATERNARY MOVEMENT ON THE CLAN ALPINE FAULT, WEST-CENTRAL NEVADA—TRENCH LOGS, SCARP PROFILES, LOCATION MAPS, AND SAMPLE AND SOIL DESCRIPTIONS

By
Michael N. Machette[1], Kathleen M. Haller[1], Cal A. Ruleman[2], Shannon A. Mahan[1], and Koji Okumura[3]
[1]U.S. Geological Survey, Denver, Colorado; [2]University of Montana, Bozeman, Montana; [3]University of Hiroshima, Hiroshima, Japan
2005

INTRODUCTION

As part of regional studies of paleoseismology in the northern Great Basin, we are studying selected major extensional Quaternary faults in a traverse from Reno, Nev., to Salt Lake City, Utah, between latitudes 39° and 41° N. In 2001, we trenched the southern part of the Clan Alpine fault (CAF) about 2 km northwest of the Alpine Ranch (see fig. 1). The fault separates the Edwards Creek Valley (on the east) from the impressive front of the uplifted Clan Alpine Mountains (on the west); faceted spurs along the front suggest substantial Quaternary movement along the CAF (dePolo, 1998). Based on the tectonic geomorphology of the mountain front, dePolo (1998) estimated a long-term slip rate of 0.15 mm/yr for the CAF. Conversely, conspicuous fault scarps exist along only part of the range front, suggesting that little movement has occurred on the CAF in late Quaternary time.

The purpose of this map product is to present stratigraphic, geomorphic, and structural evidence for interpreting the late Quaternary movement history of the CAF. The interpretive data will be presented elsewhere, pending results of further dating studies. Nevertheless, the stratigraphic relations shown on this map demonstrate two latest Quaternary surface-faulting earthquakes in the past 30 k.y., and suggest that latest Quaternary slip rates near the southern end of the fault zone are slower than previously suggested for the whole fault zone.

THE CLAN ALPINE FAULT

The Clan Alpine fault lies just to the east of the Central Nevada Seismic Belt—a zone of historically active faulting and seismicity that extends from Winnemucca, on the north, to Cedar Mountains, on the south (fig. 1). The most recent surface faulting in the vicinity was associated with the Ms 7.2 Fairview Peak and Ms 6.8 Dixie Valley earthquakes, which occurred about 4 minutes apart on December 16, 1954 (Caskey and others, 1996) about 30 km west of our study area. During these large earthquakes, minor surface ruptures also formed along the Gold King and Middlegate faults, the latter of which is a west-dipping normal fault at the southwestern margin of the Clan Alpine Mountains, about 12 km to the west-southwest of our study area.

The CAF is a major north- to northeast-striking, relatively narrow range-front fault zone that bounds the eastern flank of the Clan Alpine Mountains and the western flank of the Edwards Creek Valley. The Edwards Creek basin is probably a structural half-graben that deepens to the west. Faulting on the eastern side of the basin seems rather minor, and low bedrock knobs extend well out from the Desatoya Range, which bounds the eastern side of the Edwards Creek Valley. Near its southern end, the west-dipping Desatoya (DF) and Eastgate (EGF) faults become the major range-bounding faults of an eastward-deepening series of half- grabens. This north-to-south transition from a west-dipping half-graben to multiple east-dipping half-grabens is along a diffuse west-northwest transverse accommodation zone(?) that roughly defines the southern end of the CAF and the northern ends of the DF and EGF. Stewart and others (1999) mapped a west-northwest-trending fault that cuts across the southern part of the Clan Alpine Mountains and adjacent Miocene basin sediments; this fault may represent the surface manifestation of the suggested accommodation zone.

The Clan Alpine Mountains and Desatoya Range straddle the Edwards Creek Valley, which is presently a closed basin with a floor elevation of about 5,115 ft (1,560 m). [Elevations are shown in feet on the USGS topographic base map (fig. 1).] Lake Edwards has occupied this basin intermittently through the middle Pleistocene (750–130 ka) and late Pleistocene (130–10 ka). The latest Pleistocene lake was rather shallow (<50 m deep), rising to a maximum elevation of about 5,280 ft (1,610 m) (Mifflin and Wheat, 1979), well below all traces of the CAF. Most of the stratigraphic and geomorphic evidence for the lake are preserved at its northeastern end, where it formed a set of prominent bars, spits, and gravelly shorelines. Prior deep stages of the lake may have risen well above the 5,280-ft (1,610-m) shoreline, especially if overflow occurred from Lake Desatoya (Snyder and others, 1964) in the Smith Creek Valley. This connecting channelway has an overflow threshold at 6,230 ft (1,899 m), 8 m above the latest Pleistocene sill of Smith Creek Valley (Reheis, 1999).

The CAF extends about 35 km along the eastern front of the Clan Alpine Mountains. Along most of the range front, the fault shows down-to-the-southeast displacement of Quaternary piedmont-slope deposits against Tertiary bedrock (Dohrenwend and others, 1992). Scarps are relatively sparse and poorly preserved but consistently face east (Pearthree, 1990; Dohrenwend and others, 1992), except at the southern end where antithetic faults form about one-fourth of the young throw on the CAF. South of Starr Canyon (see fig. 1), the fault bifurcates into multiple subparallel traces that form a horsetail pattern. The largest and most continuous strand crosses Florence Canyon Road (fig. 2), and forms scarps that are as much as 8 m high. Smaller scarps (see fig. 3, scarp profile CAW-1) are formed on an alluvial-fan deposit (unit Qfm, fig. 2) that is believed to be either mid-Wisconsin (marine isotope stage IV) or pre-Wisconsin and related to the Bull Lake glaciation (marine isotope stage VI) of the Rocky Mountains. The large scarp that we trenched (fig. 6, west trench, CAW) is formed on a clearly older alluvial-fan deposit (unit Qfo), which we believe is pre-Wisconsin (marine isotope stage VI) and either related to the Bull Lake glaciation of the Rocky Mountains or to an older (marine isotope stage VIII?) glaciation of the Rocky Mountains. These deposits have not yet been dated by cosmogenic-nuclide methods; thus our correlations to geo-climatic events remain uncertain. We consider units Qfm and Qfo to be as young as 75–60 ka and 150–130 ka, respectively (younger interpretation), or to be as old as 150–130 ka and 250–230 ka, respectively (older interpretation). The estimated ages of these deposits are based on the soils developed on their relict alluvial-fan surfaces (see table 4, soil field properties). Unit Qfm is also present in the east trench (CAE, fig. 7).

Although most traces of the CAF are in a BLM Wilderness Study Area (WSA), we were able to trench a 7- to 8-m-high, partly buried scarp on the main fault in a narrow exclusion in the WSA (fig. 2) and a partly buried (<3 m high) antithetic fault scarp (fig. 4) 1.6 km downslope, east of the WSA. Exposures of the main fault (see fig. 6, CAW trench log) revealed two classic colluvial wedges (units 1 and 2, table 1) above a thicker wedge-like body of gravel (unit 3) and alluvial-fan deposits (unit 4). Unit 3 is interpreted as a combination of scarp colluvium and fluvial gravel that were deposited against the scarp from the third faulting event. The underlying and lowest unit on the hangingwall block is unit 4, a well-sorted sandy pebble to boulder gravel that was laid in against a preexisting fault scarp formed on units 6–8 of the upthrown fault block. Unit 4 is considered to be part of the fan-forming Qfm, which came from Florence Canyon and was deposited in a southerly direction (as indicated by pebble imbrication measurements). The two most recent surface-faulting earthquakes produced about 4 m of displacement in the trench and a 5- to 6-m-high scarp on the surface, about 100 m north of Florence Canyon Road. Fault-scarp colluvium units 1 and 2 gave preliminary luminescence ages of about 9±1 ka and 28±3 ka, respectively (see table 3A), which suggests that the most recent earthquake occurred at about 10 ka and the penultimate earthquake occurred at about 30 ka.

Indirect evidence of older faulting (pre-unit 4) is recorded by more than 7 m of surface displacement in the older sequence of alluvial-fan deposits (units 6–8, about 250–130 ka).

The antithetic fault is about 1.7 km to the east, and its scarps are poorly preserved east of the road north from Alpine Ranch owing to its uphill (west-facing) aspect (fig. 5). Trenching here (see fig. 7, CAE trench log) shows direct evidence for three faulting earthquakes (about 6 m of vertical displacement). The fault-scarp colluvium (units 1 and 2, table 2) gave preliminary luminescence ages of about 10±1 ka and 28±2 ka, respectively (see table 3B), which suggests that the most recent event occurred at about 10 ka and the penultimate event occurred at about 30 ka—timing that is identical to that recorded in the CAW trench. The upthrown block is mantled by a relict Bt/Bk soil (see table 4, soil field properties) formed in coarse debris-flow deposits (about 100–50 k.y.?) that directly overlie distal alluvial-fan deposits, which we estimate to be about 130–60 ka. The antithetic fault records at least 6 m of displacement (since units can't be matched across entire fault zone) and has more earthquakes that affect unit Qfm than the main fault. Thus, the antithetic fault may be a transitional, intravalley link that moves along with the east-dipping CAF and the east-dipping DF to the southeast.

Based on reconnaissance photogeologic mapping, Dohrenwend and others (1992) assigned a latest Pleistocene to Holocene age to a faulted Quaternary deposit at one locality along the CAF. On the basis of morphologic analyses, Pearthree (1990) calculated a mean age of 16.9 ka (22.6–11.2 ka) for small scarps along the southern part of the fault zone and thought that middle Holocene alluvial surfaces were unfaulted. dePolo (1998) assigned a preferred age of 130 ka (220–74 ka) to the alluvial-fan surface that is displaced 19.4 m on the southern side of Starr Canyon (SC site, see fig. 1), farther north along the southern part of the CAF. From these data, dePolo (1998) calculated a preferred vertical slip rate of 0.15 mm/yr for this site. The 130-ka age for the surface was based on relative position, surface morphology, and the presence of soils that have characteristics similar to those on Donner Lake outwash (dePolo, 1998). Conversely, we suspect that the alluvial-fan surface could be 250 ka (that is, unit Qfo) or older and that the slip rate could be substantially less.

Although cosmogenic-nuclide dating will help determine the age of the faulted landforms, the existing luminescence dating and stratigraphic relations seen in trench CAW suggest that the CAF where we studied it has a low slip rate (0.025–0.08 mm/yr) and long recurrence intervals (≥20,000 yrs). The range front's seemingly young expression may be an artifact of the bedrock lithology and (or) faster slip rates earlier in the Quaternary or Pliocene. If the two to five times lower-than-reported slip rate on the CAF suggested from our preliminary work applies to the entire fault, it has important implications for the general activity rate of many of the major normal faults in the Basin and Range Province.

REFERENCES CITED

Birkeland, P.W., 1999, Soils and geomorphology, 3rd edition: New York, Oxford University Press, 430 p.

Caskey, S.J., Wesnousky, S.G., Zhang, P., and Slemmons, D.B., 1996, Surface faulting of the 1954 Fairview Peak (Ms 7.2) and Dixie Valley (Ms 6.8) earthquakes, central Nevada: Bulletin of the Seismological Society of America, v. 86, no. 3, p. 761–787.

dePolo, C.M., 1998, A reconnaissance technique for estimating the slip rate of normal-slip faults in the Great Basin, and application to faults in Nevada, U.S.A.: Reno, Nev., University of Nevada Ph.D. dissertation, 199 p.

Dohrenwend, J.C., Schell, B.A., and Moring, B.C., 1992, Reconnaissance photogeologic map of young faults in the Millett 1° by 2° quadrangle, Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF–2176, 1 sheet, scale 1:250,000.

Mifflin, M.D., and Wheat, M.M., 1979, Pluvial lakes and estimated pluvial climates of Nevada: Bulletin of the Nevada Bureau of Mines and Geology, v. 94, 37 p.

Pearthree, P.A., 1990, Geomorphic analysis of young faulting and fault behavior in central Nevada: Tucson, Ariz., University of Arizona Ph.D. dissertation, 212 p.

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

Soil Survey Staff, 1975, Soil taxonomy: U.S. Department of Agriculture Handbook No. 436, 754 p.

Snyder, C.T., Hardman, G., and Zdenek, F.F., 1964, Pleistocene lakes in the Great Basin: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–416, scale 1:1,000,000.

Stewart, J.H., Sarna-Wojcicki, A., Meyer, C.E., Starratt, S.W., and Wan, E., 1999, Stratigraphy, tephrochronology, and structural setting of Miocene sedimentary rocks in the Middlegate area, west-central Nevada: U.S. Geological Survey Open-File Report 99–350, 1 plate, scale 1:24,000.

Figure 1. Topographic base map for Clan Alpine fault trenching study, west-central Nevada.

Figure 2. Surficial geologic map of the Clan Alpine fault, west trench site (CAW), showing locations of trench, scarp profiles, and soil pits.

Figure 3. Topographic profiles across scarps of the Clan Alpine fault, west trench site (CAW). Horizontal scale not the same as on figure 2.

Figure 4. Surficial geologic map of the Clan Alpine fault, east trench site (CAE), showing locations of trench, scarp profiles, and soil pits.

Figure 5. Topographic profiles across scarps of the Clan Alpine fault, east trench site (CAE). Horizontal scale not the same as on figure 4.

Figure 6. Trench log for Clan Alpine fault, west trench (CAW).

Figure 7. Trench log for Clan Alpine fault, east trench (CAE).

Table 1. Description of units from the Clan Alpine fault, west trench (CAW).

Table 2. Description of units from the Clan Alpine fault, east trench (CAE).

Table 3A. Luminescence age data from Clan Alpine fault, west trench site (CAW).

Table 3B. Luminescence age data from Clan Alpine fault, east trench site (CAE).

Table 4. Soil-profile descriptions from the Clan Alpine fault, west (CAW) and east (CAE) trench sites.

Suggested citation: Machette, M.N., Haller, K.M., Ruleman, C.A., Mahan, S.A., and Okumura, K., 2005, Geologic evidence for late Quaternary movement on the Clan Alpine fault, west-central Nevada—Trench logs, scarp profiles, location maps, and sample and soil descriptions: U.S. Geological Survey Scientific Investigations Map 2891, 1 sheet.

Manuscript approved for publication June 28, 2005

Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Government
This map was produced on request, directly from digital files, on an electronic plotter
For sale by U.S. Geological Survey Information Services
Box 25286, Federal Center, Denver, CO 80225
1-888-ASK-USGS
ArcInfo coverages and a PDF for this map are available at
http://pubs.usgs.gov