[Jump to Navigation]

Quaternary Fault and Fold Database of the United States

As of January 12, 2017, the USGS maintains a limited number of metadata fields that characterize the Quaternary faults and folds of the United States. For the most up-to-date information, please refer to the interactive fault map.

Steens fault zone, Denio Section (Class A) No. 856f

Last Review Date: 2016-04-18

citation for this record: Personius, S.F., Haller, K.M., and Sawyer, T.L., compilers, 2016, Fault number 856f, Steens fault zone, Denio Section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, https://earthquakes.usgs.gov/hazards/qfaults, accessed 12/14/2020 03:16 PM.

Synopsis	**General:** The nearly 200-km-long Steens fault zone is the most topographically prominent normal fault system in the northern Basin and Range province of western North America. The fault separates the eastern flanks of Steens Mountain and the Pueblo Mountains from the western margins of the Alvord Desert and Pueblo Valley in southern Oregon and northern Nevada. Steens Mountain and the Pueblo Mountains are west-tilted fault blocks comprised of Miocene volcanic rocks, whereas the adjacent Alvord Desert and Pueblo Valley are structural basins filled with thousands of meters of Tertiary-Quaternary sedimentary fill. **Sections:** This fault has 6 sections. Although detailed studies along the entire fault zone have not been reported, six sections are inferred based on geometry and timing of most-recent surface faulting at selected sites (but not on all sections) along the zone.

	Hemphill-Haley and others (1999 #4038) proposed that the Steens fault zone in Oregon be divided into five segments. Herein we retain the five segment names delineated by Hemphill-Haley and others (1999 #4038) as section names, and add a sixth, northernmost section based on mapping of Pezzopane (1993 #3544). From north to south, these sections are the Crowley [856a], Mann Lake [856b], Alvord [856c], Fields [856d], Tum Tum [856e], and Denio [856f] sections. At the north end of the zone, faults in the Crowley section [856a] offset Miocene volcanic rocks a few hundred meters, and may have moved as recently as the middle and late Quaternary. Faults in the adjacent Mann Lake section [856b] offset Miocene volcanic rock a minimum of 1600 m, and also may have moved as recently as the middle and late Quaternary. The adjacent Alvord section [856c] forms the steep eastern flank of the High Steens, and has offset Miocene volcanic rock 2–4 km. Trench and fault scarp investigations indicate one or more Holocene surface-faulting events along the Alvord section, so both the long-term (Miocene) and Quaternary slip histories indicate that this section is the most active part of the Steens fault zone. Slip apparently decreases south of the Alvord section. Faults in the adjacent Fields section [856d] offset Miocene volcanic rock a minimum of 1400 m, and show their youngest movement (latest Quaternary) on short faults that lie on the playa east of the range front. Faults in the Tum Tum section [856e] appear to be slightly older than the youngest movement on the playa strands of the Fields section [856d], but are younger than the latest movement on the range front strand of the Fields [856d] and Mann Lake [856b] sections. Trenching of the fault in the Denio section [856d], which is the southernmost part of the Steens Mountain fault zone, clearly demonstrates Holocene movement.
Name comments	**General:** The Steens fault zone forms a steep escarpment between the uplifted Steens Mountain and Pueblo Mountains, and the western margin of Pueblo Valley and the Alvord Desert. These faults have been mapped by Willden (1964 #3002), Slemmons (1966, unpublished Vya 1:250,000-scale sheet), Greene (1972 #3560), Walker and Repenning (1965 #3559), Brown and Peterson (1980 #3585), Hemphill-Haley (1987 #3960), Walker and MacLeod (1991 #3646), Dohrenwend and Moring (1991 #281), Pezzopane (1993 #3544), Madin and others (1996 #3479), Weldon and others (2002 #5144), and Personius and others (2006 #7386). The fault zone includes faults mapped as the Alvord-Steens fault zone of Pezzopane (1993 #3544) and Pezzopane and Weldon (1993 #149), and the Steens fault, Alvord Desert graben,

	and Pueblo Mountain faults of Pezzopane (1993 #3544). Geomatrix Consultants, Inc. (1995 #3593) used the name Steens-Alvord Graben faults for all structures in the Alvord Desert area, and delineated three fault source zones: the northern segment, the Western Margin fault zone, and the East Alvord graben fault. The Steens fault zone extends into northern Nevada as the Pueblo Mountains fault zone of dePolo (1998 #2845). Hemphill-Haley (1987 #3960) named several small structures in the zone (Alvord, Dune Field, Embayment, Kueny Ditch, Serrano Point, Serrano Springs, Smyth Wells, and Wildhorse Creek faults), and included them in a larger Steens fault zone. Hemphill-Haley and others (1989 #3958, 1999 #4038) later proposed that the Steens fault zone be divided into five segments. Herein we retain the name Steens fault zone for the entire structure in Oregon and Nevada, and use the five segment names delineated by Hemphill-Haley and others (1999 #4038) as section names. A sixth, northernmost section is informally defined herein on the basis of mapping by Pezzopane (1993 #3544) and Weldon and others (2002 #5144). **Section:** This section is informally named the Denio segment, as defined by Hemphill-Haley and others (1989 #3958; 1999 #4038), after the community of Denio, Nevada, which is located near the middle of the section. The northern part of this section was included in the informally named West Margin fault zone of the Steens-Alvord Graben faults by Geomatrix Consultants, Inc. (1995 #3593). In Nevada, faults in the section are included in the Pueblo Mountains fault zone (fault V9) of dePolo (1998 #2845). **Fault ID:** These structures are fault numbers 47, 48, and 49 of Pezzopane (1993 #3544), fault number 62 of Geomatrix Consultants, Inc. (1995 #3593), and fault number V9 of dePolo (1998 #2845).
County(s) and State(s)	HUMBOLDT COUNTY, NEVADA HARNEY COUNTY, OREGON
Physiographic province(s)	BASIN AND RANGE
Reliability of location	Good Compiled at 1:24,000; 1:100,000; and 1:250,000 scale. *Comments:* Fault locations in Oregon are from 1:100,000-scale mapping of Weldon and others (2002 #5648), based on 1:500,000-scale mapping of Pezzopane (1993 #3544). Fault locations in Nevada are based on 1:250,000-scale mapping of

	Dohrenwend and Moring (1991 #281) and Slemmons (1966, unpublished Vya quadrangle), and 1:24,000-scale airphoto mapping by Personius and others (2006 #7386).
Geologic setting	The Steens fault zone is marked by nearly continuous range-bounding faults on the east side of the Pueblo Mountains and Steens Mountain. The fault zone extends from near Crowley, Oregon, to the southern end of Bog Hot Valley in northern Nevada. The Pueblo Mountains and Steens Mountain are major west-tilted fault blocks (Stewart, 1978 #2866); the adjacent Alvord Desert and Pueblo Valley are structural basins (grabens) filled with 1–2.5 km of Tertiary-Quaternary sedimentary fill (Cleary and others, 1981 #7385, 1981 #5649; Oldow and others, 2005 #7388). The region is underlain by Miocene volcanic rocks, primarily the Steens Basalt (Willden, 1964 #3002; Walker and Repenning, 1965 #3559; Greene and others, 1972 #3560; Brown and Peterson, 1980 #3585; Minor and others, 1987 #3746; Minor and others, 1987 #3747; Walker and MacLeod, 1991 #3646). The Steens fault zone is the longest, most prominent normal fault zone in the Basin and Range province of eastern Oregon, and appears to truncate the southeastern end of the northwest-trending Brothers fault zone (Lawrence, 1976 #3506). Total Miocene vertical displacement of 1.75±0.25 km is reported for a location near Baltazor Hot Spring (Personius and others, 2007 #7387), and Brown and Peterson (1980 #3585) estimated offsets of 2,100–3,000 m in Miocene rocks at the southern end of the Alvord section.
Length (km)	This section is 41 km of a total fault length of 197 km.
Average strike	N10°E (for section) versus N12°E (for whole fault)
Sense of movement	Normal *Comments:* Faults in this section are mapped as normal or high-angle faults by Walker and Repenning (1965 #3559), Brown and Peterson (1980 #3585), Walker and MacLeod (1991 #3646), Pezzopane (1993 #3544), Hemphill-Haley and others (1989 #3958; 1999 #4038), Dohrenwend and Moring (1991 #281) and D.B. Slemmons (1966, unpublished Vya 1° X 2° quadrangle).
Dip Direction	SE
Paleoseismology studies	Site 856-3, Bog Hot Valley trench (Personius and others, 2006 #7386, 2007 #7387) was excavated across one of a series of right-

	stepping, 3- to 5-m-high fault scarps that extend south from the southern end of the Pueblo Mountains and traverse the floor of Bog Hot Valley. The timing of three earthquakes is based on radiocarbon and luminescence ages, and regional correlation methods. The trenched scarp has a surface offset of 4.3 m and correlating units on revealed both side of the fault have been vertically displaced a similar amount. There was not evidence of erosional unconformities in the exposure. Personius and others (2006 #7386, 2007 #7387) excavated a second trench was located on a 5-m-high scarp in alluvial sediments 7.5 km south of the site 856-3, but the trench was not mapped because of the walls collapsed. Coseismic displacements range from 1.1 to 2.2±0.5 m.
Geomorphic expression	Faults in the Denio section form a north-northeast-trending range front escarpment between the eastern margin of the Pueblo Mountains and the western margin of Pueblo Valley; short scarps on piedmont-slope deposits and linear abrupt range fronts characterize this part of the section. The fault continues south of the southern end of the Pueblo Mountains across the floor of Bog Hot Valley as right-stepping east-facing en echelon scarps that continue along the east side of a spur ridge underlain by Tertiary volcanic and sedimentary rocks. Thousand Creek flows into Bog Hot Valley as a distributed network of parallel channels that abruptly join before crossing this transecting zone of scarps, suggesting that the fluvial system has been effected by uplift and possible westward tilt along the intrabasin fault (T.L. Sawyer, written commun., 1999). A set of older (Quaternary) intermontane faults appear to splay from the range-front fault north of Continental Lake and extend northward as aligned ridge-crest saddles along the west side of Alberson Basin (Slemmons, 1966, unpublished Vya 1° X 2° quadrangle).
Age of faulted surficial deposits	Late Pleistocene and latest Pleistocene and (or) Holocene alluvial deposits are locally faulted along the front of the Pueblo Mountains and basin-fill and playa deposits are faulted along the intra-basin fault on the floor of Bog Hot Valley (Slemmons, 1996, unpublished Vya 1° X 2° quadrangle, Dohrenwend and Moring, 1991 #281).
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Results from the Bog Hot Valley trench suggest the

	most recent surface rupturing earthquake occurred 4.6±1.0 ka (Personius and others, 2007 #7387).Earlier reports on the timing of the most recent event on the Denio section, however, were not well constrained and somewhat contradictory. A latest Quaternary time of faulting in the Nevada part of the section is suggested by reconnaissance photogeologic mapping of Dohrenwend and Moring (1991 #281), Dohrenwend and others (1996 #2846), Slemmons (1966, unpublished Vya 1° X 2° quadrangle), and the compiler. Faults in the part of the section in Oregon have been mapped with latest movements in the middle and late Quaternary by Pezzopane (1993 #3544), Geomatrix Consultants, Inc. (1995 #3593), and Weldon and others (2002 #5648).
Recurrence interval	1.5–5.4 k.y. (<11.5±2.0 ka) *Comments:* Results of the Bog Hot Valley trench suggest three Holocene earthquakes at 4.6±1.0 ka, 6.1±0.5 ka, and 11.5±2.0 ka (Personius and others, 2007 #7387). These data yield recurrence intervals of 5.4±2.1 k.y., 1.5±1.1 k.y., and an elapsed time of 4.6±1.0 k.y. since the most recent earthquake.
Slip-rate category	Between 0.2 and 1.0 mm/yr *Comments:* Variable single-event vertical displacements (1.1–2.2±0.5 m) and variable recurrence intervals for the three earthquakes interpreted in the Bog Hot Valley trench (Personius and others, 2007 #7387) yields a number of interevent rates and composite rates that range from 0.2±0.22 (reported as 0.2±0.24 in Table 3) and 1.5±2.3 mm/yr. The average of these data over the past 18±2.2 k.y. is 0.24±0.06 mm/yr, which is similar to the Miocene (8.5–12.5-Ma) vertical displacement rate of 0.2±0.1 mm/yr reported at a location near Baltazor Hot Spring, a few kilometers north of the Bog Hot Valley trench site. Additional Miocene vertical displacement rates include 0.33 mm/yr (Cleary and others, 1981 #5649, 1981 #7385) and 1 mm/yr (Whipple and Oldow, 2004 #7387; Oldow and others, 2005 #7388). For the fault in Nevada, dePolo (1998 #2845) assigned a reconnaissance vertical slip rate of 0.30 mm/yr based on an empirical relationship between his preferred maximum basal facet height and vertical slip rate. The size of the facets (tens to hundreds of meters, as measured from topographic maps) indicates they are the result of many seismic cycles, and thus the derived slip rate reflects a long-term average. Unpublished data of the compiler indicate fault scarps on latest Pleistocene lake deposits on the floor of Bog Hot

	Valley have maximum surface offsets of about 4 m. Such offsets yield similar rates of slip.
Date and Compiler(s)	2016 Stephen F. Personius, U.S. Geological Survey Kathleen M. Haller, U.S. Geological Survey Thomas L. Sawyer, Piedmont Geosciences, Inc.
References	#3585 Brown, D.E., and Peterson, N.V., 1980, Preliminary geology and geothermal resource potential of the Alvord Desert Area, Oregon: State of Oregon, Department of Geology and Mineral Industries Open-File Report O-80-10, 57 p., 2 pls., scale 1:250,000. #5649 Cleary, J., Lange, I.M., Qamar, A.I., and House, H.R., 1981, Gravity, isotope, and geochemical study of the Alvord Valley geothermal area, Oregon: Geological Society of America Bulletin, Part II, v. 92, p. 934-962. #7385 Cleary, J., Lange, I.M., Qamar, A.I., and Krouse, H.R., 1981, Gravity, isotope, and geochemical study of the Alvord Valley geothermal area, Oregon—summary: Geological Society of America Bulletin, Part I, v. 92, p. 319–322. #2845 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, University of Nevada, unpublished Ph.D. dissertation, 199 p. #281 Dohrenwend, J.C., and Moring, B.C., 1991, Reconnaissance photogeologic map of young faults in the Vya 1° by 2° quadrangle, Nevada, Oregon, and California: U.S. Geological Survey Miscellaneous Field Studies Map MF-2174, 1 sheet, scale 1:250,000. #2846 Dohrenwend, J.C., Schell, B.A., Menges, C.M., Moring, B.C., and McKittrick, M.A., 1996, Reconnaissance photogeologic map of young (Quaternary and late Tertiary) faults in Nevada, *in* Singer, D.A., ed., Analysis of Nevada's metal-bearing mineral resources: Nevada Bureau of Mines and Geology Open-File Report 96-2, 1 pl., scale 1:1,000,000. #3593 Geomatrix Consultants, Inc., 1995, Seismic design mapping, State of Oregon: Technical report to Oregon Department of Transportation, Salem, Oregon, under Contract

11688, January 1995, unpaginated, 5 pls., scale 1:1,250,000.

#3560 Greene, R.C., Walker, G.W., and Corcoran, R.E., 1972, Geologic map of the Burns quadrangle, Oregon: U.S. Geological Survey Miscellaneous Geologic Investigations I-680, 2 sheet, scale 1:250,000.

#3960 Hemphill-Haley, M.A., 1987, Quaternary stratigraphy and late Holocene faulting along the base of the eastern escarpment of Steens Mountain, southeastern Oregon: Humboldt State University, unpublished M.S. thesis, 84 p., 1 pl., scale 1:24,000.

#4038 Hemphill-Haley, M.A., Carver, G.A., and Burke, B., 1999, Late Quaternary stratigraphy and Holocene faulting along the eastern margin of Steens Mountain, southeastern Oregon, *in* Quaternary geology of the northern Quinn River and Alvord Valleys, southeastern Oregon: Friends of the Pleistocene field trip guide, September 24-26, 1999, Appendix 5, p. 1-26.

#3958 Hemphill-Haley, M.A., Page, W.D., Burke, R., and Carver, G.A., 1989, Holocene activity of the Alvord Fault, Steens Mountain, southeastern Oregon: Technical report to Woodward-Clyde Consultants, under Contract Grant No. 14-08-0001-G1333, March 1989, 45 p.

#3506 Lawrence, R.D., 1976, Strike-slip faulting terminates the Basin and Range province in Oregon: Geological Society of America Bulletin, v. 87, p. 846-850.

#3479 Madin, I.P., Ferns, M.F., Langridge, R., Jellinek, A.M., and Priebe, K., 1996, Final report to Bonneville Power Administration U.S. Department of Energy Portland General Electric Company—Geothermal resources of southeast Oregon: State of Oregon, Department of Geology and Mineral Industries Open-File Report OFR-0-96-4, 41 p., 6 pls.

#3746 Minor, S.A., Rytuba, J.J., Goeldner, C.A., and Tegtmeyer, K.J., 1987, Geologic map of the Alvord Hot Springs quadrangle, Harney County, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-1916, 1 sheet, scale 1:24,000.

#3747 Minor, S.A., Rytuba, J.J., Meulen Vander, D.B., Grubensky, M.J., and Tegtmeyer, K.J., 1987, Geologic map of the Wildhorse Lake quadrangle, Harney County, Oregon: U.S.

Geological Survey Miscellaneous Field Studies Map MF-1915, 1 sheet, scale 1:24,000.

#7388 Oldow, J.S., Singleton, E.S., and Whipple, K.L., 2005, Integration of digital data resources to estimate the history and rates of deformation in the Alvord extensional basin, southeastern Oregon: Geological Society of America Abstracts with Programs, v. 37, no.7, p. 416.

#7386 Personius, S.F., Crone, A.J., Machette, M.N., Kyung, J.B., Cisneros, H., Lidke, D.J., and Mahan, S.A., 2006, Trench logs and scarp data from an investigation of the Steens fault zone, Bog Hot Valley and Pueblo Valley, Humboldt County, Nevada: U.S. Geological Survey Scientific Investigations Map 2952, http://pubs.usgs.gov/sim/ 2006/2952/.

#7387 Personius, S.F., Crone, A.J., Machette, M.N., Mahan, S.A., Kyung, J.B., Cisneros, H., and Lidke, D.J., 2007, Late Quaternary paleoseismology of the southern Steens fault zone, northern Nevada: Bulletin of the Seismological Society of America, v. 97, p. 1662–1678, doi: 10.1785/0120060202.

#3544 Pezzopane, S.K., 1993, Active faults and earthquake ground motions in Oregon: Eugene, Oregon, University of Oregon, unpublished Ph.D. dissertation, 208 p.

#149 Pezzopane, S.K., and Weldon, R.J., II, 1993, Tectonic role of active faulting in central Oregon: Tectonics, v. 12, p. 1140-1169.

#2866 Stewart, J.H., 1978, Basin-range structure in western North America—A review, *in* Smith, R.B., and Eaton, G.P., eds., Cenozoic tectonics and regional geophysics of the western cordillera: Geological Society of America Memoir 152, p. 1-31, scale 1:2,500,000.

#3646 Walker, G.W., and MacLeod, N.S., 1991, Geologic map of Oregon: U.S. Geological Survey, Special Geologic Map, 2 sheets, scale 1:500,000.

#3559 Walker, G.W., and Repenning, C.A., 1965, Reconnaissance geologic map of the Adel quadrangle, Lake, Harney, and Malheur Counties, Oregon: U.S. Geological Survey Miscellaneous Geologic Investigations I-446, 1 sheet, scale 1:250,000.

#5144 Weldon, R.J., Fletcher, D., Scharer, K.M., and Weldon, E.M., 2002, New map of active faults in central and eastern Oregon: Geological Society of America Abstracts with Programs, v. 34, no. 5, p. A-106.

#7389 Whipple, K.L., and Oldow, J.S., 2004, Late Cenozoic extension and structural evolution of the Alvord basin, southeastern Oregon: Geological Society of America Abstracts with Programs, v. 36, no. 4, p. 28.

#3002 Willden, R., 1964, Geology and mineral deposits of Humboldt County, Nevada: Nevada Bureau of Mines and Geology Bulletin 59, 154 p., scale 1:250,000.