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.

Metolius fault zone, Rimrock-Tumalo section (Class A) No. 853b

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citation for this record: **Personius, S.F., and Haller, K.M., compilers, 2016, Fault number 853b, Metolius fault zone, Rimrock-Tumalo 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 Metolius fault zone is comprised of several mostly southwest-dipping, northwest-trending normal faults that offset volcanic rocks and sediments along the eastern margin of the Cascade Range in central Oregon. The structural setting of the Metolius fault zone is open to interpretation, but the fault zone probably forms part of the eastern boundary of the Cascades graben in a structural transition zone at the northern end of the right-lateral (?) Brothers fault zone. **Sections:** This fault has 3 sections. Following Hawkins and others (1988 #2946, 1989 #2947), the Metolius fault zone is divided into the Green Ridge, the Rimrock-Tumalo, and the Northwest Rift zone sections.
Name	**General:** The Metolius fault zone of Hawkins and others (1988

comments	#2946, 1989 #2947) is a zone of primarily down to the west and southwest normal faults that extend from Green Ridge on the north to Newberry Volcano on the south. Named faults in this fault zone are, from north to south, the Green Ridge, Rimrock, and Tumalo faults and the Northwest Rift zone near Newberry volcano (Peterson and others, 1976 #3735; U.S. Army Corps of Engineers, 1983 #3484; 1983 #3485; Hawkins and others, 1988 #2946; Goles and Lambert, 1990 #3763; Mimura, 1992 #3590; Taylor and Ferns, 1994 #3759; MacLeod and others, 1995 #3557; Sherrod and others, 2004 #5172; Wellik, 2008 #7383). This fault zone should not be confused with the Metolius fault located along the Metolius River northeast of Green Ridge (U.S. Army Corps of Engineers, 1983 #3485), which has not been included in recent Quaternary fault compilations (Hawkins and others, 1988 #2946; Pezzopane, 1993 #3544; Geomatrix Consultants Inc., 1995 #3593). Fault strands in the Metolius fault zone are parallel to and have been included by various authors in the nearby Sisters and Brothers fault zones [852 and 819, respectively], but we include these faults in the Metolius fault zone of Hawkins and others (1988 #2946) because of their consistent slip direction. **Section:** This section consists of the down-to-the-southwest, northwest-trending Rimrock and Tumalo faults and antithetic faults of similar trend (Peterson and others, 1976 #3735; Taylor, 1981 #4306; 1981 #4307; U.S. Army Corps of Engineers, 1983 #3485; Hawkins and others, 1988 #2946; Pezzopane, 1993 #3544; Taylor and Ferns, 1994 #3759; Sherrod and Smith, 2000 #5165; Sherrod and others, 2004 #5172; Wellik, 2008 #7383). **Fault ID:** This fault zone is comprised of fault numbers 24, 25, and 26 of Pezzopane (1993 #3544), fault numbers 44, 46, and 47 of Geomatrix Consultants, Inc. (1995 #3593), and NWR1–NWR9 of Wellik (2008 #7383).
County(s) and State(s)	DESCHUTES COUNTY, OREGON
Physiographic province(s)	COLUMBIA PLATEAU
Reliability of location	Good Compiled at 1:24,000 scale. *Comments:* Fault traces are from mapping of Wellik (2008 #7383).

Geologic setting	The Metolius fault zone of Hawkins and others (1988 #2946) is comprised of several mostly southwest-dipping, northwest-trending normal faults (Peterson and others, 1976 #3735; U.S. Army Corps of Engineers, 1983 #3484; Hawkins and others, 1988 #2946; Geomatrix Consultants Inc., 1990 #3550; Walker and MacLeod, 1991 #3646, 1995 #3593; Sherrod and others, 2004 #5172; Wellik, 2008 #7383) that offset volcanic rocks and sediments along the eastern margin of the Cascade Range in central Oregon. Individual faults are closely associated with cinder cones (Wellik, 2008 #7383) and cumulative vertical displacement across the entire zone is likely 20 m (Geomatrix Consultants Inc., 1990 #3550). The structural setting of the Metolius fault zone is open to interpretation, but the fault zone probably forms part of the eastern boundary of the Cascades graben (Taylor, 1981 #4306; 1981 #4307; Sherrod and Smith, 2000 #5165), in a structural transition zone at the northern end of the right lateral (?) Brothers fault zone (Lawrence, 1976 #3506; Hawkins and others, 1988 #2946).
Length (km)	This section is 45 km of a total fault length of 94 km.
Average strike	N29°W (for section) versus N22°W (for whole fault)
Sense of movement	Normal, Right lateral *Comments:* Faults in the Rimrock-Tumalo section are mapped as high angle or normal faults by most workers (Peterson and others, 1976 #3735; Taylor, 1981 #4306; 1981 #4307; Walker and Nolf, 1981 #4310; 1981 #4311; U.S. Army Corps of Engineers, 1983 #3485; Walker and MacLeod, 1991 #3646; Mimura, 1992 #3590; Pezzopane, 1993 #3544; Taylor and Ferns, 1994 #3759; Sherrod and Smith, 2000 #5165; Sherrod and others, 2004 #5172; Wellik, 2008 #7383). Some investigators report right-lateral oblique slip may also be present (Mimura, 1992 #3590; Taylor and Ferns, 1994 #3759; Geomatrix Consultants Inc., 1995 #3593); however, the most detailed study concludes there is no evidence of lateral displacement Wellik (2008 #7383).
Dip	70–90° SW *Comments:* Individual faults in this zone dip southwest and northeast. Hawkins and others (1988 #2946) describe an exposure of the Tumalo fault about 0.5 km south of Upper Tumalo Reservoir where several fault planes in Pleistocene pumice and

	fluvial gravels dip southwest 70°–80°, and other workers refer to vertical or steeply dipping fault exposures and scarps along faults in the Rimrock-Tumalo section (U.S. Army Corps of Engineers, 1983 #3484; Geomatrix Consultants Inc., 1995 #3593; Sherrod and others, 2002 #5169). Geomatrix Consultants, Inc. (1995 #3593) used an estimated dip of 75° in their modeling of earthquake hazards along the Tumalo fault.
Paleoseismology studies	
Geomorphic expression	The Rimrock-Tumalo section consists of several mostly southwest-dipping, northwest trending fault strands in gently east-tilted late Tertiary and Quaternary volcanic rocks (Taylor, 1981 #4306; 1981 #4307; U.S. Army Corps of Engineers, 1983 #3484; Hawkins and others, 1988 #2946; Taylor and Ferns, 1994 #3759; Sherrod and Smith, 2000 #5165; Sherrod and others, 2004 #5172); these faults are marked by prominent scarps up to 70 m high in Miocene-Pliocene volcanic rocks, 2- to 10-m-high scarps in middle Pleistocene ash-flow tuffs and lavas (Hawkins and others, 1988 #2946; Hemphill-Haley, 2001 #5036; Sherrod and others, 2002 #5169), and in places have been mapped as faulting glacial outwash or alluvial surfaces (Peterson and others, 1976 #3735; Mimura, 1992 #3590; Taylor and Ferns, 1994 #3759). Fault scarps form linear escarpments and vegetation lineaments, and may form right-lateral offsets of stream channels northwest of Awbrey Butte (Mimura, 1992 #3590). Weldon and others (2002 #5648) observed lineaments across Quaternary deposits on 1:100,000-scale DEMs of the area. According to Wellik (2008 #7383) the Tumalo fault zone is comprised of 21 faults ranging in length from less than 1 km to more than 36 km and observed vertical surface separations a vary, from several meters to tens of meters along strike.
Age of faulted surficial deposits	Faults in the Rimrock-Tumalo section offset Miocene-Pliocene volcanic rocks, pyroclastic rocks of middle and late Pleistocene age, and glacial outwash and/or alluvial deposits of middle and late (?) Pleistocene age (Peterson and others, 1976 #3735; Taylor, 1981 #4306; 1981 #4307; U.S. Army Corps of Engineers, 1983 #3484; Hawkins and others, 1988 #2946; Mimura, 1992 #3590; Taylor and Ferns, 1994 #3759; Sherrod and Smith, 2000 #5165; Sherrod and others, 2002 #5169; Sherrod and others, 2004 #5172; Wellik, 2008 #7383). A gravel pit exposure of the Tumalo fault about 0.5 km south of Upper Tumalo Reservoir shows several

	fault planes offsetting middle Pleistocene Tumalo Tuff(?) and Bend Pumice (0.3–0.4 Ma, Sarna-Wojcicki and others, 1987 #1707; 1989 #3725; Sherrod and others, 2002 #5169, 2004 #5172), and overlying fluvial deposits or glacial outwash (Taylor, 1981 #4306; 1981 #4307; U.S. Army Corps of Engineers, 1983 #3484; Hawkins and others, 1988 #2946; Hemphill-Haley, 2001 #5036). The Tumalo fault also offsets the Shevlin Park tuff, which is thought to have been deposited <170 ka, based on paleomagnetic and geochemical correlations (Gardner and others, 1992 #3786; Taylor and Ferns, 1994 #3759; D.R. Sherrod, pers. commun., 1994, in Geomatrix Consultants Inc., 1995 #3593). Hawkins and others (1988 #2946) estimated an age of >125–150 ka for the gravel deposits based on soil development. Some High Cascade basalt flows that overlie these gravels are faulted, but their ages are poorly constrained.
Historic earthquake	
Most recent prehistoric deformation	late Quaternary (<130 ka) *Comments:* Mapping and reconnaissance studies indicate offsets of middle Pleistocene volcanic rocks (Peterson and others, 1976 #3735; Taylor, 1981 #4306; 1981 #4307; Walker and Nolf, 1981 #4310; 1981 #4311; U.S. Army Corps of Engineers, 1983 #3484; Hawkins and others, 1988 #2946; Mimura, 1992 #3590; Taylor and Ferns, 1994 #3759; Sherrod and Smith, 2000 #5165; Sherrod and others, 2002 #5169; Sherrod and others, 2004 #5172). Hawkins and others (1988 #2946) inferred late Quaternary displacement in the gravel pit exposure of the Tumalo fault. M.L. Ferns (pers. commun., 1994, in Geomatrix Consultants Inc., 1995 #3593) infers a period of significant faulting on the northern part of the Tumalo fault between 400 and 200 ka, and little or no displacement since 200 ka. Both M.L. Ferns and L.A. Chitwood (pers. communs., 1994, in Geomatrix Consultants Inc., 1995 #3593) infer that the most recent displacement on the Tumalo fault occurred >100 ka. D.R. Sherrod (pers. commun., 1994, in Geomatrix Consultants Inc., 1995 #3593) used recently obtained age control on the Shevlin Park tuff to determine that the most recent displacement on the Tumalo fault occurred <170 ka, but probably before 10 ka (Sherrod and others, 2004 #5172). Taylor and Ferns (1994 #3759) found abundant evidence for repeated displacements in middle Pleistocene volcanic rocks, but no unambiguous evidence for Holocene displacement along the Tumalo fault in the Tumalo Dam quadrangle. U.S. Army Corps of

	Engineers (1983 #3484) infer Holocene movement on the Tumalo and Rimrock faults, but Pezzopane (1993 #3544) and subsequent compilations (Geomatrix Consultants Inc., 1995 #3593; Madin and Mabey, 1996 #3575; Weldon and others, 2002 #5648) infer middle and late Quaternary (<700–780 ka) displacement on most fault strands in the Rimrock-Tumalo section. Based on detailed mapping of 21 faults ranging in length from less than 1 km to more than 36 km, Wellik (2008 #7383) concludes that Holocene deposits containing 7-ka Mazama ash are not faulted and three faults offset Quaternary sand (Qs) correlated to marine oxygen-isotope stage 6 (approximately 140 ka). The late Quaternary age category is assigned based on detailed mapping of Wellik (2008 #7383).
Recurrence interval	
Slip-rate category	Less than 0.2 mm/yr *Comments:* No detailed fault slip data are documented, but Geomatrix Consultants, Inc. (1995 #3593) use slip data and age estimates from Hawkins and others (1988 #2946) to estimate slip rates of 0.01-0.1 mm/yr on the Tumalo fault.
Date and Compiler(s)	2016 Stephen F. Personius, U.S. Geological Survey Kathleen M. Haller, U.S. Geological Survey
References	#3786 Gardner, C.A., Hill, B.E., Negrini, R.M., and Sarna-Wojcicki, A.M., 1992, Paleomagnetic correlations of middle Pleistocene ignimbrites from the Bend, Oregon area with distal tephra beds: Geological Society of America Abstracts with Programs, v. 24, no. 5, p. 26. #3550 Geomatrix Consultants, Inc., 1990, Seismotectonic evaluation of Wasco Dam site: Technical report to U.S. Department of Interior, Bureau of Reclamation, Denver, under Contract 6-CS-81-07310, 115 p., 2 pls., scale 1:250,000. #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. #3763 Goles, G., and Lambert, R.S.J., 1990, A strontium isotopic

study of Newberry volcano, central Oregon—Structural and thermal implications: Journal of Volcanology and Geothermal Research, v. 43, p. 159-174.

#2947 Hawkins, F.F., LaForge, R.C., and Gilbert, J.D., 1989, Seismotectonic study for Wickiup and Crane Prairie Dams, Deschutes Project, Oregon: U.S. Bureau of Reclamation Seismotectonic Report 89-2, 38 p., 1 pl.

#2946 Hawkins, F.F., LaForge, R.C., Templeton, M., and Gilbert, J.D., 1988, Seismotectonic study for Arthur R. Bowman and Ochoco Dams, Crooked River Project, Oregon: U.S. Bureau of Reclamation Seismotectonic Report 88-10, 57 p., 2 pls.

#5036 Hemphill-Haley, M., 2001, Appendix A—Summary of studies on the Sisters fault zone, *in* Ake, J., LaForge, R., and Hawkins, F., eds., Probabilistic seismic hazard analysis for Wickiup Dam—Deschutes project, central Oregon: Seismotectonic Report 2000-04, p. A1-B16.

#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.

#3557 MacLeod, N.S., Sherrod, D.R., Chitwood, L.A., and Jensen, R.A., 1995, Geologic map of Newberry Volcano, Deschutes, Klamath, and Lake Counties, Oregon: U.S. Geological Survey Miscellaneous Investigations Map I-2455, 2 sheets, scale 1:24,000 and 1:62,500.

#3575 Madin, I.P., and Mabey, M.A., 1996, Earthquake hazard maps for Oregon: State of Oregon, Department of Geology and Mineral Industries Geological Map Series GMS-100, 1 sheet.

#3590 Mimura, K., 1992, Reconnaissance geologic map of the west half of the bend and the east half of the Shevlin park 7 1/2 quadrangles, Deschutes County, Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-2189, 1 sheet, scale 1:24,000.

#3735 Peterson, N.V., Groh, E.A., Taylor, E.M., and Stensland, D.E., 1976, Geology and mineral resources of Deschutes County, Oregon: State of Oregon, Department of Geology and Mineral Industries Bulletin 89, 66 p., 4 pls.

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

#3725 Sarna-Wojcicki, A.M., Meyer, C.E., and Nakata, J.K., 1989, Age and correlation of mid-Quaternary ash beds and tuffs in the vicinity of Bend, Oregon, *in* Scott, W.E., Gardner, C.A., and Sarna-Wojcicki, A.M., eds., Guidebook for field trip to the Mount Bachelor-South Sister-Bend Area, central Oregon High Cascades: U.S. Geological Survey Open-File Report 89-645, p. 55-62.

#1707 Sarna-Wojcicki, A.M., Morrison, S.D., Meyer, C.E., and Hillhouse, J.W., 1987, Correlation of upper Cenozoic tephra layers between sediments of the Western United States and eastern Pacific Ocean and comparison with biostratigraphic and magnetostratigraphic age data: Geological Society of America Bulletin, v. 98, p. 207-223.

#5165 Sherrod, D.R., and Smith, J.G., 2000, Geologic map of upper Eocene to Holocene volcanic and related rocks of the Cascade Range, Oregon: U.S. Geological Survey Geologic Investigations Map I-2569, 2 sheets, scale 1:500,000.

#5169 Sherrod, D.R., Gannett, M.W., and Lite, K.E., Jr., 2002, Hydrogeology of the upper Deschutes basin, central Oregon—A young basin adjacent to the Cascade volcanic arc, *in* Moore, G.W., ed., Field guide to geologic processes in Cascadia: State of Oregon, Department of Geology and Mineral Industries Special Paper 36, p. 109-144.

#5172 Sherrod, D.R., Taylor, E.M., Ferns, M.L., Scott, W.E., Conrey, R.M., and Smith, G.A., 2004, Geologic map of the Bend 30' x 60' quadrangle, central Oregon: U.S. Geological Survey Geologic Investigations Map I-2683, 44 p. pamphlet, 2 sheets, scale 1:100,000.

#4306 Taylor, E.M., 1981, Central High Cascade roadside geology, Bend, Sisters, McKenzie Pass, and Santiam Pass, Oregon, *in* Johnston, D.A., and Donnelly-Nolan, J., eds., Guides to some volcanic terranes in Washington, Idaho, Oregon, and northern California: U.S. Geological Survey Circular 838, p. 55-58.

#4307 Taylor, E.M., 1981, Roadlog for Central High Cascade geology, Bend, Sisters, McKenzie Pass, and Santiam Pass, Oregon, *in* Johnston, D.A., and Donnelly-Nolan, J., eds., Guides to some volcanic terranes in Washington, Idaho, Oregon, and northern California: U.S. Geological Survey Circular 838, p. 59-83.

#3759 Taylor, E.M., and Ferns, M.L., 1994, Geology and mineral resource map of the Tumalo Dam quadrangle, Deschutes County, Oregon: State of Oregon, Department of Geology and Mineral Industries GMS-81, 1 sheet, scale 1:24,000.

#3484 U.S. Army Corps of Engineers, 1983, Cougar and Blue River Lakes earthquake and fault study—Design memorandum 19: U.S. Army Corps of Engineers, Portland District, v. 19, 90 p., 11 pls.

#7383 Wellik, J.M., 2008, Quaternary faulting of Deschutes County, Oregon: Arcata, California, Humboldt State University, M.S. thesis, 74 p.

Questions or comments?