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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.

Dunnigan Hills fault (Class A) No. 234

Last Review Date: 2017-03-18

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Synopsis	Relatively short, 15-km-long fault mapped along the east side of the Dunnigan Hills, a northwest-trending doubly plunging anticline (Harwood and Helley (1987). The Dunnigan Hills fault has been mapped as a late Pleistocene to Holocene fault by Helley and Herd (1977) and Helley and Barker (1979), based on photo lineaments observed in late Pleistocene surfaces. Herd (in Bryant, 1982) and Bryant (1982) did not verify the recency of displacement reported by Helley and Herd (1977) and Helley and Barker (1979). Harwood and Helley (1987) mapped a much shorter fault they termed the Zamora fault along a portion of the NE-facing escarpment of the Dunnigan Hills. The photo lineaments mapped by Helley and Herd (1977) and Helley and Barker (1979) are northwest of the northwestern end of the Zamora fault. The linear east flank of the Dunnigan Hills is a fold scarp that is probably unrelated to surface faulting. Unruh and Moores (1992) and O'Connell and others (2001) concluded that

	the Dunnigan Hills anticline is part of the surface expression of deformation near the intersection of the Trout Creek and Mysterious Ridge blind thrust faults [28c, 28d1]. Specifically, the Dunnigan Hills fold chain, as referred to by Unruh and Moores (1992) and includes the Plainfield Ridge and Dixon Rise, is attributed to a blind, west-vergent backthrust that roots into the near-horizontal detachment east of the Gordon Ridge thrust ramp (Unruh and Moores, 1992; O'Connell and others, 2001).
Name comments	Bryan (1923) first recognized the possibility of a fault along the eastern flank of the Dunnigan Hills, naming the fault the Hungry Hollow fault. Helley and Herd (1977) mapped a fault along the northeastern flank of the Dunnigan Hills, naming it the Dunnigan Hills fault. Later mapping by Harwood and Helley (1987) limited the lateral extent of the fault along the eastern side of the Dunnigan Hills; they referred to this fault as the Zamora fault. The fault in this compilation will be referred to as the Dunnigan Hills fault. **Fault ID:** Refers to number 124 (Dunnigan Hills fault) of Jennings (1994).
County(s) and State(s)	YOLO COUNTY, CALIFORNIA
Physiographic province(s)	PACIFIC BORDER
Reliability of location	Good Compiled at 1: scale. *Comments:* Location of fault from Qt_flt_ver_3-0_Final_WGS84_polyline.shp (Bryant, W.A., written communication to K.Haller, August 15, 2017) attributed to 1:62,500-scale map by Helley and Barker (1979).
Geologic setting	High angle, down to east fault located along the eastern side of the Dunnigan Hills. Dunnigan Hills, located along the west side of the Great Valley near the Great Valley-Coast Range boundary, is a broad antiformal uplift (Munk, 1993). Sense of displacement of the Dunnigan Hills fault is poorly understood, but is inferred to be predominantly vertical. Bryan (1923) reported down to the east normal displacement, but Harwood and Helley's (1987) Figure 20 shows a steeply west-dipping fault, implying a reverse sense of offset. Total displacement is not known, but Harwood and Helley

	(1987) show as much as 300 m of vertical separation of the base of the Pliocene Tehama Formation.
Length (km)	km.
Average strike	
Sense of movement	Reverse *Comments:* Harwood and Helley (1987) infer that the Dunnigan Hills fault is characterized by down to the east normal displacement, but figure 20 shows a steeply west-dipping fault, implying reverse sense of offset. Unruh and Moores (1992) consider the Dunnigan Hills (Zamora) fault to be a high angle reverse fault, based on seismic reflection data.
Dip Direction	W *Comments:* Harwood and Helley (1987) report that the Zamora fault is a near vertical down to the east normal fault. However, their cross section (figure 20) depicts a steeply west-dipping reverse fault.
Paleoseismology studies	
Geomorphic expression	Dunnigan Hills is a broad, doubly-plunging anticline with a relatively linear northeastern flank. Helley and Herd (1977) and Helley and Barker (1979) mapped a linear northeast-facing escarpment with associated linear tonal contrasts, a bench, trench, and possible closed depressions. Herd (unpublished mapping in Bryant, 1982) revised his mapping from 1977, depicting the Dunnigan Hills fault as concealed along the northeast-facing range front. Bryant (1982) did not verify the photo lineaments mapped by Helley and Barker (1979) and Helley and Herd (1977), noting that the northeast-facing escarpment on the east side of the Dunnigan Hills is not linear in detail and is dissected. Bryant noted that the tonal lineaments observed on young surfaces could also be explained as bedding, buried fluvial channels, or agricultural artifacts.
Age of faulted surficial deposits	Dunnigan Hills fault offsets Quaternary Red Bluff Formation by about 220 m (Harwood and Helley, 1987). Late Quaternary alluvial deposits conceal the fault (Herd, in Bryant, 1982).

Historic earthquake	
Most recent prehistoric deformation	late Quaternary (<130 ka) *Comments:* Timing of the most recent paleoevent is unknown. Helley and Herd (1977) mapped linear tonal contrasts in late Pleistocene alluvium near Zamora, suggesting latest Pleistocene to Holocene displacement. Alternatively, unpublished mapping by Herd (see Bryant, 1982) shows the Dunnigan Hills fault as concealed by late Pleistocene deposits, including the Riverbank Formation (130–450 ka, based on Marchand and Allwardt, 1981). Bryant (1982) concluded that geomorphic evidence of Holocene displacement along the Dunnigan Hills fault was not compelling and did not verify the recent traces mapped by Helley and Herd (1977). Harwood and Helley (1987) reported that the 0.45–1.0 Ma Red Bluff Formation is vertically displaced about 220 m. In the cross section shown in Harwood and Helley's figure 20, the Zamora fault vertically separates the base of the Pliocene Tehama Formation (3.3–3.4 Ma) about 300 m. However, underlying stratigraphic units shown in figure 20 exhibit less vertical separation (*e.g.*, the base of the erosional unconformity between the Starky Formation and the underlying upper Cretaceous sandstone/shale package is vertically separated by about 230 m).
Recurrence interval	
Slip-rate category	Between 0.2 and 1.0 mm/yr *Comments:* Harwood and Helley (1987) reported that Red Bluff Formation is vertically offset about 220 m.; the age of Red Bluff Formation is bracketed by age of overlying Rockland Ash (0.45 Ma) and underlying Deer Creek basalt (1.08 Ma). However, Harwood and Helley (1987) reported that this vertical separation is a combination of folding on the Dunnigan Hills anticline and displacement on the Zamora fault. Munk (1993) mapped and dated a series of geomorphic surfaces that are progressively uplifted. Munk (1993) concluded that deformation producing the Dunnigan Hills commenced between 0.4 and 0.2 Ma, resulting in about 90 m of uplift at a rate of 0.2–0.5 mm/yr. The T3 terrace surface, estimated to be between 55 and 75 ka, is uplifted about 5–10 m. All reported data suggest similar slip rates.
Date and	2017

Compiler(s)	William A. Bryant, California Geological Survey
References	#8504 Bryan, K., 1923, Geology and ground-water resources of Sacramento Valley, California: U.S. Geological Survey Water-Supply Paper 495, 285 p. #8505 Bryant, W.A., 1982, Fault Evaluation Report FER-134, Dunnigan Hills fault: California Division of Mines and Geology, 6 p., map scale 1:24,000, in Fault Evaluation Reports Prepared Under the Alquist-Priolo Earthquake Fault Zoning Act, Region 1 – Central California: California Geological Survey CGS CD 2002-01 (2002). #5287 Harwood, D.S., and Helley, E.J., 1987, Late Cenozoic tectonism of the Sacramento Valley, California: Professional Paper 1359, 46 p., 1, scale 1:250,000. #8137 Helley, E.J., and Barker, J.A., 1979, Preliminary geologic deposits of the Dunnigan, Woodland, Lake Berryessa, and Guinda 15-minute quadrangles, California: U.S. Geological Survey Open-File Report 79-1606, map scale 1:62,500. #8506 Helley, E.J., and Harwood, D.S., 1985, Geologic map of the late Cenozoic deposits of the Sacramento Valley and northern Sierran Foothills, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1790, map scale 1:62,500. #8136 Helley, E.J., and Herd, D.G., 1977, Map showing faults with Quaternary displacement, northeastern San Francisco Bay region, California: U.S. Geological Survey Miscellaneous Field Studies Map MF−881, scale 1:125,000. #2878 Jennings, C.W., 1994, Fault activity map of California and adjacent areas, with locations of recent volcanic eruptions: California Division of Mines and Geology Geologic Data Map 6, 92 p., 2 pls., scale 1:750,000. #8416 Marchand, D.E, and Allwardt, A., 1981, Late Cenozoic stratigraphic units, northeastern San Joaquin Valley, California: U.S. Geological Survey Bulletin 1470, 70 p. #8417 Munk, L.P., 1993, Stratigraphy, geomorphology, soils and neotectonic interpretation of the Dunnigan Hills, California: Davis, University of California, unpublished Ph.D. dissertation,

	125 p. #8420 O’Connell, D.R.H., Unruh, J.R., and Block, L.V., 2001, Source characterization and ground-motion modeling of the 1892 Vacaville-Winters earthquake sequence, California: Bulletin of the Seismological Society of America, v. 91, p. 1471–1497. #8429 Unruh, J.R., and Moores, E.M., 1992, Quaternary blind thrusting in the southwestern Sacramento Valley, California: Tectonics, v. 11, p. 192–203.