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Hurricane fault zone, Shivwitz section (Class A) No. 998d

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Compiled in cooperation with the Arizona Geological Survey

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Synopsis	**General:** The Hurricane fault is a long, generally north-trending fault zone with substantial Quaternary normal displacement near the western margin of the Colorado Plateaus province in Arizona and Utah. The Hurricane Cliffs are a fault-generated steep, curvilinear, west-facing bedrock escarpment several hundred meters high. Displacement decreases southward; there has been 200–400 m of Cenozoic normal displacement across the fault zone along most of its length in Arizona. Near the Utah border, displacement increases to at least 450 m and probably continues to increase into Utah.

	Sections: This fault has 6 sections. The Hurricane fault is divided into sections based on gross geomorphic expression, structural characteristics, and what is known about the recent rupture history of the fault. Although parts of the Hurricane escarpment south of the Colorado River is fairly linear and steep, no definitive evidence of Quaternary activity on this southern section [998f] of the fault has been reported. The Whitmore Canyon section [998e], between the Colorado River and the Mt. Trumbull area, last ruptured in the latest Pleistocene to early Holocene and has had recurrent late Quaternary activity. The escarpment associated with the fault in this section is steep, but is sinuous and erosionally embayed. The Mt. Trumbull area is probably a section boundary, because there is very little topographic relief across the Hurricane fault and Pliocene volcanic rocks have only been displaced a moderate amount. Northward along the Shivwitz section [998d], the curvilinear fault escarpment (the Hurricane Cliffs) increases to several hundred meters in height. Low fault scarps on colluvium, alluvium, and bedrock are common along the base of the Cliffs in this section, and record late Quaternary fault activity. The northern end of the Shivwitz section is defined by a major convex bend in the fault zone, across which total fault displacement increases by at least 50 percent. The Anderson Junction section [998c] begins at this convex bend and continues north into Utah. The fault escarpment is very steep and curvilinear, and scarps along the base of the Cliffs record at least 20 m of late Quaternary displacement. The youngest rupture on this section was probably in the early Holocene, but the northern extent of this rupture is uncertain. The next section to the north, the Ash Creek section [998b] is exhibits more complex fault geometry along the steep base of the Hurricane Cliffs. The northernmost section, Cedar City section [998a] is defined based on the timing of the most recent event. The major section boundaries are at zones of structural complexity.
Name comments	**General:** Early work by Gardner (1941 #2190) refers to the "Hurricane fault." The fault extends from about 2 km east of Cedar City, Utah, to about 5 km west of Peach Springs, Arizona, on U.S. Highway 66. **Section:** This name applies to the part of the Hurricane fault from the major convex fault bend about 10 km south of the Utah border, south to the Mt. Trumbull area. The Hurricane Cliffs form the eastern margin of the Shivwitz Plateau along this section. This relatively long section of the fault was further subdivided by

	Menges and Pearthree (1983 #2073) into the "Temple Trail", "Grandstand", "Merchant Tank", and "Twin Buttes" segments, but detailed studies to support this finer differentiation have not been conducted.
County(s) and State(s)	MOHAVE COUNTY, ARIZONA
Physiographic province(s)	COLORADO PLATEAUS
Reliability of location	Good Compiled at 1:250,000 scale. *Comments:* Most of the fault is mapped at 1:24,000 scale (Billingsley, 1992 #2071; 1993 #2074; 1993 #2186; 1994 #2097; 1994 #2187); this information was transferred to 1:250,000-scale topographic map for digitization.
Geologic setting	The Hurricane fault zone is one of several long, down-to-the-west, normal faults located in what is effectively a 150-km-wide transition zone between the Colorado Plateaus and Basin and Range. Substantial late Cenozoic displacement on the Grand Wash [1005], Washington [1004], Hurricane, and Sevier/Toroweap [997] faults has resulted in the formation of a series of broad plateaus and escarpments that step down to the west. Along most of its length, the Hurricane fault is marked by a high, steep bedrock escarpment with relatively thin Quaternary deposits along its base. Paleozoic strata have been vertically displaced by hundreds of meters across the Hurricane fault. Pliocene and Quaternary basalt flows have been displaced by substantial amounts, and upper Quaternary alluvium and colluvium have been faulted as well. Stewart and Taylor (1996 #3473) document 450 m of stratigraphic separation in Quaternary basalt displaced by the fault, and a total separation of 2,520 m across a portion of the Hurricane fault near Anderson Junction. Cenozoic displacement is only 200–400 m across the fault zone along most of its length in Arizona. Several swarms of historical seismicity have occurred adjacent to, but cannot be correlated directly with, the north end of the Hurricane fault. The earliest of these swarms (1942) included two approximately magnitude 5 earthquakes (Arabasz and Smith, 1979 #4438; Richins and others, 1981 #4443). The 1992 M5.8 St. George earthquake was likely on the Hurricane fault (Pechmann and others, 1995 #4442).

Length (km)	This section is 57 km of a total fault length of 238 km.
Average strike	N5°W (for section) versus N11°E,N39°E,N39°E,N39°E (for whole fault)
Sense of movement	Normal *Comments:* Based on topographic expression of the fault, stratigraphic relations, and fault trench.
Dip	75–90° W. *Comments:* As reported by Hamblin (1965 #1522); Amoroso and others (2002 #5318).
Paleoseismology studies	Site 998-3. A 40-m-long, generally 2-m-deep trench was excavated at a site called the Boulder Fan locality in the southern part of the Shivwitz section (Amoroso and others, 2002 #5318, 2004 #6887). Correlation of units in the trench suggests 4.6 m of vertical displacement in probably 2 events since 78 ka. A radiocarbon age of 8900–10,400 cal yr BP, obtained from a fissure fill, may closely approximate the age of the youngest faulting event. Vertical surface displacement in the youngest event was probably 2.3–3 m. Interpretation of the fault-related deposits suggests that the penultimate event probably occurred more than 10 k.y. prior to the most recent event (Amoroso and others, 2004 #6887) and likely involved 1.5–2.3 m of displacement (Amoroso and others, 2002 #5318).
Geomorphic expression	Faulting has generated a high, west southwest- to northwest-facing escarpment on Paleozoic bedrock. The escarpment closely follows the fault zone and is very steep and curvilinear except in the Navajo Trail-Grandstand area, where the fault zone is obviously composed of several major strands. Fault scarps formed on probable late Pleistocene colluvium and alluvium exist along much of the base of the escarpment north of Twin Butte. Scarps range in height from about 4–25 m, with maximum slope angles of 15–30°. Estimated vertical displacement across these scarps is 10 m or less. Preliminary morphologic analysis based on 10 scarp profiles suggests a latest Pleistocene age of youngest rupture (Menges and Pearthree, 1983 #2073). More recent morphologic analyses of scarps between Twin Butte and the Grandstand suggest an age of 5–25 ka for youngest faulting (Amoroso and others, 2002 #5318). Amoroso and others (2004 #6887) and Pearthree and others (2002 #6889) estimate that the amount of

	offset per event is 2–3 m.
Age of faulted surficial deposits	Paleozoic bedrock; early to middle Pleistocene basalt and late Pleistocene sediment.
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Timing of the most recent event is based on the radiocarbon sample found in a fissure resulting from the most recent event that yielded an age of 8900–10,400 cal yr BP. It is generally consistent with morphologic fault scarp age estimates for this section of the fault.
Recurrence interval	*Comments:* Amoroso and others (2004 #6887) document that two events occurred in the past 15–78 k.y. and the penultimate event occurred more than 10 k.y. prior to the most recent event.
Slip-rate category	Between 0.2 and 1.0 mm/yr *Comments:* Amoroso and others (2004 #6887) document a number of vertical displacement rates using a variety of methods and datums for this section of the Hurricane fault. Furthermore, their study shows that the displacement rate does not appear to vary over the past 100 k.y. The Moriah Knoll basalt (40Ar/39Ar age of 0.85±0.06 Ma) is offset 150–200 m. These data yield a long-term rate of about 0.2 mm/yr as stated by Pearthree and others (2002 #6889). Late Quaternary vertical displacement rates derived from ages of offset alluvial fan surfaces using pedogenic carbonate rind thickness as a calibrates proxy for age yielded rates of about 0.5 to 0.3 mm/yr. By integrating morphologic modeling, they derive vertical displacement rates of about 0.06–0.34 mm/yr, and finally the trench at Boulder Fan site showed evidence of two events that suggests vertical rates of 0.06–0.34 over a time period of 15–78 ka. Vertical displacement rate estimates based on morphologic scarp analyses and displaced late Pleistocene alluvial fans range from 0.05 to 0.3 mm/yr. The data suggests possible slip rates spanning the boundary between the two lower slip-rate categories; the higher of the two is assigned here.
Date and	2006

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