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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.**

## Hurricane fault zone, Anderson Junction section (Class A) No. 998c

**Last Review Date: 2004-06-01**

## Compiled in cooperation with the Utah Geological Survey and the Arizona Geological Survey

***citation for this record:*** **Black, B.D., Pearthree, P.A., DuRoss, C.B., Hylland, M.D., Hecker, S., and McDonald, G.N., compilers, 2004, Fault number 998c, Hurricane fault zone, Anderson Junction 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 03:11 PM.**

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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 |

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| | border, displacement increases to at least 450 m and probably continues to increase into Utah.<br><br>**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.<br><br>**Section:** This name applies to the part of the Hurricane fault from about 1 km south of U.S. highway 89 near Mt Carmel Junction south to the major convex bend in the fault about 10 km south of the Utah border. Includes the "Hurricane segment" of Menges and Pearthree (1983 #2073). |
| **County(s) and State(s)** | WASHINGTON COUNTY, UTAH<br>MOHAVE COUNTY, ARIZONA |
| **Physiographic** | BASIN AND RANGE |

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| **province(s)** | COLORADO PLATEAUS |
| **Reliability of location** | Good<br>Compiled at 1:22,000 scale.<br><br>*Comments:* Mapped at 1:24,000 scale (Billingsley, 1992 #2078). Location of fault in Utah based on 1:250,000-scale mapping by Anderson and Christenson (1989 #828); also mapped by Stewart and Taylor (1996 #3473), Biek (1998 #4440), Stenner and others (1999 #4444), Lund and others (2001 #4611),and Biek (2003 #6734), Hurlow and Biek (2003 #6736), and Hayden (2004 #6735). |
| **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 61 km of a total fault length of 238 km. |
| **Average strike** | N10°E (for section) versus N11°E,N39°E,N39°E,N39°E (for whole fault) |
| **Sense of movement** | Normal<br><br>*Comments:* Mesozoic and Paleozoic bedrock, and Quaternary volcanic rocks, alluvium, and colluvium are displaced vertically across the fault zone. Also, slickenlines reported from the fault near the Utah border |

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| | indicate dip-slip movement (Hamblin, 1970 #2184). About 3 km south of Hurricane, Utah, Stenner and others (1999 #4444) observed slickenlines in a bedrock exposure of the fault suggesting a small component of right-lateral motion. Biek (2003 #6734) measured slickenlines having a rake of 80–85° N., indicating right-lateral dip-slip motion on a bedrock fault plane about 1 km east of Hurricane. Approximately 2.5–3.5 km south of Hurricane, bedrock fault exposures indicate a small component of left-lateral strike-slip motion (rake of 70–83° S.), likely due to local variations in the fault geometry or differential movement of individual fault blocks (Biek, 2003 #6734). |
| **Dip** | 70–80° W.<br><br>*Comments:* Dips of 75–80° W. are reported by Hamblin (1970 #2184); measurements of 70–71° W. are from fault contact between colluvium and bedrock reported by Stenner and others (1999 #4444), and 70–83° W. dips are reported within bedrock (Biek, 2003 #6734). |
| **Paleoseismology studies** | Site 998-1. Stenner and others (1999 #4444) excavated two trenches at Cottonwood Canyon in Arizona. They excavated trench Q1 across a low fault scarp less than 1 m high. The trench exposed 58–60 cm of down-to-the-west displacement across a fault zone that is 2 m wide. Soil development on the units in trench Q1 suggest an age of 8,000–15,000 yr, probably early Holocene, for the faulted Q1 surface. No datable material dating was recovered from the trench. Trench Q2 extended across a 5-m-high scarp formed on the older Q2 surface, 25 m south of trench Q1. Trench Q2 exposed at least two fault strands in a complex fault zone, across which a minimum net vertical offset of 3–537 cm occurred during the most recent surface faulting event. A charcoal sample from scarp-derived colluvium in this trench yielded a radiocarbon age of 870 yr, which Stenner and others (1999 #4444) interpret as too young to be representative of the age of the colluvium. The young carbon in older deposits is likely the result of bioturbation.<br><br>Site 998-4. Stenner and others (2003 #6733) excavated a trench across a single fault scarp formed on an alluvial fan at Rock Canyon, approximately 4 km south of Cottonwood Canyon. Three surface-faulting earthquakes having variable amounts of displacement were identified. Offset during the most recent event was 0.3–0.4 m, the earlier two events accommodated 2.6–3.7 m of vertical displacement. The timing of these events, however, is unknown because radiocarbon results are not available at this time. |

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| **Geomorphic expression** | Faulting has generated a high, northwest- to west-facing escarpment on Paleozoic bedrock. The escarpment is very steep and curvilinear, and closely follows the trace of the fault zone. Low to moderately high (<30-m-high), steep (up to 35°) fault scarps are formed on probable late Pleistocene colluvium and alluvium exist along much of the base of the escarpment. Vertical surface displacement across the larger scarps is about 20 m. Smaller fault scarps have been documented at several locations along the fault. A scarp studied by Pearthree and others (1983 #2083) is about 2–2.5 m high and has a maximum slope of 22–24°, which suggests an Holocene time for the youngest rupture. A plot of maximum scarp slope vs. log of scarp height for scarps ranging in height from 2–20 m also implies a Holocene age of youngest rupture (Stenner and others, 1998 #2193). Multiple, well-preserved scarps on different-aged deposits at Cottonwood Canyon indicate recurrent Quaternary movement. At Cottonwood Canyon, Stenner and others (1999 #4444) report 0.6 m, 5–7 m, and 18.5–20 m of displacement in a younger Holocene stream and debris-flow deposit (Q1), an intermediate-age (~20–50 ka) Quaternary stream and debris-flow deposit (Q2), and an older (~70–125 ka) Quaternary alluvial-fan deposit (Q3), respectively. About 1–3 km west of the Hurricane fault trace, the Warner Valley fault bounds the west side of Warner Valley dome, with evidence for 3 m of displacement across a fault scarp on Quaternary alluvial and eolian deposits (Hayden, 2004 #6735). |
| **Age of faulted surficial deposits** | Paleozoic and Mesozoic bedrock; middle to late Pleistocene, latest Pleistocene to early Holocene sediments. |
| **Historic earthquake** | |
| **Most recent prehistoric deformation** | latest Quaternary (<15 ka)<br><br>*Comments:* Stenner and others (1999 #4444) estimated the most recent event on the southern Anderson Junction section occurred about 10–15 ka, based on soil development in trenches at Cottonwood Canyon.<br><br>Lund (2004 #6733) reports the following earthquake chronology, based on two paleoseismic trench investigations in Arizona (Stenner and others, 1999 #4444, 2003 #6737), which provide evidence for three broadly constrained surface-faulting earthquakes: Z 5–10 ka Y >5–10 ka, and <25–50 ka X >25–50 ka (?) |
| **Recurrence interval** | 5–50 k.y.<br><br>*Comments:* Multiple, well-preserved scarps on different-aged units at |

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| | Cottonwood Canyon and multiple faulting events at Rock Canyon document recurrent Quaternary movement. At Cottonwood Canyon, Stenner and others (1999 #4444) report 0.6 m displacement of a younger Holocene stream and debris-flow deposit (Q1), 5–7 m displacement of an intermediate-age (~20–50 ka) Quaternary stream and debris-flow deposit (Q2) , and 18.5–20 m displacement of an older (~70–125 ka) Quaternary alluvial-fan deposit (Q3), respectively. The amount of most-recent-event displacement is not considered typical of faulting at Cottonwood Canyon, and was likely higher in past events. Consensus recurrence-interval range (5–50 k.y.) reported in Lund (2004 #6733), based largely on vertical displacement rate information, is intentionally large to reflect uncertainty in the timing of the three youngest paleoearthquakes (events X–Z). |
| **Slip-rate category** | Between 0.2 and 1.0 mm/yr<br><br>*Comments:* Stenner and others (1999 #4444) report long-term vertical displacement rates of 0.1–0.3 mm/yr in approximately 70–125 k.y. old Q3 unit, and 0.1–0.4 mm/yr in approximately 25–50 k.y. old Q2 unit. Displaced basalt flows at the Ash Creek/Anderson Junction section boundary at South Black Ridge, at Pah Tempe Hot Springs, and at Grass Valley that were geochemically correlated across the fault were $^{40}$Ar-$^{39}$Ar-dated at 0.81 Ma, 0.35 Ma, and 1.0 Ma, respectively. These flows indicate a middle Quaternary displacement rate of 0.44–0.45 mm/yr, slowing to 0.21 mm/yr sometime before 350 k.y. ago (Lund and others, 2001). A basalt flow near Hurricane, K-Ar and thermoluminescence age dated at 206–380 ka, is displaced 87 m by the fault and provides a late Quaternary vertical displacement rate of 0.2–0.4 mm/yr based on data from Hamblin and others (1981 #2191) of about 90 m of displacement of a middle Pleistocene (200–400 ka) basalt flow 15 km north of the Arizona border. These data are slightly higher that what would be obtained based on about 20 m of vertical displacement of a late Pleistocene (~100–200 ka) alluvial fan surface. In general, older faulted deposits result in higher displacement rates than younger deposits. Lund (2004 #6733) indicates a geologic vertical displacement rate of 0.2 mm/yr (preferred), and a consensus minimum-maximum range of 0.05–0.4 mm/yr, based on scarp profiles across unconsolidated Quaternary deposits and displaced basalt flows. In general the data fall within the above category; however, all reported rates are poorly constrained and are based on open-ended time intervals, incorporating the elapsed time since the youngest event and/or the time difference between the age of a surface and the timing of the earliest event on that surface. Stenner and others (2003 #6737) state that long-term displacement rates decrease from north to south. |
| **Date and Compiler(s)** | 2004<br>Bill D. Black, Utah Geological Survey |

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| | Philip A. Pearthree, Arizona Geological Survey<br>Christopher B. DuRoss, Utah Geological Survey<br>Michael D. Hylland, Utah Geological Survey<br>Suzanne Hecker, U.S. Geological Survey<br>Greg N. McDonald, Utah Geological Survey |
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