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Quaternary Fault and Fold Database of the United States

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Yucca Mountain faults, western group (Class A) No. 1081

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Synopsis	The name Yucca Mountain faults (western group) is given here to a group of northerly striking faults in Tertiary volcanic rocks and Quaternary surficial deposits in the western part of Yucca Mountain and eastern part of Crater Flat. The main named members of this group are the Black Cone, northern Crater Flat, Southern Crater Flat, Windy Wash, and Fatigue Wash faults. Most of the displacement on these faults occurred during the Miocene, with only minor displacement in the Quaternary. The faults tend to branch and splay from one another, forming a braided pattern that controls a similar pattern in the drainages. Faults are considered as extensional (dip-slip) with a superimposed component of sinistral slip related to clockwise rotation of the faulted blocks (Fridrich and others, 1999 #3854). In general, fault displacement (and total extension) increases southward as does clockwise rotation of the faulted rocks. These patterns were

	established in Miocene time. Since the early 1980's, there have been intensive and extensive geologic studies of these faults to determine their location, length, geometry, sense of slip, total offset, and Quaternary history as part of hazards assessments for a proposed high-level nuclear waste repository at Yucca Mountain (Whitney, 1996 #3909). Surface expression of Quaternary displacement is mostly subdued and discontinuous. The faults are expressed as scarps in bedrock, fault-line scarps, bedrock/alluvium contacts, and as lineaments and scarps in alluvium, basin-fill sediments, and, along very limited traces, eolian deposits. Where expressed as scarps on Quaternary alluvium, the scarps are less than 3 m high. Long-term slip rates are low (0.001-0.03 mm/yr) and recurrence intervals are long (estimated at 17-40 ka).
Name comments	This is a new name applied to a group of northerly striking Quaternary faults in the western part of Yucca Mountain and eastern part of Crater Flat including the Black Cone, northern Crater Flat, southern Crater Flat, Windy Wash, and Fatigue Wash faults. These and other faults at Yucca Mountain with known or suspected Quaternary histories were named separately and studied in varying detail (Whitney, 1996 #3909) to evaluate the hazard they may pose to the integrity of a proposed nuclear waste repository at Yucca Mountain. For the present compilation, the faults at Yucca Mountain are divided into western (this entry) and eastern [1080] groups of subparallel interconnected faults. Faults of the western group branch from one another and have dip-direction and displacement-direction variations suggesting they are genetically related. A further justification for our geographic grouping into east-and west-side faults comes from correlation of paleoseismic data. The youngest events recognized in trenches on the west-side faults are younger than the youngest events on the east-side faults. Such correlation and differentiation (Pezzopane and others, 1996 #3424) suggests event scenarios reflecting separate Quaternary behavior of the eastern and western groups of faults. However, the groupings may be somewhat arbitrary because a southwest splay of the Solitario Canyon fault of the eastern group may merge with the Windy Wash fault of the western group (Whitney and others, 1996 #3419), further substantiating the possible interconnection of the two fault systems. The Boomerang Point fault in the west part of Yucca Mountain is not considered herein because a Quaternary history is not established for it (Whitney and Taylor, 1996 #3429) .

	Fault ID: Includes DV3A (Fatigue Wash fault) and DV3B (Windy Wash fault) of dePolo (1998 #2845).
County(s) and State(s)	NYE COUNTY, NEVADA
Physiographic province(s)	BASIN AND RANGE
Reliability of location	Poor Compiled at 1:300,000 scale. *Comments:* Quaternary faults at Yucca Mountain are mapped at 1:24,000 (Simonds and others, 1995 #2610). The traces are compiled from Figure AAR-3 of Arabasz and others (1998 #3908) at 1:300,000 scale, using maximum trace length of solid or dashed faults (not dotted extensions).
Geologic setting	The Yucca Mountain faults (western group) are located on the southern flank of the southwestern Nevada volcanic field, which is characterized by a group of calderas from which large volumes of silicic tuffs were erupted during the Miocene (Byers and others, 1976 #3038). They are also located in the central part of the Crater Flat structural domain (O'Leary, 1996 #3436), a region of generally north-striking structural grain defined by faults and tilt blocks developed mainly in pyroclastic flow and fallout tephra (Paintbrush and Timber Mountain Group, 14.0 to 11.4 Ma). The domain consists of an elevated eastern part (Yucca Mountain) and a depressed western part (Crater Flat basin) and is bounded on the west by the strongly elevated Bare Mountain block and Bare Mountain fault [1079]. This domain of moderately uniform structure resides in the conspicuously nonuniform Walker Lane structural belt characterized by structural heterogeneity (O'Leary, 1996 #3436). The domain probably formed during late-middle Miocene time under the influence of volcanism, subsidence and extension of the Crater Flat basin, and dextral shear on northwest faults of the Walker Lane belt. Most of the displacement on the Yucca Mountain faults dates to these Miocene events, with only minor displacement during Quaternary time. Yucca Mountain faults show a strong tendency to form interconnecting and anastamosing patterns in plan view suggesting similar patterns and interconnectivity may exist at depth. In general, fault displacement (and total extension) increases southward as does clockwise rotation of the faulted rocks, and much of these lateral contrasts date to the time of formation of the domain during the

	Miocene. Average extensional strain rates for the domain during and directly following this period of formation were much higher (36%-15% per Ma) during the Miocene than during the Quaternary (about 0.1% per Ma) (Fridrich and others, 1999 #3854). Much is known about the displacement history of individual faults at Yucca Mountain, including their Quaternary paleoseismic history, not because they are highly active or capable of producing large earthquakes, but because of their proximity to the proposed nuclear waste repository. One exception is the Black Cone fault in the eastern part of Crater Flat, about which little is known. Also, other faults may be buried beneath the Quaternary basin-fill deposits of Crater Flat, but their Quaternary history is largely unknown.
Length (km)	25 km.
Average strike	N°10E
Sense of movement	Normal *Comments:* Faults are considered as extensional (dip-slip) with a superimposed component of sinistral slip related to clockwise rotation of the faulted blocks (Fridrich and others, 1999 #3854).
Dip	63°-73° W *Comments:* An average dip of 63? W is reported for the southern part of the Windy Wash fault (Menges and Whitney, 1996 #3431), 70? W on the northern Crater Flat fault (Simonds and others, 1995 #2610), and 73? W on the Fatigue Wash fault (Coe and others, 1996 #3418).
Paleoseismology studies	Extensive mapping and trenching in the Yucca Mountain area has shown that the total offset of the oldest surficial deposits (generally middle to early Pleistocene or early Pleistocene) is small (1-3 m) indicating that the long-term average slip rates on all of the faults are very low (0.001-0.03 mm/yr). The stratigraphy of Quaternary deposits established during geologic mapping in the Yucca Mountain area has evolved through time, but a recent report by Whitney and others (1996 #3430) tabulates the development of understanding of that stratigraphy. Excluding one stratigraphic unit of historic age that post-dates all faulting activity, six Quaternary stratigraphic units are currently

recognized as relevant to paleoseismic investigations (Whitney and Taylor, 1996 #3429). The approximate age range for each unit (from youngest to oldest) is given in parentheses in thousands of years as follows:

Qa6 middle to late Holocene (0.5-2 ka)

Qa5 latest Pleistocene to middle Holocene (5-15 ka)

Qa4 late Pleistocene (20-100 ka)

Qa3 middle to late Pleistocene (150-250 ka)

Qa2 middle Pleistocene(?)

Qa1 early to middle Pleistocene (300->700 ka)

The relative age of these stratigraphic units is well established on the basis of age-dependent surface properties including relative stratigraphic and geomorphic position, lithologic characteristics, degree of desert pavement development, amount and degree of desert varnish accumulation, degree of preservation of original bar-and-swale topography, and degree of soil profile development. Also, correlation to chronosequences that are based on soil-stratigraphic studies in other areas aids in relative age assignment, as do interbedded tephra layers of known stratigraphic position or age.

The absolute age of the deposits is less well understood than the relative ages and are somewhat controversial as well. Data come primarily from samples taken from numerous trenches excavated across faults and fault-related surfaces in the Yucca Mountain area and from correlation with age-dated tephra and ash. For the Yucca Mountain (western) group of faults, about 75 numeric ages were acquired from 5 trenches. The ages were determined by diverse techniques, including uranium-series, uranium-trend, and thermoluminescence. Results for about 68 samples are reported by Whitney and others, (1996 #3430, Table 4.1.4). A wide range of materials was dated from each trench and these are summarized by Whitney and others (1996 #3430), together with comments on the purpose and context of the samples, and the estimated error associated with the ages. Other age data are referred to by Coe (1996 #3421). Internal to this large amount of numeric data are some systematic differences related to dating techniques leading to controversy regarding absolute ages for the

	deposits. Despite uncertainty, the numeric age data provide a basis for attempts to correlate faulting and fracturing events from trench to trench and from fault to fault (Pezzopane and others, 1996 #3424). These attempts suggest event scenarios that involved displacement on groups of faults rather than singular faults.
Geomorphic expression	The drainage pattern in western Yucca Mountain and eastern Crater Flat is largely controlled by faults of the Yucca Mountain western group. The faults are expressed as scarps on bedrock, fault-line scarps, bedrock/alluvium contacts, and as lineaments and scarps on alluvium, basin-fill sediment, and eolian deposits along very limited part of the fault traces. Where expressed as scarps on Quaternary alluvium, the scarps are less than 3 m high and are generally subtle and discontinuous. Where discontinuous, the scarps have been destroyed by erosion and the traces generally covered by post-faulting alluvium. In some places, covered traces are marked by vegetation lineaments (ground water seeps?), disturbed soil horizons, or calcium carbonate-cemented fault breccia and fractured breccia that allows for projection of the fault trace between scarps.
Age of faulted surficial deposits	These faults generally displace Holocene and latest Pleistocene deposits. The Black Cone fault displaces late Pleistocene deposits as much as 0.5 m (Faulds and others, 1994 #3068). The Fatigue Wash fault displaces late Pleistocene deposits estimated to be in the range 20-60 ka (Coe and others, 1996 #3418). The northern Crater Flat fault has about 20 cm of displacement in deposits estimated to be Holocene (Coe, 1996 #3421). The southern Crater Flat fault has about 18 cm displacement in deposits estimated to be between 2 and 6 ka (Taylor, 1996 #3420). The southern part of the Windy Wash fault has 0-10 cm of displacement in deposits estimated to be 2-3 ka (Whitney and others, 1996 #3419). In summary, Holocene to late Holocene deposits are displaced by very small amounts on the northern Crater Flat, southern Crater Flat, and Windy Wash faults.
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Most of the faults of the eastern group offset Holocene to late Holocene deposits as shown by very small, but demonstrable amounts of displacement along the northern Crater

	Flat, southern Crater Flat, and Windy Wash faults. The Black Cone and Fatigue Wash faults (not described separately herein) have evidence for older (<130 ka) movement as shown on the map.
Recurrence interval	17-40 k.y. *Comments:* Because they are determined from a robust data set, recurrence intervals based on paleoseismic data for all faults on Yucca Mountain are likely to be more reliable than for subsets such as the east- and west-side faults. Recurrence estimates for surface-rupturing events using all faults vary depending on which of two models are used. For a time window of less than 500 ka and considering only breakage on individual faults, the interval is about 20-40 k.y. For a time window of less than 150 ka and considering paleoseismic evidence for event scenarios involving groups of faults, the interval is 17 k.y. (Pezzopane and others, 1996 #3424).
Slip-rate category	Less than 0.2 mm/yr *Comments:* Extensive mapping and trenching in the Yucca Mountain area has shown that the total offset of the oldest surficial deposits (generally middle to early Pleistocene or early Pleistocene) is small (1-3 m) indicating that the long-term average slip rates on all the faults are very low (0.001-0.03 mm/yr). dePolo (1998 #2845) suggested preferred vertical slip rates of 0.005 mm/yr for the Fatigue Wash fault and 0.01 mm/yr for the Windy Wash fault. In general, the late Quaternary characteristics of the western group of faults (overall geomorphic expression, continuity of scarps, age of faulted deposits, etc.) support a very low slip rate. Accordingly, the less than 0.2 mm/yr slip-rate category has been assigned to these faults.
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