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Yucca Mountain faults, eastern group (Class A) No. 1080

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Synopsis	The name Yucca Mountain faults (eastern group) is given here to a group of northerly striking faults in Tertiary volcanic rocks and Quaternary surficial deposits in the eastern part of Yucca Mountain. The faults form a north-broadening (horsetailing) group with mainly down-to-the-west normal displacement and include the Solitario Canyon, Iron Ridge, Stagecoach Road, Paintbrush Canyon, and Bow Ridge faults. 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 hazard assessments for a proposed high-level nuclear waste repository at Yucca Mountain (Whitney and others, 1996 #3430). The eastern group of faults generally have long-term, low slip rates (0.001-0.03 mm/yr) and long recurrence intervals (estimated at 17-40 k.y.).

Name comments	This is a new name applied to a group of northerly striking Quaternary faults in the eastern part of Yucca Mountain that include the Solitario Canyon, Iron Ridge, Stagecoach Road, Paintbrush Canyon, and Bow Ridge faults. These and other faults with known or suspected Quaternary histories were named separately and studied in detail (Whitney, 1996 #3909) to evaluate the hazard they may pose to the integrity of a proposed nuclear waste repository at Yucca Mountain. They are treated as a group herein because they appear to be genetically related and either branch northward from a common fault (Stagecoach Road from Solitario Canyon, Iron Ridge from Stagecoach Road, Bow Ridge from Stagecoach Road), or are linked along strike (Stagecoach Road and Paintbrush Canyon). The faults on the eastern and western sides of the mountain appear to represent two separate subparallel but interconnected fault systems. 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. Several other named faults in the eastern part of Yucca Mountain are not considered herein because a Quaternary history is not established for them. They include the East Lathrop Cone, East Busted Butte, Midway Valley, Dune Wash, Ghost Dance, Exile Hill, Abandoned Wash, Pagony Wash, and Sever Wash faults. Several named faults in the western part of Yucca Mountain are also described as a single group [1081]. **Fault ID:** Includes DV3C (Solitario Canyon fault), DV3D and DV3E (Paintbrush Canyon fault, north and south parts), and DV3F (Stagecoach Road fault) of dePolo (1998 #2845).
County(s) and State(s)	NYE COUNTY, NEVADA
Physiographic province(s)	BASIN AND RANGE
Reliability of	Poor

location	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 (east) are located on the south flank of the southwestern Nevada volcanic field characterized by a group of calderas from which large volumes of silicic tuffs erupted during the Miocene (Byers and others, 1976 #3038). They are also located in the east part of the Crater Flat structural domain (O'Leary, 1996 #3436), a domain of generally north-striking structural grain defined by faults and tilt blocks developed mainly in pyroclastic flow and fallout tephra erupted from about 14.0 to 11.4 Ma (Paintbrush and Timber Mountain Groups). The domain consists of an elevated eastern part (Yucca Mountain) and a depressed western part (Crater Flat basin) and is bounded on the west against the strongly elevated Bare Mountain block by the 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 and its principal faults 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 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 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 Crater Flat 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) than during the Quaternary (about 0.1% per Ma) (Fridrich and others, 1999 #3854). Much is known about the displacement history of individual faults, including their Quaternary history, not because they are highly active or capable of producing large earthquakes, but because of their proximity to the proposed nuclear waste

	repository at Yucca Mountain.
Length (km)	19 km.
Average strike	N4°E
Sense of movement	Normal *Comments:* Faults are considered extensional (dip-slip) with a superimposed component of sinistral slip related to clockwise rotation of the faulted blocks (Fridrich and others, 1999 #3854). Striations along the Solitario Canyon, Iron Ridge, Bow Ridge, and Paintbrush Canyon faults suggest a sinistral slip component but only dip slip is indicated on the Stagecoach Road fault (Menges and Whitney, 1996 #3433).
Dip	68°-75° W *Comments:* Dips are reported (Menges and Whitney, 1996 #3433) for individual faults as follows: Solitario, 72? W; Iron Ridge, 68? W; Stagecoach Road, 73? W; Bow Ridge, 75? W; Paintbrush Canyon, 71? W.
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 faults are very low (0.001-0.03). The stratigraphy of Quaternary deposits established during geologic mapping in the Yucca Mountain area has evolved through time, and a report by Whitney and others (1996 #3430) tabulates the development of understanding of that stratigraphy. Excluding one stratigraphic unit of historic age that postdates all faulting activity, six Quaternary stratigraphic units are currently recognized as relevant to paleoseismic investigations (Whitney and Taylor, 1996 #3429). From youngest to oldest, with the approximate age range for each given in parentheses in thousands of years, these are: Qa6 middle to late Holocene (0.5-2); Qa5 latest Pleistocene to middle Holocene (5-15); Qa4 late Pleistocene (20-100); Qa3 Middle to late Pleistocene (150-250); Qa2 middle Pleistocene(?); Qa1 early to middle Pleistocene (300->700). 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 aid in relative-age assignment, as do interbeds of tephra and ash of known stratigraphic position. The absolute age of the deposits is less well understood than the relative ages, and 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. More than 157 numeric age dates acquired by diverse techniques, including U-series, U-trend, and TL, are reported by Whitney and others, (1996 #3430) for the Yucca Mountain faults (east). For the Paintbrush Canyon fault there are about 73 ages from 5 trenches; for the Bow Ridge fault about 23 ages from 3 trenches; for the Stage coach Road 28 ages from 2 trenches; and for the Solitario Canyon fault 33 ages from 4 trenches. A wide range of materials was dated from each trench and these are summarized by Whitney and others (1996 #3430, Table 4.1.4) together with comments on the purpose and context of the samples and the estimated error surrounding the ages. Internal to this large amount of numeric data are some systematic differences related to dating technique 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	Yucca Mountain is upland-dominated, northerly-trending bedrock ridges separated by generally south-draining and south-broadening narrow valleys, the north parts of which are V-shaped and the south parts of which tend to have flat alluviated floors. Some fault traces are in bedrock, and bedrock is widely distributed in the footwalls of the faults. Scarps and fault-line scarps in bedrock are much more common than fault scarps in alluvium. The Solitario Canyon fault is marked by a prominent fault-line scarp and subtle scarps and lineaments in alluvium; the Iron Ridge fault by prominent fault-line scarps; the Stagecoach Road fault by prominent scarps in alluvium; the Bow Ridge by a prominent fault-line scarp at the bedrock/alluvium contact and by

	subtle lineaments in alluvium; and the Paintbrush Canyon by fault-line scarps in bedrock and at the bedrock/alluvium contact and by scarps in alluvium. In general, scarps in alluvium do not exceed 3 m in height.
Age of faulted surficial deposits	These faults displace different aged Pleistocene deposits. Exposed surficial deposits cut by individual faults of the Yucca Mountain eastern group are: Paintbrush Canyon fault--latest Pleistocene to middle to early Pleistocene; Bow Ridge fault--late Pleistocene to middle Pleistocene; Stagecoach Road fault--middle Holocene to late Pleistocene; Solitario Canyon fault--late Pleistocene to early to middle Pleistocene.
Historic earthquake	
Most recent prehistoric deformation	late Quaternary (<130 ka) *Comments:* All of the faults in the eastern group have been active in late Quaternary to Quaternary time, although some are more recent. The Paintbrush Canyon fault cuts latest Pleistocene deposits; the Bow Ridge fault cuts late Pleistocene deposits; the Stagecoach Road fault cuts middle Holocene deposits; and the Solitario Canyon fault cuts late Pleistocene deposits. Collectively, they are <130 ka, but the map shows individual times for each of these faults. Some undescribed faults are shown as Quaternary (<1.6 Ma) on the map.
Recurrence interval	17-40 k.y. (0-500 ka) *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- or 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 ka. For a time window of less than 150 ka and considering paleoseismic evidence for event scenarios involving groups of faults, the interval is 17 ka (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 faults is very low (0.001-0.03 mm/yr). dePolo (1998 #2845) suggested preferred vertical slip rates of 0.012 mm/yr for the Solitario Canyon fault, 0.008 mm/yr for the Paintbrush Canyon fault, and 0.017 mm/yr for the Stagecoach Road fault. In general, the late Quaternary characteristics of the eastern group of faults (overall geomorphic expression, continuity of scarps, age of faulted deposits, etc.) support a low slip rate. Accordingly, the less than 0.2 mm/yr slip-rate category has been assigned to these faults.
Date and Compiler(s)	1998 R. Ernest Anderson, U.S. Geological Survey, Emeritus
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