Charcteristics of Quaternary Faulting at Yucca Mountain, Nevada

John Whitney

Yucca Mountain is an erosional remnant of a volcanic apron located on the southern flank of a complex of Miocene calderas in southern Nevada. The mountain is composed of north-trending and east-dipping fault blocks that are bounded by high-angle normal faults. These typical Basin-and-Range faults were formed by east-west extension during the waning phases of active volcanism 14.0 to 11.4 Ma. Yucca Mountain lies within the Walker Lane tectonic zone, which is characterized by long strike-slip faults that are interpreted to accommodate much of the Miocene extension along the western edge of the Basin and Range province. Quaternary faulting at Yucca Mountain continues the Middle Miocene pattern of normal-faulting deformation, but with substantially lower stain rates (Fridrich and others, 1999).

Detailed geological and structural mapping at Yucca Mountain identified eight north-striking, block-bounding faults that show evidence of multiple surface-rupture earthquakes during the Quaternary (Simonds and others, 1995; Keefer and others, 2004). Several inter-blocks faults were also identified; however, no evidence for Quaternary displacement was found on these bedrock faults. The anastomosing pattern, relatively short lengths (6-25 km), and close spacing between the faults indicate probable structural interconnection between some faults, either along strike or at depth.

Paleoseismic studies (Keefer and others, 2004) on the eight active faults indicate preferred slip rates of 0.001 to 0.05 mm/year and preferred average recurrence intervals of 10,000 to more than 100,000 years. Estimated ages of displacements from the paleoseismic trench studies indicate similar ages for ruptures on several faults within the resolution of the dating techniques used (see figure below). Distributive surface ruptures may have occurred on multiple faults that are close to one another and, possibly, linked at depth. Fissures along three different faults on the west side of Yucca Mountain contain basaltic ash that correlates with the eruption of the nearby Lathrop Wells volcanic center at 77±6 ka; thus, coeval surface ruptures on these faults were probably contemporaneous with that eruption. Though less certain, age data also indicate two or more faults may have been active simultaneously near 3 ka and three other faulting events at about 50, 30–20, and 13 ka (Keefer and Menges, 2004).

The three longest faults at Yucca Mountain -- the Paintbrush Canyon, Solitario Canyon and Windy Wash Faults -- are also the most active. The Paintbrush Canyon Fault is a major block-bounding fault on the east side of Midway Valley. The fault is exposed for a distance of 5 km in bedrock forming the highlands north of Yucca Wash, where it dips 56°–76° westward. Along that section of the fault, the trace is marked by a discontinuous, west-dipping fault scarp, 0.3 to 4.0 m high. To the south, the fault extends beneath alluvial cover for 5 km before strands are exposed for about 1 km in bedrock along the west side of Fran Ridge; it may then continue southward for another 8 km to a possible intersection with the southwest-striking Stagecoach Road Fault. Estimates of the amount of bedrock displacement on the Paintbrush Canyon Fault range from 210 m in the northern segment to as much as 500 m along other segments (Day and others, 1998a).

Total observed displacement of Quaternary deposits range from 5.5 to 8.0 m. The two largest surface ruptures recorded in the walls of the Busted Butte sand ramp have preferred net displacements of 142 cm and 167 cm (Menges and others, 1994).

Bedrock displacements on the Solitario Canyon Fault range from about 50 m down to the east at the north end to as much as 500 m down to the west near the mouth of Solitario Canyon to the south (Day and others, 1998a). Thus, the fault zone displays a scissors geometry that contains a null point with essentially no displacement where movement is reversed. Dips on the Solitario Canyon Fault range from 60° to 80° W. south of the null point; slickenside measurements indicate that the net slip is left oblique. The mapping of four trenches on the Solitario Canyon Fault indicates that Middle- to – late Quaternary deposits are displaced 1.7 to 2.5 m down to the west. The largest surface displacement recorded along the Solitario Canyon Fault was 110-150 cm during the past 200,000 years (Ramelli and others, 2004).

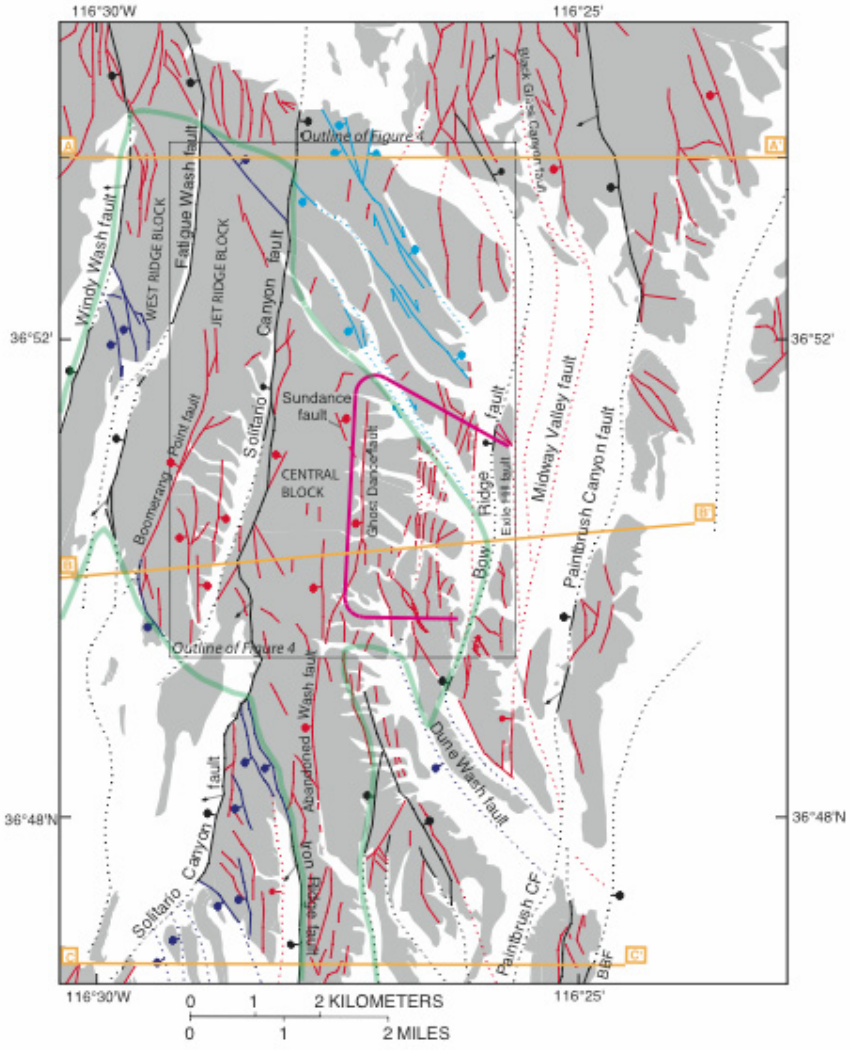
The Windy Wash Fault in Crater Flat shows clear evidence of late Holocene faulting; however, only about 3.7m of net displacement have occurred during the past 400,000 years. The largest displacement appears to be slightly less than 1m (Whitney and others, 1994).

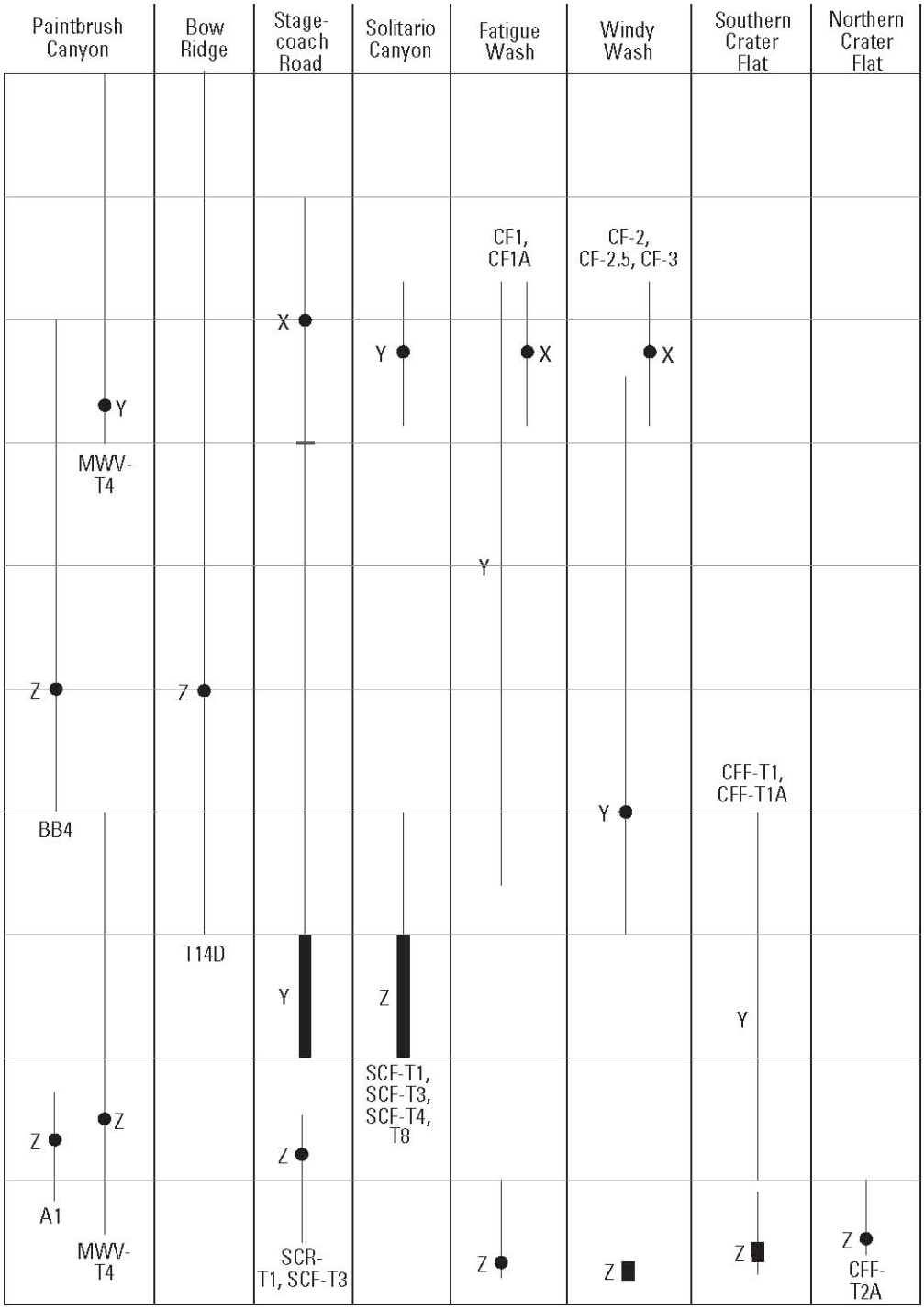
The potential for large-magnitude earthquakes near the potential HLNW repository is limited by both fault length and the history fault displacements. Average co-seismic displacement range from 20-127 cm and maximum displacements on the Yucca Mountain faults range from 32-205 cm. Preferred surface rupture lengths, as assessed by PSHA panels, range from 6-8 km on the shorter faults and 19-27 km on the Paintbrush Canyon, Solitario Canyon and Windy Wash faults (Stepp and others, 2001). Based largely on these characteristics, the largest earthquake magnitude assessed by the six seismic source teams in the PSHA analyses ranged from 6.6 to 7.0 at 10^{-5} cumulative annual frequency (Stepp and others, 2001).

Elements of the landscape at Yucca Mountain support the paleoseismic evidence of low slip rates and long recurrence intervals. Erosion on the slopes and hilltops composed of volcanic tuffs has been relatively slow for a semiarid climate. The preservation and distribution of early and middle Quaternary deposits on and around Yucca Mountain indicate that, except for a modest amount of hillslope erosion and climatically controlled vegetation changes, the landscape looks very much today as it did 100,000 years ago. Approximate long-term, average erosion rates can be calculated from the dated hillslope deposits. These average, long-term erosion rates range from <0.1 cm to .6 cm/ka. An unusually long Quaternary record is preserved in the Yucca Mountain landscape. Early and middle Quaternary hillslope and basin alluvial deposits are common, while late Quaternary deposits are generally confined to the present washes. The preservation of these older deposits, which range to over 1 million years in age, indicates an unusual geomorphic stability exists on these hillslopes, caused by both low rates of tectonic activity and small fluctuations in climate.

Another aspect of slope stability at Yucca Mountain is the preservation of precarious rocks on the footwall of the Solitario Canyon fault. Precariously balanced rocks 75,000-80,000 years old are preserved near the op of Yucca Mountain, which

indicates that it is very unlikely that these slopes have not exceeded ground motions of greater than 0.3 gravitational acceleration during this time period (Brune and Whitney, 2001). The preservation of hillslope deposits and precarious rock that are tens of thousands, and in some cases hundreds of thousands of years old strong suggests that tectonic slip rates are not only very low, but that earthquakes, when they do occur, are not of large magnitudes.


116°30'W
116°25'
36°52'
36°48'N
Outline of Figure 4
Windy Wash fault
WEST RIDGE BLOCK
Fatigue Wash fault
JET RIDGE BLOCK
Canyon fault
Solitario
Sundance fault
CENTRAL BLOCK
Boomerang Point fault
Ghost Dance fault
Bow Ridge fault
Exits Hill fault
Midway Valley fault
Paintbrush Canyon fault
Dune Wash fault
Abandoned Wash fault
Solitario Canyon fault
Paintbrush CF
Black Glass Canyon fault
0 1 2 KILOMETERS
0 1 2 MILES


Paintbrush Canyon
Bow Ridge
Stage-coach Road
Solitario Canyon
Fatigue Wash
Windy Wash
Southern Crater Flat
Northern Crater Flat
CF1, CF1A
CF-2, CF-2.5, CF-3
X
Y
X
X
Y
MWV-T4
Y
Z
Z
BB4
CFF-T1, CFF-T1A
Y
T14D
Y
Z
Y
SCF-T1, SCF-T3, SCF-T4, T8
Z
Z
Z
A1
MWV-T4
SCR-T1, SCF-T3
Z
Z
Z
CFF-T2A

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