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Northern Death Valley fault zone, Mesquite Flat-Screwbean Spring section (Class A) No. 141b

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Compiled in cooperation with the California Geological Survey

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Synopsis	**General:** The Northern Death Valley fault zone is marked by prominent Quaternary dextral-slip faults that are more-or-less coincident with (or east of) the axis of northern Death Valley. The fault zone is part of the much longer Death Valley fault system that extends from Fish Lake Valley (NV) in the north to past the Garlock fault [69] on the south. The Northern Death Valley fault zone represents a southward extension of the Fish Lake Valley

	fault zone [49] (and vice versa), although they show opposing uplift directions and (presumably) different normal-dip directions. Detailed studies of offset alluvial fans along the Grapevine Mountains suggest dextral-slip rates are 3-6 mm/yr depending on what time slice your are looking at in the Holocene to late Quaternary. To the south, the Northern Death Valley fault zone [141] merges with the Black Mountains fault zone [142] over a broad area between Salt Springs and Furnace Creek that is referred to as the Mustard Hills transition zone [142a]. Although no paleoseismic studies have been conducted on the fault zone owing to its location mainly within protected wilderness areas of Death Valley National Park, the entire trace is well mapped, and the amount of offset is well documented in a variety of middle to late Quaternary deposits. **Sections:** This fault has 3 sections. Based on Klinger's mapping and topical studies (Klinger and Sarna-Wojcicki, 2001 #4770), Machette and others (2001 #4773) divided the Northern Death Valley fault zone into three 30- to 35-km-long sections primarily on the nature of the rocks found along the fault, but also based on the fault's geomorphology, trend, continuity, and location of the fault relative to the range. From north to south, these are defined as the 1) Grapevine Mountains section [141a], 2) Mesquite Flat-Screwbean Spring section [141b], and 3) Kit Fox Hills section [141c].
Name comments	**General:** The Northern Death Valley fault zone is defined as the zone of Quaternary dextral-slip faults that are more-or-less coincident with the axis of northern Death Valley (Brogan and others, 1991 #298). It is the second of four fault zones that comprise the much larger Death Valley fault system, as modified from Machette and others (2001 #4773). The northern end of the fault zone is taken as Little Sand Springs (about 23-km northwest of Scotty's Castle in Death Valley National Park), where it joins the Fish Lake Valley fault zone [49] on the north. The southern end of the fault zone is taken as Salt Springs (about 8-km southeast of Beatty Junction (the junction between U.S. Highway 190 and the Beatty Cutoff Road). South of Salt Springs, there is an obvious gap in young faulting and a complicated structural transition to the Black Mountains fault zone [142] on the south. **Section:** Section defined and named by Klinger (2001 #4770) based on unpublished mapping for his dissertation (Machette and others, 2001 #4771). Section extends from Screwbean Spring, an informally named locality about 3.5 km southeast of the

	Grapevine Ranger Station in Death Valley National Park, south to Triangle Spring on the eastern margin of Mesquite Flat, a large sediment-filled basin north of U.S. Highway 190. This section of the fault is largely equivalent to the southern 20% of the Grapevine Canyon (GC) section, and all of the Red Wall Fan (RF) and Titus Fan (TF) sections of Brogan and others (1991 #298). **Fault ID:** Referred to as fault 211 of Jennings (1994 #2878), fault DV-1E of dePolo (1998 #2845), and fault NDV by Piety (1995 #915).
County(s) and State(s)	INYO COUNTY, CALIFORNIA
Physiographic province(s)	BASIN AND RANGE
Reliability of location	Good Compiled at 1:100,000 scale. *Comments:* Faults within this section have been mapped at 1:24,000 scale by Bryant (1988 #1456), at 1:62,500 scale by and Brogan and others (1991 #298) (using 1:12,000 scale low sun-angle photos), and at 1:100,000 scale by Reheis and Noller (1991 #1195). The traces used herein are adapted from Brogan and others (1991 #298), and Reheis and Noller (1991 #1195). The faults were transferred to a 1:100,000-scale map with topographic base.
Geologic setting	This Death Valley fault system is comprised of major strike-slip fault zones on the north and south, and an intervening (linking) primarily normal-slip fault zone. The fault system forms the strongly uplifted eastern margin of Death Valley and the western margin of Fish Lake Valley; it marks a highly extended portion of the western Basin and Range Province. The Northern Death Valley fault zone forms the western margin of the Grapevine Mountains, and its older extension to the southeast (as the Furnace Creek fault zone [144] forms the western margin of the Funeral Mountains. Structural studies by Stewart (1983 #1653) and Wernicke and others (1988 #1686) reported >80 km of northwestward extension across the valley, and proposed that much of the adjacent Panamint Range to the west has moved to its present location from atop the Black Mountains since late Miocene time. Likewise, the Grapevine Mountains are considered to be the upper plate of a detachment that moved northwest off of

	the Funeral Mountains (Hamilton, 1988 #593). The Northern Death Valley fault zone is more-or-less coincident with the axis of northern Death Valley (Klinger and Sarna-Wojcicki, 2001 #4770), and is characterized by primarily dextral slip along its entire length. The Northern Death Valley fault zone bisects and uplifts Tertiary basin-fill deposits that occupied a structural basin in the Miocene and Pliocene. This relation suggests that the fault was not actively uplifting in the late Tertiary, whereas today it is. Conversely, in the late Cenozoic, the Northern Death Valley and Furnace Creek fault zones together formed a nearly continuous, linear feature that appeared to have been one of the major lateral-slip zones in the region. However, the Furnace Creek fault zone [145] appears to have become much less active in the Quaternary owing to evolving structural integration of the Northern Death Valley [141] and Black Mountains fault zones [142] through an intervening fault transition zone [142a]. The normal dip-slip Grapevine fault [184], which bounds the western margin of the Grapevine Mountains, is parallel to much of the Northern Death Valley fault zone [Reynolds, 1969 #1613].
Length (km)	This section is 30 km of a total fault length of 100 km.
Average strike	N34°W (for section) versus N32°W (for whole fault)
Sense of movement	Right lateral *Comments:* Movement predominately dextral (right-lateral) (Klinger and Sarna-Wojcicki, 2001 #4770), with varying components of apparent vertical movement based on local topography. However, the fault zone bounds the western margin of uplifted Tertiary rocks of the southern part of the Grapevine Mountains, suggesting a long-term lesser component of down-to-the-west vertical movement.
Dip	Vertical *Comments:* The Grapevine Mountains section is considered to be a vertical, strike slip fault.
Paleoseismology studies	
Geomorphic expression	Along this section of the fault, its trace is characterized by lateral slip features such as offset stream channels and terrace risers, shutter ridges, sag ponds, grabens (trenches), beheaded channels,

	and linear valleys and gullies (Brogan and others, 1991 #298; Klinger and Sarna-Wojcicki, 2001 #4770). Reynolds (1969 #1613) noted 0.6 to 1.5 m (2 to 5 ft) of east-side-down vertical displacement associated with dextral offset of a gravel deposit (estimated Holocene age) in a small pit at the Titus Canyon Road turn off in northern Death Valley (NW1/4, sec. 34, T. 13 S., R. 44 E.). In addition, a large alluvial fan complex that emanates from Red Wall Canyon is offset by a rather spectacular narrow zone of faults that cross almost perpendicular to the fall line of the fan. Reynolds (1969 #1613) was the first to notice this feature and reported that the southeast margin of the fan (along the modern channel) was offset dextrally about 46 m since late to middle Pleistocene time.
Age of faulted surficial deposits	Brogan and others (1991 #298) noted that almost all age Quaternary deposits except the modern (<200 yrs, unit Q1a) alluvium appear to be offset along this section of the fault. Brogan and others (table 31991 #298) noted scarps heights of 23 m on a Pleistocene surface near Red Wall Canyon, 0.3 to 2 m on middle and early Holocene (2 ka to 10 ka) surfaces, and 0.3 to 1.8 m on late Holocene (0.2 ka to 2 ka) surfaces. The maximum scarp-slope angle for the 23-m-high scarp is at the angle of repose, 33? (Brogan and others, 1991 #298). The maximum scarp-slope angles for a 1.5-m-high scarp on a middle and early Holocene surface is 10? and 27? for a 1.8-m-high scarp on a late Holocene (Brogan and others, 1991 #298). Recent detailed mapping by Klinger (Stop A3, 2001 #4770) indicates that late Holocene alluvium (unit Q3c, 2-4 ka) on the Red Wall Canyon fan are offset about 12.2 m along the fault zone, suggesting multiple late Holocene faulting events. Earlier Holocene and late Pleistocene alluvial units are offset progressively larger amounts, as one would expect.
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Curry (1938 #1487) appears to be the first to recognize the relative youthfulness of the fault zone in Northern Death Valley noting that " . . . the fault is marked by a churned-up furrow in the recent alluvium." Brogan and others (1991 #298) concluded that the youngest units faulted (unit Q1c) are probably 2-10 ka in age. Klinger (2001 #4770) reported a 12.2 m offset of a latest Holocene (2-4 ka) channel margin and preserved evidence

	for the last three surface-rupturing events at a location about 250 m northwest of the southeast margin of the Redwall Canyon fan (fig. A3-2 in Klinger and Sarna-Wojcicki, 2001 #4770). These values are consistent with measured offsets between the offset channel margins stranded on the uphill sides of the fault and elsewhere along the Northern Death Valley fault zone (Klinger and Sarna-Wojcicki, 2001 #4770, fig. A-6). However, at this location the fault is comprised of several strands, all of which may have experienced some slip during this youngest event. Therefore, these measured dextral offsets are considered minimum values for the wider fault zone.
Recurrence interval	700-1300 yrs *Comments:* Brogan and others (p. 19, 1991 #298) concluded that four to six separate events have occurred on sections of the Northern Death Valley [141] and Fish Lake [49] fault zones during the Holocene (<10 ka). This number of events suggests that the recurrence interval between events is 1,700 yr to 2,500 yr along the two faults. Klinger (2001 #4770) reported evidence for a minimum of three earthquakes over a time frame of 2-4 k.y., which indicates that the return period for 2.5- to 3.5-m-offset earthquakes on the Northern Death Valley fault zone is between 700 and 1300 years at the Red Wall Canyon location (Stop A3 in Klinger and Sarna-Wojcicki, 2001 #4770) on the Mesquite Flat-Screwbean Spring section, assuming characteristic fault behavior.
Slip-rate category	Between 1.0 and 5.0 mm/yr *Comments:* Specific details pertinent to late Quaternary slip along the fault were not reported until Reynolds (p. 238 1969 #1613) noted that the southeastern margin of a Pleistocene alluvial fan (Red Wall fan) had been offset about 46 m in a dextral (right-lateral) sense. Reynolds suggested that there had been late Holocene activity along the Northern Death Valley fault zone, but interpreted the displacement of the alluvial fan north of Red Wall Canyon as having accumulated since the middle to late Pleistocene. Bryant (1988 #1456) later reevaluated the offset fan margin described by Reynolds (1969 #1613) and acknowledged the 46 m offset, but assumed that the stream incision that produced the alluvial-fan margin occurred about 20,000 years ago and that the dextral movement that displaced the fan margin followed this incision. Bryant (1988 #1456) estimated a lateral slip rate of 2.3 mm/yr for this section of the fault zone, using the

	46 m of right-lateral displacement and estimating that the displaced alluvial fan was deposited about 20 ka, but he emphasized that the slip rate was only a crude estimate. Although Brogan and others (1991 #298) did not report any new slip rates for the fault, they acknowledged Bryant's (1988 #1456) minimum rate of 2.3 mm/yr. Later estimates by Klinger and Piety (1996 #3873) suggested that the Bryant's minimum slip rate of 2.3 mm/yr might actually underestimate the late Pleistocene slip rate by a factor of three or four. New work by Klinger (2001 #4770) suggests that the reported 46 m of offset reported by Reynolds (1969 #1613) may be more likely about 250-330 m based on a palinspastic reconstruction of the Redwall Canyon alluvial fan utilizing low-altitude aerial photography. The age of the offset late Pleistocene (unit Q2c) alluvial-fan surface is estimated to be about 35 to 60 ka (table A3-1 Klinger and Sarna-Wojcicki, 2001 #4770). based on the degree of soil development and the extent of formation for other relative age criteria, and the stratigraphic relationship of the alluvial-fan surface to lacustrine deposits, Given a total offset of 250-330 m for the large incised channels since 35 to 60 ka, the average minimum late Pleistocene slip rate is between 4 and 9 mm/yr. This is consistent with, but larger than the late Holocene slip rate of 3 to 6 mm/yr provided by offset of late Holocene (2-4 ka) stream channels reported by Klinger (table A3-2 2001 #4770). Although a variety of slip rates have been reported, no chronological dating has been obtained to really constrain the timing of offset. The late Quaternary and younger slip rates seem to cluster between about >2 and 6 mm/yr, with some suggestion of rates that may approach 9 mm/yr. Pending chronologic age control of the offset Holocene and late Pleistocene channel margins reported by Klinger (2001 #4770), it seems appropriate to categorize the slip rate on this (and adjacent) section of the Northern Death Valley fault zone as being between 1 and 5 mm/yr.
Date and Compiler(s)	2002 Michael N. Machette, U.S. Geological Survey, Retired Ralph E. Klinger, U.S. Bureau of Reclamation
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