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Northern Death Valley fault zone, Grapevine Mountains section (Class A) No. 141a

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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). This section extends from Little Sand Springs (and its junction with the Cucomongo Canyon section [49d] of the Fish Lake Valley fault zone) south to Screwbean Springs, an informally named locality about 6 km south-southeast

	of the Grapevine Ranger Station in Death Valley National Park (Machette and others, 2001 #4771, fig. A-12). The section name is derived from the fault's proximity to the Grapevine Mountains in the vicinity of Grapevine Ranger Station. This section of the fault is largely equivalent to the Sand Springs (SS) section and the northern 4/5ths of the Grapevine Canyon (GC) section of the Furnace Creek fault zone of Brogan and others (1991 #298). Included within the Grapevine Mountains section is the Death Valley Wash fault, an east dipping reverse fault named by Brogan (according to Bryant, 1988 #1456) that parallels much of this section of the fault (Klinger and Sarna-Wojcicki, 2001 #4770). **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)	ESMERALDA COUNTY, NEVADA 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 38 km of a total fault length of 100 km.
Average strike	N28°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 (both east and west sides up) based on local topography. Brogan and others (1991 #298) report that dip slip movement is typically 10% of the horizontal (dextral) component. However, the fault zone bounds the western margin of uplifted Tertiary rocks of the Grapevine Mountains, suggesting a long-term component of down-to-the-west vertical movement. As for the Kit Fox Hills section [141c] to the south, structural and geomorphic evidence along this section is suggestive of oblique (i.e., north-south) compression across the fault. The Death Valley Wash fault (an east dipping reverse fault included herein) named by Brogan (according to Bryant, 1988 #1456), parallels much of this section of the fault (Bryant, 1988

	#1456; Klinger and Sarna-Wojcicki, 2001 #4770).
Dip	Vertical *Comments:* The Grapevine Mountains section is considered to be a vertical, strike slip fault. However, the Death Valley Wash fault, which parallels much of this section of the fault (Bryant, 1988 #1456; Klinger and Sarna-Wojcicki, 2001 #4770), is an east dipping reverse 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). Fault traces are distributed over a broad zone along the north part of the sections, especially north of the fault's divergence from the Grapevine Mountains (Brogan, 1991 #298, pl. 2). Brogan and others (1991 #298) map discontinuous faults as much as 7 km northeast of the main fault trace, near Oriental Wash. The scarps tend to be small and discontinuous south of Little Sand Springs, but more continuous and organized along the western front of the Grapevine Mountains. Brogan and others (table 3 in 1991 #298) measured right-lateral displacements of 12-20 m on pre-Holocene surfaces (their unit Q2, >10 ka) near the south end of the section at Grapevine Ranger Station and 8.5 m on middle and early Holocene surfaces (their Q1C unit, 2-10 ka). Vertical separations (typically apparent owing to lateral offset) are as much as 10-20 m on their unit Q2 and 1.5 m on middle and early Holocene surfaces (their Q1C unit).
Age of faulted surficial deposits	Brogan and others (1991 #298) noted that almost all age Quaternary deposits except the modern (<200 yrs, unit Q1a) and late Holocene (0.2-2.0 ka, unit Q1b) alluvium appear to be offset along this section of the fault. Conversely, Klinger (p. A24, fig. A1-5, 2001 #4770) cites evidence of 1.2-2.6 m of offset in alluvium that is mantled by a basaltic ash of the Uebehebe Crater that appears to be <300 years old.
Historic earthquake	

Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Holocene, and most probably recurrent Holocene movement has been documented along this section of the fault by Bryant , Brogan and others (p. 19, 1991 #298), and Klinger (2001 #4770). The timing of the most recent faulting event is not well constrained, but it appears to be late Holocene and appears to be younger than a basaltic ash of the Uebehebe Crater, which Klinger (p. A24 and fig. A1-5, 2001 #4770) considers to be <300 years old. In many places older deposits (unit 2 of Brogan, 1991 #298) are offset tens to hundreds of meters indicating a long history of recurrent late Quaternary offset along the fault zone.
Recurrence interval	*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 for movement somewhere along the two faults. However, no specific recurrence intervals have been defined for the Grapevine Canyon section of the Northern Death Valley fault zone. To the south, Klinger (2001 #4770) reported a recurrence interval of 700-1300 years for the Mesquite Flat-Screwball Springs section [141b] of the Northern Death Valley fault zone.
Slip-rate category	Between 1.0 and 5.0 mm/yr *Comments:* No short term (k.y.) slip rates have been reported for this section, but high-quality long term lateral offset data exist. The largest amount of dextral offset of Quaternary deposits along the Northern Death Valley fault zone was measured north of Grapevine Springs on the Grapevine Mountains section [141a] (Stop A2 in Klinger and Sarna-Wojcicki, 2001 #4770). In the thick sequences of Q1b alluvial-fan gravel exposed in the tributary canyons to Death Valley Wash, monolithologic basaltic gravel appears to have been dextrally offset from its source to the south about 4 km. The ash bed near the top of the section exposed in Lake Rogers Canyon (Klinger and Sarna-Wojcicki, 2001 #4770, fig. A2-7) may be slightly older (>1.2 Ma?), thus the Quaternary slip rate may be on the order of 3 mm/yr. A similar stratigraphic situation also exists at the northern end of the Lake Rogers basin. Alluvial-fan gravel has been folded and uplifted

	into a north-plunging anticline that is referred to as Anticline Ridge (fig. A2-3, Klinger and Sarna-Wojcicki, 2001 #4770). Erosion along drainages that cut into the eastern limb and across the axis of the anticline has exposed the 3.1-3.5 Ma Mesquite Spring tuff in the core of the anticline. Immediately overlying the tuff bed is the bouldery, basaltic gravel identified farther to the south at the mouths of several tributary canyons. This gravel can be traced continuously to this location, indicating a minimum dextral offset of the basalt gravel at this site is a little less than 8 km. These data yield an average late Pliocene to Pleistocene slip rate of about 2.4 mm/yr since 3.3 Ma.
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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