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Northern Death Valley fault zone, Kit Fox Hills section (Class A) No. 141c

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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 along the western margin of the Kit Fox Hills from Triangle Spring on the eastern margin of Mesquite Flat south to Salt Springs (about 8 km southeast of Beatty Junction (the junction between U.S. Highway 190 and the Beatty Cutoff Road). The Kit Fox Hills section of the fault is

	largely equivalent to the Death Valley Buttes (DB) and Beatty Junction (BF) sections of the Furnace Creek fault zone of Brogan and others (1991 #298). South of Salt Springs, there is a gap in young faulting (Salt Springs section of Brogan and others, 1991 #298) and a complicated structural transition (Mustard Canyon (MC) section of Brogan and others, 1991 #298) to the Black Mountains fault zone [142]. **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 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). In addition, some of the faults are shown on geologic maps at 1:48,000 scale by Wright and Troxel (1993 #1701) and at 1:96,000 scale by Hunt and Mabey (1966 #1551). 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 33 km of a total fault length of 100 km.
Average strike	N39°W (for section) versus N32°W (for whole fault)
Sense of movement	Right lateral *Comments:* Movement is 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 late Tertiary to Quaternary rocks of the Kit Fox Hills, suggesting a long-term lesser component of down-to-the-west vertical movement. Curry (1938 #1487) recognized right-lateral displacement in Death Valley north of Furnace Creek (which includes the Kit Fox Hills section] as indicated by displaced alluvial fans and drainages, shutter ridges, drag folds, horizontal slickensides, trenches, pressure ridges, and sag ponds. Moring (1986 #1588) inferred right-lateral displacement on the fault from the presence of both east- and west-facing fault scarps.

Dip	Vertical *Comments:* The Kit Fox Hills section is considered to be a vertical, strike slip fault.
Paleoseismology studies	
Geomorphic expression	As in the Grapevine Mountains section [141a], structural and geomorphic evidence along this section is suggestive of oblique compression across the fault. Portions of the fault are characterized by displaced alluvial fans and drainages, shutter ridges, drag folds, horizontal slickensides, trenches, pressure ridges, and sag ponds (Curry, 1938 #1487). A northwest-facing 3-m-high scarp near Salt Springs (Brogan and others (1991 #298) at the southern end of the section has a maximum slope angle of 31?, but this may be enhanced by salt cementation (Klinger and Sarna-Wojcicki, 2001 #4770). The trace of the fault is less continuous in this section than on those to the north [141a, 141b]. In fact, from Beatty Junction south about 8 km to Salt Springs, the trace of the fault is mainly marked by vegetation lineaments and tonal contrasts in soil. To the north of Beatty Junction, the fault zone has a more continuous trace and is characterized by scarps and offset stream channels, the largest having 9 m of offset (Brogan and others, 1991 #298).
Age of faulted surficial deposits	Deposits along this section of the fault include Holocene and late Pleistocene alluvial fan sediments, late(?) Pleistocene lacustrine deposits of Lake Manley, older alluvial fans that have been mapped as gravel 2 of Hunt and Mabey (1966 #1551), and uplifted Pliocene to Pleistocene sedimentary rocks of the Kit Fox Hills and Triangle Spring area (Klinger and Sarna-Wojcicki, 2001 #4770). The only disrupted surface that Brogan and others (1991 #298) reported as having any age control along this fault section [141c] is the surface with the 3-m-high scarp near Salt Springs (Brogan and others (1991 #298), which is at the southernmost end of the Northern Death Valley fault zone's. Here, the fault crosscuts a shoreline of a late Holocene lake that dates from about 2 ka, for which Brogan and others (1991 #298) cited Hunt (1960 #1550) and Hunt and Mabey (1966 #1551). Hunt and Mabey (1966 #1551) reported that this shoreline, at an elevation of 73 m (240 ft) below sea level, is interpreted from "the upper limit of highly saliferous ground." The 2-ka age estimate for this lake is based on

	artifacts contained in sand dunes that overlie the lake floor on the western side of Badwater Basin, west of Badwater about 35 km south of Salt Springs (Hunt and Mabey, 1966 #1551)). The artifacts are from Death Valley III and IV occupations as interpreted by Alice Hunt (1960 #1550).
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 all the Quaternary surficial units except their unit Q1a (<200 years) are offset along this section of the fault zone and noted that there is evidence (geomorphic) for 3 faulting events in their unit Q1c (2-10 ka).
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 along the two faults. However, no specific recurrence intervals have been defined for the Kit Fox Hills section of the Northern Death Valley fault zone. Brogan and others (1991 #298) noted that there is evidence (geomorphic) for 3 faulting events in their unit Q1c (2-10 ka), which allows a wide range in possible recurrence intervals (roughly 1 k.y. to 5 k.y.). To the north, Klinger (2001 #4770) reported a recurrence interval of 700-1300 years for the Mesquite Flat-Screwbean Springs section [141b] of the Northern Death Valley fault zone
Slip-rate category	Between 1.0 and 5.0 mm/yr *Comments:* Piety (1995 #915) calculated an apparent vertical slip rate of 1.5 mm/yr for the Salt Springs section of Brogan and others (1991 #298) using the 3 m vertical displacement of a 2,000-yr-old shoreline as reported by Brogan and others (1991 #298). However, the time interval between the most recent event and penultimate events is undefined, so this slip rate is poorly controlled.

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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