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SCIENTIFIC INVESTIGATIONS MAP 3013
Version 1.1

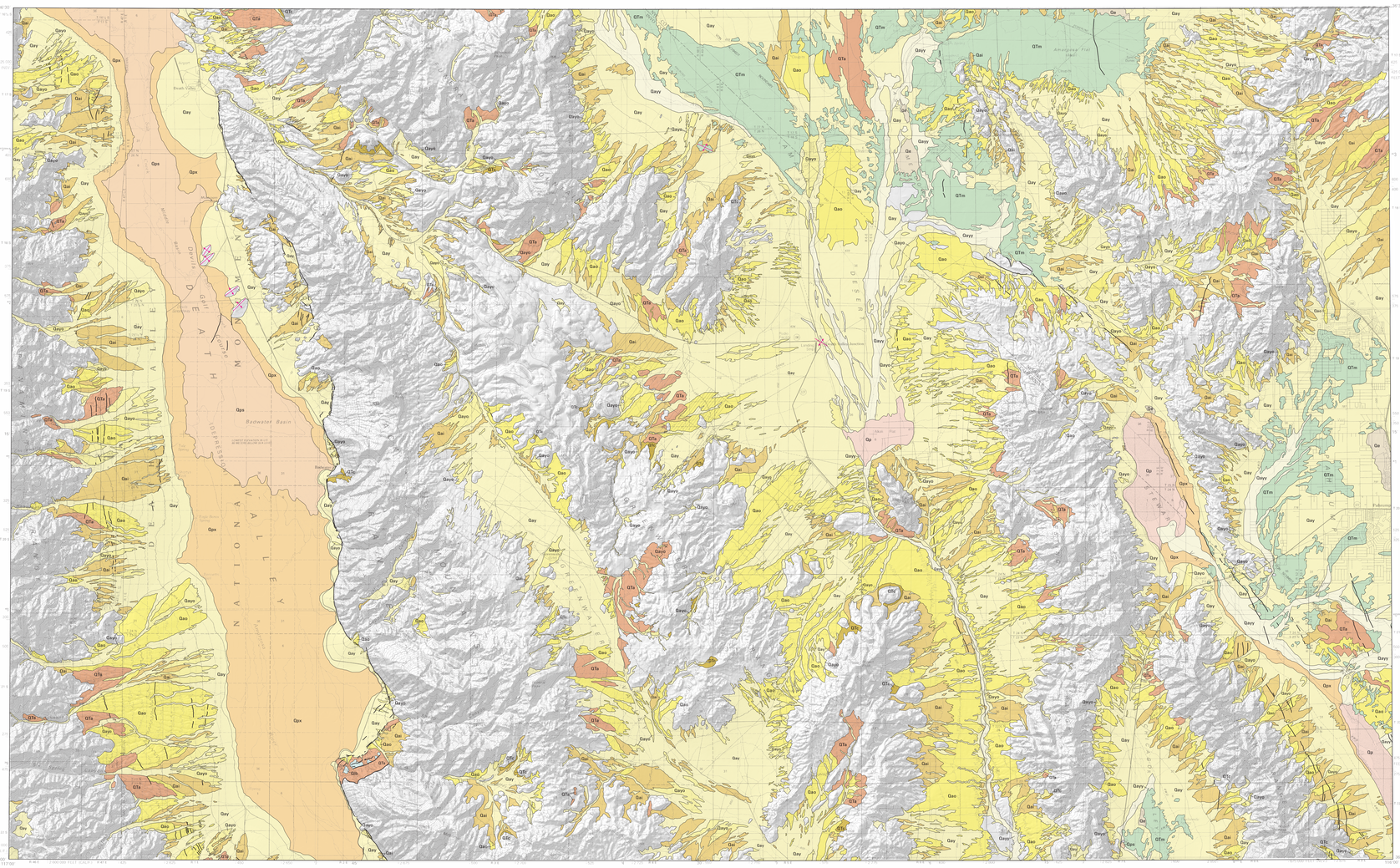

Figure 1. Shaded relief image of location of Death Valley Junction quadrangle (light blue outline) relative to Death Valley National Park (green outline), the Nevada Test Site (purple outline), and the adjoining Beatty 30 × 60' quadrangle (dark blue outline). Roads depicted as red lines.

Figure 2. Landsat 7 image of Death Valley Junction 30' x 60' quadrangle, California and Nevada. This image is a false-color composite, which combines bands 7 (SWIR, 2.09–2.35 µm), 4 (near-IR, 0.77–0.90 µm), and 2 (Green, 0.52–0.60 µm) and displays them as red, blue, and green, respectively. The appearance of shaded relief was created using the National Elevation Dataset (NED, http://ned.usgs.gov/), which is based on digital elevation models that have a resolution of 30 meters. Roads and boundaries were superimposed using the ESRI Data and Maps roads database in ArcInfo. Red lines indicate major roads. Death Valley National Park boundary depicted by black dashed and dotted line with red shading on inside of park boundary. Park boundary, latitude and longitude ticks, and scale are approximate.

CORRELATION OF MAP UNITS

SURFICIAL DEPOSITS

DESCRIPTION OF MAP UNITS

[The following conventions are used in the map unit descriptions of surficial deposits. Stages of secondary calcium-carbonate morphology are those of Gile and others (1966). Soil-horizon designations follow Soil Survey Manual guidelines (Soil Survey Division Staff, 1993). Grain sizes for surficial deposits are based on visual estimates and follow the modified Wentworth grade scale (American Geological Institute, 1982). The names for the dry colors of the less than 2-mm fraction of the surficial deposits were determined by comparison with Munsell Soil Color Charts (Munsell Color Company, 1988).]

SURFICIAL DEPOSITS

Alluvial deposits

Qay **Young alluvial deposits (Holocene)**—Gravel, sand, and silt; intermixed and interbedded. Grayish brown, pale yellowish brown, and light brownish gray to light gray; unconsolidated to poorly consolidated, poorly to moderately well sorted, non-bedded to well bedded, locally cross-bedded. Clasts are commonly angular to subrounded; locally well rounded. Clasts commonly less than 0.5 m in diameter, but as much as 2 m in diameter and near base of steep slopes, and close to mountain fronts. Sand and silt present as matrix and lenses; rarely form continuous beds. Surface commonly is irregular; bar-and-swale topography and braided channels are common. Has little or no pavement, varnish, or soil development except near dust sources such as the playa sediments of Amargosa Valley, Stewart Valley and Pahrump Valley. Death Valley apparently is too dry for soil processes to take place along the toe slopes of unit Qay there. Thickness generally ranges from less than 1 m to 20 m; locally as much as 30 m adjacent to tectonically active mountain fronts

Qayy **Young alluvial deposits, younger part (late Holocene)**—Gravel, sand and silt; intermixed and interbedded as discrete layers. Grayish brown, pale yellowish brown, and light brownish gray to light gray; unconsolidated to poorly consolidated, poorly to moderately well sorted, nonbedded to well bedded, locally cross-bedded. Clasts are commonly angular to subrounded; locally well rounded. Clasts commonly less than 0.5 m in diameter, but as much as 2 m in diameter and near base of steep slopes, and close to mountain fronts. Along large alluvial channels bodies are present several kilometers from the mountain front. Sand and silt present as matrix and lenses and rarely as continuous beds. Surface morphology commonly is irregular; bar-and-swale topography and braided channels are common. No pavement, varnish, or soil development. Generally associated with modern channels wide enough to run separately. In places Qayy includes older Holocene deposits between modern channels that are too narrow to map separately. Along the Amargosa River and in Ash Meadows, may include exhumed (Pleistocene or older) marsh deposits (QTm) or young spring deposits (unit Qsy). Thickness generally 1 to 10 m; maximum thickness about 30 m

Qayo **Young alluvial deposits, older part (middle and early Holocene)**—Gravel, sand, and silt; intermixed and interbedded. Pale yellowish brown, light brownish gray, pinkish gray, and grayish brown, unconsolidated to weakly consolidated, poorly to moderately well sorted, nonbedded to well bedded, locally cross-bedded. Clasts are commonly angular to subrounded; locally well rounded. The surface (1) has faint bar-and-swale topography with cobbles marking former bars that are slightly higher than pebbly swales, or (2) is planar with slightly to locally moderately packed desert pavement. Pavement clasts are weakly to moderately varnished. Soil typically has cambic B horizon and stage I carbonate horizon. Thickness generally ranges from less than a meter to 10 m, but may be as much as 20 m at the head of fans adjacent to tectonically active mountain fronts

Qai **Younger intermediate alluvial deposits (late and late-middle? Pleistocene)**—Gravel, sand, and silt; intermixed and interbedded, light gray, pinkish gray, and yellowish brown to grayish brown, weakly to moderately well consolidated. Clasts are unsorted to moderately well sorted, nonbedded to well bedded, angular to rounded. Clasts commonly less than 0.5 m in diameter, but locally as much as 2 m in diameter; matrix is sandy to silty. Sand is discontinuously to moderately well bedded, locally cross-bedded, moderately well sorted; commonly gravelly and locally silty. Surface is planar; locally dissected. Moderately packed to densely packed desert pavement; pavement clasts are moderately varnished. Locally, thin eolian sand deposits mantle the surface. Soil development varies from profiles with a cambic B horizon and a stage I to II carbonate (Bk) horizon to those with an argillic (Bt) horizon and an approximately 1-m-thick, stage III to IV carbonate (Bk to Kj) horizon. Terrestrial cosmogenic-nuclide (TCN) ^{36}Cl depth-profile dates of unit Qai fans along the west side of Death Valley range from about 40 ka to 100 ka (with a mean age of about 70 ka), and fluvio-palustrine marine OIS 6 cycle of Pleistocene Lake Manly, but predate the lesser, OIS 2 successor (Machette and others, 2008). Thickness less than 1 m to 10 m

Qao **Older alluvial deposits (late? to early? Pleistocene)**—Gravel, sand, and silt; intermixed and interbedded, light gray, pinkish gray, and yellowish to grayish brown, moderately well consolidated. Clasts are unsorted to moderately well sorted, nonbedded to well bedded, angular to rounded. Clasts commonly less than 0.5 m in diameter, but locally as much as 2 m in diameter; matrix is sandy to silty. Sand is discontinuously to moderately well bedded, locally cross-bedded, moderately well sorted; commonly gravelly and locally silty. Surface is generally planar; dissected and interfluves are rounded. Densely packed desert pavement; pavement clasts are well varnished making this unit medium to dark colored, due to moderate to strong accumulation of rock varnish; locally light due to erosional exposure of soil-carbonate horizon or lack of varnish development on carbonate clasts. Locally, thin eolian sand deposits mantle the surface. Soil development varies from a well-developed cambic (Bw) horizon and a stage II carbonate (Bk) horizon to an argillic (Bt) horizons and an approximately 1-m-thick, stage III to IV carbonate (Bk to Kj) horizon. Thickness less than 1 m – 10 m

QTa **Oldest alluvial deposits (middle to early Pleistocene and Pliocene?)**—Gravel, sand, and silt; intermixed and interbedded, light brownish gray to light gray. Clasts are angular to subrounded, clasts more than 1 m in diameter are common at and near base of steep slopes. Generally poorly sorted, nonbedded to poorly bedded, and moderately to well cemented with carbonate. Locally consists of moderately well bedded, poorly to moderately well-sorted pebble to cobble gravel in a sand and silt matrix. Surface is eroded and dissected; commonly forms rounded ridges known as ballenas. Where preserved, desert pavement is generally moderately to densely packed and includes tabular fragments cemented by pedogenic carbonate and opaline silica. Varnish on pavement clasts is variable but commonly strongly developed. Soils typically consist of a stage III to IV carbonate (Bk to Kj horizon as much as 2 m thick; argillic (Bt) horizons, where present, postdate much of the erosion. Thickness may exceed 40 m

Eolian deposits

Qa **Eolian sand deposits (Holocene)**—Silty fine to medium sand, pale yellowish brown to yellowish gray, well sorted, massive to poorly bedded; locally includes a few cobbles and pebbles near exposed bedrock. Forms sheets, dunes, and vegetation-stabilized mounds (coppice) near playa (Qap) and marl deposits (QTm) in the eastern half of the map area. Thickness probably less than 10 m

Playa-related deposits

Qp **Playa deposits (Holocene)**—Fine sand, silt, and clay; poorly to moderately well consolidated, light grayish brown, calcareous, moderately well sorted, thinly bedded; polygonal desiccation cracks common. Locally contains sparse thin beds or lenses of pebbly coarse sand. Generally restricted to areas of active deposition in the interior of poorly drained basins; for example, in the Amargosa Valley and Stewart and Pahrump Valleys in the eastern part of the quadrangle. Locally at least 20 m thick

Qps **Saline playa deposits (Holocene)**—Silt, fine sand, and clay; white to light gray and light brownish gray, gypsiferous and calcareous, moderately well sorted, thinly bedded. Includes sandy playa or lake deposits, gypsum and other sulfate salts, sodium carbonate and other carbonate salts, and rock salt (halite) (Hunt and Mabey, 1966; Wright and Troxel, 1993). Generally restricted to areas of active deposition in the interior of extremely arid, poorly drained basins; for example, in parts of Death Valley. Drilled thickness 186 m at Badwater, Calif., in Death Valley (DV93-1, Lowenstein and others, 1999) consisted of alternating mud flat and saline playa deposits with lacustrine deposits

Qpx **Inactive playa deposits (Holocene)**—Silt; fine sand, and clay; locally contains minor lenses of pebble gravel and spring (marls and tufa) deposits. Light gray to light brownish gray, moderately sorted. Mapped adjacent to active playas (Qps), and includes minor alluvium deposited by areas entering basin interiors. This unit fringes the saline playa deposits of Death Valley (Qps) except at Badwater, Calif., where alluvium is deposited adjacent to unit Qpa. Unit Qpx is also mapped along the valley axes between the playa deposits (Qp) of Stewart Valley and Pahrump Valley as well as adjacent to parts of those playas. Locally includes evaporative surface crusts of salt or carbonate. Thickness indeterminate; estimated at 1 to 10 m; base not exposed or drilled

Lacustrine deposits

Qlb **Lacustrine beach deposits (late and late-middle Pleistocene)**—Gravel, sand, and silt; poorly to moderately bedded; light gray, and yellowish to grayish brown, weakly to moderately well cemented. Clasts are moderately to well sorted, subrounded to rounded, reflecting nearshore depositional environments. Locally cemented by soil carbonate and silt. Similar to unit Qac, but is locally higher and more dissected; has generally finer textured gravel, is better sorted and better rounding of coarse fraction. This unit is preserved in Death Valley where we infer that it has been covered by unit Ilat or eroded. We mapped a west-side remnant on the Hanaupah Canyon, Calif., 7.5-minute quadrangle near the toe of Chuckwalla Canyon fans above Tule Spring, and 160–185 ka lake-shared conglomerates on the east side of the valley at Mormon Point. Other sites (Machette and others, 2001) for example, at Badwater, are too small to portray at 1:100,000 scale. At Hanaupah Canyon, the deposit forms a bar, which was recognized by Ibbeken and others (1998) and Ibbeken and Warnke (2000) who noted that the pebbles on the surface are better sorted than those of adjacent (lower) alluvial surfaces, units Qay to the north and Qai to the south. The upper part of the bar comprises a series of gently east-dipping planar surfaces and intervening slopes, which probably represent paleoshorelines of a once more extensive north-trending bar complex derived from streams emanating from the Hanaupah Canyon. The uppermost (highest) surface of the bar at is +30 m above sea level (asl) (on the +100 ft topographic contour), well below the uranium-series dated (Ka and others, 1998), oxygen-isotope stage (OIS) 6 shorelines that are uplifted at Mormon Point (Knott and others, 2001). Terrestrial cosmogenic-nuclide (TCN) ^{36}Cl depth-profile dating establishes the age of the lacustrine bar complex at Hanaupah Canyon to be 130 ka (Machette and others, 2008). Estimated thickness 5–15 m

Colluvial deposits

QTc **Colluvium (Holocene to Pliocene)**—Angular to subangular, granule- to boulder-sized clasts with variable amounts of sand, silt, and clay as matrix. Generally unsorted and nonbedded to poorly bedded; locally cemented by soil carbonate. Matrix probably partly of eolian origin. Forms talus and thin mantle of debris along flanks and bases of steep slopes, deposited by rainwash, debrisflow, creep, and mass wasting. Colluvium-mantled surfaces commonly have ribbed or fluted appearance due to gullying and development of steep, narrow lags. Locally includes bedrock outcrops too small to map separately. Most deposits are probably of Holocene to Pleistocene age, but the lack of dates and juxtaposition with QTa makes even older ages possible. Thickness varies, but generally less than 3 m

Marl

QTm **Marl deposits (Pleistocene and Pliocene)**—Marl, pale yellowish brown, weathers white to very light gray, silty to sandy, soft, platelet when wet. Consists of calcite, various clay minerals, quartz and opaline silica, silt, and sand-sized rock fragments. Includes several thin chalk beds as much as 1 m thick and discontinuous beds of small, irregular limestone nodules. Unit includes yellowish-gray to grayish-orange, locally calcareous silt, in part clayey, mostly unconsolidated, locally interbedded with sandy marl. Locally contains sparse to common pencil-sized calcareous cylinders that probably are calcified plant stems or insect burrows. This unit is thought to represent deposits and precipitates formed in areas of ground-water discharge, including paludal (marsh) environments. This undivided unit varies greatly in age: ranging from Pleistocene (90 to greater than 200 ka and 15–40 ka; Pace and others, 1997; Nelson and others, 2001) to Pliocene (2.1–3.8 Ma based on fission-track and K-Ar ages on interbedded ash; Swadley and Carr, 1987; Marvin and others, 1989). In the Amargosa Desert, exposed thickness is as much as 50 m (Hay and others, 1986), but the base of the unit is not exposed

Contact

Fault—Solid line where location is known; dashed where approximately located

Anticline

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Table 1. *Summary of surface morphology, tone, relative height, and landscape position of alluvial units in the Death Valley Junction 30' × 60' minute quadrangle.*

Alluvial unit	Surface morphology	Tone (on aerial photography)	Relative height (topographic position)	Landscape position
Qay—Young alluvial deposits (Holocene)	Bar-and-swale near range fronts; braided sand plains in basins.	Light, in general, due to no or little rock varnish; can appear variegated.	Lowest unit above active channel--where surfaces are incised.	Emanates from fan apices; includes active channels where they are too small to map separately.
Qayy—Young alluvial deposits, younger part (late Holocene)	Pristine bar-and-swale bedforms in modern channels.	Light, due to no or little rock varnish, or to presence of young or exhumed marl (QTm) deposits.	Lowest unit	Forms active channels
Qayo—Young alluvial deposits, older part (middle and early Holocene)	Faint bar-and-swale to nearly smooth.	Light to medium due to weak to moderate accumulation of rock varnish.	Intermediate; higher than Qayy, but lower than Qai.	Progressively older units flank younger units.
Qai—Younger intermediate alluvial deposits (late and late-middle? Pleistocene)	Planar, smooth appearance; locally dissected.	Medium, in general, due to moderate accumulation of rock varnish.	Intermediate; higher than Qayo, but lower than Qao.	Progressively older units flank younger units.
Qao—Older alluvial deposits (late? to early? Pleistocene)	Generally planar form, but surface dissected and interfluves rounded.	Medium to dark, in general, due to moderate to strong accumulation of rock varnish; locally light due to erosional exposure of soil-carbonate horizon or lack of varnish development on carbonate clasts.	Intermediate; higher than Qai, but lower than QTa.	Progressively older units flank younger units.
QTa—Oldest alluvial deposits (middle to early Pleistocene and Pliocene?)	Typically ballena (whaleback) form; locally planar.	Light, in general, due to erosional exposure of soil-carbonate horizon.	Highest where surfaces are incised.	Older units typically preserved close to the range fronts.

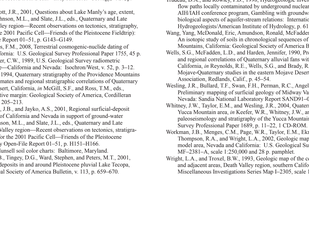
GEOLOGIC SUMMARY

INTRODUCTION

This surficial geologic map of the Death Valley Junction 30' × 60' quadrangle was compiled digitally at 1:100,000 scale. The map area covers the central part of Death Valley and adjacent mountain ranges—the Panamint Range on the west and the Funeral Mountains on the east—as well as areas east of Death Valley including some of the Amargosa Desert, the Spring Mountains and Pahrump Valley (fig. 2). Shaded relief delineates the topography and appears as gray tones in the mountain ranges where the bedrock is undifferentiated and depicted as a single unit. This geologic map augments and extends previous regional surficial geologic mapping of parts of the same area (Hunt and Mabey, 1966; Wright and Troxel, 1993; Workman and others, 2002) by providing updated and (or) more detailed Quaternary geology, and improved GIS coverages. Data collection, data analysis, and map compilation were funded primarily by the National Cooperative Geologic Mapping Program (NCGMP) of the U.S. Geological Survey (USGS) and to a lesser extent by the National Park Service (NPS).

The primary purpose of this updated geologic framework is to aid interpretation of ground-water flow through Death Valley. The Nevada Test Site (NTS), north of the mapped quadrangle (fig. 1), is centrally located within the area of the Death Valley regional groundwater-flow system of southwestern Nevada and adjacent California (Slate and others, 1999; Workman and others, 2002). During the past 40 years, the U.S. Department of Energy and its predecessor agencies conducted about 900 nuclear detonations on the NTS, of which 100 were atmospheric tests and the rest were underground (Laczniak and others, 1996). More than 200 were at or beneath the water table, which is about 500–600 m below the surface across most of the test site. Because radioactive contaminants introduced by these tests may move into water supplies off the NTS, rates and directions of ground-water flow must be determined. Knowledge about the ground-water also is needed to properly appraise potential future effects of the possible nuclear-waste repository at Yucca Mountain, adjacent to the NTS. Furthermore, hydrologists need to determine the effects of the withdrawal of ground water from upstream parts of the flow system on water levels and thus on endangered animal and plant species in springs in downstream areas such as Devils Hole, Nev. (fig. 2), Death Valley, Calif. This study continued previous work by the Geologic Division and Water Resources Division of the USGS, in cooperation with other Federal, State, and County agencies and private contractors (Laczniak and others, 1996; Trudeau and Rowley, 1998; D'Agnese and Faunt, 1999; Faunt and others, 1999; O'Brien and others, 1999; Rowley and others, 1999).

Because 95 percent of Death Valley National Park is designated as Wilderness Area as well as much of the rest of the quadrangle outside of park boundaries, the road network is sparse thereby limiting access for field studies. Owing to limited access, we compiled the surficial geology mostly by interpreting aerial photography and field-checking along roads and geologically significant sites. We used 1:80,000-scale aerial photographs that were flown in 1983 for the USGS National High-Altitude Photography (NHAP) program. We mapped the contacts of the surficial units using diapositive-film format photographs, which have significantly better resolution than paper prints at the same scale. Digital files of the contacts were made using a computerized photogrammetric mapping system that consists of Carl Zeiss Inc. VOice® software and a digital Kern model PG-2 stereoplotter. Stereo pairs of aerial photographs were mounted on the PG-2 and scaled to 1:24,000 DLG (digital line graph) files for the topographic base. This system enabled us to save time and reduce error by eliminating the steps needed to convert data from analog to digital format.



Large boulder on alluvial-fan surface on the west side of Death Valley. Photograph by Janet Slate, 2003.

Coalescing alluvial fans form bajada at Hanaupah Canyon, west side of Death Valley (fig. 2). A fault scarp cuts across the dark-toned fans in the bottom half of the photo. The West Side Road follows the base of the scarp (near the bottom of the photo), which marks locations of springs at the lowest reaches of the bajada. Photograph by Marli Bryant Miller, 2003.

GEOLOGIC MAPPING OF ALLUVIAL UNITS

We mapped six alluvial units (Qay, Qayy, Qayo, Qai, Qao, and QTa), an eolian unit (Qa), three playa or playa-related units (Qp, Qps, and Qpx), lacustrine beach deposits (Qlb), colluvium (QTc), and marl (QTm). Alluvial units Qay, Qai, and QTa are based on those of Slate and Berry (1999) and Slate and others (1999); the additional alluvial units (Qayy, Qayo, and Qao) were mapped to aid interpretation of surficial processes and geologic history. Our regional mapping is consistent with detailed drainage-basin scale mapping at Kwirk (1998) and Klinger (2002). Alluvial units may include multiple periods of deposition that were not mapped separately because of the scale of our mapping. Additionally, some map units may include other surficial deposits that are too small to be shown separately, or are so thin (less than 0.5 m) that surface characteristics are controlled by the underlying mapped unit. Interpretation of surface morphology, tone, relative height, and landscape position in aerial photography enabled us to differentiate among the alluvial units (table 1). These geomorphic attributes of the alluvial units, which make up about 80 percent of the surficial deposits contaminants introduced by these tests may move into water supplies off the NTS, rates and directions of ground-water flow must be determined. Knowledge about the ground-water also is needed to properly appraise potential future effects of the possible nuclear-waste repository at Yucca Mountain, adjacent to the NTS. Furthermore, hydrologists need to determine the effects of the withdrawal of ground water from upstream parts of the flow system on water levels and thus on endangered animal and plant species in springs in downstream areas such as Devils Hole, Nev. (fig. 2), Death Valley, Calif. This study continued previous work by the Geologic Division and Water Resources Division of the USGS, in cooperation with other Federal, State, and County agencies and private contractors (Laczniak and others, 1996; Trudeau and Rowley, 1998; D'Agnese and Faunt, 1999; Faunt and others, 1999; O'Brien and others, 1999; Rowley and others, 1999).

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Table 2. *Correlations of alluvial surficial-deposit units in the Death Valley 30' × 60' quadrangle to surficial-deposit stratigraphic sequences in studies proximal to the Death Valley area that have some independent age control.*

[Numbers in parentheses refer to minimum and maximum age estimates (in ka); number after range is preferred age estimate(s) where given. Some correlations adopted from Taylor (1986), and Klinger and Piety (1996). No mapping unit is identified for time periods denoted by dashes. Table modified from Menges and others, 2001.]

Death Valley Junction (this report) 1:100,000-scale	Death Valley Regional Flow System (DVRFS)[1] 1:250,000-scale	Yucca Mtn.-NTS, Nev.		Crater Flat, Nev.[4]	Pahrump-Las Vegas area (Las Vegas 1:100,000-scale sheet)[5]		Kyle Canyon, Nev.[6]	Fish Lake Valley, Calif.[7]	Silver Lake, Calif.[8]	Providence Mtns., Calif.[9]	Lower Colorado River, Calif.[10]
		(post-1992)[2]	(pre-1992)[3]								
Qay	Qay	Qac (0–2)	Q7 (<0.2)	Qa (0)	Modern (0)	Qay (0–3)	Q4 (0)	Late Marble Creek (0–0.75)	Q5/Q6 (0–0.7)	Q5 (0–2, ~0.1)	Q0b (0)
			Q6 (<1)	--	Crater Flat (0.4–1.5)		--	Middle Marble Creek (1–1.6)	--	Q6 (0–1, ~0.4)	Q4a (0.1–2)
	Qayy	Qay, Qfy (0–18)	--	--	--		--	Upper Marble Creek (1.9–5.3)	Q6 (2.5–3.4)	Q6 (3–8, ~4)	Q1 (2–4)
	Qayo	Qoir (4–18)	Q5 (2–17)	Qlc (3–38, ~10)	Little Cones (7–31)	Qayy (0–14)	--	--	--	--	Q2b (4–8)
							Qayy	Q3-upper (4–40, 15)	Leidy Creek (6.4–10)	--	Q3 (8–18, ~10)	Q2a (8–12)
Qai	Qai	Qfc (18–758)	Q4 (30–100)	Q2b (140–160)	Late Black Cone (<17–30)	Qayo (25–50)	Q3-lower (4–40, 50)	Indian Creek (50–130?)	Q2 (10–40)	Q4 (17–75, ~50)	Q2c (12–70)
			Q3 (100–250)		Early Black Cone (~159–200)	Qai (50–130)	Q3-lower (18–750, 130)	--	--	Q5 (29–758, ~150)	Q2b (70–200)
	Qao		Q2 (~400)	Q2c (270–300)	-- Yucca? (~343–375)	-- Qao (≥ 300–600)	--	--	Q6a	--	--	--
			Q1 (500–758)					McAfee Creek (600?–758)			Q2 (29–758, ~600)	Q2a (600–758)
QTa, QTaf (500–>758)		Q8 (>758)	QTa (900–2,000)	Solitario (~633–>758)		QTa	Q5 (750–800, 800)	Perry Aiken Creek (>758)	Tg	Q5 (758–4,000 ~1,500)	Q1 (>1,200)

[1] Workman and others, 2002.
[2] Whitney and others, 2004.
[3] Swadley and others, 1984; Taylor, 1986; Hoover, 1989. Age estimates for post-Q1, and particularly Q2 units are questionable because of reliance on uranium-trend method, which is not considered valid by most practioners of uranium-dating methods; see Rosholt, 1994.
[4] Harrington, 1988; Peterson and others, 1995. Age estimates are uncertain for some units due to use of ^{14}C varnish-dating method, which is currently considered unreliable.
[5] Bohrer and others, 1992.
[6] Slate, 1991; Roberts and Sawyer, 1997.
[7] Reheis, 1999a, 1999b.
[8] McDonald and Faulds, 1994; Wang and others, 1996.
[9] Bull and Ku, 1975; Ku and others, 1979; Bull, 1991.

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