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SCALE 1:100 000
CONTOUR INTERVAL 50 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Prepared in cooperation with the U.S. NATIONAL PARK SERVICE

# SURFICIAL GEOLOGIC MAP OF THE DEATH VALLEY JUNCTION 30′ × 60′ QUADRANGLE, CALIFORNIA AND NEVADA

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## 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 detonation tests 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., and 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. VrOne® 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.

ACKNOWLEDGMENTS

Chris Fridrich informally reviewed the map and made valuable contributions with regard to faults. Jeremy Workman consulted on faults in the eastern part of the quadrangle. David W. Moore and Michael N. Machette formally reviewed the map, and we thank them. Emily Taylor helped to develop an earlier version of table 2.

GEOLOGIC MAPPING OF ALLUVIAL UNITS

We mapped six alluvial units (Qay, Qayy, Qayo, Qai, Qao, and QTa), an eolian unit (Qe), 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 of Knott (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 in the map area, are highly generalized. Surface morphology of alluvium is a product of both depositional and post-depositional processes. Stream flows, debris flows, or some combination of the two are the main processes that deposit alluvial units. Post-depositional processes include weathering, eolian additions (surface accretion), winnowing by wind (deflation), reworking and erosion by water, creep, and bioturbation. Nevertheless, the systematic variations in alluvial surface morphology with age permit us to map and correlate geomorphic surfaces (Bull, 1991; table 2). Lithologic variations across the map area influence the tone of the alluvial units. Although young alluvial units are often light-toned due to an absence or paucity of rock varnish, they may appear dark where the source rocks are dark. Lithology also influences the development of rock varnish; fine-grained or aphanitic rocks, such as quartzite or basalt, tend to become varnished more quickly than rocks such as limestone or granite. Granite commonly disaggregates to grus before becoming varnished and limestone becomes etched. Relative height (topographic position) is useful for mapping in individual drainage basins near range fronts, but basinward, especially in tectonically inactive areas, most surfaces grade to the same base level, and relative height differs little among the alluvial units. Faulting, both the magnitude and location, also affects the map pattern of alluvial units. As faulting uplifts ranges relative to the basins, streams adjust to new base levels, abandon-ing and incising older alluvial units, thus preserving them on the footwall block of the fault. In tectonically inactive areas, streams continue to grade to the same level or aggrade, thus progressively burying older alluvial units. Therefore, map pattern of alluvial units is an important tool to evaluate late-phase basin evolution in the Basin and Range province.

## 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 at 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 such 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 at and near base of steep slopes, and close to mountain fronts. Along large alluvial channels boulders 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 map 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 (marls). 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 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 crossbedded, 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 K) horizon. Terrestrial cosmogenic-nuclide (TCN) 36Cl 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 thus post-date the 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 develop-ment 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) horizon and an approximately 1-m-thick, stage III to IV carbonate (Bk to K) 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 K) horizon as much as 2 m thick; argillic (Bt) horizons, where present, postdate much of the erosion. Thickness may exceed 40 m.

Eolian deposits

**Qe 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 (Qp) 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 (Qp), and includes minor alluvium deposited by axial streams draining basin interiors. This unit fringes the saline playa deposits of Death Valley (Qps) except at Badwater, Calif., where alluvium is deposited adjacent to unit Qps. Unit Qpx is also mapped along the valley axis 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 indetermi-nate, 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 consolidated. Clasts are moderately to well sorted, subrounded to rounded, reflecting nearshore depositional environments. Locally cemented by soil carbonate and tufa. Similar to unit Qai, but is locally higher and more dissected; has generally finer textured gravel, is better sorted and better rounding of coarse fraction. This unit is poorly preserved in Death Valley where we infer that it has been covered by unit Qai 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-stand 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 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 (Ku and others, 1998), oxygen-isotope stage (OIS) 6 shorelines that are uplifted at Mormon Point (Knott and others, 2001, 2002). Terrestrial cosmogenic-nuclide (TCN) 36Cl 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, sheetwash, creep, and mass wasting. Colluvium-mantled surfaces commonly have ribbed or fluted appearance due to gullying and development of stony surface lags. Locally includes bedrock outcrops too small to map separately. Most deposits are probably of Holocene to middle 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, plastic 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 15–60 ka; Paces 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.

Base from U.S. Geological Survey Death Valley Junction 30’ x 60’ quadrangle, 1986
Shaded relief base from the National Elevation Dataset (NED), 30-meter resolution
Projection and 10 000-meter grid: Universal Transverse Mercator, zone 11
North American Datum of 1927 (NAD27)
25 000-foot grid ticks based on California coordinate system zone 4, and Nevada coordinate system, central zone

Index map showing the Death Valley Junction 30′ × 60′ quadrangle in yellow and adjacent quadrangles.

**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.

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

Photograph caption: 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 line of vegetation (near the bottom of the photo), which marks locations of springs at the lowest reaches of the bajada. Photograph by Marli Bryant Miller, 2005.

**Table1.** Summary of surface morphology, tone, relative height, and map pattern of alluvial units in the Death Valley Junction 30 × 60-minute quadrangle.

**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.]

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