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GEOLOGIC MAP OF THE MOUND SPRING QUADRANGLE, NYE AND CLARK COUNTIES, NEVADA, AND INYO COUNTY, CALIFORNIA

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DESCRIPTION OF MAP UNITS

[Pedogenic carbonate stages from Gile and others, 1966]

Gravelly alluvium

Qayy **Youngest alluvium (Holocene)—**Noncemented alluvial gravel, with interbedded sand; poorly to moderately well sorted; massive to well-bedded; clast-supported to matrix-supported. Gravel is angular to subrounded, ranging in size from granules to boulders, and composed predominantly of carbonate rocks derived from erosion of the Spring Mountains (Burchfiel and others, 1974) and from older Quaternary deposits described below. Includes deposits of modern channels too narrow (less than 30 m) to map separately, as well as Holocene deposits between modern channels. Etching on surficial limestone clasts ranges from absent on deposits of modern channels to incipient and sparse on deposits between modern channels. Bar-and-swale depositional morphology ranges from prominent in modern channels, to variably modified and muted by addition of eolian sediment in areas between modern channels. Desert pavement ranges from absent on deposits of modern channels, to loosely packed and weakly developed on deposits between active channels. Rock varnish, which does not form on most limestone clasts, is generally very weakly developed to absent on siliceous clasts (including siliceous carbonates) except for relict rock varnish not abraded during transport. Typical non-cemented, weak soil development is characterized by the presence of stage I secondary carbonate morphology (mostly thin carbonate coats on clast undersides), and by a gradual increase of sand toward the surface in the upper 10–30 cm of the unit. The surficial sand component includes a pedogenically mixed and infiltrated eolian sediment deposited after fluvial deposition of fan gravel. This unit grades into partly correlative fine-grained facies mapped as **Qfy**. Minimum thickness is 1–2 m; base of unit is generally not exposed

Qay **Young alluvium (Holocene and latest Pleistocene)—**Noncemented alluvial-fan and wash gravel, with interbedded and intermixed sand; poorly to moderately well sorted; massive to well-bedded; clast-supported to matrix-supported. Gravel is angular to subrounded, ranging in size from granules to boulders, and composed predominantly of carbonate rocks derived from erosion of the Spring Mountains (Burchfiel and others, 1974) and from older Quaternary deposits described below. Includes Holocene and locally latest Pleistocene (younger than about 15 ka) deposits between modern channels, and deposits in modern channels that are too narrow (less than 30 m) to map separately. Etching on surficial limestone clasts ranges from absent on deposits of modern channels to incipient and sparse to moderately developed and common on deposits between modern channels. Bar-and-swale depositional morphology has been variably modified and muted by addition of eolian sand, but relict depositional morphology remains a characteristic feature: bar-and-swale morphology ranges from prominent in modern channels, to somewhat muted in areas between modern channels. Desert pavement ranges from absent on deposits in modern channels, to loosely packed and weakly developed (especially in areas of relatively low dust-flux, as on the upper part of the fan) to moderately well packed in areas of higher dust flux, such as the lower southern and western parts of the quadrangle, which are more proximal to fine- grained eolian source areas of the Pahrump Valley. Rock varnish, which does not form on most limestone clasts, is generally weakly developed to absent on siliceous clasts (including siliceous carbonates) except for relict rock varnish not abraded during transport. Typical non-cemented and weak soil development is characterized by a cambic Bw horizon, by the presence of stage I–II secondary carbonate morphology (mostly thin carbonate coats on clast undersides), and by a gradual increase of sand toward the surface through the top 0.5 m of the deposit. The surficial sand component is considered to be a pedogenically mixed and infiltrated eolian sediment deposited after fluvial deposition of fan gravel. Age control elsewhere in the Las Vegas 1:100,000 sheet indicates that **Qay** is predominantly Holocene. In the Gass Peak SW, and Tule Springs Park quadrangles to the east, correlative alluvium with similar characteristics to **Qay** either overlies or is inset within fine-grained deposits with abundant radiocarbon dates ranging from about 12 to 8 ky B.P. (Haynes, 1967: Quade, 1986; Quade and others, 1995; Bell and others, 1998), so it is likely that most alluvium at the surface of **Qay** is Holocene. **Qay** includes deposits correlative to youngest alluvium (**Qayy)** and deposits older than **Qayy**; **Qayy,** described below, is delineated separately only where there is a markedly greater proportion of modern channels and interchannel areas with minimal development of surface etching, varnish, pavement, and soil. Minimum thickness of **Qay** ranges from less than 1 m to at least 3 m, as exposed in borrow pits; base of unit is generally not exposed

Qayo **Older young alluvium (Holocene and latest Pleistocene)—**Noncemented alluvial-fan gravel, with interbedded sand; poorly to moderately well sorted; massive to well-bedded; clast-supported to matrix-supported. Gravel is angular to subrounded, ranging in size from granules to boulders, and composed predominantly of carbonate rock types derived from erosion of the Spring Mountains (Burchfiel and others, 1974) and from older Quaternary deposits described below. Etching on surficial limestone clasts is moderately developed and common. Surface is smooth, and depositional bar and swale morphology is highly muted. Desert pavement is moderately well packed. Rock varnish, which is rare on limestone clasts, is weakly to moderately developed on more siliceous rock types (including siliceous carbonates) except for relict rock varnish not abraded during transport. Typical non-cemented and weak soil development is characterized by a cambic Bw or incipient Btj horizon, by the presence of stage I–II secondary carbonate morphology (mostly thin carbonate coats on clast undersides), and by a gradual increase of sand toward the surface through the top 0.5 m of the deposit. The sand is considered to be a pedogenically mixed and infiltrated eolian sediment deposited after fluvial deposition of fan gravel. Minimum thickness of **Qayo** ranges from less than 1m to at least 3 m, as exposed in borrow pits; base of unit is generally not exposed

Qai **Intermediate alluvium (late and middle? Pleistocene)—**Cemented alluvial-fan and pediment gravel, with interbedded sand; poorly to moderately well sorted; massive to well-bedded; clast-supported to matrix-supported. Gravel is angular to sub-rounded, ranging in size from granules to boulders, and composed predominantly of carbonate rock types derived from erosion of the Spring Mountains (Burchfiel and others, 1974) and from older Quaternary deposits described below. Includes modern channels too narrow to map separately. Surface between modern channels is somewhat erosionally rounded where it is more than about a meter above grade of adjoining channels. Surface between modern channels is characterized by a moderately to tightly packed desert pavement and smooth surface, which generally lacks bar and swale depositional morphology. Though nonsiliceous limestone clasts do not have rock varnish, more siliceous clasts possess dark varnish, which imparts a darker tone to this unit on aerial photographs. This surface morphology is associated with a soil that typically includes a reddish-brown argillic (Bt) horizon and cemented stage III–IV carbonate morphology. Within the soil profile, the upward decrease in proportion of gravel is due to the addition of eolian material concurrent with pedogenesis. Within and beneath the zone of maximum pedogenic carbonate development, limestone gravel generally is distinctly more cemented than in younger Holocene alluvium. Depositional microrelief is minimal relative to other alluvial units; bar-and-swale morphology is generally absent, and surfaces are smooth between limited areas of erosional dissection. A sample taken where this unit is buried by younger fine-grained deposits in the northeast part of the quadrangle yielded a U-series date of 87.22 $\pm$ 13 ka (MSQ–3, Table 2). Exposed minimum thickness of **Qai** ranges from less than 1 m to at least 5 m; base of unit not exposed

Qau **Undivided alluvium (Holocene and late Pleistocene**)—Cemented and noncemented alluvial-fan and pediment gravel, with interbedded sand; poorly to moderately well sorted; massive to well bedded; clast-supported to matrix-supported. Gravel is angular to subrounded, ranging in size from granules to boulders, and derived from Paleozoic rocks in adjacent Spring Mountains, and locally from ridge-forming **QTa** and **Qbw**. **Qau** represents areas in which young alluvium (**Qay),** including common intermittent active channels, occurs as discontinuous but common (30–50 percent of **Qau**), thin (<1m) veneers over intermediate alluvium (**Qai**) in patches that are too narrow to map separately

QTa **Gravelly basin-fill alluvium (early Pleistocene? to late Miocene)—**Very poorly exposed alluvial gravel. Gravel is angular to subrounded, ranging in size from granules to boulders, and composed predominantly of clasts derived from Palezoic carbonate rocks. Also includes sparse granitic and volcanic clasts that were probably derived from the Kingston Range, 30 km to the south (McMackin, 1999). Unit caps rounded hills in the central part of the quadrangle that are aligned in northwest direction sub-parallel to trend of the escarpment 2 km to the east. This alignment is transverse to the southwesterly modern and late Pleistocene drainage direction. The ridges and hills are probably the result of erosional resistance of gravel relative to underlying fine-grained deposits. To the southeast within the Stump Spring quadrangle (McMackin, 1999), better exposures of deformed gravelly sediments beneath Qb include abundant and lithologically varied volcanic clasts in beds that strike northwest and dip northeast, overlain by less steeply dipping gravels with abundant Paleozoic limestone clasts probably derived from the Nopah Range. Malmberg (1967) reported a white to light-green tuff underlying this gravel, but no good exposures of the gravel or underlying stratigraphy were noted in this quadrangle. McMackin, 1999 reports an Ar/Ar date of 10.76 $\pm$ 0.09

Ma on a lapilli tuff associated with these gravels. The flanks of the gravel-covered hills are draped with thick colluvium that includes a younger eolian sand component. **QTa** in the subsurface is considered here to include basin-fill that may be equivalent to parts of the Muddy Creek and Horse Spring Formations, which are exposed and described east of the Spring Mountains (Bohannon, 1984; Maldonado and Schmidt, 1990). Maximum thickness of 2,200 meters estimated from gravity studies (Blakely and others, 1999)

Fine-grained deposits

Qd **Dune sand (late Holocene)—**Noncemented fine sand in intermittently active to inactive dunes partially vegetated by mesquite. Most dunes occur along the lower part of southwest-facing escarpments in the eastern part of the quadrangle. Most dunes are intermittently active, with evidence for recurrent activity during the late Holocene. A thermoluminescence date of about 2 ka (LV–24, Table 1) was determined on dune sand from about 3 m depth in a mesquite-covered dune that mantles a scarp. Thickness ranges from 1 to 5 meters. Included in other map units above and below, eolian fine sand and silt is ubiquitous, and often is the dominant detrital component of surface and buried soils in alluvial gravel, and in fine-grained deposits associated with past ground-water discharge

Qpy **Modern playa sediment (late Holocene)—**Fine mud, silt, and clay of modern playa. Smooth, flat, high albedo surface has several northwest-trending lineaments apparent on aerial photographs that we provisionally interpret as slightly buried (healed) probable right-lateral strike-slip faults. Margins of playa are transitional to unit **Qfy** with greater amount of fluvial sand and fluvial morphology. Thickness unknown; only upper surface of unit is exposed

Qfy **Intermittently active fluvial fine-grained alluvium (late Holocene)—**brown to gray sand, silt, mud, and interbedded gravel. Includes deposits partly correlative to units F and G of of Haynes (1967) and distal facies of alluvial fans. Erosional and depositional fluvial bar and channel morphology ranges from fresh to muted. Map unit in upwash position may represent a thin pedimented veneer across older fine grained deposits (**Qfo**) as evidenced by tension cracks and darker toned lineaments that are locally contiguous across both **Qfy** and **Qfo**. This thin veneer of intermittently active fluvial sediment grades upwash to coarser youngest alluvium (**Qayy**) to which **Qfy** is correlative. Thickness ranges from less than 50 cm to greater than 150 cm; base not exposed, especially down wash to southwest, where this unit grades into modern playa sediment (**Qpy**)

Qfo **Older fine-grained deposits (Holocene?)—**Noncemented fluvial sand and mud. Erosional and depositional fluvial bar and channel morphology is muted, especially relative to adjoining unit **Qfy**. Map unit in upwash position may represent a thin pedimented veneer across older fine-grained units**.** Unit may include unit **Qse** and deposits correlative to unit F of Haynes (1967). Thickness ranges from less than 50 cm to greater than 150 cm; base not exposed

Qsy **Youngest spring deposits (late Holocene)—**Historic and prehistoric groundwater discharge areas, including spring mounds, composed of fine-grained calcareous to organic-rich silt, clay and mud. Mound Spring was historically active, but is now dry due to ground-water pumping (Waring, 1920; Malmberg, 1967; Harrill, 1986). At Mound Spring, a central depression obscured by refuse is surrounded by a raised rim about 2–3 m high, composed of massive fine sand and silt, and with crude bedding defined by light-toned calcareous and dark, organic-rich layers. This bedding shows both outward and inward dips with respect to central depression. At another site (section 15, T. 22S., R. 54 E.), a spring mound about 20 m in diameter and 10 m high, has abundant tufa fragments with plant casts (stems of unknown types) mixed with eolian sand and colluvium that thicken on its flanks. This paleo-spring was not known to be historically active

Qse **Unit E (Haynes, 1967; Quade, 1986)—young fine grained deposits associated with past ground-water discharge (early Holocene to latest Pleistocene)—**Light-gray to light-brown unconsolidated silt, marl, sandy silt, and silty sand. Crude bedding in this otherwise massive unconsolidated silt is defined by changes in color, ranging from light gray in lower 1 m to tan brown (more oxidized) in upper 1 m. Correlated with Unit E of the Las Vegas Valley, which has numerous radiocarbon dates (Haynes, 1967; Quade, 1986; Bell and others, 1998) ranging from about 8,000 to about 15,000 yr. B.P. A radiocarbon date of 10,270 yr. BP was obtained from unit E to the north in the Pahrump quadrangle (dePolo and others, 1999). We obtained a thermoluminescence date of about 20 ka (LV–23, Table 1) in the northeast corner of the quadrangle near the base of this unit, which seems 5–10 ky too old compared with the normal age range of unit E. However, the date is plausible because unit

E at this site is stratigraphically conformable over unit D, which contrasts to an inset relation elsewhere. Includes non-fossiliferous eolian/phreatophyte flat facies of Quade and others (1995)

Qscd **Units C and D (Haynes, 1967; Quade, 1986)**—**intermediate-age fine-grained deposits associated with past ground-water discharge (late Pleistocene)—**Top 1–2 m is resistant light-gray calcareous marl that is partially cemented with calcite which weathers to curving and branching to platy nodules; some of these may be trace fossils of cicada burrows (Quade, 1986). U-series analyses yielded dates of 33 ka and 41 ka (MSQ–2B–A, 1C–A; Table 2) on carbonate concretions from unit D. We favor the younger date because it is analytically more robust (higher U concentration and lower error). Contiguous deposits in the adjoining Pahrump quadrangle to the north were radiocarbon dated at 24,150±80 yr. BP (DePolo and others, 1999). Grades downward to underlying unit C(?), which is tan-brown (more oxidized) and about 2–3-m-thick (thins to south), fine sandy silt and marl. We obtained a thermoluminescence date (LV–22, Table 1) of 21–28 ka, and a somewhat older U-series date of 55 ka (MSQ1A–A, Table 2) from unit C. This middle brown unit may include one buried soil, marked by a slight increase in prismatic structure and darker tone. Includes occasional fluvial crossbedding and carbonate nodules. Unit C overlies a sharp contact with an older red-brown unit that is probably a strongly developed red buried soil from which we obtained a thermoluminescence date (LV–21, Table 1) of 38–50 ka

Basin-fill of Browns Spring (Pleistocene)—Fine-grained bedded mud, fine sand, marl, and limestone with minor interbedded gravel. Unit is subdivided into upper, middle, and lower parts based on position relative to a resistant limestone bed as described below; Qb is only mapped as the subdivided units. Includes areas of younger fine-grained deposits associated with past groundwater discharge units **Qse** and **Qscd** (John Bell, written commun., 2000) that we have not recognized within the areas of map units **Qby**, **Qbw,** and **Qbo** on our map

Qby **Upper part of basin-fill of Browns Spring (middle Pleistocene)—**Fine-grained brown to whitish-tan mud, marl, and fine sand interbedded with minor 10–80-cm-thick beds of pebble gravel. Gravel is similar to surficial gravel in being subangular to subrounded and composed of limestone probably derived from the Paleozoic and Mesozoic rocks of the Spring Mountains. Gravel probably represents the distal ends of alluvial fans interbedded with the fine-grained deposits. Fine-grained beds are variably cemented with calcite. Probably deposited during pre-Wisconsinan groundwater discharge cycles (Spaulding and Quade, 1996). This part of the section is generally poorly exposed and covered by colluvium. At Browns Spring, in mud about 3 m above the top of the resistant Qbw bed, we obtained a thermoluminescence date (LV–27, Table 1) of 211–284 ka. Minimum exposed thickness is about 200 m, but top is not exposed, because unit is unconformably overlain by late Pleistocene deposits

Qbw **Middle white limestone of basin-fill of Browns Spring (middle Pleistocene)—**Massive, 2–4-m-thick, densely cemented limestone which forms a resistant escarpment extending to northeast and southwest of Browns Spring. Included in this unit are calcite-cemented limestone pebble gravel, 30–60 cm thick, which immediately overlies the massive limestone bed. At Browns Spring the gravel appears to be enclosed in the top of the massive limestone. U-series analysis from this unit yielded a robust date of about 370 ka (MSQ4B, Table 2)

Qbo **Lower part of basin-fill of Browns Spring (early? and middle Pleistocene)—**Fine-grained brown to whitish-tan mud, and marl, interbedded with minor pebble gravel. Marl forms resistant ledges in escarpment below **Qbw**; includes plant casts (stems of unknown taxa), and probably represent intervals of groundwater discharge. Occasional interbedded lenses and channels of pebble gravel composed of limestone clasts. We obtained thermoluminescence dates of about 275–400 ka (LV–25, LV–26, Table 1) from mud beds between more resistant marl beds. Exposed thickness at least 40 m; base of unit is not exposed

Qsu **Undivided fine-grained deposits (Holocene and Pleistocene)—**Fine-grained brown to whitish tan mud and marl, of likely groundwater discharge origin that probably includes units **Qse, Qscd,** and **Qb**

Table 1. Thermoluminescence (TL) data.

Sample	Latitude	Longitude	Depth	Stratigraphic	Modal size	% moisture		Dose rate (grays/ky)		ED[1]	TL age (ka)	
	Degrees, minutes' seconds"		(cm)	position		Field	Saturated	Field	Saturated	(grays)	Minimum	Maximum
LV-21	36, 07' 10.64"	115, 53' 15.54"	240	base of Qscd	silt	13	42	5.3	4.1	204	38	50
LV-22	36, 07' 10.64"	115, 53' 15.54"	150	in Qsc	silt	6	37	6.4	4.7	132.4	21	28
LV-23	36, 07' 00.84"	115, 53' 04.70"	120	in Qse	silt	2.2	27	3.7	2.9	74.5	20	26
LV-24	36, 04' 28"	115, 56' 23"	220	in Qd	fine sand	2.6	24	4.3	3.43	8.53	2.0	2.5
LV-25	36, 03' 03"	115, 54' 53"	800	in Qbo	silt	5.4	38	2.53	1.87	750.2	296.5	401.2
LV-26	36, 03' 03"	115, 54' 53"	500	in Qbo	silt	5.6	33	2.78	2.13	584.36	210.2	274.3
LV-27	36, 02' 00"	115, 53' 18"	200	in Qby	silt	5.2	37	2.92	2.17	616.5	211.1	284.1

[1]ED is equivalent dose determined at peak temperature of glow curves (generally about 300° C); gray is a unit of radiation absorbed per unit mass

Table 2. Uranium-series data.

Site	Sample	Unit	Depth (m)	U ppm	Th ppm	234U/238U	230Th/238U	230Th/232Th	Age (ka)	Initial 234U/238U
MSQ-1	MSQ1A-A	Qsc	2	3.13	3.12	2.5421±10.7	1.055±8.44	3.17	55 ± 8.9	2.802±0.28
MSQ-1	MSQ1C-A	Qsd	0.3	1.33	2.66	2.3031±30.6	0.74068±40.8	1.33	40.97 ± 29	2.464±0.7
MSQ-2	MSQ2B-A	Qsd	surface	3.33	2.89	2.315±8.3	0.61701±14.9	2.46	32.72 ± 7.8	2.443±0.19
MSQ-3	MSQ3A-D	Qai	2	1.1	0.94	1.6712±6.41	0.96469±7.71	3.45	87.22 ± 13	1.859±0.12
MSQ-4	MSQ4B	Qbw	1	0.86	0.06	1.4249±0.773	1.523±1.37	65.47	370.7± 43	2.215±0.11

SURFACE BASIN GEOMETRY, SURFACE GEOLOGY, TECTONICS, AND HYDROLOGY

Contours on the measured gravity field show an elongate northwest-trending high through the center of the quadrangle, approximately parallel to and just east of the State line, flanked by northwest-trending gravity lows on both sides. A 3-dimensional iterative inversion of the gravity data that separates basement gravity from basin thickness components (Blakely and others, 1999) indicates two deep steep-sided basins separated by a northwest-trending basement ridge that corresponds to the gravity high and flanking lows (cross section A–A'). The horst and flanking basins, and their approximate alignment with similar subsurface features beneath the Amargosa Desert (Blakely and others, 1999), are interpreted as transpressional and pull-apart features, respectively, along the proposed, northwest trending right–lateral Stateline fault system. We have indicated approximate traces of inferred buried faults that bound the horst beneath the gravity high (cross section A–A').

The mapped surface geology is consistent with this structural inference. The gravity high coincides with the occurrence of **QTa**, the oldest unit in this quadrangle, which forms a northwest-aligned chain of hills. This alignment is traversed and cut by the southwesterly sloping modern and late Quaternary drainage system tributary to the playa (**Qpy**) in the southwest corner of the quadrangle. A large, complex, southwest-facing, northeast-trending escarpment as much as 20 m high exists about 2 km northeast of and sub-parallel to the **QTa** hills and the crest of the gravity ridge. Though Hoffard (1991) and Anderson and others (1995) considered this as a fault scarp of a down-to-the-southwest normal fault, we interpret an opposite sense of displacement indicated by the gravity gradient. Moreover, in gully exposures near Brown Spring and in the adjoining Hidden Hills Ranch quadrangle, we can trace continuous unfaulted beds of **Qbo** from gullies cut into the scarp to a few hundred meters southwest of the scarp. The beds exposed in the scarp area dip 5–15 degrees northeast into the scarp and the main scarp is held up by the resistant limestone bed of **Qbw**. Northeast dips increase as much as 20 degrees as the scarp is crossed to the southwest, suggesting the scarp may be localized along the east side of a northeastward-facing monocline. The northeast dips on middle Pleistocene strata in a direction opposite the southwest topographic slope are consistent with middle to late Quaternary uplift in the area of the horst over the State line. Because surface fault scarps do not cut the predominantly Holocene sediments in the valley between the scarp and the **QTa** hills, we infer a buried, but intermittently active fault with down to the *northeast* displacement under the intervening sediments, consistent with both the gravity data and surface geology.

The gravity low to the southwest of the gravity ridge and **QTa** hills, roughly coincides with the lowest part of the Pahrump Valley, including the playa on its western flank. Along the linear southwest margin of the playa is an eastward-facing gravity gradient which may correspond to the East Nopah fault zone with abundant late Quaternary fault scarps in fan gravels just west of this quadrangle (Anderson and others, 1995; Schmidt and Davidson, 1999). Perhaps related to this fault zone, at least two very straight northwest-trending lineaments within the playa are parallel to the linear southwest margin of the playa. We interpret these lineaments to be possible active strike-slip (right lateral) fault strands that are readily healed by playa sedimentation. (This playa was observed to be covered with water several times during field work through the wet winter of 1997–98.) Elsewhere in the region, the contact between piedmont fans and playa sediments is not usually so abrupt or straight, suggesting fault control. In the area of fine-grained sediments between the playa and the **QTa** hills to the east, there are numerous curving lineaments that are prominent on aerial photographs, and that we interpret to be tension cracks accentuated by vegetation. They lack surface displacement and are difficult to identify on the ground. They may be related to some combination of dessication, evaporation and groundwater discharge through the playa surface, and/or extension related to the hypothesized strike-slip and pull-apart tectonics.

In the northeast corner of the quadrangle, a prominent area of late Pleistocene ground-water discharge deposits (**Qse, Qscd**) coincides with a steep down-to-the-southwest gravity gradient, also hypothesized as the margin of a pull-apart basin by Blakely and others (1999). The late Pleistocene ground-water discharge sequence is cut, repeated, and flanked on the west by several down-to-the-west fault scarps which appear to be aligned with of a set of late Quaternary scarps to the southeast that cut late Pleistocene **Qai** fan deposits. The zone of faulted fan deposits extends to the southeast into the Hidden Hills Ranch quadrangle. We consider it likely that the fault in the shallow subsurface was a barrier to southwestward flowing ground water from the Spring Mountains (the main local upland recharge area; Harrill, 1986), causing late Pleistocene ground-water discharge and formation of the climatically controlled late Pleistocene record of fine-grained sediments that is well known elsewhere around the Spring Mountains (Quade; 1986, Quade and others, 1989, Quade and others, 1995; Bell and others, 1998). It is plausible that the older and more extensively exposed middle Pleistocene **Qb** deposits, as well as modern springs like Browns Spring, similarly are related to past discharge from southwestward groundwater flow that encountered the horst and fault system along the State line to the south and west.

Cracks and related piping features were also observed and mapped along the upper parts of scarps in the late Pleistocene groundwater discharge deposits in the northeast. These are probably a result of subsidence from historic groundwater withdrawal similar to that documented in the Las Vegas Valley (Bell, 1981).

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