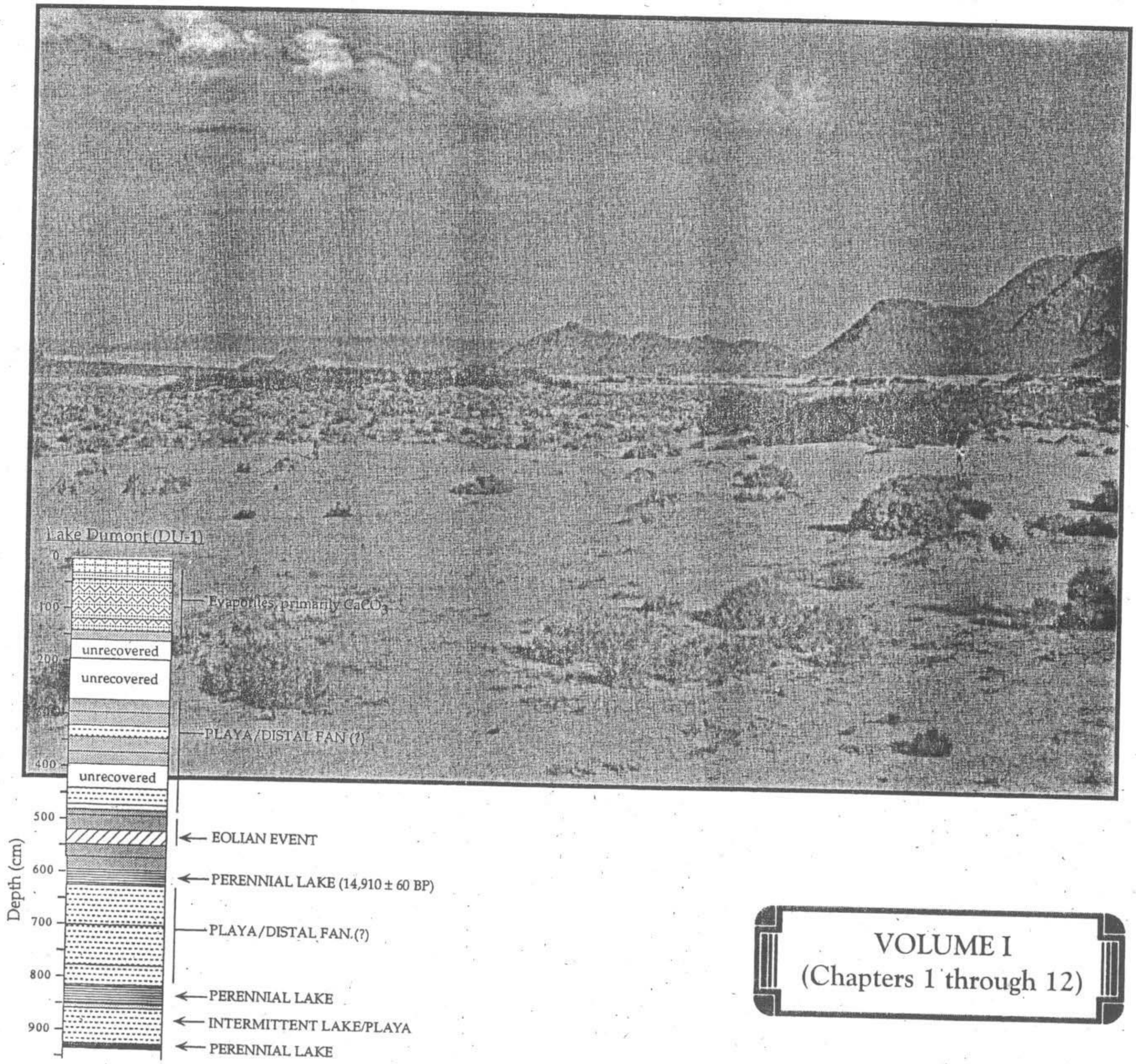
# Springs and Lakes in a Desert Landscape:
## Archaeological and Paleoenvironmental Investigations in the Silurian Valley and Adjacent Areas of Southeastern California



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(Chapters 1 through 12)

Edited by:
Brian F. Byrd

A·S·M

bedrock surfaces. Those deposits capping unit B1 (see Figure 44) are probably related to alluvial fan unit Qf5, and those capping unit B2 (see Figure 44) are most likely related to alluival fan unit Qf6. Unit Qf7 (or units Qf5 and Qf6 of Brown [1989]) are younger than Unit C (see Figure 44), or 1.5 ka, but older than some of the historic shoreline features.

# Surficial Geology of the Avawatz Mountains' Piedmont and Pluvial Lake Dumont

## Introduction

Lake Dumont occupies the last pluvial lake basin in a chain of basins extending from the Transverse Ranges of southern California to Death Valley (Figure 45). Lake Dumont is therefore the last catchment to hold waters from the Mojave River-Salt Creek drainage system prior to joining with the Amargosa River draining into Death Valley. The record of lacustrine events in Lake Dumont provides important correlative geomorphic and climatic data for interpreting paleoenvironments and archeological stratigraphy within the Silurian and southern Death Valley regions. Two 13-m deep cores provide evidence of perennial lakes, playa, and fan deposition between approximately 30,000 and 18,000 years ago. Valley fill alluvium accumulated some time between 15,000 and 2,500 years ago, probably during the early to middle Holocene. The period between 15,000 B.P. and commencement of alluvial aggradation is thought to be a time of basin scouring and throughflow of Salt Creek, carrying waters from Lake Mojave II overflow. Stratigraphic relationships of dated basin-fill deposits with piedmont fans provide a chronostratigraphic framework for interpreting periods of fan activity, soil development, and pavement formation which can ultimately be used for answering archeologically important questions.

Due to its geographic location, pluvial Lake Dumont provides a linkage between dated lacustrine, piedmont, and archeological sequences of pluvial lakes Mojave (Silver and Soda Lakes) and Manley (Death Valley). Wells et al. (1987a, 1989, 1990a) defined a period of high lake stands between approximately 22,000 and 8,000 years ago in Silver Lake basin. The older lake sequence, Lake Mojave I, ranged from approximately 22,000 to 17,000 B.P., and Lake Mojave II from about 15,000 to 800. B.P., based on uncalibrated radiocarbon ages from tufa, mollusk shells, bulk sediment, and calculated sedimentation rates (Enzel et al. 1989b, 1992). The period from 17,000 to 15,000. B.P. was evidently somewhat drier, with aeolian activity and lake desiccation (Brown 1989). A lake stand (pluvial Lake Manley) is also found during this time in Death Valley, lasting from about 30,000 to 10,000 years ago (Hooke 1972; Hunt 1975; Lowenstein et al. 1994). In addition to lacustrine studies, investigations of alluvial fan and soil relationships have provided a basis for fan correlation and age estimation in the Silver Lake-Soda Mountains, Cima volcanic field-Indian Springs piedmont, and other Mojave Desert locations (Harden et al. 1991a, 1991b; McFadden et al. 1986, 1989, 1992; Reheis et al. 1989; Ritter 1989; Wells et al. 1987a, 1990a).

The project area is dominated by the northwest-southeast trending Avawatz Mountains, where the highest point, Avawatz Peak, rises to a maximum elevation of 1877 m above sea level. The southeastern piedmont grades to an unnamed playa north of Silver Lake at an elevation of 255 m. Salt Creek flows north from Silver Lake through Silurian Valley to its confluence with the Amargosa River northwest of Salt Spring Hills. The eastern Avawatz piedmont grades to Salt Creek along which two basins, Silurian

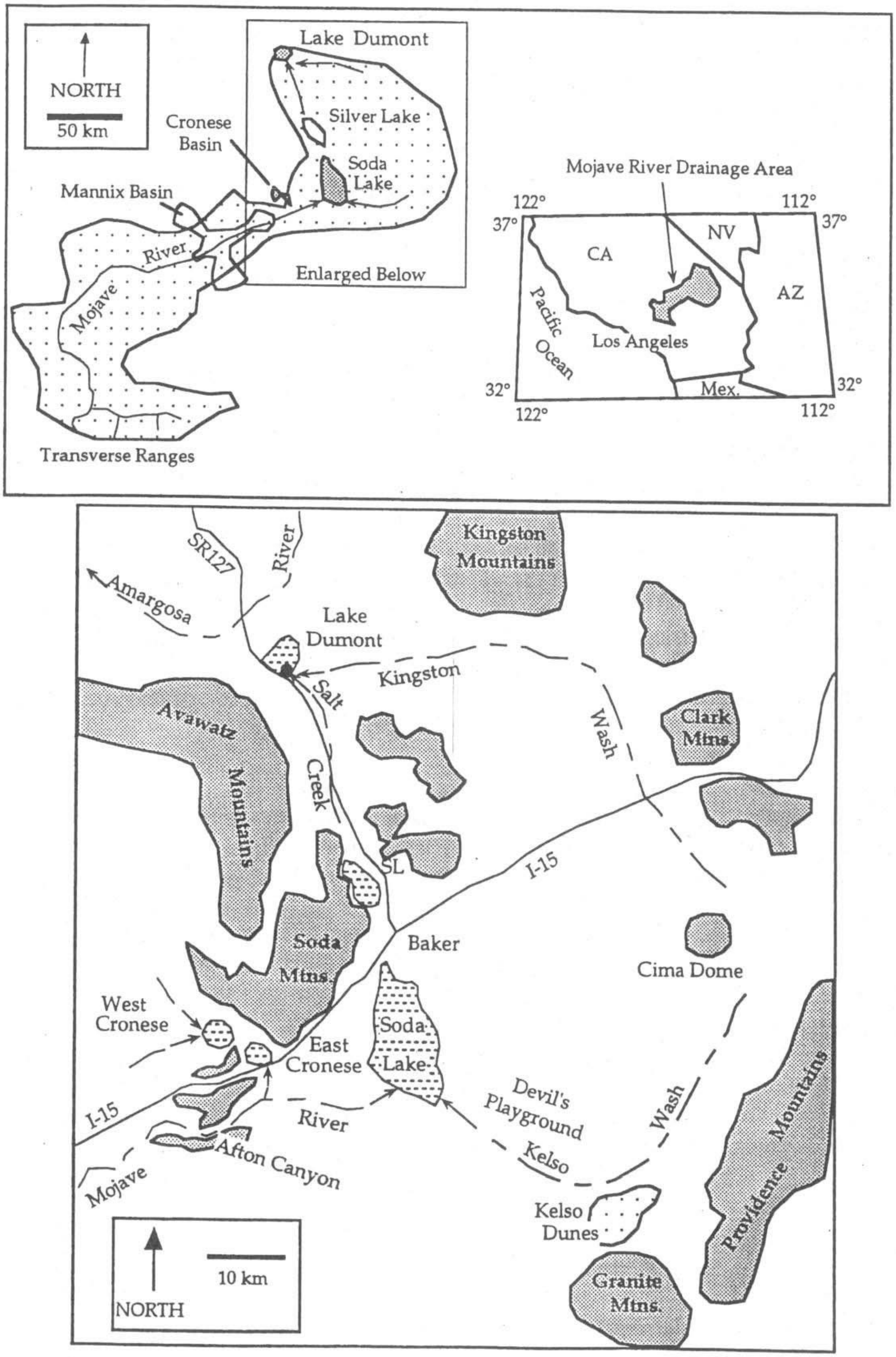

**Figure 45.** **Location map of project area showing features discussed in text.**

Lake playa and Lake Dumont, occur at elevations of 205 m and 170 m, respectively. To the north, the Avawatz piedmont grades to the Amargosa River where it enters Death Valley at an elevation of 75 m. The eastern side of Silurian Valley is a low gradient piedmont draining the Valjean, Silurian, and Hollow Hills. Between the Valjean and Silurian Hills is Valjean Valley, across which Kingston Wash flows into Salt Creek and through the Dumont basin, draining a large area including the Kingston Range, Clark Mountains, and Teutonia Peak. Between Silurian and Hollow Hills is a broad, low gradient piedmont across which Riggs Wash flows, draining a limited area, including Turquoise Mountain. The eastern Silurian Valley piedmont is characterized by older, gravel-rich alluvial fans buried by younger, fine-grained granitic fans and aeolian deposits.

Bedrock geology is summarized from the following three sources, 1) previously published geologic maps, 2) aerial photo interpretation, and 3) field reconnaissance investigations. Brady (1986a, 1990) focused on the tectonic relationship between the Garlock and southern Death Valley fault zones in the northern Avawatz Mountains. The most common unit in the range is the Mesozoic "Avawatz quartzite monsodiorite complex" and similar Mesozoic intrusives, including a variety of granitic and dioritic lithologies. In general, the quartzite monsodioritic rocks are dark to medium green in color, medium to coarse textured, equigranular, and massive. Minerals include quartz, biotite, hornblend, with minor epidote and chlorite. Within this plutonic body are Precambrian and Paleozoic roof pendants of sedimentary and metasedimentary rocks.

General geologic relationships of the plutonic core of the Avawatz Mountains include the following: 1) bounded on the west by Mesozoic granitic, metasedimentary, and metavolcanics as well as the Cenozoic Arastre Springs and Avawatz formations; 2) bounded on the north by Cenozoic Noble Hills and Military Canyon formations, and (3) bounded on the southeast by the Avawatz Formation.

To the east, piedmont fans are supplied to varying degrees by all of the above lithologies along the mountain front. Of particular interest to the present study is detailed mapping of bedrock units along the northern and eastern Avawatz Mountains' piedmont (Brady 1986a). Bedrock lithology and faults at the mouth of Sheep Creek Springs illustrate complex structural and lithological associations. Precambrian rocks include granite, granitic gneiss, gneiss, schist, talc, magnetite, quartzite, dolomite and other metasedimentary rocks. Paleozoic and Mesozoic rocks include marble and monzodiorite, respectively. Limestone, marble, and dolomite locally contain minor chert beds. Tertiary rocks are composed of the Noble Hills assemblage and are dominated by conglomeratic facies.

East of Sheep Creek Springs and south of the Salt Spring Hills, bedrock lithology becomes more granitic and includes Mesozoic granites of Avawatz Peak (Brady 1986a), and other undifferentiated Mesozoic granites. Along the eastern Avawatz Mountains' piedmont, bedrock lithology is dominated again by the Avawatz quartzite monsodiorite.

Lithologies of the drainage basins help determine the nature of the alluvial fan deposits. For instance, fans of the Sheep Creek Springs complex consist of higher proportions of more resistant lithologies, whereas those of the Anvil Canyon and Avawatz Peak alluvial fans appear to be dominated by granitic lithologies, at least in the latest Pleistocene (Qf4) and Holocene (Qf3) fan units. This will be discussed in greater detail later.

Temperature and precipitation values measured in Death Valley provide an approximation for climate in the study area, as Silurian Valley is the southward extension of Death Valley, 100 km to the north. Average precipitation is 42 mm/yr and average annual temperatures are 24.6 ° C.

Vegetation within the study area includes creoste, bursage, saltbush, and a variety of shrubs and grasses. Along Salt Creek and in the vicinity of Salt and Amargosa Springs, mesquite and arroyo willow are found. Today, the riparian corridor is dominated by tamarisk.

## Lacustrine and Alluvial Fill Sequences

The geomorphic setting of the Lake Dumont and Salt Spring Hills area is characterized by both fine and coarse alluvial fans ranging in age from late Pleistocene to Holocene (Figure 46). Prograding alluvial fans and their spatial distribution illustrate the constant encroachment of coarse clastic material towards the basin with a strong control on fan processes provided by base-level changes. Lake level fluctuations during the Pleistocene, and aggradational and degradational periods during latest Pleistocene and Holocene, have produced numerous fan sequences and periodic fan dissection along the basin periphery. Also along the Dumont basin periphery, green and gray lake (Ql) deposits are present. Within the interior of the basin, brown alluvial (and playa?) fill dominates (Qal1). Fans are both buried by the lake deposits and prograde over them. Shoreline features of pluvial lake Dumont occur on quartzite bedrock and on older alluvial fans. On the alluvial fill (Qal1) surface numerous coppice dunes occur. This surface has undergone significant erosion by both alluvial and aeolian processes. The Salt Creek fan, which emerges from a bedrock constriction, spreads over a wide area, interfingering with Amargosa River alluvium. The sediment supplied by Salt Creek to the floodplain provides sufficient material for dune activity (Qd), with the Little Dumont Dunes as evidence for modern dune formation. Along the western flanks of the Salt Spring Hills, sand and gravel ramps (Qsr) occur that are tens of meters thick and have very well-developed (Stage IV) calcic horizon development. These features attest to very active aeolian processes over a long time interval.

The chronology of late Pleistocene and Holocene lacustrine, playa, and alluvial deposits preserved along Silurian Valley and in Lake Dumont provides important constraints on regional hydrology, paleoclimate, and landscape reconstruction (Figure 47; Table 26). Seven AMS radiocarbon age estimates obtained from lake, playa, and alluvial sediments from two basins include: 1) 2 from Silurian Lake core Si-1, 2) 3 from Lake Dumont cores - 2 from core DU-1 and two from core DU-2, and 3) 2 from Holocene alluvial fill.

### Silurian Lake

The two uncalibrated AMS ages from Silurian Lake present problems for temporal correlation and environmental interpretation because they are reversed from their correct stratigraphic sequence (Figure 48). The older age, 13,450 ± 60 B.P. is from 5.8 m depth, whereas the younger age, 9250 ± 70 B.P., is at 17 m depth (Table 27). The reason for the reversal is not yet understood but may illustrate potential problems with AMS age determination on bulk sediments on alluvium. Because alluvial sediments may contain carbon from a number of different sources, such as in situ accumulation, older detritus, or aeolian influx, the various carbon sources may be of significant age differences. By applying AMS analysis to only a very small portion of the sample, a sample bias may be encountered. Therefore, one explanation for date reversal suggests the stratigraphically higher sample had older material dated and the stratigraphically lower sample had younger material dated. Bulk analysis on whole soil samples would provide at least an average age for all the carbon in the sample.

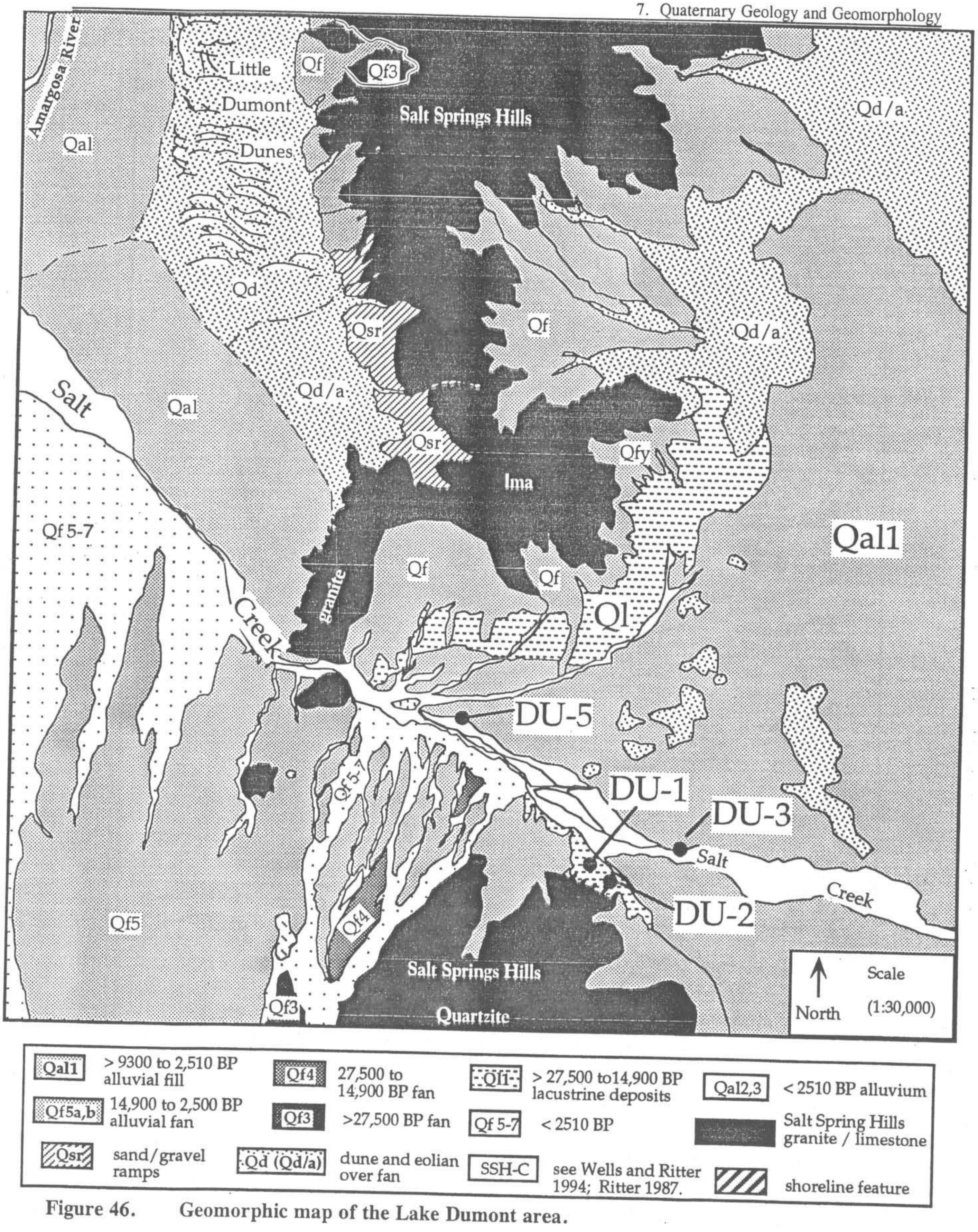

**Figure 46.** **Geomorphic map of the Lake Dumont area.**

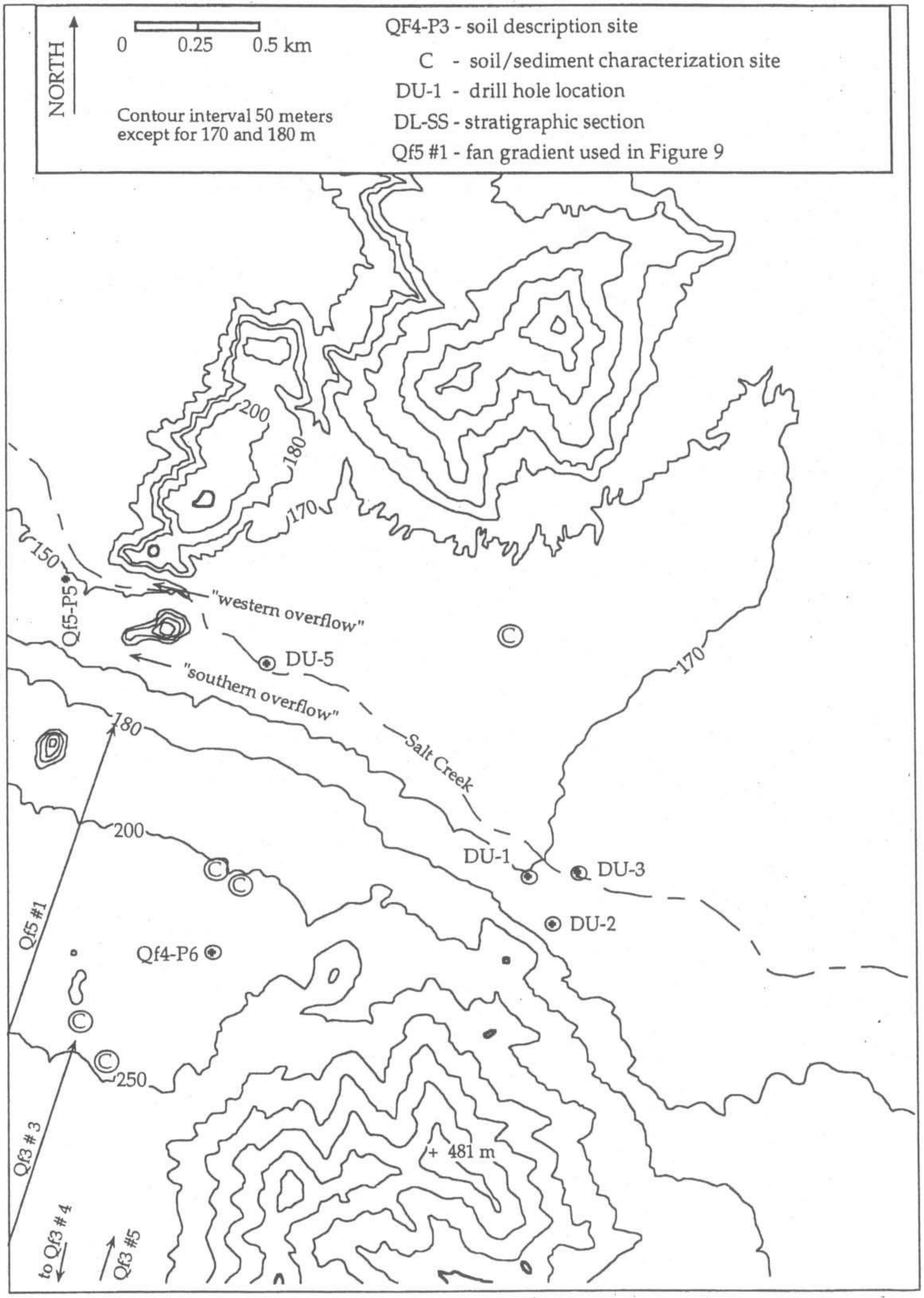

Figure 47. Topographic map of Lake Dumont area showing location of soil, and sediment sites, stratigraphic sections, location of drill holes, and fan gradient measurements discussed in the text.

Table 26. AMS ages and sample descriptions from Lake Dumont and Silurian Lake.

| Drill Hole Location | Sample No. | Lab No. | ~ Depth | Sample Type | Material Description (Munsell color; texture) | Wt (g) | AMS ages (uncalibrated) |
|---|---|---|---|---|---|---|---|
| Lake Dumont | DU-2-I | Beta-85 538 | 0.76 m | bulk sediment | 5Y 5/2<br>olive gray clay | 249 | 18,150 ± 80 B.P. |
| Lake Dumont | DU-2-IV | Beta-88 136 | 10.8 m | bulk sediment | 5Y 5/1 to 5/2<br>gray to olive gray silt and clay | 191 | 27,500 ± 360 B.P. |
| Lake Dumont | DU-1-I | Beta-93 120 | 6.6 m | bulk sediment | 5Y 6/2<br>light olive gray clay | 170 | 14,910 ± 60 B.P. |
| Lake Dumont | DU-3-Qal | Beta-94 111 | 0.6 m | disseminated charcoal | dark gray dissiminated | 100 | 9300 ± 60 B.P. |
| Lake Dumont | DU-5-Qal | Beta-93 386 | 0.6 m | charcoal | black<br>< 0.5 cm diameter | 22 | 2510 ± 50 B.P. |
| Silurian Lake | SI-1-I | Beta-85 541 | 5.8 m | bulk sediment | 10YR 6/4<br>light yellowish brown sand;<br>10YR 5/3 brown clay | 120 | 13,450 ± 60 B.P. |
| Silurian Lake | SI-1-II | Beta-85 542 | 18 m | bulk sediment | 10YR 4/2<br>dark gray brown sand;<br>10YR 4/3<br>brown clay | 161 | 9250 ± 70 B.P. |

Despite this problem, the core taken from Silurian Lake provides approximately 30 m of material for textural and environmental interpretation. The core texture and color are dominated primarily by massive brown clay and sandy clay deposits indicative of playa conditions. No obvious green or gray reduced sediments were found, suggesting that there may never have been a perennial lake occupying this basin. Stratigraphic evidence indicates flooding episodes evidenced by sand and sandy clay units as well as fine, laminated sand, silt, and clay representative of individual flooding events. This basin no longer receives overland flow from the Mojave River, and yet it held standing water for a few weeks prior to drilling for this project. Silurian Lake, therefore, receives enough water from local runoff to produce wet playa conditions, which may represent similar conditions for material described in the cores, at least for the post-Lake Mojave II period. The single core hole did not record any fluvial channel that would have represented a through-flowing stream connecting the Silver Lake and Dumont Lake basins, as might have existed during pluvial periods.

## Lake Dumont

The approximately 16-m deep DU-2 core from Lake Dumont is dominated by 5Y 5/2 (olive gray) reduced sediments, indicating numerous perennial and intermittent lake events, interbedded with white evaporites or precipitates, brown clastic sand, silt, and clay, and alluvial fan gravels. Two AMS radiocarbon samples from 0.76 and 10.8 m depth, provided uncalibrated ages of 18,150 ± 80 B.P. and 27,500 ± 360 B.P., respectively (Figure 49). Both samples are gray to olive gray clays representing reduced sediments formed during a perennial lake event. Calculating a rough sedimentation rate for this core provides an estimate of 1.0 m per 935 years, giving a maximum age estimate on the oldest lake event of approximately

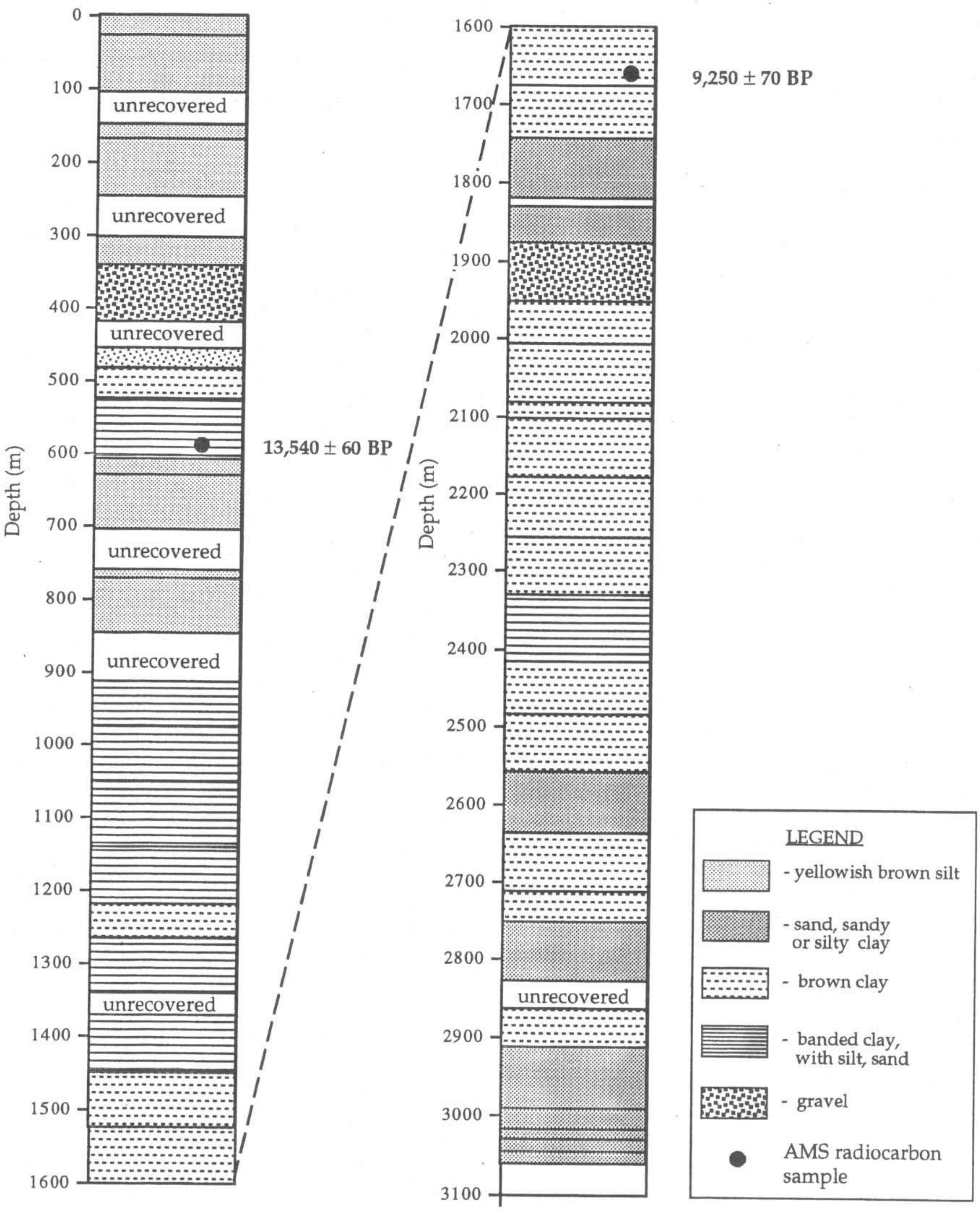

**Figure 48.** Measured and described stratigraphic section of Silurian Lake core Si-1. For details, see Table 27.

## Table 27. Summary of core data from Silurian Lake (Si-1)

| Start depth (cm) | End depth (cm) | Layer thickness (cm) | AMS age | Lithology |
|---|---|---|---|---|
| 0 | 30 | 30 | | 10YR 6/3pale brown silt |
| 30 | 106 | 76 | | 10YR 6/4 light yellowish brown silt |
| 106 | 152 | 46 | | unrecovered |
| 152 | 172 | 20 | | 10YR 6/3 pale brown silt |
| 172 | 248 | 76 | | 10YR 6/3 pale brown fine sandy silt |
| 248 | 304 | 56 | | unrecovered |
| 304 | 344 | 40 | | 10YR 5/3 brown fine sandy silt |
| 344 | 420 | 76 | | 10YR 5/3 brown sand and gravel |
| 420 | 456 | 36 | | UN |
| 456 | 486 | 30 | | 10YR 6/4 light yellowish brown sand |
| 486 | 527 | 41 | | 10YR 5/3 brown clay |
| 527 | 563 | 36 | | 10YR 6/4 to 5/3 banded very fine sand, silt, clay |
| 563 | 604 | 41 | 13,540 ± 60 B.P. | 10YR 6/4 to 5/3 banded very fine sand, silt, clay |
| 604 | 610 | 6 | | UN |
| 610 | 630 | 20 | | 10YR 6/3 pale brown fine sandy silt |
| 630 | 706 | 76 | | 10YR 5/3 brown fine sandy silt |
| 706 | 762 | 56 | | UN |
| 762 | 772 | 10 | | 10YR 5/3 brown fine sandy silt |
| 772 | 848 | 76 | | 10YR 5/3 brown fine sandy silt |
| 848 | 914 | 66 | | UN |
| 914 | 977 | 63 | | 10YR 6/4 to 4/4 banded fine sand, silt, clay |
| 977 | 1053 | 76 | | 10YR 5/3 banded fine sand, silt, clay |
| 1053 | 1067 | 14 | | unrecovered |
| 1067 | 1143 | 76 | | 10YR 6/4 to 4/3 banded fine sand, silt, clay |
| 1143 | 1219 | 76 | | 10YR 6/4 to 4/3 banded fine sand, silt, clay |
| 1219 | 1267 | 48 | | 7.5YR 5/3 to 10YR 4/3 clay |
| 1267 | 1343 | 76 | | 10YR 6/4 to 4/3 banded fine sand, silt, clay |
| 1343 | 1372 | 29 | | unrecovered |
| 1372 | 1448 | 76 | | 10YR 5/3, 5/4, and 4/4 banded sand, silt, clay; banded fine sand, silt, clay |
| 1448 | 1524 | 76 | | 10YR 4/4 yellowish brown clay |
| 1524 | 1600 | 76 | | 10YR 4/4 yellowish brown clay |
| 1600 | 1676 | 76 | | 10YR 5/3 and 4/3 dark brown clay |
| 1676 | 1743 | 67 | 9250 ± 70 B.P. | 10YR 4/3 and 4/2 dark grayish brown sand and clay |
| 1743 | 1819 | 76 | | 7.5YR 4/4 brown sandy clay |
| 1819 | 1829 | 10 | | unrecovered |
| 1829 | 1876 | 47 | | 10YR 5/3 sandy clay |
| 1876 | 1952 | 76 | | 10YR 5/3 sandy clay with pebbles near bottom |
| 1952 | 2007 | 55 | | 10YR 5/4 fine sand to 10 YR 4/4 sandy clay near bottom |
| 2007 | 2083 | 76 | | 10YR 4/4 sandy clay |
| 2083 | 2104 | 21 | | 10YR 4/4 dark yellowish brown clay |
| 2104 | 2180 | 76 | | 10YR 4/4 dark yellowish brown clay |
| 2180 | 2256 | 76 | | 10YR 4/4 dark yellowish brown clay |
| 2256 | 2329 | 73 | | 10YR 4/4 dark yellowish brown clay |
| 2329 | 2405 | 76 | | 10YR 4/3 brown clay with fine sand lenses interbedded |
| 2405 | 2408 | 3 | | unrecovered |
| 2408 | 2484 | 76 | | 7.5YR 5/3 brown clay |
| 2484 | 2560 | 76 | | 7.5YR 5/3 brown clay |
| 2560 | 2636 | 76 | | 7.5YR 5/3 brown sandy clay |
| 2636 | 2712 | 76 | | 10YR 4/4 sandy clay and clay |
| 2712 | 2752 | 40 | | 10YR 4/3 brown clay |

| Start depth (cm) | End depth (cm) | Layer thickness (cm) | AMS age | Lithology |
|---|---|---|---|---|
| 2752 | 2828 | 76 | | 10YR 4/4 and 5/2 sandy clay |
| 2828 | 2864 | 36 | | unrecovered |
| 2864 | 2914 | 50 | | 10YR 4/3 brown clay |
| 2914 | 2990 | 76 | | 10YR 4/4 sandy clay |
| 2990 | 3016 | 26 | | 10YR 4/4 and 5/3 clay and sandy clay |
| 3016 | 3031 | 15 | | 10YR 4/4 and 5/3 clay and sandy clay |
| 3031 | 3046 | 15 | | 10YR 4/4 and 5/3 clay and sandy clay |
| 3046 | 3061 | 15 | | 10YR 4/4 and 5/3 clay and sandy clay |

30,000 B.P. Using this sedimentation rate, several distinct intermittent lake, perennial lake, and alluvial fan (lake lowering) periods can be estimated (Table 28). The oldest, most persistent perennial lake period lasted from about 30,000 B.P. to 25,300 B.P. Following this period, alluvial fan coincident with lake lowering deposited approximately 1.5 m of sand and gravel. This drier period is estimated to have occurred 24,700 years ago, followed by construction of another perennial to intermittent lake with 0.75 m of gray clay around 23,400 B.P. Between about 23,400 and 19,400, the basin experienced periods of intermittent lake/playa and distal fan flood activity, with nearly 3 m of brown sand and sandy clay, culminating in nodular carbonate and white clay deposits believed to represent desiccation. Perennial lake conditions returned between about 19,400. and 18,000 years ago with nearly 2 m of olive gray clay to brown sandy clay deposits representing wetter conditions. The earlier lake that lasted from approximately 30,000 to 25,300 years ago is informally refered to as Lake Dumont I, whereas the younger period of lake activity, between about 19,400 B.P. and 18,000 B.P., is refered to as Lake Dumont II.

Core DU-2 is located approximately 100 m closer to the Salt Spring Hills bedrock than DU-1 and was initially placed to record near-shore conditions and possible shoreline or fan features (Figure 50). DU-1, being closer to the center of the basin, was placed to record deeper water conditions. However, the approximately 15-m deep core DU-1 is dominated by white capillary fringe evaporites near the top and brown sand, sandy clay, and clay throughout the core sequence (Table 29). This initial observation combined with its more basin ward location led to the interpretation that it might record the younger alluvial fill, and not the true lake deposits. A more detailed survey of the geomorphic setting, descriptions of the core material, and comparison with DU-2 have led to the conclusion that DU-1 and DU-2 are probably the same age. The difference is explained by sedimentary facies changes, where DU-1 represents a peripheral fan-delta sequence that can be correlated with the deeper water facies from DU-2. In addition, DU-1 sediments have been partially eroded and represent, to a great extent, a younger, latest Pleistocene sequence. An AMS radiocarbon age of 14,910 ± 60 B.P. suggests DU-1 contains sediments representating a lake event correlative with Lake Mojave II. Subsequent breaching prohibited further late Pleistocene and later lakes from forming in the basin.

Core DU-1 records perennial lake conditions at only two depths, 6 to 6.5 m and 8 to 9.5 m. Moist conditions may be represented by marsh and marl deposits at approximately 10 to 11 m. Similarities in DU-1 and DU-2 include alluvial fan deposits at the base; marsh and perennial lake conditions at approximately the same 10 m depth; and lake lowering events represented by alluvial fan (DU-2) and playa/distal fan (DU-1) facies at approximately 6 and 8.5 m. The time between Lake Dumont I and II is represented in DU-1 by playa, alluvial fan, and aeolian deposits. Lake Dumont II is represented in DU-1 by capillary fringe carbonates and salts, indicating that groundwater intersected the land surface and salts precipitated, probably during high water conditions.

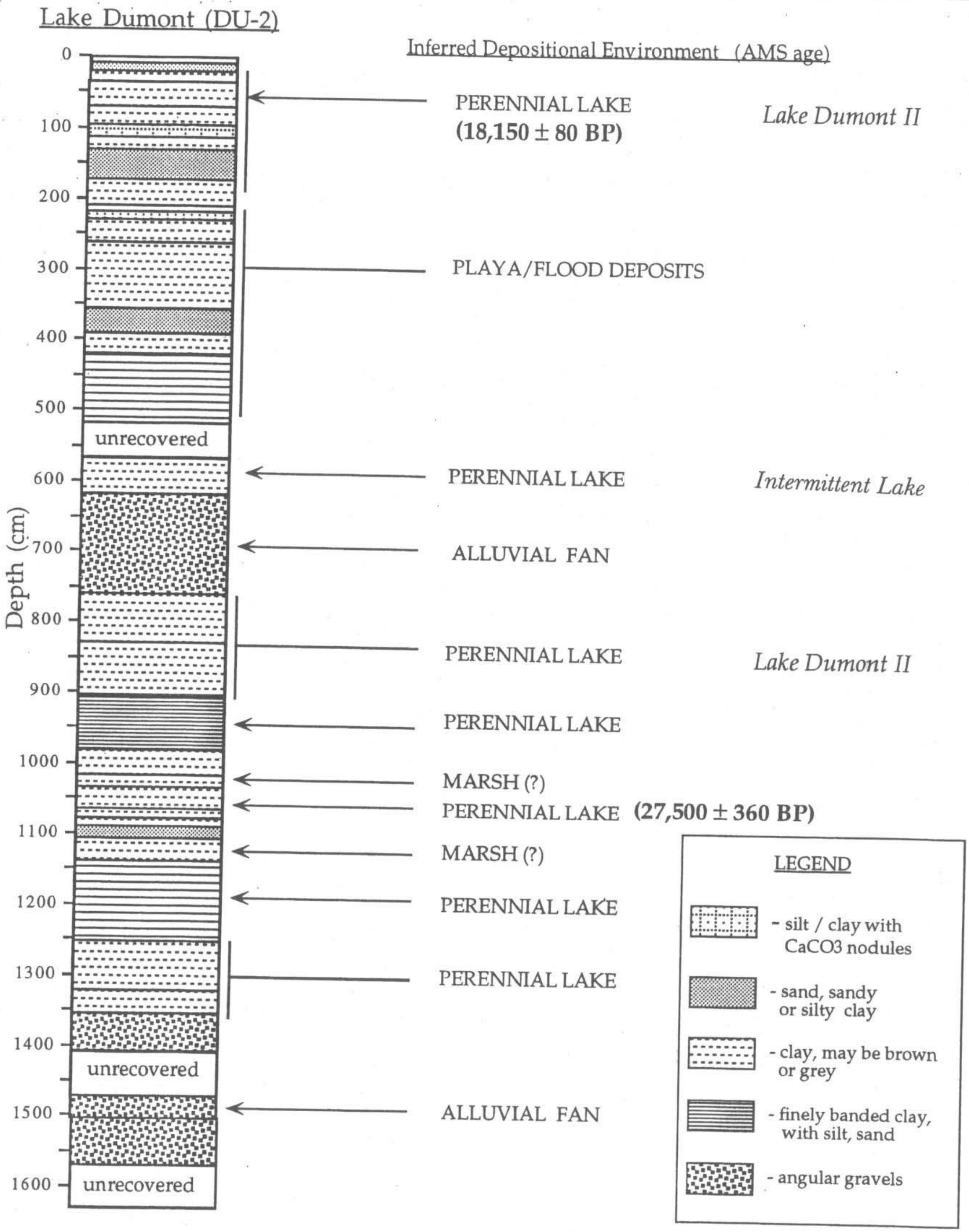

**Figure 49.** Measured and described stratigraphic section of Lake Dumont core DU-2 with probable depositional environments. For detailed core descriptions, see Table 28.

## Table 28. Summary of core data from Lake Dumont (DU-2) showing age relationships and probable depositional environments.

| Start depth (cm) | End depth (cm) | Layer Thickness (cm) | Description | Age* | Depositional Environment |
|---|---|---|---|---|---|
| 0 | 10 | 10 | UNRECOVERED | | |
| 10 | 24 | 14 | light yellowish brown (10YR 6/4) very fine sand | | |
| 24 | 39 | 15 | brown to dark brown (7.5YR 4/3) clay | | intermittent lake |
| 39 | 76 | 37 | olive gray (5Y 5/2) clay (with brown lenses) | 18,150 ± 80 B.P. | perennial lake |
| 76 | 103 | 27 | olive gray (5Y 5/2) clay (with brown lenses) | | perennial lake |
| 103 | 118 | 15 | white (10YR 8/2) nodules | | intermittent lake dessication |
| 118 | 138 | 20 | light olive gray (5Y 6/2) clay | | perennial lake |
| 138 | 183 | 45 | weak red (2.5 YR5/2) sand,clay | | intermittent lake |
| 183 | 213 | 30 | olive gray (5Y 5/2) clay | 19.400 (est.) B.P. | perennial lake |
| 213 | 229 | 16 | UNRECOVERED | | |
| 229 | 240 | 11 | white (10YR 8/2) clay | | intermittent lake dessication |
| 240 | 261 | 21 | brown to dark brown (7.5YR 4/3) clay | | playa with flood deposits |
| 261 | 369 | 108 | gray brown (10YR 5/2) clay (with light gray (10YR 7/2) nodules up to 3 cm length | | |
| 369 | 390 | 21 | brown to dark brown (10YR 4/3) sand/clay | | playa with flood deposits |
| 390 | 420 | 30 | brown (10YR 5/3) clay | | playa with flood deposits |
| 420 | 523 | 103 | brown (10YR 5/3) clay with interbedded sands lenses 5 cm thick | | playa with flood deposits |
| 523 | 564 | 41 | UNRECOVERED | | |
| 564 | 639 | 75 | olive gray (5Y 5/2) clay | 23,400 (est.) B.P. | perennial lake |
| 639 | 784 | 145 | brown (7.5YR 5/3) clay and brown (10YR 5/3) sand with rocks up to 3.5 cm diameter | 24,700 (est.) B.P. | alluvial fan |
| 784 | 844 | 60 | brown (10YR 5/3) sand to olive gray (5Y 5/2) clay transition | 25,300 (est.) B.P. | perennial lake |
| 844 | 901 | 57 | olive gray (5Y 5/2) clay | | perennial lake |
| 901 | 1014 | 113 | gray (5Y 5/1) clay with fine lamination of "grn/brn/pink" | | perennial lake |
| 1014 | 1039 | 25 | dark grayish brown (10YR 4/2) clay | | perennial lake |
| 1039 | 1079 | 40 | gray (5Y 5/1) clay | 27,500 ± 360 B.P. | perennial lake |
| 1079 | 1099 | 20 | olive gray (5Y 5/2) sand | | perennial lake |
| 1099 | 1114 | 15 | brown (10YR 5/3) sand | | |
| 1114 | 1124 | 10 | olive gray (5Y 5/2) clay | | perennial lake |
| 1124 | 1144 | 20 | grayish brown (10YR 5/2) clay | | perennial lake |
| 1144 | 1174 | 30 | olive gray (5Y 5/2) clay | | perennial lake |
| 1174 | 1294 | 120 | finely laminated olive gray (5Y 5/2) clay; white (5YR 8/2) CaCO3 nods; & brown (7.5YR 5/3) clay | | perennial lake |
| 1294 | 1334 | 40 | olive gray (5Y 5/2) clay | | perennial lake |
| 1334 | 1354 | 20 | olive gray (5Y 5/2) clay | 30,000 (est.) B.P. | perennial lake |
| 1354 | 1404 | 50 | brown sand, silt, gravel (5 cm diam) | | alluvial fan |
| 1404 | 1480 | 76 | UNRECOVERED | | |
| 1480 | 1501 | 21 | brown sand, silt, gravel w/ olive gray (5Y 5/2) mottles | | alluvial fan |
| 1501 | 1577 | 76 | brown sand, silt, gravel w/ olive gray (5Y 5/2) mottles | | alluvial fan |
| 1577 | 1632 | 55 | UNRECOVERED | | |

* (est.) = ages estimated from sedimentation rates

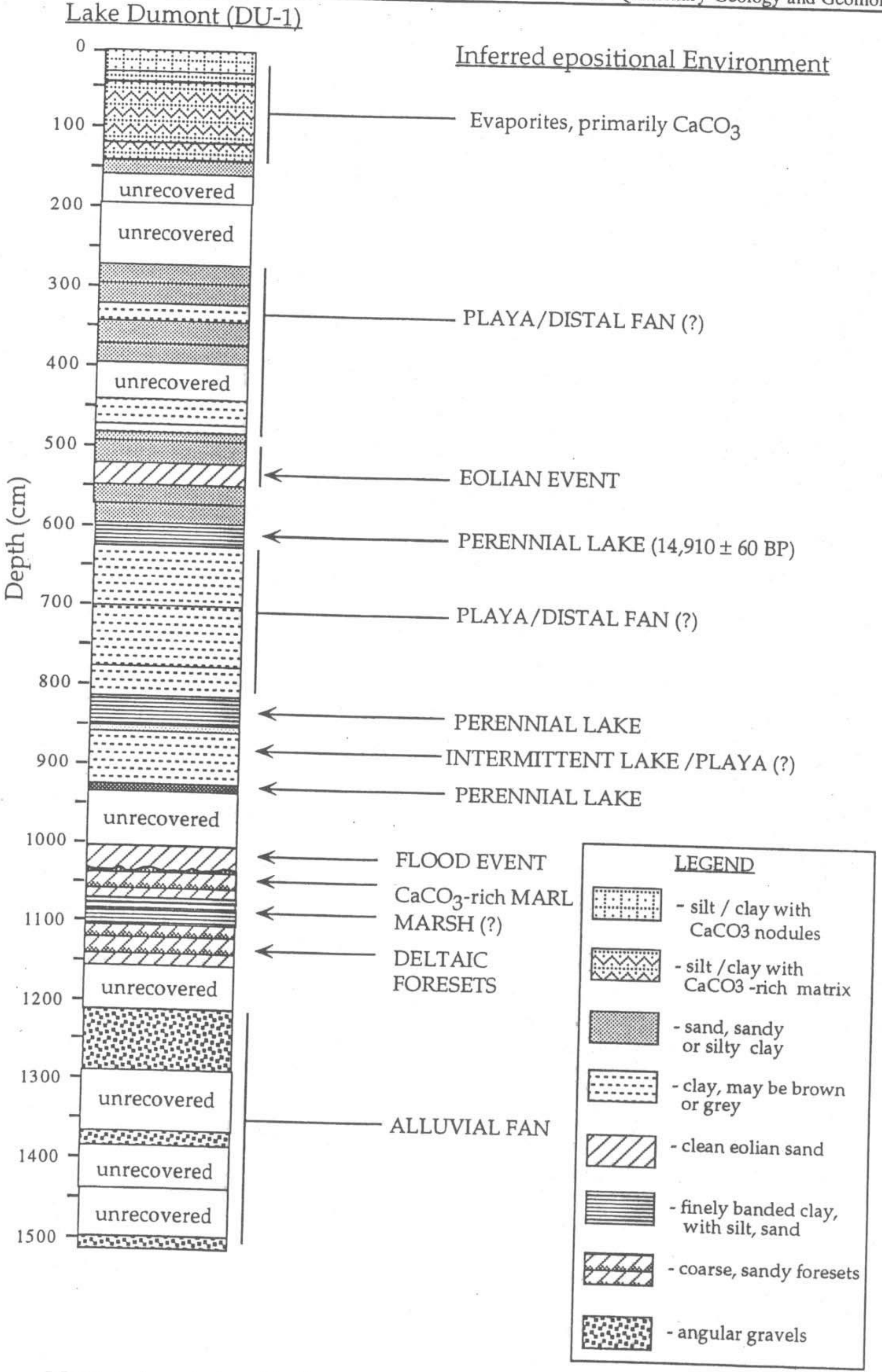

**Figure 50.** Measured and described stratigraphic section of Lake Dumont core DU-1. For detailed core description, see Table 29.

## Table 29. Summary of core data from Lake Dumont (DU-1).

| Start depth cm) | End depth (cm) | Layer Thickness (cm) | Description | AMS age | Depositional Environment |
|---|---|---|---|---|---|
| 0 | 30 | 30 | 10YR 6/4 light yellowish brown silt/clay with CaCO3 nodules | | dessication |
| 30 | 44 | 14 | 10YR 5/3 brown silt/clay with CaCO3 nodules | | dessication |
| 44 | 120 | 76 | 10YR 5/3 brown silt/clay dominated by evaporites (10YR 2/2) | | dessication |
| 120 | 140 | 20 | 10YR 5/3 brown silt/clay dominated by evaporites (10YR 8/2) | | dessication |
| 140 | 160 | 20 | 10YR 4/4 dark yellowish brown sandy clay | | dessication |
| 160 | 196 | 36 | UNRECOVERED | | |
| 196 | 272 | 76 | UNRECOVERED | | |
| 272 | 297 | 25 | 10YR 5/4 yellowish brown fine sandy clay | | playa/distal fan (?) |
| 297 | 322 | 25 | 10YR 5/4 yellowish brown sandy clay | | playa/distal fan (?) |
| 322 | 342 | 20 | 10YR 4/4 yellowish brown clay | | playa/distal fan (?) |
| 342 | 372 | 30 | 10YR 4/4 yellowish brown fine sand | | playa/distal fan (?) |
| 372 | 398 | 26 | 10YR 3/4 yellowish brown sandy clay | | playa/distal fan (?) |
| 398 | 440 | 42 | UNRECOVERED | | |
| 440 | 474 | 34 | 10YR 4/3 clay | | playa/distal fan (?) |
| 474 | 484 | 10 | 10YR 4/3 brown silty clay | | playa/distal fan (?) |
| 484 | 494 | 10 | 10YR 5/4 yellowish brown fine sand | | aeolian event |
| 494 | 524 | 30 | 10YR 4/4 dark yellowish brown fine sand | | aeolian event |
| 524 | 547 | 23 | 10YR 4/4 dark yellowish brown clean, well-sorted fine sand with foresets | | aeolian event |
| 547 | 550 | 3 | 10YR 4/4 dark yellowish brown clay | | playa/distal fan (?) |
| 550 | 573 | 23 | 10YR 4/3 silty sand | | playa/distal fan (?) |
| 573 | 596 | 23 | 10YR 5/2 silty clay | | playa/distal fan (?) |
| 596 | 626 | 30 | 5Y 6/2 light olive gray clay banded with white and brown laminae | 14,910 ± 60 B.P. | perennial lake |
| 626 | 702 | 76 | 10YR 5/3 brown clay | | playa/distal fan delta (?) |
| 702 | 778 | 76 | 10YR 5/4 yellowish brown clay | | playa/distal fan delta (?) |
| 778 | 816 | 38 | 10YR 5/4 yellowish brown clay | | playa/distal fan delta (?) |
| 816 | 854 | 38 | 5Y 5/2 clay with finely banded white, brown, red silt and clay | | perennial lake |
| 854 | 860 | 6 | 10YR 4/4 dark yellowish brown fine sand | | intermittent lake |
| 860 | 926 | 66 | 10YR 4/3 brown sand transition from clays below | | perennial lake |
| 926 | 936 | 10 | 5Y 5/2 olive gray clay banded with reddish brown (5YR 4/3) clay | | perennial lake |
| 936 | 1006 | 70 | UNRECOVERED | | |
| 1006 | 1037 | 31 | 10YR 4/4 dark yellowish brown fine sand | | flood event with erosional lower boundary |
| 1037 | 1072 | 35 | 2.5Y 8/0 white sandy clay; violent reaction to HCl | | CaCO3-rich laminated sandy clay possibly freshwater marl |
| 1072 | 1082 | 10 | 10YR 3/1 black sandy clay | | marsh |
| 1082 | 1089 | 7 | 10YR 5/3 brown clay | | marsh |
| 1089 | 1109 | 20 | 10YR 5/3 brown clay interbedded with brown sands | | flood deposits |
| 1109 | 1161 | 52 | 10YR 5/3 sand and interbedded clay and CaCO3 with dipping foresets | | fan-delta foresets |
| 1161 | 1215 | 54 | 5YR 5/4 reddish brown and black Fe and Mn stains in brown sand matrix | | fan-delta with oxidizing conditions |
| 1215 | 1291 | 76 | 10YR 4/2 dark grayish brown fine sand and clay with gravels | | alluvial fan-delta |

| Start depth cm) | End depth (cm) | Layer Thickness (cm) | Description | AMS age | Depositional Environment |
|---|---|---|---|---|---|
| 1291 | 1367 | 76 | UNRECOVERED | | |
| 1367 | 1387 | 20 | quartzite gravels | | alluvial fan |
| 1387 | 1443 | 56 | UNRECOVERED | | |
| 1443 | 1504 | 61 | UNRECOVERED | | |
| 1504 | 1519 | 15 | quartzite gravels | | alluvial fan |

The valley fill alluvium (Qal1) is brown and generally fine textured. It can be subdivided into three distinct depositional units (1, 2, and 3) (Figure 51). Unit 1, the lower unit, consists of thinly bedded clay and sand deposits that fine upwards. Ripple laminae and less than 5-cm thick trough cross-bedding is preserved. Unit 2 consists of thicker bedded sands with minor, discontinuous clay lenses. Unit 3 is the upper 0.5 m and consists of silt and clay cemented with gypsum and CaCO3. A radiocarbon sample collected from 0.6 m yielded an uncalibrated age of 2510 ± 50 B.P. Another sample from approximately 1 km upstream was collected from the same depth from a "burn" layer, that consisted of a 1-cm oxidized red zone overlain by 1 cm of dark gray, ashy disseminated charcoal. This couplet persisted for ten or more meters laterally. The AMS radiocarbon age 9300 ± 60 B.P. suggests the valley-fill material consists of a nearly complete Holocene alluvial package, with important implications for buried archeological material.

## Alluvial Fan Stratigraphy

Preliminary age estimates of geomorphic surfaces were established by tentative correlation to a fan sequence in the Salt Spring Hills and a dated fan sequence in the Soda Mountains, near Silver Lake (Wells and Ritter 1994; Wells et al. 1987b). Refinement and age control were then obtained by correlation of stratigraphic alluvial fan sections to dated lacustrine and playa depositional units. This provided constraints on Qf3 through Qf7 fan deposition, and identification of secondary fan units such as Qf4a, Qf4b, Qf5a, Qf5b, Qf6a, and Qf6b. These higher resolution subdivisions of fan units are defined in the vicinity of the Dumont basin with their occurrence and preservation probably a result of base-level fluctuations within Dumont basin and fan gradient changes resulting thereof. Correlation of mapped units across the project area was subsequently made on the basis of geomorphic position, soil development, degree of alteration of geomorphic surfaces, and elevation above local base level (Figure 52; Table 30).

As mentioned previously, Lake Dumont and its associated fan and alluvial deposits are located where Silurian Valley ends and southern Death Valley begins. Salt Creek, which flows from Silver Lake through Silurian Valley and Lake Dumont, has its confluence with the Amargosa River about 3 m to the northwest of the Salt Spring Hills. The Avawatz Mountains' piedmont grades to Salt Creek to the east and to the Amargosa River to the north. Along the eastern Avawatz Mountain piedmont, mapped fan units are correlative with those along the northern piedmont, with Neogene and early to middle Pleistocene deposits represented by valley-and-ridge morphology and highly dissected fan remnants. These older deposits are located close to the mountain front and may or may not be recognizable in plan view as alluvial fan landforms.

The Qf3 depositional unit forms the most recognizable fan land form, from both aerial photograph and ground perspectives. They are dark toned, smooth surfaces with very little vegetation and distinctly tapered erosional morphology when viewed in plan section. The dark tone and smooth surface are from the very well-developed desert pavement and strong varnish development. Soils are not as well developed as surface characteristics might suggest, with Stage II to II$^+$ carbonate morphology and a relatively weak

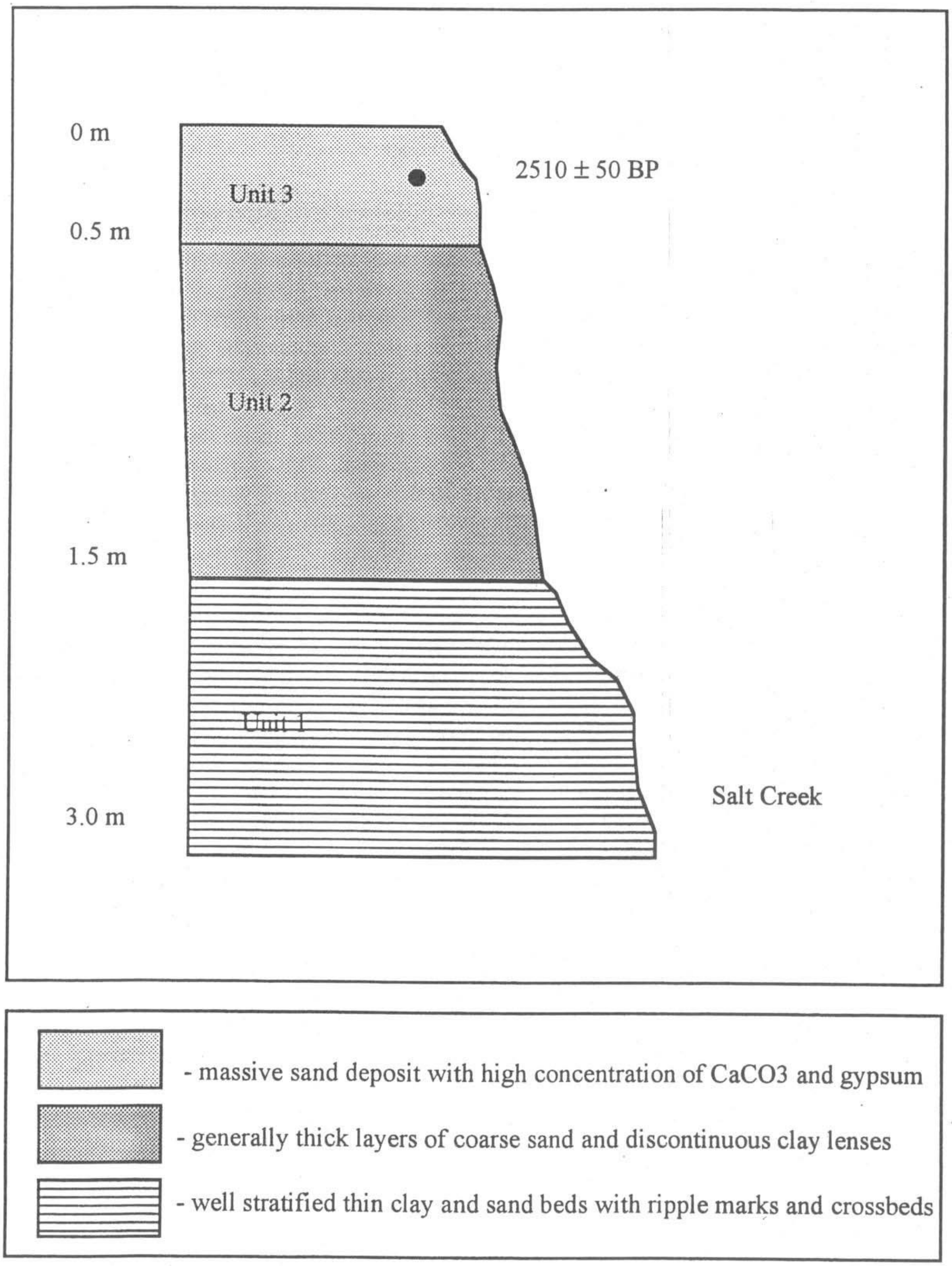

**Figure 51.** **Stratigraphic section of DU-5-Qal showing AMS radiocarbon sample location and relationships to Qal1 depositional units discussed in the text.**

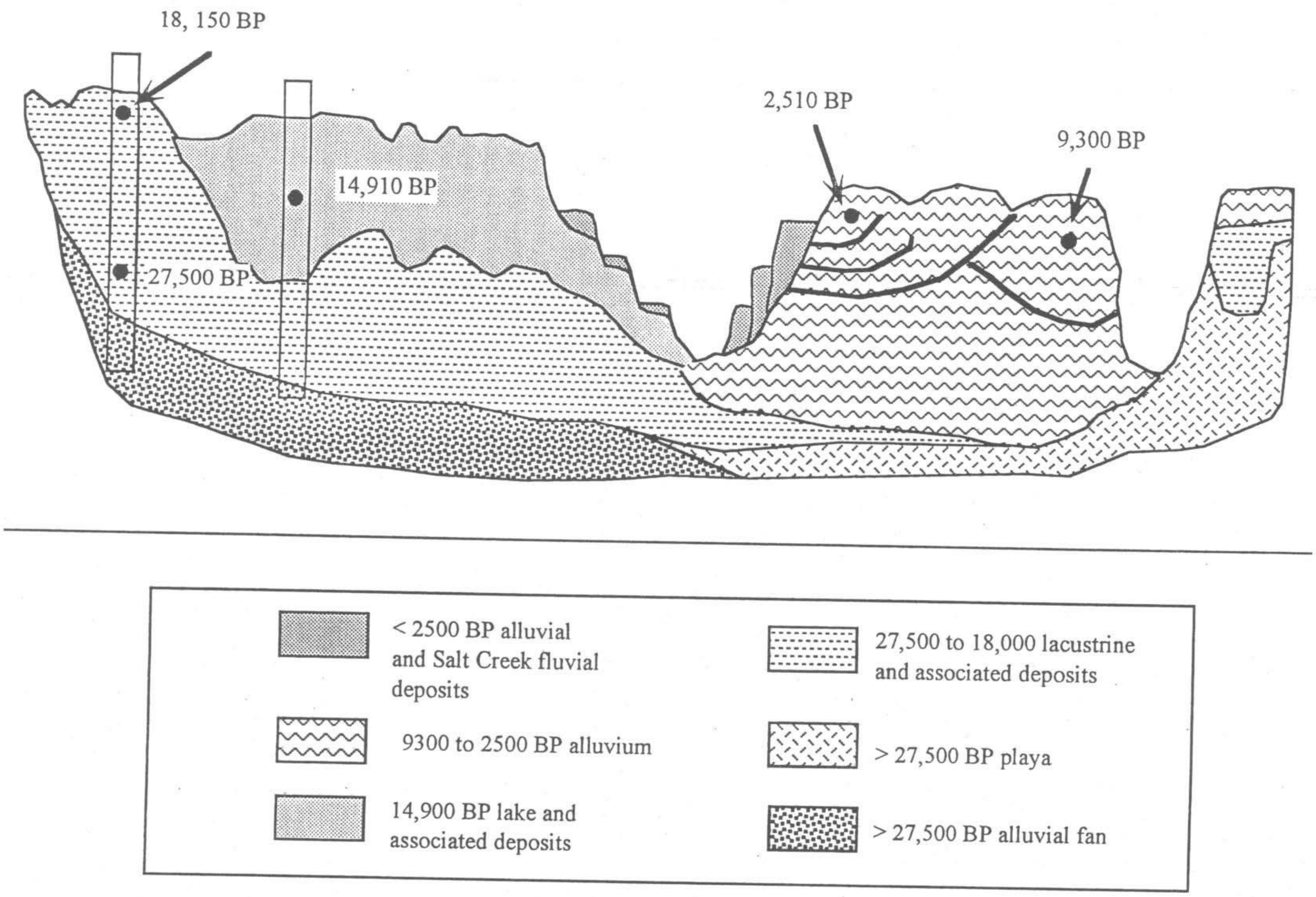

**Figure 52.** **Schematic diagram illustrating stratigraphic relationships of dated lake cores and valley-fill alluvium. (Details discussed in the text.)**

## Table 30. Late Cenozoic alluvial fan stratigraphy along the Avawatz Mountains' piedmont and correlations with lake building events in pluvial Lake Dumont, Mojave Desert.

| Avawatz Mtns | Description of Fans along Avawatz Mountains' Piedmont (this study) |
|---|---|
| Qf7 | Active channel; no varnish; no pavement; rounded to subrounded clasts; well-developed bar and swale topography. |
| Qf6<br>(< 2.5 ka) | Stable bars; active during high magnitude events; very weak varnish, very weak pavement; dust accumulation minor with Av < 0.5 mm. In vicinity of Salt Spring Hills this deposit is related to lowering of Salt Creek base level and downcutting through Salt Creek alluvial fill that may be differentiated into Qf6a and Qf6b, both younger than 2.5 ka and grading to main stream alluvial strath terraces. |
| Qf5a, b | Differentiated into Qf5a and Qf5b in vicinity of Salt Spring Hills. Qf5a progrades over lake deposits, reworking and regrading Qf4b surface. Qf5b inset into lake and older fans and may have formed constriction necessary to build up Salt Creek alluvial fill dated > 2.5 ka. |
| Qf5(latest Pleistocene to early Holocene)<br>(14.9 to 2.5 ka) | Extensive broad fans and elongate fan remnants extending from mountain front to basin; dissected by Qf5b, Qf6 and first order drainages; weak to moderate varnish (7.5YR 3/0); moderate to strong interlocking clasts; moderate boulder density; strong to moderate bar-and-swale relief with bar relief dominant; strong, well-sorted pavement on broad interfluves with sheetflood bedforms; moderate clast splitting; clast rubification - 2.5YR to 5YR 4/4. Avtk-(Bw)-Ck soils. |
| Qf4a, b | Differentiated into Qf4a and Qf4b in vicinity of Salt Spring Hills, with Qf4a representing fan-delta facies contemporaneous with lake building periods (18 to > 27 ka), and Qf4b representing fan deposition closely following lake lowering. |
| Qf4 latest Pleistocene<br>(30-14.9 ka) | Isolated, elongate to equant fan remnants on piedmont slopes; moderate to strong varnish development; moderate but distinct bar-and-swale relief; strong interlocking pavement clast; sheetflood bedforms present; common clast splitting; Av-Bk-Ck soils. |
| Qf3mid-late Pleistocene<br>(>30 ka) | Isolated, elongate fan remnants on piedmont, equant remnants near mountain front; complex geomorphic relationships with younger units with both inset, and superposed stratigraphy due to convergence of fan gradients in distal regions; surface dissected by high order drainages; very strong varnish (7.5YR 3/0); very well-developed pavement with sheetflood bedforms; pavement contains $CaCO_3$ rinds and angular to subrounded clasts; low boulder density; bar relief minimal, single clast relief dominant; bars not common; well-developed soil with argillic and calcic horizons. In places stratigraphically below Lake Dumont I phase (app. 24 to 30 ka). Avtk-Bvtk-Btk1-Btk2 soils. |
| Qf2 Early-mid Pleistocene (possibly Neogene) | Isolated fan remnants at mountain front and within catchment areas; surface dissected by high order streams; moderate to strong varnish where preserved; deeply dissected with rounded interfluves; some remnants have very well-developed pavements on broad, flat interfluves; single clast relief of cobbles; boulders are rare; soils may be stripped with younger (Holocene?) vesicular surface horizons; calcic or argillic soil below weak or strong pavement; commonly faulted; probably wide age range. May correlate to older Pleistocene or Pliocene fanglomerates of Brady (1986a). |
| Qf1Neogene or Pleistocene | Thick fanglomerates modified to ridge-and-ravine topography with loss of original fan morphology; isolated remnants along mountain front, along drainages, and capping ridges; commonly faulted; soils stripped. These may correlate with Avawatz Formation, Noble Hills Assemblage, or oldest Pleistocene or Pliocene fanglomerate of Brady (1986a). |

argillic horizon with colloidal staining on grains rather than true clay skins on clasts or peds faces (Table 31). The vesicular A horizon is 6 cm thick. Although there is no direct dating control on Qf3 deposits, and the stratigraphic evidence for confident relative correlations is limited, Qf3 predates Lake Dumont I (> 30,000 B.P.) and may be the boulder deposit underlying the Qf4 fan-delta sequence (see Figure 52).

**Table 31. Summary of soil descriptions for Late Pleistocene to Holocene alluvial fans on the Avawatz piedmont**

| Alluvial Unit | Horizon | Depth (cm) | Color Dry | Color Moist | Texture (<2mm) | Structure | Dry | Moist | Wet | Clay films | % Gravel | Roots | Pores | CaCO3 Stage | HC1 | Bound |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Qf3 | C | 0-0.5 | -- | -- | LS | m | so | vfr | so,p | -- | -- | -- | -- | -- | es | as |
| | Avtk | 0.5-6 | 10YR 6/4 | 10YR 4/4 | SL | 2,vc,pl - 2,m,abk | sh-h cw | fi | ss,p | 1,n,po co | 5 | -- | 3,vf-f,con-ran,in,v-t | I-I+ | es | aw |
| | Bvtk | 6-15 | 10YR 5/4 | 10YR 4/4 | SL | 2,vc,pl - 2,c,abk-pr | h | fi | ss,sp | 1,n,po co | 5 | -- | 3,vf-f,con-ran,in,v-t | I-I+ | es | as |
| | Btk1 | 15-57 | 10YR 4/6 | 10YR 3/4 | LS | m | so | vfr | so,p | co | 50 | -- | -- | I+ | es | as |
| | Btk2 | 57-85 | 10YR 5/4 | 10YR 3/4 | SL | m | so-h | vfr | so,p | co | 25 | -- | -- | II | es | -- |
| Qf4 | C | 0-0.5 | 10YR 6/3 | 10YR 4/3 | LS | m | so | vfr | so,p | -- | -- | -- | -- | -- | es | as |
| | Avtk | 0.5-3 | 10YR 6/3 | 10YR 3/4 | SCIL | 2,m,pl - 2,m,pr | sh-h cw | fr | ss,p | 1,n,po | 10 | -- | 3,vf-f,con-ran,in,v-t | I+ | ev | cw |
| | Bvk | 3-12 | 10YR 6/4 | 10YR 4/4 | SL | 2,m,abk | so | vfr | ss,p | -- | 20 | 2,f | 3,vf-f,con-ran,in,v-t | II- | ev | cs |
| | Bk1 | 12-35 | 10YR 6/3 | 10YR 4/3 | SL | 2,c,abk | so | vfr | ss,p | -- | 30 | 2,f | -- | I | ev | as |
| | Ck1 | 35-60 | 10YR 6/3 | 10YR 5/3 | vcS | m | lo | vfr | so,p | -- | 60 | -- | -- | I | ev | as |
| | Ck2 | 60-100 | 10YR 6/3 | 10YR 5/3 | vcS | m | lo | vfr | so,p | -- | 80 | -- | -- | I | es | -- |
| Qf5 | C | 0-0.5 | 10YR 6/3 | 10YR 4/3 | fS | m | lo | lo | so,p | -- | -- | -- | -- | -- | es | as |
| | Avtk1 | 0.5-2 | 10YR 4/3 | 10YR 4/4 | SL | 3,fpl - 3,f,abk-pr | sh-h | fi | so,p | 1,n,po | 10 | 1,vf | 3,vf-f,con-ran,in,v-t | I | es | aw |
| | Avtk2 | 2-3.5 | 10YR 6/3 | 10YR 5/4 | LS | 2,cpl | h;cw | vfr | s,p | 1,n,br; | 25 | 1,vf | 1,vf-f,con-ran,in,v | I | es | aw |
| | Ck1 | 3.5-15 | 10YR 6/3 | 10YR 5/3 | S | m,sed. | so | vfr | so,p | co | 75 | 2,f | -- | I- | ve | cw |
| | Ck2 | 15-60 | 10YR 6/3 | 10YR 5/3 | cS | m,sed. | so | vfr | so,p | -- | 75 | 2,f | -- | I- | ve | cs |
| | Ck3 | 60-120 | 10YR 6/3 | 10YR 5/3 | S | m,sed. | so;cw | vfr | so,po | -- | 75 | 2,f | -- | I+ | ve | -- |

Qf4 is preserved as isolated fan remnants or relatively broad stable surfaces with distinct recognizable dark, though variable tones representing strong pavement and varnish development on well-preserved bar-and-swale topography. Soil development is moderate, with Stage I carbonate morphology and no clay skins evident. The vesicular A horizon is 3 cm thick. Exhibiting variability across the Avawatz piedmont, Qf4 is similar to Qf3 with the exception of subtle differences in varnish and bar-and-swale morphology. Commonly, Qf4 has reworked the Qf3 surface and subsequently been stabilized. The best age control on this feature is in the vicinity of Lake Dumont, where the Qf4 has been subdivided into an older fan-delta sequence (Qf4a) that is syndepositional with Lake Dumont I and II and a Qf4b sequence that progrades over the Qf4a and lake deposits. Distal portions of Qf4 were recovered in core DU-1, where sand foresets, gravel, and sandy clay deposits have been described. Therefore, Qf4a dates between 30,000 and 18,000 B.P. Qf4b progrades over both Qf4a and the lake deposits and therefore postdates the Lake Dumont phases (<15,000 B.P.). This thin fan unit reworks the older fans during the recessional/dessicational lake phase.

Qf5 is present as a very common, broad fan sequence extending across the Avawatz piedmont, and grading from the mountain front to the basin floor. On aerial photographs, Qf5 has variability in tone due to lithologic control on clast texture, pavement, and varnish development. In addition, Qf5 has at least two depositional units that may also result in different surface characteristics. Soils from Qf5 are weak, with no B horizon formed, except possibly a very weak color B (Bw), and weak Stage I carbonate on clast bottoms. The vesicular A horizon is less than 1 cm thick. Qf5 fan deposits are between 18,000 and 2500 B.P. in age.

Two Qf5 units have been defined in the Lake Dumont basin, with age correlations from dated lacustrine and alluvial deposits. Qf5a bevels both lake and Qf4b deposits, creating an erosional surface that grades basinward. Qf5b apparently is correlative with the top of the alluvial fill unit dating to 2500 B.P. and therefore may have formed during the early to middle Holocene period of aggradation. Qf5 may have constricted the channel enough to cause aggradation of the alluvial fill. Qf5 therefore dates from latest Pleistocene (post-Lake Mojave II?) to 2500 B.P.

Along the Avawatz piedmont, stable alluvial bars are slightly higher in elevation than the modern channel and therefore represent a slightly older period of alluvial fan activity. These bars are labelled Qf6. They may be active during high magnitude flooding events, or they may be buried and reworked. These bars have only very weak, dark brown varnish development and weakly interlocking pavement. The vesicular A horizon is <0.5 cm thick, forming in a very thin aeolian accumulation. In the vicinity of Salt Creek, downcutting through the lake and alluvial deposits has created strath deposits grading to different levels of older Salt Creek channels. Qf6a and Qf6b are thin fan gravels that may be correlative with main channel fluvial gravels on strath cuts along Salt Creek. These deposits represent late Holocene periods of incision.

Finally, along the distal alluvial apron fringe of Dumont basin, fans of all ages have experienced the extreme weathering conditions common to hyperarid, saline environments. Salt weathering and dissolution of even quartzite cobbles makes correlation of fan units based on surface characteristics tenuous at best. Also, thin fans overlying saline lacustrine deposits enhance pedogenic accumulation of salts and may inhibit translocation of clays due to flocculation. Therefore, the two most useful fan-stratigraphic/relative-age indicators - surface properties and soil development—are of limited use here, where elevation and geomorphic position appear to be the most useful.

## Correlations with Salt Spring Hills Alluvial Fan Stratigraphy

The stratigraphic correlations of the Salt Spring Hills (SSH) alluvial fan chronology with that of Silver Lake fan sequences were based, primarily, on geomorphic relationships, soil development, and surface modification parameters (McFadden et al. 1989; Wells et al 1990b). The degree of varnish and soil development were determined to be the best indicators of relative age in the SSH fan sequence. Based on those criteria, age determinations were estimated when compared to the dated Silver Lake chronology (McFadden et al. 1989; Ritter 1987). As a result of the present study, and correlations of Avawatz fans with dated lake deposits, a re-evaluation of the Salt Spring Hills chronology is necessary. Although the

## Summary of Geomorphic Events

By addressing three problems related to the geomorphic history of Dumont basin, late Pleistocene through late Holocene geomorphic events can be summarized. First, what dammed the Pleistocene lake basin to create a pluvial lake? Second, when did the basin become throughflowing, preventing post-Lake Dumont lake formation? Third, what dammed the basin to cause aggradation of the Holocene Qal1 deposits? Several scenarios can be developed for creating a lake dam in this geomorphic location. Massive, indurated sand and gravel ramps, which are present along the western side of the Salt Spring Hills, could easily dam the basin. However, there is no evidence that such a feature existed in the necessary location. Also, there appears to be no evidence for tectonic activity either producing or removing fault controlled barriers.

It is possible that the "southern" overflow route was dammed by Qf3 or Qf4a alluvial fans. Although no evidence of older fans has been found at the damming site, an older fan is present below the Qf4a fan delta sequence and may be a remnant of an older, larger fan. The lowest gradient, highest elevation Qf3 fan on the piedmont slopes to a high enough elevation to enclose the basin along the "southern" overflow route (Qf3 #4, 5) (Figures 47 and 53).

The "western" overflow, through which Salt Creek now flows, may have been dammed by an alluvial fan, a bedrock dam, or an alluvial fan over bedrock. There is no evidence of a fan extending over this portion of the bedrock knob, though projection of the Qf3 gradient elevation might extend that far. The eroded bedrock channel is "old" in appearance in that it is relatively wide for such a small creek; and the bedrock along the edges is irregular, weathered, and fractured. This weathering, however, may reflect lithologic characteristics of the easily erodable granitic bedrock, rather than age. Slight "shoulders" at the approximate elevation for closure are also highly weathered and only suggestive of a once more extensive bedrock connection between the opposite walls. At this time, answers to the dam question are only speculative.

The timing of basin breaching is also speculative, although it did occur sometime between 18,000 and 9300 B.P. During Lake Dumont II the basin was nearly filled with sediment, as estimated from the difference in elevation between the truncated 18,000 year old lake deposits and the probably correlative shoreline. The truncated lake deposits (172 m) are only 3 m below the highest shoreline (175.4 m), which in turn is above any feature that could contain a lake, given the present topographic conditions. Substantial erosion since 18,000 B.P. scoured the basin, removed the majority of lake deposits, and left only remnants around the basin periphery. Subsequent deposition of the brown alluvium filled the basin to about 169 m sometime between about 9300 B.P. and 2500 B.P.

Several characteristics lead to speculation that the breach and downcutting was noncatastrophic, but rather a slow, progressive basin drying. First, it appears from core logs discussed earlier, the last lake deposit was accompanied by green clays in the deeper core, but extensive capillary fringe carbonates and salts in the shallow core. This may indicate standing water in the basin interior, with groundwater just below the surface drawing upwards by capillary action during a time of low lake levels. The terminal phase of Lake Dumont II represents a period of sedimentation and desiccation, rather than increased lake levels overtopping the sill. Second, it appears that, where preserved, Qf4b fans prograde over the top of the lake, as would be consistent with slow lake recession. Catastrophic overflow might cause rapid downcutting which would cause fans to grade to the new lower level, rather than across the top of the lake beds. These graded fans simply prograded basinward during lake level lowering. Finally, the enigmatic and qualitative description of the channel as "old" might be explained by a gradual downcutting for nearly 18,000 years.

relative age determinations for the SSH fans still hold, numeric age assignments can now be provided (Table 32).

**Table 32. Late Cenozoic alluvial fan chronostratigraphic units along the Avawatz Mountains' piedmont and correlations with the Salt Spring Hills fan sequence. (Age estimates are based on correlations with AMS dated lake deposits of pluvial Lake Dumont, Mojave Desert, California)**

| Avawatz Mountains Alluvial Fans (this study) | Salt Spring Hills Alluvial Fans (Ritter 1987) |
|---|---|
| Qf7 | Qf6<br>(Modern wash) |
| Qf6<br>(< 2.5 ka) | Qf5<br>(latest Holocene) |
| Qf5 b<br>(latest Pleistocene to *mid-late Holocene*)<br>(>9.3 to 2.5 ka) | Qf4b<br>(late Holocene <3400 B.P.) |
| Qf5a<br>(latest Pleistocene to *mid-late Holocene*)<br>(<14.9 to 9.3 ka) | Qf4a<br>(middle to late Holocene<br>8000 - 3400 B.P.) |
| eroded? | Qf3<br>(early Holocene 10,500-8000 B.P.) |
| Qf4b<br>latest Pleistocene (<14.9 ka) | late Qf2 ? |
| Qf4a<br>latest Pleistocene (30-18 ka) | early Qf2<br>(late Pleistocene > 15,500 B.P.) |
| Qf3mid-late Pleistocene<br>(>30 ka) | Qf1 (late Pleistocene > 15,500 B.P.) |

Qf3 along the Avawatz piedmont predates Lake Dumont I and correlates with Qf1 in the SSH, providing an age on the SSH Qf1 of >30,000 B.P. Qf4a on the Avawatz piedmont is contemporaneous with Lake Dumont, and possibly correlates with an early Qf2 phase in the SSH. Because the lake deposits in the cores date to 30,000 to 18,000 B.P., with perennial lake conditions existing for much of that time, it is thought that the prominent shoreline preserved on the quartzite outcrops of the Salt Spring Hills also dates to that period. However, Qf2 in the SSH (SSH-C, see Figure 46) is truncated by a well-developed shoreline, indicating it pre-dates one of the Lake Dumont high lake stands. It is possible that Qf2 prograded basinward during the low lake stand between Dumont I and II, and was then truncated by the Lake Dumont II increase in water level. This might explain a well-preserved 18,000 year old shoreline cut into fan material rather than 30,000 year old shoreline.

Qf4b of the Avawatz fans may correlate with a post-lake fan deposit correlative with SSH Qf2, and explain the variability observed by Ritter (1987) in soil and surface characteristics of the Qf2 fans. Deposits of latest Pleistocene and early Holocene are missing in the Lake Dumont/Avawatz fan sequence, but are thought to be present in the SSH fans and date between 10,500 and 8000 B.P.

Qf5a appears to correlate with the SSH Qf4a, and Qf5b with the SSH Qf4b, based on the degree of soil development and stratigraphic position. Latest Holocene and modern deposits appear to date to less than 2500 B.P., with several periods of downcutting and fan progradation occurring.

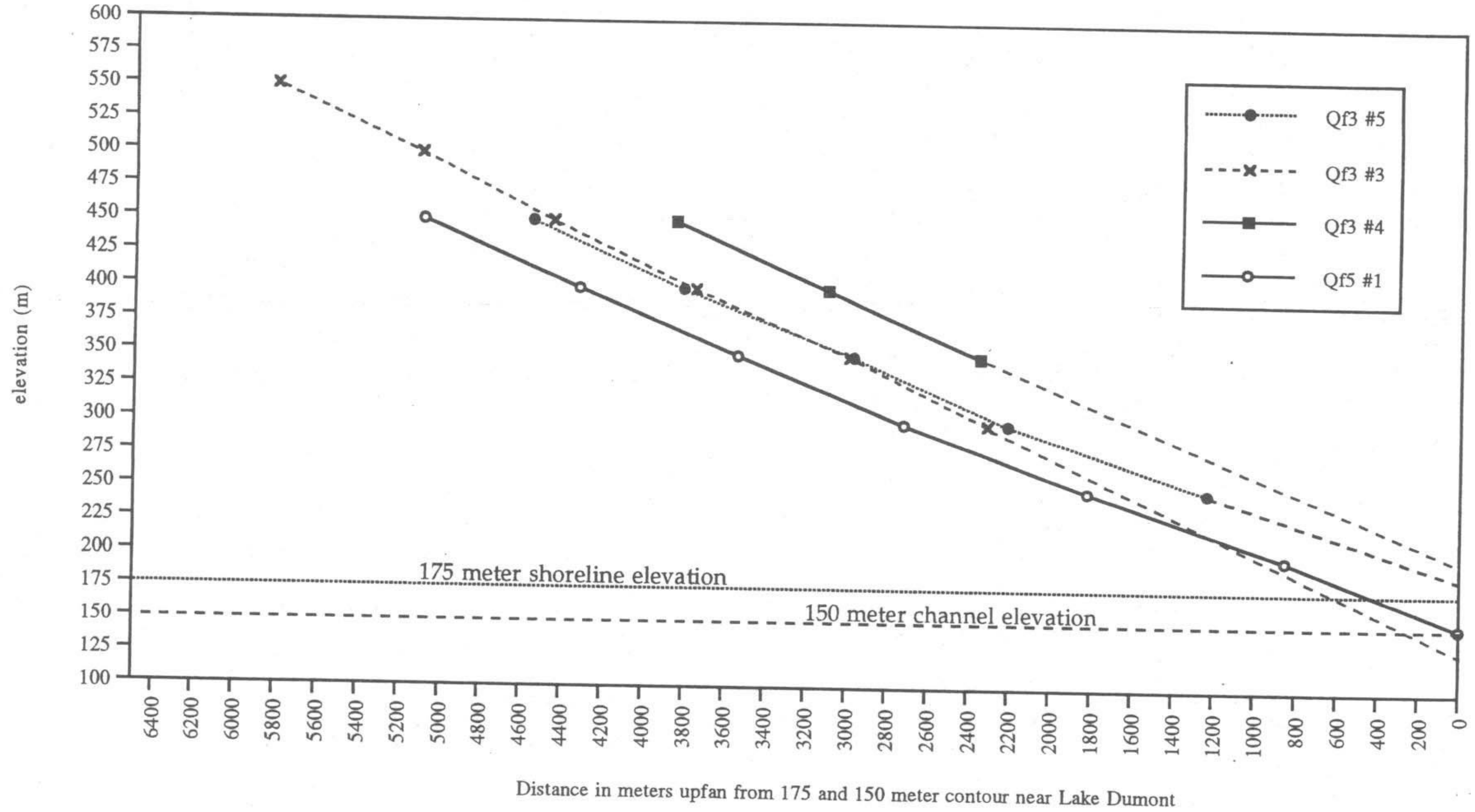

**Figure 53.** **Gradients of fan segments measured from 7.5 minute USGS topographic maps. Solid lines are measured sections, dotted lines are extrapolated from previous two points.**

The Holocene damming of the basin to allow deposition of younger alluvial fill was probably caused by the Qf5 fan sequence, as it clearly postdates Lake Dumont II. In appearance, the early to mid-Holocene fan is concordant with the 169 m top of the eroded alluvial surface, though no surveying was done on this section. Given the confined nature of the Salt Creek channel through the bedrock constriction, aggradation of a Holocene fan is a likely cause of the damming and subsequent alluvial fill preservation.

Based on field mapping, stratigraphic correlations with AMS dated lake deposits, and distribution of geomorphic features, a conceptual framework for Pleistocene and Holocene geomorphic history is as follows:

a) Pre-Lake Dumont closed basin with Qf3 blocking the "southern" overflow and bedrock blocking the "western" overflow: early playa deposition prior to about 30,000 B.P.,
b) Lake Dumont I and II closed basin between 30,000 and 18,000 B.P.,
c) Continued pluvial activity/basin sedimentation and shallow water,
d) Overflow/slow downcutting through the bedrock dam, <18,000 B.P.,
e) Scouring of basin during Mojave II by throughflowing Salt Creek after about 14,900 B.P. ,
f) Increased post-Mojave II fan activity at end of Pleistocene creating impediment to throughflow and aggradation of early Holocene alluvium,
g) Aggradation during mid-Holocene which ended shortly after 2,500 B.P.,
h) Salt Creek downcutting in two or more phases, creating fluvial strath terraces and alluvial fan progradation basinward.

# Quaternary Geology of the Denning Springs Wash Area, Northern Avawatz Mountains Piedmont

## Introduction

The Denning Springs Wash is one of the largest fluvial systems draining the northern flank of the Avawatz Mountains. The Wash is located near the intersection of two significant fault systems, the Garlock fault zone and the Death Valley fault zone (Figure 54). The wash heads at an elevation of approximately 1500 m, traversing the Avawatz Mountains and Noble Hills prior to its confluence with the Amargosa Wash at an elevation of 60 m.

Within the upper reaches of the Denning Springs Wash near Denning Springs, 29 archaeological sites have been recorded. In order to provide a general geologic context for these sites, a large-scale surficial geologic map was produced along with a three-day geologic field reconnaissance. Prior to this study, none of the Quaternary mapping had been conducted in this area. As a consequence of this study, we have mapped broad exposures of relatively massive, light colored, fine-grained deposits distributed around the Garlock fault zone (Figure 55). We have intepreted these fine-grained deposits within the Denning Springs area as paleospring discharge deposits similar to those first recognized in southern Nevada (e.g. Haynes 1967; Mifflin and Wheat 1979) and most recently studied by Quade et al. (1995).