Pleistocene Lake Mojave Stratigraphy and Associated Cultural Material

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The problems of geoarchaeology addressed in this paper were probably most clearly stated very early in the research, almost 40 years ago (Warren and DeCosta 1964). To adequately date the artifact assemblages from the 24 "surface sites" on the high beach lines of Pluvial Lake Mojave, two tasks must be successfully completed: (1) construct the geomorphic history of Lake Mojave from the stratigraphy, topographic relationships, radiocarbon dates, and any other useful data, and (2) demonstrate the stratigraphic relationship between prehistoric artifacts and lacustrine deposits of Lake Mojave. These two tasks are addressed in this paper.

Introduction

The Mojave River periodically flowed into Death Valley during the late Pleistocene and early Holocene. On its way to Death Valley, it filled the basins of today's Silver and Soda playas to overflow levels, forming Pleistocene (and early Holocene) Lake Mojave (Map 1). The final overflow stage of Pleistocene Lake Mojave was probably about 9,000 years ago. With the increasing aridity of the early Holocene, the flow of the Mojave River decreased, and by 7,500 years ago Lake Mojave was a desiccated basin.

Three sets of data were used in the reconstruction of changes in the water level of Lake Mojave during the late Pleistocene and early Holocene. These data sets are from three locations and three different contexts within the Lake Mojave Basin: (1) the high beach ridges between ca. 289 and 285 m in elevation; (2) the stratigraphy of intermediate beach and slope deposits, including the Silver Lake Gravel Pit, Beach Ridge V, and excavation units at Bench Mark Bay, and (3) the subsurface stratigraphy of Silver Playa as illustrated by a series of cores (Map 2, Figure 1).

Anodonta Geochronology and Dates of Shoreline Features

The three high-elevation beach ridges of late Pleistocene and early Holocene Lake Mojave have been identified by five different geological investigations (Antevs 1937, Bode 1937, Rogers 1939, Ore and Warren 1971, Wells et al. 1989). The El Capitan Beach Complex in the northwest corner of the lake basin is the key to demonstrating the sequence of beach-ridge formation at Lake Mojave (Antevs 1937; Ore and Warren 1971; Wells et al. 1989). Additional data from other locations within the range of elevations of the high beach ridges are integrated with observations made at the El Capitan Beach Complex.

Within the uppermost portion of the Lake Mojave Basin are three high beach ridges referred to as BRI, BRII, and BRIII. These are the most extensive shoreline features formed by the early high stands of Lake Mojave. These beach ridges are easily observed and have been dated by ^{14}C determinations on *Anodonta* shells and on tufa formed on rocks at the water's edge (refer to Figure 1).

The elevation of the lake level was controlled by an outlet channel at the north end of Lake Mojave. Over time, erosion lowered the bedrock sill of the outlet-channel spillway from 288.5 m to about 285.5 m. These elevation measurements at the overflow-channel spillway correspond to the elevations of the three highest beach ridges. The two highest of these (BRI-I and BRI-II) were formed between 13,700 and 11,500 years ago. During this period, the spillway was lowered significantly. Although the lake level was at its highest during this period, it must have periodically dropped below the overflow level. These conditions were in effect until just before 11,500 years ago, when a major drought occurred. After 11,500 B.P., another high lake filled the basin, reached the overflow level, and formed BRI-III at ca. 287.5 m in elevation.

The higher beach ridges did not generally incorporate *Anodonta* (freshwater mussel) shells from lower lake stands. Since the level of

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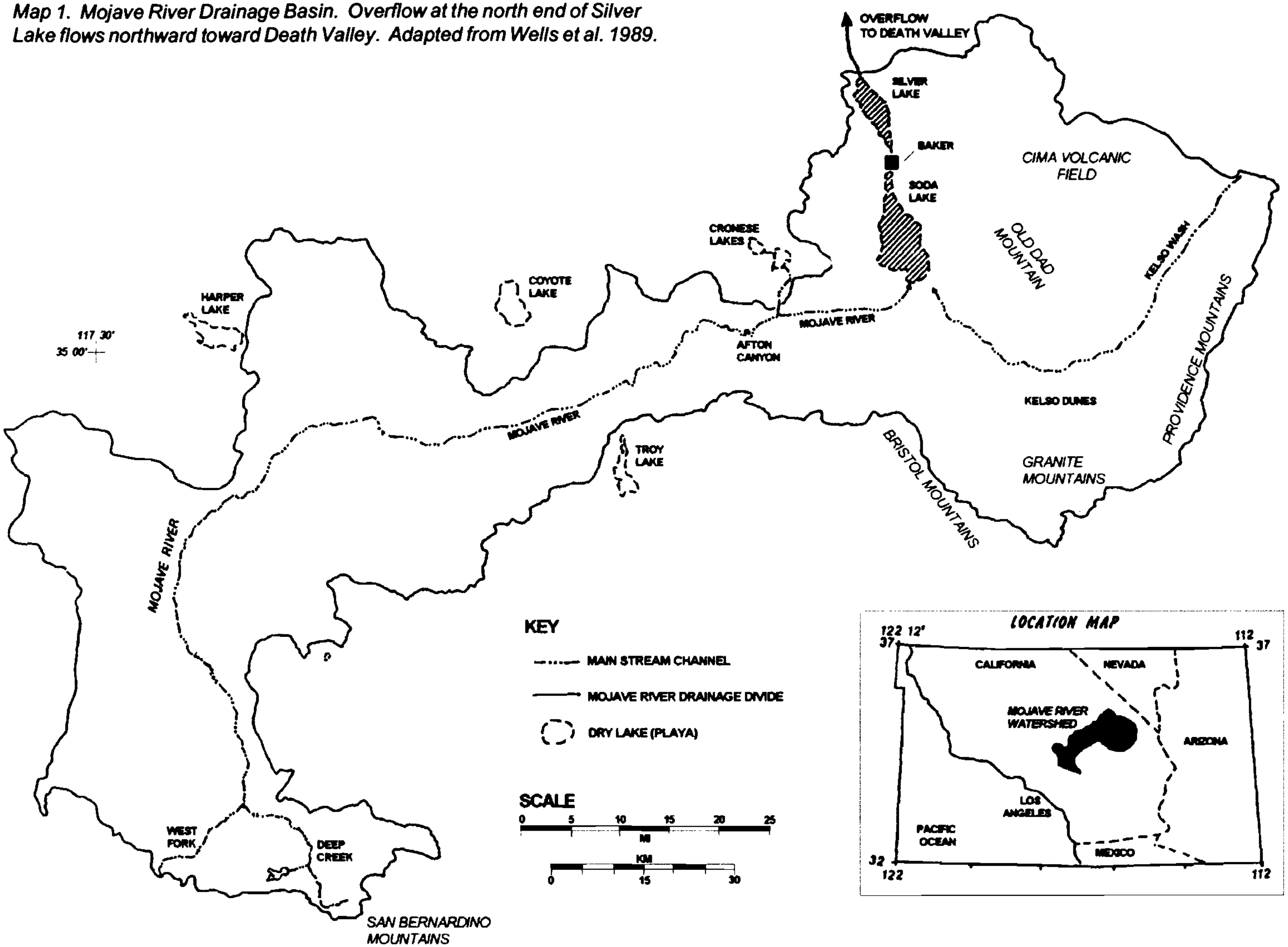
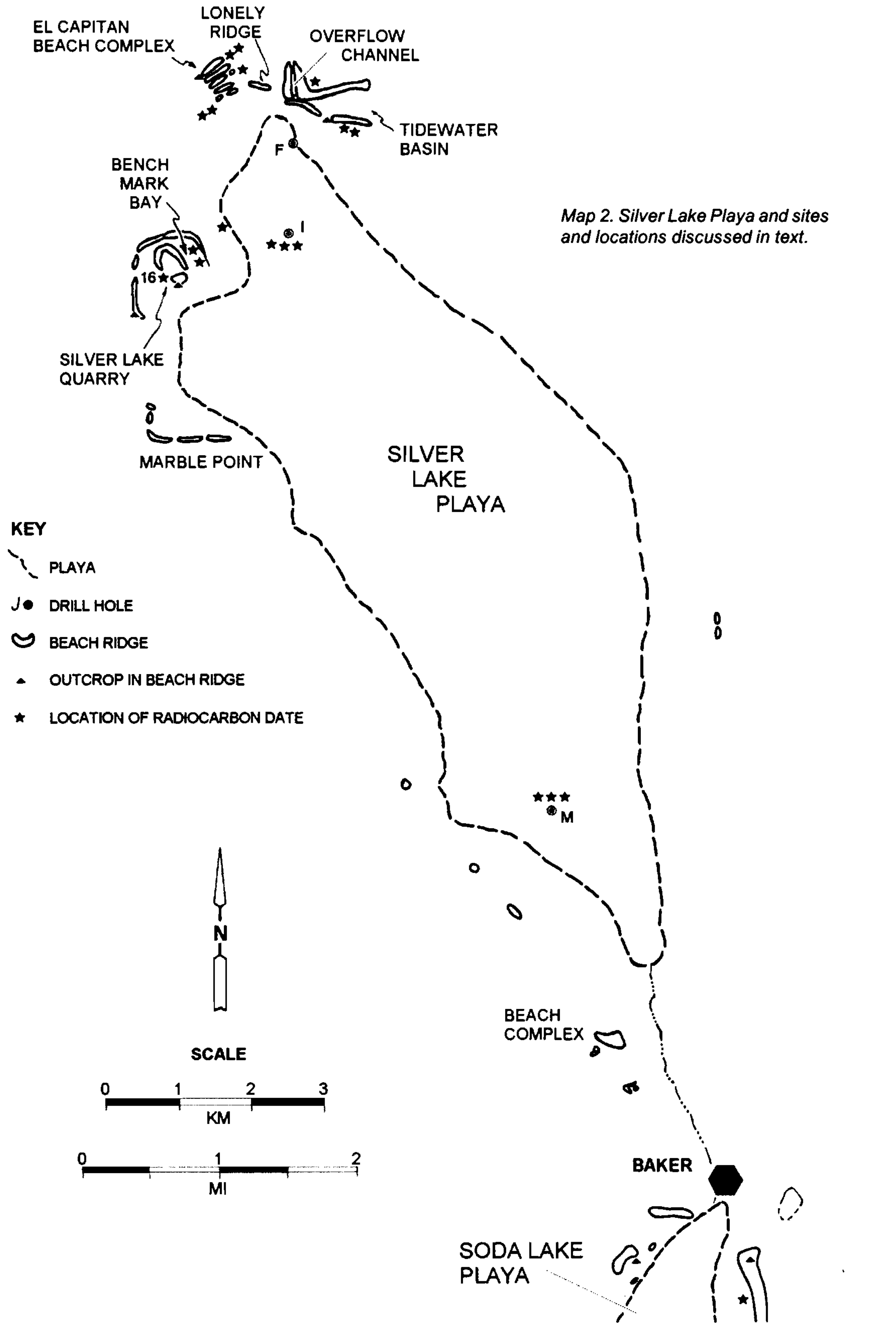
Map 1. Mojave River Drainage Basin. Overflow at the north end of Silver Lake flows northward toward Death Valley. Adapted from Wells et al. 1989.





Map 2. Silver Lake Playa and sites and locations discussed in text.

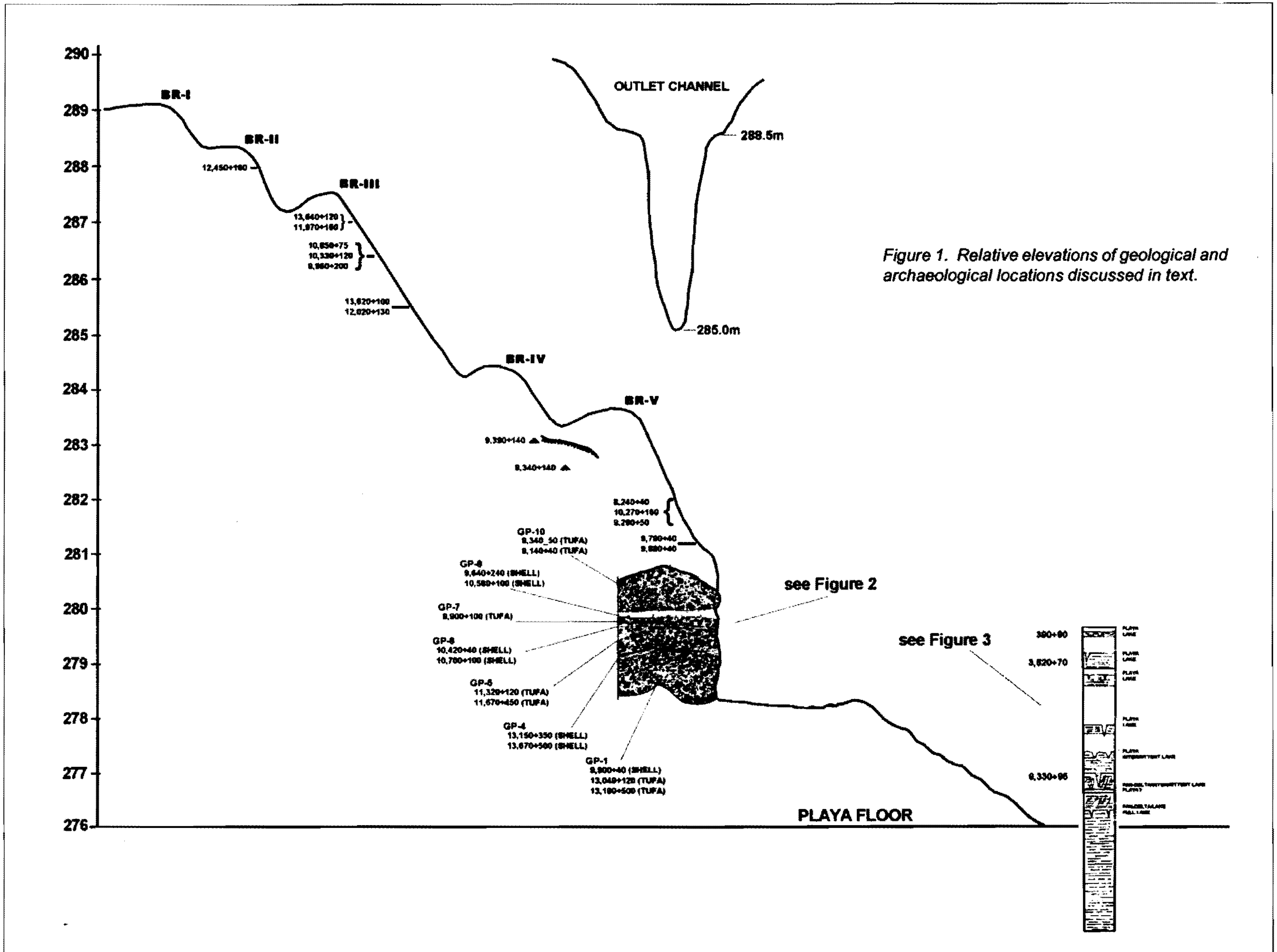


Figure 1. Relative elevations of geological and archaeological locations discussed in text.

Pleistocene Lake Mojave was generally regressive through time, with occasional reversals, the youngest dated shell from a beach ridge corresponds to the date when the lake level last reached that elevation. Freshwater mussels live in greatest density at depths of less than two meters, but may also live at depths of up to seven meters in large lakes. *Anodonta* individuals are able to move to more favorable surroundings as water levels seasonally recede and rise (Warren and DeCosta 1964:207). Furthermore, the valves (either paired or detached shells) of dead animals may be transported by water currents from their primary shallow-water contexts and redeposited at greater depths in the lake. *Anodonta* may also burrow into the sandy lake bottoms and may die within their burrows. For example, when the lake was forming Beach Ridge II at 289 m elevation, living *Anodonta* populations would have been most dense at elevations down to ca. 287 m. Therefore, *Anodonta* shells with ages corresponding to those of a given beach ridge probably would be found at lower elevations than that of the beach ridge itself.

CHRONOLOGY OF THE HIGH BEACH RIDGES

Radiocarbon dates on *Anodonta* shell and tufa from the three high beach ridges (Figure 1) can be divided into two groups: those that are associated with beach deposits at and above 287 m in elevation, and those that are associated with beach deposits at elevations lower than 287 m. All dates on shell or tufa above 287 m are *older* than 11,800 B.P., while four of six dates below 287 m are *younger* than 11,000 B.P. These data suggest that BRI and BRII were created by a single, somewhat fluctuating lake, and that BRIII was the result of a later, high-lake stand. Additional data, discussed below, support this interpretation.

Beach Ridge I (BRI) and Beach Ridge II (BRII) of the El Capitan Beach Complex, at ca. 287-289 m in elevation, have six dates on shell:

Date	Lab No.	Elevation (m)
12,450 ± 120 B.P.	Y-2408	288.7
13,640 ± 120 B.P.	Beta-26456	287.0
11,970 ± 160 B.P.	Beta pc	287.0
11,860 ± 95	DIC-2824	287.0
13,620 ± 100	Y-1585	285.6
12,020 ± 130	Beta-2119	285.0

These data indicate the existence of a lake at the overflow level beginning ca. 13,670 years ago and continuing to approximately 11,860 years ago. BRI and BRII reflect relative stand-stills in the lake fluctuations during the time the bedrock spillway was being eroded.

Three radiocarbon dates on shell and tufa, from elevations of 286-286.5 m, date BRIII of the El Capitan Beach Complex:

Date	Lab No.	Elevation (m)
10,330 ± 120 B.P. (shell)	Beta-21200	286.5
10,850 ± 75 B.P. (tufa)	DIC-2823	286.0
9960 ± 200 B.P. (tufa)	Y-2410	286.0

These data from Beach Ridge III indicate that there was a high lake stand dated to between 10,850 and 9,960 years ago.

During the period when BRI, BRII, and BRIII were formed, the elevation of the lake level was controlled by the outlet spillway. Erosion successively lowered the sill of the outlet channel from 288.3 to 285.5 m, a difference of 2.8 m. The greatest volume of overflow and the highest rate of erosion of the bedrock spillway is thought to have occurred between ca. 13,670 and 11,500 years B.P. After that, the periods of overflow of the lake were neither so great in volume nor so long in duration. After 11,500 years ago, the high lake levels, represented by BRIII, date from 9960 B.P. to 10,850 B.P.

STRATIGRAPHY OF INTERMEDIATE SLOPE DEPOSITS

The intermediate slope deposits lie roughly between 285 m and 277 m elevation (refer to Figure 1). These deposits include the following:

(1) Beach Ridge V of the El Capitan series,
(2) the lower beach of Bench Mark Bay at ca. 280-283 m elevation, and
(3) the Silver Lake Gravel Pit exposure.

STRATIGRAPHY AT BEACH RIDGE V

Beach Ridge V (BRV) is at ca. 283.5 m in elevation. Neither BRIV nor BRV contain shell or other datable material. Beach Ridge V uncomformably overlies deposits containing *Anodonta* shells dated to 9390 ± 140 B.P. (Beta-

29552) at 282.5 m, and 9340 ± 140 B.P. (Y-2407) at 283.2 m. Beach Ridge V is roughly 3 m below the sill of the outlet channel. The shell samples from this location comprised whole valves (complete but not articulated), suggesting that the shells were recovered from near the elevation at which the *Anodonta* lived. If so, the lake level at ca. 9,350 years ago probably was at and above the overflow sill.

STRATIGRAPHY OF BENCH MARK BAY

Bench Mark Bay is an elongated, north-south oriented bay ca. 450 m long and 100 m wide, located on the northwestern edge of Silver Playa (see Map 2). Wave-cut cliffs at the mouth of the bay are well developed, both on the headlands and on the sides of the bay where the rocky slopes are steep. A long, sloping beach with an uppermost elevation of ca. 288.5 m curves around the head of the bay. A road-cut has heavily impacted site CA-SBR-264, located on the 288-m shoreline at the head of the bay.

Warren and Ore excavated at this site in the mid 1960s. One unit was excavated at 282.2 m in elevation. This excavation reached a depth of 60 cm and exposed typical offshore silty sand with varying amounts of caliche cement throughout the deposit. Between 15 and 40 cm below the surface, four man-made flakes and one formed artifact were found. Enough fragmented *Anodonta* shell was recovered from between 15 and 45 cm to provide material for a single radiocarbon date of 10,270 ± 160 B.P. (see Figure 1) (Warren and Ore 1978:181). It now appears that these shell fragments may have been eroded from an earlier, higher beach and redeposited at this elevation.

Eighteen other units, varying in surface elevation from 282.2 to 288.3 m, were also excavated. Fourteen of these yielded cultural material, primarily flakes. The excavations revealed that low on the beach or foreshore, at ca. 181-184 m in surface elevation, the cultural remains were covered to a depth of ca. 60 cm, whereas the cultural material on the higher beach lines (ca. 286 to 287.5 m) occurred in shallower contexts, at a depth of only 15 cm.

That the deposits on the lower beach were typical offshore silty sand became apparent in a unit at 282.2 m, after a sandstorm removed the fine, loose sediments from the sidewall profile of the unit. This exposed a series of fissures extending from the surface to a depth of about 60 cm. At the bottom of one of these vertical fissures was an articulated *Anodonta* (with both valves intact). At that time, the fissure was interpreted as the track of the mussel as it burrowed into the lake deposits (Warren and Ore 1978). In retrospect, it seems more probable that the fissures were desiccation cracks in the floor of the lake that predated the *Anodonta*. The mussel may have burrowed to this depth in the softer, sandy fill of the desiccation crack as the lake was declining. Either interpretation leads to the conclusion that the *Anodonta* was derived from a lake whose bed was stratigraphically above the flakes and artifact recovered. Therefore, the artifacts were deposited earlier than the formation of the lake in which the *Anodonta* lived.

RECENT INVESTIGATIONS AT BENCH MARK BAY

In 2000 and 2002, limited investigations were conducted at Bench Mark Bay and the Silver Lake Gravel Pit exposure. This work was supported by the Western Center for Archaeology & Paleontology and carried out under the direction of the authors and Lewis Owen. The following comments must be considered tentative and do not include all data, because the investigation and analyses have not yet been completed.

A series of nine 1-x-2-m units, two 1-x-1-m units, and a contiguous group of five 1-x-1-m units were excavated at SBR-264. Here, we consider four locations on the lower beach, all between 280 and 282 m surface elevation (refer to Fig 1). The sediments in these units contain both lacustrine and colluvial material, but the sediment deposits vary in texture and color with location. In each location, near the present surface, there appears to be a lacustrine stratum that exhibits desiccation fissures. Below this stratum, at deeper levels, there are other lacustrine deposits with desiccation cracks. In all units excavated to sufficient depth, the basal stratum exposed was a lacustrine deposit of silty clay with a greenish cast. These deposits are discussed further, below.

STRATIGRAPHY AT THE SILVER LAKE GRAVEL PIT

The Gravel Pit is located on the west side of Silver Lake. It was originally excavated (for commercial purposes) into a small, curved, rocky spit at the end of a rocky point protruding into Silver Playa (see Map 2). The base of the exposed face in the gravel pit is at ca. 278 m in elevation, just two meters above the present playa surface. On the slope above the gravel pit, beach lines are well marked (refer to Fig 1).

A number of investigators have recorded and dated the strata exposed in the gravel-pit profile (Hubbs et al. 1962, 1965; Woodward and Woodward 1966; Ore and Warren 1971; Owen and Warren n.d.). The stratigraphy, as described here, is based primarily on Ore and Warren (1971), with additional dates and some additional observations by Anne Perez, graduate student in Earth Sciences at UC Riverside, who recently completed a detailed study of the gravel pit. The pit exposure exhibits a series of strata which may be divided into two types (refer to figures 1 and 2):

(1) Rocky scree with tufa-coated clasts, similar to the present surface deposit. This type comprises strata GP1, GP5, GP7, and GP10. All strata are composed of poorly sorted, tufa-covered gravel exhibiting no internal stratification. Generally, clasts are subangular, with tufa coating the entire clast surface. No general tufa cementation of the strata is apparent. Some clasts appear to lack tufa. The presence of tufa indicates a shallow-lake-edge environment where water, rock, air, and sunshine meet. The fact that the tufa encases each clast, rather than appearing only on the exposed surface, has environmental implications. The encasing tufa indicates that the clasts were located on a spit across which waves washed, rolling the clasts and exposing all sides to the elements leading to tufa formation. These strata are dated by ^{14}C measurement of the tufa.

(2) Clayey silt, clean sand, and sand including *Anodonta* shells. Three "groups" of strata of this combination of materials interdigitate with the tufa-covered gravel strata (see above). The three groups are as follows: (a) strata GP2, GP3, and GP4; (b) stratum GP6 (a group of one); and (c) strata GP8 and GP9. Strata GP2 and GP9 are clayey silts with a blocky structure; GP3 is composed of clean sand. These strata contain no *Anodonta*, and have not been dated. The remaining strata, GP4, GP6, and GP8, have a sandy matrix, contain *Anodonta* shells and have been dated.

The stratigraphy of the Silver Lake Gravel Pit exposure is an impressive record of a fluctuating lake (figures 1 and 2; see also Table 1). The tufa-covered gravel deposits represent low lake levels at the elevation of each stratum between ca. 278 m and 279 m, 10 - 11 m below the highest beach ridge and only two meters above the level of the present playa surface. The lake deposits, interdigitated with these tufa-covered rock strata, should correspond chronologically with the high lake stands recorded in BRI, BRII, and BRIII. This is so, but with a few unexplained inconsistencies.

The closely-packed concentrations of *Anodonta* shell in strata GP4, GP6, and GP8 date to periods of high lake stands of BRI and BRIII. The shell strata in the gravel pit are composed of shells of dead animals that accumulated in the backwater behind the small, rocky spit. The intercalated gravel layers (strata GP1, GP5, GP7, and GP10), derived as scree and colluvium from the rocky point directly above the gravel pit, accumulated at the edge of a shallow lake. They represent periods of low lake stands at their respective elevations and are dated by radiocarbon assays of the tufa that covers individual clasts in each of the strata.

The dated lacustral shell-containing deposits represent an internally consistent sequence of lake formations that corresponds chronologically with the high beach ridges. GP4 is dated by five radiocarbon dates that range from 13,670 to 13,150 B.P. and equate with the dates of 13,640 and 13,620 B.P. from the high beach ridges. Beach Ridge II is not represented by the samples collected from the Silver Lake Gravel Pit profile.

The shell layer, Stratum GP6, is dated between 10,700 and 10,420 B.P. by four radiocarbon dates. These dates correspond to the age of Beach Ridge III.

A thin layer of gravel (Stratum GP7), dated at 9900 B.P. on tufa, separates GP6 from GP8, the third shell-bearing deposit. There are five dates

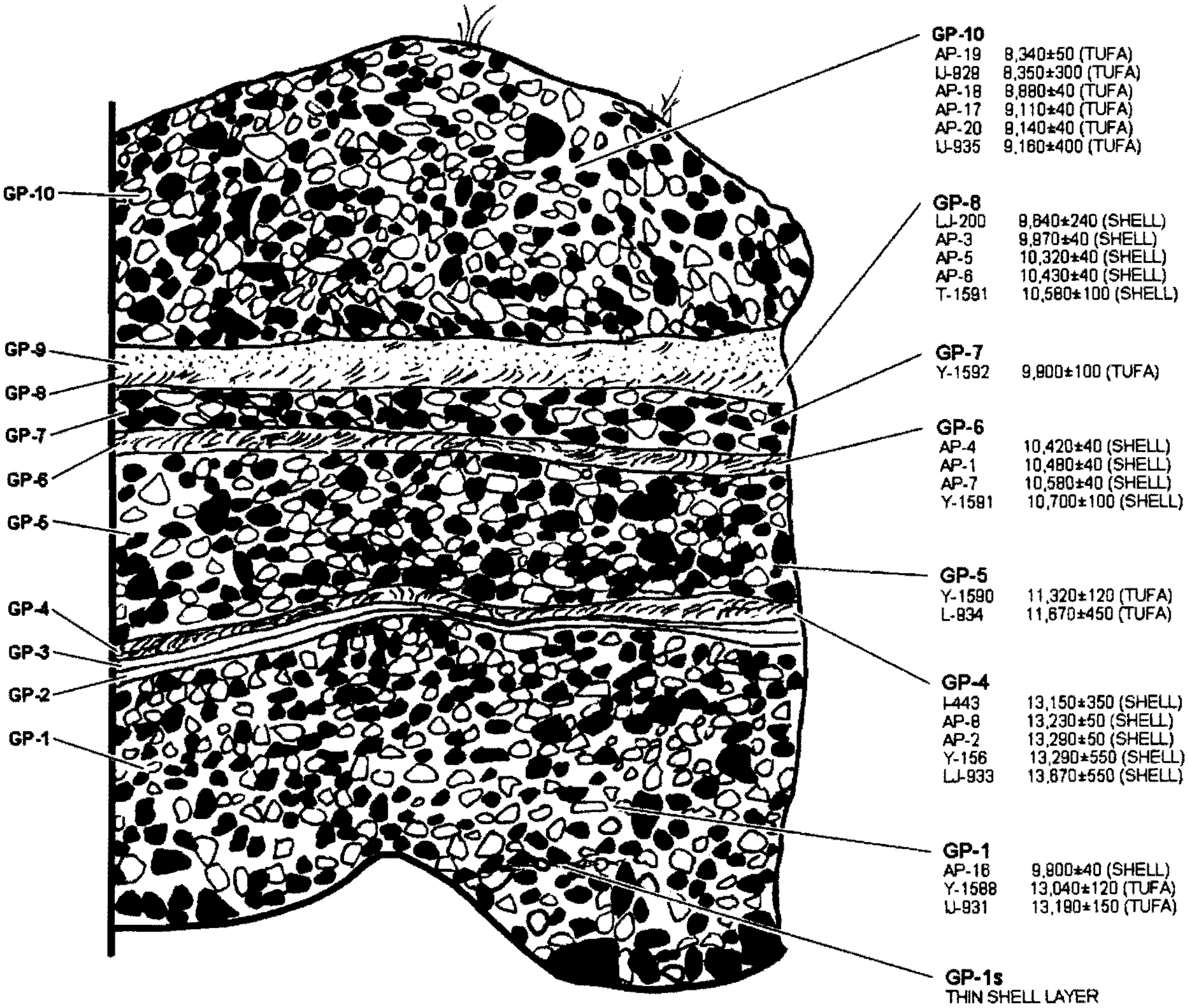


Figure 2. Stratigraphy and ¹⁴C dates at the Silver Lake gravel pit profile.

from GP8: 10,580 B.P., 10,430 B.P., 10,230 B.P., 9970 B.P., and 9640 B.P. The first three dates, which are too old, are best explained by a disturbance of GP6 and GP7 by wave action across the spit, with shells from GP6 being redeposited in GP8, floating in under the calm-water conditions behind the gravel spit. The shell dates of 9640 B.P. and 9970 B.P. from GP8 suggest a contemporaneity with late BRIII formation.

Stratum GP9 has a range of tufa dates from 8340 B.P. back to 9140 B.P., a period of fluctuating lake levels, during which Lake Mojave probably did not reach overflow levels.

STRATIGRAPHY OF SILVER PLAYA

Wells et al. (1989:95-96) removed a core, SIL-M, from the southern end of Silver Playa at an elevation slightly higher than central Silver Playa (Map 2, figures 1 and 3). Several components of this core were dated. The oldest date, 9330 ± 95 B.P., was obtained from organic carbon found at the top of the last continuous lacustrine sediments. This sample came from a depth of 3.15 m to 3.17 m below the present surface of the playa. Overlying these sediments are oxidized, brown silts with lesser amounts of clay and sand, which locally dominate this interval. Many episodes of desiccation, overlain by flooding events, are present, indicating highly fluctuating lake levels.

Wells et al. (1989:104-109) present other evidence for periods of drought and lowered lake levels from a series of cores in Silver Lake. These cores provide no evidence for maximum levels of water, since there is no information from above the level of the playa. However, minimum levels of water can be inferred from the presence of partial drying/lake lowering, and total drying events as evidenced in the cores. Wells and others identified characteristics of five lake conditions that would reflect water level. There are based on varying conditions at the edge and central portions of the playa. These are presented below, in order of increasing dryness indicators (for example, drying at the play a edges would precede drying in the central portion of the playa):

5. Lake clays lacking drying cracks or partial drying events (water level was above the level of the playa floor, but how far above is unknown).
4. Lake lowering and precipitation of evaporites at Core SIL-F, located closest to the edge of the playa.
3. Lake lowering and preciptation of evaporites at Core SIL-I, located closest to the central area of the playa.
2. Total drying conditions at location of Core SIL-F, located closest to the edge of the playa.
1. Total drying conditions at location of Core SIL-I, located closest to the central area of the playa.

Using these conditions, Wells and his colleagues reconstructed a sequence of Lake Mojave fluctuations (Map 2 and Figure 4). They developed a chronology for this sequence based on "sediment characteristics from Silver Lake cores....[and] on average sedimentation rates calculated from AMS core dates and stratigraphic correlations of subsurface sediments with dated shoreline features." The results are shown, in part, in Figure 4.

Summary and Interpretation of Geological Data

The data presented so far are summarized in Table 1 and Figure 1. Beach Ridge I deposits correspond with stratum GP4 at the Gravel Pit profile. However, there is no clear chronological equivalent of Beach Ridge II in the gravel pit. The missing chronological unit in the pit may have been removed by a period of erosion soon after it was exposed. Alternatively, changing environmental conditions at the gravel pit location may have prevented the deposition of shells during this period.

Stratum GP5, in the gravel pit, represents the period of desiccation between about 11,800 and 10,800 years ago. This was a period of drought and low fluctuation of lake levels, also recognized in the playa sediments. These deposits correspond chronologically to the Clovis Drought as characterized by Haynes (1991).

The following 1,500 years was a period of highly fluctuating lake levels, ending with the final desiccation of Lake Mojave. Beach Ridge III corresponds chronologically most closely to GP6 and represents a lake at overflow level between ca. 10,800 and 10,000 B.P. This interval ends with a short period of desiccation and a low lake level, as indicated by the tufa-covered gravel stratum GP7 in the Gravel Pit profile, dated at about 10,000 years ago. This low stand is also indicated in the playa sediments but is estimated as occurring less than 9,600 years ago (Figure 4).

What happened in the following 1,000 years is more difficult to determine. We do know that following this brief drought, the lake was again at the overflow level by about 9,350 years ago, as determined by the position and dates of *Anodonta* beneath BRV. A tufa date of 9960 B.P. recorded for an elevation of 286.5 m, and a date of 9970 B.P. on shell within GP8, suggest the period of drought was brief and was probably somewhat earlier than 9,900 years ago. This higher lake stand may have persisted until 9,300 years ago, as indicated by the shell dates at the 283 m elevation and the date of 9330 B.P. for the end of continuous lake-stand deposits as derived from Core SIL-M.

Stratum GP8, which follows the drought of 9,900 years ago, has dates that are inconsistent; three of five dates are too old. These dates (refer to Figure 2) range from 10,320 to 10,560 B.P. and would fit comfortably in Stratum GP6. We consider these shell samples as being disturbed and redeposited.

Stratum GP10 indicates a period of highly fluctuating lake levels between about 9,160 and 8,340 years ago. The date of 8240 B.P. for an

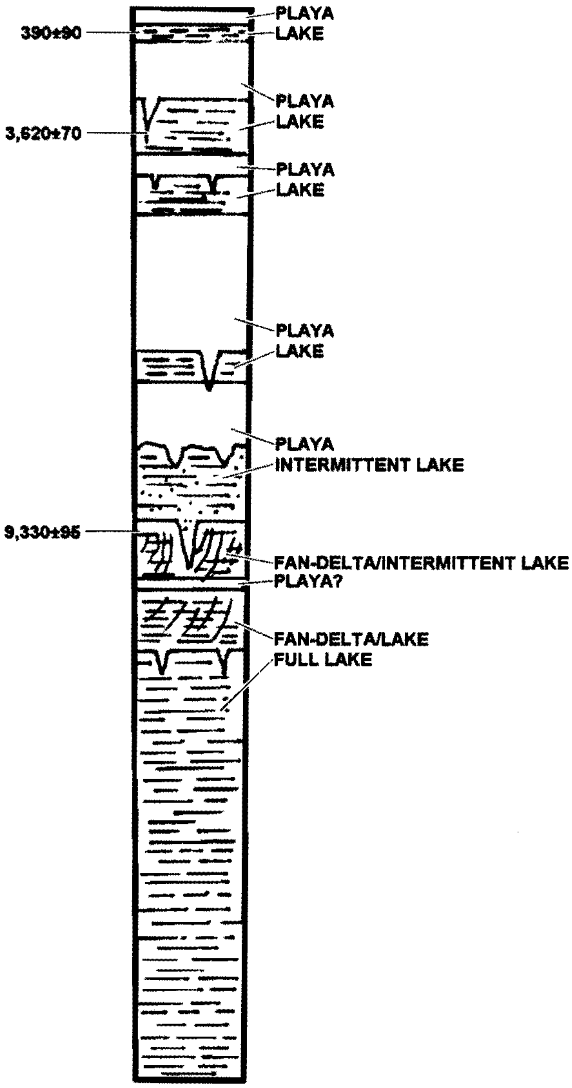


Figure 3. Core SIL-M from the south end of Silver Lake playa.

Anodonta shell at Bench Mark Bay, at ca. 282 m in elevation, suggests a brief, high lake stand about 8,000 years ago, not represented in the Gravel Pit stratigraphic sequence. The fluctuating lake levels of this period ended in a final retreat about 8,000 years ago.

Summary of Integration of Stratigraphic Units, Radiocarbon Dates, and Cultural Remains

In summary, the sequence of high and low lake levels in the Lake Mojave Basin have been dated as follows (Table 1):

Table 1: Stages of Pluvial Lake Mojave

6. Highly fluctuating lake	9200 to 8000 B.P.
5. Intermittent Lake Mojave IIIb	10,000 to 9200 B.P.
4. Brief drought	10,200 to 10,000 B.P.
3. Intermittent Lake Mojave IIIa	10,800 to 10,200 B.P.
2. Clovis Drought	11,900 to 10,800 B.P.
1. Lake Mojave III	13,670 to 11,900 B.P.

These high lake stands and their intervening low stands formed the geological strata which, at some locations, must have incorporated the cultural materials of the early humans who occupied the land at the edge of the lake.

In the Fall of 2000, the further investigation of the beach deposits at Bench Mark Bay began; investigation is continuing. The purpose of the new investigation is to locate a sequence of lacustrine deposits separated by colluvial materials. If found, these would represent the high and low stands of the lake, and shells within the deposits could be dated. The recent excavation units were placed immediately downslope from site SBR-264, recorded on the highest beach ridge, near the 1968 excavations of Warren and Ore. This placement was made in the hope that flaked stone material would be found in stratigraphic context within the sequence of alternating lacustrine and colluvial strata.

Units 122s1w, 176s0e, and 98s48w produced radiocarbon samples that have been dated. Unit 98s48w is the higher of the three, at an elevation of about 282 m on the gently sloping beach. The excavation of this and four contiguous units exposed a man-made stone feature and a single associated flake. In the typical lakeshore sediments immediately overlying this feature, an *Anodonta* was recovered, with both valves present but not articulated. These were two whole valves; all other sparse shell from these units was very fragmented, suggesting that the complete *Anodonta* shell was located where the individual mussel had died. This shell, dated at 8240 B.P., is the youngest, by about 1,000 years, of any *Anodonta* shell dated from Lake Mojave. This suggests that a relatively high, freshwater lake stand occurred at that time. Humans were certainly present prior to that date.

The second unit, 122s1w, was located closer to the north end of the site, where fans from an adjacent ridge spread out onto the lower beach. This unit was excavated to 105 cm and produced limited cultural material. The unit has clear stratification (Figure 5): the upper 60 cm consist of thin, laminated layers of fine sands and silts separated by very thin layers of water-deposited, silty clay. This laminated stratum consist of sorted sediments forming alternating layers of fine compacted silt and clay, probably the work of near-shore "wash" of the lake waters. This stratum also exhibits pronounced desiccation cracks in its horizontal surface (also visible in profile). There are no cultural materials in the upper 60 cm of the deposit.

Between 60 and 80 cm is a colluvial layer of subangular, pea-sized gravel and shell fragments within a fine-to-coarse tan sand matrix. In some areas of the profile this stratum is laminated, suggesting sorting of the deposit by the lake waters. Shell from this stratum, dated at 9290 ± 50 B.P., may have been redeposited from a higher elevation.

Stratum 2, immediately below Stratum 4, is composed of gravelly sand with some clayey silt and sparse shell fragments. This unit contained three flakes, one of which is a biface reduction flake of Coso obsidian with an hydration rind of 23.1 microns. Below this is Stratum 1, composed of sandy clay of a greenish cast, clearly lacustrine in origin. The thickness of this stratum was not penetrated in this unit.

Unit 176s0e, located low on the beach at about 181 m in elevation, contains a stratigraphic sequence similar to that of 122s1w (see Figure 5, Table 2). Below the surface colluvium, starting at about 10 cm depth, is a hard, silty stratum with pronounced desiccation cracks; this stratum equates with Stratum 6c in Unit 122s1w. Below this is a stratum with laminations similar to Stratum 6a-b of Unit 122s1w; it extends to a depth of 50 cm below the surface where it rests on a coarse sand and gravel. The coarse sand and gravel stratum equates with Stratum 4 of Unit 122s-1w. Coarse, slightly rounded pebbles, mixed with fine sand, lie below and equate with Stratum 2 in Unit 122s1w. Strata 1 and 2, green sand and green sand with calcium carbonates, respectively, equate with Stratum 1 of Unit 122s1w. Stratum Z in Unit 176s0e is composed of a gray/brown silty sand containing angular pebbles and some shell fragments.

At Bench Mark Bay, the beach deposits contain both lacustrine and colluvial materials, but they vary in texture and color with location, making it difficult to correlate strata in excavation units separated by some distance, as is the case with the sample units excavated during this investigation. It is clear, however, that in each unit there are colluvial materials, some of which are reworked and sorted by the lake waters, and there are lacustrine deposits. One stratum is clearly lacustrine, a green silty clay, at or near the bottom of all units excavated to a sufficient depth on the lower beach (e.g., Stratum 1 in units 176s0e and 122s1w). This green lacustrine deposit is from a lake of long duration, probably dating to the Intermittent Lake Mojave IIIa, between about 10,800 and 10,200 years ago. Three flakes were recovered from this stratum in Unit 176s0e. In that unit, Stratum 1 was penetrated, revealing a gray/brown silty sand with angular pebbles, recorded as Stratum Z. A shell sample was recovered from Stratum Z, but has not yet been dated.

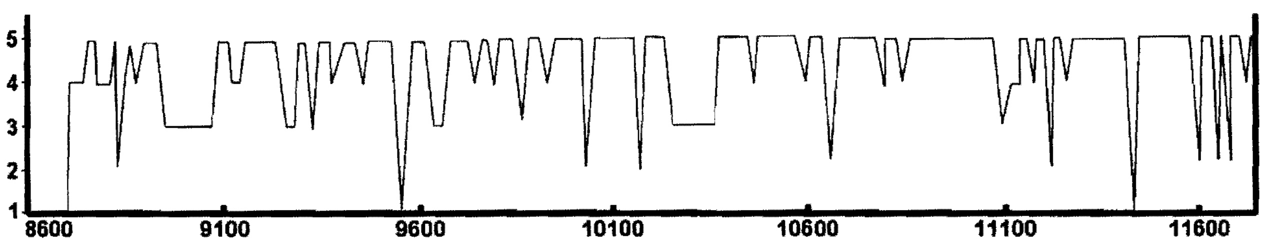


Figure 4. Lake fluctuations as interpreted by Wells et al. 1989 from playa cores. The numbers along the vertical axis indicate presence of water in the Silver Lake (i.e., Lake Mojave Basin. For example: 1= no evidence of water present; 3= lower lake stand (water in center of basin, but not covering margins; 5 =complete playa covered with water. Dates along the horizontal axis are years Before Present (BP). Adapted from Wells et al. 1989.

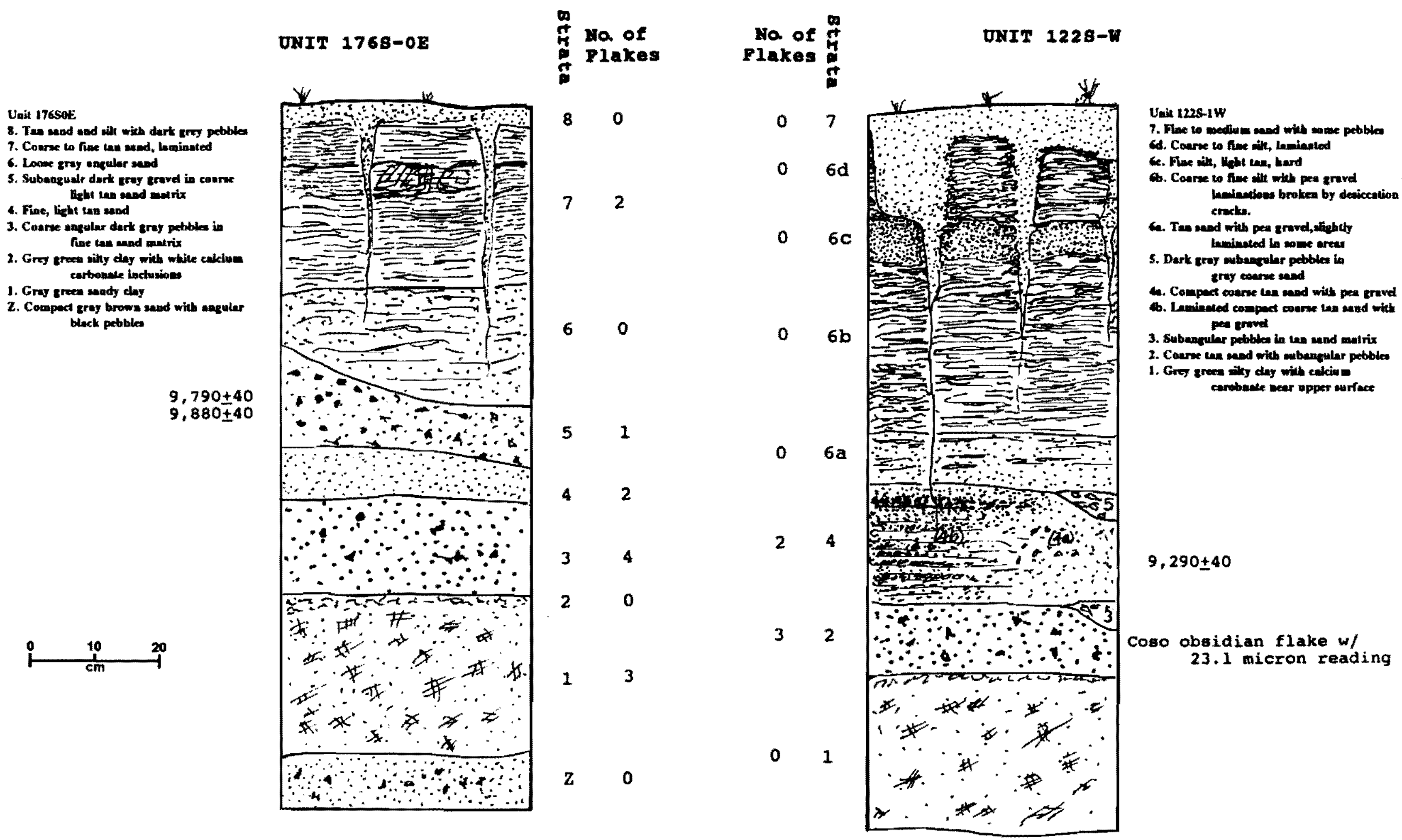


Figure 5. Stratigraphy and ^{14}C dates in Units 176s0e and 122s1w.

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