Chapter III

CHRONOLOGICAL FRAMEWORK

Dating the late prehistoric adaptation to lacustrine conditions in Coachella Valley hinges on the dating of the last stand of Lake Cahuilla. Several approaches can be used to estimate the dating of the last stand of the lake, including radiocarbon, historical accounts, and cross-dating of artifacts found on the lakeshore. However, none of these provides a fully satisfactory means of dating.

DATING THE RECENT STAND OF LAKE CAHUILLA

Radiocarbon

A large body of radiocarbon data pertinent to the various stands of Lake Cahuilla is available, but the data are difficult to interpret. Table 3 lists analyzed radiocarbon samples that document or suggest lake stands in the Salton Basin during the last 2000 years.[1] The apparent age ranges of these samples in radiocarbon years before the present are plotted in Table 4. Table 4 also shows the equivalent calendar date range for each sample based on data derived from the measurement of the radiocarbon content of dendrochronologically dated bristlecone pine (*Pinus longaeva*) samples (Ferguson 1970; Suess 1970). While each dated sample must be evaluated on its own grounds with reference to association and the basic parameters of radiocarbon dating (Ralph 1971), the available age determinations cluster into three groups. It is evident, however, that while a cluster of radiocarbon measurements suggests a single lake stand, it may in reality indicate two or more closely successive fillings of the basin. The term "lacustral interval" is used here to describe a period in which there was a single lake stand of prolonged duration, or several shorter, closely successive, lake stands. It describes a period of generally aquatic, rather than generally arid, conditions in the basin.[2] Radiocarbon measurements are not precise enough to determine the number of lakes that formed within a given lacustral interval, however Table 4 is interpreted to portray three such intervals separated by periods in which desert conditions presumably prevailed. The whole Salton Basin is a desert, but the floor of the basin was either covered with water or it was also arid. References to periods of arid conditions, or desert conditions, which follow, should be considered to refer to arid conditions on the floor of the Salton Basin.

Available data suggest that the earliest episode of lake fillings in the last 2000 years began sometime around the beginning of the Christian era, perhaps shortly before, and lasted until perhaps A.D. 600. It is of little concern to the present study, and no substantive archaeological data are presently known that clearly date to this interval.

Table 3

SUMMARY OF RADIOCARBON DATA ON LAKE CAHUILLA DURING THE LAST 2000 YEARS

Lab code	Age, ^{14}C years B.P.	Source	Material	Associations	Comment
UCR-125	<100	[3]	Human coprolite	Coprolite Bed B, Myoma Dunes	Exposed by deflation
UCR-350	<100	[8]	Charcoal	Midden at fishing station designated Wadi Beadmaker, northeast shore near Orocopia Wash, depth 2-5 cm.	Last filling inferred
UCR-349	<100	[8]	Charcoal	Same as above, but sample from hearth at depth 10-20 cm.	
UCR-348	<150	[8]	Charcoal	Same as above, but sample from base of midden	
UCR-163	<150	[3]	Charcoal	Beam from house adjacent to Coprolite Bed A, Myoma Dunes	
UCR-319	<150	[8]	Charcoal	Hearth at heron rookery, Bat Caves Buttes; burned heron bones	Site on island 4.5 miles from northeast shore
M-598	120^{+200}_{-120}	[1]	Charcoal	Fire pits about house rings on west shore; fish bones, pottery, late projectile points	Last filling?
M-597	130^{+200}_{-130}	[1]	Charcoal	Lower level of Split Mountain dune site; "Playa" projectile points, trace of pottery, freshwater fish bones	Re-run as LJ-GAP-59
LJ-102	220±100	[2]	Charred tule	East shoreline	Extensive tule fire
UCR-153	235±150	[3]	Bulrush seed	Residue of decomposing coprolites, Bed A, Myoma Dunes	Date on aquatic fraction
UCR-152	240±150	[3]	Mesquite seeds	Same as above	Date on terrestrial fraction
UCLA-192	270±60	[4]	Charcoal	From hearths with freshwater fish bones, elevation -160 feet	
LJ-15	300±100	[2]	Charcoal	Archaeological site, SW shore, 2 miles south of international border	Last filling inferred
UCR-124	365±140	[3]	Human coprolite	Myoma Dunes Bed D; squash (*Cucurbita* sp.) seeds recovered in association	Same gas re-counted as cross-check: 420±80 B.P. (UCLA-1889)
UCR-380	415±140	[8]	Burned fish bone	Midden at fishing station of Wadi Beadmaker	Composite sample from entire depth of midden. To check results obtained on charcoal (UCR-348, UCR-349, UCR-350)
LJ-GAP-58	420±100	[7]	Charcoal	Surface of Split Mountain archaeological site, west shore	Last filling inferred
PCV-2**	450±130	[9]	Shells	Beach deposit at mouth of Martinez Canyon	
M-596	450±200	[1]	Charcoal	Archaeological zone in clay deposit behind longshore bar; freshwater fish bones	Last filling?
LJ-GAP-59	470±100	[7]	Charcoal	Archaeological stratum in Split Mountain dune site 60 cm. below surface; ceramics	Association with "Playa" points questionable
LJ-GAP-70	720±100	[7]	Charcoal	Archaeological stratum in Split Mountain dune site 1.5 m. below surface; "crude" points	Associations unclear from published data in date list
LJ-99	760±100	[2]	Charcoal	Charcoal in silt stratum which was formed during second of three cycles of inundation documented in the section	Next-to-last filling?
LJ-965	830±140	[6]	*Anodonta* sp. valves	From hearth in archaeological site at headwater forks of Fish Creek in mountains west of Lake Cahuilla	Cross-check of LJ-7
LJ-106	960±100	[2]	Charcoal	Archaeological stratum in arroyo cut on east shore of lake near Siphon 15 on Coachella Canal; ceramics, fish bone	1.7 m. deep in silt behind bar
LJ-7	1000±200	[2]	Charcoal	From hearth in archaeological site at headwater forks of Fish Creek in mountains west of Lake Cahuilla; fish bones of species common to Lake Cahuilla	

(Continued)

Table 3 (continued)

LJ-960	1010±220	[6]	*Anodonta* sp. valves	Valves from west shoreline	
PCV-3**	1250±120	[9]	*Unio* shell	Lake sediments at New River Gorge, 1 mile south of Seeley, Imperial Valley (P. C. Van de Kamp, personal correspondence)	
LJ-105	1440±100	[2]	Charcoal	From archaeological stratum exposed in wall of arroyo, in silt behind bar at depth of 2.0 m., near Siphon 15, Coachella Canal, east shore; fish bones	
LJ-530	1510±180	[5]	Tufa	Tufa coating cobbles on west shoreline	
LJ-101	1580±200	[2]	Charcoal	From depth of 45 cm. in silt flat behind sand bar, SW of Valerie, west shore	
LJ-513	1800±200	[5]	Tufa	From outer 5 cm. of tufa coating on boulders of Travertine Rock, islet just off west shore	Sample is cross-check of LJ-458
LJ-458	1890±500	[5]	Tufa	Same as above	

**Not official laboratory numbers. The dates were run by Shell Development Company and never submitted for publication in *Radiocarbon* (see Van de Kamp 1973). The laboratory is no longer operating.

Adapted from D. Weide (1976b) and expanded.

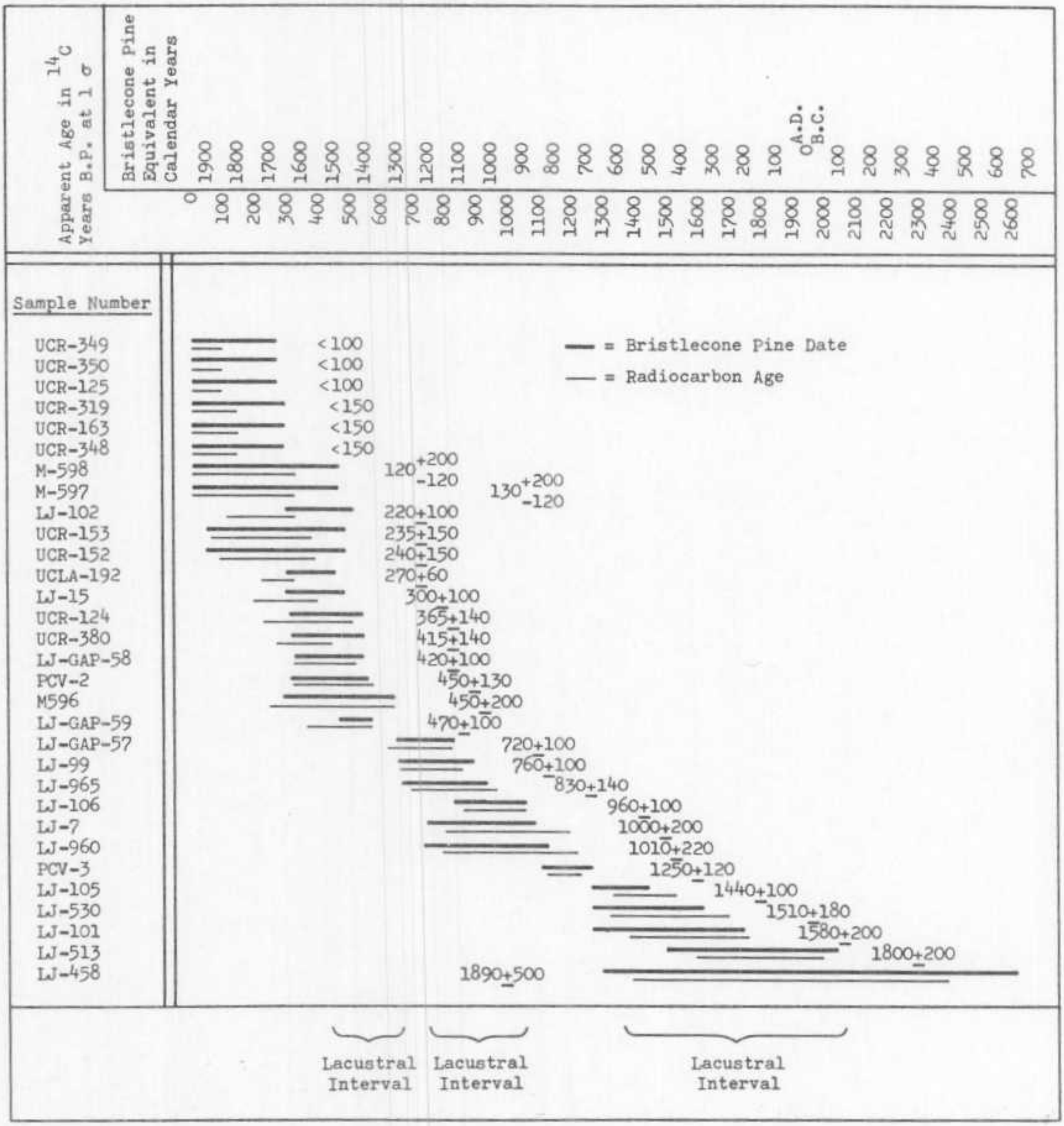
Sources:
[1] Crane and Griffin (1958)
[2] Hubbs, Bien, and Suess (1960)
[3] Taylor (1975)
[4] Fergusson and Libby (1963)
[5] Hubbs, Bien, and Suess (1963)
[6] Hubbs, Bien, and Suess (1965)
[7] Hubbs and Bien (1967)
[8] R. E. Taylor (in preparation)
[9] Van de Kamp (1973)

Two lacustral intervals are suggested for the period after A.D. 900. Sample LJ-99 (760±100 radiocarbon years B.P.) is of particular importance to the interpretation of these. It was collected by G. M. Stanley from a bed of silt on the west shore of the lake near Travertine Point. The silt "formed during the second of three cycles of inundation (due, presumably, to fluctuating lake level)" indicated in the exposed section (Hubbs, Bien, and Suess 1960:215). The apparent age of the sample is clearly within the cluster of measurements shown in Table 4 that suggests the second period of lake fillings within the last 2000 years. The stratigraphic interpretation did not indicate the magnitude of the fluctuation involved, whether it was minor, or whether it represents a complete drying of the lake. If a minor fluctuation is indicated, there may have been only one lake stand during the last millenium. This stand would therefore have lasted for well over 500 years. If a complete recession of the lake is indicated, which is suggested by the data in Tables 3 and 4, there were two periods of lake fillings within the last 1000 years or so.

Evidence from Perris Reservoir, near Riverside, about 100 miles to the northwest, tends to support the latter interpretation. Excavations at the Peppertree site (CA-Riv-463) (Wilke 1974) at Perris Reservoir yielded obsidian flakes and artifacts. Source analysis revealed that some of this obsidian originated in deposits at Obsidian Buttes, low rhyolite extrusions on the bed of Lake Cahuilla near the south end of the Salton Sea.[3] These buttes are of very low elevation, not rising above about 130 feet below sea level, and were thus under about 175 feet of water whenever Lake Cahuilla was filled to overflow. Access to the obsidian deposits was possible only in periods when the lake was dry or nearly so. At the Peppertree site, the obsidian from this source occurred

Table 4

RADIOCARBON CHRONOLOGY OF LAKE CAHUILLA
DURING THE LAST 2000 YEARS
WITH BRISTLECONE PINE CORRELATIONS



from level *g*, dated at 870+80 radiocarbon years B.P. (UCLA-1815), through level *d*, dated at 215+60 radiocarbon years B.P. (UCLA 1816). When these measurements are converted to calendar years after Suess (1970), they yield the following results: 870+80 radiocarbon years B.P. = A.D. 1050-1200; 215+60 radiocarbon years B.P. = A.D. 1470-1750.[4] These figures indicate that sometime during the last 1000 or 1100 years obsidian from the Obsidian Buttes locality was being quarried and taken out of the basin (see Fig. 14). In other words, there must have been one or more periods of complete desiccation between stands of Lake Cahuilla after A.D. 900. However, information now available does not permit precise delimitation of the number of stands of the lake, or the duration of each, within the last 1000 years.

Table 4 shows a cluster of samples with apparent ages ranging from modern (<150 ^{14}C years) to 470±100 radiocarbon years B.P. These measurements suggest that the latest lacustral interval occurred after ca. A.D. 1400. Moreover, the data suggest that the last stand of the lake had a probable duration of several hundred years, which is difficult to reconcile with available historical information.

Several radiocarbon samples analyzed in connection with the present study yielded apparent ages of less than 150 radiocarbon years. These include a series of three wood charcoal samples from the site of Wadi Beadmaker, a fishing station on the northeast shore of Lake Cahuilla at Orocopia Wash. These samples were taken from the ca. 30-cm.-deep midden which contained very abundant fish bones. Thus, association with a recent stand of Lake Cahuilla (here considered the most recent stand) is firmly established.

The radiocarbon content of these samples (UCR-348, UCR-349, UCR-350) was calibrated against that of a tree ring formed in 1890 which did not differ significantly from the count rate of 0.95 N.B.S. oxalic acid standard. The samples were found to have a higher radiocarbon content, and thus a younger apparent age, than the 1890 tree ring and the 0.95 N.B.S. oxalic acid standard. Table 3 lists other samples which are considered to have been associated with the most recent stand of Lake Cahuilla, and that yielded anomalously young radiocarbon ages. The material analyzed is also identified.

There are several possible explanations for this apparently anomalous dating. The first may lie with secular variations that are known to have occurred in the radiocarbon content of the biosphere, as reflected in tree rings. It has been shown by Suess (1970) and Ferguson (1970) that during the last four centuries there have been pronounced fluctuations in levels of atmospheric radiocarbon. One of these fluctuations peaked at about the end of the seventeenth century, when the radiocarbon level of the atmosphere (and all terrestrial living material) was roughly equivalent to that of the present (i.e., since 1890, prior to extensive burning of fossil fuels and the detonation of nuclear devices in the atmosphere). Another slightly smaller surge in radiocarbon levels occurred in the middle of the sixteenth century. If the last lake stand ended early in the sixteenth century, superficial cultural material on the lakeshore, dating to the closing phases of this stand, could yield essentially modern radiocarbon age determinations, given the accuracy of presently available counting methods. Perhaps this explains some of the apparently anomalous dates obtained on material associated with the last lake stand.[5]

Another possible explanation of the apparent modern ages (<150 ^{14}C years) of some of the radiocarbon samples from the shore of Lake Cahuilla may lie in as yet not understood phenomena peculiar to the Salton Basin. It is thought by most geophysicists that radiocarbon atoms produced by the detonation of nuclear and thermonuclear devices cannot exchange with carbon atoms in the organic residues of superficial archaeological deposits. If, however, such replacement or exchange did occur, it would enrich the radiocarbon content of the samples, causing them to have apparent ages more modern than expected. Given the present understanding of radiocarbon dating, it does not seem advisable to suggest contamination of samples by exchange with bomb ^{14}C, since the problem has not been observed elsewhere, and there is no particular reason to believe that it should occur in the Salton Basin. Future research may, however, show that such exchange can occur.

Isotopic fractionation, or selection for a heavier or lighter carbon isotope, in the metabolic processes that produced the sample material would affect the radiocarbon content slightly. However, when this occurs, it is usually in the direction of the lighter isotope, with the result that the apparent age is too old, rather than too young, and mass spectrometric checks of the $^{13}C/^{12}C$ ratios indicated that fractionation had not occurred.

It is theoretically possible that fractionation might also have occurred during combustion in an ancient campfire (Peter Slota, personal communication, 1976). In this case, the lighter isotope, ^{12}C, would be more active in oxidation, and a disproportionately large amount of it might be oxidized to CO_2. This would leave the partially burned organic sample enriched slightly with the heavier isotope, ^{14}C, which, upon analysis, would yield an apparent age more recent than expected. Such fractionation might account for the modernity of the three charcoal samples analyzed from Wadi Beadmaker (UCR-348, UCR-349, UCR-350). If such fractionation occurred in the aboriginal burning of wood, but not the burning of bone, it could account for the apparent age of 415$\pm$140 radiocarbon years (UCR-380) obtained on burned fish bone from the same deposits (see Table 3). The fish bone might have been in part composed of carbonate ions of great radiometric age drawn from the waters of Lake Cahuilla, so the question remains open. It would seem useful, therefore, to give additional attention to the problem of fractionation during combustion in ancient fires, and to determine if it might be a source of error in radiocarbon determinations, although the matter is usually considered a nonproblem.

Although not suggested by historical records, it is possible that the last stand of Lake Cahuilla was more recent than heretofore realized or expected. Such an event would be in harmony with the recent radiocarbon age determinations. To evaluate this possibility, it is necessary to examine briefly the historical record of the flow of the Colorado River and to see if there are periods in historic time (post-A.D. 1540) when the river could have flowed into the Salton Sink causing Lake Cahuilla to fill.

Historical Records

Explorations in the Colorado River delta region provide general information on the drainage pattern of the river after A.D. 1540. Not only did explorers of the region follow the river downstream to tidewater, and thereby establish that it was not flowing into Lake Cahuilla, they also sailed up the river from its mouth or ascended it by land. The history of the region is treated in works by Alvarez de Williams (1975), Bolton (1925), Forbes (1965), Sykes (1937), Venegas (1759), and Wagner (1929), among others. Since 1540, no period of more than 95 years has elapsed in which it is not possible to rule out an inflow of the Colorado to the Salton Basin from evidence contained in historical records, assuming that these are interpreted correctly. The historical record is summarized as follows:

1539--Francisco de Ulloa sailed from Acapulco to the head of the Gulf of California. The shoals and reddish water he described indicate that he reached the Colorado Delta, but he did not go ashore (Wagner 1929:11-50, 293-312).

1540--Hernando de Alarcón sailed from Colima to the head of the Gulf of California as part of the expedition of Francisco de Coronado. He ascended the Colorado River in ship's boats probably to just below the junction with the Gila (Hammond and Rey 1940:124-155), possibly as far as present Parker, Arizona, and found the river flowing directly into the gulf.

1540--Melchior Díaz led an overland expedition from Corazones, Sorona, to the Colorado, also in connection with the Coronado expedition. He found messages left for him on the Colorado by Alarcón, ascended the river an unknown distance (possibly as far as present Blythe), crossed it, and descended it on the west (California) side. He almost certainly reached the mud volcanoes near Cerro Prieto (the site of the outlet channel of Lake Cahuilla, which was not seen), and was fatally wounded in an accident in the western part of the delta (Hammond and Rey 1940:231-232).

1604-05--Don Juan de Oñate led an overland expedition from New Mexico to the Colorado, which he reached by descending the Bill Williams River. He followed the Colorado down to tidewater along its approximate present course (Hammond and Rey 1953).

1615--Juan de Iturbi, pearl fisher, sailed up the gulf to near the Colorado Delta (Venegas 1759, I:180-181; Forbes 1965: 111). He was not in a position to observe the drainage pattern of the upper delta.

1700--Father Eusebio Kino led a missionary expedition from Mission Dolores, Sonora, to the junction of the Gila and the Colorado by way of the Gila. He ascended a high mountain in the vicinity, and with the aid of a powerful telescope he saw the Colorado flowing southwest 10 leagues and then southward 20 leagues more to the Gulf of California. To the northwest, in California, he reported seeing only the Peninsular Range (Venegas 1759, I:300-302). He thus determined that California was not an island. This was a widespread misconception at the time (Leighly 1972).

1701--Father Kino returned to the Gila junction and descended the Colorado River to Quiquima (Halyikwamai) territory (Venegas 1759, I:308-309).

1702--Father Kino again led a missionary expedition to the Colorado by way of the Gila and descended the Colorado to its mouth (Venegas 1759, I:310; Bolton 1948).

1706--Father Kino returned to the Colorado with Father Manuel de Ojuela. He found conditions there as before (Venegas 1759, I:311).

1721--Father Juan de Ugarte sailed from Loreto on the east coast of Baja California to the head of the Gulf of California. He attempted to ascend the Colorado River, but was discouraged by the summer floods, tidal disturbances, and storms (Venegas 1759, II:46-62; Clavigero 1937:246-254). He could not have seen anything about the river that would indicate whether it was flowing out from the Salton Basin, or whether it was flowing directly into the Gulf of California.

1744--Father Jacobo Sedelmayr journeyed from Tubutama, Sonora, to the Colorado by way of the Gila. Little is known of his observations or the extent of his movements there (Venegas 1759, II:183; Ives 1939).

1746--Father Ferdinand (Fernando) Consag (Konschak, Konšćak, etc.) journeyed northward by sea along the east coast of Baja California to the Colorado Delta (Venegas 1759, II:308-353). He explored the delta for a short distance upstream, but his observations were so limited in scope that nothing can be said for the possible existence of Lake Cahuilla.

1748--Father Sedelmayr journeyed from Tubutama, Sonora, to the Colorado River by way of the Gila. He descended the Colorado to Yuma (Quechan) territory (Venegas 1759, II:209). The evidence is inconclusive, but he probably would have seen Lake Cahuilla had it then been in existence.

1771--Father Francisco Garcés descended the Gila to the Colorado, followed the latter to its mouth, crossed it, and explored the western edge of the delta as far north as Signal Mountain, near the present international border (Bolton 1930, I:31-32). Had Lake Cahuilla been in existence, he would have seen it.

1772--Pedro de Fages pursued deserters from San Diego to Imperial Valley and was forced to return to the Peninsular Range for lack of water (Bolton 1931:219).

1773--Sebastián Taravál, a Cochimí Indian originally of Santa Gertrudis Mission in Baja California, fled from San Gabriel Mission to the Colorado River. His route took him to the San Sebastián Marsh, across Imperial Valley, and through the Algodones Dunes, where his wife died of thirst (Bolton 1930, III:65).

1774--The first Anza expedition reached the Colorado River, traversed the delta, crossed the Cocopah Mountains, proceeded to the north end of the Pattie Basin, and entered the Imperial Valley at Signal Mountain (Bolton 1930, I:67-101). The Salton Basin was dry.

After the first Anza expedition, explorations in the Lower Colorado River region and in the Salton Basin were so frequent that it is clear the Colorado generally followed its recent pattern of flow into the gulf. From the historical record spanning the period 1540-1774, it would appear that there was no interval in which the Colorado could have flowed into the Salton Basin long enough to fill it to overflow, maintain it long enough for its shores to develop a substantial archaeological residue, and return to its pattern of draining into the gulf without such a diversion being observed and noted. The longest gap in the historical record is 95 years, from 1605, when Oñate descended the Colorado, to 1700, when Kino reached the Colorado and saw it flowing into the Gulf of California. It is possible that shortly after Oñate's expedition the river was again diverted into the basin forming another stand of Lake Cahuilla, and returned to its old channel by the beginning of the eighteenth century. If this did occur, Lake Cahuilla could have been undergoing its final recession even as Kino visited the delta. But if this actually did happen, we should have to wonder why Kino did not see the lake or learn of it from the Indians. In view of the net annual evaporation suggested for Lake Cahuilla (nearly six feet per year, as deduced from present climatic conditions), it would have required nearly 60 years to dry completely if all inflow from the river ceased abruptly. And there remains the question of whether a lake stand of only one or two generations could have resulted in the abundance of archaeological remains which apparently dates to the most recent stand. This does not seem at all probable.

If the historical records are interpreted correctly, it would appear that there has been no stand of Lake Cahuilla since A.D. 1540.

Unresolved Historical Problems

There remain several perplexing problems in the history of the Colorado Delta region and the possible late existence of Lake Cahuilla that were not mentioned above. Godfrey Sykes (1914:15) called attention to the remarkable map of John Rocque (ca. 1762) in the cartographic archives of the British Museum. The map clearly shows the combined streams of the Gila and the Colorado flowing into a lake of sizeable proportions, located to the north of the Colorado Delta, and having no outlet to the sea. The source of the information on which this part of Rocque's map is based remains a mystery.

Several early explorers on the Lower Colorado were told by the Indians of a mythical lake. Alarcón first learned of it in 1540 (Hammond and Rey 1940:144-145), and Oñate was told of it when he reached the confluence of Bill Williams Fork and the Colorado River on his expedition from New Mexico in 1604-05. According to Zárate Salmerón's account of the Oñate expedition,

> Here was heard the first news of the Lake of Copalla . . . . They described this lake and land and all its banks as densely populated. An Indian said Copalla very plainly . . . . And those Indians also said that those of that language wore bracelets of gold . . . and that from there they were fourteen days' journey, of those which they travelled. They pointed to this language [of Copalla] between west and northwest [quoted from Bolton 1925:271-272].

The fact that the lakeshore inhabitants are described as having gold suggests that the Spaniards elicited the answers they sought to the loaded questions they must have asked. But perhaps the tale of this lake told by the Indians of the Colorado had a kernel of truth, recalling the former existence of Lake Cahuilla in the then recent past.

Some authors have noted that early maps and records of exploration sometimes indicate the head of the Gulf of California at about 34° North latitude, where it is actually less than 32° North. George Carter (1964) suggested that if Spanish vessels of shallow draft entered the outlet channel of Lake Cahuilla, they might have sailed to the north end of it and reached 34° North latitude (actually only 33½° North). Carter's discussion relates specifically to the voyage of Francisco de Ulloa to the head of the gulf in 1539. Study of Ulloa's narrative (Wagner 1929:11-50, 293-312) does not seem to support Carter's contention, and the error of two degrees is possibly attributable to the limited accuracy of the astrolabes then in use. But even with sixteenth century astrolabes, the navigational measurements should have been more accurate. In any event, the fatal march of Melchior Díaz a year later seems to rule out any possibility that Lake Cahuilla ever existed in Ulloa's time.

It would, however, seem possible (in theory, at least) that Spanish vessels could have sailed up the outlet channel of Lake Cahuilla and entered the lake, had it been in existence, since some of these ships were of very small dimensions by today's standards. Two of Ulloa's three ships reached the head of the gulf and one of these, the *Trinidad*, displaced only 35 tons. An even smaller vessel, the *Santo Tomás*, displacing only 20 tons, was damaged in a storm and blown far to the south (Wagner 1929:12). Vessels of this size presumably could have navigated the shallow waters of the delta and entered the outlet of Lake Cahuilla. Such a voyage could account for the origin of a myth to this effect recorded in the last century:

> The Cahuillas . . . . also have a tradition that long ago white birds bearing little men came sailing over the waters [of Lake Cahuilla] seeking provisions of the Indians, after which they sailed away and they heard of them no more. This indicates ships and sailors, but who could they have been, and from what nation did they come? In view of the probable long time that must have elapsed since there was water in this desert sufficient to float ships, the answer would be mere conjecture [Bowers 1891:230].

And so the myth remains, even today (O'Dell 1957:147-151). Homer Aschmann has suggested to me that this tale might have originated among the Cocopah or other groups of the Colorado Delta, and only later been transferred to the Cahuilla. This would seem a reasonable explanation.

Carter (1964) also suggested that the presence of Lake Cahuilla might have contributed to the notion that California was an island separated from the mainland by the Strait of Anian, as portrayed by seventeenth century map makers the world over (Leighly 1972). While there remain certain intriguing aspects of the history of the Colorado Delta region, it seems most reasonable to conclude that the Colorado River had already ceased flowing into Lake Cahuilla when the Spanish frontier reached the head of the Sea of Cortez in 1539.

Cross-Dating

An attempt was made to cross-date the most recent stand of Lake Cahuilla with shell beads and other ornaments. Twenty-six lots of shell artifacts from Coachella Valley originated in archaeological contexts which suggested association with recent stands of the lake. For the most part, these were surface collections made from archaeological sites on or adjacent to the shoreline. The samples were selected because of proximity to the shoreline. Many were in clear association with aquatic remains, such as fish bone, burned *Anodonta* valves, etc. Some historic items were expected to occur in the sample because ethnographic Cahuilla villages were located at Indian Wells and in the vicinity of Indio, where the collections were made. Some of the shell items were grave offerings associated with cremations exposed over the years by deflation of the sandy shoreline deposits.[6] One lot came from the excavated site of Wadi Beadmaker, but the lack of contextual association of some of the surface collections is recognized.

Many of the shell artifacts were manufactured by the ancestral Chumash Indians of the Santa Barbara Channel region of the Pacific coast of southern California. These beads had both decorative and monetary value in the aboriginal cultures through which they were exchanged, and their styles changed markedly over time. Studies of the beads and other ornaments from coastal sites have resulted in a working chronology of styles. Earlier shell artifacts are placed in time by radiocarbon. Later shell and glass beads are dated by both radiocarbon associations and historical records, including mission registers. Seriation of individual lots has helped to refine the chronology.

Not all of the shell artifacts examined originated on the Pacific coast. Some of them were made from the valves of molluscs whose distributions are restricted to the Gulf of California, but the chronology of the artifacts made from gulf species is less well known. In the Southwest, where cultural chronology has been worked out to a high degree of precision by means of tree-ring correlations and ceramic stratigraphy, artifacts of gulf shell are widely distributed. The problem with extending this refined chronology to shell artifacts and cross-dating into the southern California deserts stems from the fact that shell artifacts are generally not well described in literature. This makes it difficult to correlate types.[7] Probably some day it will be possible to date inland southern

California sites by cross-dating into the southwestern chronology by means of Gulf of California shell artifacts; however, for the present, one must rely largely on comparisons with the Santa Barbara Channel region. One rather common form of shell ornament in archaeological deposits at Lake Cahuilla is made by grinding both ends from the valve of the Gulf of California gastropod *Olivella dama*. The result is a barrel-shaped to cylindrical or even ring-shaped bead. Haury (1976:309) reports similar ornaments from Santa Cruz and Sacaton Phase (A.D. 700-1100) deposits at the Hohokam site of Snaketown, in Arizona.

The shell artifacts were examined by Chester D. King, and will be reported elsewhere. For the present, it can be noted that no firm dating of the last stand of Lake Cahuilla is possible due to the lack of definite temporal association of certain of the bead lots with the lakeshore, and the long time span in which many of the ornaments were manufactured. Most of the lots, however, were judged to be equivalent with Phase 1 of the Late Period of the Santa Barbara Channel region, or roughly within the interval A.D. 800±100 to 1500±100. The Pacific coast specimens in the small assemblage from the excavated site of Wadi Beadmaker dated to this period. The few items which could be cross-dated into the southwestern sequence were in use during, or limited to, this period of time also. Thus, there is general agreement between this method of dating and the dating of the last two lacustral intervals of the Salton Basin as established by radiocarbon dating.

A few lots comprised or included shell items of later periods, including the Historic Period of the Santa Barbara coast, which for practical purposes begins about A.D. 1785, or roughly when the Spanish missions were established in that region. For reasons already stated, this was as expected. Most of the analyzed lots are probably contemporaneous with one or more recent lake stands, and date to some portion of the interval A.D. 800±100 to 1500±100, based on correlations with the Santa Barbara Channel region. More precise determinations based on cross-dating of shell artifacts are not at present possible.

Two other categories of artifacts from lakeshore contexts provide limited information for dating the recent stand of Lake Cahuilla. These are projectile points and ceramics, neither of which is as precisely datable as certain shell artifacts.

Examination of projectile point collections from the shore of Lake Cahuilla reveals that nearly all of these fall into the Desert Side-notched series, originally defined as a type with four variants by Baumhoff and Byrne (1959), and the Cottonwood series, originally defined by Lanning (1963). Both of these styles originated about A.D. 1000, as indicated by published radiocarbon dates associated with them (Hester 1973:35-37), and continued in use into historic times. In their discussion of the time periods in inland southern California prehistory, Bettinger and Taylor (1974) placed the origin of these point styles at A.D. 1300. This is undoubtedly conservative, in view of the fact that similar projectile points occurred in large numbers in Sedentary Period Hohokam contexts (A.D. 900-1100) in Painted Rocks Reservoir on the Gila River near Gila Bend, Arizona (Wesley and Johnson 1965:30). The projectile points recovered from the site of Wadi Beadmaker were exclusively of these two styles, and serve therefore to date the site to some time after A.D. 900.

To date, only one ceramic assemblage from a shoreline site at Lake Cahuilla has been studied in detail, namely that from Wadi Beadmaker (King 1975). Of more than 900 sherds studied, nearly all of them were classified as Tumco Buff and Tumco Stucco after Schroeder (1952), with the former predominating. These styles are thought to have originated prior to A.D. 900, and Tumco Buff is thought to have been manufactured until perhaps at least A.D. 1450.

While these additional artifact categories are useful in providing a general chronological framework for shoreline sites associated with the last stand of Lake Cahuilla, they are not as time-sensitive as the shell artifacts, and can only be considered to augment and support dates derived from other means.

Summary

Radiocarbon data suggest that there have been three lacustral intervals in the Salton Basin representing an unknown number of stands of Lake Cahuilla during approximately the last 2000 years. The earliest of these is dated by radiocarbon between 100 B.C. and A.D. 600. The second occurred from perhaps A.D. 900 to 1250. The final lake stand occurred between approximately A.D. 1300 and 1500, to judge from available information. That at least two lake stands separated by dry conditions occurred between A.D. 900 and 1500 is suggested by the occurrence of obsidian from Obsidian Buttes (submerged by the waters of Lake Cahuilla) in archaeological deposits dating to this period at Perris Reservoir a hundred miles to the northwest. A cluster of radiocarbon measurements and the contextual interpretation of sample LJ-99 collected near Travertine Point (discussed above) also suggest that there have been two periods of lake fillings since A.D. 900. Historical records and cross-dates on shell artifacts found in proximity to the lakeshore indicate that the last stand of Lake Cahuilla did not last much, if any, later than A.D. 1500. Thus, while available information does not give a concise historical framework for the recent stands of Lake Cahuilla, it is possible to summarize the data now available. This provisional hydrologic history of the Salton Basin over the last two millenia is shown in Fig. 14.

For the present purpose, and given the available dating information, it seems most reasonable to conclude that the latest period of lacustrine conditions in the Salton Basin occurred between A.D. 1300 and 1500. It came to a close shortly before the Spanish exploration reached the Lower Colorado in 1540.

POST-LAKE CAHUILLA TIME

The recession of Lake Cahuilla is seen as a time of accelerated environmental changes. Present evidence would suggest that the lake dried essentially in the late fifteenth and early sixteenth centuries. Within perhaps 55-60 years the waters became saline, marshes disappeared,

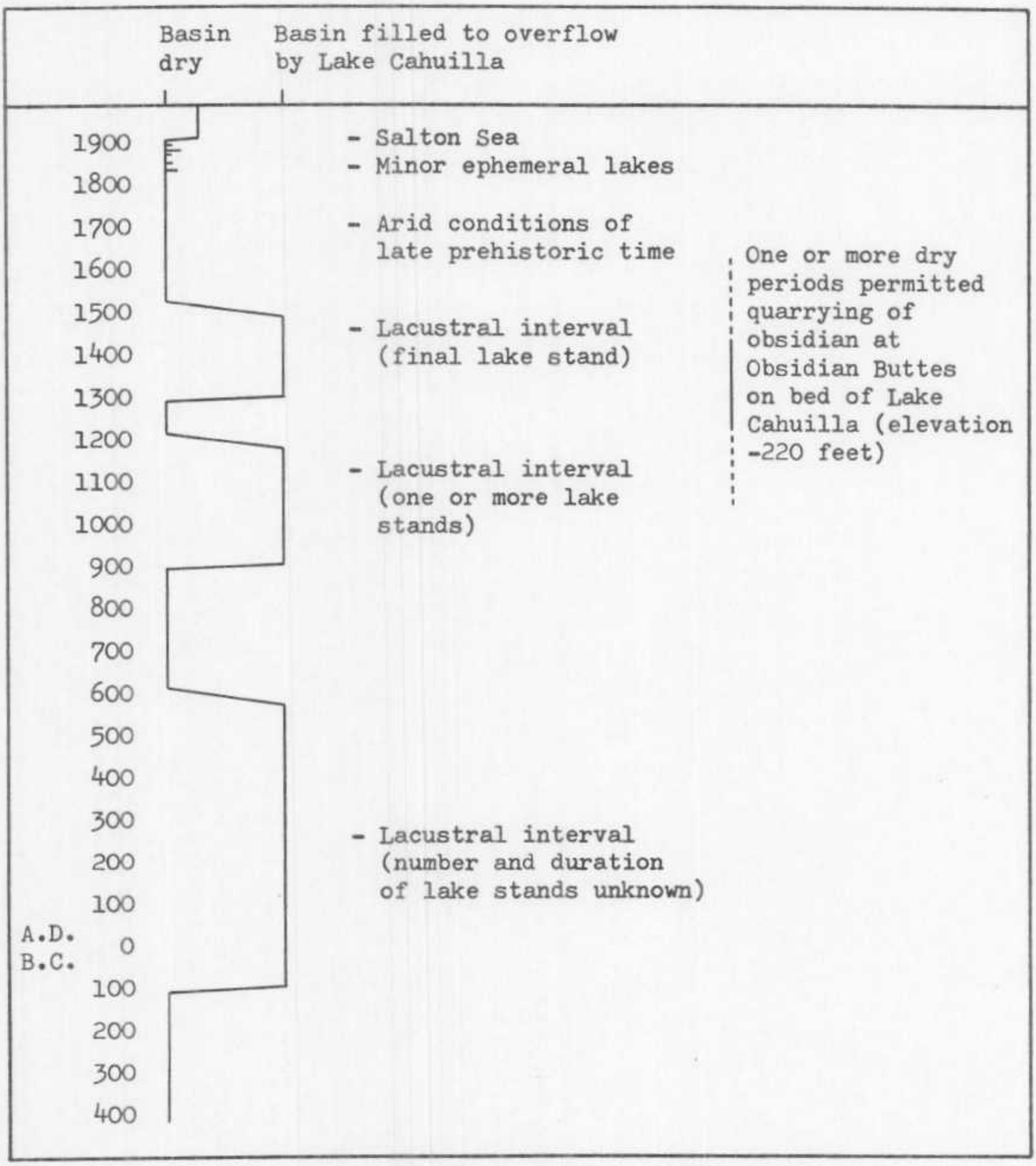


Fig. 14. Hydrologic history of the Salton Basin during the last 2000 years, as reconstructed in this text.

fish and shellfish died, aquatic birds sought better conditions elsewhere, the lake was reduced to a playa, and Colorado Desert vegetation invaded the lakebed. The transition from aquatic to typical Colorado Desert conditions probably required less than a century, assuming that the drying of Lake Cahuilla occurred in 55-60 years and a lag of several decades occurred as the desert vegetation became well established.

The return to desert conditions apparently had occurred by A.D. 1540 when Spanish exploration reached the southern end of Imperial Valley. The Salton Basin was probably characterized by meager resources with conditions gradually improving as the desert vegetation became established. In the Coachella Valley, desert conditions continued into historic time, being interrupted only in the lowest parts of the sink by transient lakes that formed by overflow from the Colorado Delta.

It is recognized that this transition from aquatic to desert conditions in the Salton Basin is only the most recent in a long series of environmental transformations that have characterized the region. There were many lakes formed over the duration of Holocene time, and between them conditions probably were not greatly unlike those encountered by the Spanish exploration.

The reconstructed environmental settings of the Salton Basin and the presumed dating of these are plotted against the several cultural sequences which have been proposed for neighboring regions of the Lower Colorado Basin (Rogers 1945; Harner 1958), the California Desert in general (Wallace 1962b), the Providence Mountains (Donnan 1964), the Owens Lake region (Lanning 1963), and the inland southern California portion of the Great Basin (Bettinger and Taylor 1974) (Fig. 15).

The following chapter examines the human ecology of lakeside adaptation in Coachella Valley during the recent stand(s) of Lake Cahuilla.

NOTES

1. For listings of radiocarbon dates relevant to older stands of Lake Cahuilla, of which there were undoubtedly many, and including those dating far back into the Pleistocene, see Hubbs, Bien, and Suess (1965) and D. Weide (1976b).

2. In geological studies the term "lacustral interval" generally refers to periods of pluvial conditions in which lake basins filled, or at least the lakes in them increased in size. As used in this text, the term implies no climatic changes toward pluvial conditions.

3. Source analysis of obsidians from Perris Reservoir was kindly undertaken by Jonathan Ericson, Isotope Laboratory, University of California, Los Angeles. A report of this analysis is in preparation.

4. Determining calendar date from radiocarbon age determinations is accomplished by working backward from data provided by Suess (1970). He originally determined the radiocarbon content (the unknown) of bristlecone pine tree rings of known age. From his long series of dated samples, it is possible to match the apparent radiocarbon age of any sample at hand with the approximate calendar years in which comparative amounts of radiocarbon were in the atmosphere, thus converting radiocarbon *age* into calendar *date*.

5. Not all investigators accept Suess' interpretations of the minor fluctuations or oscillations he believes he sees in the past radio-

Environmental Conditions in the Salton Basin (this text)	California Desert Cultural Sequences					
	Lower Colorado Basin (Rogers 1939)	Lower Colorado Basin (Harner 1958)	California Deserts (Wallace 1962b)	Providence Mountains (Donnan 1964)	Owens Lake Region (Lanning 1963)	Interior Southern California (Bettinger and Taylor 1974)
Desert (lake dry)	Yuman III	Historic	Historic	Historic	Late Cottonwood	Marana
Lake Cahuilla	Yuman II	Moon Mountain	Period IV - Prehistoric Yuman and Shoshonean	Shoshonean Horizon	Early Cottonwood	Haiwee
(dry)	Yuman I	Bouse 2	Period III Amargosa	Yuman Horizon	Late Rose Spring	Newberry
Lake Cahuilla		Bouse 1		Non-ceramic Yuman	Middle Rose Spring	
(dry)		Preceramic phases		Amargosa		
Lake Cahuilla						

A.D. 1900, 1800, 1700, 1600, 1500, 1400, 1300, 1200, 1100, 1000, 900, 800, 700, 600, 500, 400, 300, 200, 100, 0

Fig. 15. Correlation of reconstructed environmental conditions in the Salton Basin with postulated California Desert cultural sequences.

carbon content of the atmosphere based on measurements of the radiocarbon activity of tree rings of known age (see, for example, Ralph 1971:27). In the absence of any better method of correlating radiocarbon age with true age, the Suess curve is employed here and will continue to be used until proven incorrect or otherwise unsatisfactory.

6. These cremations were subsequently reinterred in the Torres-Martinez cemetery.

7. Many of these are simply identified to the generic level, which in the case of olivellas is not sufficient to determine whether the shells originated on the Pacific coast or on the Gulf of California.