THE CHRONOLOGY OF LAKE CAHUILLA'S FINAL STAND

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ABSTRACT

Lake Cahuilla was a large freshwater lake in the Salton Basin of Imperial and Riverside Counties, formed by the natural diversion of the lower Colorado River. New evidence from the Elmore Site (IMP-6427) establishes the existence of a substantial stand for the lake in the seventeenth century A.D. Chronological evidence bearing on the problem comes from radiocarbon dates, obsidian hydration measurements, ceramics, early historical accounts, and hydrological modelling.

During the Late Prehistoric period, Lake Cahuilla stretched from north of Indio to south of Mexicali. It was fed by the waters of the Colorado River, and when full, it spilled southward to the Colorado delta and the Gulf of California. Considerable controversy exists concerning the importance of the lake in aboriginal subsistence and settlement patterns and the importance of its desiccation in ethnic displacements and social adaptations.

Several chronologies for Lake Cahuilla during the last thousand years have been suggested. Rogers (1945) wrote of a single stand of the lake lasting from about A.D. 1000 and A.D. 1450. Wilke (1978) suggested two stands, between about A.D. 900 and 1250 and between about 1300 and 1500. Waters (1983) proposed a more complex scenario: a full stand between A.D. 940 and 1210, then a complete desiccation immediately followed by another full stand after 1250, interrupted by two partial desiccations, in the early thirteenth century and in the fifteenth century. This was followed by the final desiccation beginning in the early 16th century. Several investigators have mentioned the possibility of a later, historic-period stand (Dominici 1987:13; Schaefer 1986:11; Sieh 1981).

The particular point of reference for the present discussion is the Elmore Site, IMP-6427, in western Imperial County (Laylander 1994). Located at about 180 feet below sea level, the Elmore Site is a relatively small habitation site, with a single charcoal-rich occupational horizon, containing lithics and ceramics, sandwiched between essentially sterile sand strata. The midden contains large amounts of aquatic bird bone and some freshwater fish bone. The site is located some distance from any modern natural water source or other obvious attraction for settlement. The faunal remains and the site location seem to establish that the aboriginal occupation was directly related to the presence of a low shoreline of Lake Cahuilla. Soils testing indicates that the site was not covered by any stand of the lake subsequent to formation of the single, fairly thin, generally undisturbed cultural lens. For these reasons, the site is believed to represent a single occupation, probably fairly short-term, which was associated with Lake Cahuilla when the lake's level was somewhat below -180 feet, and which postdated any higher lake stand. There is also some reason to suspect that this lake stand represented recession from a full or near-full level.

Ten radiocarbon dates have been obtained for the site, all of them based on charcoal, all ^{13}C-corrected, and calibrated (Table 1). If two extreme values are excluded, the other eight are statistically acceptable as estimates of a single event. Pooled (Aitken 1990) and calibrated (Stuiver and Reimer 1993), these date the site to about A.D. 1669, with a one-sigma probability range between A.D. 1663 and 1675.

Seventy-five additional radiocarbon dates which appear to have bearing on the status of Lake Cahuilla during the last 1000 years have also been collected and interpreted (Figure 1). The principal of interpretation employed was to attempt to reconstruct the simplest model of the lake's rises and falls which would be compatible with this body of evidence. Using this approach (with a little input also from the written historical record), a minimum of three full lake stands and three major recessions during the last millennium can be discerned. According to this scenario, Lake Cahuilla was full in the thirteenth century and receded sometime in the late fourteenth or early fifteenth century. It had filled again by the fifteenth century, and receded again in the late fifteenth or early sixteenth century. Finally, it filled again in the early seventeenth century; and it receded for the last time in the late seventeenth century -- the recession represented at the Elmore Site. For that final cycle of filling and recession, there are now 20 radiocarbon dates which appear to relate to the final full stand of the lake and 13 dates which appear to relate to its final recession. The data available at present do not justify any greater precision than this, and they do not either support or rule out more complex scenarios involving additional fillings and desiccations. However, they do argue forcefully against any simpler scenario.

How does the historical record square with the radiocarbon evidence? Ulloa first sailed to the head of the Gulf of California in 1539, and he found the Colorado River emptying into the Gulf (Hakluyt 1903-1905:206-278; Wagner 1929:12-46). This indicates, at any rate, that the river was not fully consumed with filling the lake at that date. More significantly, in the following year, Alarcón sailed to the head of the Gulf and then travelled up the river. By general consensus, he got at least as far as Yuma (Elsasser 1979; Forbes 1958, 1965; Hammond and Rey 1940; Wagner 1929). In the same year, 1540, Díaz travelled overland from Sonora to the lower Colorado River (Forbes 1958, 1965; Ives 1973; Sykes 1937). He then crossed to the west side and made further explorations, either in northeastern Baja California or southeastern California. The Alarcón and Díaz evidence appears to be fully compatible with the lake's having been either entirely absent or greatly reduced around 1540. On the other hand, it seems to fit poorly with the suggestions of Waters (1983) that the lake was only beginning to recede at that date.

The next historical event was the arrival on the lower Colorado River in 1604-1605 of the Oñate expedition from New Mexico (Bolton 1908; Colahan and Rodríguez 1986; Hammond and Rey 1953; Wagner 1929). The Oñate party followed the river from the Bill Williams Fork down to the Gulf. At the mouth of the river, they reported that the Gulf continued farther north, perhaps because at that time it may have extended into the Laguna Macuata basin. Oñate's party also heard reports that the Gulf continued for an indefinite distance, first northwest, then north, then northeast, then east. They also heard reports of a Lago de Oro, or Lake of Gold, a fairly short distance to the northwest. The Alarcón expedition in 1540 and the Espejo expedition in western Arizona in 1583 [Bolton 1908; Hammond and Rey 1966] had also heard vague reports of a lake.

The reports of the Oñate expedition freely intermixed fact and fantasy. They gave to seventeenth-century geographers two imaginary elements which would endure for decades: the

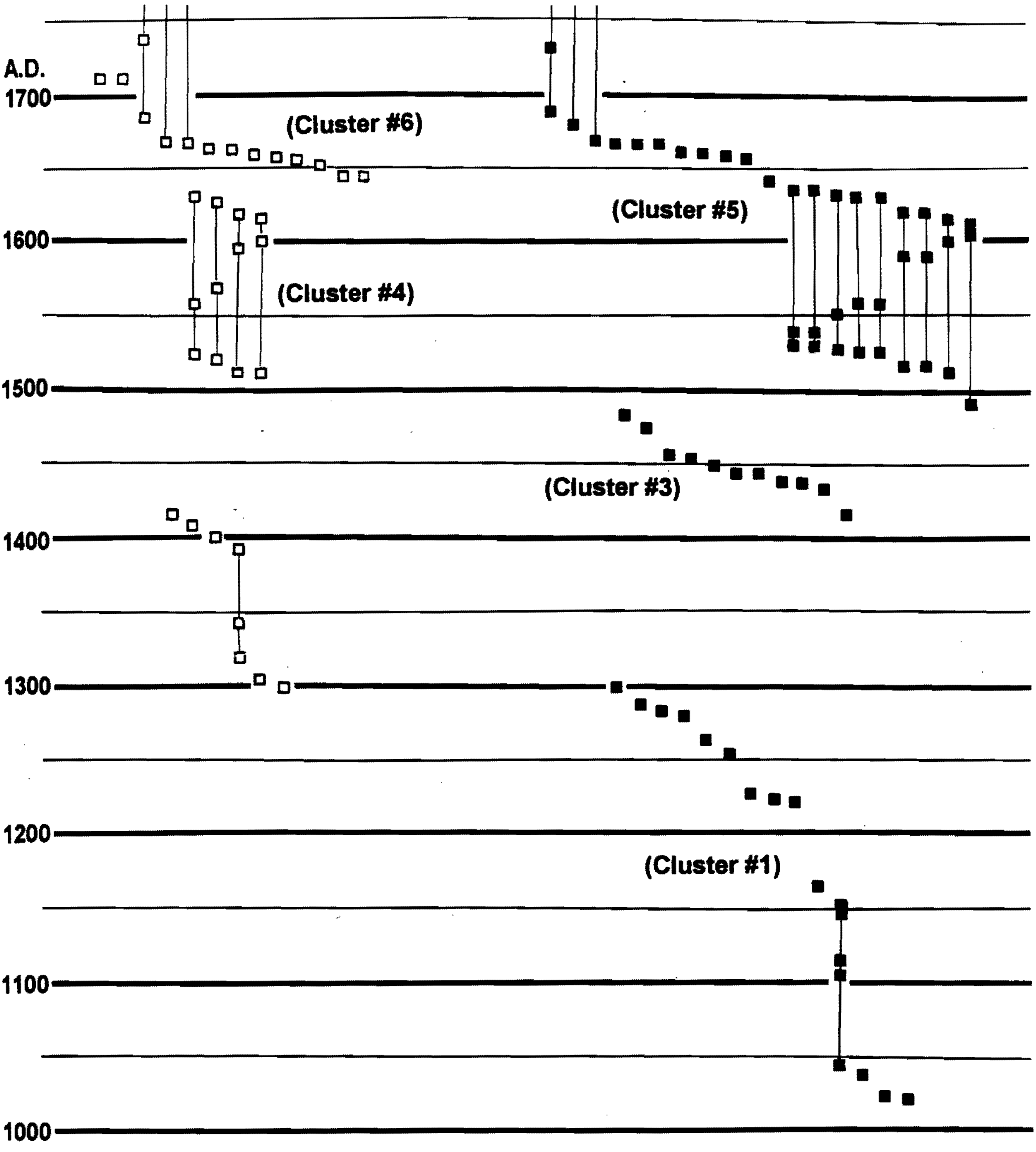

Figure 1. Clusters of radiocarbon dates associated with Lake Cahuilla [solid squares represent radiocarbon dates associated with the +40-foot shoreline; open squares represent dates associated with lower, presumably recessional, shorelines; vertical lines connect multiple calibrations for single radiocarbon dates].

TABLE 1
Radiocarbon Dates from the Elmore Site (IMP-6427)

Lab No.	^{14}C Age	^{13}C-Adjusted Age	Best-Estimate Date	One-Sigma Range
Beta-42011	110 ± 60	110 ± 60	A.D. 1710, etc.	A.D. 1680-1753, etc.
Beta-42012	330 ± 80	370 ± 80	A.D. 1488, 1609, 1611	A.D. 1443-1644
Beta-53003	250 ± 50	260 ± 50	A.D. 1654	A.D. 1638-1669, etc.
Beta-53004	130 ± 70	150 ± 70	A.D. 1686, 1738, etc.	post A.D. 1666
Beta-53005	200 ± 50	250 ± 50	A.D. 1657	A.D. 1641-1672, etc.
Beta-53006	30 ± 70	30 ± 70	modern	modern
Beta-53007	220 ± 70	240 ± 70	A.D. 1660	A.D. 1638-1680, etc.
Beta-53008	100 ± 50	110 ± 50	A.D. 1710, etc.	A.D. 1683-1745, etc.
Beta-53009	190 ± 60	230 ± 60	A.D. 1663	A.D. 1644-1680, etc.
Beta-53010	260 ± 50	290 ± 50	A.D. 1644	A.D. 1520-1569, 1627-1660

notion that California was an island (cf. Polk 1991), and the existence of the Lago de Oro to the west of the Colorado River. It is possible that both of these illusions may have had a basis in a partial stand of Lake Cahuilla at the time, as well as in the Spaniards' wishful thinking.

In 1701 and 1702, Kino travelled from the Gila River to the mouth of the Colorado. From his accounts and maps, it seems clear that no lake was present then (Burrus 1965, 1971; León-Portilla 1989). Several other travellers in the early eighteenth century either sailed to the head of the Gulf or visited the lower Colorado River by land above the delta. In the 1770s, Garcés, Fages, and Anza entered and crossed the Lake Cahuilla basin, establishing beyond doubt that no remnant of the lake was present at that time (Bolton 1930, 1931; Coues 1900). Accounts from the late eighteenth to early nineteenth century are sparse, but sufficient to indicate that there was no full stand during that period.

To sum up, the historical record indicates that the lake was at least not full, and most likely was not present at all, in 1540; that it probably was not at a full stand but may or may not have been partially present in 1605; and that it is unlikely to have had any very substantial stand as late as the beginning of the eighteenth century.

It may be useful to consider the constraints imposed by physical models for the lake. For the recession of the lake, Weide (1976), Wilke (1978), and Waters (1983) discussed a hydrological model based on modern climatic conditions. A slightly revised version of this model (Laylander 1994; Table 2) suggests that it would have taken about 56 years of uninterrupted drying for the lake to recede from the +40-foot shoreline to a dry basin. It would have taken about seven years to reach sea level, 28 years to expose the peak of Obsidian Butte, and 39 years to expose the Elmore Site. These numbers assume that none of the Colorado River's waters reached the basin during those periods. They also assume that evaporation rates were not significantly lower, during a period which, elsewhere, has been termed the "little Ice Age". The filling of Lake Cahuilla can also be modelled, using estimates of the area of the basin at successive levels and the modern average volume of the Colorado River's flow prior to damming. This suggests that about 18 years would have been required to fill the lake to the +40-foot level, and a little over one year's complete diversion would have been needed to fill it to near the Elmore Site.

TABLE 2
Estimated Surface Areas, Volumes, Filing Times, and Recesion Times
for Lake Cahuilla, at 20-foot Contour Inmtervals

Elevation	Area	Volume	Filing Schedule	Recession Schedule
+ 40 ft	2113 mi^2	8190 10^9 ft^3	18 yr 6 mo	0 yr 6 mo
+ 20	1897	7073	15 4	3 9
+ 0	1656	6083	12 6	7 5
- 20	1505	5202	10 6	10 9
- 40	1314	4417	8 6	14 5
- 60	1155	3729	7 5	17 9
- 80	1044	3116	5 12	21 5
-100	943	2563	4 9	24 9
-120	839	2066	3 11	28 4
-140	719	1632	3 4	31 8
-160	644	1252	2 6	35 4
-180	560	916	1 9	39 8
-200	486	624	1 6	42 4
-220	402	371	0 11	45 8
-240	302	169	0 6	49 3
-260	185	34	0 6	52 8
-280	0	0	0 6	56 3

A couple of other points may be made about plausible scenarios for the lake. Waters (1983), in his chronological model, suggested some partial desiccations of the lake but no partial fillings. This seems reasonable. Given the steeper gradient into the basin than into the Gulf, and given the loose lacustrine sediments over which the river was flowing, it is likely that once a substantial diversion into the basin had been established, the river would have entrenched itself and maintained its flow in that direction. On the other hand, Waters' chronology suggests long periods of full lake stands, and it suggests that two episodes of complete desiccation were immediately followed by new fillings. These events are certainly possible, but they are not necessarily the most likely scenarios. There is no obvious physical mechanism which would tend to cause refilling to begin promptly once desiccation had been completed. On the other hand, there are physical mechanisms which would probably tend to cause desiccation to begin shortly after filling was completed. Once the lake had reached the +40-foot level, the gradient advantage of flow into the basin would have been largely lost, and the river's abundant silt would have begun to be dumped at the inlet to the lake.

The Elmore Site, with its relatively tight dating, can contribute to the evaluation of several other indicators of regional chronology. One of these is the hydration of obsidian from the Obsidian Butte source in Imperial County. Obsidian hydration measurements from the Elmore Site (Table 3) support several conclusions. The first is that obsidian specimens from subsurface contexts at the site give fairly consistent hydration readings; they suggest a one-sigma error factor of about 0.34 microns -- this is under something like optimal conditions. Second, obsidian from surface contexts yields substantially larger hydration values than subsurface specimens, and the surface readings may also be substantially more erratic. Third, the hydration rate which is suggested by the Elmore data is distinct from, but intermediate to, the previous proposals for Obsidian Butte material (Figure 2). It is slower than the rates proposed by Chace (1980), Dominici (1984), and Koerper et al. (1986), but it is faster than those proposed by Friedman and Obradovich (1981)

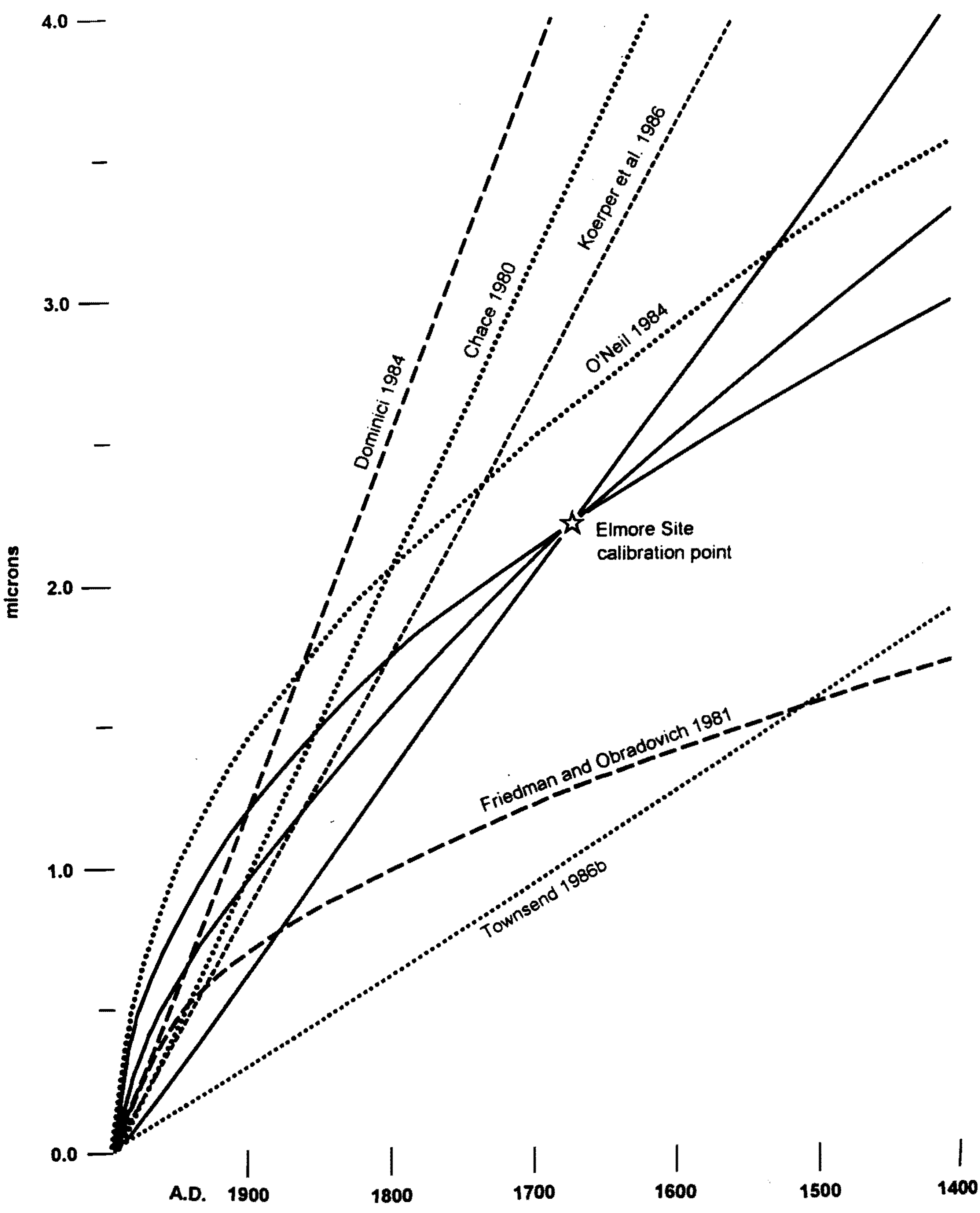

Figure 2. Calibration curves for the hydration of obsidian from Obsidian Butte.

TABLE 3

Obsidian Hydration Readings from the Elmore Site (IMP-6427)

Provenience	Hydration Readings (microns)
Surface	no visible hydration; 2.4*, 2.5, 2.6*, 2.8, 2.9, 3.0, 3.0, 3.1*, 3.4*, 3.4, 3.5*, 3.8*, 3.8/7.1*, 4.5/6.6*
Subsurface	no visible hydration, 1.9, 1.9, 1.9, 1.9, 1.9, 1.9, 2.0*, 2.0/2.4, 2.1*, 2.1*, 2.1* 2.1, 2.1, 2.1, 2.2, 2.2, 2.2, 2.3, 2.4, 2.7, 3.1, 3.2

* specimen chemically sourced to Obsidian Butte; other specimens were visually sourced to Obsidian Butte

and by Coughlin and Ericson (Townsend 1986). The linear rate would be about 147 years per micron; the diffusion rate, about 67 years per micron squared.

Ceramic types are a second proposed chronological indicator. Among others, Rogers (1936, 1945), Schroeder (1958), May (1978), and Waters (1982a, 1982b, 1982c) have made proposals, but Waters' typology and chronology are the best documented and the most widely followed. Most of the pottery recovered from the Elmore Site is probably assignable to Waters' Colorado Buff type within Lower Colorado Buff Wear. This is consistent with Waters' Patayan III, that is, post-A.D. 1500, date for that particular type. However, the Elmore Site also yielded significant numbers of sherds which are assignable to Waters' pre-Patayan III types, particularly Tumco Buff and Salton Buff. This fits with similar observations by Schaefer (1994) and others for the occurrence of these types in anomalously late contexts. The apparent conclusion to be drawn is that Waters' types do not have the strict chronological values which were suggested for them. They probably overlap considerably in their time ranges. Possibly the types (or better still, the attributes on which they are based) are better thought of as primarily geographical indicators rather than chronological ones.

To sum up, the Elmore Site has provided what seems to be fairly convincing proof that the final substantial stand of Lake Cahuilla occurred in the seventeenth century, subsequent to the first Spanish entry into the general region. Historical records and physical models for the lake are compatible with this interpretation. Data from the site suggest that obsidian hydration measurements on Obsidian Butte material may be a moderately useful chronometric tool, at least under certain conditions. Ceramic types appear to be of doubtful value for making fine distinctions within the Late Prehistoric period, at least when considered on a presence/absence basis.

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