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Obsidian Hydration and the Pinto Chronology in the Mojave Desert

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IN his review of the Pinto problem in the Mojave Desert, Warren (1980:74) suggested that it is possible to elucidate the nature of the Pinto problem and construct certain hypotheses by examining Mojave cultural chronologies. He noted that the Pinto Period is that period of time characterized by alleged Pinto projectile points and identified as a unit of time between the Lake Mojave and Gypsum periods (Warren 1980: 74).

> ... because the Pinto points have been inadequately dated in the Mojave Desert, and because Pinto points are not consistently distinguished from Elko and Humboldt series, the Pinto Period, or its equivalent, has been variously dated by various archaeologists.

This paper[1] is an evaluation of three different chronological placements of the Pinto Period in light of obsidian hydration readings from the Stahl, or Little Lake, site (Harrington 1957; Meighan 1981) and the Awl site located at the west end of Drinkwater Basin on Fort Irwin (Fig. 1). The three chronologies selected are representative of different views concerning the beginning and ending dates for the Pinto Period and its cultural relationship to the earlier Lake Mojave Period (Fig. 2). Wallace's (1962) chronological placement of the Pinto Period sets a terminal date of A.D. 1 and an initial date of 2500 B.C., with a cultural hiatus separating the Lake Mojave and Pinto periods. Bettinger and Taylor (1974) place their Little Lake (Pinto) Period between 1200 and 4000 B.C., immediately following the Lake Mojave Period. Warren and Crabtree (in press) date the Pinto Period between 2000 and 5000 B.C., immediately following the Lake Mojave Period. These proposed beginning and ending dates for the Pinto Period, and the presence or absence of a preceding cultural hiatus, can be evaluated with data that include obsidian hydration measurements from the Little Lake and Awl sites, and available radiocarbon dates pertaining to the outset of the Gypsum (or Newberry) Period.

There are currently two commonly used hydration rates for Coso obsidian: 220 years/micron and 344 years/micron. The Little Lake and Awl sites are characterized by a predominance of Pinto points and are assumed to date primarily from the Pinto Period. Therefore, the majority of obsidian hydration measurements from both sites should represent absolute dates older than the oldest acceptable radiocarbon date for the ensuing Gypsum Period. In order to determine the most accurate of the two hydration rates, it is necessary to consider the oldest acceptable date for the Gypsum Period, which in effect would be the terminal date for the Pinto Period.

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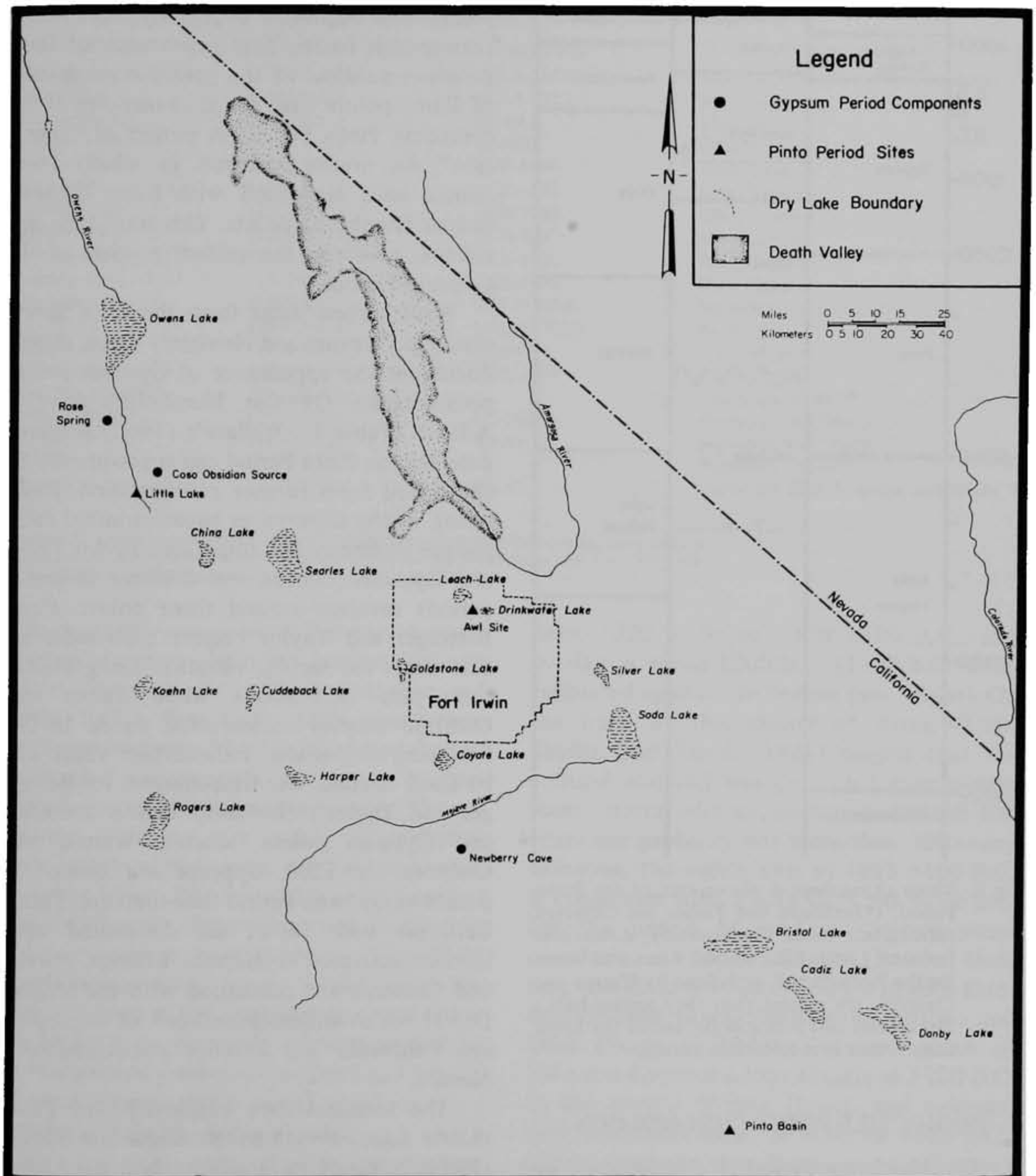

Fig. 1. Location of archaeological sites and major topographic features.

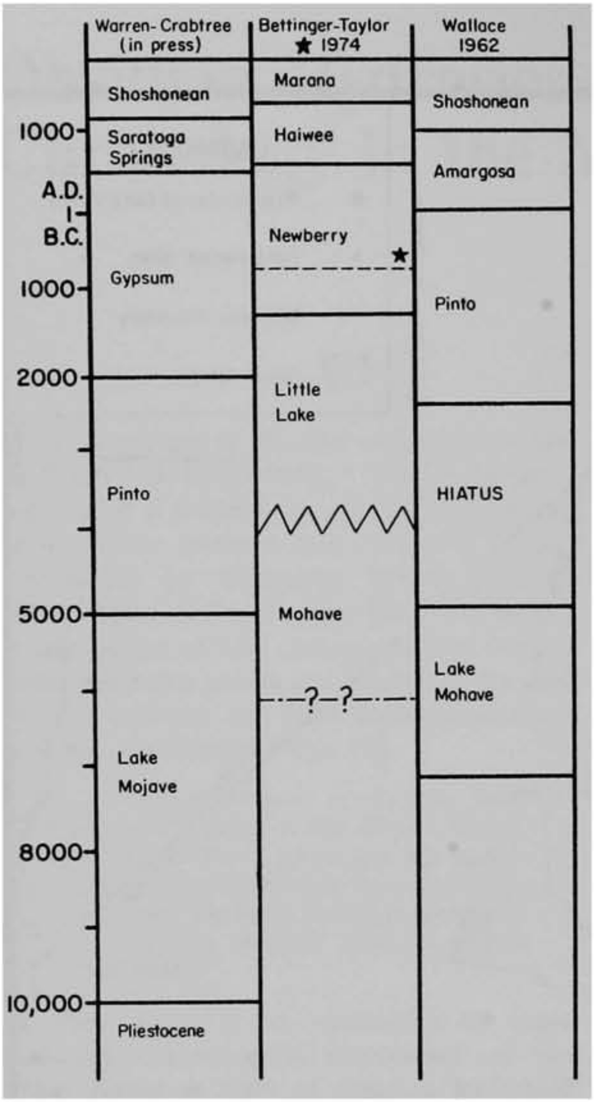

Fig. 2. Three chronological placements of the Pinto Period. (*Bettinger and Taylor use corrected radiocarbon dates. Consequently, differences between Little Lake Period dates and those for the Pinto Period, as defined by Warren and Crabtree, are greater than they appear here.) The dashed line indicates the end of the Little Lake Period in radiocarbon years.

PROJECTILE POINT CHRONOLOGY

The Newberry Period is distinguished by the presence of Elko series and Gypsum points according to Bettinger and Taylor (1974). Elko, Gypsum, and Humboldt series points characterize the Gypsum (Newberry) Period according to Warren and Crabtree (in press). The beginning of the Gypsum Period corresponds to the first appearance of these points—regardless of the presence or absence of Pinto points that are time-markers of the preceding Pinto Period. A period of "transition" no doubt occurred in which Pinto points were associated with Elko, Gypsum and/or Humboldt points. This transition represents, however, the earliest portion of the Gypsum Period.

Radiocarbon dates from the Rose Spring site, and Gypsum and Newberry caves, clearly document the appearance of Gypsum Period points (Elko, Gypsum, Humboldt) prior to A.D. 1 (Table 1). Wallace's (1962) terminal date for the Pinto Period can consequently be eliminated from further consideration. Resolution of the differences between initial dates for the Newberry (Bettinger and Taylor 1974) and Gypsum (Warren and Crabtree in press) periods revolves around three points. First, Bettinger and Taylor correct their radiocarbon dates for secular variation using bristlecone pine calibrations, while Warren and Crabtree employ uncorrected dates. In the following discussion, radiocarbon years will be used. Second, the time-markers for Bettinger and Taylor's Newberry Period are Elko and Gypsum points, whereas Warren and Crabtree use Elko, Gypsum *and Humboldt* points as Gypsum Period time-markers. Third, Bettinger and Taylor are concerned with interior southern California, whereas Warren and Crabtree are concerned with the Mojave Desert which includes portions of southeastern California and extends across southern Nevada.

The terminal date assigned to the Pinto (Little Lake) Period by Bettinger and Taylor (1974) is based on a radiocarbon date from the 72-84 in. level at the Rose Spring site. Bettinger and Taylor (1974: 14) claim that this level contained most of the Little Lake

Table 1

PERTINENT RADIOCARBON DATES
FROM THE GREAT BASIN AND MOJAVE DESERT

Sites	^{14}C Dates	Sample No.	Point Types
Rose Spring	(950 B.C.)	UCLA-1093B	Elko, Gypsum, Humboldt, and Pinto
Gypsum Cave	(950 B.C.)	UCLA-1223	Elko, Gypsum
O'Malley Shelter	(1020 B.C.)	RL-44	Elko, Gypsum
Newberry Cave	(1020 B.C.)	LJ-993	Elko, Gypsum
Newberry Cave	(1065 B.C.)	UCR-1095	Elko, Gypsum
Newberry Cave	(1065 B.C.)	UCR-1093	Elko, Gypsum
Newberry Cave	(1120 B.C.)	UCR-1092	Elko, Gypsum
Newberry Cave	(1255 B.C.)	UCR-1097	Elko, Gypsum
Newberry Cave	(1350 B.C.)	UCR-1103	Elko, Gypsum
Newberry Cave	(1370 B.C.)	UCR-1096	Elko, Gypsum
Rose Spring	(1570 B.C.)	UCLA-1093C	No points
Rose Spring	(1630 B.C.)	UCLA-1093D	No points
O'Malley Shelter	(1790 B.C.)	RL-93	Elko, Gypsum
Newberry Cave	(1815 B.C.)	UCR-1094	Elko, Gypsum
Stuart Rockshelter	(1920 B.C.)		Humboldt (Pinto?)[a]
O'Malley Shelter	(1970 B.C.)	RL-106	Humboldt and "Pinto"[a]
O'Malley Shelter	(1990 B.C.)	RL-45	Humboldt and "Pinto"[a]
Stuart Rockshelter	(2100 B.C.)		Humboldt (Pinto?)[a]
O'Malley Shelter	(2680 B.C.)	RL-91	Humboldt, Elko, Gypsum, and "Pinto"[a]

[a]Relatively finely pressure-flaked "Pinto" projectile points that differ from more robust, often percussion-flaked "Pinto" forms described for the Pinto Basin and Awl sites, and including some of the specimens from the Little Lake site.

(Pinto) points recovered at the site. A single radiocarbon assay dates the level at 950 ±80 *radiocarbon* years B.C. (Clewlow, Heizer, and Berger 1970). Five Little Lake points were recovered from the 72-84 in. level, but four of these are "leaf-shaped" and cannot be considered to be time-sensitive forms. The remaining specimen is a small, "shoulderless Pinto" point with a deep, narrow basal notch (Lanning 1963: 250, 254, 322). Also found at that depth were three Elko, two Humboldt, and one Gypsum point (Lanning 1963: 254). These latter point types would place the 72-84 in. level at the Rose Spring site in either the Gypsum or Newberry periods as defined by Warren and Crabtree (in press) and Bettinger and Taylor (1974: 14).

More recently, Davis, Taylor, and Smith (1981) report a suite of eight radiocarbon dates from Newberry Cave that apply to split-twig animal figurines and Gypsum and Elko Series points. Seven of the dates range from 1020 ±250 to 1370 ±180 B.C., and overlap at about 1200 B.C. (1500 B.C. when calibrated against bristlecone pine values). On the basis of this cluster of dates, Davis, Taylor, and Smith (1981) suggest that the cultural material was deposited over a very short interval of time, perhaps as little as 100 years and probably not more than 500 years. However, the eighth date of 1815 ±100 B.C. is consistent with a date of 1790 ±170 B.C. for the period of greatest Gypsum point popularity at O'Malley Shelter (Fowler, Madsen, and Hattori 1973: 42-43), and with dates on split-twig animal figurines in Arizona and Utah (Schroedl 1977). The occurrence of Elko and Gypsum points as early as 1200 B.C. in the central Mojave Desert, and evidence that they may occur as early at 1800 B.C., clearly indicate that Bettinger and Taylor's date of 950 radiocarbon years B.C. for the beginning of the Gypsum (Newberry) Period is too late.

On the other hand, the argument presented by Warren and Crabtree (in press) for a 2000 B.C. date for the beginning of the Gypsum Period is also not without problems. Although Humboldt points are unreliable time-markers for later periods, they were not found at the Pinto Basin site (Campbell and Campbell 1935) and were recognized by Rogers (1939: 67) as contemporaneous with his Amargosa I complex. Humboldt, Elko, and Gypsum points were found in Unit II at O'Malley Shelter as were "Pinto points" (Fowler, Madsen, and Hattori 1973). Three radiocarbon dates are reported for Unit II: 1970, 1990, and 2680 B.C. At Stuart Rockshelter, three points were identified by Shutler, Shutler, and Griffith (1960) as shoulderless Pinto forms, but these appear more similar to Humboldt points than to the Shoulderless Pinto points from Pinto Basin (Campbell and Campbell 1935: 47), or to Rogers' (1939: 54) Pinto-equivalent Type 1 points. Two radiocarbon dates of 1920 ±250 and 2100 ±300 B.C., appear to bracket the three points found at Stuart Rockshelter (Shutler, Shutler, and Griffith 1960: 8).

Radiocarbon dates supporting an initial appearance of Humboldt, Elko, and Gypsum points ca. 2000 B.C. derive from the eastern Mojave Desert and may not apply to the central and western Mojave. Elko points appear to have greater time depth in the eastern Great Basin than in the western and central Great Basin (Thomas 1981: 32). Unit I at O'Malley Shelter, which yielded only Elko points, is dated by two radiocarbon assays at 4570 ±140 and 5150 ±190 B.C. (Fowler, Madsen, and Hattori 1973: 15, 28), and may be the westernmost extension of this early occurrence of Elko points.

The association of Humboldt, Elko, and Gypsum points with finely made Pinto points in deposits dated between 1970 and 2680 B.C. at O'Malley Shelter (Fowler, Madsen, and Hattori 1973: 25, 28) may represent a late occurrence of "Pinto" points. The presence of Elko and possible Humboldt points at the Little Lake site (Meighan 1981: 206, 204, Fig. 3L-O) suggests that the site may have contained the same combination of points late in its occupation. This is further supported by the fact that the finely flaked Pinto points at Little Lake and O'Malley Shelter (Harrington 1957: 51-53; Fowler, Madsen, and Hattori 1973: 20) contrast with those from the central Mojave described as thick and crudely flaked (Amsden 1935: 44; Rogers 1939: 54).

Co-occurrences of finely flaked Pinto points and Elko, Gypsum, and Humboldt points may be characteristic of the earlier portion of the Gypsum Period. It seems logical that at its outset the Gypsum Period would be characterized by the introduction of Elko, Gypsum, and Humboldt point forms, and the continued but declining use of Pinto points. If such is the case, then the beginning date for the Gypsum Period probably predates the occupation of Newberry Cave where no Pinto points were found. Therefore, this transition in point morphologies early in the Gypsum Period may have taken place between ca. 1500 and 2000 B.C. Most of the relatively late obsidian hydration dates from the Little Lake and Awl sites should conform to these dates, although there are some data indicating even later occupations at both sites.

OBSIDIAN HYDRATION DATA

The Awl site is located at the western edge of Drinkwater Basin in the central Mojave Desert, at an elevation of 3,200 ft. (1,000 m.), and at approximately 35° 30' latitude. The Little Lake site is located near Little Lake at an elevation of 3,200 ft. (1,000 m.), and at approximately 35° 58' latitude. Comparable elevation and latitude suggest that temperatures at the two sites are not overly dissimilar and that temperature probably is not a major factor in differences between the obsidian hydration rates at these sites, although the winter snowpack on the nearby Sierra Nevada may produce a somewhat cooler average temperature at Little Lake.

The geologic source of obsidian artifacts at the Little Lake site is assumed to be Coso because of its close proximity to the site and because of the consistently thick hydration rinds measured on sample specimens (Meighan 1981). Hydration measurements were performed at the University of California, Los Angeles, Obsidian Laboratory. The Awl site obsidian artifacts were chemically sourced and hydration measurements obtained under the direction of Jonathan Ericson at Harvard University.

Meighan (1981) reports hydration measurements on 65 identifiable obsidian projectile points from the Little Lake site. Five of the points have no visible hydration bands, and three are late prehistoric point types believed to be intrusive. No debitage was included in Meighan's sample. The hydration readings range from 6.4 to 17.3 microns, but appear to display two clusters (Fig. 3). Meighan states (1981: 206), "The later group (n=46) ranges from 6.4 to 12.3 microns and averages 9.74. The earlier group (n=11) ranges from 13.5 to 17.3 microns and averages 15.45."

Recent data recovery efforts[2] at the Awl site (4-SBR-4562), located within the Fort Irwin military reservation yielded 153 obsidian artifacts and pieces of debitage. Hydration measurements and geologic sources have been determined for 71 of the specimens. Sixty-six of the specimens derive from the Coso source, three from Casa Diablo, and two from unidentified sources. Four identifiable projectile points (one Pinto and two possible Silver Lake types, and one unique point form), a point tip, a point midsection, and a fragment of a large biface were the only tools included in the sample. The remainder of the sample consists of debitage.

Including the non-obsidian specimens, the most common point types found at the Awl site were Pinto and leaf-shaped forms (Figs. 4-6). Stemmed points from the site include Silver Lake and Great Basin Stemmed types, as well as several unique and reworked specimens. A single Rosegate (Thomas 1981) point was recovered on the surface at the edge of the site, and is considered intrusive. There are no Humboldt points, but there are three possible Elko Eared points and one fragmentary specimen that may be a Gypsum point (Figs. 4-6). Occupation of the site is attributed primarily to the Pinto Period and appears to have persisted from late Lake Mojave-early Pinto times to early in the Gypsum Period. "Nondiagnostic" specimens comprising the majority of the obsidian sample can be reasonably assumed to date to this period of occupation. Of the 66 Coso obsidian specimens, 30 were recovered from subsurface deposits and the remaining 36 were found on the surface. The Awl site cultural deposit is up to 2 m. in depth, and the subsurface obsidian artifacts were recovered from 40 to 190 cm. below the surface. The surface material resulted from disturbances of three types: (1) burrowing animals bringing artifacts to the surface; (2) a general lowering of the surface through deflation and sheet washing; and (3) headward erosion of arroyos that are cutting into the deeper, as well as shallow, deposits of the site. Consequently, the sample from the surface is assumed to be derived from all depths of the deposit. Sixty-five of the 66 obsidian hydration readings fall between 6.8 and 21.5 microns. The one remaining specimen has two readings of 3.6 and 9.7 microns. It appears to have been "reworked" by humans or nature after the site had been abandoned. It is excluded from further consideration.

Hydration measurement frequencies from the Awl site more nearly conform to a normal

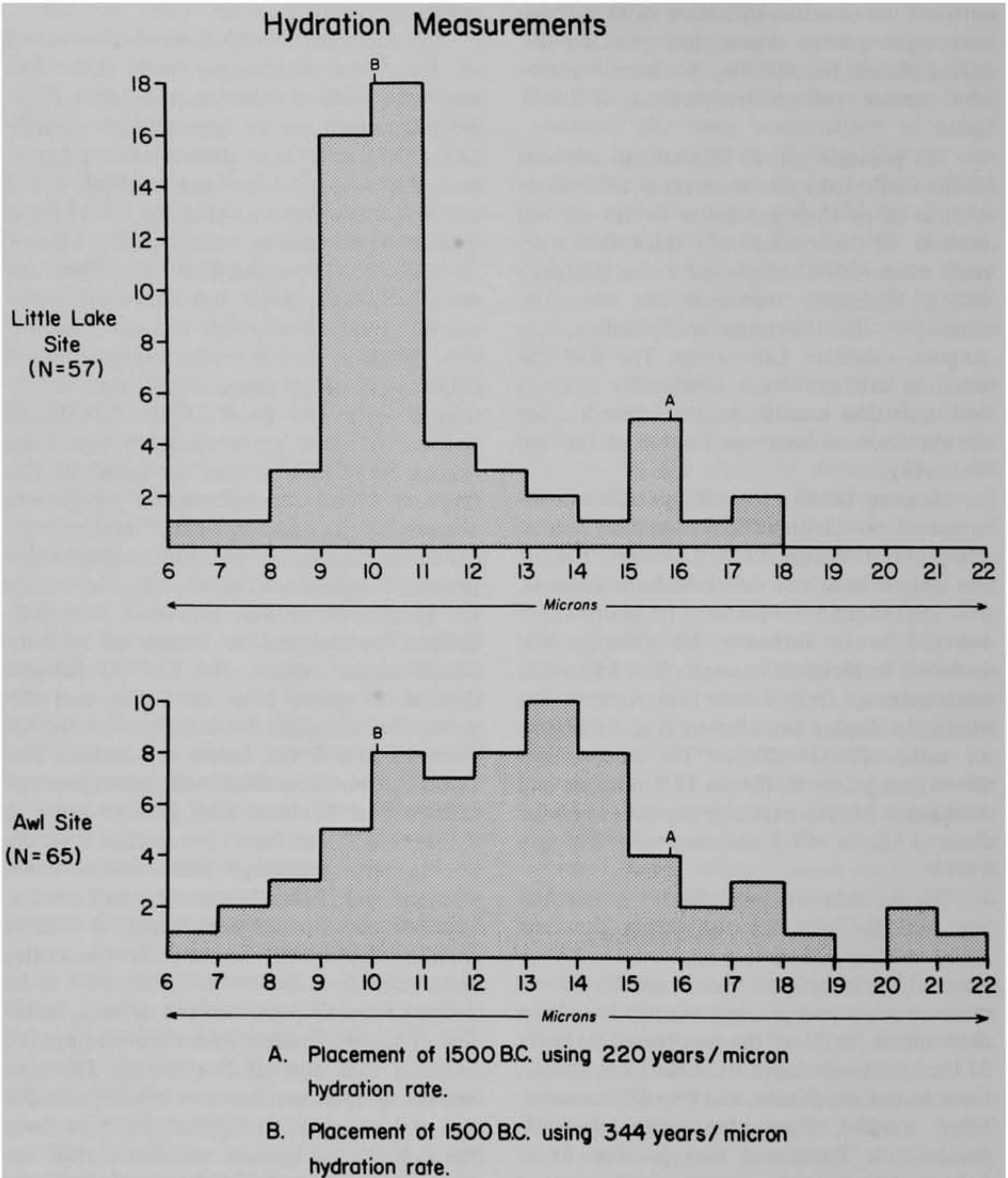

Fig. 3. Histograms of hydration measurements from the Little Lake and Awl sites. Little Lake data as reported by Meighan (1981). A, 1500 B.C. using 220 years/micron hydration rate; B, 1500 B.C. using 344 years/micron hydration rate.

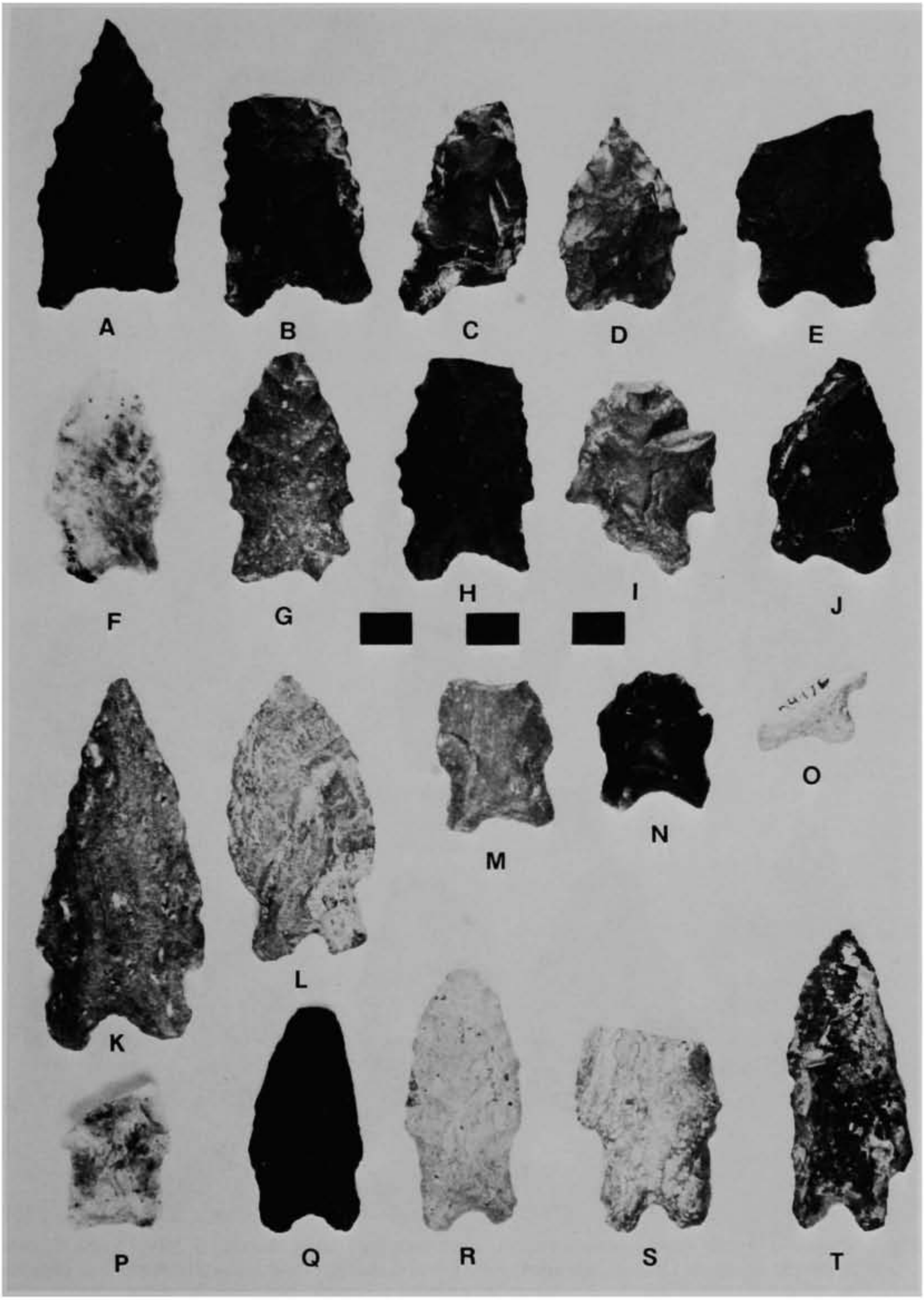

Fig. 4. Pinto projectile points from the Awl site. E, I, and L could be classified as Elko series points.

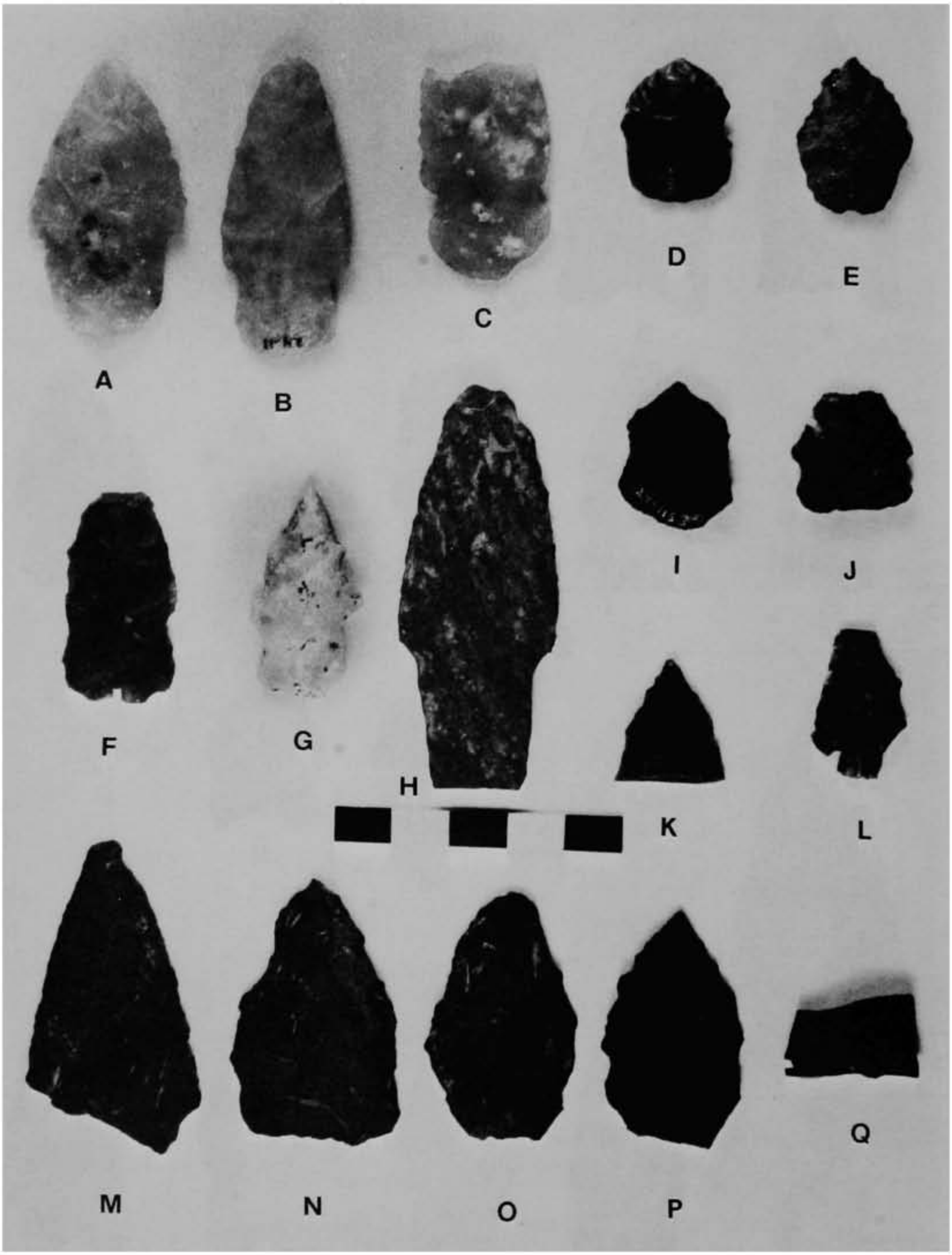

Fig. 5. Projectile points from the Awl site. A, short-stemmed Lake Mojave; B, Silver Lake; C, Silver Lake (?); D, Silver Lake; E, untyped; F-G, Silver Lake; H, Great Basin Stemmed; I-J, untyped; K, obsidian biface tip; L, Rosegate; M, possible Gypsum; N, triangular point; O-P, possible Pinto (fragmentary); Q, obsidian biface midsection.

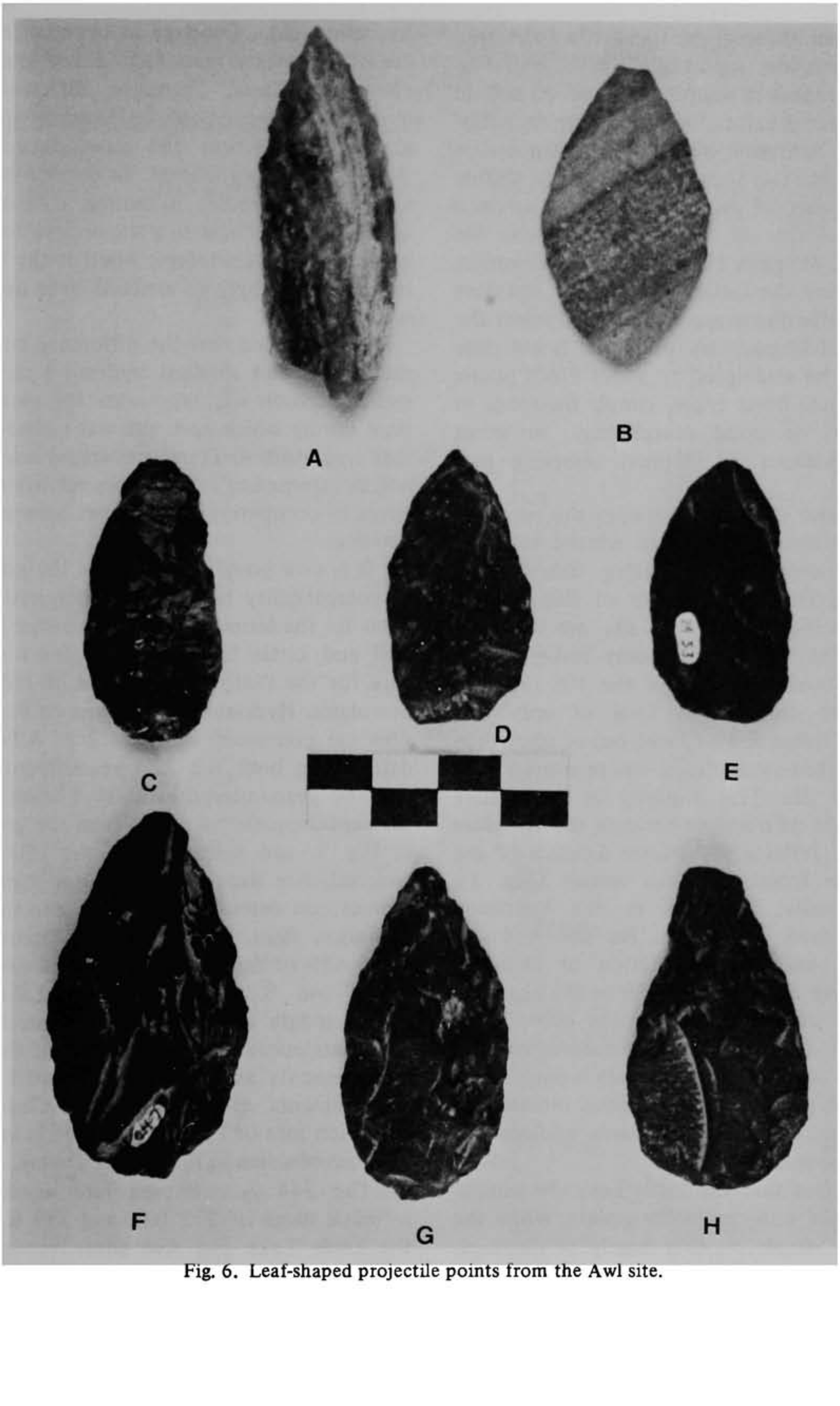

Fig. 6. Leaf-shaped projectile points from the Awl site.

curve than those from the Little Lake site, but nonetheless appear slightly skewed (Fig. 3). Differences in sample composition should be considered before further examining differences in hydration measurement frequencies between the two sites. The Little Lake sample consists only of projectile points, whereas a large majority of the Awl specimens are debitage. Meighan (1981) excluded complete points from the Little Lake Sample, but does not describe the procedure used to select the sample of fragmentary points. It is not clear whether he attempted to select Pinto points and exclude other types, sample the range of variability in point morphology, or select points without an explicit sampling procedure.

A major difference between the two sites is the quantity of obsidian relative to other raw material used in making flaked stone artifacts. The vast majority of flaked stone tools at the Little Lake site are obsidian, whereas at the Awl site only seven of 115 bifacial tools and none of the 108 unifacial tools are obsidian. A total of only 153 obsidian flakes and artifacts, out of more than 2,400 flaked stone items, was recovered from the Awl site. This disparity in the relative abundance of obsidian between the two sites probably reflects the greater distance of the Awl site from the Coso source (Fig. 1). Consequently, variation in the hydration measurement frequencies for the Awl site (Fig. 3) may be a function of changing availability of Coso obsidian or the changing intensity of occupation. On the other hand, variation in the hydration measurement frequencies for the Little Lake site is more likely to reflect changes in occupational intensity or a bias in the sample of items selected for hydration analysis.

The fact that the Little Lake site sample consists of only projectile points, while the Awl site sample consists largely of debitage, should not invalidate inter-site comparison of hydration data. Debitage at occupation sites results from the manufacture and maintenance of artifacts. Therefore, differences in hydration measurements obtained on artifacts and debitage from the same occupations should not be significant. In the comparison made here, obsidian hydration readings are used as a means of dating site occupation, not artifact types. Therefore, whether the hydration readings apply to artifacts or to debitage is irrelevant.

It is assumed that the difference between the largest and smallest hydration measurements at each site represents the period of time during which each site was utilized, but that hydration measurement frequencies cannot be interpreted as indicating relative differences in occupational intensities between the two sites.

It is now possible to address the problem of compatibility between obsidian hydration dates for the termination of occupation at the Awl and Little Lake sites and the terminal date for the Pinto Period based on radiocarbon dates. Hydration measurements for both sites are converted in Table 2 to A.D./B.C. dates using both the 220 years/micron and the 344 years/micron rates. Hydration measurement frequencies per micron are graphed in Fig. 3, and placement of the 1500 B.C. terminal date for the Pinto Period based on radiocarbon dates is shown relative to the two hydration rates. The 220 years/micron rate places 61% of the Awl site hydration measurements and 82% of the Little Lake site measurements after 1500 B.C., whereas the 344 years/micron rate places 26% of the Awl measurements and 34% of the Little Lake measurements after 1500 B.C. Clearly, a hydration rate of 220 years/micron is too fast for Coso obsidian in the Mojave Desert.

The 344 years/micron rate would give terminal dates of 222 B.C. and 359 B.C. for the Little Lake and Awl sites, respectively; about 1200 years younger than the terminal

Table 2

OBSIDIAN HYDRATION DATES FROM THE LITTLE LAKE AND AWL SITES

	Little Lake Series[a]			Awl Site Series		
	Hydration Measurement (microns)	Calculated Date 344 yrs/micron	Calculated Date 220 yrs/micron	Hydration Measurement (microns)	Calculated Date 344 yrs/micron	Calculated Date 220 yrs/micron
1.	6.4	232 B.C.	A.D. 562	6.8	359 B.C.	A.D. 484
2.	7.3	541	364	7.1 (8.8)	462 (1047)	418 (44)
3.	8.0	782	210	7.5	600	330
4.	8.1	816	188	8.6	978	88
5.	8.7	1023	56	8.7	1013	66
6.	9.0	1126	10 B.C.	8.7 (11.4)	1013 (1941)	A.D. 66 (528 B.C.)
7.	9.0	1126	10	9.0	1116	A.D. 1
8.	9.0	1126	10	9.4 (12.2)	1254 (2217)	88 B.C. (704)
9.	9.0	1126	10	9.6	1322	132
10.	9.1	1160	32	9.8	1391	176
11.	9.1	1160	32	9.9	1426	198
12.	9.2 (11.6)	1194 (2020)	54 (582)	10.0	1460	220
13.	9.2	1194	54	10.0	1460	220
14.	9.3	1229	76	10.0	1460	220
15.	9.3	1229	76	10.2	1529	264
16.	9.5	1298	119	10.6	1666	352
17.	9.6	1332	142	10.7	1701	374
18.	9.6	1332	142	10.9	1770	418
19	9.6	1332	142	10.9	1770	418
20.	9.8	1401	186	11.0	1804	440
21.	9.8	1401	186	11.1 (13.3)	1838 (2595)	462 (946)
22.	10.0	1470	230	11.2	1872	484
23.	10.0	1470	230	11.3	1907	506
24.	10.0	1470	230	11.3	1907	506
25.	10.0	1470	230	11.6	2010	572
26.	10.1	1504	252	11.7	2045	594
27.	10.2	1539	274	12.0	2148	660
28.	10.2	1539	274	12.0	2148	660
29.	10.3	1573	296	12.1	2182	682
30.	10.3	1573	296	12.2	2217	704
31.	10.3	1573	296	12.3	2251	726
32.	10.5	1642	340	12.6	2354	792
33.	10.5	1642	340	12.7	2389	814
34.	10.6	1676	362	12.8 (15.0)	2423 (3180)	836 (1320)
35.	10.6	1676	362	13.1	2526	902
36.	10.8	1745	406	13.2	2561	924
37.	10.8	1745	406	13.3	2595	946
38.	10.8	1745	406	13.5	2664	990
39.	10.9	1780	438	13.5	2664	990
40.	11.3	1917	516	13.6	2698	1012
41.	11.7	2055	604	13.7	2733	1034
42.	11.7	2055	604	13.7	2733	1034
43.	11.8	2089	626	13.8	2767	1056
44.	12.3	2261	736	13.9 (16.4)	2802 (3662)	1078 (1628)
45.	12.3	2261	736	14.2	2904	1144
46.	12.3	2261	736	14.3	2939	1166
47.	13.5	2674	1000	14.4	2974	1188
48.	13.6	2708	1022	14.5 (17.1)	3008 (3902)	1210 (1782)
49.	14.5	3018	1220	14.5 (16.3)	3008 (3627)	1210 (1606)
50.	15.3	3293	1330	14.5	3008	1210

(Table 2 continued)

	Little Lake Series[a]			Awl Site Series		
	Hydration Measurement (microns)	Calculated Date 344 yrs/micron	Calculated Date 220 yrs/micron	Hydration Measurement (microns)	Calculated Date 344 yrs/micron	Calculated Date 220 yrs/micron
51.	15.5	3362	1440	14.7	3077	1254
52.	15.5	3362	1440	14.9 (11.8)	3146 (2079)	1298 (616)
53.	15.7	3431	1484	15.0	3180	1320
54.	15.9	3500	1528	15.0	3180	1320
55.	16.0	3534	1550	15.4	3318	1408
56.	17.2	3947	1814	15.5	3352	1430
57.	17.3	3981	1836	16.0	3524	1540
58.				16.2	3593	1584
59.				17.0	3868	1760
60.				17.5	4040	1870
61.				17.9	4178	1958
62.				18.0	4212	1980
63.				20.3	5003	2486
64.				20.8	5175	2596
65.				21.5	5416	2750

[a]Little Lake data reported by Meighan (1981).

date for the Pinto Period based on radiocarbon dates. It may be assumed that the smaller hydration readings are aberrant and eliminate from consideration those less than 8 microns, thus giving terminal dates of ca. 800 and 1000 B.C. for the Little Lake and Awl sites, respectively—still several hundred years too young.

In an attempt to resolve the discrepancy between radiocarbon and obsidian hydration dates, an examination was made of the hydration measurements for Coso obsidian at the Rose Spring site (Ericson 1977). Measurements were obtained on a small sample of obsidian specimens from each of five, radiocarbon-dated, arbitrary levels. The levels with corresponding radiocarbon dates and obsidian hydration measurements are given in Table 3.

The fact that there are no significant differences between obsidian hydration measurements from throughout a deposit that is 5-ft. deep and represents more than 1,500 radiocarbon years of occupation suggests: (1) something is very much wrong with the (a) obsidian sample, (b) hydration measurements, or (c) radiocarbon dates; or (2) there are factors affecting obsidian hydration at the site that are not understood. If the hydration measurements are taken at face value, it is clear that the greater part of the Rose Spring site occupation was later than that at the Awl and Little Lake sites. If such is the case, then a terminal date between 1500 and 2000 B.C. for the Awl and Little Lake site occupations appears reasonable. This, however, would require a hydration rate of about 390 years/micron for Coso obsidian in the Mojave Desert.

The transition from Pinto to Gypsum (Newberry) periods cannot be precisely dated at this time. Radiocarbon dates suggest 1500 to 2000 B.C. as the period of transition, but obsidian hydration dating would extend the occupation of the Awl site to at least 1000 B.C. (and perhaps as late as 360 B.C.), and the use of Pinto points at the Little Lake site to as late as 250 B.C. There is no doubt that the use of Pinto points continued into the Gypsum Period (i.e., after the introduction of Elko, Gypsum, and Humboldt points). This

Table 3

CORRELATION OF LEVELS, RADIOCARBON DATES, AND OBSIDIAN HYDRATION MEASUREMENTS AT ROSE SPRING, CA-INY 372

C-14 Sample[a]	Level[a]	Age in Radio-carbon Years[a]	Obsidian Hydration Measurements[b] (microns)	Mean Hydration Measurement and Age Calculated at 344 yrs/micron
UCLA 1093A	60- 64 in.	290 ±145 B.C.	7.2	mean 8.09
			10.5	833 B.C.
			9.8	
			6.3	
			8.0	
			7.6	
			8.2	
			7.1	
UCLA 1093B	72- 84 in.[c]	950 ±80 B.C.	5.9	mean 8.09
			16.5	833 B.C.
			8.1	
			7.8	
			8.2	
			9.4	
			NBS	
			8.1	
			8.8	
UCLA 1093C	84- 92 in.	1570 ±80 B.C.	8.4[d]	mean 8.2
			8.4[d]	870 B.C.
			8.1[e]	
			7.9[e]	
UCLA 1093D	96-100 in.[f]	1630 ±80 B.C.	11.4	mean 8.48
			8.0	967 B.C.
			8.2	
			8.0	
			8.3	
			7.9	
			8.4	
			8.5	
			7.9	
			8.2	
UCLA 1093E	108-120 in.[g]	1950 ±80 B.C.	8.4	mean 8.16
			8.6	857 B.C.
			8.1	
			7.5	
			8.2	

[a] Clewlow et al. (1970)
[b] Ericson (1977: 358-359)
[c] Listed as 60 to 64 in. by Ericson (1977: 341)
[d] Listed as 84 to 90 in. by Ericson (1977: 341)
[e] Listed as 90 to 102 in. by Ericson (1977: 341)
[f] Listed as 96 to 102 in. by Ericson (1977: 341)
[g] Listed as 102 to 108 in. by Ericson (1977: 341)

may be the case at the Little Lake and Awl sites.

Wallace (1962: 175) placed the initial date for the Pinto Period at between 2500 and 3000 B.C., following the presumed Altithermal drought (Antevs 1952) in the central Mojave. In this pioneering paper, Wallace clarified cultural units and established a relative chronology, but he lacked radiocarbon dates. He assumed that much of the Mojave Desert was abandoned during the Altithermal and that Pinto material represented a reoccupation of the area at the beginning of the Medithermal.

Bettinger and Taylor (1974: 14) based their initial date for the Little Lake (Pinto) Period on radiocarbon dates from Surprise Valley in northeastern California and Spooner Lake near Carson City, Nevada. At these locations "Little Lake points," which they assumed to be contemporaneous with Pinto points in the Mojave Desert, were dated at 2970 ±120 and 3300 ±120 B.C. radiocarbon years. On the basis of these dates, Bettinger and Taylor tentatively placed the beginning of their Little Lake Period sometime after ca. 4000 B.C.

Warren and Crabtree (in press) argue that Pinto Period assemblages were a development out of earlier Lake Mojave Period assemblages associated with a high stand of Pleistocene Lake Mojave. Pinto Period material is interpreted to represent an adaptation to a more arid environment following the disappearance of Pleistocene lakes ca. 5000 B.C. Therefore, the initial date for the Pinto Period is placed at about 5000 B.C. A period of increased moisture ca. 3500 to 4500 B.C. (Mehringer 1977) is considered to have been wetter than modern conditions, as is suggested by the frequent association of Pinto material with currently dry drainages and playa margins (Warren and Crabtree in press).

There are no radiocarbon dates from the Mojave Desert that are applicable to dating the beginning of the Pinto Period. The obsidian hydration dates from the Awl and Little Lake sites are the first chronometric dates that can be considered relevant to this problem. If the present analysis of problems with using these dates is valid, the hydration rate of 344 years/micron is conservative, i.e., too fast. Therefore, an initial date for the Pinto Period based on this rate is more likely to be too young than too old.

Applying the 344 years/micron rate results in an initial date of 3980 B.C. for the Little Lake site and 5415 B.C. for the Awl site. The three largest hydration measurements from the Awl site appear somewhat aberrant and may represent an earlier occupation. If these three measurements are discounted, the earliest Awl site date would be 4210 B.C. Using the 344 years/micron rate, the initial date for the Pinto Period may be placed between 4000 and 5000 B.C.

CONCLUDING REMARKS

This paper was structured so as to test the validity of alternative chronological placements of the Pinto Period by using obsidian hydration measurements from the Little Lake and Awl sites. However, this paper has proved to be as much a test of obsidian hydration dating as of the validity of the Pinto chronologies. Neither test has been completely successful. It is clear that obsidian hydration dating in the Mojave Desert is far from a precise dating technique. The test of obsidian hydration dating will necessarily be pragmatic. Many more hydration measurements for obsidian samples located in close association with material datable by the radiocarbon technique are required to both refine and test obsidian hydration dating.

The test of the validity of various chronological placements of the Pinto Period was at least partially successful. It now seems clear that a "short chronology" for the Pinto Period preceded by a cultural hiatus is invalid.

Radiocarbon dates suggest a date of between 1500 and 2000 B.C. for the introduction of Gypsum Period projectile points and for the end of the Pinto Period. Thick hydration bands on obsidian artifacts at both the Little Lake and Awl sites suggest a date of no less than 4000 B.C., but perhaps as early as 5000 B.C., for the initial occurrence of Pinto points and the beginning of the Pinto Period. Although these conclusions are tentative, it is clear the hydration measurements on Coso obsidian can provide valuable chronological data for the early periods in the Mojave Desert. If hydration measurements can be obtained for samples of Coso obsidian from Lake Mojave Period sites, then a relative chronology can be established and the question of the cultural hiatus between the Pinto and Lake Mojave periods put to rest. There is little doubt that radiocarbon dates for Pinto and Lake Mojave sites will be obtained within the next decade. With luck, radiocarbon dates will be obtained that provide the age for hydration measurements and the basis for a more accurate obsidian hydration rate.

NOTES

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