CONTRIBUTIONS TO
TULARE LAKE ARCHAEOLOGY IV

ICE-AGE STONE TOOLS FROM THE SAN JOAQUIN VALLEY

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(TULARG) members (left to right) Jerry Hopkins, Don McGeein, William Wallace, Edith Wallace, and Fritz Riddell conducting inspections of archaeological sites at Tulare Lake. Photograph by Jim West.

Preface

This is the fourth publication in the series resulting from the Tulare Lake Archaeological Research Group (TULARG). This series of monographs were originally the brainchild of William Wallace and Francis (Fritz) Riddell and began in earnest in late 1988. Dr. Wallace proposed that, "Quite likely, Tulare Lake saw human usage and habitation throughout the entire span of California's prehistory," a suggestion that excited and drew the attention of many California archaeologists. The initial intention of the founders was to gather, examine, and report archaeological information about the region's ecologically rich past.

The present publication consists of four manuscripts (included as chapters one through four). Initially, six chapters were planned but two authors could not meet the time constraints. Hopefully, they will be included in a subsequent TULARG publication.

Briefly, Chapter 1 surveys and identifies a flaked stone assemblage of time-diagnostic artifacts from Tulare Lake. This is the first published attempt to categorize and describe Tulare Lake's Paleoindian tool kit. Chapter 2 presents the initial attempts at obsidian tracing and hydration dating of Tulare Lake's ancient artifacts as well as providing a small sample from China Lake in eastern California. Chapter 3 critically reevaluates the number of reported Clovis-like projectile point discoveries from Tulare Lake and finally, Chapter 4 describes a unique ground stone "butterfly" crescent from the study area and discusses its possible meaning, function, and significance.

Tulare Lake, located in California's southern San Joaquin Valley midway between the San Francisco Bay and the Los Angeles Basin, was formed sometime during the later part of the Pleistocene epoch and, over millennia, expanded to cover about 760 square miles before it was drained and reclaimed for agricultural crops. Artifacts collected from early shorelines suggest the lake supported Paleoindian people for a considerable amount of time before the earliest Yokuts occupation.

While a respectable amount of information was gathered and made available about the region's archaeological past, the founders' research aims were left far from complete. Their dedication to the project has encouraged others to continue their efforts. Consequently, Bill and Fritz's research project will carry on. This publication, dedicated to both these pioneers in the study of California prehistory, is a step in that direction.

Jerry N. Hopkins and Alan P. Garfinkel

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Ancient Stones of Black Glass: Tracing and Dating Paleoindian Obsidian Artifacts from China and Tulare Lakes

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Abstract: *Archaeological sites within the Great Basin and California appear to demonstrate that human occupation occurred in late Pleistocene and early Holocene times from ca. 12,000 to 6,000 B.C. A prominent locality for Paleoindian material is China Lake. Thousands of artifacts dot the fossil shoreline on the desert floor of eastern Kern County at the interface of the Mojave Desert and the Great Basin near Ridgecrest (Davis 1978).*

In Central California, projectile points hypothesized to date from these periods have been discovered in abundance at the Witt locality (CA-Kin-32) on the southwest margins of Tulare Lake in Kings County in the southern San Joaquin Valley (Dillon 2002, Moratto 2000; Riddell and Olsen 1969; Wallace 1991). Some of these artifacts are basally thinned, Concave Base points (over 500). These projectiles are similar to Clovis points but are often smaller, somewhat thinner, are pressure rather than percussion flaked, and, most often, lack the distinguishing flutes (Rondeau 2005a, 2005b; Rondeau et al. 2007; Wallace 1991; West et al. 1991). The range of variation for these points, typically assigned to the Great Basin Concave Base Series, has not been clearly defined. The Tulare Lake points appear to be a local variant of this same tradition.

Until recently, no direct dates for the flaked stone materials found at either locality have been published (yet, see Basgall 2003, 2005a, 2005b). An indirect means of obtaining such temporal parameters is the use of obsidian tracing and hydration dating. Thirty-eight (38) artifacts from China (n = 5) and Tulare (n = 33) Lakes were chemically characterized to source and analyzed for their hydration measurements. Results of these studies indicate that obsidian hydration dating is a useful tool even for very ancient artifacts of volcanic glass. Obsidian tracing and dating indicate that Concave Base points are partly contemporaneous with Clovis age artifacts, although they have a far lengthier duration dating from ca. 13,500 to 10,000 years cal before present (BP). Great Basin Stemmed Series points are of more recent age dating from ca. 11,000 to 7,000 years cal BP. Eccentric crescents are apparently coeval with both Concave Base and Great Basin Stemmed Series points and have a lengthy temporal span from 13,500 to 7,000 years cal BP.

Tracing studies of the early obsidian implements from Tulare Lake, in this study, indicate that Concave Base tradition foragers were far more mobile than the Great Basin Stemmed Series cultural expression. Obsidian originated in no less than six (6) different source localities from 100 to 250 miles distant. These late Pleistocene hunter-gathers traversed enormous foraging territories and either directly accessed or traded for volcanic glass and fused shale from the Napa Valley, Casa

Diablo, Coso, Mount Hicks, Mono Glass Mountain, Queen, and Grimes Canyon sources. Later, early Holocene Stemmed Series peoples had a smaller, more limited foraging radius and more protracted mobility patterns procuring only Coso and Casa Diablo volcanic glass sources.

INTRODUCTION

Within California, the attribution of Clovis-like materials and their purported association with the earliest time frames for aboriginal occupation has remained somewhat conjectural (cf. Arnold et al. 2004: 43). Arnold et al. (2004), in recently assessing the current state of our knowledge, reminds us that most of these "Paleoindian material(s) from California are surface artifacts that are nearly impossible to accurately date." Admittedly, in the general region where China Lake is located we have precious few reported obsidian hydration rim measurements (and until recently, no radiocarbon assays) on Concave Base points (CB), Clovis-like fluted points, and crescents. Likewise, in the Tulare Lake collections the authors believe that there were no obsidian dates at all.

In an effort to expand this data-set and provide some limited resolution, with respect to the age of these assemblages, flaked stone artifacts manufactured from obsidian (particularly those artifacts that are presumed to be temporally diagnostic of late Pleistocene and early Holocene age) were gathered from these two areas. These artifacts are reviewed here and the results of obsidian studies are discussed in some depth.

OBSIDIAN HYDRATION BAND GROWTH AND WEATHERING

It has been acknowledged that there often are problems obtaining hydration rim measurements on artifacts of presumed Paleoindian age. Many times, researchers simply do not attempt such analyses believing that their efforts will be in vain and that analysts will routinely find that these artifacts exhibit no visible hydration bands, diffuse hydration rims, or bands of variable width (cf. Sutton and Wilke 1984; Zimmerman et al. 1989). It has been assumed that environmental conditions cause degraded surface characteristics for these artifacts and these conditions effect the formation and sustainability of the diffusion fronts. It is plausible that the hydration readings could manifest variable widths or be smaller than expected due to the effects of erosion and that bands may have formed, eroded, and re-developed over the many thousands of years that the artifacts lay on the surface of the ground.

Discussions with Tim Carpenter at Archaeo-Metrics indicated that he has developed a new method of obtaining hydration rim values from weathered specimens based on his observation and measurement of hydration rinds from unweathered internal cracks. He has had considerable success in obtaining relatively valid and accurate obsidian hydration measurements on such ancient artifacts, even on artifacts with severely eroded surfaces. He has determined that making cuts in these specimens oriented to take advantage of cracks (step fractures) developed as a function of the techniques of their manufacture can often reveal internal hydration bands. Fluting or thinning of points often creates internal hinge fractures that allow hydration rims to exist even when the more exterior surface hydration bands are highly eroded.

Surface erosion and severe wear are evident on many of the artifacts examined for this study. The specimens from China Lake were far more eroded than those from Tulare Lake. Sandblasting and water tumbling had, no doubt, affected the surface morphology of many of the items. Most specimens had flake scar arrises that were severely rounded and abraded and the fluted forms had the greatest degree of surfical weathering. It was thought that detection of hydration measurements on the internal cracks emanating from the hinge fractures might provide a more representative and authentic measure of their age, and, accordingly, this strategy was pursued.

OBSIDIAN DATING AND EFFECTIVE HYDRATION TEMPERATURE (EHT)

Most researchers attempting to refine the obsidian dating technique have come to recognize the importance of factoring in the mean annual temperature in the area from which the archaeological remains were recovered. Integrating what has come to be known as effective hydration temperature (EHT) into the equation has done much to explain the variability in hydration measurements. Recent research by Rogers (2006a) has aided in further refinement of obsidian dating and has re-evaluated the calculations and methods used for effective hydration temperature (EHT) adjustments (Rogers 2006b, 2007a, 2007b).

Many factors affect EHT and cause it to fluctuate through time. Among these are paleoclimatic change, pedoturbation (buried versus surface contexts), site aspect, vegetation cover, latitude, and elevation. Consequently, EHTs are simply estimates influenced by a wide variety of environmental factors. The preferred strategy is to develop obsidian hydration and radiocarbon pairs for each locality and period since a single formula rarely provides reasonable age estimates for all times and places.

The source specific hydration rates employed here have mostly been developed from research in eastern California in the southern Owens Valley and vicinity (e.g., Lubkin Creek for Coso, Mono Basin for Casa Diablo, and the Volcanic Tablelands for Queen). The EHT for the southern Owens Valley has been estimated at 20.4 degrees centigrade (Rogers 2007a for Lubkin Creek). A little lower in elevation but quite similar in thermal regime and precipitation is the Coso Volcanic Field and China Lake areas with a proxy indicator from the communities of Ridgecrest at 19.3 degrees centigrade or Inyokern at 21.1. Remarkably, the EHT estimate for Tulare Lake using the Hanford area as a proxy (about 45 miles from the Witt Site), is almost identical to the southern Owens Valley at 19.9. Consequently, EHT adjustments between the source specific rates for Coso, Casa Diablo, and Queen from eastern California to Tulare Lake are rather minor (Table 3). Judging from the similarity in the ranges, means, and standard deviation measurements (provided here) for chronologically diagnostic projectile point series, these areas exhibit virtually the same hydration measurement metrics and are in most cases statistically indistinguishable (see Table 8).

Most researchers, until recently, adjusted for EHT referencing Lee's work (Lee 1969) and estimated that each degree of difference in EHT was equivalent to a 6% adjustment. Basgall, using that procedure and an empirically derived estimate, suggested that his Fort Irwin Coso hydration measurement was about 10% smaller than those exhibited at lowland sites (< 5,000 feet amsl) in the southern Owens Valley and in the Coso Volcanic Fields (Basgall 1990). Nonetheless, examination of the range, mean, and standard deviation for the stemmed series points of Coso obsidian from Fort Irwin compared with those from Tulare Lake and Coso region suggests that there is very little difference between hydration measurements with respect to stemmed series points from Fort Irwin and those from other areas examined here (Table 8).

Other researchers are now recognizing that air temperature does not always correlate uniformly with differences in radiocarbon age and hydration means (Rosenthal 2005). Such temperature correction (EHT adjustments) appears to improve results more dramatically where EHT variation is of greater extremes. In this study, we have chosen to use obsidian hydration dating equations without any adjustments for EHT for the source-specific obsidian dating equations that we apply. We believe that the resulting estimates are reasonable approximations given all the factors that enter into the hydration process and the resulting age attributions are simply a rudimentary means of attaching estimated dates to those hydration values.

COSO OBSIDIAN HYDRATION

One of the most widely traded obsidians in California is toolstone quarried from the Coso obsidian sources in eastern California, southern Inyo County (Ericson 1977). Coso volcanic glass has been recovered from prehistoric sites as far west as the Channel Islands and east to San Bernardino County near the town of Baker at Lake Mojave in the eastern Mojave Desert (Warren and Ore 2006). Coso obsidian has been the focus of intensive academic studies and may be one of the "most thoroughly investigated obsidians in North America" (Gilreath and Hildebrandt 1997: 10).

Coso obsidian hydration rims are exceptional in that they provide a bigger yardstick than any other source in California. Significantly, Coso is one of the fastest hydrating obsidians in the world (Craig Skinner personal communication 2007; Chris Stevenson personal communication 2007). Rims in the 22 to 27 micron range on presumed early Holocene and late Pleistocene age artifacts have now been reported (Basgall 2004; Byrd 2006; Gilreath and Hildebrandt 1997; Warren and Ore 2006).

Many empirical and experimental hydration equations have been developed for Coso obsidian (see Garfinkel 2007). These rates have met with varying degrees of success. Basgall's 1990 hydration rate is one of the most widely used formulas. It allows researchers to factor in the EHT (effective hydration temperature) in the area from which the archaeological remains were recovered. The rate does explain much of the variability in the measurements. Yet, a number of researchers have cautioned and the rate developer himself even agrees that this equation over-estimates the age of some materials. The rate particularly misrepresents early Holocene and late Pleistocene artifacts having rim measurements larger than 10 or so microns, as is the case for some (n = 8) of the Coso obsidian artifacts in the present sample (cf. Delacorte 1999; Gilreath and Hildebrandt 1997; Rosenthal et al. 2001).

One of the reasons for the excessive age attributions is that hydration/radiocarbon age pairs dating to this time are rare (however, see discussion below) and so, secure dates for this period are difficult to establish. Additionally, associated radiocarbon dates are not routinely calibrated and, as such, many of the current Coso hydration equations under-estimate the true age of the older obsidian hydration rims by as much as 1,000 to 2,000 years (Fiedel 1999). To help alleviate some of these problems, Basgall and Hall (2000) presented a revised Coso obsidian hydration rate equation based on an expanded corpus of hydration measurements and radiocarbon pairs that include some larger rims and earlier radiocarbon dates. That rate is:

$$Y = 659.21 - 516.04x + 155.02x^2 - 4.56x^3$$

Where Y is the age in radiocarbon years before present (present = AD 1950) and x is the hydration measurement in microns.

Unfortunately, details regarding the derivation of that equation have yet to be presented in full. However, that equation does produce reasonably valid age estimates (uncalibrated radiocarbon dates) in conformance with some of the associated radiocarbon ages for a suite of hydration rims spanning the last 8,000 years (Tables 2 and 4). The rate also provides somewhat more accurate late Pleistocene and early Holocene age attributions than the earlier one (cf. Basgall 1990). However, this newly revised rate still attributes excessive ages for the largest Coso hydration measurements. Calibrated ages about perhaps two to five thousand years greater than would be considered reasonable result when applying this rate on artifacts with rims of 10 or more microns (see Tables 2 and 4).

Admittedly, obsidian hydration measurements are not amenable to great precision and yield only a general indication of age and not an "absolute" date. However, even radiocarbon determinations result in sigma values and calibration issues that only allow for bracketed age ranges rather than single fixed points in time. So, even the most absolute of chronological assays still, to some degree, provide only a relative date.

Volcanic glass scientists generally expect that the largest hydration measurements are apt to produce much greater variability in their hydration rim measurements than the smaller readings (greater variation and larger standard deviations). Given this variability, single hydration rims are rarely reported with calendar-specific dates. Normally, a number of readings are averaged and attempts are made to identify them with significant associations and correlations with an assemblage of artifacts (e.g., certain time-sensitive projectile point types or a sample of readings on debitage thought to date an associated cultural deposit) in order to provide some measure for dating them. It has become the practice among some obsidian researchers to view the mean and a single standard deviation above and below the average as a useful approximation of the age of a projectile point type (cf. Basgall and Hall 2000; Haynes 2004). Using that approximation, the hydration measurements and time spans (Table 1) can be reconstructed that would be characteristic of Coso obsidian point types in the lowland Coso Volcanic Field areas in and about China Lake and the Coso Range of eastern California.

Several observations concerning the Coso obsidian hydration rate can now be made that are critically important to our understanding of the most reasonable hydration equation for dating this toolstone when attempting to estimate the age of artifacts from the late Pleistocene and early Holocene. From inspection of the lowland Coso obsidian hydration data from eastern California (Owens and Rose Valleys), Pearson (1995) was one of the first to recognize that the first micron of Coso hydration represents approximately 125 years and that each micron of additional hydration takes approximately 50 years longer to form than the preceding micron. Furthermore, current evidence favors the position that upon reaching about 9 microns the hydration of Coso obsidian actually speeds up and takes half the time to grow a hydration band of one micron than during the preceding period (Table 1). During the time span represented by hydration rims in the 6.4 to 8.4 micron range, each additional micron of hydration takes on average about 1,250 years to accumulate. However, during the time frame represented by the 10 to 16 micron range the rate at which each additional micron forms is on average only about 500 to 575 years per micron. It also appears that for the very largest rim measurements (16 to 20+ microns), each additional micron is added on average in only about 500 years. Basgall (1990) also recognized this fact and observed that the Coso rate flattens out for the most ancient ages associated with the largest hydration measurements.

One might conclude from this pattern that Coso obsidian characteristically accumulates the first few microns of hydration rather quickly then slows down, as Pearson (1995) observed, as additional microns of hydration accumulate. Then, as a larger hydration band is produced and grows to a size in excess of 9 microns, additional band thickness is added at a much faster rate than previously - in fact, at a rate that is apparently almost twice as fast (Table 1).

The physical process for the development of a hydration band of Coso obsidian, especially at the largest rim measurements, is difficult to understand. None of the many hydration equations developed for Coso obsidian (Nathan Stevens personal communication 2006) has resulted in an acceptable equation that provides reasonable ages for middle and late Holocene hydration rims (<10 microns) while simultaneously giving relatively accurate dates for early Holocene and late Pleistocene hydration measurements (10-20+ microns) (cf. Rogers 2007a). Further, the Coso hydration process cannot be compared or modeled with most other obsidians since they follow other patterns and do not achieve the large rim sizes of Coso hydration measurements. Most other obsidian sources only accumulate, at most, 10 to 13 microns of hydration over the entire span of North American prehistory at ca. 14,000 years. Coso obsidian grows rims twice that size over that same time.

The reason Coso obsidian hydration measurements might be better for examining the more ancient artifacts is that all hydration readings are subject to significant errors. Observation error is about plus or minus 0.2 microns. Additionally, given the vagaries of hydration measurements due to erosion of the rims, effects of temperature, and other unknown factors all acting on the physical dimensions of the diffusion front, a bigger measure allows for a bit more wiggle room and greater variability can be encompassed in the sigma with larger rims and a faster rate. Hence, a bigger yardstick allows each micron to represent only a smaller segment of time. Other obsidians track only, at most, 10 to 12 microns over 14,000 years with each micron at the earliest age representing a millennium or more. Coso obsidian grows hydration bands that at the earliest time spans equate 500 years or less per micron for rims approximately 15 to 20 or more microns. Why this is so is unclear. However, such a pattern does help explain the anomalously old ages derived by previously developed rate equations for large rimmed Coso obsidian artifacts.

THE "COSO CONUNDRUM"

Another potential confounding element has recently been discovered that could affect our efforts at establishing the age of early Coso obsidian artifacts. Fredrickson et al. (2005) and recent work by Tom Origer (personal communication 2007) revealed that Coso obsidian may not be as uniform a source as original perceived. It may be that sub-source differences, not addressed through past chemical characterization studies, play a significant role in differing rates of hydration. This would be problematic for most researchers attempting to establish a single hydration rate for Coso as multiple rates might in fact apply.

This phenomenon was first recognized when Casa Diablo and Coso obsidian of purportedly similar ages were discovered with nearly identical hydration rim measurements (Fredrickson et al. 2005). Given the very different hydration rates for these two obsidians, a potential problem with the Coso rate was recognized. Induced hydration experiments were conducted that supported a different hydration pattern for "Colossal Quarry" Coso obsidian from Sugarloaf Mountain versus "lag" deposits of Coso obsidian found away from the primary high quality sources. The primary quarry at Sugarloaf Mountain may grow rims more slowly than lag deposits. In addition, the former may have been a variety of obsidian used more recently in time. In contrast, the lag sources may be types that produce very large hydration measurements and are apt to have been exploited at a much earlier date.

At this point, much of the above is still conjectural but both empirical and experimental data do support the hypothesized pattern. Nevertheless, since we are dealing here with Coso artifacts having some of the largest rims ever recorded, these implements would most likely have been acquired from only the lag quarries that grow exceptionally thick rims (assuming that the Coso sub-source model of differing hydration patterns is ultimately supported).

COSO HYDRATION DATING: AGE ESTIMATIONS FOR EARLY HOLOCENE/LATE PLEISTOCENE HYDRATION RIMS

Extensive research in eastern California has provided a robust database of obsidian hydration measurements and associated radiocarbon determinations. Researchers agree that several Coso hydration rates all work reasonably well for hydration measurements attributable to the middle to late Holocene (Basgall 1990; Basgall and Hall 2000; King 2000; Onken 2001; Pearson 1995; Rogers 2007a). The central problem has been that all rates provide excessive ages for the largest Coso hydration measurements. Very thick Coso hydration rims imply great antiquity. However, it is notoriously difficult and few models seem to work well to provide consistent and reasonable ages with these late Pleistocene and early Holocene assemblages. Given the lack of sound radiocarbon obsidian hydration measurement correlations, some other means must be developed to date these artifacts.

One of the things we are trying to do here is develop some method of attaching an age to Coso obsidian artifacts with very thick hydration measurements. These artifacts with very large rinds produce excessively old ages when diffusion equation rate models are fitted to the calibrated radiocarbon age-rind pairings. Although less theoretically acceptable, empirical efforts might be justifiable for practical archaeological application where gross estimates on an archaeological assemblage is the objective (as is the present case).

Site	Number	Hydration Rims	RC Dates	Mean Calibration RC Age	Reference
INY-4554	93	10.1±1.4	6,740±90 7,010±100 7,780±90	7,698	Gilreath and Holanda (2000)

Note: Data taken from Gilreath and Holanda (2000:41). Chauvenet's criterion applied and four outlier values are excluded (2.4, 17.8, 18.0, and 18.4 microns). Coefficient of variation for this tightly clustered sample is 0.14, argued to be representative of a single population.

A large sample (n = 93) of Coso hydration measurements and several (n = 3) associated radiocarbon assays are available from a site near Owens Lake in eastern California that might help serve as a baseline (see box, above).

If we assume that 10 microns roughly conforms to 7,700 calendar years ago (calibrated radiocarbon age) as the above data might suggest, then it appears that each additional micron of hydration (above 10 microns) accumulates almost twice as fast at a range of 575 to 500 years per micron (see Table 1). If we take the average of the three largest estimates of rim growth in years per micron for Concave Base, Great Basin Stemmed, and Pinto points, that would give us a mean accumulation of 543 years per micron. Accordingly, each successive micron of hydration added would be equivalent to that estimate. A simple projection (really a *pro-rata* allocation) of that estimate provides the following rough yardstick of estimated ages with the accompanying hydration measurements and age equivalents extrapolated for these very large Coso hydration readings. These measures would apply only in the lowlands of eastern California and in other areas that are environmentally similar with roughly comparable effective hydration temperature (EHT) estimates (see box below).

A simple equation to convert these large rims (Coso hydration measurements of 10.0 or more microns) to calendar ages would be the following:

$$Y = 7{,}700 + 543(x-10.0)$$

Where Y is the age in calendar years before present (present = AD 1950) and x is the hydration measurement in microns.

Admittedly, this equation and method is simple-minded, rather primitive, and not theoretically in alignment with the diffusion equation for the

"Coso Thick Rim Yardstick"

Rims (microns)	Age Estimate (Calibrated Radiocarbon Date / Calendar Age)
10.0	7,700
11.0	8,243 (±760 years per micron)
12.0	8,786 (±760 years per micron)
13.0	9,329 (±760 years per micron)
14.0	9,872 (±760 years per micron)
15.0	10,415 (±760 years per micron)
16.0	10,958 (±760 years per micron)
17.0	11,501 (±760 years per micron)
18.0	12,044 (±760 years per micron)
19.0	12,587 (±760 years per micron)
20.0	13,130 (±760 years per micron)
21.0	13,673 (±760 years per micron)
22.0	14,216 (±760 years per micron)

hydration process. In fact, one could argue quite cogently that this "rate development" is rather nearly circular thinking. Nevertheless, it does seem to work relatively well and provides some reasonable ages for these large rims, which is our primary objective here. They say that "the proof is in the pudding"—therefore, as more and better chronometric data bearing on this question is made available to researchers, we expect to develop a more refined and elegant hydration dating equation.

As a quick and independent check of our rough method of age determinations (see Table 2), we can compare our estimates with the hydration-radiocarbon pairs for early Holocene and late Pleistocene Coso hydration rims from feature contexts at Fort Irwin (Basgall 1993; Basgall and Hall 1991, 1992; Hall 1992). As is clear from this comparison, large hydration readings are apt to give somewhat inconsistent results and these data points are not always in sequential order—where larger mean rim values necessarily equate with more ancient ages. Nevertheless, even given the vagaries of the hydration process, there is a reasonably good fit between our Coso estimates and the mean calibrated radiocarbon age. Our projections are consistently neither over nor under estimates but render dates that are a little bit of both. The error rates vary from an under estimation of 1,500 years to an over estimation of 1,500 years with two estimates providing ages a little less than a millennium in error—being too old.

CHINA LAKE

Emma Lou Davis discovered early cultural materials from China Lake. These artifacts are primarily flaked stone and include a number of formalized implements. The total collection is rather large. Davis estimated that classifiable tools numbered more than 5,347 pieces. Small fractions of these materials were Paleoindian projectile points and obsidian artifacts were only a miniscule fraction of this assemblage. It is generally acknowledged that a preference for non-obsidian toolstone is characteristic of many (if not most) early Holocene/late Pleistocene age flaked stone assemblages. Later cultural assemblages are predominantly obsidian. Five artifacts were identified as early hunting implements of obsidian (Tables 4 and 9).

Provenience for China Lake Specimens

Davis (1978) indicated that the materials we reviewed and analyzed here were:

> Within the large area of Section 28 (1 statute mile square), a number of fossil microenvironments are represented, each of which was suitable for different activities. Mammoths 1 and 2 are probably remains of kill and butchery work. Hunts, drives and stalks were confined to more distant grasslands, but the marshes were used as natural traps for big animals that were either driven there or stampeded while drinking. Birding and foraging were the activities of the marshes, streams, and shallows. Processing of large animals took place along the nearest shore, whereas manufactures of portable objects was largely done in camp. These camps were on dry, slightly higher terrain, of which Stakes 1, 22 and 25 are good examples. Test excavations have already been made at Stake 1 and we know that there are artifacts buried under the sand resting on or in the strong paleosol which dates somewhere between 11,000 and 7,000 years B.P.
>
> This part of the collection was made while we were scouting around, before we had decided on the techniques and extent of the mapping program… Therefore, artifacts from Section 28 are interesting but are an uncontrolled collection. They seem to represent the whole range of Paleo-Indian tools characteristic of this valley.

Great Basin Concave Base and Fluted Points

Over time, it has become evident that there exists a class of projectiles that are large, lanceolate specimens with concave bases that date to the early Holocene and perhaps to the late Pleistocene as well. These bifaces are very similar to the Humboldt series (Garfinkel and Yohe 2005), yet they are often basally ground and sometimes exhibit grinding along their lateral margins. These points have been classified and given the name of either Black Rock Concave Base or Great Basin Concave Base (CB) and have been suggested to date ca. 11,000-13,500 cal BP. (Clewlow 1968; Fiedel 1999; Justice 2002; Pendleton 1979). These points have often been mistaken and mislabeled as classic Clovis points. In the Far West, most often these points *do not* exhibit the standard features and characteristics of classic Clovis points, often lacking true bifacial flutes and other characteristic elements (Warren and Phagan 1988; Rondeau et al. 2007). There seems to be considerable disagreement regarding their age and possible cultural associations in that they may be more akin (in age and technological features) to points labeled elsewhere as Plano, Plainview, Midland, or Goshen (Rondeau et al. 2007: 141). As Justice (2002: 80) has noted, classic Clovis assemblages in interior North America contain unfluted basally thinned lanceolate projectile points that would be easily included as representative of the Black Rock or Great Basin Concave Base type. However, these points from California and the Great Basin are ill defined in terms of their temporal and cultural affiliation.

Nevertheless, Concave Base forms of this very early type are recognized in Long Valley (Basgall 1988), Mono Basin (Hall 1991), Rose Valley (Borden 1971), Coso Range (Basgall 2003, 2004, 2005a, 2005b, 2007; Gilreath and Hildebrandt 1997), China Lake (Davis 1978), Sherwin Summit (Eerkens and King 2002), Bridgeport Valley (Halford 1998, 2001), Black Rock Desert (Clewlow 1968), Tulare Lake (Riddell and Olson 1969; Wilke 1991), and Lake Tonopah (Pendleton 1979; Tuohy 1984). Two points from two sites in Kennedy Meadows (TUL-897/KM-2 and TUL-899/KM–4) in the far southern Sierra Nevada Mountains at an elevation of nearly 6,000 feet (amsl) have also been assigned to this category (Garfinkel 2007; Gold 2005). Obsidian hydration rims on these two points manufactured from Coso obsidian (at 11.4 and 12.2 microns) have been equated with dates of 9,507 and 11,250 calendar years BP using a source-specific, temperature-adjusted hydration rate (Garfinkel 2007; Gold 2005). Such dates are roughly commensurate with prior estimates for the age of these forms (see Fiedel 1999; Justice 2002).

There has been some question concerning the age of Concave Base points (CB) and also some potential confusion concerning their ontogeny (Davis 1964; Glennan 1971; Jackson 1985; Jennings 1986; Justice 2002: 93). These points are thought by some to have preceded the Great Basin Stemmed (GBS) Series points of Lake Mojave and Silver Lake types. Such a determination is based in part on obsidian studies from Hanging Rock Shelter and Cougar Mountain Cave (Layton 1972a, 1972b: 28). A CB obsidian point from Hanging Rock Shelter exhibited a hydration measurement of over 10 microns and is the largest hydration reading for any point recovered from that site. Other possibly associated dates on these forms are suggestive of an age from 10,000 to 13,500 calendar years (Fagan 1975).

Within the China Lake collection, we identified a CB point (UAMS-5, Figure 1), attributed by trace element analysis to the Coso source (West Sugarloaf sub-source), and that point exhibited a hydration rim of 14.8 microns (Table 4). Emma Lou Davis reported that this point was found in the general vicinity of her Mammoth 4. If the mammoth and the point were deposited contemporaneously, that would certainly be of considerable interest. Davis (1978: 17) indicates that a radiocarbon date was calculated (UCLA-1800) at 18,600 ± 4,500 radiocarbon years before present on the ivory of Mammoth 4. Six pounds of ivory were assayed and the large sigma value was indicated as characteristic of all fossilized materials from China Lake. Both the mammoth material and the point were located at China Lake in Township 25 South, Range 40 East, in the Northeast quarter of Section 28 at an elevation of slightly less than 2,171 feet (amsl).

If our projected estimates for the thick rimmed Coso obsidian points are relatively correct (14.8 = 10,306 years cal BP) and if the date applied to the mammoth is also generally accurate, then the obsidian flaked stone point would have been deposited more recently than the death of the mammoth (mammoth dated at a minimum age of 14,100 rcybp or about 16,000 years cal BP). That minimum age for the mammoth is considerably older than the revised dates now suggested for the earliest inception of the Clovis Complex in interior North America at 11,050 rcybp (Waters and Stafford 2007).

A second CB point (Figure 1) was identified to the general provenance of Section 28 (A-19) and has a larger hydration band of at least 18.4 microns. It has been chemically characterized to the Coso source field and the West Sugarloaf subsource (Table 1). The point is highly weathered (sand blasted) yet appears to have been unifacially fluted. However, we cannot assert that this is the case with absolute certainty due to the great degree of damage and abrasion the point has experienced. Our thick rim Coso age estimator would provide a date of 12,261 years cal BP.

One other Coso obsidian, Paleoindian point has been previously examined and a hydration rim measurement reported (Tuohy 1969: 170-171; 1984, Figure 5m). That point was chemically characterized to source and identified as coming from one of the Coso Volcanic Field sources and exhibited a hydration measurement of 15.7 microns. It was discovered lying on the edge of Lake Tonopah in Nevada. From the description and metrics, it is a bifacially fluted, Clovis-like form. This hydration measurement is in accord with the range of readings that would be predicted for CB points derived from the general environs, elevation, and thermal regime of the lowland Coso Volcanic Field area.

Fluted Points

A heavily sandblasted, apparently bifacially fluted point base was also found in the same general area as the other materials that have undergone study at China Lake (T25S, R40E, Section 28, Catalogue Number A-320, Figure 1). It has a surprisingly small hydration band of 10.3 microns and was determined to have been quarried from the Saline Valley obsidian source. No hydration rate has yet been developed for that source. Saline Valley lies northeast of the Coso Range, some 50 miles distant.

Crescents

A crescent of obsidian was discovered in the adjacent area of Section 21 (A-512, Figure 1) and was identified through XRF study as having been manufactured from an unknown source of obsidian and has a hydration measurement of 15.4 microns. Given this large measurement, all obsidian dating equations would indicate a late Pleistocene/early Holocene age. Another crescent of similar form and location (A-45) did not reveal a hydration band under analysis and was manufactured from a similar source of obsidian that has no known geographic source.

Great Basin Concave Base (CB)

Two new obsidian hydration measurements on CB Coso obsidian points are now available from China Lake that range from 14.8 to 18.4 microns. We can also add to the small sample the two Concave Base points previously identified in the Gilreath and Hildebrandt (1997) study in the nearby Coso Volcanic Field. It is therefore possible to obtain a more refined chronological estimate for the expanded suite of four (4) China Lake/Coso Range Concave Base hydration rims using our rough estimations for thick Coso obsidian hydration rims. Extrapolating from the hydration measurements using the mean and a single standard deviation from the average as a general age range for those points, suggests a mean age of 11,446 years cal BP and a range from 9,546 to 13,727 cal years BP (Tables 1, 4, 5, 6 and 9).

Given the small sample of Coso hydration measurements (n = 4), it is difficult to ascertain the precise chronological range represented by these early points. However, if the rims do in fact even roughly represent the relative ages of these forms then, that range of hydration measurements would seem to support the notion that these style points endured for some time (perhaps for three or four thousand years) and have a much lengthier tenure than that recently reported for the classic Clovis Complex suggested now as lasting, at most, for only a few centuries (Waters and Stafford 2007).

Recently, Mark Basgall (2003, 2004, 2005a, 2005b, 2007) revisited Pleistocene China Lake with an eye toward updating and refining the early work of Emma Lou Davis (1974, 1975, 1978). Basgall's initial report (2003) on his efforts indicates that he was able to obtain three radiocarbon dates within the vicinity of Davis' collection areas. Two dates were obtained on a spring-related peat stratum: 9,870±50 and 10,010±110 rcybp and a single date of 8,390±130 rcybp was assayed on an artifact-bearing paleosol. Those dates when calibrated provide a range of 9,000 to 12,000 cal years BP and, as such, would be in general agreement with the chronological position suggested here for CB points in the China Lake area. Our estimate would place Concave Base points in the range of 10,000 to 13,500 years cal BP (see below).

Dating Stemmed Series vs. Concave Base and Clovis-Like Fluted Points

The relationship between GBS points (cf. Lake Mojave and Silver Lake) and CB / Clovis-like Fluted points has been unclear (cf. Beck and Jones 1997). These artifacts often co-occur, but are also identified in distinctively different microtopographic associations. As Basgall (2003) has noted, there are three alternatives that might explain these patterns: (1) the two assemblages are truly of differing age and are only conflated (mixed together) due to overprinting of recurrent occupations; (2) they are of comparable age but have separate (cultural) origins; or (3) they are contemporaneous elements of a single adaptive pattern. Growing evidence from eastern California seems to support the notion that these expressions are manifestations of two distinct depositional events of differing age there and that the Concave Base and fluted forms are the oldest expressions and the stemmed series points are younger (see discussion below). Our research bears on this question.

The small suite (n = 4) of Coso obsidian hydration measurements provides some new evidence supporting the differentiation of stemmed series points versus basally thinned and fluted Concave Base points. Coso obsidian is an especially good yardstick for such an evaluation since it produces the largest hydration reading measurements of any obsidian in California. It can be noted that the stemmed series points have an associated suite of largely non-overlapping hydration rims with a mean that differs significantly from the CB forms. The mean for the GBS points is consistently in the range of 13.0 microns while the mean for CB forms is four microns greater at about 17.0 microns (Table 5).

Figure 2 presents a t-test for the data set. The t-value for the entire data set is 2.063 with a probability of .007959, supporting the hypothesis that the mean hydration values for GBS and CB are statistically different. Although the sample size for the CB is very low (n = 4), nonetheless, we would conclude that the two point types were used at different periods of time.

Recent research by Waters and Stafford Jr. (2007: 1125) allow for the possibility that Clovis and GBS Series artifacts might be coeval in part at Bonneville Estates Rockshelter, Nevada (Goebel et al. 2006). It seems reasonable, given the metrics presented here, that there is indeed some limited overlap in the dating of these two early assemblages. Willig et al. (1988: 10-11) suggested a brief overlap of only two hundred years in Western Clovis and GBS Series points. The spread of hydration readings for these two forms, the range in rim measurements, and the conversion of rim measurements to approximate

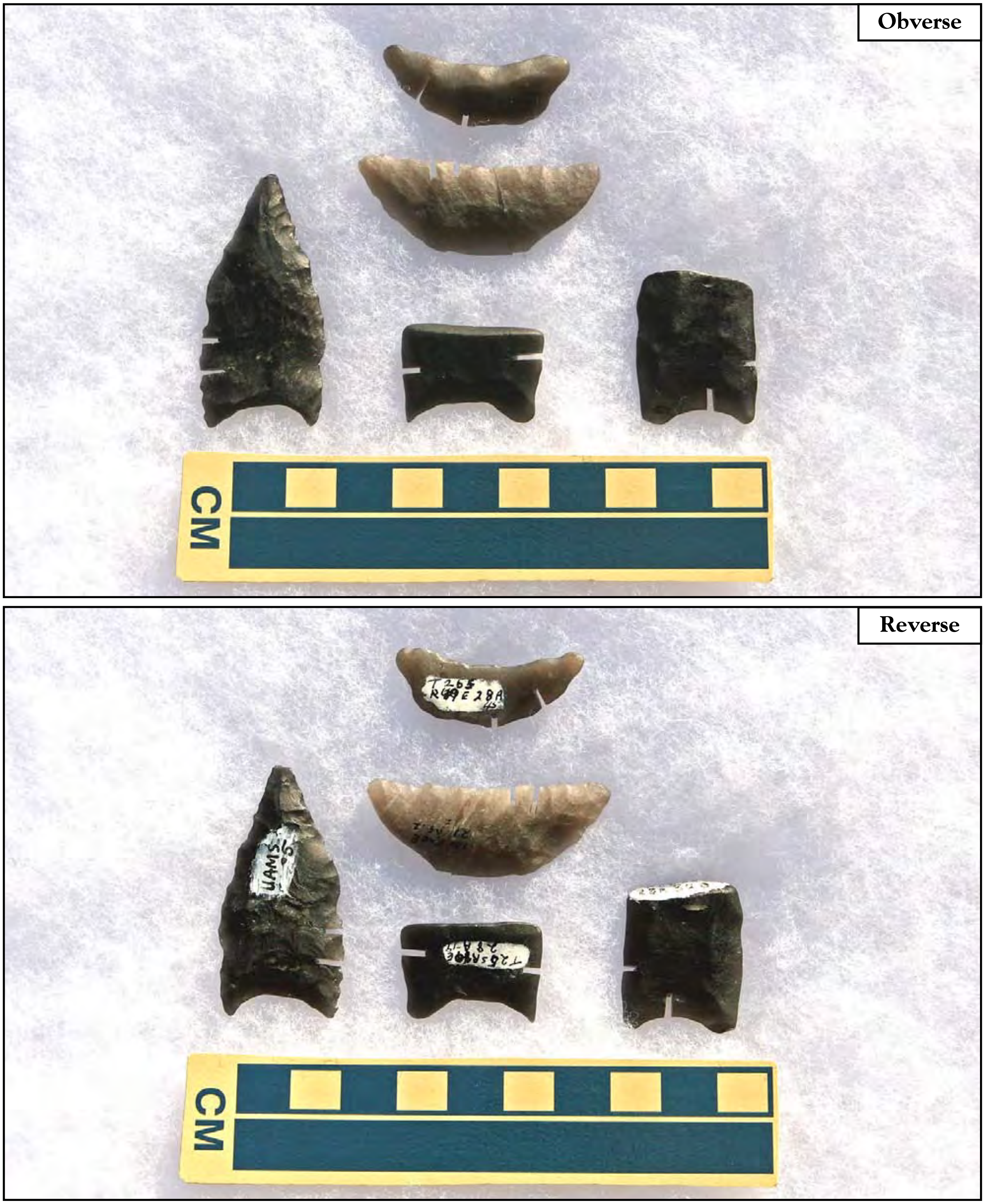

Figure 1: Concave base points. Bottom row, left to right: VAMS-5, A-19, A-320. Middle: lunate crescent, A-512. Top, crescent shaped item, A-45.

dates presented here and below does not seem to support such a brief overlap but one of much greater duration perhaps at a minimum of one to two thousand years. We agree with Haynes (2004) in his rough approximation for the age of Stemmed Series points in the Great Basin and suggest that these forms, most likely, date from ca. 8,000 to 11,000 calendar years before present (see further discussion below).

Given the overlap in hydration ranges for the CB and the few examples of more Clovis-like points, it seems likely that the CB points continued in use (after the termination of the classic Clovis forms), but appears probable that these points were the most distinctive flaked stone expressions for some of the earliest populations occupying North America and were initially employed ca. 13,500 years cal BP.

TULARE LAKE

One of us, Jerry Hopkins, has been an avid avocational archaeologist for many years and has been a student of the prehistory and history of the Tulare Lake region for more than 50 years. Through Hopkins' investigations, we were able to access his unique collection of Paleoindian materials, including obsidian artifacts from the Witt locality near Dudley Ridge (see Hopkins, this volume).

Provenience for Tulare Lake Specimens (Witt Locality)

The majority of the flaked stone assemblage was found on the surface of the fossil shorelines at elevations between 190 and 195 feet (amsl) in Township 23 South, Range 20 East, in various sections. This contour marks a level at which Tulare Lake stood for a considerable time span during the late Pleistocene/early Holocene, well below the 210 foot shoreline of more recent lake high-stands that would have placed these earlier shorelines under water.

Ages of Tulare Lake Obsidian Artifacts

Based on their obsidian hydration measurements, it appears that CB and fluted projectile points are at least partly contemporaneous and the oldest artifacts recovered from Tulare Lake. Both forms are most likely variants of the same technological and cultural tradition. The CB points differ only slightly from the classic Clovis points recovered from the Plains states. As mentioned earlier, it may be that most of these CB points are

Figure 2. Data from Coso Volcanic Field and China Lake.

Point Type	N=	Mean	St. Dev.	SE Mean	CV
GBS	21	12.9	2.7	0.6037	.21
CB	4	16.9	3.5	2.0207	.21

T= 2.063 P=.007959 Pooled Standard Deviation=7.3709

The metric data for each suite of readings presented here includes mean, standard deviation, number of measurements, and the coefficient of variation (CV). The latter measure is calculated by dividing the standard deviation by the mean and is useful in comparing multiple samples with varying means (Blalock 1979: 84). The CV provides a useful statistic to evaluate a sample's relative homogeneity. Tightly clustered readings, presumably, represent a single chronological period and have been recently defined as having a CV of 0.25 or less (Gilreath and Hildebrandt 1997). Such is the case with respect to the samples described here for both the GBS series and the CB points.

Key: GBS = Great Basin Stemmed, CB = Concave Base. Data for GBS and CB measurements from Gilreath and Hildebrandt (1997) and the present study.

more aligned with forms labeled as Plano, Plainview, Midland, or Goshen. However, true look-alike Clovis forms with all the classic recognized features are found at Tulare Lake at the Witt locality, though they number far fewer than previously estimated. Still, dozens of such examples are known from private collections including the Hopkins assemblage (Rondeau 2005a, 2005b; Rondeau et al. 2007). The number of such points discovered at the Witt locality is still, in fact, far greater than that at any other archaeological site where fluted points have been discovered within California.

Age of Concave Base and Fluted Points

Coso

Four (n = 4) Concave Base and fluted points of Coso obsidian derive from the Witt locality at Tulare Lake (Figure 3). The first of the smaller rimmed specimens (D30943; 9.0 microns) is unifacially fluted and the second small rimmed CB artifact (DRL6GF1; 5.2/9.1) is basally thinned. One of the large rimmed examples (D41199; 19.8 microns) is simply thinned and the other artifact (DRL6GF2; 11.4/11.7/12.7/14.0 microns) is bifacially fluted, edge ground, and also exhibits channel scratching. We are uncertain of why the former two specimens bear such modest hydration measurements. We suspect that these measures do not validly represent the antiquity of these pieces, since we have other specimens of differing glass that all support the interpretation that these stylistically distinct specimens are in fact late Pleistocene and early Holocene in age.

Dismissing these two anomalously small rimmed artifacts as outliers or the products of more recent episodes of reworking and scavenging, the largest rimmed specimen would equate with an age of about 13,000 calendar years BP (13,021 calendar years based on our Coso thick rim estimator presented above) and for the other artifact, its largest rim (14.0 microns) would equate with an age of 9,872 years cal BP). Significantly, the small sample of thick-rimmed CB Tulare Lake points has a mean that is identical to that of the Coso Volcanic Field CB finds.

Casa Diablo

Two (n = 2) CB points (Figure 3) of Casa Diablo obsidian (different sub-sources) were recognized from Tulare Lake (D30950, 6.1 microns and D41262, 12.1 microns). The two obsidian hydration measurements match the end points in the range of readings for similar CB points of Casa Diablo obsidian recovered from the Komodo site in eastern California (Basgall 1987, 1988). Using the unadjusted Casa Diablo (Hall and Jackson 1989) obsidian hydration rate to convert the rims to radiocarbon ages provides a range of 3,522 rcybp and 12,301 rcybp. Given that the smaller rim is so distinctly at odds with our other supporting data, we would tend to view that recent age as anomalous or a statistical outlier. The late Pleistocene date is more in line with the other dates from large rimmed CB points manufactured from a variety of different obsidian sources located throughout California. When the derived radiocarbon date using the Hall and Jackson (1989) equation is calibrated, it would appear to result in a date of ca. 14,500 years cal BP.

Queen

Two (n = 2) CB points (Figure 3) bearing flutes on both faces and appearing very similar to true Clovis material on the Plains were identified at Tulare Lake (D41036, 10.7 microns; D41179, 7.9/6.1/5.5 microns). The source specific Queen obsidian hydration rate uses the formula:

$$Y = 82.74\,(x)^{2.06}$$

where x = micron measurement and Y = age in radiocarbon years (Basgall and Giambastiani 1995: 44).

That rate was developed for the Volcanic Tablelands of the Owens Valley. The latter point with multiple rims appears to have been scavenged and reworked so frequently it is doubtful that any of these readings represent its true age.

Even the largest rim reading at 7.9 microns would provide an age of only 5,845 rcybp.

The other point with the larger hydration measurement (D41036, 10.7 microns) would provide an uncalibrated age of 10,920 rcybp and that date would convert to a calendar age of approximately 12,900 years cal BP. Such a date is quite close to our expected age for true Clovis points in the interior of the United States. Recent study (Johnson et al. 2007) of a high elevation (8,200 feet amsl) find in the Sierra Nevada in Fresno county reported on a nearly complete classic Clovis point manufactured of Queen obsidian that was bifacially fluted on its concave base. That point provided a similar size obsidian hydration measurement, when adjusted for EHT, of 11.1 microns. The point was argued to have an estimated age of 13,500 years cal BP (Johnston et al. 2007).

Napa

Surprisingly, one (n = 1) Tulare Lake CB (Figure 3) was crafted from obsidian derived from the Napa glass source in northern California (D41272, 8.4 microns). This is the northernmost source and the farthest distant obsidian source (235 miles to the northwest) represented within the Witt locality at Tulare Lake. We believe this artifact may represent one of the southernmost examples of aboriginal use of Napa Valley obsidian documented archaeologically. Two rates are often used to provide age estimates for Napa obsidian hydration measurements (Origer 1982; Rosenthal 2005). Rosenthal's recent efforts (Rosenthal 2005) are perhaps the most rigorous attempt at developing a source-specific hydration dating equation. Using 33 radiocarbon-hydration pairs from throughout the Central Valley, his Model A provided the best approximation of calendar dates for hydration rim suites within the last 3000 years of prehistory. Rate A provides that:

$$Y = 148.7\, x^2$$

where Y is a date in calibrated radiocarbon years and x is the hydration measurement in microns.

At 8.4 microns the estimated calendar age for the artifact would be 10,493 years cal BP.

Others (Mono Glass Mountain, Mt. Hicks)

Finally, two (n = 2) additional CB points (Figure 3) emanate from volcanic glass sources that do not have well-developed source-specific hydration dating equations. A unifacially fluted CB point (D41101) exhibited a hydration measurement of 10.8 microns and was traced to the Mono Glass Mountain source in eastern California in Mono County. The other CB point was derived from the Mt. Hicks source and manifested a dual rim of 6.0 and 12.9 microns (D411100). If these two obsidian sources exhibited hydration rates comparable to most of the other sources recognized in California (except for Coso), the larger rims of 10.8 and 12.9 would by those measures support an early Holocene or even perhaps a late Pleistocene age for these specimens.

Mono Glass Mountain has an obsidian hydration rate developed for the source reported by Overly (2003). Applying that rate to the hydration rim of 10.8 for the CB point (D41101) would result in an excessively ancient and unreasonable radiocarbon age of 26,000 years.

Based on recent communication from Tim Carpenter, Mount Hicks obsidian is said to have a hydration rate the same as Casa Diablo and perhaps also that of Bodie Hills obsidian (Tim Carpenter personal communication 2007). We would argue that the larger hydration measurement would presumably date the original time of manufacture for the CB point (D411100). The Casa Diablo rate provides an uncalibrated radiocarbon age for the 12.9-micron rim of 13,827 rcybp. If that date was calibrated it would appear rather too old and unreasonably ancient, but nevertheless indicating a date probably of late Pleistocene age.

Figure 3: Concave Base points. Bottom row, left to right, bottom to top: D30943, DRL6GF1, D41199, DRL6GF2, D30950, D41262, D41036, D41179, D41272, D41101, D411100.

Age of Great Basin Stemmed Points

Coso

Six (n = 6) GBS points (Figure 4) of Coso obsidian from the West Sugarloaf sub-source were identified (D31069, D1150, D31063, D31068, DRL6GF4, and DRL6GF10). These artifacts have rims of 11.8/14.6, 10.0, 9.5, 12.3, 6.1/10.4/11.9 with two outliers both at 6.1 microns. Excluding the smallest rims and incorporating both measures from the dual rimmed specimen would provide an average for that small sample (n = 7) of 11.5 microns and a standard deviation of 2.3. Using our rate for thick Coso rims, we would calculate that this average rim measure to equate with 8,514 years cal BP. Using a single standard deviation above and below the mean provides an age range from ca. 9,763 to 7,266 years cal BP for these GBS points.

Casa Diablo

Three (n = 3) GBS points (Figure 4) were fashioned from Casa Diablo obsidian (D1552, 10.1; D1047, 10.0; D1019, 9.7). These artifacts range from 9.7 to 10.1 microns. This small collection has a mean of 9.9 microns and a standard deviation of .2. The mean rim measure equates with an age of 8,528 rcybp (Hall and Jackson 1989). Correcting that age provides a date of ca. 9,500 years cal BP. Applying the mean plus one standard deviation above and below the average gives us an age range of ca. 9,200 to 9,800 years cal BP.

Age of Tulare Lake Widestem Points

Widestem (WS) points of obsidian are somewhat common at the Witt locality at Tulare Lake. Within the Hopkins collection, there are 81 examples of this style and they are manufactured from both the locally available chert (n = 46) and imported non-local obsidian (n = 35). Nearly identical forms are known from Northern California and were identified at the Borax Lake Site that appear to overlap in age with both fluted points and crescents, but continued to be employed until a much more recent era and discontinued at ca. 6,000 years cal BP. Therefore, with an eye toward identifying whether these morphologically similar forms from Tulare Lake and the Witt locality are of similar age to the other late Pleistocene and early Holocene materials recovered from Borax Lake, we analyzed a small sample (Figure 4) of these artifacts (n = 2).

Both WS points were analyzed to determine the geographical source of their obsidian. Both were acquired from Casa Diablo but from different sub-sources. The first (DRL6GF8) was from Lookout Mountain and did not have a readable hydration rind. The other derived from Sawmill Ridge (DRL6GF9) and exhibited two hydration rims of 9.6 and 11.0 microns. Assuming that the larger rim dates the initial manufacture of that point and that the smaller rim is a product of reuse, then the 11.0 micron reading would equate with an age (using the Hall and Jackson 1989 rate without any adjustment for possible temperature differences) of 10,336 rcybp. Correcting that radiocarbon age into calendar years provides a calibrated mean age of 11,505 years cal BP.

Age of Eccentric and Lunate Crescents

Bifacial and unifacial crescents are not uncommonly associated with early Paleoindian materials thought to be commensurate in age with Clovis and Great Basin Stemmed Series sites (Justice 2002: 74). In the Far West, a number of researchers have identified crescents and attributed them as part of the flaked stone assemblage of "Clovis" hunters (Davis and Shutler 1969; Heizer and Hester 1978). Nevertheless, in California crescents have defied adequate dating. Among the only examples associated with a datable stratigraphic context are those reported from the deeply buried soil at CA-KER-116, Buena Vista Lake (Fredrickson and Grossman 1977; Hartzell 1992). Associated radiocarbon dates on freshwater mussel shell for that lowermost stratum ranged between 7,175 and 6,450 years cal. B.C. Some researchers have argued that crescents are distinct technologically from fluted Paleoindian technologies and that most evidence would indi-

Figure 4: Great Basin stemmed points. Bottom row, left to right: D31069, D1150, D31063, D31069, DRL6GF4, DRL6GF10, D1552, D41047, D1019. Tulare Lake Basin widestem points: DRL6GF8, DRL6GF9.

cate that they were in use primarily from 6,500 to 8,500 years cal BP (see Fenenga, this volume).

However, other data from the Borax Lake Site in northern California supports the position that crescents are at least in part coterminous with fluted points (Meighan and Haynes 1968, 1970; White 2002). Obsidian hydration measurements on fluted projectile points, stemmed points, and crescents from the Borax Lake Site support substantial temporal overlap as these stone implements uniformly exhibit hydration measurements that range between 8.0 and 9.7 microns and are interpreted as dating from ca. 10,000 to over 13,000 years cal BP.

Crescents are sometimes referred to as "Great Basin Transverse Points" since it was thought that they might have been hafted lengthwise and used as bunts in the hunting of waterfowl. Alternately, use wear analysis reveals that they may have functioned as a knife or scraper similar in form to an Inuit's women's knife or *ulu*.

Eccentric Crescents

Coso

Three (n = 3) eccentric crescents (Figure 5) of Coso obsidian were identified from Tulare Lake (L10874, D21528, and D31023). All had distinctive chemical signatures matching the trace element profile for the West Sugarloaf sub-source. Almost four microns separates the smallest and largest rim measurements providing a range from 7.9 to 11.7 microns. These three data points provide a suite of readings with a mean of 9.2 microns, standard deviation of 2.1, and coefficient of variation of .23. Since the lower range in hydration measurements is less than 10.0 microns, we used the Basgall and Hall (2000) rate to estimate the average age of these three artifacts. That lower range (7.9 microns) provides an estimated age of 6,078 rcybp or ca. 6,975 years cal BP. The uppermost range of 11.7 microns provides an age estimate of 8,623 years cal BP. Therefore, the Coso obsidian eccentric crescents might best be estimated at an age of 7,000 to 9,000 years cal BP. This would be largely commensurate with the GBS points identified from Tulare and China Lakes.

Casa Diablo

Seven (n = 7) eccentric crescents (Figure 5) of Casa Diablo obsidian were also identified from Tulare Lake (D41010, 13.5; D41219, 3.7/11.7; D41017, 10.1; D30931, 10.1; DRL6GF7, 11.0; DRL6GF11, 3.5, 10.3; DRL5GF5, 7.6). All were chemically fingerprinted as manufactured from volcanic glass from the Sawmill Ridge (n = 6) and Lookout Mountain (n = 1) sub-sources from the Casa Diablo obsidian field. The hydration measurements on six of these artifacts revealed a range of measurements from 10.1 to 13.5 microns (Table 9). The artifact with the 11.7-micron measurement must have been subject to reuse since it revealed a much more recent and smaller secondary rim of 3.7 microns. Similarly, another eccentric crescent with a 10.3-micron reading apparently was used more recently and exhibited a smaller secondary reading similar to the other artifact with a dual reading at 3.5 microns. Additionally, a third aberrant reading was derived from another eccentric that was either an eroded rim or the product of secondary use and scavenging.

Disregarding the rim readings smaller than 10.1 microns, these six eccentric crescents have hydration measurements with a mean of 11.3 microns and a standard deviation of 1.61 microns. Assuming that the Casa Diablo hydration rate developed for eastern California (Hall and Jackson 1989) can be applied without significant temperature adjustments to these Tulare Lake specimens, then that 11.3 micron measurement would equate with a radiocarbon age of about 10,857 rcybp (12,840 years cal BP). Estimating the chronological position using the mean and a single standard deviation provides an age range from 9,200 to greater than 13,500 years cal BP.

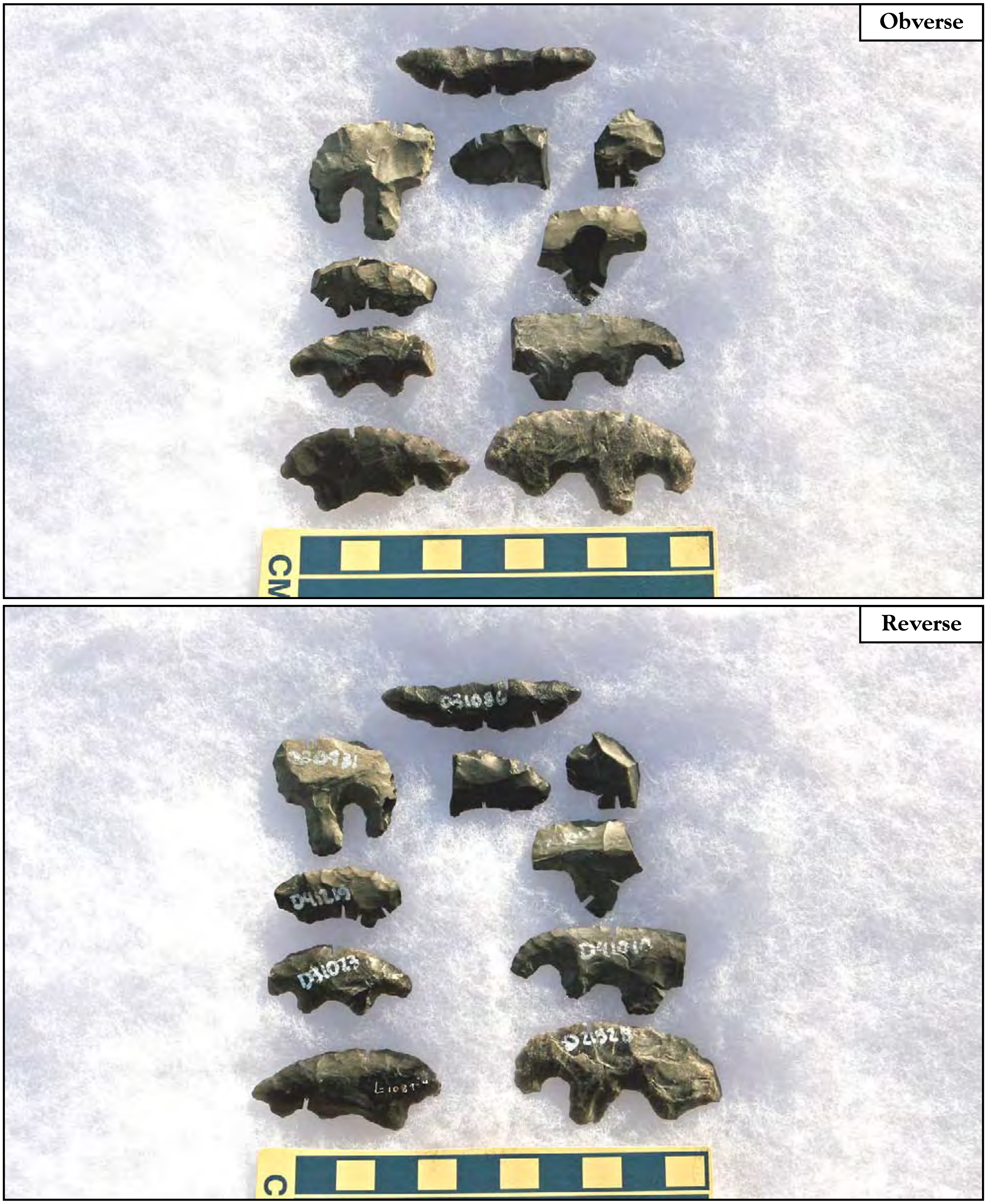

Figure 5: Eccentric crescents Bottom row, left to right, bottom to top: L10874, D21528, D31025, D41010, D41219, D30931, DRL6GF7, DRL6GF11.

Lunate Crescent

Coso

One (n = 1) bifacially flaked lunate crescent (D31086, 6.1) was traced to the West Sugarloaf sub-source within the Coso Volcanic Field (Figure 5). It had a surprisingly small hydration measurement of only 6.1 microns. That rim would convert to a more recent age than most of the other crescents of only 2,245 rcybp (Basgall and Hall 2000). This anomalous reading is probably best viewed as a statistical outlier or perhaps a manifestation of reworking of an older piece.

CONCLUSIONS AND GENERALIZATIONS

Thirteen (13) obsidian Concave Base and fluted points provided hydration measurements and source determinations. The hydration metrics for many of these artifacts (n = 9; 69%) support an early Paleoindian age. Hence, this assemblage apparently represents a time range from about 10,000 to 13,500 years cal BP with the majority (n = 7; 54%) of our age estimates and source-specific obsidian dates approaching the earliest millennia dating to that period.

Nine (9) Great Basin Stemmed obsidian points were analyzed from the Witt locality at Tulare Lake. Hydration measurements and source-specific obsidian age estimates indicate a distinctly more recent assemblage than the CB points. Date estimates overlap the CB temporal range only slightly suggesting a time span for the GBS assemblage from ca. 7,000 to 11,000 years cal BP. Many researchers posit just such an age for GBS Series points and our small sample supports those prior estimates and would fit quite nicely within that period.

Eleven (11) obsidian crescents of two types were examined. The rarest and most unusual are the eccentric crescents (n = 9). These artifacts were apparently coeval with the temporal range of both CB and GBS points. The earliest examples (n = 5) were almost exclusively manufactured of Casa Diablo obsidian from the Sawmill Ridge locality. Obsidian dates attest that these specimens date from ca. 9,000 to 13,500 years cal BP. Eccentric crescents of exclusively Coso obsidian have a more recent time frame. They are estimated as dating from ca 9,000 to 7,000 years cal BP.

Three (3) other crescents of more ordinary form were also noted. One specimen from China Lake bore no visible hydration rim and another from a similar provenience could not be traced to source but had a very large hydration rim (15.4 microns). That measure, if recognized for any of the known obsidian sources in California, would provide ages suggesting an early Holocene if not late Pleistocene date. One lunate crescent of Coso obsidian came from Tulare Lake had a surprisingly small hydration measurement of 6.1 microns. That anomalously small reading may owe to scavenging or reworking of this artifact. A Tulare Lake Widestem point of Casa Diablo obsidian apparently dates to ca. 11,500 years cal BP based on the largest hydration measurement exhibited on the specimen.

Results of these studies, in general, indicate that obsidian hydration dating can be a useful tool even for very ancient and heavily weathered artifacts of volcanic glass. Obsidian tracing and dating indicate that Concave Base points are partly contemporaneous with Clovis age artifacts, but they have a far lengthier duration dating from ca. 13,500 to 10,000 years cal (BP). Stemmed series points are of more recent vintage dating from ca. 11,000 to 7,000 years cal BP. Eccentric crescents are apparently coeval with both Concave Base and Stemmed Series points and have a temporal span from 13,500 to 7,000 years cal BP.

Geochemical trace element studies of obsidian procurement from Tulare Lake indicate that Concave Base tradition foragers were far more mobile than the Great Basin Stemmed cultural expression. Obsidian originated in no less than six (6) different source localities from 100 to 250 miles distant. These late Pleistocene hunter-gatherers apparently traversed enormous foraging territories (cf. Jones et al. 2003) and either directly accessed or traded for volcanic glass from the Napa Valley, Casa Diablo, Coso, Mount Hicks, Mono Glass Mountain, and Queen obsidian sources, and fused shale from the Grimes Canyon toolstone source. Later early Holocene stemmed series foragers had a smaller, more limited foraging radius and more protracted mobility patterns accessing only Coso and Casa Diablo volcanic glass sources.

If these chronological assessments are generally accurate, with respect to the temporal placement of these early assemblages, this has significant and far-reaching implications for the study of the early peopling of the Americas. A lengthy tradition of distinctively thinned or fluted Concave Base points appears to have endured far longer than the Clovis expression in the more eastern portions of the United States. This Clovis Tradition is now believed to have lasted for only 200 – 500 years (Waters and Stafford 2007). The number of CB and fluted points recognized from Tulare Lake is easily in the hundreds and exhibits a far greater profusion than any other location exhibiting fluted points in California and contains one of the largest Paleoindian assemblages in North America (cf. Dillon 2002).

Dillon noted that there were probably more fluted points at the Witt locality than all other fluted point finds combined for California (Dillon 2002: 16, Table 1). Rondeau et al. (2007) believes that statement is in error and that many, if not most, of the fluted points from the Witt locality are rather simply thinned or at some variance from typical Clovis points from the interior of the United States (see Rondeau 2005a and 2005b). Nevertheless, the Tulare Lake CB and fluted points are at least early Holocene in age, definitely Paleoindian, and obsidian dating evidence would lead us to argue that they are most likely, in part, fully contemporaneous with the earliest dates for Classic Clovis points. If that interpretation is correct, this pattern would be indicative of an area of origin or node of in-migration into California.

Current knowledge now reflects the view that ethnically mixed early peoples from northern and eastern Asia moved into the Americas not exclusively via Beringia, but at an earlier date traveling via watercrafts along the shores of the west coast of the United States (Erlandson et al. 2007; Moratto and Chartkoff 2007). This initial in-migration took place some two to three millennia before the opening of the ice-free corridor. Therefore, California would have been one of the first sites for initial colonization of the Americas. Such an inference implies a different migration path moving from the west to the east. Perhaps the Tulare Lake CB and Fluted point assemblage could represent a considerable and concentrated locus of early Paleoindian activity that fueled the more far reaching, spatially expansive, and accelerated dispersion of slightly later classic Clovis populations. Such an initial migration and movement of early populations might only be substantiated when we can obtain better temporal controls on the earliest prehistoric assemblages recovered from the Far West.

ENDNOTES

(1) Alexander K. (Sandy) Rogers, in a recent personal communication (2007) has independently studied the physical processes of Coso hydration dating. He estimates the actual velocity of the front of hydration on very old obsidians is on the order of 500 years/micron supporting the estimate developed here.

(2) Recent efforts by Rogers (2006a, 2006b, 2007a, 2007b) to reevaluate the entire methodology in which obsidian hydration dating is accomplished are quite laudable. In a paper (in press) he revisits the Coso obsidian hydration rate and provides a new equation and model and incorporates adjustments for the EHT of an archaeological site's location – thermal regime, the depth of the material that was recovered below the surface of the ground – EHT subsurface adjustment, and the effects of the Altithermal. Since all the artifacts described and analyzed here for this study are from surface contexts, the only two adjustments that might be relevant for these materials, vis-à-vis Roger's suggested method, are that for surface EHT and for the Altithermal. As was discussed in the text of this paper, it appears based both on empirical evidence and weather station data the EHT estimate for Tulare Lake and the Witt locality may be quite comparable to that of the Ridge-

crest, Inyokern, and the southern Owens Valley areas. The Altithermal correction would appear to be in the range of 9,470 to 9,920 reducing some of our larger hydration readings (>10.0 microns). Coso hydration rims for CB points might average somewhere between 16.0 and 16.7 microns (instead of the uncorrected mean of 16.9 microns) and have a mean calendar age, based on the new Rogers' Coso physical hydration rate formula (formula: $42.14x^2$ = calendar years BP with present = A.D. 2000), in the area of 11,334 cal years BP. The average uncorrected rim range for CB points (combining the statistically indistinguishable Tulare and Coso samples; n = 6 with outliers removed) would be 13.7 to 20.4. Corrected rims with Rogers' new age estimates would be in the range of 12.6 to 19.3 microns and would convert to ages dating from 6,693 to 15,700 years BP. Obviously that initial age estimate and date of 6,700 cal years BP is far too recent and would be on the order of three millennia too recent (3,000 years too young) and the basal date appears to be a bit too ancient by perhaps two millennia (2,000 years too old). To provide a fair assessment of the rate, the uncorrected rim values as high as 18 microns and his data for the 14 to 16 micron range show considerable spread and he opines that his model should only be used with great caution for these exceptionally large readings (see Rogers 2008).

(3) One of the most well known sites for fluted points in all of California is the Borax Lake Site located in the North Coast Range near Clear Lake. It is interesting to note that all the fluted points coming from that site total no more than 20 such finds (White 1999). There seems to be a good indication at that site for an *in situ* development from the fluted Concave Base forms to fluted Borax Lake Widestem points as both exhibit fluting and basal grinding technology. It is unclear whether the fluted points from Borax Lake are more akin to Clovis or rather Folsom technology since the Borax Lake fluted points appear to have flutes that may be longer than those considered to be characteristic of "classic" Clovis points from the interior United States. Consequently, the dating for those points might be slightly later than the recently revised dating for the Clovis expression based on high-resolution radiocarbon dates from classic Clovis sites (Waters and Stafford 2007).

Table 1 **Comparative Hydration Measurements for Coso Obsidian Projectile Points from the Coso Region.**

Projectile Point Type	Number	Range	Spread (microns)	Mean	SD	CV
Desert Series	12	1.2 - 4.7	3.5	3.0	1.2	0.40
Rosegate	20	3.6 - 6.9	3.3	5.2	0.8	0.15
"Wide" Humboldt Basal-notched Bifaces	33	4.7 - 7.7	3.0	6.3	1.0	0.13
Thin Elko	12	6.0 - 9.3	3.3	7.4	1.0	0.13
Thick Elko	8	8.7 - 18.9	10.2	12.3	3.3	0.27
Pinto	12	9.1 - 21.5	12.4	14.2	4.3	0.30
Great Basin Stemmed	21	8.7 - 17.8	9.1	12.9	2.7	0.21
Concave Base	4	13.4 - 21.1	7.0	16.9	3.5	0.21

Projectile Point Type	Mean & SD	Range w/1 SD	Duration	Spread (microns)	Rim Growth yrs/micron	Speed
Desert	3.0 ± 1.2	1.8 - 4.2	550	2.4	229	Very Fast
Rosegate	5.2 ± 0.8	4.4 - 6.0	1,150	1.6	719	Fast
Wide HBN	6.3 ± 1.0	5.3 - 7.3	1,500	2.0	750	Fast
Thin Elko	7.4 ± 1.0	6.4 - 8.4	2,500	2.0	1,250	Slow
Thick Elko	12.3 ± 3.3	9.0 - 15.6	?	6.6	?	?
Pinto	14.2 ± 4.3	9.9 - 18.5	5,000	8.7	575	Fast
GBS	12.9 ± 2.7	10.2 - 15.6	3,000	5.4	555	Fast
CB	16.9 ± 3.5	13.4 - 20.4	3,500	7.0	500	Fast

Note:
SD = Standard Deviation. CV = Coefficient of Variation.
Humboldt Basal-notched Biface measurements abstracted from Garfinkel and Yohe (2005). Other point type data and obsidian hydration measurement metrics from Gilreath and Hildebrandt (1997). Estimated age ranges (calendar years from AD 1950) are: Desert Series, 100 - 650 BP; Rosegate Series, 650 - 1800 BP; Thin Elko, 1,500 - 4,000 BP; Wide Humboldt Basal-notched Bifaces, 950 - 2450 BP; Pinto, 4,000 - 9,000 BP; Great Basin Stemmed (GBS), 8000 - 11,000 BP, and Concave Base (CB), 10,000 - 13,500 BP. Concave Base mean and standard deviation metrics is based on research conducted on the chronological placement of these point forms. This research includes the following studies: Basgall and Hall (2000), Garfinkel and Yohe (2005), Gold (2005), Haynes (2004), Schroth (1994) and Yohe (1992).

Table 2 Comparison of Hydration-Radiocarbon Pairs and Hydration Rate Estimates.

Site	Hydration Mean	C^{14} CalBP	Coso Estimate	Variance
SBR-4966	12.4	8,122	9,003	+881
SBR-4562	12.8	10,769	9,220	-1,549
SBR-5250	14.2	9,328	9,980	+652
SBR-5250	15.4	9,089	10,632	+1,543

Site	Hydration Mean	C^{14} CalBP	Basgall & Hall Estimate	Variance
SBR-4966	12.4	8,122	10,769	+2,647
SBR-4562	12.8	10,769	11,021	+252
SBR-5250	14.2	9,328	13,602	+4,277
SBR-5250	15.4	9,089	14,513	+5,424

Note:
Coso Estimate is based on the Coso hydration rate developed in this paper.
Resulting Basgall and Hall (2000) Coso hydration dating equation radiocarbon dates have been converted to mean calibrated calendar ages. The second column are mean radiocarbon dates calibrated to calendar ages. Obsidian hydration measurements have not been adjusted for any EHT changes between the areas where the Coso rate equation was originally developed and the resulting measurements at Fort Irwin. Some researchers have argued that these hydration measurements should be increased by 10% because of differences in temperature from the southern Owens Valley, Coso Volcanic Field, and Fort Irwin. Were we to adjust the hydration rims accordingly, the disparities between the associated calibrated radiocarbon assays and the resulting dates from the Coso hydration dating equation would show considerably greater variance.

Table 3 EHT for Various California Locations.

Eastern California	EHT	Other Areas	EHT
Bishop	17.0	Cajon Pass	17.8
Haiwee	18.7	Hanford	19.9
Independence	19.1	Fresno	20.5
Inyokern	21.1	Tehachapi	15.5
Lubkin Creek	20.5	Malibu	16.9
Lone Pine	13.5		
Mohave	20.3		
Randsburg	20.4		

Note: EHT estimates after Fredrickson et al. (2006) with the exception of Lubkin Creek. That estimate is from Rogers (2006a) and Fort Irwin is from Gilreath and Hildebrandt (1997).

Table 4 China Lake and Tonopah Lake Paleoindian Artifacts.

Catalog Number	Source	Form	Provenience	Hydration Measurement
	Coso***	Fluted	Tonopah Lake	15.7
A-320	Saline Range Variety 1	Fluted	T. 25 S., R. 40 E., Section 28 A	10.3
UAMS-5	Coso*	Concave Base	T. 25 S., R. 40 E., Section 28 A (Mammoth # 4)	14.8
A-19	Coso*	Concave Base	T. 25 S., R. 40 E., Section 28 A	18.4**
A-512	Unknown	Crescent	T. 25 S., R. 40 E., Section 21	15.4 **
A-45	Unknown	Crescent	T. 25 S., R. 40 E., Section 28 A	No Visible Rims

Note:
* Chemically characterized to source via x-ray fluorescence at Northwest Reasearch Obsidian Laboratories. The Coso source identified is the West Sugarloaf subsource.
** Minimum estimate for highy eroded rim. Original rim would have been larger given age and extent of sand-blasting.
*** Measurement provided in Tuohy (1984, illustration Figure 5m, metrics Table 1).

Table 5 Coso Obsidian Hydration Readings for Concave Base Points from China Lake and the Coso Volcanic Field.

Location	Hydration Measurement (microns)	Number	Mean	Standard Deviation
China Lake*	18.4+, 14.8	N = 2	16.6	2.54
Coso Volcanic Field**	13.4, 21.1	N = 2	17.2	5.44
Range for Total Sample	13.4 - 21.1	N = 4	16.9	3.49

Note:
* Hydration measurements from present study.
** Hydration measurements from Gilreath and Hildebrandt (1997).
Coefficient of variation for total sample is .21.

Table 6 **Lowland Coso Hydration Rate Chronology Comparison.**

Sequence	Rim Measurements (microns)	Time Span (cal BP)	Uncalibrated Radiocarbon Ages (Basgall and Hall 2000 Rate)
Marana	≤ 3.7	< 650	641
Haiwee	3.7 - 4.9	650 - 1,350	641 - 1,316
Newberry	4.9 - 7.6	1,350 - 3,500	1,316 - 3,689
Little Lake	7.6 - 16.0	3,500 - 8,500	3,689 - 13,409
Mohave	16.0 - 21.1	8,500 - 13,500	13,409 - 15,951

Note:
Sequence names as per Bettinger and Taylor (1974). Bracketed rim measurements and time spans as interpreted in Gold (2005) and Garfinkel (2007). Time spans are in calibrated radiocarbon dates or calendar years before present (present = AD 1950). The Basgall and Hall (2000) rate ages are uncalibrated radiocarbon ages and, as such, are not directly comparable. The Basgall and Hall (2000) Coso hydration dating equation provides ages in radiocarbon years before present. When calibrated, these ages are from 2,000 to 4,000 years greater than would be anticipated based on other independent chronological estimates.

Table 7 Casa Diablo Obsidian Hydration Readings for Great Basin Concave Base Points from the Komodo Site (CA-Mno-679) and the Witt Site (CA-Kin-32).

Location	Hydration Measurement (microns)	Number	Mean	Standard Deviation
Komodo	5.5 - 12.2	24	9.1	DM
Witt Site - Tulare Lake	6.1 - 12.1	2	8.9	DM
Range for Total Sample	5.5 - 12.2	26		DM

Note:
Komodo site data from Basgall (1988a).
Standard deviations could not be computed.
DM = data missing

Table 8 Comparison of Coso Obsidian Stemmed Series, Great Basin Concave Base, and Fluted Points.

Location	Hydration Measurement (microns)	Number	Mean	Range	SD
	Great Basin Stemmed Series				
Stahl	9.2, 11.3, 15.5, 15.9	4	13.0	9.2 - 15.9	3.3
Fort Irwin	Raw Data Unavailable	11	13.3	10.0 - 16.9	2.5
Coso Vol. Field	See Gilreath and Hildebrandt 1997	21	12.9	8.7 - 17.8	2.7
Tulare Lake	(6.1), 9.5, 10.0, 11.8/14.6 (6.1/10.4/11.9/12.3)	7	12.9	9.5 - 14.6	1.7
	Concave Base				
China Lake and Coso Vol. Field	13.4, 14.8, 18.4+, 21.1	4	16.9	13.4 - 21.1	3.5
	Concave Base and Fluted				
Tulare Lake	(9.0),(9.1), (11.7/12.7/)/14.0, 19.8	2	16.9	14.0 - 19.8	4.1
Lake Tonopah	15.7	1	15.7	na	na

Table 9 Tulare and China Lake Obsidian Artifacts, Sources, and Hydration Measurements.

Catalog Number	Temporary Catalog No.	Obsidian Source and Artifact Form	Collection Area	Hydration Rims (microns)
		Mt. Hicks		
D411100	WALF2	CB	Tulare Lake	12.9, 6.0[AM]
		Queen		
D41036		CB (bifacially fluted)	Tulare Lake	10.7[AM]
D41179	WALF5 - T16	CB (bifacially fluted)	Tulare Lake	5.5, 6.1, 7.9[AM]
		Mono Glass Mountain		
D41101	WALF3	CB (unifacially fluted)	Tulare Lake	10.8[NW]
		Casa Diablo: Lookout Mountain		
D30950		CB	Tulare Lake	6.1[AM]
DRL5GF5		Eccentric Crescent	Tulare Lake	NVR[NW]/7.6[AM]
DRL6GF8		TLWS	Tulare Lake	NVR[NW]/UNR[AM]
		Casa Diablo: Sawmill Ridge		
D41010		Eccentric Crescent	Tulare Lake	13.5[AM]
D41219		Eccentric Crescent	Tulare Lake	3.7, 11.7[AM]
D41017		Eccentric Crescent	Tulare Lake	10.1[AM]
D30931		Eccentric Crescent	Tulare Lake	10.1[AM]
DRL6GF7		Eccentric Crescent	Tulare Lake	NVR[NW]/11.0[AM]
DRL6GF11		Eccentric Crescent	Tulare Lake	3.5[NW]/10.3[AM]
D41262		CB	Tulare Lake	12.1[AM]
D1552		GBS (Lake Mohave)	Tulare Lake	10.1[AM]
D1047		GBS (Lake Mohave)	Tulare Lake	10.0[AM]
D1019		GBS (Lake Mohave)	Tulare Lake	9.7[AM]
DRL6GF9		TLWS	Tulare Lake	NVR[NW]/11.0[AM]
		Saline Range: Variety 1		
A-320		CB (bifacially fluted)	China Lake	10.3[NW]
		Coso: West Sugarloaf		
D41199	WALF1	CB	Tulare Lake	19.8[NW]
DRL6GF1		CB	Tulare Lake	5.2[NW]/9.1[AM]
DRL6GF2		CB	Tulare Lake	11.7[NW]/12.7, 14.0[AM]
D30943		CB	Tulare Lake	9.0[AM]
A-19		CB (unifacially fluted)	China Lake	18.4[NW]

Table 9 (continued).

UAMS-5		CB	China Lake	14.8[NW]
D31069		GBS (Lake Mohave)	Tulare Lake	14.6, 11.8[AM]
D31068		GBS (Lake Mohave)	Tulare Lake	6.1[NW]
DRL6GF4		GBS (Lake Mohave)	Tulare Lake	NVR[NW]/12.3[AM]
DRL6GF10		GBS (Silver Lake)	Tulare Lake	6.1[NW]/10.4, 11.9[AM]
D1150		GBS (Lake Mohave)	Tulare Lake	10.0[AM]
D31063		GBS (Lake Mohave)	Tulare Lake	9.5[NW]
D21528		Eccentric Crescent	Tulare Lake	8.1[NW]
L10874		Eccentric Crescent	Tulare Lake	11.7[AM]
D31023		Eccentric Crescent	Tulare Lake	7.9[NW]
D31086		Lunate Crescent	Tulare Lake	6.1[AM]
		Unknown Source		
A-512		Lunate Crescent	China Lake	15.4[NW]
A-45		Crescent-shaped Item	China Lake	NVR[NW]
		Napa Valley		
D41272	WALF4 - T8	CB	Tulare Lake	8.4[AM]

Note: [AM] = ArchaeoMetrics Laboratory obsidian hydration measurements completed by Tim Carpenter.
[NW] = Northwest Research Obsidian Studies Laboratory hydration measurements completed by Craig Skinner.

Key: CB = Concave Base point, GBS = Great Basin Stemmed point, TLWS = Tulare Lake Widestem point, NVR = No Visible Rims, UNR = Unreadable.

REFERENCES CITED

Arnold, Jeanne E., Michael R. Walsh, and Sandra E. Hollimon
2004 The Archaeology of California. *Journal of Archaeological Research* 12(1):1-73.

Basgall, Mark E.
1987 Paleoindian Occupation in Central Eastern California: The Komodo Site. *Current Research in the Pleistocene* 4:50-54.
1988 The Archaeology of CA-Mno-679: A Pre-Archaic Site in Long Valley Caldera, Mono County, California. *In* Early Human Occupation in Far Western North America: The Clovis-Archaic Interface. Edited by Judith A. Willig, C. Melvin Aikens, and John L. Fagan, pp. 103-120. *Nevada State Museum Anthropological Papers* 21.
1990 Hydration Dating of Coso Obsidian: Problems and Prospects. Paper presented at the 24th Annual Meeting of the Society for California Archaeology, Foster City.
1993 *Early Holocene Prehistory of the North Central Mojave Desert*. Ph.D. dissertation. Department of Anthropology, University of California, Davis.
2003 Revisiting the Late-Pleistocene/Early Holocene Archaeology of Pleistocene Lake China and the CRBR Locality. *Current Research in the Pleistocene* 20:3-5.
2004 The Archaeology of Charlie Range Basalt Ridge: An Initial Assessment of CA-INY-5825 Locality, Naval Air Weapons Station, China Lake, Inyo County, California. *Archaeological Research Center Technical Report* 04-82, California State University, Sacramento.
2005a Another Look at the Ancient Californians: Resurvey of the Emma Lou Davis Stakes and Reassessment of Collections, Naval Air Weapons Station, China Lake, Kern County, California. *Archaeological Research Center Technical Report* 05-95, California State University, Sacramento.
2005b Revisiting the Late-Pleistocene/Early Holocene Archaeology of Pleistocene Lake China and the CRBR Locality. *Current Research in the Pleistocene* 20:3-5.
2007 Prehistoric People in an Evolving Landscape. A Sample Survey of the Lake China Basin and its Implications for Paleoindian Land Use. *Archaeological Research Center Technical Report* 06-116, Department of Anthropology, California State University, Sacramento.

Basgall, Mark E., and Mark Giambastiani
1995 Prehistoric Use of a Marginal Environment: Continuity and Change in Occupation of the Volcanic Tablelands, Mono and Inyo Counties, California. *Center for Archaeological Research at Davis Publication* 12.

Basgall, Mark E. and Matthew C. Hall
1991 Relationships Between Fluted and Stemmed Points in the Mojave Desert. *Current Research in the Pleistocene* 8:61-64.
1992 Archaeology of the Awl Site (CA-SBR-4562), Fort Irwin, San Bernardino County, California: An Early Holocene Residential Base in the North-Central Mojave Desert. Report on file with the Eastern California Information Center, Department of Anthropology, University of California, Riverside.
2000 Morphological and Temporal Variation in Bifurcate-Stemmed Dart Points of the Western Great Basin. *Journal of California and Great Basin Anthropology* 22(2):237-276.

Beck, Charlotte and George T. Jones
1997 The Terminal Pleistocene/Early Holocene Archaeology of the Great Basin. *Journal of World Prehistory* 11(2):161-236.

Bettinger, Robert L. and R. E. Taylor
1974 Suggested Revisions in Archaeological Sequences of the Great Basin in Interior Southern California. *Nevada Archaeological Survey Research Paper* 5:1-26.

Blalock, J. M.
1979 *Social Statistics*. 2nd Edition. New York: McGraw Hill Company.

Borden, Ferris
1971 The Use of Surface Erosion Observations to Determine Chronological Sequence in Artifacts from a Mojave Desert Site. *Archaeological Survey Association of Southern California Paper* 7.

Byrd, Brian F.
2006 Volume 1: Report and Appendices A-E. Archaeological Survey of 2,760 Acres of Target Buffer Zones in the Baker, Charlie, and George Ranges, NAWS China Lake, Inyo and Kern Counties, California. On file with the Southern San Joaquin Valley Information Center, California State University, Bakersfield. Report KE 03351.

Clewlow, C. William, Jr.
1968 Surface Archaeology of the Black Rock Desert, Nevada. *University of California Archaeological Survey Reports* 73:1-94.

Davis, Emma Lou
1964 An Archaeological Survey of the Mono Lake Basin and Excavations of Two Rockshelters, Mono Lake, California. *Archaeological Survey Annual Report* 1963-64, pp. 251-392. University of California, Los Angeles.
1974 PaleoIndian Land Use Patterns at China Lake, California. *Pacific Coast Archaeological Society Quarterly* 10(2):1-16.
1975 The "Exposed Archaeology" of China Lake, California. *American Antiquity* 40(1):39-53.
1978 The Ancient Californians: Rancholabrean Hunters of the Mojave Lakes Country. Natural History Museum of Los Angeles County, *Science Series* 29.

Davis, Emma Lou and Richard Shutler, Jr.
1969 Recent Discoveries of Fluted Points in California and Nevada. *Nevada State Museum Anthropological Papers* 14:154-177.

Delacorte, Michael
1999 The Changing Role of Riverine Environments in the Prehistory of the Central-Western Great Basin: Data Recovery Excavations at Six Prehistoric Sites in Owens Valley, California. Report on file at California Department of Transportation, District 09, Bishop.

Dillon, Brian D.
2002 California PalaeoIndians: Lack of Evidence, or Evidence of a Lack? *In* Essays in California Archaeology: A Memorial to Franklin Fenenga, edited by W. J. Wallace and F. A. Riddell, pp. 25-54. *Contributions of the University of California Archaeological Research Facility* 60. Berkeley.

Eerkens, Jelmer W. and Jerome H King
2002 Phase II Archaeological Investigations for the Sherwin Summit Rehabilitation Project, US. Highway 395, Inyo and Mono Counties, California. Report on file, California Department of Transportation, District 09, Bishop.

Ericson, Jon E.
1977 *Prehistoric Exchange Systems in California: The Results of Obsidian Dating and Tracing*. Ph.D. Dissertation, Department of Anthropology, University of California, Los Angeles.

Erlandson, Jon M., Torben C. Rick, Terry L. Jones, and Judith F. Porcasi
2007 One If by Land. Two If by Sea: Who were the First Californians? In *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, pp. 53-62. AltaMira Press, Lanham, Maryland.

Fagan, John L.
1975 A Supposed Fluted Point form Fort Rock Cave, An Error of Identification and Its Consequences. *American Antiquity* 40: 356-357.

Fiedel, Stuart J.
1999 Older Than We Thought: Implications for Corrected Dates for Paleoindians. *American Antiquity* 64(1):95-115.

Fredrickson, David A., Janine Loyd, Ted Jones, Sueann Schroder and Thomas Origer
2003 The Coso–Casa Diablo Hydration Conundrum. *Proceedings of the Society for California Archaeology* 19:151-156.

Fredrickson, David A. and Joel Grossman
1977 A San Dieguito Component at Buena Vista Lake, California. *The Journal of California Anthropology* 4(2):173-190.

Garfinkel, Alan P.
2007 Archaeology and Rock Art in the Eastern Sierra and Great Basin Frontier. *Maturango Museum Publication* 22. Maturango Museum Press, Ridgecrest, California.

Garfinkel, Alan P. and Robert M. Yohe, II
2005 Antiquity and Function: Humboldt Basal-notched Bifaces in the Southwestern Great Basin. *Journal of California and Great Basin Anthropology* 24(1):103-105.

Gilreath, Amy J. and William R. Hildebrandt
1997 Prehistoric Use of the Coso Volcanic Field. *Contributions of the University of California Archaeological Research Facility* 56. University of California, Berkeley

Gilreath, Amy J. and Kimberly Holanda
2000 By the Lake By the Mountains: Archaeological Investigations at CA-INY-4554 and CA-INY-1428. Report on file, California Department of Transportation, District 9, Bishop.

Glennan, William S.
1971 Concave-based Lanceolate Fluted Projectile Points from California. *The Masterkey* 45(1):27-32.

Goebel, Ted, Brian Hockett, Keith Graf, and David Rhode
2003 Bonneville Estates Rockshelter, Nevada. Paper presented at the 30th Annual Great Basin Conference, Las Vegas, Nevada.

Gold, Alan P.
2005 *Linguistic Archaeology: Prehistoric Population Movements and Cultural Identity in the Southwestern Great Basin and far southern Sierra Nevada*. Ph.D. dissertation, Department of Prehistoric Forager Ecology, University of California, Davis.

Halford, F. Kirk
1998 *Archaeology and Environment on the Dry Lakes Plateau, Bodie Hills, California: Hunter-Gatherer Coping Strategies for Holocene Environmental Variability*. M.A. Thesis, Department of Anthropology, University of Nevada, Reno.
2001 New Evidence for Early Holocene Acquisition and Production of Bodie Hills Obsidian. *Society for California Archaeology Newsletter* 35(1):32-37.

Hall, Matthew C.
1991 Early Holocene Archaeological Sites in the Mono Basin, East-Central California/Southwestern Nevada. *Current Research in the Pleistocene* 8.
1992 Final Report on the Archaeology of the Tiefort Basin, Fort Irwin, San Bernardino County, California. Report on file with the Eastern California Information Center, Department of Anthropology, University of California, Riverside.

Hall, Matthew C. and Robert J. Jackson
1989 Obsidian Hydration Rates in California. *In* Current Directions in California Obsidian Studies, R. E. Hughes, editor, pp. 31-58. *Contributions of the University of California Archaeological Research Facility* 48. University of California, Berkeley.

Hartzell, Leslie. L.
1992 *Hunter-Gatherer Adaptive Strategies and Lacustrine Environments in the Buena Vista Lake Basin, Kern County, California*. Ph.D. dissertation. Department of Anthropology, University of California, Davis.

Haynes, Gregory M.
2004 An Evaluation of the Chronological Relationships Between Great Basin Stemmed and Pinto Series Projectile Points in the Mojave Desert. *In* The Human Journey and Ancient Life in California Deserts, Proceedings from the 2001 Millennium Conference. Mark W. Allen and Judith M. Reed, eds., pp. 117-128. *Maturango Museum Publication* 15, Ridgecrest, California.

Heizer, Robert F. and Thomas R. Hester
1978 Great Basin Projectile Points: Forms and Chronology. *Ballena Press Publications in Archaeology, Ethnology, and History* 10.

Jackson, Robert J.
1985 An Archaeological Survey of the Wet, Antelope, Railroad, and Ford Timber Sale Compartments in the Inyo National Forest. Report on file, United States Forest Service, Inyo National Forest, Bishop.

Jennings, Jesse D.
1986 Prehistory: Introduction. *Handbook of North American Indians, Volume 11. Great Basin*, edited by Warren L. d'Azevedo. Smithsonian Institution, Washington, D.C.

Johnston, Sarah, Jeanne Day Binning, and Alan P. Garfinkel
2007 A Clovis Point from the High Sierra, Fresno County, California. *Current Research in the Pleistocene*, in press.

Jones, George T., Charlotte Beck, E. E. Jones, and Richard E. Hughes
2003 Lithic Source Use and Paleoarchaic Foraging Territories in the Great Basin. *American Antiquity* 68:5-38.

Justice, Noel D.
1999 *Stone Age Spear and Arrow Points of California and the Great Basin*. Indiana University Press, Bloomington.

King, Jerome
2000 Re-examining Coso Obsidian Hydration Rates. Paper presented at the Society for California Archaeology Meeting, Riverside.

Layton, Thomas N.
1972a Lithic Chronology in the Fort Rock Valley, Oregon. *Tebiwa* 15(2):1-21.
1972b A 12,000 Year Obsidian Hydration Record of Occupation, Abandonment, and Lithic Change from the Northwestern Great Basin. *Tebiwa* 15(2):22-29.

Lee, R.
1968 Chemical Temperature Integration. *Journal of Applied Meteorology* 8:423-430

Meighan, Clement W.
1981 The Little Lake Site, Pinto Points, and Obsidian Hydration in the Great Basin. *Journal of California and Great Basin Anthropology* 3(2):200-214.

Meighan, Clement W. and C. Vance Haynes
1968 New Studies on the Age of the Borax Lake Site. *The Masterkey* 42(1).
1970 The Borax Lake Site Revisited. *Science* 167:1213-1221.

Moratto, Michael J.
2000 Fluted Points in California: What Do They Mean? Paper presented at the Annual Meetings of the Society for California Archaeology, Riverside, California.

Moratto, Michael J. and Joseph L. Chartkoff
2007 Archaeological Progress since 1984. In *California Prehistory: Colonization, Culture and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, pp. 1-10. AltaMira Press, Lanham, Maryland.

Onken, Jill A.
2001 Chronosequencing. In Metropolitan Water District of Southern California, Eastside Reservoir Project, Final Report of Archaeological Investigations, Volume 4 by Applied Earthworks, Inc., pp. 91-136. Report on file Eastern Information Center, Department of Anthropology, University of California, Riverside.

Origer, Thomas M.
1982 *Temporal Control in the Southern North Coast Ranges of California: the Application of Obsidian Hydration Analysis*. Master's thesis, Department of Anthropology, San Francisco State University, San Francisco.

Overly, Stephen A.
2003 Obsidian Studies. In Phase II Evaluations at Nine Archaeological Sites Near Independence, Inyo County, California by Mark Basgall and Michael Delacorte. Report on file with the Eastern Information Center, University of California, Riverside.

Pearson, James L.
1995 *Prehistoric Occupation at Little Lake, Inyo County, California: A Definitive Chronology*. M.A. thesis, Department of Anthropology, Loyola University of Los Angeles.

Pendleton, Loranne S.
1979 *Lithic Technology in Early Nevada Assemblages*. Master's thesis, Department of Anthropology, California State University, Long Beach.

Riddell, Francis A. and William H. Olsen
1969 An Early Man Site in the San Joaquin Valley, California. *American Antiquity* 61(1):136-148.

Rogers, Alexander K.
2006a An Improved Method for Computing Effective Hydration Temperature of Obsidian. *Society for California Archaeology Newsletter* 40(2):35-41.
2006b Coso Obsidian Hydration Rates Revisited: A Reanalysis With Improved EHT Algorithm. Maturango Museum Working Manuscript #9, dated 8 September 2006. Report on file, Maturango Museum, Ridgecrest, California.
2007a Effective Hydration Temperature of Obsidian: A Diffusion-Theory Analysis of Time Dependent Hydration Rates. *Journal of Archaeological Science* 34:656-665.
2007b A Tale of Two Gophers: Depth Correction for Obsidian Effective Hydration Temperature in the Presence of Site Turbation Effects. *International Association of Obsidian Bulletin*, Summer 2007.
2008 An Improved Evaluation of Coso Obsidian Hydration Rate, Based on the Weighted Total Least Squares Algorithm Applied to Obsidian-Radiocarbon Pairings. *Pacific Coast Archaeological Society Quarterly*. To be submitted.

Rondeau, Michael F.

2005a A Summary of Analysis for Projectile Points from Tulare Lake, California. CalFluted Research Report No. 10. On file Rondeau Archaeological, Sacramento, California.

2005b Revising the Number of Reported Clovis Points from Tulare Lake, California. *Current Research in the Pleistocene* 23:140-142.

Rondeau, Michael, Jim Cassidy and Terry L. Jones

2007 Colonization Technologies: Fluted Projectile Points and the San Clemente Island Woodworking/Microblade Complex. In *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, pp. 63-70. Altamira Press, New York.

Rosenthal, Jeffrey S.

2005 Chronology: Worsaae's Law and Obsidian Hydration Dating – An Evaluation of the Method. *In* Lithic Production and Craft Specialization in the Middle Period: Data Recovery Excavation at CA-NAP-172, by Kim Carpenter and Pat Mikkelsen, pp. 66-75. On file at Far Western Anthropological Research Group, Davis, California.

Rosenthal, Jeffrey S., Kimberly L. Carpenter, and D. Craig Young, Jr.

2001 Archaeological Survey of Target Area Buffer Zones in the Airport Lake, Baker, and George Ranges, Naval Air Weapons Station, China Lake, Inyo and Kern, Counties, California. Report on file, Southwest Division, Naval Facilities Engineering Command, San Diego, California.

Schroth, Adella B.

1994 *The Pinto Point Controversy in the Western United States*. Ph.D. dissertation, Department of Anthropology, University of California, Riverside.

Sutton, Mark Q. and Philip J. Wilke

1984 New Observations on a Clovis Point from the Central Mojave Desert, California. *Journal of California and Great Basin Anthropology* 6(1):113-115.

Tuohy, Donald R.

1969 Appendix to Recent Discoveries of Fluted Points in California and Nevada. *Nevada State Museum Anthropological Papers* 14:170-177.

1984 Implications of Obsidian Hydration Readings and Source Determinations for 28 "Early Man" Points from Nevada. *In* Obsidian Studies in the Great Basin, edited by Richard E. Hughes, pp. 193-221. *Contributions of the University of California Archaeological Research Facility* 45.

Wallace, William J.

1991 Tulare Lake's Archaeological Past. In *Contributions to Tulare Lake Archaeology I: Background to a Study of Tulare Lake's Archaeological Past*, William J. Wallace and Francis A. Riddell, eds., pp. 23-33. The Tulare Lake Archaeological Research Group, Redondo Beach.

Warren, Claude N. and H. Thomas Ore

2006 Data Recovery at Pleistocene Lake Mojave: Sites CA-SBR-140, CA-SBR-6566, CA-SBR-264. Report on file at the Southern San Joaquin Valley Information Center, Report KE-2946.

Warren, Claude N. and Carl Phagan

1988 Fluted Points in the Mojave Desert: Their Technology and Cultural Context. *In* Early Human Occupation in Far Western North America: The Clovis-Archaic Interface, C. Melvin Aikens, Judith A. Willig, and John L. Fagan, editors, pp. 121-130. *Nevada State Museum Anthropological Papers* 21.

Waters, Michael R. and Thomas W. Stafford Jr.

2007 Redefining the Age of Clovis: Implications for the Peopling of the Americas. *Science* 315:1122-1126.

West, G. James, Owen K. Davis and William J. Wallace

1991 Fluted Points at Tulare Lake, California: Environmental Background, In *Contributions to Tulare Lake Archaeology 1: Background to a Study of Tulare Lake's Archaeological Past*, William J. Wallace and Francis A. Riddell, editors, pp. 1-10. Tulare Lake Archaeological Research Group, Redondo Beach.

White, Greg (editor)

2002 Cultural Diversity and Culture Change in Prehistoric Clear Lake Basin: Final Report of the Anderson Flat Project. *Center for Archaeological Research at Davis Publication* 13.

Willig, Judith A., C. Melvin Aikens, and John L. Fagan (eds.)
1988 Early Human Occupation in Far Western North America: The Clovis-Archaic Interface. *Nevada State Museum Anthropological Papers* 21.

Wilke, Phillip J
1991 Lanceolate Projectile Points from Tulare Lake, California: Environmental Background, In *Contributions to Tulare Lake Archaeology 1: Background to a Study of Tulare Lake's Archaeological Past*, William J. Wallace and Francis A. Riddell, Editors, pp. 41-52. The Tulare Lake Archaeological Research Group, Redondo Beach.

Yohe, Robert M., II
1992 *A Reevaluation of Western Great Basin Cultural Chronology and Evidence for the Timing of the Introduction of the Bow and Arrow to Eastern California Based on New Excavations at the Rose Spring Site (CA-Iny-372)*. Ph.D. dissertation, Anthropology Department, University of California, Riverside.

Zimmerman, Kelly L., Catherine Lewis Pruett, and Mark Q. Sutton
1989 A Clovis-like Point from the Southern Sierra Nevada, California. *Journal of California and Great Basin Anthropology* 11(1):89-90.