ASSESSING THE MAGNITUDE OF HYDRATION CHRONOLOGY ERROR FOR COSO OBSIDIAN IN WESTERN INYO COUNTY

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What accuracy and precision should be attributed to obsidian hydration measurements as chronological estimates? An attempt is made to assess the magnitude of error in individual dates, on the basis of (a) hydration readings on Elko, Rose Spring, and Desert-series points from western Inyo County sites, (b) conventional Newberry, Haiwee, and Marana time-period divisions, (c) Basgall's 1988 conversion formula for Coso hydration, and (d) a statistical computer simulation. Also considered are different ways of expressing that error – as plus or minus so many years of age or microns of hydration, or a percentage of years or microns.

Obsidian hydration is well-accepted as a standard tool for archaeologists working in many parts of California, and particularly in the Inyo-Mono region. It is generally also recognized that there are limits to the accuracy or precision that can be expected in individual age estimates based on hydration. But little attention has been given to pinning down the size of the overall error factor in hydration dates. The magnitude of this error has important implications, both in deciding whether or not to use hydration to address particular research problems, and in correctly interpreting hydration results.

The total amount of uncontrolled error in hydration dates could be estimated in several different ways, each with its particular strengths and limitations. One approach would be to consider the discrepancies between radiocarbon dates and associated hydration dates. Another would be to quantify the amount of variability in hydration readings from a single-event archaeological assemblage.

The approach discussed here is based on chronologically-sensitive projectile point types. Specifically, this paper considers hydration readings on Elko, Rose Spring, and Desert-series points which were made from Coso obsidian and which have been recovered from relatively low-elevation sites in western Inyo County. Hydration error is estimated from the extent to which those readings, when they are converted to chronological ages (based on Basgall's 1988 formula), depart from expectations based on the commonly-accepted chronological ranges for the point types. A computer program is used to simulate expected distributions of hydration readings, based on variable assumptions about the size and the form of the error factor.

It should be stressed that what is estimated here is not the fundamental error which may be inherent in hydration. It is conceivable that refinements in the ways hydration is measured and interpreted could reduce very substantially the error in hydration dates. Be that as it may, what is addressed in this paper is the uncontrolled error in hydration chronology as it is actually being applied today.

Uncontrolled error is probably a composite product of a number of different factors. These may include (a) randomness in the physical process of hydration; (b) diffuse, blurry, or irregular hydration fronts, or a variable relationship between birefringence lines and hydration fronts; (c) random or systematic laboratory errors in hydration readings; (d) inter- and intra-source chemical and physical variability in obsidian; (e) variability in postdepositional temperature histories and other environmental factors; (f) incorrect matching between the measured surfaces and the dating objectives; and (g) non-optimal conversion formulas. In this study, only two of the factors have been controlled: the general material source (Coso), and regional setting (low-elevation western Inyo County), taken to be a proxy for general postdepositional temperature history. The other factors have been accepted as uncontrolled, as they normally are in actual applications of hydration chronology.

Several other underlying assumptions of the study should also be noted. First, each point type is assumed to have been produced exclusively within its specified period. Overlapping time ranges for the types could reduce the error factor, or perhaps even eliminate it entirely, if the overlaps were assumed to have been extreme enough. Second, point production represented in the sample is assumed to have occurred at random frequency throughout each time period. If production were concentrated near the end-points of a period, the size of the error would be overestimated by this method. If it were concentrated in the middle of the period, the error would be underestimated. Also, for mathematical convenience, error has been assumed to be normally distributed. In actuality, the evidence indicates that error is both more systematically skewed and more erratic than that. And finally, it is assumed that the samples have not been biased by any exclusion of anomalous readings. If any such readings have been screened out, the error factor may be significantly underestimated.

The sample consists of hydration readings on 40 Elko-series points, 99 Rose Spring or Saratoga Spring points, and 97 Desert-series points (Table1 & Figure 1). Each reading has been converted to a date expressed in years B.P. using Basgall's 1988 formula, and the proportions of readings for each point series which fall before the beginning point or after the end point for that series have been noted. A computer program has been used to simulate hydration readings on a corresponding number of points produced at random dates during each of the three periods. Random, normally-distributed errors have then been added to or subtracted from each reading, with the standard deviation for this error factor being varied until the frequencies of out-of-period readings in multiple runs of simulated data most nearly matched those in the actual data.

One complication is that there are several ways in which the error factor can be modeled mathematically. Because uncontrolled error is probably a composite product of several quite different factors, as noted above, it may well be a mathematical hybrid, not matching any of the simple models very exactly. Four ways of expressing the error have been considered, and an evaluation has been made of their relative effectiveness in matching the observed patterns of error. One way of expressing error is as plus or minus so many years from the actual date. This would produce a pattern of errors which would be symmetrically distributed and independent of age. The other three methods express error as plus or minus so many microns, plus or minus such-and-such a percentage of the age, and plus or minus such-and-such a percentage of the hydration reading. These latter three types of errors would produce patterns which, translated into years, would be asymmetrical and have larger errors on older specimens. With Basgall's Coso formula, this skewing is less extreme for an error expressed as plus or minus so many microns than for one expressed as plus or minus a percentage of either years or microns.

The observed degree of asymmetry in the errors is most consistent with the model of error expressed as plus or minus so many microns. Error expressed as plus or minus so many years works the least well among the four models considered. The actual proportion of wrong-period dates increases steadily with age, from 34% for Desert-series points, to 45% for Rose Spring/Saratoga Spring, to 55% for Elko. For each of the three periods, overestimates of age strongly outnumber underestimates. However, the skewing toward greater errors for earlier periods is somewhat less than would be predicted by a model of error as a percentage of either age or hydration.

Table 1. Sources of hydration readings on typed projectile points

Source	Elko Series	Rose Spring/ Sarasota Sprngs	Desert Springs
Basgall andMcGuire 1988	3	14	45
Delacorte 1999	-	9	2
Delacorte and McGuire 1993	9	14	14
Eerkens 2000	-	17	-
Gilreath 1995	-	12	20
Gilreath and Hildebrand 1997	25	27	13
Yohe 19988	3	6	2

The size of the error factor was found to be best modeled in the simulation by a standard deviation of about ± 0.9 µm (Table 2). This seems to be a reasonable working estimate of the present level of accuracy under the given conditions (for Coso obsidian in western Inyo County, using the Basgall 1988 formula). For comparison, this is roughly the same level of resolution that is provided by projectile point types in the conventional regional chronology. It is possible to sharpen the resolution of a hydration date by combining a suite of hydration readings. However, this is valid only if all the readings can legitimately be taken to refer to the same point in time.

The potential for recognizing the presence or absence of multiple components within a site deposit is similarly constrained by this resolution. For instance, with a reasonably large hydration sample, it may be possible to establish the presence of separate Haiwee and Marana components within an assemblage, but it is unlikely that the presence of separate early and late Haiwee components will be either recognized or ruled out.

It will continue to be important to test the results obtained in hydration chronology, in order to establish what the size of the residual error factor really is at any given stage in the refinement of the method. One way this can be done is through amplifying and refining the set of readings on typed projectile points. Another is to give a higher priority to identifying and analyzing single-event obsidian debitage assemblages, which are often neglected as potential archaeological resources.

Table 2. Estimates of the best matches between actual and simulated data

Form of Error Factor	Size of Error	2â (95% probability) ranges for 2.0 µm	2â (95% probability) ranges for 6.0 µm	Comments
Years of age	± 400 yrs	0 - 958 BP	1220 - 2820 BP	poorest match
Percents of age	± 60 %	0 - 347 BP	0 - 4444 BP	--
Microns of hydration	± 0.9 µm	1 - 700 BP	883 - 3712 BP	best match
Percent of microns	± 30 %	19 - 470 BP	241 - 6009 BP	--

CONCLUSION

Use of obsidian hydration should be conditioned by its resolution. On the one hand, exaggerated claims for the accuracy and precision of hydration dates should be avoided. On the other hand, the method should not be dismissed or neglected when the available level of resolution is sufficient to effectively address significant research issues.

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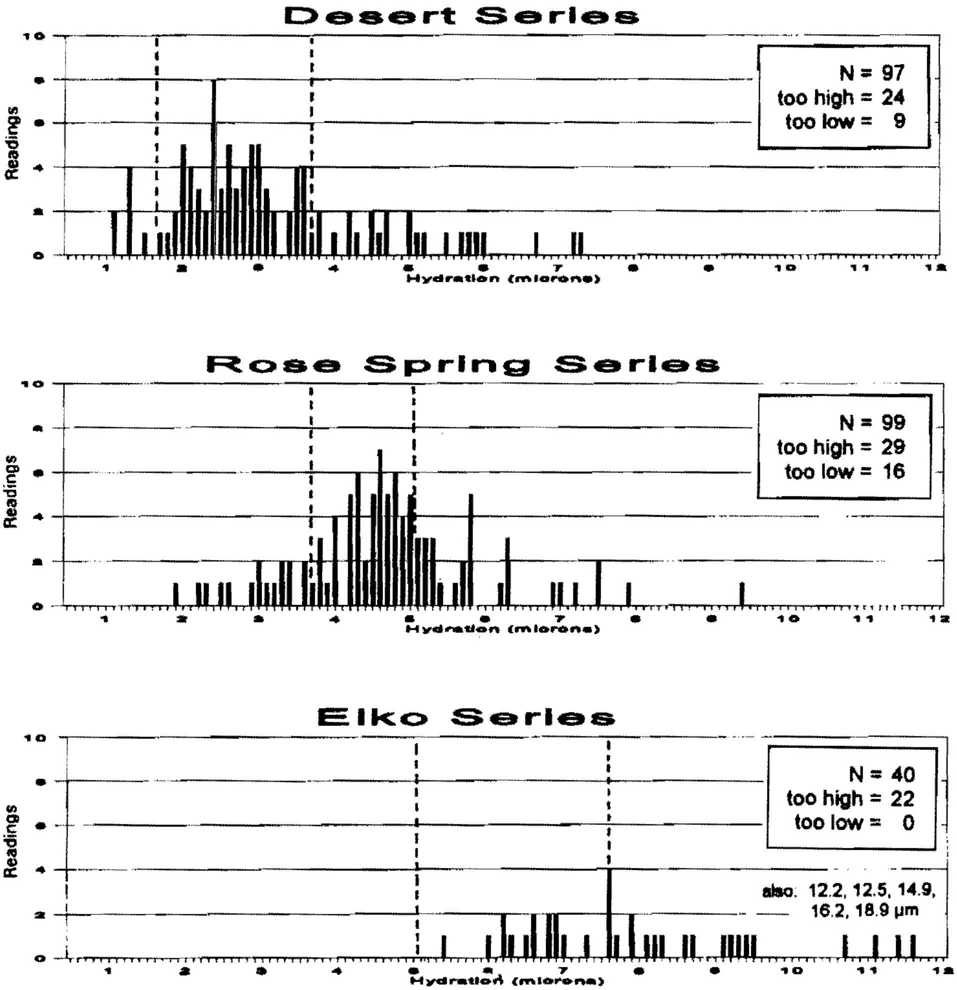

$Y = 31.62\ X^{2.32}$:

100 BP =	1.64 µm
650 BP =	3.68 µm
1350 BP =	5.04 µm
3500 BP =	7.60 µm

Figure 1. Hydration readings on typed projectile points.