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International Association for Obsidian Studies

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NEWS AND INFORMATION

We regret to announce that Lisa Swillinger passed away in the summer of 2006. Lisa was IAOS Secretary/Treasurer 1990-1993 and worked with Blossom Hamusek on the *Bulletin* 1994-1995. Her Master's thesis was on intersource variability in the Borax Lake obsidian source. Please see page 2 of the *Bulletin* for her full obituary. Thanks to Tom Origer and Janine Loyd for providing this information.

CONSIDER PUBLISHING IN THE IAOS *BULLETIN*

The *Bulletin* is a twice-yearly publication that reaches a wide audience in the obsidian community. Please review your research notes and consider submitting an article, research update, or lab report for publication in the IAOS B*ulletin*! Articles and inquiries can be sent to cdillian@princeton.edu Thank you for your help and support!

CALL FOR PAPERS

The International Association for Obsidian Studies (IAOS) is organizing a session for next year's Society for American Archaeology (SAA) annual meeting, March 26-30, in Vancouver, Canada. While the deadline for submissions is not until September, we would like at least a simple response indicating your potential interest, by June 30, so that the session(s) would be well-organized. After that, a title and 100-word abstract would be required along with conference pre-registration. So please let us know if you would be interested in participating. See the formal announcement on page 16 of this issue of the *Bulletin.*

For more information, please contact Robert Tykot at rtykot@cas.usf.edu

NOTES FROM THE PRESIDENT

Greetings! I am pleased to be involved with IAOS during this time of momentum in the organization. Outgoing president Phil LeTourneau has provided excellent leadership during the past two years, and as IAOS vice president he will continue to play a much-needed role. Secretary-Treasurer Colby Phillips and Phil have done a great job in streamlining the membership process and organizing the IAOS files and financial records. And the *Bulletin* has blossomed into a polished and informative source for obsidian studies news and research under Carolyn Dillian's skillful editorship.

Discussion at the IAOS annual meeting in Austin, Texas this April focused on proposed changes to the schedule of the membership year, use of the IAOS member email list, and plans for IAOS-sponsored events at the Society for American Archaeology annual meetings next year in Vancouver. Please make note that the IAOS membership schedule will transition from a rolling membership to one tied to the calendar year. Questions concerning how the membership email list could be used for announcements of interest to members but not directly tied to official IAOS activities or events led to the decision to allow members to opt out of such applications of the emailing list. Keep an eye out for an email from me asking your preference as a member, or feel free to contact me directly.

For the SAA meetings next year we are planning two events: a symposium and a workshop. Rob Tykot is organizing the symposium; the call-for-papers can be found in this issue of the Bulletin. The second event, entitled "Workshop on the Sourcing and Dating of Obsidian: Updates on X-ray Fluorescence and Surface Analysis Methods" was first suggested at last year's IAOS annual meeting as a ten-year follow-up the IAOS obsidian studies workshop held in Seattle in 1998. The 2008 workshop is being organized by Chris Stevenson and Mike Glascock; look for more information on the workshop in the next issue of the Bulletin.

We are continuing to accept nominations for the student conference paper awards. Please send your nominees for obsidian-related papers or posters to me. What else can you do to help the IAOS expand and improve? Send papers, research notes, and articles to Carolyn Dillian, *Bulletin* Editor, at cdillian@princeton.edu to share your research and promote dialogue. Distribute IAOS fliers at your department, office, organization, or field camp. Forward this *Bulletin* to colleagues who may be interested. Send ideas, suggestions, or comments to me for how we can expand or improve the IAOS, further its mission, increase inter-disciplinary involvement and dialogue, add venues for communication and interchange, or increase opportunities to respond to the interests and assist in the needs of students, researchers, and cultural resource managers who are not obsidian specialists. Finally, visit the IAOS website at http://www.peak.org/obsidian. Our excellent webmaster, Craig Skinner, is continually adding and updating—likely there is something new since your last visit.

Sincerely,
Ana Steffen
asteffen@unm.edu
asteffen@vallescaldera.gov

LISA SWILLINGER

Lisa Swillinger of Chico, CA, passed away at her residence on July 8, 2006 at the age of 49. Born Sept. 13, 1956, in San Francisco, Lisa grew up in Stockton, CA. She attended Amos Alonzo Stagg High School, where she was active in dramatics - both at Stagg and at other Stockton community theaters - before graduating with the class of 1974. She received her Masters degree in anthropology from California State University, Chico. She later became coordinator at the university-based Northeast Information Center, an archaeological clearinghouse for the state of California. Most recently she held a position with Butte County's Search Program. Her life's pleasures were people, animals, music and drama. The beloved daughter of the late Margery Swillinger, Lisa is survived by her father and his wife, Edwin and Rosemary Swillinger of Stockton; her brother Timothy Swillinger and his wife Lisa Mandelbaum of El Granada; her sister Mrs. Rebecca S. Shelley of Eugene, OR; and her sister Heidi Swillinger and partner Gregory Glover of Berkeley. The family requests that memorial donations be made to: Butte County Dept. of Behavioral Health (Search Program), 109 Parmac Road, Suite 9, Chico, CA 95926.

WDXRF Spectroscopy of Obsidian Tools in the Northwest of Iran

Farhang Khademi Nadooshan, Associate Professor, Department of Archaeology, Tarbiat Modares University, Tehran, Iran
S. Colby Phillips, Department of Anthropology, University of Washington, Seattle, USA
Mohammad Safari, Head of XRF Laboratory, Faculty of Basic Sciences, Tarbiat Modares University, Tehran Iran

Abstract:
Obsidian tools recovered from several newly discovered Neolithic and Chalcolithic sites in Iran have shed new light on the paleoeconomy of the region, including prehistoric trade networks. Obsidian from these sites is shown to have been procured and used locally, as opposed to being obtained from more distant sources in Anatolia and Armenia.

Key words: Trades, Prehistory, Iran, Obsidian, WDXRF

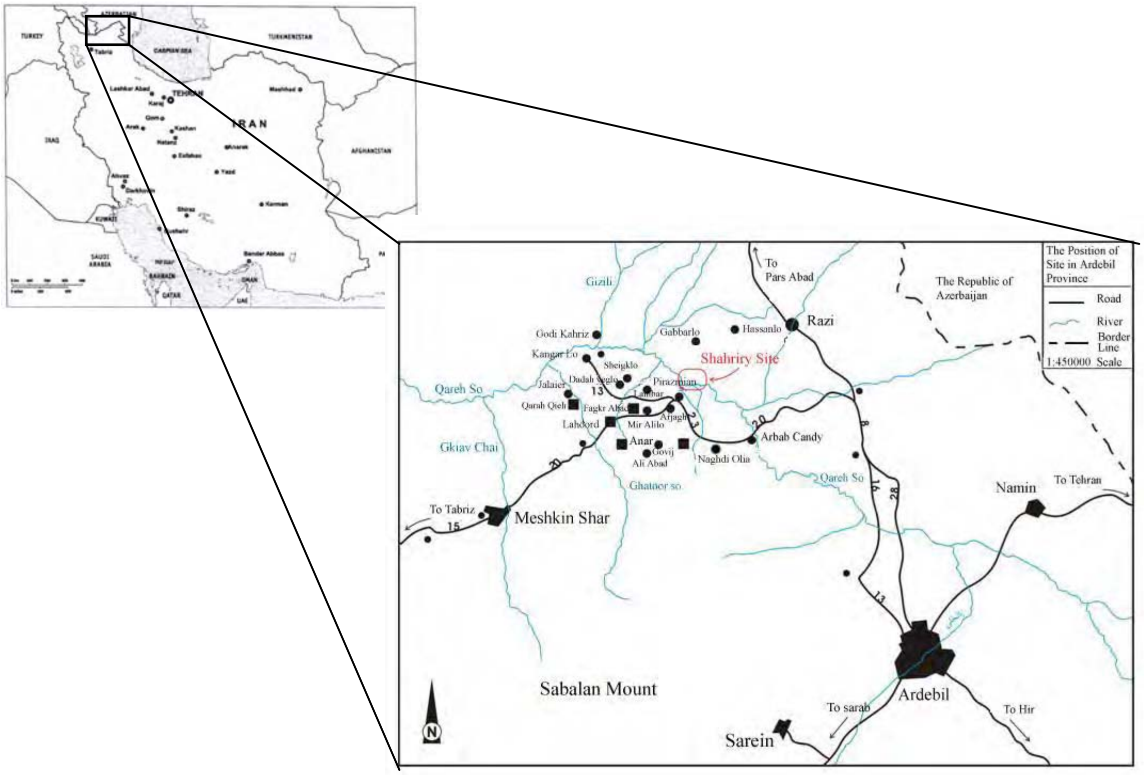
Introduction

Until very recently, there has been no archaeometry reporting on archaeological sites located in northern Iran. Research on obsidian sourcing in Anatolia and the Near East began in the mid-1960s by Renfrew and colleagues with a primary focus on sources in central and eastern Turkey, the Lake Van region including the Nemerut Dag volcano, as well as several Armenian sources (Cann and Renfrew 1964; Gratuze et al 1993; Renfrew and Dixon 1976; Renfrew et al 1966, 1968; Wright 1969). At the time, it was assumed that all obsidian in the Near East came from these sources (Beale 1973). Based on early obsidian sourcing studies, trade networks between several regions including Anatolia, the Levant, and southern Iran were reconstructed (Cann and Renfrew 1964; Tykot 2002). During the early phases of the Neolithic, obsidian trade networks were embedded within local trade between pastoralists and agriculturalists, which was expanded into long-distance trade networks. An example is the trade of domesticated wheat from the Jordan Valley into the Zagros-Taurus mountains and the movement of sheep and obsidian into the Levant (Wright 1969). Blackman (1984) identified trade between source locations in central Anatolia and archaeological sites in the southern Iranian highlands. Additional work on the more northerly Armenian sources has characterized obsidian from these sources as more locally distributed, and not a part of the larger long-distance trade networks (Chataigner et al 2003; Constaninescu et al 2002; Keller et al 1994; Rosen et al 2005; Williams-Thorpe 1995).

New Sites and Sources

Recently, several new archaeological sites excavated by Alireza Hejabir Noubari in the Ghoshania district in northern Iran have begun to provide new information about obsidian procurement and use in this region. Obsidian tools from Neolithic and Chalcolithic settlements appear to have been produced from lithic raw materials that were obtained locally. The site of Shahryri is located in the foothills of the Mount Sabalan volcano (Figure 1), a local source of obsidian. The site of Shiramin, where many obsidian tools have been excavated, situated on the shores of Lake Uremia, near the Mount Sahand volcano, which was first proposed as an obsidian source in the mid-1960s (Burney 1964). These sites have been dated to early Neolithic and Chalcolithic based on the comparative chronology based on ceramics from the Haji Firuz and Yanik Tepe sites, two Dalma culture sites in northwestern Iran.

Figure 1. Site location.



Sample Processing and Analysis

While a number of different analytical techniques are used to determine obsidian chemical composition, X-ray microanalysis using wavelength dispersive spectrometry (WDS) provides usable results, and allows for small sample sizes (<1mm3), is relatively fast technique, and does not require the sample to be destroyed (Verita et al 1994). However, since WDXRF results can be improved by processing powdered samples, debitage from the Shahryri and Shiramin sites was powdered for spectroscopy using a Philips PW2404 XRF instrument calibrated to CPM standards for the most accurate results. The results of the elemental analysis are listed in Table I.

Results and Discussion

The results of the spectroscopy analysis shown in Table I demonstrates that obsidian for the tools recovered from the site of Shiramin was obtained from the local source at Mount Sahand. Similarly, obsidian tools excavated from Shahryri were sourced from the local obsidian at Mount Sabalan. Obsidian tools from other sites in the Ghoshanian region, including Ghaleh Khosrow, were also sourced to the Mount Sabalan location. Analysis of artifacts from sites located on the central plain of Iran, such as Jiroft and Tepe Ashanah, shows that obsidian present in these sites came from different sources in other parts of Iran.

Table 1. Results of elemental analysis.

Sample	SiO2 (%)	Al2O3 (%)	TiO2 (%)	Fe2O3 (%)	MgO (%)	Na2O (%)	K2O (%)	MnO (%)
Shahryri	69.32	10.58	0.101	1.13	0.06	3.8	4.13	0.063
Shahryri	72.72	10.98	0.092	0.843	0.04	3.95	4.15	0.07
Shahryri	67.71	11.61	0.124	0.874	0.12	4.1	3.94	0.057
Shahryri	67.3	10.9	0.093	0.8	0.06	3.99	4.13	0.067
Shahryri	65.2	10.7	0.098	0.885	0.07	3.8	4.15	0.06
Shahryri	66.45	11.14	0.107	1.005	0.11	4.06	4.1	0.063
Shahryri	62.75	10.31	0.093	0.837	0.02	3.7	4.04	0.064
Shahryri	68.3	8.76	0.114	1.353	0	3.49	3.48	0.066
Shahryri	76.736	12.016	0.076	1.242	0.07	3.56	3.85	0.081
Shahryri	77.106	11.535	0.1	1.088	0.03	3.68	4.12	0.061
Shahryri	77.899	9.848	0.092	0.66	0.23	3.58	3.9	0.06
Shahryri	79.286	10.34	0.096	0.795	0.01	3.86	4.04	0.064
Ghalah Khosrow	61.01	10.25	0.098	1.165	0.03	3.6	4.14	0.06
Shiramin	73.26	11.04	0.105	0.857	0.04	3.95	4.25	0.059
Shiramin	70.52	10.71	0.078	0.708	0.02	3.94	3.97	0.079
Shiramin	68.19	10.68	0.081	0.789	0.03	3.78	4	0.078
Tape Ashana	75.751	10.381	0.17	3.328	0.121	4.78	4.03	0.076
Jiroft	62.624	10.845	0.606	5.498	2.23	2.21	2.5	0.117

Conclusion

Stone tools, and specifically tools made from obsidian, played important technological and economic roles during the Neolithic and Chalcolithic periods of Iran at Dalma culture sites. Recent excavations in northwestern Iran have revealed several sites that utilized locally available obsidian from the Mount Sahand and Mount Sabalan areas for stone tool making. This research is interesting in comparison with stone tool analysis from Dalma culture sites in other parts of Iran where stone tools made from chert are much more common than those made from obsidian, indicative of a decline in obsidian trade during this time that forced people who were not geographically close to obsidian sources to utilize other raw materials (Singh 1974). Also, obsidian from the Sahand and Sabalan sources is not found in other parts of the Near East region, indicating a distinctive localization of tool production in northwest Iran during the Neolithic, and lack of commercial trade linkages with Anatolia, Armenia, and Mesopotamia. Economic activities of northwest Iran may have been restricted by the mountainous nature of the region, in contrast to the plains of central and southern Iran which facilitated more opportunities for trade and communication.

Acknowledgements

We would like to extremely thank Mr. Reza Rezalou, Mr. Salehi Kakhki and Mr. Hassan Arab who encouraged us in this work and provided their samples for the spectroscopy.

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A Tale of Two Gophers: Depth Correction for Obsidian Effective Hydration Temperature in the Presence of Site Turbation Effects

Alexander K. Rogers
Archaeology Curator and Staff Archaeologist
Maturango Museum, Ridgecrest, CA

Abstract:

Obsidian hydration rim formation is strongly temperature-sensitive, and rim data must be corrected for effective hydration temperature (EHT) prior to being used in chronological analyses. Furthermore, EHT of an artifact is a function of burial depth, which should, in principle, be accounted for in the EHT correction. However, mixing or turbation during site formation is frequently encountered, which calls into question whether a depth correction adds value. This paper reports the results of a simulation-based study of site formation and its effect on chronological analysis based on obsidian hydration. It suggests that making a depth correction to EHT (and hence to rim data) provides more accurate chronological results than using uncorrected rims, even in the presence of severe mixing.

Introduction

Accurate use of obsidian hydration data for chronological analysis requires compensating the measured rim thickness for the effective hydration temperature (EHT) to which the artifact was exposed. Generally, the issue is to correct the data from one site to make them comparable to those from another site. However EHT is also a function of depth at a given site, and ideally it should be corrected to surface conditions prior to analysis. Rogers (2006a, 2007) proposed a mathematical technique for performing these calculations.

However, vertical mixing of artifacts during site formation is a fact of life, and can often be severe. The question addressed here is whether EHT compensation for depth adds any value, given the existence of mixing or turbation (the terms are used interchangeably herein). This is done by means of a Monte Carlo simulation of site formation and its effect on a set of obsidian artifacts. The simulation is a logical and numerical model of the scenarios described below.

SCENARIOS

Site Creation

Joe Pinto sits down next to Lubkin Creek and makes a set of artifacts 8,000 years ago. All are created the same day, from the same Coso obsidian. He digs a hole, and distributes the artifacts at random depths, from the surface to a maximum depth MaxD. The artifacts sit there at a constant depth for 8,000 years, exposed to the effective hydration temperature (EHT) appropriate to that depth and climate conditions, and developing corresponding hydration rims.

On 1 December 2006 two enterprising gophers rearrange the depths of the artifacts. The first one, Uniform Gopher, causes the artifacts to be arranged at random positions from 0 to MaxD, regardless of level of origin, based on a uniform distribution. This is the maximum case of mixing.

As an excursion, we ask what would happen if the mixing were normally distributed instead of uniform. The Uniform Gopher's cousin, Gaussian Gopher, moves each artifact a vertical distance described by a normal (Gaussian) distribution of standard deviation σ about its original position. This corresponds to a lesser degree of mixing.

This scenario amounts to the artifacts being in a long-term steady condition, and then being mixed in a single event. Another possible scenario would involve mixing on a repeated basis as time passes; this case was examined as an additional excursion.

Site Recovery

Here, four cases are defined, based on the archaeologists who excavate the site on 2 December 2006.

Conscientious Archaeologist (Case I and IA): The site is excavated by a conscientious archaeologist, who duly assigns a depth to each artifact, not knowing about the gopher's activity. When he performs obsidian hydration analysis on the artifacts, he assigns a rim correction factor to each artifact based on its depth at the time of excavation. Case I is the Uniform Gopher, and Case IA is the Gaussian Gopher.

Nervous Archaeologist (Case II and Case IIA): This archaeologist is well aware that mixing may have occurred, so she is not sure correcting each artifact's rim by its depth makes sense. Still, she feels she must do some sort of correction for depth, so instead of applying an individual correction based on the depth of each artifact, she simply computes a nominal correction based on the mean depth of the artifact assemblage, and uses it for all the artifacts. Again, Case II assumes uniformly distributed mixing, while Case IIA is Gaussian mixing.

Frustrated Archaeologist (Case III): The third archaeologist, frustrated by the uncertainties introduced by site mixing, throws up his hands and uses all the rim readings as is, without attempting to correct for depth.

Lucky Archaeologist (Case IV): The fourth archaeologist lucks out. She applies a depth correction to each artifact as in Case I. However, it turns out the gophers overslept and forgot to rearrange the artifacts, so the depth assigned by the archaeologist actually does represent the conditions to which each artifact was exposed.

Note that mixing by the Uniform Gopher is the maximum mixing, or worst case. The Gaussian Gopher causes a moderate degree of mixing, while the last case, in which the gophers overslept, amounts to no mixing.

Simulation

The question then is, which archaeologist's algorithm yields the best answer, based on mean and standard deviation of the collection of rim readings? To answer this, a simulation of hydration and site formation was written in Matlab 5.3. Interested researchers may obtain a copy of the program listing by contacting the author at matmus1@maturango.org.

The physics and chemistry of obsidian hydration have been thoroughly discussed elsewhere (e.g. Doremus (1994, 1999, 2002; summary in Rogers 2007) and are not repeated here. Computations for EHT follow the equations derived in Rogers 2007:

$$EHT = T_a(1 - 3.8\times 10^{-5}\, y) + .0096\, y^{0.95} \qquad (1)$$

where T_a is annual mean temperature and y is the variation factor given by

$$y = \exp(-1.32z)\,[V_a^{\,2} + V_d^{\,2}]. \qquad (2)$$

Here z is burial depth in meters, V_a is the annual temperature variation (hot month mean minus cold month mean), and V_d is mean diurnal temperature variation. All temperatures are in degrees Celsius.

To correct the rim thickness of each buried artifact to the thickness it would have acquired had it been exposed to the EHT of the surface, EHT_0, the rim thickness of the i^{th} artifact is multiplied by a rim correction factor (RCF) given by

$$RCF_i = \exp[-0.06(EHT_i - EHT_0)]. \qquad (3)$$

The rim data for the simulation were computed from equation 4:

$$x = \sqrt{(t/H)}, \qquad (4)$$

where t is age in years and H is the hydration constant in yrs/μ^2. This gives a baseline rim value of 13.48µ at the surface for the 8,000 year old artifacts created by Joe Pinto.

The simulation first creates the baseline rim reading for the artifact set. It then distributes the artifacts at random burial depths, from the surface to maximum depth for the site (MaxD); the distribution based on a uniform random number generator. An EHT, rim correction factor (RCF), and rim thickness are computed for each artifact, based on its depth , and the baseline rim thickness adjusted appropriately.

The artifacts are then mixed by the gopher, resulting in the depth the archaeologist observes. The Uniform Gopher generates a uniform distribution between 0 and MaxD, regardless of initial burial depth. The Gaussian Gopher produces depth displacement which is normally distributed about the burial depth, with a specified standard deviation.

For the Case I algorithm, the rims are then corrected for EHT based on the observed depth, and mean and standard deviation are computed. For Case II the archaeologist computes the mean depth of the collection, computes an EHT for that depth, and applies it to the whole collection. For Case III the mean and standard deviation are computed for the uncorrected rim readings, and for Case IV the rims are adjusted with EHT for the (correct) burial depth.

The numerical values assumed are summarized in Table 1.

Table 1. Input values for simulation

Parameter	Symbol	Value	Units
Annual average temperature	Ta	18.2	deg. C
Annual temperature variation	Va	28.7	deg. C
Mean diurnal temperature variation	Vd	26.7	deg. C
Hydration constant at 24.7 deg. C (surface conditions)	H	44	yrs/u^2
Depth of site (range of mixing, Uniform Gopher)	MaxD	2	meters
Standard deviation of mixing, Gaussian Gopher	sigma	0.4	meters
Number of artifacts	10,000		

The temperature data are representative of Lubkin Creek (CA-INY-30), surface conditions, and represent an offset from air temperatures (Johnson et al. 2002; Rogers 2006b). The hydration constant (reciprocal of the hydration rate) is nominal and typical of Coso obsidian. Figures 1 and 2 show the variation of EHT and RCF with depth for these site conditions

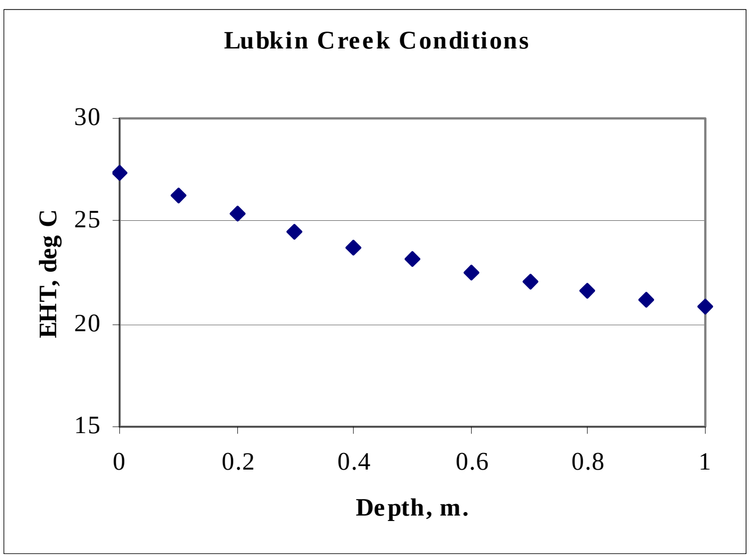

Figure 1. EHT as a function of depth for the simulated conditions.

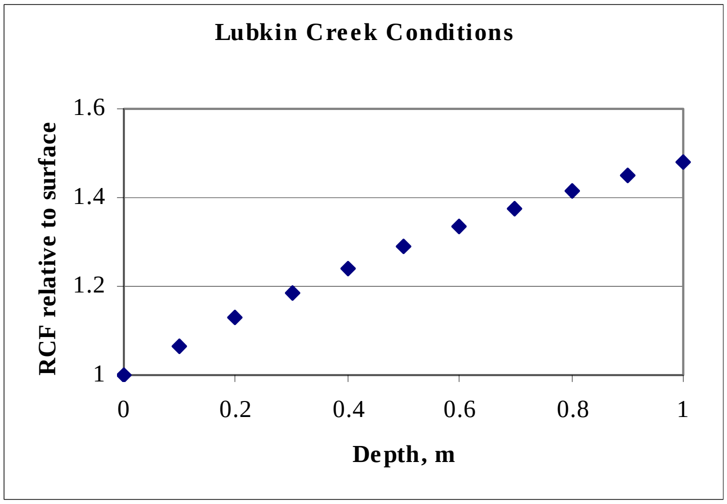

Figure 2. Rim correction factor as a function of depth for the simulated conditions.

Discussion

Results of simulation runs are summarized in Table 2, with the order of results rearranged for clarity. The table shows the EHT correction strategy employed by the archaeologist, the degree of mixing of the site, and the resulting rim and age data.

Table 2. Simulation results for alternative depth-correction strategies

Archaeologist's EHT Correction Strategy	Degree of Mixing	Mean of estimated rims, microns	Standard deviation of estimated rims, microns	Estimated age and 1-sigma range, years	Simulation Case
Correction for depth of each artifact	None	13.48	0.00	8,000	IV
Correction for depth of each artifact	Worst (complete)	13.74	2.71	8,307 (11,907 - 5,333)	I
Correction for depth of each artifact	Medium (sigma = 0.4m)	13.47	0.75	7,983 (8,897 - 7,119)	IA
Correction based on single nominal value for average depth	Worst (complete)	14.23	2.10	8,909 (11,733 - 6,474)	II
Correction based on single nominal value for average depth	Medium (sigma = 0.4m)	14.24	2.08	8,922 11,719 - 6,506)	IIA
No depth correction	Worst or medium	9.64	1.42	4,089 (5,382 - 2,973)	III

Several points emerge from inspection of the data. First, rim correction for EHT based on depth in the absence of turbation gives the best results, not surprisingly. Second, using the uncorrected rim readings for chronological analysis is not a good strategy; computing age based on 9.64µ in equation 4 yields an age of 4,089 years, only about half the actual age. Third, and very surprisingly, performing a correction based on depth of each artifact gives improves accuracy of the central tendency of the data even in the presence of severe mixing. On the average the technique slightly overestimates the age, but it is better than using the uncorrected readings. As the degree of mixing decreases, the numerical results approach the best case of no mixing. Finally, correcting the entire collection using a single value based on an average depth does not work well, but overestimates the age significantly.

The effects of repeated disturbance were examined by a second simulation, which follows the time history of an artifact. In this case one of Joe Pinto's artifacts, assumed to be Coso obsidian, is assigned an initial EHT of 27.4°C, and is buried. Every 80 years it is mixed such that the EHT randomly changes, the changes being generated from a random number generator with a uniform distribution, with a range consistent with the range of EHT values in Figure 1. The hydration constant H was again 44 yrs/μ^2, which is equivalent to a hydration rate of 22.73 μ^2 /1000 yrs. This experiment is then repeated 10,000 times, and the mean and standard deviation of the hydration rate are computed. Results are summarized in Table 3.

Table 3. Effects of frequent random mixing on effective hydration rate

Delta EHT, deg C	Effective hydration rate, u^2/1000 yrs	Effective hydration rate standard deviation, u^2/1000 yrs	Effective hydration constant, yrs/u^2
0.00	22.73	0.00	44.00
6.00	23.12	0.44	43.25
7.00	23.28	0.53	42.96
8.00	23.43	0.60	42.68

Reference to Figure 1 shows a range of EHT (ΔEHT) of about 7ºC for the conditions simulated. The data in Table 3 show that the effect of random EHT variations of such a magnitude would lead to errors in age estimation of the order of 2 – 3%.

To put this into context, Scheetz and Stevenson (1988) examined the magnitude of rim measurement errors arising from optical microscopy, based on the physics of the optical system and the human eye, and concluded that approximately ±0.25μ is the best accuracy that can be achieved consistently. This translates to an error in age estimation of about 4% for the present case, which exceeds the errors introduced by rapid mixing as modeled in Table 3. Thus, rapid mixing effects should not be a major source of concern.

Finally, what about individual artifacts? The simulation assumes explicitly that the artifacts are the same age, and assumes tacitly that the artifacts are not otherwise distinguishable. Thus, computation of a mean rim thickness for a group of artifacts is a valid analytical technique - this is how one would analyze debitage, for example. However, if the artifacts were temporally diagnostic, such as projectile points, one might not compute an average but analyze and report each one separately. Even then, EHT correction based on depth will, in general, improve accuracy of the age estimate. This must be so, because since the strategy improves the mean rim estimate, this implies that, on the average, any individual rim is more likely improved than not. Thus, EHT correction based on observed depth is still the best strategy for individual artifacts, although the degree of improvement cannot be quantified.

Conclusions

In the first place, it should be noted that, because of the design of the simulation, the mixing described as "worst" is actually complete mixing, equivalent to homogenizing the site. All stratigraphic data would be lost. Very few sites will be so completely mixed, but will tend more toward the "medium" case.

The scenarios simulated show that long-term stability of a site, followed by rapid mixing, is probably the worst case for obsidian hydration dating. This is because each artifact has time to develop a distinct degree of hydration characteristic of its depth, but then the depth data become corrupted prior to excavation. On the other hand, frequent mixing of a site seems to have little effect on hydration rate, probably because the positive and negative perturbations approximately cancel one another.

Results of the simulations show that applying a rim correction to each artifact based on its depth of recovery is the best chronological analysis strategy, even in cases of extreme mixing. For cases where data are to be aggregated, this strategy will lead to improvement in the mean of the rim data relative to use of uncorrected rim data; for individual artifacts it will lead to better rim estimates on the average.

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RESEARCH NEWS AND NOTES

This new section of the IAOS *Bulletin* is devoted to research news and notes from our membership. Please consider submitting an abstract or brief description of your current research, and include your contact information if you would like to receive comments, questions, or suggestions from our readers. Contributions for the research news and notes can be emailed to the *Bulletin* editor at cdillian@princeton.edu

The Scottish Archaeological Pitchstone Project

Torben Bjarke Ballin
LITHIC RESEARCH,
Banknock Cottage, Denny,
Stirlingshire FK6 5NA, Scotland, UK
Tel: 0044 1324 840 968

As most IAOS members know, volcanic glass comes in two main forms. One form is obsidian (< 1% H_2O), whereas the other is pitchstone (typically 3-10% H_20). Most pitchstones have > 5% H_20, and most obsidians < 0.5%. Volcanic glass is known from igneous complexes throughout the world, but in Britain it is only found in western Scotland and Northern Ireland (the British Tertiary Volcanic Province; Emeleus 2005). All volcanic glass found in Britain is in the form of pitchstone, and it is generally accepted that only pitchstone from the island of Arran, immediately west of Glasgow (Fig. 1), had the properties required to become widely used as a toolstone.

However, *archaeological* pitchstone is found not only on Arran, but throughout Scotland, and it has even been recovered from archaeological sites in northern England, Northern Ireland, and on the Isle of Man (the most remote pieces of archaeological pitchstone were recovered on the Orkney Islands – more than 400 km north of Arran). Thin-section analysis and analysis of geochemistry, crystallites and spherulites have confirmed that all, or almost all, archaeological pitchstone found on Arran derives from this island, and that most of this material was imported from outcrops of aphyric pitchstone in the Corriegills district on Arran's east-coast.

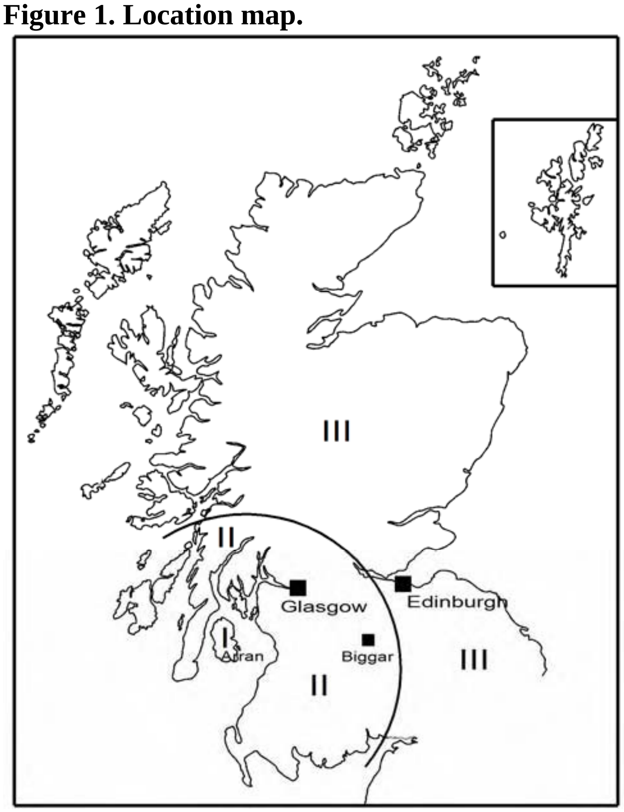
In 1984, Williams Thorpe & Thorpe published their pioneering, and now widely cited, paper on the distribution and sources of archaeological pitchstone in northern Britain. Their catalogue included 1,392 pieces from 101 archaeological sites, with most pitchstone-bearing sites being located either on Arran or on the Scottish mainland immediately adjacent to Arran. Only a small proportion of these finds were recovered by excavation. Now, a quarter of a century later, many more pitchstone artifacts have been recovered, from archaeological excavations and fieldwork, with dramatic consequences to the general distribution pattern.

Consequently, the main aims of the present project are to 1) update Williams Thorpe & Thorpe (1984) by producing an Access database of all presently known pieces of archaeological pitchstone, and 2) re-interpret the distribution of archaeological pitchstone across northern Britain. The final database will be presented to the National Monuments Record of Scotland (NMRS) in Edinburgh on a CD, as well as to the main Scottish museums. The re-interpretation of the pitchstone distribution will take the form of an academic paper which will be offered to an appropriate archaeological journal.

The project's interpretive Part 2 is mainly a large-scale distribution analysis, in which the distribution of archaeological pitchstone across northern Britain is to be assessed. Presently, the available archaeological literature suggests that prehistoric Scotland may have been sub-divided into three main zones (I-III). Arran itself represents Zone I (local procurement: general use of pitchstone throughout the Mesolithic, Neolithic and Early Bronze Age periods; all types present), the mainland east of Arran Zone II (regional procurement: pitchstone occasionally forms substantial proportions of assemblages; almost exclusively an Early Neolithic resource; most types present but with a lower implement ratio than in Zone I), and beyond this area, in Zone III, the frequency of pitchstone drops markedly (exotic procurement: individual pieces; almost exclusively an Early Neolithic resource; mostly flakes and blades, with cores and tools being rare).

It is assumed that this tripartite division of Scotland represents the rudiments of a prehistoric territorial structure. Where the three-part division of Scotland into regions based on the exploitation of quartz, flint/flint-like materials, and a combination of the two may represent different *techno-complexes* (Ballin 2004), the three pitchstone zones most likely represent different *social territories*, that is, territories with, for example, different ideologies (eg, different perceptions of pitchstone as mainly functional [Zone I] and mainly stylistic/symbolic [Zone III]) (cf. Ballin 2007). In this sense, the Pitchstone Project represents a continuation of, and a complement to, the project 'Quartz Technology in Scottish Prehistory' (Ballin forthcoming), and it forms part of the general study of the exploitation of natural resources in prehistoric Scotland.

Figure 1. Location map.



An important element of the analysis will be scrutiny of the fall-off curve (Renfrew 1977) of the exported Arran pitchstone. A direct relationship between quantity and distance to source (the larger the distance, the smaller the quantity) would imply that Scottish pitchstone was perceived entirely in functional terms by prehistoric people, and the study of pitchstone distribution would reveal little of relevance to the understanding of the territorial structure of Neolithic Scotland. Although my impression of Scottish pitchstone distribution is presently best characterized as subjective, it is clear that the pitchstone fall-off curve is *not* gently sloping. The question is therefore whether the fall-off curve will turn out to be stepped, with the steps indicating the borders of territories, or whether it will have a number of peaks, each indicating a local centre of re-distribution – or whether the distribution pattern will form a combination of these two options. The results may be somewhat biased by different local levels of archaeological activity (population density, infrastructure, dedicated amateurs, etc.).

The project is expected to take a number of years, with each year allowing another batch of museum collections to be catalogued. In 2006, the collections of the National Museums of Scotland (Edinburgh) were dealt with, and in 2007 the main Glaswegian museum collections are to be catalogued. It is hoped that it will be possible to secure funding in 2008 for the examination of the pitchstone-bearing assemblages held by Biggar Museum. A number of very large pitchstone collections have been retrieved from the area around Biggar, in central southern Scotland (Fig. 1).

As part of a second pitchstone project (the Arran Pitchstone Survey Project), I have surveyed pitchstone outcrops on the island of Arran, and I am presently in the process of producing a gazetteer of Arran pitchstone outcrops with geologist Dr. John Faithfull from the Hunterian Museum, Glasgow (Ballin and Faithfull forthcoming). At the moment, approximately 100 sources are known, one-third of which is aphyric, whereas two-thirds are porphyritic. Although most archaeological pitchstone on the Scottish mainland is aphyric, on Arran prehistoric people exploited both forms. It is therefore hoped that this gazetteer may become a useful tool in the discussion of pitchstone use on Arran itself, including the questions of procurement, territoriality and exchange within the island. As part of this process, the pitchstone samples in the stores of the Hunterian Museum were examined, and a selection of pitchstone samples have been photographed and thin-sectioned by Dr Faithfull. These photos and thin-sections can be seen at: http://www.huntsearch.gla.ac.uk/cgi-bin/foxweb/huntsearch/SearchForm.fwx?collection=geology – simply write 'pitchstone' in the available search-field.

The Scottish Archaeological Pitchstone Project and the Arran Pitchstone Survey Project have received funding from Historic Scotland, the National Museums of Scotland, and the Society of Antiquaries of Scotland, for which I am grateful.

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Thank you,
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