Title
IAOS Bulletin 45

Author
Dillian, Carolyn D., cdillian@coastal.edu

Publication Date
2011-06-15

IAOS

International Association for Obsidian Studies

Bulletin

Number 45 **Summer 2011**

CONTENTS

NEWS AND INFORMATION

IAOS Election Results

The results of our recent election are in! Dr. Ellery Frahm, University of Minnesota, is our new President-Elect, and Kyle Freund of McMaster University has already begun his duties as the new IAOS Secretary-Treasurer.

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, news, or lab report for publication in the IAOS *Bulletin*. Articles and inquiries can be sent to cdillian@coastal.edu Thank you for your help and support!

IAOS Student Paper Awards

The IAOS is pleased to announce the recipients of 2011 student paper/poster awards granted for papers presented at the 2011 Society for American Archaeology annual meeting. The winners are: Lucas Martindale Johnson (University of Florida), Scott Bigney (California State University, Dominguez Hills), and Allison Barden (University of California, Berkeley). Congratulations to our award recipients. Winners receive free membership to the IAOS and are invited to publish their papers in the IAOS *Bulletin*. Watch for a writeup of their research papers in the next issue.

NOTES FROM THE PRESIDENT

It's nearly the end of May and finally the sun has deigned to appear in Ontario skies; I should be delighted – after a very long and miserable winter – but actually need to stay indoors and write the Çatalhöyük obsidian report before leaving for another season of fieldwork in Greece and Turkey. It has been a busy and productive winter/spring for us in the IAOS, with a lot more to follow in the coming academic year. Before I comment further on that I want to lead off with some important Association news.

This past fall and early winter we had elections for our next president and secretary/treasurer, for which we had an excellent virtual turn out, with over 60% of you voting. Both were very closely contested positions, and I am delighted to be able to announce that our new president elect is Dr. Ellery Frahm, a Lecturer in Anthropology and Earth Sciences at the University of Minnesota, who will assume his full presidential tenure in April 2012, at our next annual meeting. We also have a new secretary/treasurer, Kyle Freund, a Ph.D. candidate from McMaster University, who has already commenced his responsibilities. I think we are very lucky to have both on board and to be in such good hands for the next few years. I would like to offer a heartfelt thanks to both Dr. Jeff Ferguson and Adam Nazaroff, the narrowly defeated candidates for these positions; it is only through the membership putting themselves forward for these positions that keeps us an active and productive association. Thank you also to Dr. Ana Steffen, our past president who has now completed her four-year cycle of committee responsibilities and Colby Phillips for all his sterling work as secretary/treasurer.

Our 2011 gathering was of course held at the annual meeting of the Society for American Archaeology in Sacramento, California. This was an excellent turn out for the IAOS, with a great many of us involved in various conference presentations, not least our own panel, co-sponsored by the Society for Archaeological Science, held on the first evening of the SAA's and titled *The Cutting Edge: The State of Play in World Obsidian Studies*. The panel had both a methodological (characterization and dating) and regional component, the latter detailing Mediterranean, Pacific island, African, plus South and North American case studies. It was a wonderful gathering and great in particular to have Robin Torrence and Marina Milić travel all the way from Australia and the UK respectively. After the academic engagement there was a social gathering at one of Sacramento's brew pubs that provided a terrific opportunity for everyone to reconnect and meet anew. The highlight of the next day for many of us was our own Prof. Steve Shackley receiving the *Society for American Archaeology's* Excellence in Archaeological Analysis award, a thoroughly well-deserved prize for one of our long-standing IAOS members and a mentor, collaborator and friend for many of us.

We are planning ahead for next year's meetings and Prof. Mike Glascock has already sent out a call for papers for a panel to be – provisionally – titled *Alaska to Patagonia: New Directions in Americanist Obsidian Studies*. Talking of Prof. Glascock, congratulations are in order for him and Prof. Yaroslav V. Kuzmin for their new BAR volume that developed from their panel at the 2005 SAA's. This volume: *Crossing the Straits: Prehistoric Obsidian Source Exploitation in the North Pacific Rim* (BAR Int. Series 2152, 2010, Archaeopress, Oxford) is a very welcome addition to the literature and will prove an invaluable reference for those interested in current developments in Japan, the Russian Far East, Alaska and the Pacific coast as far south as Mexico on the North American side.

Further news, includes the fact that Craig Skinner continues to update the IAOS web-site, a sterling endeavour for which everyone is grateful for (http://members.peak.org/~obsidian/); once again, in helping Craig to maintain this wonderful facility we encourage you to alert him (or me) of your most recent publications and/or those that are missing from the web-site's bibliography (skinncr@peak.org or stringy@mcmater.ca).

Well that's where I will leave it for now. I wish everyone the best for their summer plans, as I too gear up for more source sampling in the east of Turkey and the Aegean with a small group of colleagues, students and fellow IAOS members. A report on that and the work by my own McMaster Archaeological XRF Lab [MAX Lab] on Eastern Mediterranean and Mesoamerican obsidian in the next Bulletin. Have a great summer and catch you in the fall!

Tristan Carter
stringy@mcmaster.ca
President IAOS
Assistant Professor, Dept. Anthropology,
McMaster University / Director MAX Lab

Post-panel drinks at the 2011 Society for American Archaeology meetings in Sacramento, California.

NEWS AND NOTES: Have announcements or research updates to share? Send news or notes to the *Bulletin* editor at cdillian@coastal.edu with the subject line "IAOS news."

2011 Award for Excellence in Archaeological Analysis, given by the Society for American Archaeology to M. Steven Shackley, University of California, Berkeley

Established in 2001, this award recognizes the excellence of an archaeologist whose innovative and enduring research has made a significant impact on the discipline. Nominees are evaluated on their demonstrated ability to successfully create an interpretive bridge between good ideas, empirical evidence, research, and analysis. This award now subsumes within in it three themes presented on a cyclical basis: (1) an Unrestricted or general Category; (2) Lithic Analysis; and (3) Ceramic Analysis.

I have known Steve for thirteen years, and he is unequaled as an outstanding mentor, scholar, and colleague. His research has paved the way for the ubiquitous use of geochemical characterization and sourcing of obsidian artifacts in archaeological contexts around the globe. He has not only personally greatly advanced our knowledge of obsidian sourcing, but has also helped to democratize the science, making trace element data publicly available on the web and widely publishing both the methods and the results of his research. As a result, almost all archaeological research in obsidian-rich regions now uses geochemical sourcing as an additional data set aiding our understanding of the past. In fact, his Ph.D. dissertation, *Early Hunter-Gatherer Procurement Ranges in the Southwest: Evidence from Obsidian Geochemistry and Lithic Technology,* is the seminal work on obsidian sourcing in the American Southwest. His subsequent published books on obsidian including *Archaeological Obsidian Studies: Method and Theory* (Plenum Press), and *Obsidian: Geology and Archaeology in the North American Southwest* (University of Arizona Press), and numerous peer-reviewed articles only further reinforce his position as a leader in the field.

I first met Steve at the Society for American Archaeology meetings in 1997, and he subsequently served as my Ph.D. adviser at the University of California, Berkeley, where I received my degree in 2002. As a mentor, Steve is unmatched. He was a strong supporter of my research goals and graduate ambitions, but also made a special effort to involve me in his own work on obsidian geochemistry. Under his tutelage, I received training in the operation of the energy dispersive X-ray fluorescence machine in the Berkeley Archaeological XRF Laboratory, and the interpretation of the resulting data. Steve encouraged me to work with him on research projects that resulted in some of my earliest co-authored publications. He maintains a strong dedication to his students, both at the graduate and undergraduate level, and I received outstanding support throughout my graduate career. I ultimately conducted my own Ph.D. dissertation research on obsidian in northeastern California, and benefited greatly from Steve's expertise and experience.

Following to the completion of my Ph.D. in 2002, Steve continued to serve as a mentor and colleague. We have collaborated on a research project looking at the long-distance movement of rare obsidian artifacts recorded in eastern United States archaeological collections. Though these finds are often disputed as evidence of more recent transport of archaeological materials, we have documented a substantial number of specimens from museum collections and more recent excavations. These artifacts have been geochemically analyzed and sourced using X-ray fluorescence and revealed western U.S. geologic provenance, suggesting raw material transport on a continental scale. Steve worked with me on these analyses, and is co-author of two peer-reviewed articles on this research. His devotion to students clearly does not end with the granting of the degree, but he continues to offer expertise and assistance whenever he can.

My personal experience with Steve is typical of the kind of support he offers to students and colleagues. Yet beyond his dedication to teaching and mentoring, his research has provided new methods and new interpretations. He demonstrated that a wider range of obsidian sources were available and used prehistorically in the American Southwest than originally thought, yielding interpretations about procurement and exchange that are vastly more complex. His publications on the use of secondary deposits of obsidian nodules have served as cautionary tales for researchers looking to pinpoint quarry locales, suggesting that these secondary deposits must also be viewed as procurement sites for models of raw material use and exchange. And, he has expanded obsidian sourcing research to include personal contributions in Peru, Honduras, Ethiopia, Mexico, Russia, and Turkey.

In addition to the award, Steve also presented a retrospective of his long career in archaeology entitled "Rattlesnakes, Arrowheads, and Obsidian: Thirty years of geoarchaeological science in the North American Southwest" at the Archaeological Research Facility at U.C. Berkeley on April 13, 2011.

I can only imagine that the presentation announcement was written by Steve himself:

"Beginning in the desert of southeastern San Diego County, this will be a retrospective of an amusing career of long desert treks for a young geology student who was drawn into anthropology as a way to apply geology to the human condition. Along the way the journey was a discovery that a poor son of blue collar workers could animate the American dream and change the intellectual course of Southwestern archaeology by integrating petrology and geochemistry with archaeological method and theory, and warping the minds of young archaeology students."

Carolyn Dillian
Coastal Carolina University

Photo by Michael Ashley

2011 Pomerance Award for Scientific Contributions to Archaeology, given by the Archaeological Institute of America to Michael D. Glascock, University of Missouri

In recognition of his distinguished record of contribution to the advancement of archaeological science, the 2011 Pomerance Science Medal Award is awarded to Michael D. Glasock. Dr. Glascock, Research Professor and Group Leader of the Archaeometry Lab at the University of Missouri, is renowned worldwide for his application of methods of elemental analysis to determine the source of archaeological ceramics and obsidian and to reconstruct ancient trade and socioeconomic systems.

Since earning his PhD in Nuclear Physics at Iowa State University in 1975, Michael Glascock has been on the research staff of Missouri University Research Reactor (MURR). He personally established the Archaeometry Laboratory in 1988, using instrumental neutron activation analysis (INAA) for chemical fingerprinting of archaeological materials. With eight major grants from the National Science Foundation, and awards from other agencies to support his laboratory, this has resulted in significant subsidies for collaborative analyses of archaeological artifacts from thousands of archaeological sites in the United States, Latin America, and many other parts of the world, with nearly 100,000 artifacts analyzed. In the past decade his laboratory has expanded beyond INAA to include X-ray fluorescence (XRF), and laser ablation ICP mass spectrometry (LA-ICP-MS).

While his own research interests have focused on the western US and Mesoamerica, Michael Glascock has made significant contributions to archaeological studies in the Mediterranean and other parts of the world. In addition to performing such analyses, Michael Glascock has truly collaborated in the initial development and organization of research projects, as well as the interpretation and dissemination of the data ultimately produced. In many cases, he has himself visited archaeological sites and collections around the world in order to assist in the organization of the research and selection of samples for analysis. Overall, this has resulted in more than 400 publications in major journals (including *Science*, *Nature*, and many archaeology journals such as *Archaeometry*, and *Journal of Archaeological Science*). He has also published several edited volumes, including *Archaeological Chemistry: Analytical Techniques and Archaeological Interpretation* (2007); *Laser Ablation ICP-MS in Archaeological Research* (2005, with R.J. Speakman); and *Geochemical Evidence for Long-Distance Exchange* (2002).

At the same time, Michael Glascock has directly trained and supervised more than 30 undergraduate and graduate students, as well as post-docs, from the University of Missouri, and more than 100 from other institutions, while promoting in general the education of archaeologists and students in scientific research. He has welcomed the sharing of data, led pilot and experimental projects, and performed extensive public and extracurricular service as well, all representative of his kind, friendly, and generous character.

For his outstanding contributions in the areas of research, service, and teaching in archaeological science, the Archaeological Institute of America honors Michael D. Glascock with the 2011 Pomerance Award for Scientific Contributions to Archaeology.

A special Pomerance Award Colloquium was held at the 112th Annual Meeting of the Archaeological Institute of America, San Antonio, Texas, January 6-9, 2011, organized by Robert Tykot & Hector Neff, titled "Scientific Analyses of Obsidian and Ceramics. Papers in Honor of Michael D. Glascock" and which included six presentations plus Mike as the discussant.

Mike Glascock served as President of IAOS from 1994-1996. For description of the Pomerance Award and a list of previous winners: http://www.archaeological.org/awards/pomerance

IAOS members may submit nominations for future awards to Robert H. Tykot, Pomerance Award for Scientific Contributions to Archaeology Committee, email: rtykot@usf.edu

---

Obsidian papers presented at the 112th Archaeological Institute of America annual conference:

Obsidian Circulation in Bolivia, Chile and Argentina

Martin Giesso, Northeastern Illinois University

Research on obsidian sourcing in the Andes south of Peru has taken an important place in archaeological research in the last two decades. Expanding from my research in the Titicaca basin and central Argentina, in this paper I integrate published information by national (Bolivian, Chilean and Argentine) and foreign scholars working in the Titicaca basin, northern Chile and northwestern Argentina, central Chile and central-western Argentina, and in Patagonia, in order to understand the procurement and distribution mechanisms as well as interconnections between different Precolumbian societies along the Andean chain from a cross-cultural perspective. Sites where obsidian was utilized date from the Late Pleistocene-Early Holocene transition (11,000-10,000 BP) to the Late Horizon (A.D. 1500), covering all of the human settlement of the region since the arrival of the first inhabitants to the southern Andes. The paper will include comparisons between foraging societies and agriculturalists and between state and non-state societies both of the Andes and the non-Andean regions located to the East. Sourcing methods include instrumental neutron activation analysis (INAA), portable and nonportable X-ray fluorescence spectrometry (XRF), and proton induced X-ray emission (PIXE), from the Missouri University Research Reactor and other facilities.

Selective Use of Obsidian Subsources on Mediterranean Islands

Robert H. Tykot, University of South Florida

Previous research on obsidian trade in Italy has demonstrated the importance of identifying specific geological subsources on Sardinia, and analyzing lithic assemblages to reconstruct prehistoric selection, acquisition, and transport strategies. Subsequently, detailed surveys and analyses of obsidian outcrops on Lipari, Palmarola, and Pantelleria, presented at previous AIA annual meetings, also revealed the existence of multiple, chemically distinguishable subsources on each. These analyses were conducted by Michael Glascock and colleagues at the University of Missouri, using instrumental neutron activation analysis, laser ablation ICP mass spectrometry, and X-ray fluorescence.

In this presentation, results of analyses of archaeological artifacts made of obsidian from these central Mediterranean islands, used primarily in the Neolithic and Bronze Ages, again illustrate the utility of attribution to specific subsources. Large assemblages from multiple archaeological sites on Malta, in central Italy, and in different parts of Croatia were recently analyzed using a non-destructive, portable XRF spectrometer that produces quantitative trace element data. The results for this analysis of hundreds of artifacts provide statistically significant data on the use of these island obsidian subsources. When combined with the quality and quantity of geological obsidian at different subsource areas, both coastal and inland, along with available information on contemporary occupation sites, the obsidian data allow interpretations to be made regarding territorial control, accessibility, maritime transport - of obsidian and likely other materials as well - and sociopolitical changes over time.

THE SCOTTISH ARCHAEOLOGICAL PITCHSTONE PROJECT: RESULTS

Torben Bjarke Ballin, Lithic Research
Honorary Research Fellow, Archaeological Sciences, University of Bradford

The Scottish Archaeological Pitchstone Project (SAPP) was presented in IAOS Bulletin 37 (Ballin 2007), and it has now been completed (Ballin 2009). Below, the project's results are briefly summarized.

As explained in the Bulletin's volume 37, volcanic glass comes in two main forms. One form is obsidian (usually $< 0.5\% H_20$), whereas the other is pitchstone (typically $> 5\% H_20$). 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 & Bell 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 (Figs. 1 and 5), had the properties required to become widely used as a toolstone.

The project was started in 2004, with the aim to update older publications on archaeological pitchstone by 1) producing a computer database of all known artefacts in Arran pitchstone, and 2) discussing the now available evidence, not least the distribution of the finds. The database replaces that of Williams Thorpe & Thorpe's catalogue (1984), which embraced 1,392 pieces from 101 sites. The SAPP database includes two sub-databases, namely a detailed one for material examined in Scottish museums, or – for newer material – at the premises of the various excavating units, and a less detailed one for material which is still being processed, and which therefore was not available to the analyst. In total, 5,542 pieces of worked pitchstone was examined and characterized, deriving from approximately 350 sites. In addition, 14,707 pieces have been included in the database of not-examined artefacts, deriving from *c*. 125 sites. Approximately 13,300 of the latter were retrieved in connection with Glasgow University's Archaeological Research Division's recent work on Arran.

Figure 1. The great pitchstone sill at Dun Fionn, on Arran's east-coast.

As part of the SAPP, a number of parallel projects were undertaken, namely: 1) the analysis of all archaeological pitchstone at Biggar Museum, South Lanarkshire (Ballin & Ward 2008); 2) the analysis, with Chris Barrowman and John Faithfull (2009), of the large porphyritic pitchstone assemblage from Blackpark Plantation East on Bute; 3) the analysis of the pitchstone assemblage from the Barnhouse Neolithic village on Orkney (to be published in the New Orcadian Antiquarian Journal); and 4) the production, with John Faithfull (2009), of a gazetteer of Arran pitchstone outcrops.

The project's most immediate results have been the full or partial rejection of a number of myths, which had developed over the years, such as: 'in Scotland, pitchstone was used from the Mesolithic period to the Early Bronze Age'; 'all pitchstone outwith Arran is aphyric and derive from the Corriegills district in eastern Arran'; and 'there are no pitchstone tools in assemblages outwith Arran'. In terms of the dating of pitchstone use, this material was in use from the Mesolithic period to the Early Bronze Age, but only on Arran itself. Outwith Arran, there is no evidence to support Mesolithic pitchstone use, and on the Scottish mainland there is no evidence of use in the Bronze Age (possibly excluding the county of Argyll & Bute, immediately north of Arran). Most probably pitchstone was introduced outside Arran at the beginning of the Early Neolithic period, and – apart from in the west and on Orkney (north of Scotland) – exchange in pitchstone probably stopped at the transition between the Early and Late Neolithic periods (pitchstone artefacts from a number of non-Arran sites shown as Figures 2-4).

Figure 2. Aphyric pitchstone artefacts from Auchategan in Argyll (Ballin 2006), Barnhouse on Orkney (Ballin forthcoming a), and Blackpark Plantation East on Bute (Ballin et al. 2009).

Figure 3. Spherulitic/lightly porphyritic pitchstone artefacts from Auchategan in Argyll (Ballin 2006), Barnhouse on Orkney (Ballin forthcoming a), and Blackpark Plantation East on Bute (Ballin et al. 2009).

Figure 4. coarsely porphyritic pitchstone artefacts from Auchategan in Argyll (Ballin 2006), Barnhouse on Orkney (Ballin forthcoming a), and Blackpark Plantation East on Bute (Ballin et al. 2009).

It is true that aphyric pitchstone dominates the Scottish mainland east of Arran almost completely: the more than 700 pieces from Biggar, central southern Scotland, include only one piece with large crystalline inclusions, and the *c*. 1,700 pieces from Luce Bay in the south-west also only include one coarsely porphyritic piece. However, assemblages from Argyll & Bute generally include more porphyritic specimens than their eastern counterparts, and at Blackpark Plantation East, on the Isle of Bute, a probably Late Neolithic assemblage of now *c*. 400 pieces of mostly porphyritic pitchstone was found.

In terms of pitchstone assemblages and tools, the question is how ‘a tool’ is defined? If it is accepted that a tool is a secondarily modified blank, pitchstone assemblages off Arran include relatively large numbers of tools, although mostly in the form of simple edge-trimmed pieces. However, formal tools are also present, embracing arrowheads, scrapers, piercers and truncated pieces. Interestingly, pitchstone implements become relatively more numerous with increasing distance to the sources on Arran, probably in an attempt not to waste a precious resource. The same phenomenon is known from, for example, the Western Isles (formerly the Outher Hebrides), where flint has a considerably higher tool ratio than the more abundant, but less precious, quartz.

The distribution of Arran pitchstone across Scotland and northern Britain shows several interesting trends, which all need careful consideration: 1) A number of factors (eg, types of pitchstone, duration of pitchstone use) indicate similarities between Arran and Argyll & Bute, and most likely these areas formed part of the same social territory. This territory is also defined by the construction of simple Clyde cairns and distinct local forms of pottery.

2) The distribution of pitchstone across Scotland shows a marked tendency to cluster (Figure 5), and it is thought that the exchange of Arran pitchstone may have been organized in a complex network based on redistribution centres. Two fall-off curves were produced, one for the area north of Arran (Figure 6), and one for the remaining parts of Scotland and northern Britain (Figure 7). They suggest that two different mechanisms may have been involved: on the Irish and British mainlands, redistribution occurred via very large centres, supplying extensive areas of hinterland, whereas in the western Scottish archipelago and fiord landscape, redistribution occurred via smaller centres on the individual islands and in the fiords.

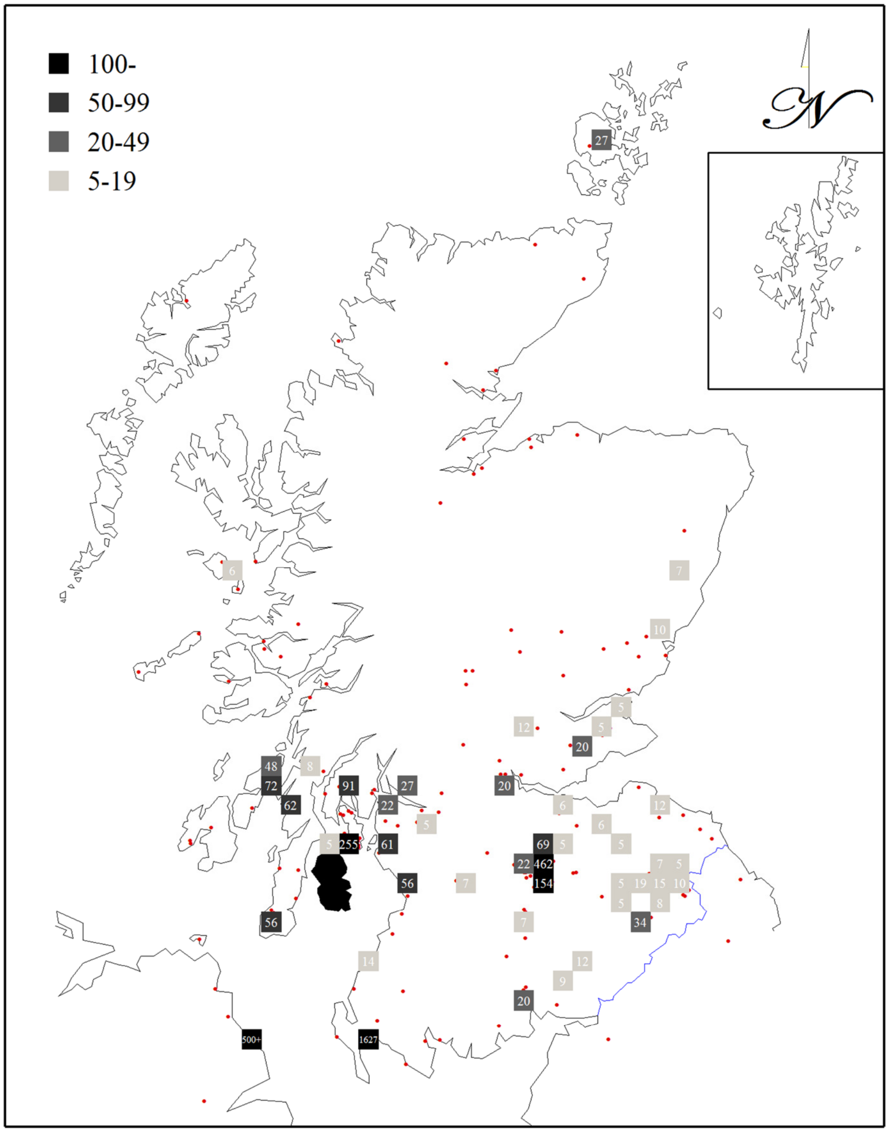

Figure 5. The distribution of worked pitchstone across northern Britain. Arran has been highlighted.

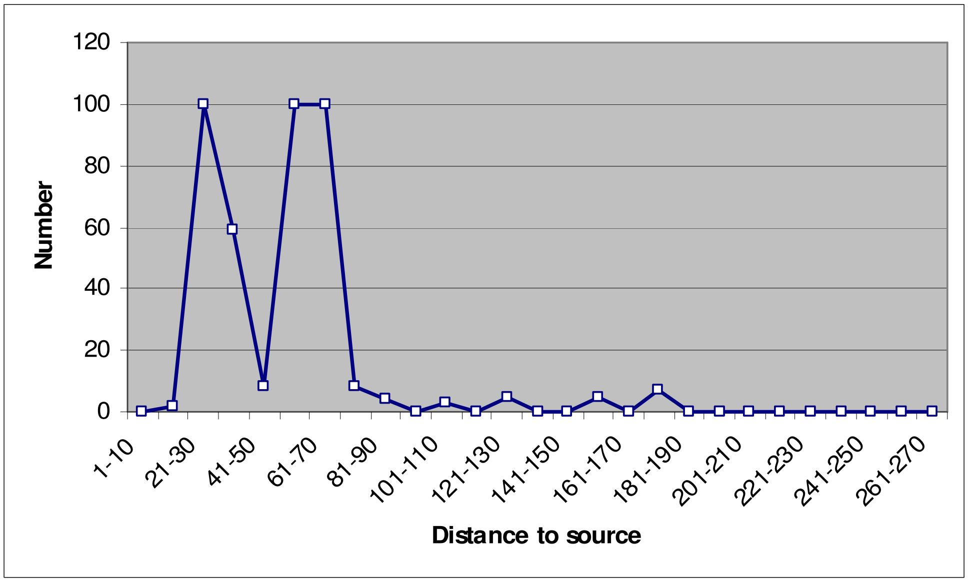

Figure 6. Fall-off curve for the area north of Arran.

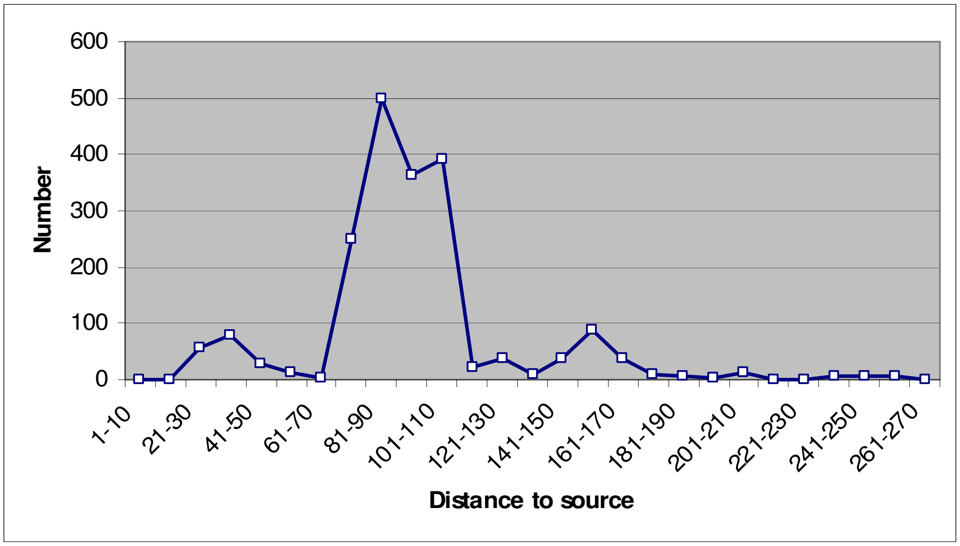

Figure 7. Fall-off curve for the remainder of northern Britain.

3) The frequency of pitchstone clearly declines with growing distance to the sources on Arran, and it is possible to suggest a zonation of Scotland / northern Britain based on this fact: Arran itself represents one zone, characterised by very high proportions of pitchstone and use of volcanic glass throughout the Mesolithic, Neolithic and Early Bronze Age periods (outwith Arran, pitchstone use is largely an Early Neolithic phenomenon); a zone around Arran – involving the western half of southern Scotland and Northern Ireland – is characterised by the presence of vast centres, each counting more than 500 pieces within one 10x10 km square (Fig. 8); in a third zone – SE Scotland and the area around the Firth of Forth (near Edinburgh) – pitchstone is still relatively common, but it does not occur in these exceptional numbers; and in a peripheral zone (up to 400 km from Arran), pitchstone-bearing sites are characterised by the presence of, at most, one or two pieces.

Since the completion of the SAPP, the analyst has carried out another research project (Ballin forthcoming b), which was funded by, and carried out at, the National Museums Scotland, in Edinburgh. This project focused on the Late Neolithic assemblages from Overhowden and Airhouse in the Scottish Borders, south-east Scotland, and the use at these sites of predominantly grey and black flint from north-east England ('Yorkshire flint'). The latter project complements the SAPP, and, combined, the two projects may show how a prehistoric exchange network changed radically at the transition between the Early and Late Neolithic periods: in the Early Neolithic, pitchstone moved through southern Scotland from west towards east, whereas in the Late Neolithic, so-called Yorkshire flint moved in the opposite direction.

Although the SAPP has now been completed, the analyst hopes that it will be possible to continuously update the distribution of Scottish archaeological pitchstone as new finds are being made. One area in need of future attention is the unsolved matter of pitchstone use in England (Ballin 2008). At present, only four pieces have been published from three sites, all recovered immediately south of the Anglo-Scottish border. If Arran pitchstone travelled as far towards the south as it did towards the north (400 km), one should expect to be able to find pitchstone at least as far south as Manchester, and probably further, as the distribution towards the north may mainly have been stopped by the Atlantic Ocean. Most probably, much 'English' pitchstone has simply been misidentified as black chert, dark flint, or glassy slag.

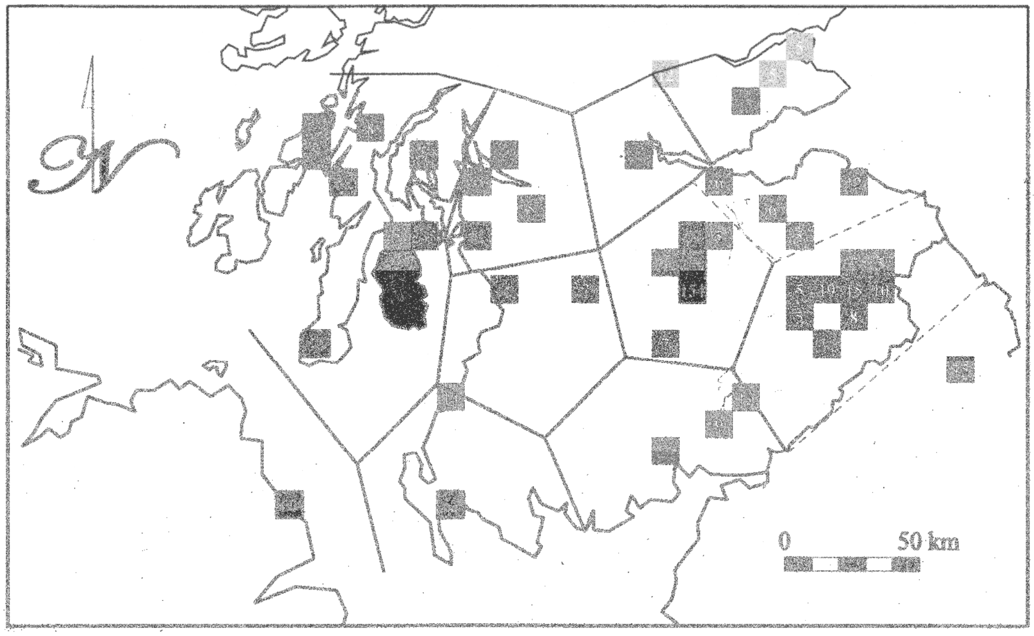

Figure 8. The likely territorial structure of central and southern Scotland – subdivision by Thiessen polygons.

The analyst would like to thank a number of grant-aiding institutions, without the help of which it would not have been possible to carry out this project. They are: Historic Scotland, National Museums Scotland, the Society of Antiquaries of Scotland, the Robert Kiln Trust, and the Catherine Mackichan Bursary Trust.

Bibliography

Ballin, T.B. (2006) Re-examination of the Early Neolithic pitchstone-bearing assemblage from Auchategan, Argyll, Scotland. *Lithics* 27 (2006): 12-32. [http://www.soton.ac.uk/~drus105/LithicsPDFs/Lithics%2027/Lithics_27_2006_Ballin_12_32.pdf]

Ballin, T.B. (2007) The Scottish Archaeological Pitchstone Project. *IAOS (International Association for Obsidian Studies) Bulletin* 37 (Summer), 13-15. [http://members.peak.org/~obsidian/iaos_b37.pdf].

Ballin, T.B. (2008) The distribution of Arran pitchstone – territories, exchange and the 'English Problem'. *PAST* 2008: 10-13.

Ballin, T.B. (2009) *Archaeological Pitchstone in Northern Britain. Characterization and interpretation of an important prehistoric source*. British Archaeological Reports British Series 476. Oxford: Archaeopress.

Ballin, T.B. (forthcoming a) Detailed characterisation and discussion of the pitchstone artefacts from Barnhouse in the light of recent research into Scottish archaeological pitchstone. *The New Orkney Antiquarian Journal*.

Ballin, T.B. (forthcoming b) *The Late Neolithic lithic finds from Airhouse and Overhowden, near the Overhowden Henge, Scottish Borders. Characterization and discussion of two unusual assemblages and their parent sites*. British Archaeological Reports British Series.

Ballin, T.B., & Faithfull, J. (2009) Gazetteer of Arran Pitchstone Sources. Presentation of exposed pitchstone dykes and sills across the Isle of Arran, and discussion of the possible archaeological relevance of these outcrops. *Scottish Archaeological Internet Reports (SAIR)* 38. [http://www.sair.org.uk/sair38/index.html].

Ballin, T.B., & Ward, T. (2008) General characterisation of the Biggar pitchstone artefacts, and discussion of Biggar's role in the distribution of pitchstone across Neolithic northern Britain. [http://www.biggararchaeology.org.uk/pdf_reports/SR_PITCHSTONE_REP_08.pdf]

Ballin, T.B., Barrowman, C., & Faithfull, J. (2009) The unusual pitchstone-bearing assemblage from Blackpark Plantation East, Bute. *Transactions of the Buteshire Natural History Society* XXVII (2008): 23-51.

Emeleus, C.H. & Bell, B.R. (2005) *The Palaeogene volcanic districts of Scotland.* British Regional Geology. Nottingham: British Geological Survey.

Williams Thorpe, O. & Thorpe, R.S. (1984) The Distribution and Sources of Archaeological Pitchstone in Britain. *Journal of Archaeological Science* 11**:** 1-34.

THE ORIGINS OF OBSIDIAN TOOLS FROM KUL TEPE, IRAN

Mostafa Khazaee[1], M.D. Glascock[2], P. Masjedi[1], A. Abedi[1], and F.K. Nadooshan[1]
[1] Tarbiat Modares University, Department of Archaeology, Tehran, IRAN
[2] Research Reactor Center, University of Missouri, Columbia, MO 65211, USA

Abstract

Recent excavations in northwestern Iran at the ancient site of Kul Tepe, located near the city of Jolfa in the province of Eastern Azerbaijan, brought to light several obsidian tools indicating that Kul Tepe was a workshop. In this paper, we report on the provenance results for 53 of the obsidian tools analyzed by X-ray fluorescence (XRF).

Introduction

Obsidian has a special significance in archaeological studies. The fracturing properties of this stone which make it important for tool manufacture and its compositional properties and which are useful for determining source make obsidian ideal for studying trade and exchange. In the mid-1960s, Renfrew and his colleagues (Renfrew *et al.* 1966; 1968) studied obsidian in northwestern Iran. Later, Blackman (1984) demonstrated that long distance trade existed between ancient sites in southern Iran and obsidian sources located in central Anatolia. Renfrew's research on obsidian sources in Anatolia and the Near East focused on sources in central and eastern Turkey, the Lake Van region and several Armenian sources. And, it demonstrated that all obsidian artifacts found in Near East originated from the above-mentioned regions.

More recent research by (Ghorabi *et al.* 2010 and Niknami *et al.* 2009) showed that some obsidian tools might have come from an unknown source located in Iran (perhaps Sahand Mountain). The aim of this research is to determine the origins of the tools from Kul Tepe to establish a better understanding of trade and exchange between the prehistoric cultures in this region.

The site of Kul Tepe (E 45° 39' 43"- N 38° 50' 19", 967m asl) shown in Figure 1, located near the city of Jolfa (Alamdar - Gargar), is a *tell* about 4-6ha in extent and rises 19m above the surrounding land. The site was originally discovered by an expedition to the East Azerbaijan province in 1968 under the supervision of Kambakhshfard, and was later reported by Omrani (1994). New excavations, by two of us, retrieved different materials from the Late Chalcolithic, Bronze Age, Iron III, Urartian and Parthian periods, with fragments of bone as well as lithic specimens made of chert and obsidian (Abedi *et al.* 2009, Khatib Shahidi and Abedi 2011).

The first season of excavation at Kul Tepe was carried out from June to August 2010. The excavation yielded materials from different time periods. According to a new excavation that took place at Ovçular Tepesi (Bakhshaliyev et al. 2010; Marro et al. 2010) and also according to our first comparative analysis of potsherds from the adjacent site of the Kul Tepe in the Nakhichevan region with absolute C14 dating, Kul Tepe is contemporaneous with Ovçlar Tepesi, namely Late Chalcolithic Period. Upper levels revealed different material culture from the Early, Middle and Late Bronze ages. During these periods, Kul Tepe reached its maximum extent. Our preliminary investigation of materials (i.e., distinctive black-burnished ware of Early Bronze Age, a circular house, animal figurines, and bronze objects) indicates cultural relations with sites in the Trans-Caucasus, Eastern Anatolia and the Lake Urmia Basin. Bronze Age materials have direct similarity with Kul Tepe I, Kul Tepe II, Nakhichevan, Maxta and most of the southern Caucasus sites, and also with Tepe Baruj, Yanik Tepe, Geoy Tepe, Tepe Haftavan, and the Lake Urmia Basin. The uppermost layers at Kul Tepe encompass materials from historical periods especially the Iron III, Urartian and Parthian periods (Khatib Shahid and Abedi 2011).

Experimental

A total of 53 obsidian artifacts from the site of Kul Tepe were submitted to the Archaeometry Laboratory at the University of Missouri Research Reactor (MURR) for non-destructive analysis by energy dispersive XRF. The artifacts ranged in size from about 4mm to 1.5cm in diameter and 1mm to 3mm in thickness.

The artifacts were analyzed using a Bruker III-V XRF spectrometer. The spectrometer is equipped with an air-cooled rhodium anode with 140 micron Be window and a thermoelectrically cooled Si-PIN diode detector. The detector has a resolution of 180 eV for the 5.9 keV peak from iron. Beam dimensions are approximately 2 x 3 mm. The X-ray tube was operated at 40 kV using a tube current of about 17 μA yielding in a count rate of about 1,200 counts per second. Measurement times were 180 seconds. Peak deconvolution and element concentrations were determined using the Bruker analysis software which enabled reliable measurement for eight elements (Fe, Zn, Ga, Rb, Sr, Y, Zr, and Nb) in most obsidian. Calibration for the instrument is based on the compositional data collected on a series of well-characterized source samples from the MURR obsidian reference collection, including eleven Mesoamerican sources (El Chayal, Ixtepeque, San Martin Jilotepeque, Guadalupe Victoria, Pico de Orizaba, Otumba, Paredon, Sierra de Pachuca, Ucareo, Zaragoza, and Zacualtipan) and three Peruvian sources (Alca, Chivay, and Quispisisa). Consensus values for these source samples were previously determined by NAA and XRF at MURR and in a round-robin exercise with several other XRF laboratories.

Prior to arrival of the obsidian artifacts from Kul Tepe, the Archaeometry Laboratory had analyzed samples from sources in eastern Turkey, Armenia, Azerbaijan, Georgia, and Iran using source specimens obtained from other obsidian researchers, including Jim Blackman (Smithsonian Institution), Bastien Varoutsikos (graduate student at Harvard University), Bernard Gratuze (CNRS-France) and Ellery Frahm (University of Minnesota). One sample purportedly from the Sahand Mountain source in Iran was also analyzed. The current Near East database consists of 215 obsidian source samples from 21 different sources all of which were analyzed by neutron activation analysis (NAA) and XRF. The map in Figure 2 shows the locations of the Near East obsidian sources previously analyzed.

Examination of the compositional data determined that most, but not all, of sources could be successfully differentiated from one another by either XRF or NAA. The main exceptions were some of the neighboring subsources in Armenia which were found to be chemically similar on the elements possible by XRF. Due to this similarity, the samples from Metz Arteni and Pokr Arteni were combined into a single Arteni compositional group; samples from Geghasar and Spitaksar were combined to create the Gegham compositional group; and samples from Sevkar, Metz Sevkar, Satanakar, Metz Satanakar, and Pokr Satanakar were combined to create the Syunik compositional group. For studies requiring a more detailed differentiation between the above-mentioned subsources, use of NAA can accomplish that.

Results and Conclusions

The compositional data for the artifacts from Kul Tepe was tabulated and compared to the database for sources from the Near East. A scatterplot of the results is shown in Figure 3 where the ratios for Rb/Sr are plotted against the ratios for Zr/Nb for each artifact. The use of ratios helps to compensate for the limitations due to the range of size and thickness of samples incurred when using energy dispersive XRF to analyze the samples. From the plot and related tabulation, it was possible to determine that the 53 artifacts from the site of Kul Tepe came from eight different sources. The sources are: Syunik (41 artifacts), Meydan Tepe (4 artifacts), Nemrut Dag (2 artifacts), Geghasar (1 artifact), Bazenk (1 artifact), Choraphor (1 artifact), Gutansar (1 artifact), and unassigned (1 artifact).

Our conclusion is that the site of Kul Tepe was involved in an extensive network of trade and exchange of obsidian. The main source of obsidian to the workshops in Kul Tepe was Syunik but obsidian sources as far as west as the Lake Van region and as far north as Gutansar were also utilized.

Acknowledgements

We acknowledge James Blackman, Bastien Varoutsikos, Bernard Gratuze and Ellery Frahm who provided source samples from Turkey, Armenia, Georgia, and Azerbaijan to enable an obsidian source database for the ancient Near East to be established in the Archaeometry Lab at MURR. We also thank our student Alex Brechbuhler who measured the artifacts by XRF in

the Archaeometry Lab. Any errors in this paper are the responsibility of the authors.

References

Abedi, A., B. Omrani and N. Eskandari (2009). Kul Tepe: An Early Bronze Age Site in NW Iran. *Antiquity* 83, Issue 322. Available at: http://antiquity.ac.uk/projgall/abedi322/

Bakhshaliyev, V., C. Marro and S. Ashurov (2010). Ovçulartepesi (2006-2008- ci il tadqiqatlarinin ilk naticalari. First Preliminary Report: the 2006-2008 seasons), Baki: Elm, 156s.

Blackman, M.J. (1984). Provenance studies of Middle Eastern obsidian from Sites in Highland Iran, in *Archaeological Chemistry-III* (ed. J. B. Lambert), pp. 19-50, Advances in Chemistry Series 205, American Chemical Society, Washington, DC.

Ghorabi, S., F. Khademi Nadooshan, M.D. Glascock, A. Hejabara Noubari and M. Ghorabani, (2010). Provenance of obsidian tools from northwestern Iran using X-Ray fluorescence analysis and neutron activation analysis. *IAOS Bulletin* No.43, p. 14-20.

Khatib Shahidi, H. and A. Abedi, 2011. Excavations at Kul Tepe of Jolfa, unpublished report prepared for ICHHTO (in Persian).

Marro, C., V. Bakhshaliyev and S. Ashurov (2010). Excavation at Ovçular Tepesi (Nakhichevan, Azerbaijan). First Preliminary Report: the 2006-2008 seasons. Anatolia Antiqua, IFEA, Paris.

Niknami, K., A.C. Amirkhiz and M.D. Glascock (2009). Provenance studies of Chalcolithic obsidian artifacts from near Lake Urmia, northwestern Iran using WDXRF analysis. *Archaeometry* 52(1): 19-30.

Omrani, B. (1994). Simay-e bastanshenasi-e shargh-e daryachey-e Urmia az dorey-e nosangi ta asr-e ahan, payanname-e karshenasiearshad bastanshenasi, daneshkade adebiat, daneshga-e Tehran (unpublished in Persian).

Renfrew, C., G.R. Cann and J.E. Dixon (1966). Obsidian and early cultural contact in the Near East. *Proceedings of the Prehistoric Society* 32: 30-72.

Renfrew, C., G.R. Cann and J.E. Dixon (1968). Further analysis of Near Eastern obsidians. *Proceeding of the Prehistoric Society* 34: 319-331.

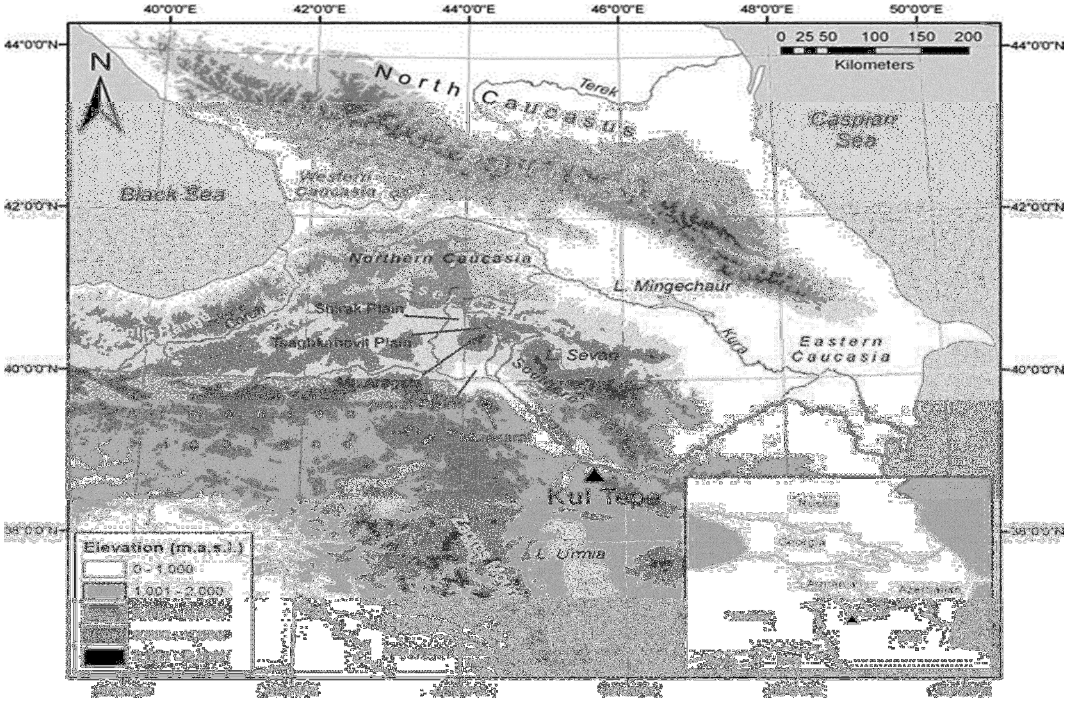

Figure 1. Map showing the location of Kul Tepe in the northwest of Iran.

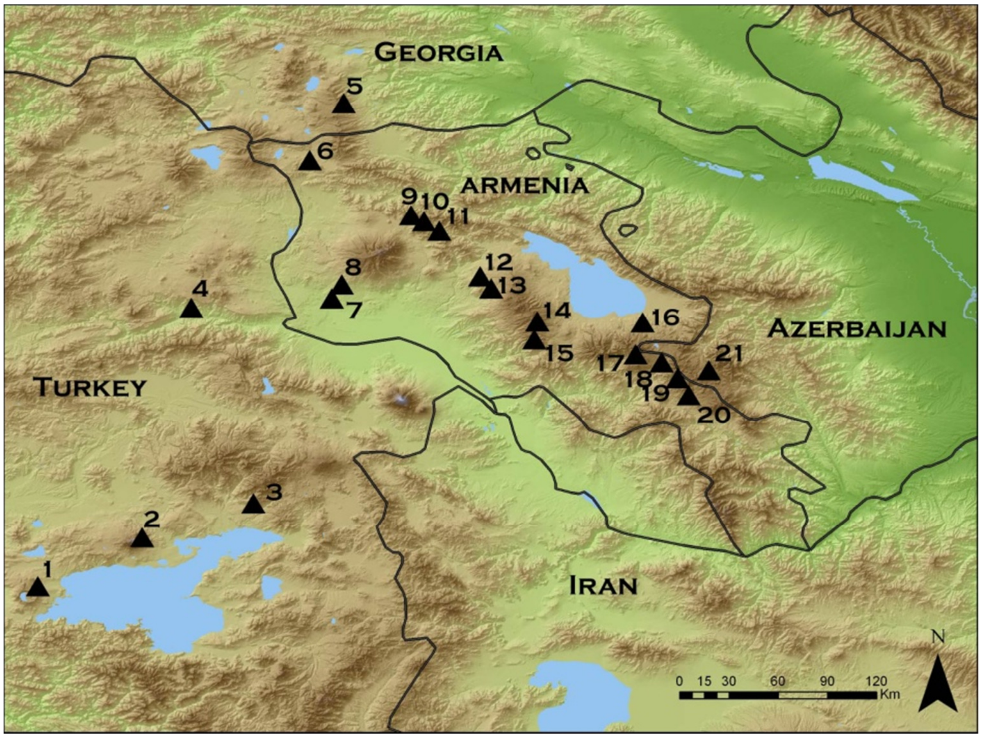

Fig. 2. Maps showing locations of obsidian sources from the Near East analyzed by XRF and NAA in the Archaeometry Lab at MURR. Source names are as follows: (1) Nemrut Dag; (2) Suphan Dag; (3) Meydan Tepe; (4) Sarikamis; (5) Chikiani; (6) Ashotsk; (7) Pokr Arteni; (8) Metz Arteni; (9) Damlik-Hankavan; (10) Tsaghkunyats; (11) Kamakar ; (12) Gutansar ; (13) Hatis ; (14) Geghasar; (15) Spitaksar; (16) Vardenis; (17) Choraphor; (18) Satanakar; (19) Sevkar; (20) Bazenk; and (21) Kelbadzhar.

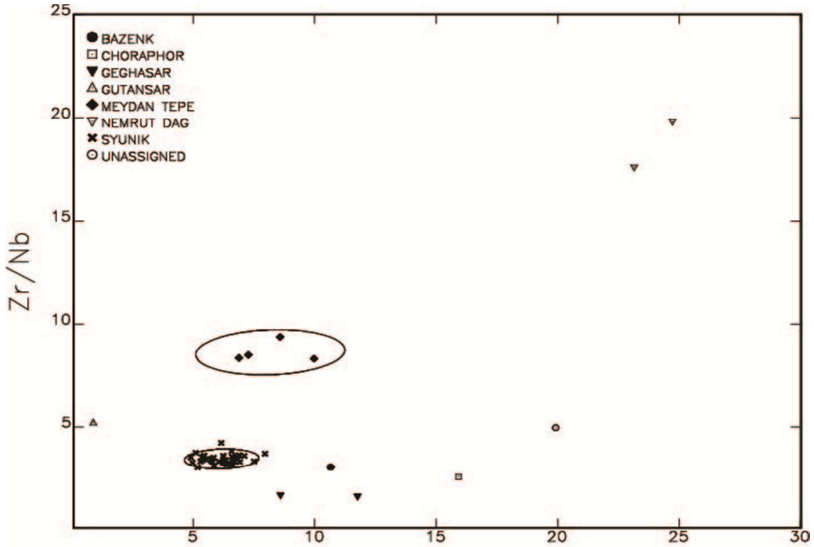

Fig. 3. Scatterplot of Rb/Sr versus Zr/Nb for obsidian artifacts from the site of Kul Tepe, Iran grouped by assigned source. Ellipses are plotted at the 90% confidence level.

DO FLOW-SPECIFIC HYDRATION RATES IMPROVE CHRONOLOGICAL ANALYSIS?
A CASE STUDY FOR COSO OBSIDIAN

Alexander K. Rogers, MA, MS, RPA
Archaeology Curator, Maturango Museum

Abstract

It has long been known that obsidians from different flows in the Coso volcanic field do not hydrate at the same rate. This paper develops flow-specific rates for four Coso flows: West Sugarloaf, Sugarloaf Mountain, West Cactus Peak, and Joshua Ridge. Three of these flow-specific rates are applied to chronological analysis of a collection of fluted points from Rose Valley in Inyo County, eastern California. The analysis demonstrates that flow-specific rates can, in some cases, improve the quality of chronological analysis with obsidian hydration dating.

Introduction

Flow-specific hydration rates in the Coso volcanic field have been the subject of research for years (e.g. Stevenson and Scheetz 1989; Stevenson et al. 1993, 1998, 2000; Rogers 2008a), but did not seem to yield archaeologically-valid results (Gilreath and Hildebrandt 1997). The recent measurement of hydration rims for nine fluted points from three Coso obsidian flows, recovered from the same general provenience, provides a basis for a case study.

The archaeological collection of the Maturango Museum in Ridgecrest, California, contains, *inter alia*, a collection of Paleoindian points from Rose Valley in southern Inyo County, California (the Borden Collection, Acc. No. 08.29). The Coso volcanic field adjoins Rose Valley on the east, so plentiful high-quality obsidian is available as tool stone. Rose Valley itself was the outflow channel during the Pleistocene for glacial Owens Lake. During the desiccation following the last glacial maximum, the valley was the location of wetlands and oxbow lakes, where fauna in the valley were apparently exploited by local populations. The valley is a desert today (Figure 1).

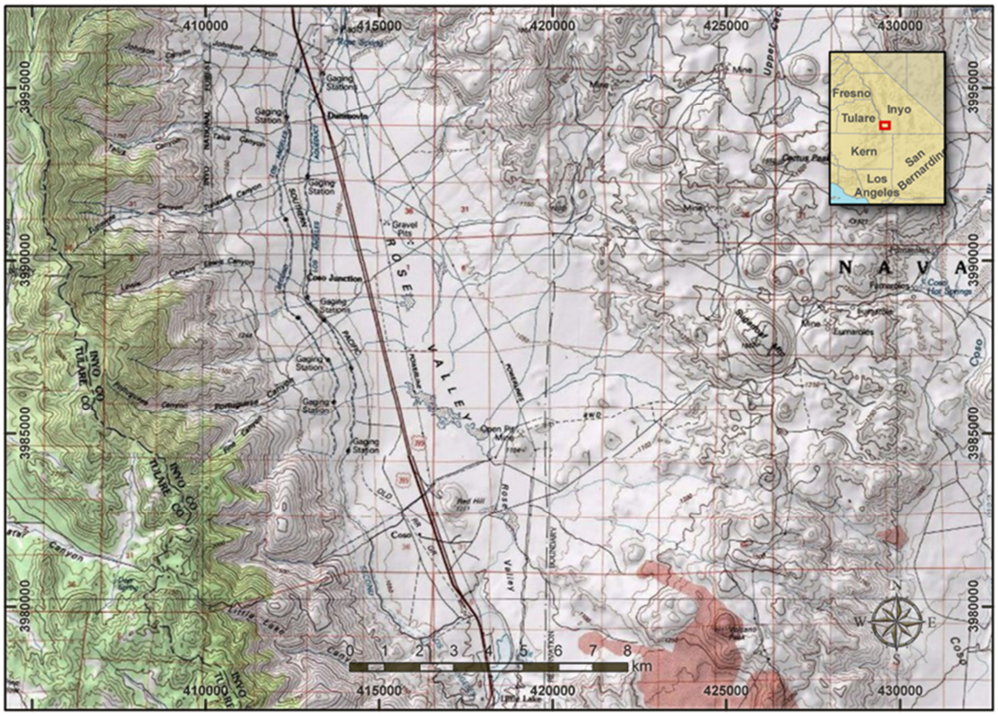

Figure 1. Rose Valley, southern Inyo County, California. Borden points were surface-collected along ancient river banks east of Coso Junction.

Among the obsidian points are fourteen which are concave-based, including the nine fluted points (Rondeau 2009a, 2009b) which are the subject of this study. The fluted points were manufactured from obsidians from West Sugarloaf, West Cactus Peak, and Sugarloaf Mountain. They were recovered around 1970 by the late Mr. Ferris Borden under the auspices of the Archaeological Survey Association. All were recovered from shallow or surface contexts near the ancient river channels of the glacial Owens River.

This paper develops flow-specific rates for four Coso flows: West Sugarloaf (WSL), Sugarloaf Mountain (SLM), West Cactus Peak (WCP), and Joshua Ridge (JRR). The flow-specific rates are the applied to chronological analysis of the nine fluted points. The hydration dating analysis employs temperature dependent diffusion theory (Rogers 2007); the specific algorithms are described in Rogers 2011a. The analysis demonstrates that flow-specific rates improve the quality of chronological analysis in this case, and alter the archaeological conclusions to be drawn from the data.

In the analysis that follows, all ages are in calibrated years before 2000 (cyb2k)

Flow-Specific Rates: Sugarloaf Mountain Flow

Stevenson and Scheetz reported flow-specific hydration rates determined by induced hydration in the laboratory for WSL and SLM obsidians (Stevenson and Scheetz 1989: 25, Table 2 - note that sample 4-1 corresponds to SLM and 1-1 corresponds to WSL). The technique involves hydrating obsidian at elevated temperatures ($100 < T < 170°C$), measuring the hydration rims, and scaling to temperatures of archaeological interest.

It is known that the hydration rate depends on temperature by the Arrhenius equation (Doremus 2002)

$$k = Ae^{(-E/T)} \qquad (1)$$

where k is rate in μ^2/yr, A is the diffusion constant in μ^2/yr, E is the activation energy in °K, and T is temperature in °K. Further, it is known that

$$r^2 = kt \qquad (2)$$

where r is the hydration rim in μ and t is age in years (Doremus 1994, 1999, 2002; Friedman and Long 1976; Friedman and Smith 1960; Stevenson et al. 1989, 1998, 2004). Eliminating k between the two equations gives

$$r^2/t = Ae^{(-E/T)} \qquad (3)$$

or, in logarithmic form

$$\ln(r^2/t) = \ln(A) - E/T \qquad (4)$$

Defining $y = \ln(r^2/t)$ and $x = 1/T$, equation (4) becomes a linear equation in two unknowns, which can be solved for ln(A) and E by a linear least-squares best fit. The parameter A can then be computed from ln(A), and the computed values of E and A can then be used in equation (1) to compute k at any desired temperature. The least-squares computation requires inclusion of weighting factors $w_i = r_i^2/t_i$ to compensate for the logarithm in the definition of y (Cvetanovic et al. 1979); the protocol is described in detail in Rogers 2011b.

Stevenson and Scheetz reported data for both the SLM and WSL flows. However, only the SLM data are used in the present study, because anomalies appeared in the WSL data set during analysis. In particular, the WSL data when plotted are not as smooth as the SLM data, and the numerical results are very sensitive to the inclusion or exclusion of particular data points. Unfortunately, the authors did not describe their algorithm or treatment of the data in detail, so the calculation cannot be reconstructed. With the SLM data, by contrast, the plotted data are smooth, and inclusion or exclusion of any data point has little effect on results. Based on these considerations a decision was made to use the SLM data from Stevenson and Scheetz 1989 to compute obsidian parameters for this flow, but not the WSL data.

The SLM data were analyzed by the algorithm described above (weighted linear best fit to equation 4). The obsidian parameters A and E, which are independent of temperature, were determined and used to compute the hydration rate k at 20°C. Results are presented in Table 1, which agree reasonably well with Stevenson and Scheetz (1989).

Parameter	Units	Mean	Std. Dev
A	μ^2/yr	1.18E+13	6.90E+12
E	°K	9875	213
k @ 20 deg C	μ^2/1000 yr	28.5	6.3

Table 1. Obsidian Parameters for Sugarloaf Mountain Source

Scaling of Rates for Other Flows

The hydration rates for WSL, WCP and JRR were computed by a different technique: scaling from the SLM rate based on intrinsic water content. Both theory and experimental results suggest that the hydration rate of obsidian should be directly proportional to the intrinsic water concentration (Karsten and Delaney 1981; Karsten et al. 1982; Rogers 2008a; Zhang and Behrens 2000; Zhang et al. 1991). Thus, if the hydration rate and water concentration are known for one obsidian source, the rates for other sources can be inferred if their corresponding concentrations are known.

Stevenson et al. (1993) suggested the dominant factor affecting rate is the hydroxyl ion (OH^-) concentration rather than the H_2O concentration; however, since the two are roughly proportional (Ambrose and Stevenson 2004; Zhang et al. 1991), the effect is the same. To complicate matters further, Zhang and Behrens (2002) developed a relationship which scales rate based on total water concentration. For the present study, scaling is performed on all three bases and the results compared.

The data used for scaling here are those of Stevenson et al. (1993) as refined by Rogers (2008a). Concentration of total water is given by [Total Water] = $[H_2O]$ + $[OH^-]$. Total water concentration for these flows lies between 1 – 2% wt; Table 2 provides details.

Source	$[H_2O]$	$[OH^-]$	Total Water
SLM	1.02	0.80	1.82
WSL	0.62	0.48	1.10
WCP	1.01	0.71	1.72
JRR	0.81	0.62	1.43

SLM = Sugarloaf Mountain
WSL = West Sugarloaf
WCP = West Cactus Peak
JRR = Joshua Ridge

Table 2. H_2O and OH^- Concentrations in Coso Obsidians (wt %)

If rate is directly proportional to concentration, then the rate of an unmeasured source can be inferred from that of a known source by

$$k_u = k_{SLM} \times [u] / [SLM] \qquad (5)$$

where k_u be the rate for a source whose rate is unknown, [u] is the water concentration (OH^-, H_2O, or total) for that source, k_{SLM} is the rate for the SLM source, and [SLM] is the corresponding concentration for SLM.

If this calculation is performed using the concentration data of Table 2 and a rate for SLM of 28.50 μ^2/1000 yrs from Table 1, the resulting hydration rates are 17.21 μ^2/1000 yrs for WSL, 26.76 μ^2/1000 yrs for WCP, and 22.36 μ^2/1000 yrs for JRR, at an effective hydration temperature (EHT) of 20°C. Details are shown in Table 3; in this case the resulting rates for each scaling method agree very closely, so the simple average of the three methods was used for chronological analysis. Further, based on the linear model of equation 5, the coefficient of variation (CV) of the hydration rate is simply equal to the CV of the intrinsic water concentration, and is also shown in Table 3. (Stevenson et al. 1993; Rogers 2008a).

Averaging the flow-specific rates to compute a composite rate yields 23.71 μ^2/1000 yrs, which agrees well with previously-published data for the Coso volcanic field based on obsidian-radiocarbon association (e.g. Rogers 2008b, 2009; Rogers and Yohe 2011).

Obsidian Hydration Dating Procedures

Obsidian hydration dating is based on application of equation 2, with appropriate corrections for obsidian source and temperature history, characterized by EHT. The rate k employed is specific to an obsidian source, and the hydration rim values r are adjusted to the same EHT as k. In the case of Coso obsidian the current best aggregate rate for the Coso volcanic field is 23.42 μ^2/1000 cal. years (Rogers and Yohe 2011).

The archaeologist performing an OHD analysis must make a number of assumptions, some of which are tacit. First, it is obviously best to have as large a sample size as possible, which encourages aggregation of hydration rim readings. Usually specimens are aggregated if they have the same provenience (location and burial depth) and

	Hydration Rate, μ^2/1000 yrs				
Source	$[H_2O]$ Scaling	$[OH^-]$ Scaling	[Total Water] Scaling	Mean	CV
SLM	-	-	-	28.50	0.18
WSL	17.32	17.10	17.23	17.21	0.26
WCP	28.22	25.29	26.93	26.76	0.53
JRR	22.63	22.09	22.39	22.36	0.37

SLM = Sugarloaf Mountain
WSL = West Sugarloaf
WCP = West Cactus Peak
JRR = Joshua Ridge

Table 3. Scaled Hydration Rates, Coso Volcanic Field, 20°C EHT

Spec. No.	Cut Seq. No.	Mean rim, u	Flow	Remarks
1	1	3.2	WSL	Exclude by Chauvenet's criterion.
1	2	15.3	WSL	
3	5	18.5	WSL	
4	6	14.6	WSL	
4	7	14.8	WSL	
4	8	14.9	WSL	
5	9	13.0	WSL	
5	10	13.0	WSL	
2	3	15.7	SLM	
2	4	24.6	SLM	
7	13	22.1	SLM	
6	11	16.0	WCP	
6	12	17.0	WCP	
14	16	21.0	WCP	

WSL = West Sugarloaf
SLM = Sugarloaf Mountain
WCP = West Cactus Peak

Table 4. Hydration Data for Borden Fluted Points.

stem from the same obsidian source. In Coso analyses the various flows are not treated as separate sources, and artifacts tend to be aggregated regardless of flow (e.g. Gilreath and Hildebrandt 1997; Rogers 2008b). In other cases samples which appear bimodal may be separated, especially if the peaks are statistically distinguishable. The present analysis treats three cases: partitioning the sample based on obsidian flow and using flow-specific rates; aggregating the sample and using a single aggregated rate; and partitioning the sample based on flow but using the single aggregated rate. It will be shown that the three techniques yield different conclusions.

Case Study: Borden Fluted Points

The data set contains fluted points which were manufactured from WSL, SLM, and WCP obsidians. Source and hydration rim data are presented in Table 4; non-fluted points, and one fluted point from Fish Springs obsidian, have been excluded. In some cases more than one measurement was made on a given point, leading to fourteen individual rim measurements.

Flow	Mean, u	SD, u	CV	N
WSL	14.9	1.85	0.12	7
SLM	20.8	4.59	0.22	3
WCP	18.0	2.65	0.15	3
SLM+WCP	19.4	3.69	0.19	6
Aggregated	17.0	3.59	0.21	13

Table 5. Hydration rim statistics for Borden fluted points.

Coso Obsidian Flows

The Coso data points in Table 4 are grouped by obsidian flow; one data point was excluded from the WSL data set by Chauvenet's criterion (seq. no. 1 at 3.2µ). Hydration rim means and standard deviations of the resulting data sets were computed (Table 5), which shows that the mean value of the hydration rims for WSL artifacts (14.9 ± 1.85µ) is noticeably smaller than those from SLM (20.8 ± 4.59µ) or WCP (18.0 ± 2.65 µ). Applying Student's t-test shows that WSL specimens can be distinguished from other Coso sources at the 95% confidence level.

This difference in mean rim value could be due to any of three factors: differing hydration rates of the obsidian flows, a different temperature history (EHT), or different ages. Since the points are similar in typology and manufacture, and are from the same provenience, there is no reason to suspect different ages or different EHT. The hypothesis is adopted that the artifacts actually represent essentially the same age but hydrated at different rates.

Hydration rim data from the WCP and SLM sources cannot be distinguished from each other at the 95% level, so for further analysis they are combined into a single data set (19.4 ± 3.69µ) . This expectation is further supported by examination of the SLM and WCP rates and their respective CV values in Table 3; an estimate based on Student's t-test shows that a sample size >14 for each flow would be required to distinguish between them.

Table 5 presents the hydration rim statistics for the Borden fluted points; the last line in the table, labeled "Aggregated", treats the entire data set as an entity (17.0 ± 3.59µ).

Age Analysis with Flow-Specific Rates

Ages (t) for the Borden fluted points were computed from

$$t = (r \times RCF)^2 / k, \qquad (6)$$

where r is the mean hydration rim from Table 4, k is the rate from Table 3, and RCF is the rim correction factor to correct for the EHT difference between the site and the reference EHT. For the case of SLM+WCP obsidians, the rate employed is the average of the individual rates for the two sources (27.66 μ^2/1000 yrs.).

Temperature parameters for the site are computed by regional temperature scaling, based on a site altitude of 3420 ft amsl, yielding an EHT of 20.56°C (Rogers 2008c). The reference EHT is 20°C, so the rim correction factor to control for the EHT difference is 0.967. Surface conditions are assumed for the finds. The age computation did not include a correction for paleotemperature change (Rogers 2010a).

The standard deviation of age σ_t is (Rogers 2010b)

$$\sigma_t = 2 \times CV_r \times t \qquad (7)$$

where CV_r is the coefficient of variation of the rim from Table 2 and t is age from equation 6.

	Rate,	Age, cyb2k			
Flow	u^2/1000y	Mean	SD	CV	N
WSL	17.21	12005	2986	0.25	7
SLM+WCP	27.66	12723	4834	0.38	6

Table 6. Ages for Borden fluted points

For the WSL points, the age computation yields 12,005 ± 2986 cyb2k, while the age for the SLM+WCP data set is 12,723 ± 4834 cyb2k (Table 6). Applying Student's t-test shows that the ages cannot be distinguished at the 95% confidence level, which supports the hypothesis that the apparent difference in age could be accounted for by differences in hydration rate.

Since the mean ages cannot be distinguished statistically, they may be combined for an estimate of the age of the complete set of fluted points. Computing a weighted average of both mean and variance results in an age for the Borden fluted points of 12,337 cyb2k, with a probable error of 1,095 yrs and a standard deviation of 3,848 years. The coefficient of variation is 0.32.

	Age, cyb2k			
Method	Mean	SD	CV	PE
Flow-specific	12337	3948	0.32	1095
Aggregated	11485	4863	0.42	1349

Table 7. Age comparison for Borden fluted points: flow-specific rates vs. aggregate rate.

Aggregate Rate, Aggregated Data Set

The usual way to compute the age would be to use a rate for the Coso volcanic field, and hydration rim data for the Aggregated case (Table 5). The best available estimate for the aggregate rate for the Coso field is 23.42 μ^2/1000 cal. years (Rogers and Yohe 2011). Using these values in equations 6 and 7 yields an age of 11,485 cyb2k, with a standard deviation of 4,863 years and a coefficient of variation of 0.42.

Aggregate Rate, Partitioned Data Set

An alternative approach would be to partition the data set, treat the WSL and SLM+WCP samples as independent, and compute ages using the aggregate rate value for the Coso volcanic field. This procedure represents a very likely analytical scenario, and is fully justifiable statistically, since the WSL and SLM+WCP data sets are distinguishable by Student's t-test. If this is done the age computed for the WSL sample is 8,864 ± 2,127 cyb2k, and the age of the SLM+WCP sample is 15,027 ± 5,710 cyb2k. The respective values of CV are 0.24 and 0.38.

Discussion and Conclusions

The hydration rim values for the WSL sample are significantly different from those from the SLM+WCP sample (14.9 ± 1.85μ vs. 19.4 ± 3.69μ, respectively). However, the computed ages using flow-specific hydration rates (12,005 ± 2986 cyb2k for WSL, and 12,723 ± 4834 cyb2k for SLM+WCP) are not statistically distinguishable. It is thus reasonable to assume that the artifacts from WSL, WCP, and SLM obsidian were manufactured at essentially the same time (12,337 ± 3848 cyb2k, with a probable error of 1,095 years).

In comparison, if the WSL and SLM+WCP samples had been analyzed using a single aggregated hydration rate, the analysis would have erroneously indicated two separate episodes of manufacture (8,864 ± 2,127 cyb2k and 15,027 ± 5,710 cyb2k). In addition, these are both unrealistic for this point type.

Turning to the method of using an aggregated sample with a single aggregated rate, the computed age is 11,485 ± 4863 cyb2k. This compares with the best estimate of age of 12,337 ± 3948 cyb2k using flow-specific rates. The mean values of these ages are not statistically distinguishable at the 95% confidence level, so the two methods gave essentially the same age. This is partly fortuitous, since the aggregated method is sensitive to the relative sizes of the two samples, and the fraction of WSL and SLM+WCP obsidians is essentially the same in this case (7/13 vs. 6/13); if the proportions were more skewed, the age computed from the aggregate data set would also be more skewed, toward the flow with the larger proportion. The age computed with flow-specific rates would not be affected by such a change in proportions, and hence is more robust. In both cases the analyst would reach the conclusion that the points were manufactured during a single, extended, period.

Analysis using flow-specific hydration rates suggests that the differences in hydration rate fully account for the differences in mean rim value in this case, and that the artifacts from WSL, WCP, and SLM obsidian were manufactured at essentially the same time and experienced similar overall EHT. The remaining spread in hydration rims is probably due to flow-specific variability in intrinsic water and to minor differences in temperature history. As a caveat, it should be noted that the ages computed are a minimum, assuming surface conditions; if the points were buried at a significant depth for part of their existence, the actual ages corresponding to the measured hydration rims values would be older. Finally, for simplicity of comparison, the calculation did not include a correction for paleotemperature variation.

Aside from the mean value of age, it is clear that use of flow-specific rates improves the precision of the age estimate. The flow-specific method results in a considerably smaller standard deviation of the ages, and a reduction of nearly 20% in the probable error (PE, Table 7).

Conclusions

It appears that use of flow-specific hydration rates in OHD analyses yields a more robust value of age in this case, with better precision. The ages computed agree with expected ages for this point type, and reinforce the idea of a single manufacturing episode instead of two widely-separated episodes. It will not compensate for intra-flow variations in hydration rate due to intrinsic water variations, but it will at least correct for rate differences between flows due to the mean water content of each flow.

References Cited

Ambrose, W. R., and C. M Stevenson (2004) Obsidian Density, Connate Water, and Hydration Dating. *Mediterranean Archaeology and Archaeometry* 4(2):5-16.

Cvetanovic, R. J., D. L. Singleton, and G. Paraskevopoulos (1979) Evaluations of the Mean Values and Standard Errors of Rate Constants and their Temperature Coefficients. *Journal of Physical Chemistry* 83(1):50-60.

Doremus, R. H. (1994) *Glass Science*, 2nd. ed. New York: Wiley Interscience.

Doremus, R. H. (2000) Diffusion of Water in Rhyolite Glass: Diffusion-reaction Model. *Journal of Non-Crystalline Solids* 261 (1):101-107.

Doremus, R. H. (2002) *Diffusion of Reactive Molecules in Solids and Melts*. New York: Wiley Interscience.

Friedman, Irving, and W. Long (1976) Hydration rate of obsidian. *Science* 191(1976):347-352.

Friedman, Irving, and R. A. Smith (1960) New Method of Dating using Obsidian; Part 1, The Development of the Method. *American Antiquity* 25 (4):476-522.

Gilreath, A. J., and W. R. Hildebrandt (1997) *Prehistoric Use of the Coso Volcanic Field.* No. 56, Contributions of the University of California Archaeological Research Facility. Berkeley.

Karsten, J. R., and J. L. Delaney (1981) Ion microprobe studies of water in silicate melts: concentration-dependent water diffusion in obsidian. *Earth and Planetary Science Letters* 52: 191-202.

Karsten , J. L., J. R. Holloway, and J. L. Delaney (1982) Ion microprobe studies of water in silicate melts: temperature-dependent water diffusion in obsidian. *Earth and Planetary Science Letters* 59:420-428.

Rogers, Alexander K. (2007) Effective Hydration Temperature of Obsidian: A Diffusion-Theory Analysis of Time-Dependent Hydration Rates. *Journal of Archaeological Science* 34:656-665.

Rogers, Alexander K. (2008a) Obsidian Hydration Dating: Accuracy and Resolution Limitations Imposed by Intrinsic Water Variability. *Journal of Archaeological Science*. 35:2009-2016.

Rogers, Alexander K. (2008b) An Evaluation of Obsidian Hydration Dating as a Chronometric Technique, Based on Data from Rose Spring (CA-INY-372), Eastern California. *Bulletin of the International Association for Obsidian Studies,* No. 40, Winter 2008, pp. 12-32.

Rogers, Alexander K. (2008c) Regional Scaling for Obsidian Hydration Temperature Correction. *Bulletin of the International Association for Obsidian Studies No. 39*, Summer 2008, pp. 15-23.

Rogers, Alexander K. (2009) An Estimate of Coso Obsidian Hydration Rate, Based on Obsidian-Radiocarbon Pairings and the "Weighted Total Least-Squares" Method. *Bulletin of the International Association for Obsidian Studies,* No. 41, Summer 2009, pp. 9-20.

Rogers, Alexander K. (2010a) How Did Paleotemperature Change Affect Obsidian Hydration Rates? *Bulletin of the International Association for Obsidian Studies,* No. 42, Winter 201, pp. 13-20.

Rogers, Alexander K. (2010b) Accuracy of Obsidian Hydration Dating based on Radiocarbon Association and Optical Microscopy. *Journal of Archaeological Science*. 37: 3239-3246.

Rogers, Alexander K. (2011a) *Chronological Analysis by Obsidian Hydration Dating (OHD): Theory and Algorithms.* Maturango Museum Working Manuscript MS70, Rev D, Dated 22 March 2011. Maturango Museum, Ridgecrest.

Rogers, Alexander K. (2011b) *A Protocol for Calculation of Obsidian Hydration Rate and Intra-Source Variability from Laboratory Measurements*. Maturango Museum Working Manuscript MS80, Rev C, Dated 1 March 2011. Maturango Museum, Ridgecrest.

Rogers, Alexander K., and Robert M. Yohe II (2011) *An Improved Equation for Coso Obsidian Hydration Dating, Based on Obsidian-Radiocarbon Association.* Paper presented at the annual meeting of the Society for California Archaeology, Rohnert Park.

Rondeau, Michael F. (2009a) *A Study of Selected Obsidian Concave Base Points from the Borden Collection, Inyo County, California.* CalFLUTED Research Report No. 62, revised October 2009. Sacramento: Rondeau Archaeological.

Rondeau, Michael F. (2009b) *Research on Additional Bifaces from the Borden Collection, Inyo County, California.* CalFLUTED Research Report No. 69, dated November 2009. Sacramento: Rondeau Archaeological.

Stevenson, C. M., and B. E. Scheetz (1989) Induced Hydration Rate Development of Obsidians from the Coso Volcanic Field: A Comparison of Experimental Procedures. In: *Current Directions in California Obsidian Studies*, R. E. Hughes, ed., pp. 23-30. Contributions of the University of California Archaeological Research Facility No. 48. Berkeley: University of California.

Stevenson, Christopher M., E. Knauss, J. J. Mazer, and J. K. Bates (1993) The Homogeneity of Water Content in Obsidian from the Coso Volcanic Field: Implications for Obsidian Hydration Dating. *Geoarchaeology* 8(5):371-384.

Stevenson, Christopher M., J. J. Mazer, and B. E. Scheetz (1998) Laboratory Obsidian Hydration Rates: Theory, Method, and Application. In: *Archaeological Obsidian Studies: Method and Theory. Advances in Archaeological and Museum Science*, Vol. 3, M. S. Shackley, ed., pp.181-204. New York: Plenum Press.

Stevenson, Christopher M., Mike Gottesman, and Michael Macko (2000) Redefining the Working Assumptions for Obsidian Hydration Dating. *Journal of California and Great Basin Anthropology* 22(2):223-236.

Stevenson, C. M., I. M. Abdelrehim., and S. W. Novak (2004) High Precision Measurement of Obsidian Hydration Layers on Artifacts from the Hopewell Site using Secondary Ion Mass Spectrometry. *American Antiquity* 69(4):555-568.

Zhang, Y., E. M. Stolper, and G. J. Wasserburg (1991) Diffusion of Water in Rhyolytic Glasses. *Geochimica et Cosmochimica Acta* 55:441-456.

Zhang, Y, and H. Behrens (2000) H_2O Diffusion in Rhyolitic Melts and Glasses. *Chemical Geology* 169:243-262.

ABOUT OUR WEB SITE

The IAOS maintains a website at http://members.peak.org/~obsidian/
The site has some great resources available to the public, and our webmaster, Craig Skinner, continues to update the list of publications and must-have volumes.

You can now become a member online or renew your current IAOS membership using PayPal. Please take advantage of this opportunity to continue your support of the IAOS.

Other items on our website include:

- World obsidian source catalog
- Back issues of the *Bulletin.*
- An obsidian bibliography
- An obsidian laboratory directory
- Photos and maps of some source locations
- Links

Thanks to Craig Skinner for maintaining the website. Please check it out!

CALL FOR ARTICLES

Submissions of articles, short reports, abstracts, or announcements for inclusion in the *Bulletin* are always welcome. We accept electronic media on CD in MS Word. Tables should be submitted as Excel files and images as .jpg files. Please use the *American Antiquity* style guide available at www.saa.org/publications/StyleGuide/styFrame.html for formatting references and bibliographies.

Submissions can also be emailed to the *Bulletin* at cdillian@coastal.edu Please include the phrase "IAOS Bulletin" in the subject line. An acknowledgement email will be sent in reply, so if you do not hear from us, please email again and inquire.

Deadline for Issue #46 is November 1, 2011.

Send submissions to:

Carolyn Dillian
IAOS *Bulletin* Editor
c/o Department of History
Coastal Carolina University
P.O. Box 261954
Conway, SC 29528
U.S.A.

Inquiries, suggestions, and comments about the *Bulletin* can be sent to cdillian@coastal.edu Please send updated address information to Kyle Freund at freundkp@mcmaster.ca

MEMBERSHIP

The IAOS needs membership to ensure success of the organization. To be included as a member and receive all of the benefits thereof, you may apply for membership in one of the following categories:

Regular Member: $20/year*
Student Member: $10/year or FREE with submission of a paper to the *Bulletin* for publication. Please provide copy of current student identification.
Lifetime Member: $200

Regular Members are individuals or institutions who are interested in obsidian studies, and who wish to support the goals of the IAOS. Regular members will receive any general mailings; announcements of meetings, conferences, and symposia; the *Bulletin*; and papers distributed by the IAOS during the year. Regular members are entitled to vote for officers.

*Membership fees may be reduced and/or waived in cases of financial hardship or difficulty in paying in foreign currency. Please complete the form and return it to the Secretary-Treasurer with a short explanation regarding lack of payment.

NOTE: Because membership fees are very low, the IAOS asks that all payments be made in U.S. Dollars, in international money orders, or checks payable on a bank with a U.S. branch. Otherwise, please use PayPal on our website to pay with a credit card. http://members.peak.org/~obsidian/

For more information about the IAOS, contact our Secretary-Treasurer:

Kyle Freund
IAOS
c/o McMaster University
Department of Anthropology
Chester New Hall Rm. 524
1280 Main Street West
Hamilton, Ontario, Canada
L8S 4L9
freundkp@mcmaster.ca

Membership inquiries, address changes, or payment questions can also be emailed to freundkp@mcmaster.ca

ABOUT THE IAOS

The International Association for Obsidian Studies (IAOS) was formed in 1989 to provide a forum for obsidian researchers throughout the world. Major interest areas include: obsidian hydration dating, obsidian and materials characterization ("sourcing"), geoarchaeological obsidian studies, obsidian and lithic technology, and the prehistoric procurement and utilization of obsidian. In addition to disseminating information about advances in obsidian research to archaeologists and other interested parties, the IAOS was also established to:

1. Develop standards for analytic procedures and ensure inter-laboratory comparability.
2. Develop standards for recording and reporting obsidian hydration and characterization results
3. Provide technical support in the form of training and workshops for those wanting to develop their expertise in the field
4. Provide a central source of information regarding the advances in obsidian studies and the analytic capabilities of various laboratories and institutions.

MEMBERSHIP RENEWAL FORM

We hope you will continue your membership. Please complete the renewal form below.

NOTE: You can now renew your IAOS membership online! Please go to the IAOS website at http://members.peak.org/~obsidian/ and check it out! Please note that due to changes in the membership calendar, your renewal will be for the next calendar year. Unless you specify, the *Bulletin* will be sent to you as a link to a .pdf available on the IAOS website.

___ Yes, I'd like to renew my membership. A check or money order for the annual membership fee is enclosed (see below).

___ Yes, I'd like to become a new member of the IAOS. A check or money order for the annual membership fee is enclosed (see below). Please send my first issue of the IAOS *Bulletin*.

___ Yes, I'd like to become a student member of the IAOS. I have enclosed either an obsidian-related article for publication in the IAOS *Bulletin* or an abstract of such an article published elsewhere. I have also enclosed a copy of my current student ID. Please send my first issue of the IAOS *Bulletin.*

NAME: ____

TITLE: ________________________ AFFILIATION:_______________________________________

STREET ADDRESS: ____

CITY, STATE, ZIP: ____

COUNTRY: ____

WORK PHONE: _______________________________ FAX: __________________________

HOME PHONE (OPTIONAL): ____

EMAIL ADDRESS: ____

My check or money order is enclosed for the following amount (please check one):
___ $20 Regular
___ $10 Student (include copy of student ID)
___ FREE Student (include copy of article for *Bulletin* and student ID)
___ $200 Lifetime

Please return this form with payment to: (or pay online with PayPal)
Kyle Freund
IAOS
c/o McMaster University
Department of Anthropology
Chester New Hall Rm. 524
1280 Main Street West
Hamilton, Ontario, Canada
L8S 4L9