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NEWS AND INFORMATION

From the President's Desk

by David A. Fredrickson
Sonoma State University (Professor Emeritus)

As I briefly discussed in the Fall 1998 issue of the *IAOS Bulletin*, the IAOS is truly an international organization. Our membership is spread throughout the world, representing 10 countries (including the U.S.A.). Within the U.S.A., 23 states are represented (see below). I'm somewhat surprised that we have no members from Hawaii. Given the wide distribution of our membership, it certainly makes sense for the IAOS annual meeting to be held concurrently with the Society for American Archaeology. But we all know that it isn't possible for all members to attend, and that members often participate in regional meetings. In this issue, we present the program on the effects of fire on obsidian, organized by past president Tom Origer, which will be held at the upcoming meeting of the Society for California Archaeology in Sacramento in April. We also note the archaeometry workshops held at SUNY Buffalo, which will probably have taken place by the time you read this.

I am leading up to what I believe is an important issue. The editors of the bulletin depend upon the membership to provide information regarding upcoming meetings, publications, and work in progress. Communication is important and I would like to suggest that the role of the *IAOS Bulletin* is to keep the membership informed about obsidian-related activities. If you participate in or know about a regional meeting or are involved in an obsidian-related activity, please let the bulletin editors know. They will be pleased to pass information that relates to obsidian issues on to the membership, whether it be about sessions, papers, works in progress, or other kinds of information. Is it too broad a statement to say that anything that pertains to obsidian studies is of relevance to the IAOS membership? I think not.

This issue of the bulletin concludes with an important contribution by past-president Michael Glascock. In a Special Report, Mike presents an inter-laboratory comparison of results in determining obsidian element compositions. We welcome comments and questions from our readership.

In conclusion, I invite any member who has an item that they would like to see on the agenda for the next annual meeting of the IAOS in Chicago to please let me know. My e-mail address is vmda@aol.com—I would like to hear from you.

(For a reminder to our readers who might be curious, the following countries are home to our membership: Argentina, Australia, Canada, France, Greece, Israel, Mexico, New Zealand, Russia, and the United States. The Post Office state abbreviations for the mailing addresses of IAOS members in the United States are AK, AZ, CA, CO, FL, IA, IL, LA, MI, MN, MO, MT, NJ, NM, NV, NY, OH, OR, TN, TX, UT, WA, WI.)

Meeting Notes

Among the **Society for American Archaeology** Chicago meeting symposia of interest to IAOS members:

- Friday, March 26 - General Sessions: Lithic Quarries and Procurement (morning session); and Lithic Studies (afternoon)
- Saturday, March 27 - Symposia: Morphology, Myth, and Meaning: New Directions in Lithic Debitage Analysis (morning); and Postclassic Systems of Production, Distribution, and Consumption in Central and Western Mexico: Contributions from Materials Composition Analysis (afternoon).

Society for California Archaeology Annual Meeting, Sacramento, papers of interest to IAOS members:

Symposium 2: The Effects of Fire/Heat on Obsidian.
- Friday afternoon, April 23 (Part 1);
- Saturday morning, April 24 (Part 2)

[see more information elsewhere in this issue]

Saturday, April 24 - General Session 5:
- 8:20 - A Review of Obsidian Studies in the Southern San Joaquin Valley, California, Mark Q. Sutton and Matthew R. Des Lauriers.
- 11:20 - High Sierra Surveys in Kings Canyon National Park – 1997 and 1998, Thomas L. Burge and William Mc.Matthews [**Note:** see their article, "An Annual Trip to California/Nevada Obsidian Quarries," in IAOS Bulletin No. 22].

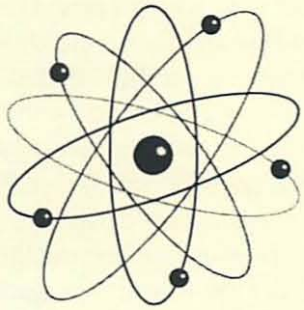
Saturday, April 24 - Roundtable 2: Obsidian Hydration Chronology in the Inyo-Mono Region. [see more information elsewhere in this issue]

The above is from a very preliminary schedule: be sure to check for updates!!

Inter-laboratory Comparison Report

In this issue of the *IAOS Bulletin* we present Michael Glascock's report on the inter-laboratory comparison of obsidian element compositions that he initially proposed in 1996. His report presents the results from eight laboratories in the United States, France, Brazil, Australia, and Italy.

The report should be of interest to all lab researchers. We hope it will stimulate readers to send in questions and comments for publication in the *Bulletin*, and that it will ultimately lead to additional comparative studies.



ABSTRACTS AND ANNOTATIONS OF REPORTS AND PUBLICATIONS

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The volume of so-called "gray literature" in archaeology is staggering, making it difficult for researchers who are not "plugged-in" to contract or research archaeology of a certain region or to hear of and gain access to reports. In addition, the proliferation and number of journals, along with the interdisciplinary nature of obsidian and glass studies, make it difficult to keep abreast of all relevant current literature. The *IAOS Bulletin* will alert readers to some of this information by reproducing abstracts and summarizing literature that may be of particular interest to IAOS members.

Connolly, Thomas J. (Museum of Anthropology, University of Oregon)
The Effect of Volcanism on Pre- and Post-Mazama Lithic Procurement Strategies in Newberry Crater. Paper presented at the 26th Great Basin Anthropological Conference, Bend Oregon.

Pre- and post-Mazama land use and lithic procurement strategies differ significantly in Newberry Crater, a volcanic caldera that now cradles Paulina and East Lakes. Prior to the Mazama eruption, evidence suggests that the Paulina Lake shore was the focus of hunting and gathering base camps. Between about 7500 and 7000 years ago, the caldera was blanketed by tephra from nearby Mt. Mazama as well as from eruptions of Newberry Volcano itself. These eruptions negatively altered the biotic character of the local landscape, but left multiple flows of toolstone-quality obsidian glass. This paper explores how these landscape changes are reflected in local land use and lithic procurement strategies.

Hartwell, William T. (Desert Research Institute)
Shoshone Peak Obsidian: A Newly Discovered Source for Nodules found Along Fortymile, Yucca, and Topopah Washes on the Nevada Test Site. Paper presented at the 26th Great Basin Anthropological Conference, Bend Oregon.

Archaeological studies at Yucca Mountain on the Nevada Test Site have been ongoing for the past two decades, and are associated with efforts to characterize the mountain's suitability for placement of a long-term repository for spent nuclear fuel. Until recently, obsidian, a preferred material for production of projectile points in the region, was known to occur only as secondarily deposited nodules within and along the terraces of Fortymile, Yucca, and Topopah Washes. In January of this year, a primary obsidian source was discovered on the north-facing slope of Shoshone Mountain. XRF analysis confirms it as the source for these secondary deposits. The relation of nodule size to position and distance from the primary source is examined

Johnson, Lynn (California State University, Sacramento) and David L. Wagner (CA Department of Conservation)
Obsidian Quarry Sites in the Saline Range, Inyo County, California. Poster presented at the 26th Great Basin Anthropological Conference, Bend Oregon.

Preliminary investigations of the Saline Range, Inyo County, California, have identified three previously unreported prehistoric obsidian quarry sites which occur in a discontinuous vesicular vitrophyre at the base of a sequence of silicic tuffs. The vitrophyre contains obsidian nodules ranging from less than 1 cm to over 20 cm in size. Nodules are also abundant in the alluvial fans issuing from the Saline Range. Macroscopic examination of obsidian from primary and secondary contexts suggests a high degree of variability. This presentation discusses various aspects of the macroscopic examination, as well as geochemical analyses.

Lyons, William H. (Washington State University) and Scott P. Thomas (Bureau of Land Management - Burns District)
Ancient Band Territory: Obsidian Source Data Suggest a Dominant Mobility Pattern for at least 3,000 years, Harney Basin, Southeastern Oregon. Paper presented at the 26th Great Basin Anthropological Conference, Bend Oregon.

We review obsidian X-ray fluorescence data from seven dated Harney Basin sites, along with new data from Lost Dune (35RA792) and McCoy Creek (35HA1263). Obsidian artifacts from the nine sites match two sources to the north, three to the east, two to the south, and ten to the west. Sources for all but two artifacts are from within the ethnographic Burns Paiute annual round. Excluding nearby sources, proportions of obsidian from north, east, south and west source groups are comparable among variously dated sites, suggesting a long-term dominant mobility pattern within Harney Basin.

Nakazawa, Yuichi

Thermal Alteration of Obsidian. *Hokkaido Paleolithic Studies*, 1998 Volume 3. (Note: this journal is published in Japanese, the following summary was included in English)

This paper proposes criteria for identification of thermal alteration of obsidian artifacts using non-destructive methods. Using an optical light microscope, at magnifications of 15x to 60x, researchers can detect thermal alteration as cohesive tiny cracks on the surface of thermally altered obsidian. Below its surface, tiny bubbles are also observed. Laboratory experiments reveal that formation of these tiny cracks is constrained by three factors: 1) application of heated wood ash, 2) heat, and 3) extended duration of heating. Only when hot wood ash is applied does the obsidian lose its inherent vitreousness. This change appeared at a minimum temperature of 550° C (982° F). Extended duration of heating is necessary to reduce vitreousness correlated with the above two factors.

Macroscopic observation of Upper Paleolithic thermally altered obsidian artifacts represents a variety of morphological characteristics in which cracks are also apparently detectable under the microscope. Three distinctive morphological characteristics, which are *microfracturing, breaks and explosion*, are identifiable by their prominent characteristics compared with normal obsidian artifacts. These morphological characteristics can be traits used to detect thermal alteration of obsidian artifacts.

Thermal alteration gives us variable clues to reconstruct human behavior in relation to use of fire across the site. As the prime procedure for anthropogenic reconstruction, explicit experiments are required to ascertain conditions that produce the above distinctive morphological characteristics of thermally altered obsidian, taking into consideration physical chemistry. Second, it is necessary to examine specimens for natural modifications, which will make some sorts of characteristics resemble the above morphological characteristics. After completion of those two procedures, identification of intentional human behavior, in connection with manufacture, use, maintenance and discard processes of obsidian artifacts, must be our final aim to pursue.

Ramos, Brian A. (University of California, Davis)

New Temporal Data from the Truman/Queen Obsidian Quarry, Mono County California and Mineral County Nevada. Paper presented at the 26th Great Basin Anthropological Conference, Bend Oregon.

Previous archaeological studies at three western Great Basin obsidian quarries have identified similar patterns of source use and technological change throughout the Holocene. There are two main points of view regarding quarry use in the area. One contends that the patterns of use are the consequences of toolstone acquisition conducted through intergroup trans-Sierran exchange, and thus reflect socio-political and population change in central and southern California. The other view holds that mobility is the main determinant of technological organization and thus quarry use. New obsidian hydration data from the Truman/Queen source are presented and discussed relative to these models of quarry use.

Raymond, Anan (U.S. Fish and Wildlife Service)

Blades on the Beach. Poster presented at the 26th Great Basin Anthropological Conference, Bend Oregon.

Although the late prehistoric Wada'tika Northern Paiute ranged over a vast area of southeastern Oregon, they maintained large, seasonal, residential settlements at a few key points on the landscape. Archaeological investigation has documented one of these key residential settlements at Harney Lake on Malheur National Wildlife Refuge. It then examines the methods by which the people organized the acquisition, manufacture, and use of stone tools. They imported and stockpiled obsidian from many far-flung sources. This allowed for the expedient manufacture of blade flake-tools, and discard of conical cores.

Richman, Jennifer R., and Mark E. Basgall (California Sate University, Sacramento)

Spatial and Temporal Variability in Obsidian Use within the Western Great Basin: Results from the Analysis of 600 Artifacts from 94 Sites in Inyo and Mono Counties, California. Paper presented at the 26th Great Basin Anthropological Conference, Bend Oregon.

The Caltrans Transportation Enhancement Activities Project, traversing much of the eastern Sierra region, provided a unique opportunity to study variation in prehistoric adaptive patterns across a range of environmental and ethnogeographic zones. These patterns are reflected, in part, in the acquisition and movement of obsidian resources within the region. Obsidian artifact samples were analyzed from a sample of the sites which contained an obsidian component, amounting to approximately 600 artifacts from 94 sites. The sites are located from as far north as Topaz Lake in northern Mono County to as far south as Death Valley. This paper explores the results of these analyses.

Rotell, Donald A. (Malheur National Forest), Don Hann (Malheur National Forest), and Craig E. Skinner (Northwest Research Obsidian Studies Lab)

A Preliminary Report from the Malheur National Forest Obsidian Characterization Project: Insights on Prehistoric Use of Strawberry Mountain Obsidian. Paper presented at the 26th Great Basin Anthropological Conference, Bend Oregon.

The Malheur National Forest occupies an upland environment peripheral to the northern Great Basin in eastern Oregon. It holds widespread outcrops of obsidian derived from Miocene eruptions near Strawberry Mountain. Deposits are unevenly distributed over 100 square miles and often contain superior quality tool stone. Identification and geochemical characterization of the obsidian sources began in 1989. To date, eight unique varieties of glass have been distinguished and further geochemical and field investigations are underway. Trace element and hydration analysis of archaeological obsidian from the Forest and surrounding regions indicates that the Strawberry Mountain sources were intensively exploited throughout much of prehistory.

Walsh, Michael R. (CLA) and C. William Clewlow, Jr. (Ancient Enterprises, Inc.)

An Early Obsidian Biface Cache from Central Oregon. Paper presented at the 26th Great Basin Anthropological Conference, Bend Oregon.

A cache of obsidian bifaces was recovered from a disturbed context near Fort Rock, in central Oregon. There is firm suggestion, however, that the cache is pre-Mazama in age, based on reconstructed stratigraphy and the nature of artifact patination. The latter issue will be addressed by obsidian hydration studies. The study collection contains 219 points, of which 122 are complete. Nearly all are lanceolate form, but the pieces display considerable variation in thickness, longitudinal curvature, degree of patination, tip and basal treatment, and craftsmanship. At least two obsidian sources are represented. The collection is analyzed for chronological and typological attributes, and speculations are offered on potential social implications of caching behavior.

Recent Publications on Obsidian Provenience Studies (Chile, Colombia, Ecuador, Anatolia)

submitted by Gérard R. Poupeau
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Grenoble, France (poupeau@ujf-grenoble.fr)

Poupeau G., and Scorzelli R. (1997)
Fission track dating in archaeomaterials provenience studies : the obsidian artefacts case (in Portuguese), *in* Proc. Intern. Symposium "Análises Físicas e Quimicas no Estudo de Material Arqueologico, Ed. M. B. B. Florenzano, *Revista do Museu de Arqueologia e Etnologia, Suplemento 2*, Universidade de São Paulo (Brésil), 191-215.

Petrick S., Scorzelli R. B., Rossi A., Poupeau G. et Seelenfreund A. (1997)
Mössbauer spectroscopy: one clue for the deciphering of obsidian archaeological artefacts provenience?, *J. Hyperfine Interaction (C)*, **2**, 10-13.

Balestrieri M. L.., Bigazzi G., Bouska V., Labrin E., Hadler Neto J. C., Kitada N., Osorio Araia A. M., Poupeau G., Wadatsumi K. and Zunega A. (1997)
Potential glass age standards for fission-track dating : an overview, *in*: *Advances in Fission Track Dating*, Eds. P. Van den Haute et F. de Corte, Kluwer Academic Publishers, Dordrecht, 287-304.

Dorighel O., Poupeau G., Labrin E. and Bellot-Gurlet L. (1997)
Fission track dating of obsidians and archaeological artefacts provenience studies in Colombia and Ecuador, *in*: *Advances in Fission Track Dating*, Eds. P. Van den Haute et F. de Corte, Kluwer Academic Publishers, Dordrecht, 313-324.

Poupeau G., Dorighel O. and Bellot-Gurlet L. (1997)
La datation par traces de fission des verres naturels et artificiels. Applications en archéologie, *in* : *Essays on Interdisciplinary Topics in Natural Sciences*, Eds. R. B. Scorzelli, I. Souza Azevedo et E. Baggio Saitovitch, Editions Nouvelles Frontières, Paris, 85-110.

Bustamante A. D., Petrick S., Scorzelli R. B., Rossi A. M., Poupeau G. and Seelenfreund A. (1998)
Mössbauer and ESR studies of obsidian provenience in the northern Andes, *J. Hyperfine Interactions (C)*, **3**, 360-363.

Yegingil Y., Bigazzi G., Poupeau G. and Bellot-Gurlet L. (1998)

Provenance studies of obsidian artefacts in Anatolia: the contribution of the fission track analyses, *in*: *Light on Top of the Black Hill*, Studies presented to Halet Cambel, eds. G. Arsebük, M. J. Mellink et W. Schirmer, Ege Yayinlari, Publications, Istambul, 823-844.

Poupeau G., Bigazzi G., Bellot-Gurlet L. and Dorighel O. (1998)

Fission-track dating of obsidians and archaeology, in: *"L'obsidienne au Proche et Moyen Orient : du volcan à l'outil"*, Eds. M.-C. Cauvin, A. Gourgaud, B. Gratuze, N. Arnaud, G. Poupeau, J.-L. Poidevin et C. Chataigner, Bar International Series 738, Archaeopress, Oxford, 53-67.

Bigazzi G., Poupeau G., Bellot-Gurlet L. and Yezingili Z. (1998)

Provenance studies of obsidian artefacts in Anatolia using the fission-track dating method : an overview, in: *"L'obsidienne au Proche et Moyen Orient : du volcan à l'outil"*, Eds. M.-C. Cauvin, A. Gourgaud, B. Gratuze, N. Arnaud, G. Poupeau, J.-L. Poidevin et C. Chataigner, Bar International Series, Archaeopress, Oxford, 69-89.

Gnecco C., Patiño D., Dorighel O., Bellot-Gurlet L., Poupeau G. and Glascock M. (1998)

La articulacion prehispanica costa-Andes en el suroccidente de Colombia vista a traves de las redes de circulacion de obsidiana, *in "Intercambio y Comercio entre Costa, Andes y Selva : Arqueologia y Etnohistoria de Suramerica"*, eds. F. Cardenas et T. Bray, Universidade de los Andes, Bogota, sous presse.

Bellot-Gurlet L., Dorighel O., Poupeau G., Keller F. and Scorzelli R. B. (1998)

First characterization of obsidian from Colombian and Ecuadorian sources using ICP-AES and ICP-MS, *Proc. 31th Intern. Symposium on Archaeometry*, Budapest, Hongrie, 27 avril-1er mai, BAR International Series, sous presse.

Bellot-Gurlet L., Calligaro Th., Dorighel O., Dran J.-C., Poupeau G. and Salomon J. (1998)

PIXE analysis and fission track dating of obsidian from South American prehispanic cultures : an insight over the circulation of a lithic industry raw material, *Nuclear Instruments and Methods B*, accepted.

Bellot-Gurlet L., Poupeau G., Dorighel O., Calligaro Th., Dran J.-C. and Salomon J. (1998)

A fission track dating/PIXE approach to sourcing studies of obsidian artefacts in Colombia and Ecuador, *J. Archaeol. Sci.*, accepted.

Announcement

Publication of : *L'obsidienne au Proche et Moyen Orient. Du volcan à l'Outil*

(Obsidian in the Near and Middle East: From volcanoes to lithic tools) by Marie-Claire Cauvin et al. (eds.), BAR International Series 738, Archaeopress, Oxford, 388 pages., 21 x 29.7 cm, 1998.

This volume is a collection of 16 essays, of which 3 are written in English (on fission track dating and the chemical characterization of Caucasian obsidians) and the remaining in French. Since the early works of C. Renfrew, J. R. Cann, and J. E. Dixon some 35 years ago, obsidian archaeometric studies in the Near and Middle East have remained an active area of study. It is the goal of this book to present the current status of obsidian research in the region.

After a foreword by Prof. Lord Renfrew and a general introduction by Marie-Claire Cauvin, the book is organized into two parts. Part 1 is devoted to the Geology, Geochemistry, and Chronometry of geological obsidians from Anatolia and Caucasia. Eight chapters concern respectively the geology of obsidians (A. Gourgaud), their methods of chemical characterization (B. Gratuze) and dating (N. Arnaud et G. Poupeau), with chapters on fission track (G. Poupeau et al.) and K-Ar and $^{40}Ar/^{39}Ar$ (N. Arnaud) dating. Two chapters summarize the geochemical data presently available on Turkish, Transcaucasian (J.-L. Poidevin) and Caucasian (J. Blackman) obsidians. Two other chapters give an overview of obsidian ages from these region as obtained by the fission track (Bigazzi et al.) and K-Ar or $^{40}Ar/^{39}Ar$ (J.-L. Poidevin) methods.

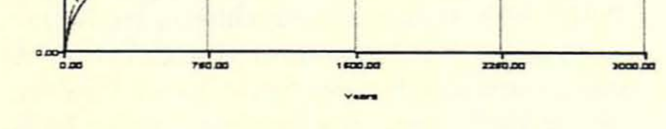
Part 2 is entitled Archaeology, again with eight chapters. Four are about recent discoveries in the Palaeolithic of Oriental Anatolia (I. Yalcinkaya), Neolithic sites of the Near and Middle East (M.-C. Cauvin), eastern Mediterranean post-Neolithic sites (E. Coqueugniot), and Kalatepe nucleus and knapping workshops in Cappadocia (N. Bakan-Atli and G. der Aprahamian). The question of the distribution of obsidian artifacts in Near and Middle Eastern archaeological sites and their sources is addressed in two chapters (respectively by M.-C. Cauvin and C. Chataigner and C. Chataigner). Finally, the history of the word 'obsidian' is discussed (J.-C. Decourt), as is the symbolic meaning of this glassy rock (J. Cauvin).

Temperature Uncertainty in the Application of Obsidian Hydration Dating: Computer Modeling Studies at Sonoma State University

Ted Jones
Anthropological Studies Center
Sonoma State University

It is clear that temperature is a fundamental factor in the process of obsidian hydration. However, due to the many uncertainties regarding the temperature history of obsidian specimens from archaeological deposits, the reliability of obsidian hydration as a dating technique is often called into question. In practice, it is generally assumed that hydration rim growth follows a curve defined by the diffusion equation $x=kt^{.5}$. This is usually represented as a smooth curve; the actual growth of an artifact hydration rim, however, should form an irregular line due to the dynamic effect of environmental temperature changes on the hydration rate (see figure).

To understand better the sensitivity of our calculations to these unknown environmental temperature variations, a computer model is currently being developed at Sonoma State University. By observing the growth of many modeled hydration rims under varying temperature scenarios, we hope to augment our age estimates with a confidence range based on the temperature uncertainty of an artifact's provenience.



The top line represents an artifact with an extreme early history but settling down to 16.1C by year 1000. The bottom line is an artifact hydrating at a constant temperature of 16.1C.

Developing the model implies that we accept that obsidian hydration is understood well enough to define it mathematically. Studies such as Origer's 1987 calibration of Napa Valley and Annadel obsidians provide fixed constants based on estimated effective hydration temperatures (EHT). The above diffusion equation is easy enough to model given such archaeologically derived source constants, but for the model to reveal the intended sensitivity analysis, the dynamic effect of temperature change needs to be defined more precisely than an estimated percentage adjustment per degree. A promising attempt at this was Michels' 1983 regression analysis of induced hydration results. While this provided a slope and intercept ideally suited for our model, the extension of the regression to expected ambient temperatures has not been consistent with radiocarbon-verified archaeological associations. This, coupled with inconsistencies in inter-source rim comparison ratios found at high temperatures and those at ambient temperatures, suggests that further work is required in this area.

The initial computer iteration of the model has a rim growth rate driven by the diffusion equation. This rate is informed by a temperature array, which contains fluctuating EHT by year, and slope and intercept constants which represent the effect of temperature on the hydration rate of the source being modeled. A number of likely and extreme temperature scenarios can be run and compared to conventionally calculated dates. In addition to estimates of climatic changes, depositional variations must also be considered. For example, an artifact may be exposed to direct sunlight for years before being buried, and may spend additional years at shallow depths that are more temperature variable than deeper ones.

Because this is currently a single-rate model, the effects of all naturally occurring processes are combined in the growth rate (i.e., growth rate is actually growth minus dissolution). Additional iterations of the model must disaggregate the process into multiple rates. The next rate to be modeled is dissolution of the hydration rim. Induced hydration experiments used to calibrate temperature effect must be buffered with silica gel to inhibit dissolution. To translate the high-temperature-derived constants to archaeological conditions, therefore, requires isolating rim growth from rim dissolution. A great deal more must be learned about this process, such as the possible effects of highly alkaline soils. Jack Meyer and Tom Origer of the Anthropological Studies Center here at SSU are currently conducting experiments to understand these processes.

The computer model can serve as a workbench upon which to analyze the incremental improvements in our understanding of obsidian hydration mechanics. In its current state, the model can help us study the compound effect of temperature on obsidian weathering; eventually it may clarify the effects of the other attributes on the long list of potential factors involved in the hydration process.

An Update on Obsidian Sources in the Saline Range, Inyo County California

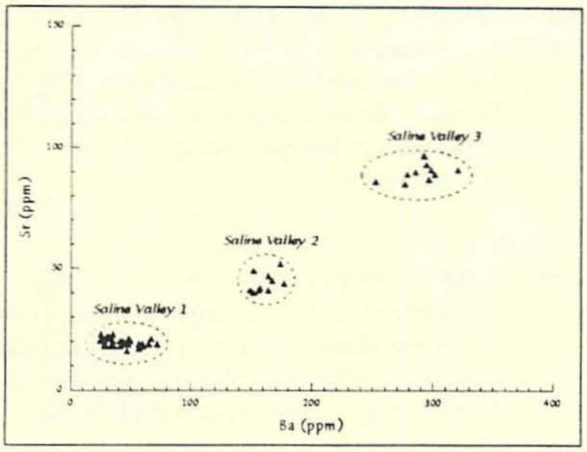
Lynn Johnson, Archaeological Research Center,
California State University Sacramento
Craig E. Skinner, Northwest Research Obsidian
Studies Laboratory, Corvallis, Oregon
David L. Wagner, California Division of Mines
and Geology, Sacramento

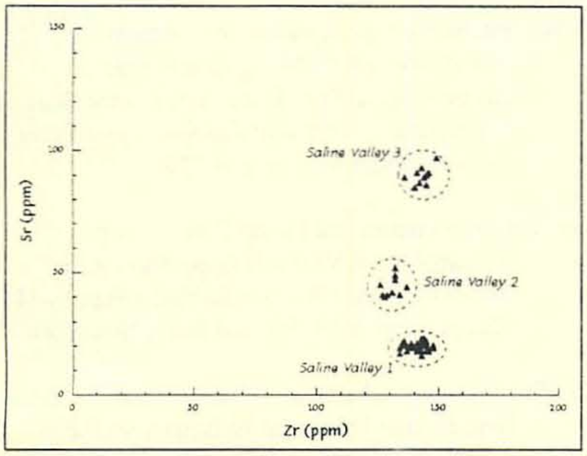
The Saline Range, a remote volcanic tableland located within Death Valley National Park in the southwestern Great Basin, has recently been reported as a source for archaeological obsidian (Johnson and Wagner 1998). Obsidian-bearing rhyolitic flows and tuffs in the Saline Range were emplaced over preexisting topography and later disrupted by Basin and Range faulting, creating complex outcrop patterns. Furthermore, obsidian nodules have been transported and redeposited more than 20 kilometers from primary outcrops. In some instances these secondary deposits contain nodules derived from different stratigraphic units. The geologic complexity of the Saline Range volcanic field presents substantial interpretive problems, as discussed by Hughes and Smith (1993), Hughes (1998a), and Shackley (1994, 1998a, 1998b).

Our research in the Saline Range began in 1989. Initial efforts focused on locating and mapping both primary outcrops and secondary deposits in the eastern and western potions of the range, as well as documenting evidence of prehistoric exploitation. In addition, a systematic sampling program was conducted.

In 1998, Jelmer Eerkens and Michael Glascock analyzed a small sample of obsidian nodules collected from both primary and secondary contexts in the Saline Range at the University of Missouri Research Reactor Facility (MURR). Data from neutron activation analysis suggested three geochemically distinct obsidian types occur in the Saline Range. A much larger sample was recently analyzed at Northwest Research Obsidian Studies Lab in Corvallis, Oregon. X-ray fluorescence (XRF) data confirm the Saline Range obsidians can indeed be separated geochemically into three source groups, provisionally named Saline Valley 1, Saline Valley 2, and Saline Valley 3 (see figures).

Although Saline Valley has previously been reported as a source for archaeological obsidian (Norwood, Bull, and Quinn 1980; Delacorte, Hall, and Basgall 1995; Burton 1996a, 1996b; Burton and Farrell 1996; Reynolds 1996), neither the geologic provenance of the obsidian nodules used to characterize the "Saline Valley" glass type nor the sample provenience was certain; nodules were likely collected in Saline Valley from alluvial fans emanating from the eastern side of the Saline Range. The samples analyzed at Northwest Research Obsidian Studies Lab were collected from primary outcrops in the Saline Range. The trace element chemistry of the Saline Range samples was compared with data from XRF analysis of artifacts recovered from archaeological sites located in Owens Valley (Hughes 1996b, 1997, 1998b; Delacorte 1999; Gilreath and Nelson 1999) and on Hunter Mountain (Hughes 1996a). A strong correlation between Saline Valley 3 and the "Saline Valley" glass type and Saline Valley 1 and an unknown glass type dubbed "Queen Imposter" was noted. Although it has yet to be determined, Saline Valley 2 probably correlates with one of the other "unknowns" found at archaeological sites in the region.





This study underscores the need to conduct a systematic sampling strategy in order to document possible intrasource geochemical variability within a particular "source" area. Continued research on the geochemical variability of obsidians occurring in the Saline Range, as well as on spatial and temporal patterns of exploitation, will aid our understanding of obsidian procurement and use in the southwestern Great Basin.

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Be sure to tune in to the

International Association of Obsidian Studies

Home Page

http://www.peak.org/obsidian/obsidian.html

Contains the following (and more!):

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– Election 1999 –

Ballots and candidate statements for IAOS President-elect and Secretary-Treasurer for 1999-2000 are being mailed with this issue of the *Bulletin*.

Return your completed ballot to arrive in San Jose no later than March 24, 1999. Members outside of the USA can e-mail their ballots to padng@AOL.com.

Obsidian Sessions
Society for California Archaeology
33rd Annual Meeting
Sacramento
April 23-25, 1999

Obsidian research is always high on the list of topics at the annual meetings of the SCA; this year is especially noteworthy, with a two-session symposium and a roundtable. Below are contributors, paper titles, and a preliminary schedule. (There may well be changes over the next two months; **be sure to consult updated schedules when available.**)

Symposium 2 . The Effects of Fire/Heat on Obsidian. Tom Origer and Dave Fredrickson, Organizers and Chairs.

Part 1 - Friday afternoon, April 23:
- 1:20 - Introduction. **Tom Origer**
- 1:30 - A Synthesis of Previous Studies that Explored the Effects of Fire on Obsidian: Where We've Been and Where We're Going. **Sue Ann Schroder**
- 1.50 - Re-Hydrated Obsidian Projectile Points on the Warner Mountains, California. **Dee Green**
- 2:10 - The Dome Fire Study: Extreme Forest Fire Effects on Jemez Obsidian. **Anastasia Steffen**
- 2:30 - The Trench Canyon Prescribed Burn: An Analysis of Fire Effects on Archaeological Resources within the Sagebrush Steppe Community. **F. Kirk Halford and Anne S. Halford**

— Break
- 3:10 - Fire and Glass: Experimental Approaches to Understanding the Effects of Prescribed Burning on Obsidian Hydration Bands. **Madeline Soloman.**
- 3:30 - Effects of Fire on Obsidian Hydration Rind Thickness. **Arlene Benson**
- 4:10 - Manual Fuel Load Reduction as a Means of Reducing the Effects of Fire on Obsidian Hydration: An Example from Lassen Volcanic National Park. **Nelson Siefkin**
- 4:30 - Fire Regimes and Fire History: Implications for Obsidian Hydration Dating. **Carl N. Skinner and C. Phillip Weatherspoon**

Part 2 - Saturday morning, April 24
- 8:30 - Introduction. **David A. Fredrickson**
- 8:40 - An Overview of Obsidian Studies within NPS Park Projects. **Roger Kelly**
- 9:00 - Thermal and Environmental Effects on Obsidian Geochemistry: Ex[erimental and Archaeological Evidence. **M. Steven Shackley and Carolyn Dillian**
- 9:20 - Effects of Prescribed Burning on Obsidian and Implications for Reconstructing Past Landscape Conditions. **Krista Deal and Denise McLemore**
- 9:40 - Break
- 10:00 - Rehydration of Burned Obsidian. **Janine Loyd**
- 10:20 - Protecting Archaeological Sites with Prescribed Fire. **Jim Smith**
- 11:00 - Discussion

Saturday, April 24:
Roundtable 2 - Obsidian Hydration Chronology in the Inyo-Mono Region. **Kirk Halford and Don Laylander**, Organizers and Chairs.

Panelists: Mark E. Basgall, Mark Giambasiani, Amy Gilreath, M.C. Hall, Richard E. Hughes, Robert J. Jackson, Tom Origer, Linda Reynolds

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Back Issues

Back issues of the *IAOS Bulletin* are available for $1.50 per issue. Bulletins 1, 2, 4, and 5 are only available as xeroxed copies. If interested, send a list of the issues you want, along with a check for the requisite amount, to IAOS, Department of Anthropology, San Jose State University, San Jose, CA 95192-0113.

Publication Available

We have three copies of

> *Obsidian Dates IV, A Compendium of the Obsidian Hydration Determinations Made at the UCLA Obsidian Hydration Laboratory,* Clement W. Meighan and Janet L. Scalise, editors. Monograph XXIX, Institute of Archaeology, University of California, Los Angeles, 1988.

available to IAOS members for only $10 each, plus postage — $3.00 (inside U.S.) or $5.00 (outside U.S.). If you are interested, please send a check payable to the IAOS, Department of Anthropology, San Jose State University, San Jose, CA 95192.

1999 Northwest Research Obsidian Studies Lab Grant

Announcement reproduced from Northwest Obsidian Lab's web site

If you are a university graduate student (Master's or Ph.D. level in any state or country) and your thesis or dissertation research concerns an Oregon archaeological project, you are eligible for our newly instituted annual laboratory research grant. This grant is good for $1,000 worth of obsidian characterization and/or hydration studies carried out at the lab (computed at our present price rate). Laboratory analytical services include the trace element characterization, source identification, and hydration analysis of obsidian artifacts and XRF analysis of geologic source material. The grantee gets to decide how to mix or match the different types of analytical work.

Should more than one applicant be selected, the lab grant will be awarded for each successful applicant at a percentage to be determined by Northwest Research Obsidian Studies Laboratory.

The 1999 grant deadline application is June 1, 1999. To apply, all you have to do is to send the lab a brief proposal concerning your obsidian-related research. The proposal should run no longer than about two pages — if we have questions, we'll ask.

Here's what we need to know in your application:

Name
Address
Telephone contact number
E-mail address
A few details about your academic program
Thesis/dissertation title or topic
Specific project research objectives and a brief description of the overall scope of your research
How you plan on applying the lab analytical services in your research
The specific services for which you would like to use the grant money (e.g., number of samples and types of analysis)

That's it! You can submit your application by mailing it to us at the lab or by sending it as an e-mail attachment file (WordPerfect, Microsoft Word, Adobe Acrobat .PDF, RTF, or straight text formats are all accepted). We will review all applications and will announce the big winner(s) on the Northwest Obsidian Lab web page [http://www.obsidianlab.com/grant.html] on June 15, 1999.

Good luck!

Northwest Research Obsidian Studies Laboratory - 1414 NW Polk - Corvallis, OR 97330
E-mail: cskinner@obsidianlab.com

CALENDAR OF EVENTS

Get your events added to the calendar listings by dropping an e-mail note to the editor.

March 24-28. The 64th Annual Meeting of the Society for American Archaeology. Sheraton Chicago Hotel and Towers, Chicago, Illinois. Act now! Pre-registration closes February 22, 1999. Contact the SAA staff by phone 202/789-8200, or fax 202/789-0284, or e-mail: meetings@saa.org

March 25. Annual Meeting of the International Association of Obsidian Studies at the SAA Annual Meeting in Chicago (see above). Thursday, 5:00 to 6:00 p.m. (Please check program for location.)

April 23-25. Society for California Archaeology Annual Meeting. Red Lion Inn, Sacramento, California. Contact Bill Hildebrandt or Kelly McGuire (530) 756-3941, or Kathleen Hull (510) 465-4962, fax (510) 465-1138, or e-mail hull@qal.berkeley.edu

IAOS Special Report

An Inter-Laboratory Comparison of Element Compositions for Two Obsidian Sources

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During the Spring of 1996, it occurred to me that a number of IAOS members might be interested in participating in an inter-laboratory comparison exercise on obsidian element compositions by applying the different analytical techniques available in member labs. The only previously known obsidian materials for inter-laboratory comparison are the standard reference material SRM-278 Obsidian Rock Powder available from the National Institute of Standards and Technology (NIST) and the Pantelleria and Monte Arci obsidian powders from Dr. Francaviglia. Since there is significant potential for contamination by grinding, I thought it would be additionally interesting to provide obsidian flakes which are physically more similar to artifacts than the above-mentioned powders.

The initial invitation to participate in this exercise was announced in *IAOS Bulletin* (17:2) published in Fall 1996. A total of nine different laboratories requested samples for analysis. Eight of the nine laboratories have responded with data. Some of the laboratories also performed more than one type of analysis. The various analytical techniques employed were instrumental neutron activation analysis (INAA), accelerator-induced fast neutron activation analysis (FNAA), proton induced x-ray emission (PIXE), proton induced gamma-ray emission (PIGME), x-ray fluorescence (XRF), inductively coupled-atomic emission spectroscopy (ICP-AES), inductively coupled-mass spectroscopy (ICP-MS), and laser ablation-inductively coupled plasma-mass spectroscopy (LA-ICP-MS).

The obsidian source samples for this inter-comparison came from two famous obsidian sources. The first of these is the Pachuca obsidian source (also known as "Sierra de Pachuca", "Sierra de las Navajas", "Huasca") from the state of Hidalgo, Mexico. The source is located approximately 50km northeast of the Valley of Teotihuacan with approximate geographic coordinates of 98°33′ west longitude and 20°06′ north latitude. The sample fragments for the inter-laboratory comparison were taken from a large obsidian boulder collected by Robert Cobean in 1980. Artifacts from the Pachuca obsidian source are mostly a bright green or gold-tinted green color that appears to be unique among central Mexican obsidians.

The second obsidian sample for this comparison came from the Little Glass Buttes source located in Lake County, Oregon approximately 80km west of the town of Burns. The sample came from a single obsidian boulder collected by Mike Glascock, Jessica Ambroz, and Craig Skinner during the summer of 1996. The geographic coordinates for the particular outcrop from which the boulder came are 119°59′21″ west longitude and 43°31′23″ north latitude. The obsidian from Glass Buttes is usually black or mahogany in color with thin samples forming a high-quality, transparent glass.

The purpose of this report is not to judge the quality of work from any particular laboratory, but rather to provide a comparative database for self-examination. As a result, I make no evaluation or comments about the accuracy or precision of any particular laboratory or any of the analytical methods.

A few of the contributing laboratories reported concentrations as oxides (e.g., Al_2O_3, SiO_2) and others reported concentrations of the elements only. In order to facilitate comparison of the different data, oxide values were converted to elements by using the following multipliers: Al_2O_3 to Al using 0.5291; CaO to Ca using 0.7148; Fe_2O_3 to Fe using 0.6988; K_2O to K using 0.8299; MgO to Mg using 0.6031; MnO to Mn using 0.7740; Na_2O to Na using 0.7418; P_2O_5 to P using 0.4359; SiO_2 to Si using 0.4671; and TiO_2 to Ti using 0.5992. The results for Sierra de Pachuca and Little Glass Buttes are presented in Tables I and II, respectively. Each of the participating laboratories submitted a brief report describing their procedures.

Table I. Inter-comparison of analytical results for the obsidian source at Sierra de Pachuca, Hidalgo, Mexico.

	A	B	C	D	E	F	G	D	I	J
Element	MURR INAA (n=5)	Orleans FNAA (n=2)	Orleans LA-ICP-MS (n=3)	Rio ICP-AES/ICP-MS (n=1)	Grenoble ICP-AES/ICP-MS (n=3)	Grenoble PIXE (n=7)	ANSTO PIXE/PIGME (n=3)	Rome XRF (n=1)	Ashe Analytics XRF (n=1)	NW Research XRF (n=1)
Li (ppm)			63 ± 0.3	65.6						
B (ppm)			23 ± 1							
F (ppm)							2850 ± 190			
Mg (ppm)		2100 ± 600	286 ± 6	344	326 ± 1			844		
Na (%)	3.80 ± 0.09	4.45 ± 0.40	3.78 ± 0.17	3.91	3.92 ± 0.07	3.83 ± 0.08	4.53 ± 0.27	3.74		
Al (%)		6.19 ± 0.04	6.51 ± 0.22	6.52	5.52 ± 0.21	6.06 ± 0.04	6.57 ± 0.35	5.78		
Si (%)		34.3 ± 0.3	35.2 ± 0.1			35.7 ± 0.05	38.2 ± 2.0	35.3		
P (ppm)			196 ± 1		26 ± 1					
Cl (ppm)	1460 ± 150					1647 ± 116				
K (%)	3.78 ± 0.24	4.23 ± 0.06	3.46 ± 0.03	3.69	3.11 ± 0.07	3.39 ± 0.03	3.83 ± 0.17	3.47		
Ca (ppm)		1160 ± 240	2362 ± 105	640	750 ± 11	769 ± 45	894 ± 31	786		
Sc (ppm)	3.21 ± 0.04			2.82						
Ti (ppm)		1300 ± 60	1190 ± 7	1050	1049 ± 22	1028 ± 29	1118 ± 65	1258		1141 ± 96
V (ppm)			4.4 ± 0.1	3.67						
Mn (ppm)	1149 ± 20	990 ± 140	1048 ± 40	837	1231 ± 50	1008 ± 24	1265 ± 85	1161	1095 ± 70	1124 ± 48
Fe (%)	1.58 ± 0.02	1.72 ± 0.10	1.66 ± 0.01	1.66	1.62 ± 0.06	1.56 ± 0.02	1.81 ± 0.12	1.89	1.64 ± 0.11	1.72 ± 0.08
Co (ppm)	0.054 ± 0.011			0.09	0.065 ± 0.031					
Zn (ppm)	191 ± 12	240 ± 2	219 ± 2	206		221 ± 4	292 ± 19		224 ± 14	224 ± 8
Ga (ppm)				30.5		29 ± 1				
As (ppm)			3.1 ± 0.4							
Rb (ppm)	192 ± 3	219 ± 13	203 ± 1	181	185 ± 2	211 ± 8	224 ± 15	194	200 ± 8	225 ± 3
Sr (ppm)			1.86 ± 0.08	2.10	2.34 ± 0.07		2.7 ± 0.5	5	2.4 ± 0.9	5 ± 9
Y (ppm)		112 ± 7	111 ± 18	99.7	117 ± 1	109 ± 9		146	118 ± 9	118 ± 3
Zr (ppm)	888 ± 40	1020 ± 5	1058 ± 143	796	1005 ± 12	1008 ± 13	1097 ± 92	1055	991 ± 35	965 ± 9
Nb (ppm)		91 ± 1	116 ± 9	83.8	91.2 ± 0.9	97 ± 13		91	91.2 ± 3.8	99 ± 2
Sb (ppm)	0.264 ± 0.022	162 ± 10	0.23 ± 0.02	0.27						
Cs (ppm)	3.92 ± 0.06	6.6 ± 0.5	3.88 ± 0.03	4.07	4.82 ± 0.04					
Ba (ppm)	30 ± 12	21 ± 6	9.3 ± 0.6	12.6	16.6 ± 3.8				20 ± 9	14 ± 14
La (ppm)	38.6 ± 0.9		38 ± 4	38.8	37.6 ± 0.4				61.6 ± 6.4	
Ce (ppm)	92.0 ± 1.6	93 ± 2	91 ± 3	90.0	92.7 ± 0.6				133 ± 13	
Pr (ppm)			10.5 ± 0.4	11.2	11.0 ± 0.1					
Nd (ppm)	33.0 ± 2.4		38 ± 1	39.5	38.0 ± 0.2					
Sm (ppm)	9.90 ± 0.22		10.1 ± 0.7	10.4	9.93 ± 0.03					
Eu (ppm)	1.59 ± 0.03		1.6 ± 0.1	1.66	1.54 ± 0.01					
Gd (ppm)			11.6 ± 0.8	12.1	11.1 ± 0.1					
Tb (ppm)	2.25 ± 0.06		2.3 ± 0.1	2.50	2.29 ± 0.01					
Dy (ppm)	15.8 ± 0.8		16.4 ± 0.8	15.9	15.5 ± 0.1					
Ho (ppm)			3.7 ± 0.3	3.49	3.61 ± 0.02					
Er (ppm)			12.0 ± 0.8	11.1	11.1 ± 0.1					
Tm (ppm)			1.8 ± 0.1	1.76						
Yb (ppm)	12.3 ± 0.3		13.2 ± 0.8	11.5	12.3 ± 0.1					
Lu (ppm)	1.85 ± 0.04		2.0 ± 0.2	1.91	1.93 ± 0.02					
Hf (ppm)	27.0 ± 0.4		29 ± 2	25.6	28.0 ± 0.2					
Ta (ppm)	4.87 ± 0.07		6.5 ± 0.5	4.97	5.43 ± 0.03					
Pb (ppm)			35 ± 4	28.0	28.1 ± 0.1				28.5 ± 3.0	37 ± 4
Th (ppm)	17.9 ± 0.3		21 ± 1	18.9	17.0 ± 0.1					
U (ppm)	6.9 ± 2.1	8.5 ± 0.6	7.5 ± 0.2	6.15	6.08 ± 0.02					

Table II. Inter-comparison of analytical results for the obsidian source at Little Glass Buttes, Oregon.

	A	B	C	D	E	F	G	H	I	J
Element	MURR INAA (n=5)	Orleans FNAA (n=2)	Orleans LA-ICP-MS (n=3)	Rio ICP-AES/ICP-MS (n=1)	Grenoble ICP-AES/ICP-MS (n=3)	Grenoble PIXE (n=7)	ANSTO PIXE/PIGME (n=3)	Rome XRF (n=1)	Ashe Analytics XRF (n=1)	NW Research XRF (n=1)
Li (ppm)			33.1 ± 0.4	34.6						
B (ppm)			12.0 ± 0.5							
F (ppm)							357 ± 8			
Mg (ppm)		3640 ± 1690	501 ± 15	656	603 ± 16			1266		
Na (%)	2.84 ± 0.06	3.34 ± 0.08	2.97 ± 0.07	2.92	2.83 ± 0.06	2.85 ± 0.07	3.35 ± 0.14	2.86		
Al (%)		7.03 ± 0.20	7.09 ± 0.11	7.74	7.08 ± 0.19	6.98 ± 0.03	7.45 ± 0.34	6.67		
Si (%)		34.9 ± 0.1	35.6 ± 0.1			36.0 ± 0.05	38.6 ± 0.8	35.9		
P (ppm)			244 ± 3	45.3	74 ± 5			87		
Cl (ppm)	113 ± 29									
K (%)	3.52 ± 0.16	3.90 ± 0.05	3.43 ± 0.05	3.60	3.15 ± 0.06	3.24 ± 0.03	3.57 ± 0.02	3.44		
Ca (ppm)		5900 ± 30	6813 ± 69	5432	6219 ± 246	5565 ± 97	6230 ± 50	5933		
Sc (ppm)	2.81 ± 0.05			2.82						
Ti (ppm)		690 ± 25	595 ± 5	600	527 ± 34	788 ± 38	691 ± 16	659		570 ± 97
V (ppm)			1.43 ± 0.04	1.21						
Mn (ppm)	327 ± 6	297 ± 30	269 ± 5	303	333 ± 10	291 ± 11	357 ± 9	387	298 ± 13	349 ± 47
Fe (%)	0.62 ± 0.01	0.65 ± 0.03	0.684 ± 0.028	0.61	0.650 ± 0.036	0.607 ± 0.011	0.702 ± 0.023	0.79	0.573 ± 0.015	0.66 ± 0.08
Co (ppm)	0.39 ± 0.01			0.45	0.436 ± 0.014					
Zn (ppm)	31 ± 7	90 ± 3	26.5 ± 0.5	29.3		27 ± 2	36 ± 1		24.2 ± 2.6	41 ± 7
Ga (ppm)				15.9		15 ± 2				
As (ppm)			0.86 ± 0.04							
Rb (ppm)	95 ± 1	110 ± 1	97 ± 1	94.6	93.9 ± 1.3	105 ± 6	109 ± 6	97	96.0 ± 2.3	101 ± 3
Sr (ppm)	78 ± 20		52 ± 0.5	66.0	66.7 ± 0.7	73 ± 5	81 ± 6	71	69.1 ± 3.2	73 ± 9
Y (ppm)		23 ± 1	18 ± 2	23.1	25.8 ± 0.3			28	26.2 ± 1.5	29 ± 3
Zr (ppm)	118 ± 7	99 ± 10	83 ± 7	106	106 ± 2	105 ± 8	107 ± 3	105	96.3 ± 2.6	109 ± 8
Nb (ppm)		12 ± 1	9.1 ± 0.1	7.88	7.92 ± 0.10			8	7.1 ± 1.2	8 ± 2
Sb (ppm)	0.20 ± 0.01		0.22 ± 0.02	0.18						
Cs (ppm)	3.40 ± 0.05	6 ± 2	3.2 ± 0.2	3.66	4.29 ± 0.06					
Ba (ppm)	1270 ± 20	1550 ± 130	1080 ± 2	843	1237 ± 14				1270 ± 13	1338 ± 14
La (ppm)	25.8 ± 0.4		21.0 ± 0.5	25.4	25.9 ± 0.3				22.8 ± 4.0	
Ce (ppm)	48.4 ± 1.0	46 ± 2	43 ± 1	48.5	49.7 ± 0.6				50 ± 7	
Pr (ppm)			4.5 ± 0.4	5.67	5.44 ± 0.05					
Nd (ppm)	18.7 ± 4.9		15.4 ± 0.6	19.6	18.4 ± 0.2					
Sm (ppm)	3.66 ± 0.05		2.87 ± 0.02	4.34	3.52 ± 0.03					
Eu (ppm)	0.58 ± 0.01		0.56 ± 0.07	1.00	0.587 ± 0.002					
Gd (ppm)			3.51 ± 0.06	4.28	3.47 ± 0.05					
Tb (ppm)	0.55 ± 0.03		0.42 ± 0.01	0.67	0.572 ± 0.003					
Dy (ppm)	3.6 ± 0.3		3.0 ± 0.1	3.77	3.57 ± 0.04					
Ho (ppm)			0.56 ± 0.04	0.83	0.793 ± 0.007					
Er (ppm)			2.0 ± 0.1	2.6	2.379 ± 0.013					
Tm (ppm)			0.28 ± 0.02	0.39						
Yb (ppm)	2.77 ± 0.10		2.4 ± 0.3	2.73	2.73 ± 0.05					
Lu (ppm)	0.44 ± 0.01		0.38 ± 0.06	0.45	0.451 ± 0.007					
Hf (ppm)	3.67 ± 0.06		3.0 ± 0.2	3.48	3.82 ± 0.05					
Ta (ppm)	0.66 ± 0.01		1.09 ± 0.05	0.74	0.738 ± 0.003					
Pb (ppm)			17 ± 2	16.9	16.2 ± 0.2				14.2 ± 1.3	13 ± 4
Th (ppm)	8.48 ± 0.13		8.1 ± 0.7	9.54	8.15 ± 0.06					
U (ppm)	4.1 ± 0.6	3.6 ± 0.1	3.9 ± 0.2	3.37	3.35 ± 0.02					

A. Description of the procedures for INAA at MURR

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Analytical samples were prepared by crushing the original specimens between two plates made of tool steel. A number of clean interior fragments (25-50 mg) without crushing scars or metallic streaks were extracted.

Two irradiation procedures and three measurements were employed on each sample. More detailed descriptions of the procedures employed can be found in Cobean *et al.* (1992), Glascock *et al.* (1994), and Glascock and Anderson (1993). For the short irradiation procedure, 100 mg of fragments were weighed into clean high-density polyethylene vials and fixed at the bottom by inserting a plug made of clean styrofoam. For the long irradiation procedure, 300 mg of fragments were weighed into clean high-purity quartz vials which were sealed shut using an oxygen torch flame. Five replicate samples were prepared for each source. In addition, standards and quality control samples made from the National Institute of Standards and Technology (NIST) reference materials SRM-278 Obsidian Rock and SRM-1633a Coal Fly Ash, respectively, were similarly prepared.

The short irradiation samples and standards were sequentially irradiated for five seconds each in a thermal neutron flux of 8×10^{13} n cm^{-2} s^{-1}. Twenty five minutes after the end of irradiation, the samples were placed 15 cm from a horizonatally mounted, high-purity germanium (HPGe) detector to measure the emitted gamma rays. The samples were rotated continuously during a 12-minute counting period. The elements Cl, Dy, K, Mn and Na were determined by comparing the counts per second per mg of sample to the counts per second per mg of standard using the known concentration of the SRM-278 standard.

The long irradiation samples and standards were irradiated simultaneously in an aluminum-foil wrapped bundle. Following a 70-hour irradiation and eight-day decay, the samples were cleaned and mounted on an automatic sample changer coupled to a HPGe detector where each sample was counted for 2,000 seconds to measure seven medium-lived elements (i.e., Ba, La, Lu, Nd, Sm, U, and Yb). Four weeks later, the samples were recounted for a period of three hours to measure 15 long-lived elements (i.e., Ce, Co, Cs, Eu, Fe, Hf, Rb, Sb, Sc, Sr, Ta, Tb, Th, Zn, and Zr). Ratios between the unknown samples and standards were again used to determine the concentrations.

The results from INAA at MURR for the Sierra de Pachuca and Little Glass Buttes obsidian samples were tabulated. The means and standard deviations for five replicates are presented in Column A of Tables I and II, respectively.

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B. Description of the procedures for FNAA at Orleans, France

Bernard Gratuze

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The experimental facilities of the Centre d' Etude et de Recherche par Irradiation (CERI) of the CNRS in Orléans were used for fast neutron activation analysis (FNAA) on the two obsidian inter-comparison samples. The fast neutron beam is produced by a 17.5-MeV deuteron beam impinging on a thick beryllium target. The neutron spectrum has a maximum energy of about 18 MeV, the mean neutron beam energy lies between 7 and 8 MeV and for a 30 mA deuteron beam intensity, the neutron flux is about 10^{11} to 10^{12} neutrons/second.

To determine the greatest number of elements, two successive irradiations in the fast neutron flux followed by direct gamma-ray spectrometry measurement are carried out on each sample. The first irradiation is a 30-second irradiation with a current beam intensity in the range of 100 nA to 30 mA, depending on the sample's weight. The radioactivity is measured for 30 minutes after a 20 minute cooling time. Silicon, aluminum, magnesium, chlorine and potassium are readily determined. The second irradiation is carried out a few days latter with a current beam intensity of 30mA and an irradiation time in the range of 5 to 240 minutes, depending on the weight of the sample. Three measurements of the radioactivity are made for period ranging from 12 to 24 hours after the respective cooling times of 3, 5 and 60 days. Twenty-six elements can be determined in most samples.

In order to correlate the data from all the different irradiations and to take into account the geometrical shape of each sample, a calibration method using two internal standards, ^{22}Na and ^{24}Na, was developed (Gratuze *et al.* 1992). For calibration, we define an experimental ratio K_i/Na between the specific activity of the radioisotope produced by the element *i* and the specific activity of ^{22}Na produced from sodium. These ratios are calculated by simultaneous irradiation of sodium salt pellets with either small disks of the pure metallic element or one of its salts.

The results from FNAA for the Sierra de Pachuca and Little Glass Buttes source samples are presented in Column B of Tables I and II, respectively.

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C. Description of the procedures for LA-ICP-MS analysis at Orleans, France

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The instrumentation used is a VG Plasma Quad PQXS Inductively Coupled Plasma Mass Spectrometer and a VG UV Laser probe laser ablation sampling device. The laser beam is generated by a Nd YAG pulsed laser whose frequency is quadrupled allowing it to operate in the ultraviolet region at 266 nm.

The artefact is sampled by using a laser beam which is focused onto its surface through the window of a quartz sample cell. The diameter of the ablation crater can range from 20 µm to 200 µm and its depth is around 250 µm. The ablated aerosol is carried, by an argon gas flow, through nylon and tygon tubing to the injector inlet of a plasma torch, where the matter is dissociated, atomised and ionised. The ions are then injected, using a two-aperture system, into the vacuum chamber of a quadrupole system where they are selected depending upon their mass-to-charge ratio by the quadrupole mass filter and are hence collected by a channel electron multiplier assembly. This technique allows a nearly non destructive analysis of the objects.

To perform the most accurate and sensitive analysis, the elements are determined within different analytical menus, their numbers could vary from two to four, depending on the number of elements determined and of their level of concentration. In routine condition, two or three element menus are used for obsidian characterisation. For each menu, three analysis are made, the final concentration is the mean value of the three runs. From twenty to fifty elements could be determined in obsidian samples. Detection limits, calculated on a pure quartz sample, range from a few tenths of ppb to some ppm, depending on the measured isotope and on the size of the laser spot.

Referenced materials (glasses from the NIST -N610 and N612- and rocks from the C.R.P.G. of Nancy -basalt BR and biotite Mica Fe-) are used for calibration. The references values used for these standards are those proposed by Hollocher and Ruiz (Hollocher and Ruiz, 1995) and for some element they were recently readjusted by Norman (Norman et al., 1996). For major element calibration (mainly Al, K and Fe), some geological obsidian given by J.L. Poidevin analysed by XRF were used as standard

A sensitivity ranging from $5x10^5$ to $1x10^6$ counts per second is achieved for the isotope 115 of indium in the glass standard NIST 610 containing about 450 ppm of indium.

The results from LA-ICP-MS for the Sierra de Pachuca and Little Glass Buttes obsidian are presented in Column C of Tables I and II, respectively.

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D. Description of the procedures for ICP-AES and ICP-MS analysis at the Catholic University of Rio de Janiero, Brazil

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Analytical samples were prepared in duplicate from the original obsidian inter-comparison specimens by removing fragments weighing about 0.1 g. The samples were treated with a mixture of 1.5 ml sub-distilled HNO_3 and 2 ml HF p.a. (Merck) and taken to dryness. The residues were twice evaporated to dryness with 2 ml of the same HNO_3, and the final residues dissolved in 10 ml HNO_3 10%. Element concentrations were determined by either ICP-AES (Perkin Elmer model Plasma 1000) or ICP-MS (Perkin Elmer Sciex model Elan 5000A) as described below.

Elements determined by ICP-AES: Calcium, iron and scandium were determined from the solutions mentioned above, while aluminium, sodium and potassium were determined following a ten-fold dilution. For instrument calibration we used solutions with 10, 50 and 100 ppm concentration, except for the determination of scandium, for which the solutions were reduced to 0.1, 0.5 and 1 ppm concentration.

Elements determined by ICP-MS: All other elements were determined by ICP-MS in a ten-fold diluted solution. A refined semi-quantitative calibration standard (TotalQuant) was used which approaches very closely the results obtained by a quantitative calibration. Calibration was made using a solution containing **57 (!)** elements and by this means the response factors of all elements are very similar to those obtained by quantitative analysis. The concentrations used were 550 ppb for Na, Mg, P, K, Ca and Fe and 50 ppb for the rest of the elements.

Interferences from elements present at higher concentrations were tested and corrected when necessary. In particular, the concentrations of Co and Ni were corrected for the interference from Ca, Pd was corrected for the interferences from Sr and Ag, Cd was corrected for the interference from Zr, and Sm and Eu were corrected for the interference from Ba.

The results from ICP-AES and ICP-MS for the Sierra de Pachuca and Little Glass Buttes obsidian are presented in Column D of Tables I and II, respectively, except for elements determined only by this laboratory. The additional elements and concentrations are presented in Table III.

Table III. Other elements measured by ICP-MS at the Catholic University of Rio.

Element	**Sierra de Pachuca**	**Little Glass Buttes**
Be (ppm)	9.93	1.59
Cr (ppm)	2.71	2.45
Ni (ppm)	1.40	0.88
Cu (ppm)	1.61	2.80
Ge (ppm)	6.67	4.03
Mo (ppm)	6.62	3.02
Pd (ppm)	11.6	2.61
Ag (ppm)	4.44	0.48
Cd (ppm)	1.63	0.17
W (ppm)	0.86	0.55
Pt (ppm)	0.89	0.13
Tl (ppm)	1.07	0.43
Bi (ppm)	0.14	0.19

E. Description of the procedures for ICP-AES and ICP-MS analysis at Grenoble, France

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The inter-comparison samples were crushed and clear interior fragments (20-50 mg) were selected. For each sample, about 200 mg of chips were dissolved in a screw-top Teflon bomb using HF and HNO_3 at 150°C. Obsidians were without acid resistant phases and complete sample dissolution was always achieved. After evaporation to dryness of the HF-HNO_3 mixture, the samples were taken up in 40 mg of 6M HCl. From this "mother solution" aliquots were analysed for the determination of elemental abundances (Barrat and Nesbitt, 1996; Barrat *et al.*, 1997).

For all measurements on ICP-AES and -MS devices, signal drift was monitored by running a calibration standard every five samples such that a linear drift correction could be applied. Blank solutions were prepared along with sample solutions and analysed together with them. Appropriate corrections were accordingly applied for element concentration determinations.

The content of Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, TiO_2 and P_2O_5 were determined by ICP-AES using a Jobin Yvon JY24 spectrometer. Depending on the elements and their concentrations, measurements were performed on the mother solution or diluted aliquots with dilution factors up to 15,000. Silica, evaporated after sample solution, was not measured but its content could be estimated by difference. Element concentrations were calculated by reference with four homemade synthetic standard solutions at different concentration levels. Results were checked by measurements of international standards SRM278, BIR-1, WS-E and BHVO-1 prepared with the samples.

The concentrations of Co, Rb, Sr, Y, Zr, Nb, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Yb, Lu, Hf, Ta, Pb, Th and U were determined by ICP-MS using a Fisons Plasma Quad turbo 2+ spectrometer. Measurements were performed after a Tm spiking of an aliquot of the mother solution, following Barrat *et al.* (1996) for REE. An aliquot of the mother solution was spiked with a solution of pure Tm (typically 400-700 ng of Tm for the equivalent of 200 mg of sample). The solution was dried in an open PTFE beaker, the residue re-dissolved with 10 drops of conc. HNO_3, mixed with 40 g of high-quality Millipore-prepared water and transferred to a previously unused bottle for storage until measurement. The trace elements and REE abundances in the sample were calculated using the amount of Tm added. First the concentration of Tm coming from the analysed solution was interpolated from Er and Yb concentrations (ppm) in the solution with the chondritic abundances (Eversen et al., 1978) and the shape of the REE pattern :

$$C_{Tm\bullet} = 0.02561 \sqrt{\frac{C_{Er}}{0.166}\ \frac{C_{Yb}}{0.1651}}$$

From the measured concentration of an element X in the solution (C_X) its concentration in the sample is given by:

$$[X]_{ppm} = \frac{M_{Tm} \cdot C_x}{M\left(C_{Tm} - C_{Tm\bullet}\right)}$$

Where M is the weight of sample in g and C_{Tm} is the measured Tm concentration.

The results from ICP-AES and ICP-MS obtained from Grenoble for the Sierra de Pachuca and Little Glass Buttes obsidian are presented in Column E of Tables I and II, respectively.

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F. Description of the procedures for PIXE analysis at AGLAE, France

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The PIXE data were obtained at the AGLAE facility of the Laboratoire de Recherche des Musées de France (Menu *et al.*, 1990). AGLAE is based on a 2 MV tandem accelerator Pelletron 6SDH-2 built by National Electrostatics Co. For obsidian analyses, we used an external proton beam (Calligaro *et al.*, 1996) with an energy of 3 MeV before its exit outside the accelerator vacuum. The entire X-ray spectrum is recorded by means of two Si(Li) detectors located very close to the target and oriented at 45° with respect to the proton beam direction. A high resolution detector covers the energy range 0.3-10 keV for analyzing low-Z major elements of the matrix and a second one the range 5-40 keV for trace elements. Quantification of the raw data is obtained by processing the data with the GUPIX software (Maxwell *et al.*, 1995). GUPIX is a "standardless" software package introduced to treat PIXE spectra from thick specimen.

Obsidian slices were embedded in epoxy resin and polished to a microprobe-quality with diamond pastes. Polished surfaces were exposed perpendicularly to the proton beam. The proton flux and beam diameter were optimized in order to have X-ray acquisition times reasonably short. Using routinely a 0.5 mm beam diameter and a constant proton dose, each acquisition takes roughly 10 min. Given a 2.85-MeV proton energy on sample surface, the depth probed in obsidian is about 50 µm. Under these conditions 13 to 16 major, minor and trace elements : Na, Al, Si, Cl, K, Ca, Ti, Mn, Fe, Zn, Ga, Rb, Sr, Y, Zr and Nb were determined.

The results from PIXE analysis obtained by AGLAE for the Sierra de Pachuca and Little Glass Buttes obsidian are presented in Column F of Tables I and II, respectively.

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G. Description of the procedures for PIXE-PIGME analysis at ANSTO

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Proton Induced X-ray Emission (PIXE) and Proton Induced GaMma-ray Emission (PIGME) were run at the Australian Nuclear Science and Technology Organisation (ANSTO) at Lucas Heights, Australia in March 1997. Three elements (F, Na, Al) are detected best by PIGME and 12 (Si, K, Ca, Ti, Mn, Fe, Zn, Rb, Sr, Y, Zr, Nb) by PIXE. The four flakes we received were labelled Mexican 1, Mexican 2, Oregon 1, Oregon 2. These samples were mounted with steel wire onto plates 14 x 40 mm in size with a raised portion at the centre which has a 5 mm diameter hole for the beam. Mexican 1, Oregon 1, and Oregon 2 were sawn on one edge and this flat surface was presented to the beam. Oregon 2 was mounted as for a normal artifact with the flattest surface possible facing the beam. As the mounts are chromium plated, the results for chromium are not used in the analysis in case any protons strike the plates. A small piece was cut from Mexican 1 and Oregon 1, powdered, and pressed with 20 per cent carbon into a small container: Mexican 1 pressed; Oregon 1 pressed. Previous experience has shown that slightly different results are obtained from solid and powdered/pressed samples.

The samples were irradiated by a 2.5-MeV proton beam from a 3 MV de Graaff accelerator. Beam current was 300nA, beam diameter of 2 mm, and beam dose at 150 µC with a measuring time of ten minutes. An electron flood was used for all measurements to overcome the effects of samples charging. These conditions are identical to those used in the past 7 years for characterising Pacific obsidian sources and artifacts. The samples were analysed as part of a normal run including artifacts from Papua New Guinea, in order to replicate typical operating conditions. Additional details about the equipment used can be found in Summerhayes *et al.* (1998).

Since machine conditions vary slightly for each run and different sized samples charge to varying degrees, it is necessary to standardise each run to allow comparison between different runs. This is carried out by placing standards within each run. The variability of the standard in the run is compared to the reference values, which have been determined by multiple previous runs. Values for elements which depart from the reference by more than 5 per cent, are standardised according to the reference set and corrections are made to each sample. This step removes any systematic differences between spectrum processing procedures used for the new data from those used for the reference data. With the Pacfic data, a reference set of obsidian from the Admiralty Islands is used. In the case of the Mexican and Oregon obsidians the result from running the NIST standard SRM278 which was powdered and pressed with 20 per cent carbon, was used to standardise the results (cf. Bird *et al.* 1997: 62).

The results from PIXE-PIGME at ANSTO for the Sierra de Pachuca and Little Glass Buttes obsidian are presented in Column G of Tables I and II, respectively. A discussion of the precision and accuracy of PIXE-PIGME has been presented in Bird *et al.* (1997). Accuracy tested against 23 international standards was found to have been better than 10 per cent. Precision, based on running a single sample 60 times, was determined as better than 10 per cent at 2 standard deviations for 10 elements.

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I. Description of the procedures for XRF analysis at Ashe Analytics

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Specimens from the obsidian sources obtained for the inter-laboratory comparison study were measured by energy-dispersive x-ray fluorescence spectroscopy (EDXRF). A SPECTRACE 5000 spectrometer was used to excite the sample and measure the resulting characteristic x-rays. The spectrometer was calibrated using standard reference materials from the National Institute of Standards and Technology (NIST), the U.S. Geological Survey, The National Research Council of Canada, and by locally-prepared (generally single- or dual-element) standards. Most elements were measured with a setting of 35 kV excitation potential and a Rh filter that produces primarily Rh "K" radiation. The elements Ba, La, and Ce were measured with a 50 kV excitation potential and a thick Cu beam filter that produces a broad spectrum of x-rays primarily in the 30-50 keV range. Results were normalized to appropriate scatter regions of the detected spectrum to account for the geometric variability of the samples.

The results from XRF analysis obtained by Ashe Analytics on the obsidian inter-comparison samples from Sierra de Pachuca and Little Glass Buttes are presented in Column I of Tables I and II, respectively. All results are given in parts per million for the elemental concentrations. The indicated uncertainties are one standard deviation calculated from repeated measurements on each sample. They do not take into account the absolute accuracy of the calibration.

H. Description of the procedures for XRF analysis at CNR-ITABC, Rome, Italy

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In our case, the inter-comparison samples were prepared for analysis by mixing 90% of a fine obsidian powder (< 265#) with 10% of Henkel wax powder as a binding medium. A Herzog HTP 40 press was used to form the samples into pellets of 38mm diameter.

A Siemens SRS 200 sequential, automatic XRF spectrometer equipped with a rhodium side-window tube (3000 W) was used to measure a total of 14 elements in each sample. The spectrometer's sample changer allows storing of up to 10 pellet samples, simultaneously. All spectral lines were measured in vacuum. As a general rule, as far as the trace elements are concerned, peak and two symmetrical backgrounds were measured for every spectral line. The major elements determined were: Si, Al, Fe, Mg, Ca, Na and K; the minor elements were: Mn and Ti; and the trace elements were: Nb, Zr, Y, Sr and Rb.

The assay method used was that of Leoni & Saitta (1976), in which the inter-element and overlapping peak effects were fully corrected. There are no cases of overlapping of spectral lines as far as the major and minor elements are concerned, except for the partial overlap of the line Cr Kß on the Mn Kα. However, this is of more theoretical problem than a practical one for two reasons. First, the Cr content in obsidian is much lower than that of Mn and it is the weaker Cr Kß (1/5 of the intensity of the Cr Kα.) which overlaps. Second, Mn has a lesser importance for discrimination between obsidians.

In the case of the trace elements, the inter-element effects of the major and minor elements on one another were calculated. Furthermore, the partial or total overlappings of the following spectral lines: Y Kß on Nb Kα, Sr Kß on Zr Kα, Rb Kß on Y Kα, Ti Kß on V Kα, and Fe Kß on Co Kα were taken into account. This means, that the measurement of Nb Kα is affected by the abundance of yttrium, which is in its turn influenced by the presence of Rb. It follows that the Nb determination is affected by a double error due to the presence of both Y and Rb and by the error of measurement due to its scant abundance (10-50 ppm). Of the five elements only rubidium is a *sure* element in that it is unaffected by overlapping from other spectral lines. On the other hand, strontium, although not affected by the overlapping of other spectral lines, lies at the lower limit of detectability in hyperalkaline rocks.

The results from XRF analysis for the Sierra de Pachuca and Little Glass Buttes obsidian are presented in Column H of Tables I and II, respectively.

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J. Description of the procedures for XRF analysis at Northwest Research

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Analysis of the inter-laboratory comparison samples was completed using a Spectrace 5000 energy dispersive X-ray fluorescence spectrometer. The system is equipped with a Si(Li) detector with a resolution of 155 eV FWHM for 5.9 keV X-rays (at 1000 counts per second) in an area 30 mm^2. Signals from the spectrometer are amplified and filtered by a time variant pulse processor and sent to a 100 MHz Wilkinson type analog-to-digital converter. The X-ray tube employed is a Bremsstrahlung type, with a rhodium target, and 5 mil Be window. The tube is driven by a 50 kV 1 mA high-voltage power supply, providing a voltage range of 4 to 50 kV.

For analysis of the elements zinc (Zn), lead (Pb), thorium (Th), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb), the X-ray tube is operated at 30 kV, 0.30 mA (pulsed), with a 0.127 mm Pd filter. Analytical lines used are Zn (K-alpha), Pb (L-alpha), Th (L-alpha), Rb (K-alpha), Sr (K-alpha), Y (K-alpha), Zr (K-alpha) and Nb (K-alpha). Samples are scanned for 200 seconds livetime in an air path.

Peak intensities for the above elements are calculated as ratios to the Compton scatter peak of rhodium, and converted to parts-per-million (ppm) by weight using linear regressions derived from the analysis of twenty rock standards from the U.S. Geological Survey, the Geologic Survey of Japan, and the National Bureau of Standards. The analyte to Compton scatter peak ratio is employed to correct for variation in sample size, surface irregularities, and variation in the sample matrix.

For analysis of the elements titanium (Ti), manganese (Mn), and iron ($Fe_2O_3^T$), the X-ray tube is operated at 12 kV, 0.27 mA with a 0.127 mm aluminum filter. Samples are scanned for 200 seconds livetime in a vacuum path. Analytical lines used are Ti (K-alpha), Mn (K-alpha), and Fe (K-alpha).

Concentration values (parts per million for titanium and manganese, weight percent for iron) are calculated using linear regressions derived from the analysis of thirteen standards from the U.S. Geological Survey, the Geologic Survey of Japan and the National Bureau of Standards. However, these values are not corrected against the Compton scatter peak or other scatter regions, resulting in lower than normal trace element values for small samples that fall below the minimum size requirement.

For analysis of the elements barium (Ba), lanthanum (La) and cerium (Ce), the X-ray tube is operated at 50 kV, 0.25 mA with a 0.63 mm copper filter in the X-ray path. Analytical lines used are Ba (K-alpha), La (K-alpha), and Ce (K-alpha). Samples are scanned in an air path for 100 to 600 seconds livetime, depending upon trace element concentration. Trace element intensities are calculated as ratios to the Bremsstrahlung region between 25.0 and 30.98 keV, and converted to parts-per-million by weight using a polynomial fit routine derived from the analysis of sixteen rock standards from the U.S. Geological Survey and the Geologic Survey of Japan. It should be noted that the Bremsstrahlung region corrects for sample mass only and does not account for matrix effects.

All samples are scanned as unmodified rock specimens. Reported errors represent counting and fitting error uncertainty only, and do not account for instrumental precision or effects related to the analysis of unmodified obsidian. When the latter effects are considered, relative analytical uncertainty is estimated to be between three and five percent.

The results from XRF analysis obtained by Northwest Research Obsidian Studies Laboratory on the obsidian inter-comparison samples from Sierra de Pachuca and Little Glass Buttes are presented in Column J of Tables I and II, respectively. All trace element values are reported in ppm with ± indicating the estimated analytical uncertainty (in ppm).

NEW MEMBERS

New IAOS members since the last issue of the Bulletin:

Helen R. Haines, Scarborough, Ontario, Canada; affiliation: Institute of Archaeology, London, UK

Ted Jones, Valley Ford, CA; Sonoma State University

Robert Lamborn, St. Helena, CA; Lamborn Family

ABOUT THE IAOS

The IAOS was 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, and;
4. provide a central source of information regarding the advances in obsidian studies and the analytic capabilities of various laboratories and institutions.

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Deadline for issue No. 24 is 1 May 1999.

Send submissions to –

Suzanne Stewart
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Anthropological Studies Center, Bldg. 29
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INTERNATIONAL ASSOCIATION FOR OBSIDIAN STUDIES

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