International Obsidian Conference

1 – 3 June 2016

Regional Aeolian Archaeological Museum
"Luigi Bernabò Brea"

Lipari, Italy

Program and Abstracts

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Dr. Yaroslav V. Kuzmin, Institute of Geology & Mineralogy, Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russia

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International Association for Obsidian Studies

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Schedule Outline, 1–3 June 2016

Wednesday, 1 June

8:30 – 9:20	Registration
9:20 – 9:45	Opening of conference and welcome addresses
9:45 – 13:05	Morning oral session (Methods; and Mediterranean Region)
13:05 – 15:00	Lunch break
15:00 – 17:00	Afternoon oral session (Mediterranean Region)
17:00 – 17:30	Coffee break
17:30 – 19:00	Poster Session I

Thursday, 2 June

9:00 – 13:00	Morning oral session (Europe; Africa; and Latin America)
13:00 – 15:00	Lunch break
15:00 – 16:00	Poster Session II
16:00 – 20:00	Lipari Island tour (with visit to obsidian sources)
20:00 – 22:00	Conference dinner

Friday, 3 June

9:00 – 13:00	Morning oral session (Anatolia and the Near East; East Asia)
13:00 – 15:00	Lunch break
15:00 – 17:00	Afternoon oral session (East Asia)
17:00 – 17:30	Coffee break
17:30 – 18:00	Discussion; place for next meeting; end of conference
18:00 – 19:00	Tour of museum (optional)

The Aeolian Islands and Lipari

The Castello and Lipari Museum in the center of town of Lipari

International Obsidian Conference Program

Museo Archeologico Regionale “L. Bernabò Brea”
Via del Castello, Lipari

Wednesday, June 1

8:30 *Registration*

9:15 Welcome
Maria Amalia Mastelloni, Director, Luigi Bernabò Brea Archaeological Regional Museum

Introduction
Colin Renfrew

Robert H. Tykot, Yaroslav V. Kuzmin, Maria Clara Martinelli

Methods

9:45 ***Keynote I***: Reflections on the contribution of obsidian characterization studies to archaeological research: The role of analytical methods
Michael D. Glascock

10:15 SEM and XRF analyses as a tool to discriminate obsidian provenance from archaeological sites of central and southern Italy
Pasquale Acquafredda, Felice Larocca, Italo Maria Muntoni, Mauro Pallara

10:35 Sourcing obsidian artifacts by LA-ICP-MS at the SOLARIS platform
Marie Orange, François-Xavier Le Bourdonnec, Anja Scheffers, Renaud Joannes-Boyau

10:55 Magnetic granulometry as a sourcing characteristic of archaeological obsidian in the Mediterranean
Enzo Ferrara, Evdokia Tema, Elena Zanella, Elena Pavesio, Andrea Perino

11:15 ***Coffee Break***

11:45 Microstructure, morphology and magnetism of Monte Arci obsidian
Valentina Mameli, Anna Musinu, Daniel Niznansky, Davide Peddis, Guido Ennas, Andrea Ardu, Carlo Lugliè, Carla Cannas

Mediterranean Region

12:05 Lipari obsidian in the Late Neolithic. Artifacts, supply and function
Maria Clara Martinelli, Maria Rosa Iovino, Robert H. Tykot, Andrea Vianello

12:25 Lipari obsidian sources and distribution in the prehistoric central Mediterranean
Robert H. Tykot

12:45 Archaeological obsidian provenance of several Italian Neolithic sites using a non-destructive XRF method
Anna Maria De Francesco, Marco Bocci, Vincenzo Francavigilia, Gino Mirocle Crisci

13:05 ***Lunch***

15:00 Obsidian out of time: evidence from the Late Copper Age settlement at Poggio dell'Aquila - Adrano (Catania, Sicily)
Massimo Cultraro, Lighea Pappalardo, Giuseppe Pappalardo

15:20 Sourcing, circulation and technology of obsidian in Neolithic Apulia (South-East Italy)
Italo Maria Muntoni, Francesca Radina, Sandra Sivilli, Maria Clara Martinelli

15:40 A long-term perspective on the exploitation of Lipari obsidian in central Mediterranean prehistory
Kyle P. Freund

16:00 Towards the Hyperboreans: tracing out a parabola of Sardinian obsidian exploitation and distribution during the Neolithic
Carlo Lugliè, François-Xavier Le Bourdonnec

16:20 Research into Characterization and Geochemical Provenance of Obsidian Artefacts from Pantelleria Island, Sicily (Italy)
Emiliano Tufano, Sebastiano Tusa, Angela D'Amora, Marco Trifuoggi

16:40 Consumption of obsidian during the Middle Bronze Age: a use wear analysis of obsidian from Kirrha (Phocis, Greece)
Marie-Philippine Montagne

17:00 ***Coffee Break***

17:30 **Poster Session I** (Methods, Mesoamerica, South America, East Asia)

1. Reassessment of an XRF method based on trace elements peak intensity ratios for obsidian provenance determination
Pasquale Acquafredda, Italo Maria Muntoni, Mauro Pallara

2. Do I really need to analyze the sources myself? Testing the limits of inter-instrumental XRF obsidian data exchange
Jeffrey Ferguson

3. A comparative study of non-destructive PGAA and XRF used for provenancing archaeological obsidian
Zsolt Kasztovszky, Boglárka Maróti, Ildikó Harsányi, Dénes Párkányi, Veronika Szilágyi, Katalin T. Biró, András Markó

4. Link between WD-XRF, ED-XRF and P-XRF for archaeological obsidian analyses
Hidehisa Mashima

5. Characterization of the pyroclastic deposit of Cerro Allende (Altotonga, Veracruz), used as aggregate in Teotihuacan plasters
Donatella Barca, Luis Barba, Jorge Blancas, Gino Mirocle Crisci, Linda Rosa Manzanila, Stefano Marabini, Domenico Miriello, Agustin Ortiz, Aleandro Pastrana, Alessandra Pecci

6. Macroscopic and chemical variation in the obsidian of Sierra Las Navajas (Hidalgo, Mexico)
Paola Donato, Rosanna De Rosa, Giancarlo Niceforo, Alejandro Pastrana, Matteo Montesani, Luis A. Barba Pingarron, Gino M. Crisci

7. Lipari (Aeolian Islands, Italy) and Sierra Las Navajas (Hidalgo, Mexico) obsidians: A comparative study
Paola Donato, Rosanna De Rosa, Giancarlo Niceforo, Alejandro Pastrana, Ida Perrotta, Mariano Davoli, Luis A. Barba Pingarron, Gino M. Crisci

8. Provenance of obsidian artifacts from the natural protected area Laguna del Diamante (Mendoza, Argentina) and the upper Maipo valley (Chile) by LA-ICP-MS
Anna Maria De Francesco, Donatella Barca, Victor Durán, Valeria Cortegoso, Ramiro Barberena, Marco Bocci

9. Obsidian sources of northwestern Patagonia (Andean forest region of southern Argentina)
Martin Giesso, Alberto E. Perez, Michael D. Glascock

10. Obsidian in the forest: Chemical characterization of archaeological artifacts from northwest Patagonia, Argentina
Charles R. Stern, Mariana Carballido Calatayud, Cristina Bellelli

11. Obsidian of the Nulgery Paleolithic site in Korea
Jong Chan Kim

12. Obsidian provenance as a tool to study human movements in the Upper Paleolithic, Neolithic, and Paleometal of northeast Asia: an overview of current studies
Yaroslav V. Kuzmin

13. Obsidian sources in the Democratic People's Republic of Korea (North Korea)
Yaroslav V. Kuzmin, Michael D. Glascock, Jong Chan Kim, Clive Oppenheimer, Mi-Young Hong

19:00 **Museum closes**

Thursday, June 2

Europe

9:00 Dynamism in the utilization of Carpathian obsidian
Katalin T. Biró

9:20 Use of obsidian during the Last Glacial Maximum: case studies from the Ságvárian sites in Hungary
András Markó

Africa

9:40 ***Keynote II***: Risk and opportunity at Nabro volcano, Eritrea: a deep time perspective
Clive Oppenheimer, Bernard Gratuze, Lamya Khalidi, Bill McIntosh

10:10 Obsidian hydration dating of Late Pleistocene deposits at the Mochena Borago rockshelter, Ethiopia
Christopher M. Stevenson, Steven A. Brandt, Alexander Rogers; Stanley H. Ambrose

10:30 The effect of latitude on raw material transfers and human social behavior: the case of Palaeolithic obsidian
Theodora Moutsiou

10:50 Obsidian sourcing in southwest Arabia and the Horn of Africa: implications for human mobility and interaction in the Neolithic
Lamya Khalidi, Bernard Gratuze, Clive Oppenheimer, Edward Keall, Jessie Cauliez

11:10 ***Coffee Break***

11:40 Obsidian trade across the Red Sea in Neolithic times: the case for Tihamah sites
Vincenzo Francaviglia, Marco Ferretti

Latin America

12:00 Geographic vectors of inter-mountain human circulation: the role of Andean obsidian (central Argentina and central Chile)
Martin Giesso, Victor A. Duran, Valeria Cortegoso, Ramiro Barberena, Michael D. Glascock

12:20 Obsidian sources and distribution in Patagonia, southernmost South America: a general overview
Charles R. Stern

12:40 Spatial and temporal distributions of exotic/local obsidian in the Aisén region, southernmost South America
César Méndez, Charles Stern, Amalia Nuevo Delaunay, Omar Reyes, Felipe Gutiérrez

13:00 ***Lunch***

15:00 **Poster Session II** (Mediterranean, Europe, Near East)

14. New data on Antiparos obsidian (Greece) for provenance study by SEM and XRF
Pasquale Acquafredda, Italo Maria Muntoni, Robert H. Tykot

15. A multidisciplinary approach to the study of obsidian fragments: the case of Ustica Island (Palermo, Sicily)
Franco Foresta Martin, Andrea Di Piazza, Claudia D'Oriano, Maria Luisa Carapezza, Antonio Paonita, Silvio Giuseppe Rotolo, Leonardo Sagnotti

16. Semi-quantitative characterization by micro-XRF mapping and SEM/EDS observations of obsidian artifacts from Pantelleria and Levanzo, Sicily (Italy)
Antonella Giarra, Angela D'Amora, Valentina Roviello, Marco Trifuoggi, Emiliano Tufano, Sebastiano Tusa

17. Obsidian from the Bronze Age village of San Vincenzo - Stromboli: provenance, production, use and distribution
Sara T. Levi, Diego Calliari, Valentina Cannavo, Andrea Di Renzoni, Effie Photos-Jones

18. Sicily. The Neolithic site of San Martino: Working and circulation of obsidian from Lipari
Maria Clara Martinelli, Tania Quero

19. Obsidian source selection in the Early Bronze Age Cyclades
Jessica A. Morgan, Robert H. Tykot, Tristan Carter

20. Obsidian industry of Lago di Venere settlement in Pantelleria
Emiliano Tufano, Sebastiano Tusa

21. Obsidian Access along the Adriatic: Sourcing Studies and Maritime Trade in Croatia
Robert H. Tykot, Staso Forenbaher, Damir Kliskic, Zlatko Perhoc, Emil Podrug, Dinko Radic

22. Novel investigations on the mineralogy of Carpathian mahogany obsidian
Károly Lázár, Viktória Kovács Kis, Adél Len, Zsolt Kasztovszky, András Markó, Katalin T. Biró

23. Large-scale provenancing of obsidian artifacts from various sites in the Near East
Stuart Campbell, Elizabeth A. Healey

24. Diffusion of Anatolian and Caucasian obsidian in Iran: elements of explanation in “least cost path” models
Christine Chataigner, Olivier Barge

25. New data on source characterization and exploitation of obsidian from the Chikiani area (Georgia)
Bernard Gratuze, Paolo Biagi

26. Emplacement of obsidian outcrops in Meydan and obsidian characteristics
Anne-Kyria Robin, Damase Mouralis, Ebru Akköprü, Katherine Kuzucuoglu, Bernard Gratuze

16:00 **Lipari Island Tour**

20:00 **Conference dinner**

Friday, June 3

Anatolia and the Near East

9:00 Identification and characterization of a new obsidian source in the Nemrut volcano (Eastern Anatolia, Turkey): the Sicaksu obsidian
Anne-Kyria Robin, Damase Mouralis, Ebru Akköprü, Katherine Kuzucuoglu, Bernard Gratuze

9:20 Arslantepe (Eastern Anatolia): Procurement of obsidian from Anatolian geological sources during the Chalcolithic and Middle Bronze Age
Damase Mouralis, Massimo Massussi, Ebru Akköprü, Francesca Balosi, M. Korhan Erturaç, Delphine Grancher, Bernard Gratuze, Fatima Mokadem, Katherine Kuzucuoglu, Giulio Palumbi, Anne-Kyria Robin

9:40 Obsidian at Mesolithic Sites in Georgia
Ana Tetruashvili

10:00 Networks of obsidian use and exchange in the Neolithic eastern Fertile Crescent
Amy L. Richardson

10:20 The spread of obsidian on the Iranian Plateau during the Neolithic and the Bronze Age. The possible role of mobile pastoralists
Bernard Gratuze, Marjan Mashkour, Mohamad Hossein Azizi Kharananghi, Ali Zalaghi, Sepideh Maziar, Damase Mouralis, Anne-Kyria Robin

10:40 Obsidian in the southern Caucasus between cooking and knapping. The case of the obsidian-tempered ceramics from Aratashen (Armenia) and Mentesh Tepe (Azerbaijan)
Giulio Palumbi, Denis Guilbeau, Laurence Astruc, Bernard Gratuze, Bertille Lyonnet, Christine Chataigner, Armine Harutyunyan

11:00 ***Coffee Break***

East Asia

11:30 ***Keynote III***: The Impact of obsidian source studies on archaeology: A view from the Japanese islands
Akira Ono

12:00 New obsidian sources and Late Pleistocene/Early Holocene maritime interaction in southeastern Indonesia - East Timor
Christian Reepmeyer, Sue O'Connor, Mahirta, Tim Maloney

12:20 Obsidian provenance for prehistoric sites on Chukotka (northeastern Siberia, Russia): First results and interpretations
Yaroslav V. Kuzmin, Andrei V. Grebennikov, Michael D. Glascock

12:40 Internal structures of a Quaternary obsidian lava at Sanuka-yama, Kouzu Island, Japan
Yoshihiko Goto, Keiji Wada

13:00 ***Lunch***

15:00 Transporting Kozushima Island obsidian across the Pacific Ocean at the beginning of the early Upper Paleolithic, Japan
Nobuyuki Ikeya

15:20 Changes in obsidian use and human responses to the LGM climate conditions in central Japan
Kazutaka Shimada

15:40 Genesis of internal structure of Shirataki obsidian, northern Hokkaido, Japan
Keiji Wada, Kyohei Sano

16:00 Provenance study of obsidian artifacts from Hiroppara site in Kirigamine, central Japan
Yoshimitsu Suda

16:20 Two contrasting provenances of prehistoric obsidian artifacts in South Korea: mineralogical and geochemical evidence
Yong-Joo Jwa, Seonbok Yi

16:40 Obsidian sourcing and characterization in the Celebes region: An initial interpretation on the "Celebes Seafaring People"
Leee Anthony M. Neri

17:00 ***Coffee Break***

17:30 **Discussion**

18:00 **Place for next conference; end of meeting; visit museum**

19:00 **Museum closes**

Conference Abstracts

SEM and XRF Analyses as a Tool to Discriminate Obsidian Provenance from Archaeological Sites of Central and Southern Italy

Pasquale Acquafredda
Università degli Studi di Bari Aldo Moro, Bari 70125, ITALY;
email: pasquale.acquafredda@uniba.it

Felice Larocca
Centro di Ricerca Speleo-Archeologica "Enzo dei Medici", Roseto Capo Spulico 87070, ITALY

Italo Maria Muntoni
Soprintendenza Archeologia della Puglia, Foggia 71121, ITALY

Mauro Pallara
Università degli Studi di Bari Aldo Moro, Bari 70125, ITALY

This research synthesizes our data on the provenance of obsidian from Neolithic sites in central and southern Italy, and compares two different non-destructive techniques, SEM–EDS and XRF, using peak intensity ratios of some trace elements useful for geological source determination. A systematic program for determining provenance, carried out with SEM–EDS and XRF, has provided a well-defined outline of the various geological derivation outcrops. This has confirmed the clear, sometimes exclusive, predominance of Lipari obsidian in the Neolithic at many sites of Tuscany, Latium, Marche, Apulia, and Calabria. A significant presence of Pontine obsidian in Apulia (at Ripa Tetta, Monte Aquilone, Passo di Corvo, Masseria Candelaro, and Balsignano sites) and in Marche (at Esanatoglia and Maddalena di Muccia sites) was confirmed, which is greater than previously thought; as well as an (albeit limited) presence of obsidian from Monte Arci within the Pulo di Molfetta doline (SC sub-source) along the Adriatic coast of Apulia, and at Franciana (SA and SC sub-sources) along the Tyrrhenian coast of the Tuscany.

The obsidian artifacts provenance was non-destructively determined, analyzing only a small portion of their glass surface, with a SEM (Scanning Electron Microscope) coupled with an ED (Energy Dispersive) spectrometer; alternatively, the whole obsidian specimen, glass and microphenocrysts, were characterized, in an absolutely non-destructive way, measuring the peak intensity ratios of various trace elements by XRF (X-ray Fluorescence), in order to establish the geological outcrops from which the rocks were extracted during the Neolithic.

The SEM–EDS method allows us to characterize specimen up to 15 cm long but necessitate that the specimen, or a little part of its surface, have to be covered by a tiny carbon film before analysis, and it can be easily removed at the end of the determination. Geochemical data obtained this way can be also easily compared with other information from literature obtained by different methods, such as EPMA or LA–ICP–MS.

More readily, the XRF technique grants a quick acquisition of chemical parameters, useful for obsidian provenance determination, only on specimen no bigger than 4 cm; the samples are very quickly analyzed in the XRF equipment without treatment, but the XRF characteristic intensities do not allow any comparison with results generated by other methods unless exactly the same procedure was employed.

This overview allows us to propose some hypotheses about the circulation model(s) of this raw material in central and southern Italy that underwent significant development during the Neolithic.

Reassessment of an XRF Method Based on Trace Elements Peak Intensity Ratios for Obsidian Provenance Determination

Pasquale Acquafredda
Università degli Studi di Bari Aldo Moro, Bari 70125, ITALY
email: pasquale.acquafredda@uniba.it

Italo Maria Muntoni
Soprintendenza Archeologia della Puglia, Foggia 71121, ITALY

Mauro Pallara
Università degli Studi di Bari Aldo Moro, Bari 70125, ITALY

X-ray Fluorescence (XRF) technique using peak intensity ratios of trace elements is one of the quicker, less expensive, and less invasive methods to locate obsidian sources among the numerous entirely non-destructive or minimally destructive techniques such as SEM−EDS, EPMA, and LA−ICP−MS. Moreover, the XRF peak intensity ratios are particularly useful when the artifact is slightly altered, particularly affecting the alkali cations, or when its surfaces are covered by a tiny film of carbonates formed during the burial period of the sample.

The limitation of this technique is due to the dimension of the analyzable obsidian: samples bigger than 4 cm do not enter in the sample holder of the XRF spectrometer. Very small obsidian samples, on the other hand, are difficult to analyze because very few X-rays are emitted by their surface.

To make it possible to analyze very small specimens, an aluminum holder closed at the bottom with a very thin Mylar© polyester film was prepared. The specimen, positioned at the center of the surface of Mylar film, was placed in the XRF spectrometer. The use a new XRF apparatus equipped with a 4 kWatt Rh anode X-ray tube coupled with an accurate measurement of refined X-ray Rayleigh lines, that exclude the X-ray background contribution, of five trace elements (Rb, Sr, Y, Zr, and Nb), allowed to discriminate source geological outcrop for obsidian samples as light as 0.04 g. Consequently, a database of peak/background ratios for these trace elements was produced for obsidian samples from Lipari, Palmarola, Monte Arci, Melos, and Gyali sources. These peak/background values, from which the X-ray background contribution is excluded, can also be used in other XRF laboratories as long as they measure the net intensity of the peaks for Rb, Sr, Y, Zr, and Nb.

The proposed XRF method was tested by analyzing Neolithic obsidians from four Apulian sites (Ripa Tetta at Lucera and Palestra ex GIL at Foggia; and Pulo di Molfetta and Grotta di Santa Barbara at Polignano a Mare) whose source outcrops were just determined by SEM−EDS: the analytical results gave the same provenance using the data obtained by SEM–EDS or XRF peak intensity ratios.

New Data on Antiparos Obsidians (Greece) for Provenance Study by SEM and XRF

Pasquale Acquafredda
Università degli Studi di Bari Aldo Moro, Bari 70125, ITALY
email: pasquale.acquafredda@uniba.it

Italo Maria Muntoni
Soprintendenza Archeologia della Puglia, Foggia 71121, ITALY

Robert H. Tykot
University of South Florida, Tampa, FL 33620, USA

The island of Antiparos belongs to the Aegean volcanic arc: its volcanic activity is of Pliocene age (4.78 Ma by fission track on obsidians) and has calc-alkaline affinity. The products of volcanism are rhyolitic lava domes, containing also obsidian that rises mainly in the south of the island. The obsidian outcrops offer samples of excellent tool-making quality but of small size making the raw material less attractive than what is available from other obsidian sources.

Geological samples collected at Soros beach, Blaco and Mastichi localities, in the southern part of the island, were analyzed by both X-ray Fluorescence (XRF) spectrometry of whole rock and Scanning Electron Microscope with Energy Dispersive Spectrometer (SEM−EDS) analysis of glass and microliths/microphenocrysts.

The XRF spectrometer was used to analyze major and trace elements in powdered specimens, which is destructive; the same spectrometer was also used to characterize the same samples nondestructively as solids, using their X-ray peak intensity ratios of the trace elements.

Moreover, the SEM−EDS technique was used to characterize the obsidian glass of the samples prepared as thin sections or as raw surfaces; on thin sections the microphenocrysts (mainly pyroxenes and amphiboles) present in the glass were also characterized by back scattered electron (BSE) images and the energy dispersive spectrum.

The data obtained demonstrates the possibility of discriminating Antiparos obsidian from the other major Mediterranean sources, including Monte Arci in Sardinia, Palmarola, Lipari, Pantelleria, Gyali, and Melos, in an absolutely non-destructive way using an XRF spectrometer, by X-ray peak intensity ratios, or alternatively with SEM−EDS analyzing the glass or the microphenocrysts.

Characterization of Pyroclastic Deposit of Cerro Allende (Altotonga, Veracruz), Used as Aggregate in Teotihuacan Plasters

Donatella Barca
University of Calabria, Rende 87036, ITALY; email: d.barca@unical.it

Luis Barba & Jorge Blancas
Universidad Nacional Autónoma de México, México City 04510, MEXICO

Gino Mirocle Crisci
University of Calabria, Rende 87036, ITALY

Linda Rosa Manzanila
Universidad Nacional Autónoma de México, México City 04510, MEXICO

Stefano Marabini & Domenico Miriello
University of Calabria, Rende 87036, ITALY

Augustin Ortiz
Universidad Nacional Autónoma de México, México City 04510, MEXICO

Alejandro Pastrana
Instituto Nacional de Antropología e Historia, Mexico D.F. 06100, MEXICO

Alessandra Pecci
Universitat de Barcelona, Barcelona, SPAIN

Recent studies conducted by our research team on the plaster of Teotihuacan, the most important city in ancient Mesoamerica during the Classic Period, revealed the use of volcanic glass shards as aggregate in the manufacture of the plaster. In Mesoamerican outcrops, large volumes of rhyolites and ignimbrites are related to two important volcanic provinces, the Sierra Madre Occidental (SMO), and the Trans-Mexican Volcanic Belt (TMVB).

Assuming that the glass shards in pyroclastic deposit and obsidian samples are from the same magmatic system with the same composition, as preliminary screening aimed to the identification of the possible source area, we compared the chemical compositions of glass shards in the archaeological plasters with the bibliographic data of geological obsidian sources (Cobean 2002; Cobean et al., 1991; Ponomanenko 2004; Carballo et al., 2007). The comparison allowed the identification of Altotonga (Veracruz) magmatic system as the source of the rhyolitic glass shards used as an aggregate for plasters (Barca et al. 2013).

In a second phase of this study, we conducted a geological field in the area of Cerro Allende (Altotonga Veracruz). During the surveys, four samples of volcanic cinder, white in color and rich in glass shards at a simple mesoscopic observation, were collected in three different outcrops around the Altotonga Town. Six other samples were collected: three from the locality of El Frijol Colorado; and three near the archaeological site of Cantona.

The petrographic study showed that the samples of Altotonga are richer in glass shards than the other samples, which on the contrary contain higher quantity of pomiceous fragments and minerals (feldspar and plagioclase). To determine the chemical compositions of the glass shards, the samples were embedded in epoxy resin and the glass shards were analyzed using two microanalitycal thechniques: Scanning Electron Microscopy coupled with X-ray Spectrometry (SEM–EDS) to determine major elements, and Laser Ablation Inductively-Coupled Plasma Mass

Spectrometry (LA–ICP–MS) for trace elements. The results of analyses confirm that the pyroclastic deposits around Altotonga Town are the source for the glass shards used as aggregate in the plasters of Teotihuacan.

Dynamism in the Utilization of Carpathian Obsidians

Katalin T. Biró

Hungarian National Museum, Budapest H-1088, HUNGARY; email: tbk@ace.hu

Obsidian is one of the rare commodities that can be traced back beyond doubt to sources of origin. It was one of the long-distance trade items important in the prehistory of the Carpathian Basin in particular (see Flóris 1878; Biró 2014), and Central Europe in general.

This paper tries to make inquiries into the dynamism of utilization of the Carpathian obsidians. Several generations of archaeologists devoted time and attention to mapping occurrences of archaeological obsidian. By now, we have adequate means for assigning even the distant obsidian artifacts to known sources. The earliest dated archaeological instances can be traced back at least to the Middle Paleolithic period, and documented obsidian use extended over the whole prehistory of the region. The directions of spread, ratio, and importance in different time periods were obviously changing. The temporal and spatial dynamism of obsidian use will be summarized on the basis of current evidence, with particular attention to interaction zones and 'blank spots'.

References

Flóris, R. 1878. Les silex taillés et les obsidiennes en Hongrie. In: *VIII Congrès International d'Anthropologie et d'Archéologie Préhistoriques, 1876. Compte-Rendu de la Huitième Session à Budapest. Tome 2***.** Budapest: Musée National Hongrois, pp. 5–17.

Biró, K.T. 2014: Carpathian obsidians: state of art. In: M. Yamada, A. Ono (Eds.), *Lithic Raw Material Exploitation and Circulation in Prehistory* (ERAUL 138). Liege: University of Liege, pp. 47–69.

Large-scale Provenancing of Obsidian Artifacts from Various Sites in the Near East

Stuart Campbell
University of Manchester, Manchester M13 9PL, UK

Elizabeth Healey
University of Manchester, Manchester M13 9PL, UK
email: elizabeth.healey@manchester.ac.uk

Large-scale provenance analysis coupled with techno-morphological and contextual studies of obsidian artifacts within individual assemblages in the Near East transforms the potential for interpreting the distribution of obsidian artifacts. It is particularly driven by low-cost, portable methods of analysis, in our case the use of pXRF. In this paper we use the data obtained from such analyses to provide a more solid basis for the discussion of how obsidian from different sources is used both locally and over a wider area.

Recent comprehensive analyses by T. Carter and others of the obsidian from sites such as Çatalhöyük in central Anatolia (where obsidian is the main raw material used for the chipped stone tool kit) and elsewhere, for example at Körtik Tepe in the upper Tigris River valley in southeastern Anatolia (where obsidian accounts for between 15 to 20% of the chipped stone at any one time), have suggested that obsidian acquisition and use is likely to be much more nuanced than has been recognized hitherto. Our work builds on this and looks at contextual analysis of obsidian within a number of sites. We also consider marginal sources (which often include the sources most distant from the site) that make only an insignificant contribution to the overall profile of obsidian use within the particular assemblage, but add considerably to our appreciation of the extent of obsidian sources active at any one time. This allows the development of more subtle models of obsidian acquisition, and may give particular insight into both extent of exchange networks and their underlying mechanisms.

By drawing on our recent provenance analysis of obsidian artifacts from various other sites in the Near East, we particularly focus the use of obsidian at sites that do not depend on it as the primary raw material for chipped stone. Provenance analysis of over 1400 obsidian artifacts from Kenan Tepe in southeastern Anatolia and Umm Dabagiyah in northern Iraq (see Figure 1), where obsidian accounts for about 26% and 6.3%, respectively, of the raw material used in the chipped stone tool kits, used in conjunction with techno-morphological and contextual studies, not only allows us to show how the use of obsidian from different sources changed through time and space, but also enables us to look at how it was used by the various sub-communities at these sites.

Diffusion of Anatolian and Caucasian Obsidian in Iran: Elements of Explanation in 'Least Cost Path' Models

Christine Chataigner

CNRS – UMR 5133 Archeorient, Lyon 69007, FRANCE

email: christine.chataigner@mom.fr

Olivier Barge

CNRS – UMR 5133 Archeorient, Lyon 69007, FRANCE

Obsidian artifacts were found in archaeological contexts of the 12th millennium B.C. on the western flank of the Zagros Mountains (Zarzi, Shanidar Cave). This material then spread into eastern Iraq during the Epi-Paleolithic and the early Neolithic, penetrating into the central Iranian Zagros during the 8th millennium B.C. (Abdul Hosein, Tepe Guran, and Ali Kosh sites). For the period between the 7th and 3rd millennia B.C., obsidian is attested in Iran on a growing number of sites, as far as the northeastern (Sang-e Chakhmaq) and the southeastern (Tepe Yahya) parts of the country, although it remains an "exotic" material in the lithic tool assemblages. Provenance analyses were carried out for limited number of samples only, but the results concur indicating that the origin of the obsidian lies in the regions of Bingöl and Lake Van (southeastern Turkey); and then, beginning in the 6th millennium B.C., in some deposits of the Caucasus.

As all these obsidian sources are several hundred kilometers away from the sites where the obsidian artifacts were found, the presence of this material gives rise to many questions, such as the reasons for its diffusion and the modes of its progression in different periods. In order to explore the different forms that this diffusion could have taken, and to discern the 'patterns' related to space and those dependent upon chrono-cultural contexts, we have sought elements of explanation in models created thanks to 'Least Cost Paths analysis.' This method takes into account natural constraints (topography, crossing of large rivers, etc.) as well as non-environmental factors (quantity and quality of obsidian assemblage on the site; seasonal or permanent site's occupation; correspondence to a regional cultural entity; exchange networks revealed by the presence of other exotic materials, etc.).

Models of 'Least Cost Path analysis' enable revelation of several aspects of obsidian diffusion from southeastern Anatolian sources towards Iran during prehistory: 1) variation in pathways in the Lake Van region and across the Zagros Mountains according to period; 2) patterns of redistribution between the sites; 3) probable role of tranhumance or nomadism; and others.

Obsidian Out of Time: Evidence from the Late Copper Age Settlement at Poggio dell'Aquila – Adrano (Catania, Sicily)

Massimo Cultraro
Council of National Researches, Catania 95124, ITALY
email: masimo.cultraro@cnr.it

Lighea Pappalardo
Council of National Researches, Catania 95124, ITALY

Giuseppe Pappalardo
National Institute for Nuclear Physics, University of Catania, Catania 95126, ITALY

The settlement on the hill named as Poggio dell'Aquila, near Adrano (Catania), on the western slopes of Etna Volcano, was systematically explored in 1953–55; an impressive stratigraphic sequence contributes to identify different architectural levels dated in the late Copper Age (2800–2500 B.C.). One of the most relevant evidence is the large amount of obsidian artifacts, which confirms that the lithic assemblage was mostly characterized by the use of obsidian and, conversely, flint and quartzite are rare.

Portable X-ray Fluorescence (pXRF) spectrometry analysis confirms the provenance of obsidian as from the Aeolian Islands sources, and, in some cases, it was possible to identity, according to a complete classical petrochemical methods, the composition of the volcanic glass and its provenance from different sources in Lipari's archipelago. The archaeological evidence at Poggio dell'Aquila is of relevant significance in terms of the wide persistence and circulation of this precious material in eastern part of Sicily during the late Copper Age, when in different parts of the island obsidian artifacts are rare, and they were replaced by quartzite.

The multidisciplinary research will focus on the transition between the late Copper Age and Bronze Age FN in relation to the obsidian industry as exemplified by the material found at the Poggio dell'Aquila settlement. The rarity and importance of this site in understanding the re-organization of the obsidian industry cannot be underestimated. Perhaps, more importantly it offers the first evidence of metallurgical activity during the early Copper Age. The introduction of metals at such an early stage plays a leading role in the transition of obsidian industry as well. The industry diverges completely by the Neolithic period where uniformity or strict standardization becomes the norm. The reasons for this must have been the result of the use of a metal punch in conjunction with some core holding device.

One of the important events at the site of Poggio dell'Aquila is the recovery of certain bladelet types with characteristics typical of later Neolithic blades in association with these earlier larger blades from the Copper Age contexts. Although no metal tools were recovered from the site, microscopic examination of some of the obsidian artifacts exhibit impact marks that are characteristic of a metal punch. The contemporaneous use of these two techniques in the manufacture of blades at Poggio dell'Aquila gives a rare perspective on this seminal event that was instrumental in the re-organization of obsidian industry.

Provenance of Obsidian Artifacts from the Natural Protected Area Laguna del Diamante (Mendoza, Argentina) and Upper Maipo Valley (Chile) by LA–ICP–MS Method

Anna Maria De Francesco
University of Calabria, Rende 87036, ITALY; email: defrancesco@unical.it

Donatella Barca
University of Calabria, Rende 87036, ITALY

Víctor Durán, Valeria Cortegoso, Ramiro Barberena
CONICET, Mendoza CP 5500, ARGENTINA

Marco Bocci
University of Calabria, Rende 87036, ITALY

Several obsidian artifacts coming from the Natural Protected Area Laguna del Diamante (Mendoza, Argentina) and upper Maipo Valley (Chile) were analyzed by Laser Ablation Inductively-Coupled Plasma Mass Spectrometry (LA–ICP–MS). This analytical method, almost non-destructive, is a powerful tool for determination of trace elements, and is very useful in characterizing the provenance of obsidian artifacts. Its major advantage is that 29 trace and rare earth elements (REE) can be analyzed in a very short time, without any sample manipulation.

The first phase of work consisted in the chemical characterization on powders, through X-ray Fluorescence (XRF), of the obsidian geological sources (De Francesco et al. 2006; Durán et al. 2012). In these papers, several artifacts (processed waste flakes) from two archaeological sites of Laguna del Diamante, and one site from upper Maipo Valley, were analyzed by the XRF (De Francesco et al. 2008) and attributed to obsidian source. The Laguna del Diamante (sub-sources Laguna del Diamante and Arroyo Paramillos), Laguna Negra, Arroyo de Las Cargas (all in Mendoza, Argentina); Cerro Huenul (Neuquén, Argentina); and Laguna del Maule (Región del Maule, Chile), represent the main obsidian sources located in the southern Central Andes but there are also some sub-sources as Paramillos, particularly interesting for archaeological implications.

The present study reports the results of LA–ICP–MS on obsidian samples collected from outcrops of the above mentioned obsidian sources, and on obsidian artifacts from sites of Laguna del Diamante and upper Maipo Valley which are already analyzed. The aim is the comparison of the results obtained through different analytical methods to improve the distinction between Las Cargas obsidian source and Paramillos sub-source, due to the greater number of trace elements and REE analyzed by the LA–ICP–MS.

Finally, the better characterization of obsidian sources in the Laguna del Diamante and neighboring regions helps to understand better the issues such as mobility, exchange, and use of obsidian resources in the mountains of Southern Mendoza – Central Chile.

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Provenance of Archaeological Obsidians from Several Italian Neolithic Sites Using Non-Destructive XRF Method

Anna Maria De Francesco
University of Calabria, Rende 87036, ITALY; email: defrancesco@unical.it

Marco Bocci
University of Calabria, Rende 87036, ITALY

Vincenzo Francaviglia
Istituto per le Tecnologie Applicate ai Beni Culturali, Rome, ITALY

Gino Mirocle Crisci
University of Calabria, Rende 87036, ITALY

The provenance of more than 1000 obsidian artifacts was determined using the non-destructive X-ray Fluorescence (XRF) analysis based on the secondary X-ray intensity (Crisci et al. 1994). This method consists of testing the whole samples, avoiding the normal procedures used for rocks in XRF (i.e. powdering). As a matter of fact, the major limitation in the analysis of archaeological obsidians by traditional methods (XRF, atomic absorption [AA], etc.) consists in losing the analysed sample. The XRF analysis was conducted on the splinters taken from the obsidian sources (i.e. primary outcrops), with a similar shape to the refuses usually found at archaeological sites. To test this methodology, a comparison with the classical XRF method on powders (concentrations of major elements and selected trace elements, such as Nb, Y, Zr, Rb, and Sr), was preliminarily carried out on several obsidian samples representative for all geological outcrops in the Mediterranean, e.g. Lipari, Pantelleria, Sardinia, and Palmarola; in Hungary; and from the islands of Melos and Giali (De Francesco et al. 2008). The provenance of archaeological obsidians is determined by comparing their composition with that of the source obsidians in the Mediterranean. The comparison between intensity ratios and concentration ratios of the chosen trace elements for obsidian sources show that the discriminant diagrams obtained are perfectly equivalent. Therefore, the provenance of archaeological samples is determined by comparing their intensity ratios vs. that of obsidian sources. Information about the content of only five elements (the intensity ratios for Nb, Y, Zr, Rb, and Sr) is sufficient to characterize the different sources because they are particularly indicative of the genetic processes which produced obsidian. Using this approach in XRF methodology, we analyzed about 1400 artifacts from numerous Italian Neolithic sites of the Tuscan Archipelago, Tuscany, Abruzzo, Lazio, Campania, and Marche regions, and also from the Corsica. The provenance of the 96% of archaeological obsidians was undoubtedly determined.

Macroscopic and Chemical Variation in the Obsidians of Sierra Las Navajas (Hidalgo, Mexico)

Paola Donato
University of Calabria, Rende 87036, ITALY; email: paola.donato@unical.it

Rosanna De Rosa & Giancarlo Niceforo
University of Calabria, Rende 87036, ITALY

Alejandro Pastrana
Instituto Nacional de Antropología e Historia México, México D.F. 06100, MEXICO

Matteo Montesani
University of Calabria, Rende 87036, ITALY

Luis Barba Pingarron
Instituto Nacional de Antropología e Historia México, México D.F. 06100, MEXICO

Gino Crisci
University of Calabria, Rende 87036, ITALY

The volcanic complex of Sierra Las Navajas is located along the northern edge of the eastern sector of the Trans-Mexican Volcanic Belt (TMVB). The activity in Sierra Las Navajas started with the eruptions of the lavas and pyroclastics of Las Minas and Guajalote complexes, building the original volcanic edifice. Successively, a sector of the northern side of the volcano collapsed, which produced a debris avalanche deposit and formed a depression where rhyolitic activity continued, forming the Ixatla and El Horcon complexes. Obsidians of different color were erupted during the pre- and post-collapse activity, and our work aims to compare them in order to understand if their different macroscopic aspect can be related to difference in the geochemical composition. Some of the analyzed samples are the green obsidians of Las Minas, well known by archaeologists because they have been widely used by pre-colonial Mesoamerican populations. Their color is deep green with golden/silver hues, and they are completely aphiric. Similar obsidians are found on the peak of Cruz del Milagro.

Obsidians of the second period of activity (post-debris avalanche) were sampled in Ixtula Sembo and El Horcon. In both cases no *in situ* outcrop was found, and obsidians come from reworked deposits. In Ixtula Sembo, deep green obsidians very similar to those of Las Minas complex, were analyzed together with a completely different type, grey in color and with coarse (> 2 mm in size) crystals of anorthoclase. Finally, green obsidian was collected at the base of El Horcon peak.

Chemical analyses revealed that all the obsidians are peralkaline rhyolites. Composition of major and trace elements showed a general homogeneity between pre- and post-debris avalanche obsidians, including the grey, porphiric one of Ixtula Sembo. The only exception is represented by the El Horcon green obsidian, showing significantly higher content of Al, Ba, and alkalis, and lower amount of incompatible elements (Zr, Rb, and Nb). Its chemical characteristics are compatible with a slightly lower degree of evolution of the magma from which it formed. Similar variations in the chemical composition were found in other rhyolites (lavas, pumices, and ignimbrites) of Las Minas Complex, thus witnessing that the chemistry of erupted products did not change after the sector collapsed.

The results obtained suggest that at Sierra las Navajas the color of obsidians does not depend on their chemical composition, as similar obsidians have different composition (e.g. green obsidians of El Horcon and Las Minas), while rocks with a completely different aspect show undistinguishable chemistry (e.g. porphiric grey and aphiric green obsidians of Ixtula Sembo). The reason for beautiful green color, which makes the Sierra las Navajas obsidians unique all over the world, is probably related to the microtextural and structural features of the glass.

This work was carried on in the framework of the project "Messa a punto di nuove procedure analitiche LA–ICP–MS per l'individuazione della provenienza delle materie prime usate nell'edilizia storico-archeologica di monumenti precolombiani del Messico" (2011–2013), financially supported by Ministero degli Esteri–MAE.

Obsidians from Lipari (Aeolian Islands, Italy) and Sierra Las Navajas (Hidalgo, Mexico): A Comparative Study

Paola Donato
University of Calabria, Rende 87036, ITALY; email: paola.donato@unical.it

Rosanna De Rosa & Giancarlo Niceforo
University of Calabria, Rende 87036, ITALY

Alejandro Pastrana
Instituto Nacional de Antropología e Historia México, México D.F. 06100, MEXICO

Ida Perrotta & Mariano Davoli
University of Calabria, Rende 87036, ITALY

Luis Barba Pingarron
Instituto Nacional de Antropología e Historia México, México D.F. 06100, MEXICO

Gino Crisci
University of Calabria, Rende 87036, ITALY

Though most of obsidians are commonly black, a number of them has different color, ranging from reddish to green, silver, or "rainbow". This study is focused on three varieties of obsidians: black and grey ones from Pilato eruption (Lipari); and green ones from Sierra las Navajas (Mexico). A preliminary comparative geochemical, micromorphological, and microstructural study was conducted, in order to investigate the influence of chemical and microscopic features on the macroscopic aspect of the obsidians.

Geochemical compositions (major and trace elements) were obtained by X-rays Fluorescence (XRF) analysis and Neutron Activation Analysis (NAA).The micromorphological analysis has been conducted by Scanning Electron Microscope (SEM) observation on small obsidian fragments. The atomic arrangement in the volcanic glass was investigated by Transmission Electron Microscope (TEM) diffraction on micron-sized powder grains.

The Lipari black obsidians are completely aphiric, with a clear conchoidal fracture. They are rhyolites (content of silica is ca. 74.5%), belonging to the high potassium calc-alkaline series. Under the SEM they appear completely homogeneous, lacking any evidence of incipient crystallization or vesiculation. Most diffraction patterns obtained by TEM are those typical for completely amorphous materials. However, a small percentage of grains show diffraction patterns intermediate between the amorphous and crystalline solids.

The Lipari grey obsidians, always associated with the black variety, generally show a glassy surface and an opaque inner portion. Geochemically the grey and black obsidians are undistinguishable both in terms of major and trace elements (including REE). The SEM observation revealed that both external surface and inner portion are characterized by the presence of many very small (diameter of < 0.5 microns) round vesicles. Moreover, the surface shows heterogeneities at the nanometer-scale, probably due to crystal seeds. Diffraction patterns range from those typical of ordered, crystalline solids, to poorly-crystalline, quasi-amorphous substance, with a very small percentage of fragments showing the diffraction pattern typical of glass.

The Sierra Las Navajas green obsidians are aphiric, with silver/gold hue and conchoidal fracture. They are peralkaline rhyolites (comendites), and their content in high field strength elements is much higher than the Lipari obsidians. Under the SEM, green obsidians show many stretched vesicles, displaced on preferential planes and elongated in a single direction. The section of vesicles ranges from circular to very flattened, and is in the range of some tens of microns. The diffraction patterns demonstrate that they are completely amorphous.

The preliminary results of this study suggest that the difference in color between Pilato grey and black obsidians is related to the presence of vesicles and devitrification processes in the grey fragments, which can also account for their not perfect conchoidal fracture. Bigger, preferentially oriented vesicles can be responsible of the shimmering silver/gold hue of Sierra las Navajas green obsidians.

This work was carried on in the framework of the project “Messa a punto di nuove procedure analitiche LA–ICP–MS per l’individuazione della provenienza delle materie prime usate nell’edilizia storico-archeologica di monumenti precolombiani del Messico” (2011–2013), financially supported by Ministero degli Esteri–MAE.

Do I Really Need to Analyze the Sources Myself? Testing the Limits of Inter-instrumental XRF Obsidian Data Exchange

Jeffrey Ferguson
University of Missouri, Columbia, MO 65211, USA; email: fergusonje@missouri.edu

Researchers worldwide are embracing the affordable availability of Energy Dispersive X-ray Fluorescence (ED–XRF) technology, particularly portable versions, in obsidian provenance studies, and this has resulted in the enthusiastic analysis of archaeological assemblages. Linking artifacts to specific geologic obsidian sources is a critical step to making these data meaningful to archaeological research. Unfortunately, many XRF users neglect the necessary steps of creating a proper empirical calibration and analyzing all relevant geologic source material on the same instrument, using the same calibration and instrument settings.

Some researchers have argued that if properly calibrated, ED–XRF artifact data can be compared to published source data to make source assignments. However, ED–XRF calibrations are generally more complicated than other techniques (i.e. Neutron Activation Analysis and Inductive-Coupled Plasma – Mass Spectrometry), and the ability to exchange data collected on different instruments has not been adequately addressed. This study explores the limits of data exchange through the analysis of a realistic set of obsidian flakes from four know sources by over a dozen different laboratories operating a variety of XRF instruments and calibrations. If the scale of inter-instrumental variability exceeds the variability between regional obsidian sources, then we may need to reconsider the utility of publishing artifact compositional data unless all comparable reference material is also presented.

Much of this confusion may be a result of different points of reference. Researchers with backgrounds in geology and chemistry tend place great importance on accuracy of compositional data, while many archaeologists are more concerned with source assignments that have behavioral meaning. I argue for an approach that emphasizes correct analytical methodologies while also recognizing the limits of ED–XRF.

Magnetic Granulometry as a Sourcing Characteristic of Archaeological Obsidian in the Mediterranean

Enzo Ferrara
Istituto Nazionale di Ricerca Metrologica, Turin 10135, ITALY; email: ferrara@inrim.it

Evdokia Tema & Elena Zanella
Università degli Studi di Torino, Turin 10125, ITALY

Elena Pavesio & Andrea Perino
Istituto Nazionale di Ricerca Metrologica, Turin 10135, ITALY

Since the pioneering work of McDougall et al. (1983) on the Mediterranean sources, several studies have been focused on the use of magnetic properties for obsidian provenance determination. In fact, the size, distribution, and composition of ferrous grains embedded in the obsidian amorphous matrix may vary according to geochemical composition of the lava and the conditions under which the volcanic eruption took place. Magnetic measurements thus represent a non-destructive, fast, and inexpensive approach to investigate obsidian provenance, alternative to conventional trace element analysis and examination of physical-chemical properties such as the thickness of the hydrated strata or the extent of geochronological fission tracks.

Most of the previous studies on magnetic properties of obsidian involved the use of several parameters like the low field susceptibility, frequency dependent susceptibility, saturation magnetization, and coercivity of remanence. The Mössbauer spectroscopy and Electron Spin Resonance have also been used to highlight diversities in distribution and dimensions of the ferrous grains in volcanic glasses through the analysis of the associated magnetic state. More recently, the anisotropy of susceptibility, first-order reversal curves, and paleo-intensity determinations were also applied for obsidian sourcing, focusing on microstructural changes indistinguishable by other geochemical techniques, in order to identify even slight variations among quarries of the same flow.

This study presents the results that compare and integrate the magnetic properties previously assessed on geological obsidian samples from the Mediterranean area with those of 59 obsidian bladelets and nodules found at Neolithic sites in northern Italy. Specifically, 39 specimens came from the prehistoric settlements of Castello d'Annone, Brignano Frascata, Cascina Chiappona, Casalnoceto, and Garbagna, spread along the Tanaro River in Piedmont, and 20 other specimens came from the large Neolithic site of Via Guidorossi, Parma. The magnetic granulometry of these obsidian artifacts was investigated using magnetic quantities as susceptibility (χ), anhysteretic susceptibility (χ_a), saturation of isothermal remanent magnetization at room temperature ($SIRM_{293}$) and in liquid nitrogen ($SIRM_{77}$), which were measured for all artifacts and used as source diagnostic parameters. Provenance was then attributed using graphic representations of parameters such as χ_a vs. χ; or $Q_a = \chi_a / \chi$ vs. $St = SIRM_{77}/SIRM_{293}$, which are affected by the relative amount of single domain (SD) and smaller paramagnetic grains, and revealed suitable to identify samples from most of the Mediterranean sites. Moreover, the anisotropy of magnetic susceptibility was analyzed to discriminate samples between sources at Lipari and Sardinia, undistinguishable only using the previous studied magnetic parameters.

A multivariate analysis on the resulting dataset was finally applied, based on the representation of the measured parameters as vectors in a multidimensional space. The Euclidean distance between samples, defined by the magnetic vectors after data normalization, makes it possible to discriminate different obsidian groups, establishing correlations with the volcanic sources when geological and archaeological samples fall in the same group. Generally, most of the archaeological samples recovered from the Neolithic sites of Piedmont and Parma were attributed to Lipari as the most probable Mediterranean source, with very few exceptions and one outlier (non-obsidian artifact).

A Multidisciplinary Approach to the Study of Obsidian Artifacts: the Case of Ustica Island (Palermo, Sicily)

Franco Foresta Martin
Laboratorio Museo di Scienze della Terra, Ustica 90010, ITALY
email: labmust.ustica@gmail.com

Andrea Di Piazza, Claudia D'Oriano, Maria Luisa Carapezza
Istituto Nazionale di Geofisica e Vulcanologia, Rome 00143, ITALY

Antonio Paonita
Istituto Nazionale di Geofisica e Vulcanologia, Palermo 90146, ITALY

Silvio Giuseppe Rotolo
Università degli Studi di Palermo, Palermo 90123, ITALY

Leonardo Sagnotti
Istituto Nazionale di Geofisica e Vulcanologia, Rome 00143, ITALY

The Ustica Island (70 km north of the coast of Palermo, Sicily) has the northernmost prehistoric settlement of western Sicily, and an unexpected center of ancient trade and cultural exchanges. The island has been inhabited in the antiquity, as testified by some archaeological sites dated from the Neolithic to Bronze Age. Despite not having autochthonous sources of obsidian, the countryside of Ustica is rich in pieces of this kind of volcanic glass imported from other source areas. The primary goal of this study is to make a significant statistical investigation on the provenance of Ustica obsidians collected close to archaeological sites. We applied a multidisciplinary approach, coupling geophysical and geochemical measurements, to unveil the provenance of 175 obsidian flakes.

The study of physical characteristics such as color, opacity, textural heterogeneity, and density, confirmed the presence of two main sources: 1) transparent obsidians with grey to brownish coloration and various amount of microliths or microlith-free, and a mode density of 2.35 g/cm^3, that are attributed to the Lipari sources; 2) dark greenish to black obsidians, with a mode density of 2.47 g/cm^3, attributed to the Pantelleria sources. In addition, rock magnetic properties suggested the possibility of other primary sources, notably from Palmarola (Latium) and Monte Arci (Sardinia). To verify this hypothesis, we performed the major (Electron Microprobe Analysis) and trace elements characterization (LA–ICP–MS), and we confirmed the presence of obsidians from Lipari and Pantelleria, and also discovered that one sample can be reliably attributed to the source of Palmarola, an island situated ca. 250 km north of Ustica. At the same time, geochemical data indicate the absence of fragments from the Sardinian sources. We thus came to the conclusion that about 87.7% of the analyzed Ustica obsidian fragments come from Lipari; 11.7% from Pantelleria; and only 0.6% from Palmarola.

Through the comparison of different analytical methodologies, we confirm that the analysis of trace elements by LA–ICP–MS is the most effective way to distinguish primary sources for obsidian fragments. Our results confirmed the provenance of some flakes from Pantelleria Island, as already known in literature (see Tykot 1995), and revealed for the first time the occurrence of a Palmarola obsidian flake at the Ustica Island. This result extends southward the known diffusion area of obsidians from Palmarola, that until now was limited to northern and central Italy, and the Adriatic coast (Freund 2014). Our results shed a new light on the commercial exchanges of the peri-Tyrrhenian area in prehistory.

Obsidian Trade across the Red Sea in Neolithic Times: The Case for Tihāmah Sites

Vincenzo Francaviglia
Council of National Researches, Rome, ITALY
email: vincenzo.francaviglia@itabc.cnr.it

Marco Ferretti
Council of National Researches, Rome, ITALY

There is sufficient evidence exists today that some obsidian trade existed since the Neolithic across the Red Sea. We analyzed 248 obsidian tools from the Neolithic, Bronze Age, and Iron Age sites in the Yemeni Tihāmah (236 samples from Wādī Surdūd) and Farasān Islands.

Previously, we characterized by XRF a very large number of quarried obsidian samples from flows of two well-known volcanoes in northern Yemen: Jabal Isbīl and Jabal al-Īsī. Now, with a very few exceptions, we are able to state that only a few obsidian artifacts originated from these volcanoes, as it would be logical to expect due to the short distance between the sites and these primary sources of volcanic glass.

Moreover, ^{14}C dating of shell middens containing glassy material allows us to assert that the tools collected at the Early Neolithic site of ash-Shafiyah (Yemeni Tihāmah) can be dated to the 7-th millennium B.C. All the investigated archaeological samples form homogeneous geochemical clusters; it seems reasonable to assume that they originate from extended volcanic fields which could be located along the coast of Eritrea or in Djibouti.

Very recent papers on South Arabian archaeological tools and geological volcanic glass further support our hypothesis of a foreign provenance for significant portion of the archaeological obsidians from the Tihāmah region.

A Long-Term Perspective on the Exploitation of Lipari Obsidian in Central Mediterranean Prehistory

Kyle Freund

Indian River State College, Ft. Pierce, FL 34981, USA

Of the four major island sources of obsidian in the Central Mediterranean, Lipari raw materials have the widest distribution, being found at over 200 archaeological sites throughout mainland Italy, southern France, northern Africa, and Sicily. As a means contextualizing the importance of Lipari obsidian within broader cultural processes, this presentation discusses the long-term exploitation of the island's raw materials from the 6th to 2nd millennia B.C., in turn emphasizing the reflexive relationship between the movement of Lipari obsidian and the broader circumstances that mediated its use.

Over the past 50 years, a large number of studies have been published on obsidian in the Central Mediterranean. While these include geoarchaeological research of the sources themselves, the majority relate to the sourcing of archaeological objects. In total, over 10,000 artifacts have been elementally or visually characterized from well over 400 archaeological sites. Using a newly complied database of prior obsidian studies, this paper highlights the importance of Lipari obsidian within wider networks of interaction. Through a diachronic overview of the distribution of Lipari obsidian along with a consideration of how these materials were consequently reduced and used, this paper highlights the impact of the spread of Neolithic lifeways on the establishment of large-scale obsidian circulation networks as well as the effects that shifting value regimes associated with the adoption and proliferation of metal technology had on the collapse of long-distance exchange networks. By the 2nd millennium B.C., the use of Lipari obsidian becomes a localized phenomenon largely restricted to sites on Sicily. While it is easy to explain the continued use of obsidian in these areas as being the result of its ease of procurement, the last vestiges of a dying practice, this presentation demonstrates that the situation is slightly more complex.

In many ways, the exploitation history of Lipari obsidian mirrors that of other Central Mediterranean sources. However, this paper brings to light unique factors that allowed raw materials from a relatively small island in Aeolian Archipelago to become an object of value throughout the entire Central Mediterranean.

Semi-quantitative characterization by micro-XRF mapping and SEM/EDS observations of obsidian artifacts from Pantelleria and Levanzo, Sicily (Italy)

Antonella Giarra, Angela D'Amora, Valentina Roviello, Marco Trifuoggi
University of Naples Federico II, Napoli 80126 ITALY
email: mtrifuog@unina.it

Emiliano Tufano
Messigno 120, Pompei, 80045 ITALY

Sebastiano Tusa
Soprintendenza del Mare della Regione Sicilia, Palermo 90133 ITALY

The semi-quantitative determination of the composition of the obsidian artifacts was carried out by micro-XRF analysis in mapping mode. This technique has a higher spatial resolution and a more intense irradiation than the conventional XRF systems; this allows getting a higher resolution of small features. The XRF imaging was here used to obtain 2D images that show differences in composition of metals and different inclusions in obsidian artifact from the islands of Pantelleria (Mursia) and Levanzo (Grotta Niurume).

Moreover, the SEM/EDS observations provided important information about the crystalline structures in several regions of the samples, especially near of the green threads, which are typical on the obsidian from the Island of Pantelleria.

Obsidian Sources of Northwestern Patagonia (Andean Forest Region of Southern Argentina)

Martin Giesso
Northeastern Illinois University, Chicago, IL 60625–4699, USA
email: mgiesso@neiu.edu

Alberto E. Perez
Fundación de Historia Natural Félix de Azara, Buenos Aires, ARGENTINA

Michael D. Glascock
University of Missouri, Columbia, MO 65211, USA

In this paper we present data of NAA and XRF analyses of obsidian from five major sources, and of archaeological sites located along the lakes and inland forests of the Lanín National Park (Neuquén, Argentina). This region is characterized by the presence of numerous volcanoes, by having the southernmost evidence of agriculture, pottery, and metallurgy of the southern Andes, as well as being easily connected to the western side, as mountain passes are a very low altitude. Historically it is known for the presence of Mapuche, and we characterize their ancestors as the Archaeological Tradition of the Temperate Forests of Center-South Chile and the eastern slopes of the Andes of Argentina. Sites range from early human settlements of the Early Holocene to the time of the Spanish conquest in the 16^{th} and 17^{th} centuries AD., both open air and rockshelters, as well as from surface collections.

A total of 363 obsidian artifacts including nodules, cores, debitage, and projectile points were analyzed by XRF, and 29 fragments from primary sources by NAA. Many of the obsidian come from sites that date to the last 3000 years. During the Late Holocene, the two most used sources were from a source in Cerro Las Planicies in the basin of Lake Lolog (CP/LL1); and from Paillakura (PK), a hill of the Chapelco range which had been previously identified as Unknown source 1. The CP/LL1 obsidian is also the most widespread of these, reaching the Atlantic coast (some 550 km to the east). Other main sources were Quilahuinto/Pocahullo (QY/AP) and Meliquina (MQ). Along the shores of lakes Lácar and Meliquina, the most commonly used obsidian was from the Yuco source. Curiously, no obsidian from Western Andes slopes (southern Chile) was identified. The presence of obsidian from Portada Covunco (200 km away) and Huenul (400 km away) are new findings that indicate contact with groups located further north, that are outside the forested lake region.

Analysis was conducted at the Missouri University Research Reactor (MURR) by NAA, and with a MURR portable XRF in Argentina.

Geographic Vectors of Inter-Mountain Human Circulation: the Role of Andean Obsidian (Central Argentina and Chile)

Martin Giesso
Northeastern Illinois University, Chicago, IL 60625–4699, USA
email: mgiesso@neiu.edu

Víctor Durán, Valeria Cortegoso, Ramiro Barberena
CONICET, Mendoza CP 5500, ARGENTINA

Michael D. Glascock
University of Missouri, Columbia, MO 65211, USA

The Laguna del Diamante is the northernmost obsidian source of central Argentina. It was used less intensively than sources located further south along the Andes (Las Cargas and Laguna del Maule). We selected this source for in-depth discussion here because, since it is located in the Andean Highlands at 3200 m a.s.l. in a traditional inter-mountain East-West pass, it provides the chance to assess patterns of access and circulation across this key biogeographical feature of South America. Access to this source is seasonally restricted from both sides. This geographical frame is used to describe and interpret the archaeological distribution of obsidian artifacts.

The lagoon is emplaced in an ancient volcanic caldera that was utilized during the summers as a hunting ground. The area includes diverse pyroclastic deposits containing obsidian nodules of diverse size and quality, which were assigned to two distinct chemical types based on NAA and XRF analyses (Arroyo Paramillos and Laguna del Diamante types). The size of nodules decreases in size from 3800 m a.s.l., along the streams that drain into the lagoon.

In recent years, the remains of several late Holocene stone walled precincts were excavated with maximum ^{14}C ages of 2200 BP. Interestingly, in Chile there is evidence of the use of this source since the early Holocene, though it has not been recorded at the source area. Here we present the results for the source and a number of residential sites from the joint project between CONICET (Argentina) and the Missouri University Research Reactor (USA). This includes the recent analysis of 282 obsidian samples (260 from excavations at three sites: LD-S1, S2, and S13; dated between 2100 and 1400 BP in LD-S2, and 1100 to 200 BP in S4; and 22 from surface collections). Sites form groups of up to five circular stone rooms located close to the lagoon and the volcanic flows of the Maipo. Identifying the sources of obsidian helps understand the movement of the peoples that occupied the caldera during summers, including their geographic origin. These settings would have been accessed and occupied from multiple regions. Nevertheless, *dominant geographic vectors* of use may emerge under specific conditions. The least cost analyses presented here provide the geographical basis for an assessment of patterns of human circulation.

The geochemical results discussed for the two chemical types indicate human transport and discard that is spatially heterogeneous, being skewed towards the west in terms of scale and intensity of transport. This is particularly evident during the late Holocene. We suggest that this indicates an *asymmetric human use of highland Andean settings with a dominant vector of access from the western lowlands*. We suggest that biogeographical conditions do not determine actual patterns of human spatial organization, while demographic and economic conditions across the Andes could provide the social basis for such an asymmetric dynamic of circulation. These results will be combined with stable isotope data ($\delta^{87}Sr$, $\delta^{18}O$) on human remains in an attempt to correlate patterns in the transport of material goods with strategies of human mobility and migrations.

Reflections on the Contribution of Obsidian Characterization Studies to Archaeological Research: the Role of Analytical Methods

Michael D. Glascock
University of Missouri, Columbia, MO 65211, USA
email: glascockm@missouri.edu

Since the mid-1950s, obsidian characterization studies have been used to investigate numerous archaeological questions of significant global importance. In recent years, the pace of obsidian characterization studies has increased substantially, and hundreds of obsidian investigations are underway by researchers from around the world. Obsidian is a unique geologic material that offers a number of physical and chemical properties that make it an ideal subject for geological and archaeological investigation. The physical properties with respect to its glassy properties, visual appearance, and availability made it attractive to prehistoric humans for the manufacture of sharp-edged tools, knives, weapons, jewelry, etc. On the other hand, the chemical properties of obsidian sources and their artifacts have made it one of the most convenient and successful materials for archaeological inquiry. Procurement practices, mobility patterns, migration routes, technological development, traditions, chronology, social interaction, trade and exchange are among the many important topics that have been investigated through obsidian research. A variety of chemical analytical methods have played an integral role in advancing this research. Without the development of these analytical methods, obtaining answers to this myriad of archaeological questions would not have been possible.

At present, researchers have characterized more than 800 obsidian sources from at least 40 different countries. In addition, it is probably reasonable to estimate that > 100,000 obsidian artifacts have been studied since obsidian research began. This presentation will offer a review of the history of the application of different analytical methods to obsidian research along with their many contributions. The current status of preferred analytical methods will be discussed, along with their advantages and limitations. Finally, recommendations for maximizing the long-term return from individual obsidian characterization studies will be offered.

Internal Structures of Quaternary Obsidian Lava at Sanuka-yama, Kozu Island, Japan

Yoshihiko Goto
Muroran Institute of Technology, Muroran 050-8585, JAPAN
email: ygoto@mmm.muroran-it.ac.jp

Keiji Wada
Hokkaido University of Education, Asahikawa 070–8621, JAPAN

The Quaternary obsidian lava at Sanuka-yama, Kozu Island, central Japan (Sanuka-yama lava), displays well-preserved, primary internal structures in a cross-section exposure along the seashore. The dimensions of the Sanuka-yama lava are: 2000 m long, 600 m wide, and 100–150 m thick. The lower contact of the lava is not exposed. A fission-track age of 0.11 ± 0.03 Ma has been reported for this lava. The internal structures of the Sanuka-yama lava comprise five zones. They are (from bottom to top): 1) stony rhyolite zone; 2) rhyolite–obsidian transition zone; 3) obsidian zone; 4) interlayered obsidian – vesicular rhyolite zone; and 5) vesicular rhyolite zone.

The stony rhyolite zone (> 40 m thick) consists of grey, poorly-vesicular rhyolite that has well-developed flow-banding. The flow-banding consists of alternating layers of glassy rhyolite and partly crystalline rhyolite, each 1–10 mm thick. At the base of this zone, the flow-banding is highly folded and produces S- or U- shaped folds up to 10 m in size. This zone grades upward into the rhyolite–obsidian transition zone. The latter (10 m thick) consists of black massive obsidian that contains a number of blobs of pale grey, vesicular rhyolite. Each blob of vesicular rhyolite has an irregular sub-rounded outline, and is 5–30 cm thick and 10–100 cm long. The blobs show sub-parallel arrangement. This zone grades upward into the obsidian zone (20 cm thick) which consists of black massive obsidian. The obsidian is characterized by conchoidal fractures < 10 cm across, and perlite cracks < 5 mm across. The obsidian rarely includes pale grey, vesicular rhyolite. A tuffisite vein (< 1 m wide, and > 20 m long) occurs at the lower part of this zone. The obsidian zone grades upward into the interlayered obsidian – vesicular rhyolite zone, which is 10 m thick and consists of alternating layers of black massive obsidian (5–20 cm thick) and pale grey, vesicular rhyolite (5−30 cm thick). This zone grades upward into the vesicular rhyolite zone. The latter is 35 m thick, and comprises pale grey, flow-banded, vesicular rhyolite. The lower to middle part of this zone is massive with columnar joints 20–100 cm across, whereas the upper part is massive to partly brecciated. Each brecciated domain (< 6 m high, and < 8 m wide) consists of angular, rhyolite pumice clasts (5–30 cm across) set in a fine-grained matrix. We infer that the internal structures of the Sanuka-yama lava reflect cooling and vesiculation of a rhyolite magma that was inhomogenous in water content.

New Data on Source Characterization and Exploitation of Obsidian from the Chikiani Area (Georgia)

Bernard Gratuze
CNRS / Université d'Orléans, Orleans 45071, FRANCE
email: gratuze@cnrs-orleans.fr

Paolo Biagi
Ca' Foscari University, Venice 30125, ITALY

The source of Chikiani was recently discussed in different publications, and it was shown that it forms a single chemical compositional group characterized by low zirconium and high barium (400 to 700 ppm) contents; these elements demonstrate a continuous variation of concentrations (Chataigner and Gratuze 2014; Le Bourdonnec et al. 2012).

However, recent unpublished research carried out at the IRAMAT–CEB in the framework of different analytical programs dealing with the obsidian supply of Azeri, Armenian, and Georgian archaeological sites (most of them are dated from the 5th millennium B.C.) have revealed, among the studied artifacts, the existence of an obsidian compositional groups characterized by a high barium content (900 to 1200 ppm), that appears to be significantly different from any previously described Caucasian obsidian groups. Comparison of the above different sets of data with published and unpublished information on Chikiani's obsidian (Blackman et al. 1998; Keller et al. 1996) show that all the Chikiani obsidian samples probably do not form a chemically homogenous source as it was stated until now, but in contrast point out a more complex pattern.

This talk presents the results obtained from two brief surveys carried out in 2012 and 2014 along the slopes of Mount Chikiani in southern Georgia. The scope of the surveys was to collect obsidian samples for characterization, in order to improve our knowledge of the raw material resources exploited in prehistoric times. The analysis of 69 samples retrieved from 20 different points, precisely geo-referenced, have revealed that Chikiani obsidian is to be sub-divided into three main groups characterized by variable percentages of barium and zirconium. These new results have important implications for the prehistory of the Caucasus and its related regions, and contribute to re-definition of the complex pattern of procurement and exchange of Caucasian obsidian in prehistory. New data also improve our knowledge on the exploitation of obsidian resources and their circulation in the given region.

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The Spread of Obsidian on the Iranian Plateau during the Neolithic and the Bronze Age. The Possible Role of Mobile Pastoralists

Bernard Gratuze
CNRS / Université d'Orléans, Orleans 45071, FRANCE; email: gratuze@cnrs-orleans.fr

Marjan Mashkour
CNRS / Muséum National d'Histoire Naturelle, Paris 75005, FRANCE

Mohamad Hossein Azizi Kharananghi
Iranian Cultural Heritage, Handicraft and Tourism Organization, Tehran, IRAN

Ali Zalaghi, *Johannes Gutenberg University, Mainz, GERMANY*

Sepideh Maziar, *Goethe University, Frankfurt-am-Main, GERMANY*

Damase Mouralis
Université de Rouen & CNRS, Mont-Saint-Aignan76130, FRANCE

Anne-Kyria Robin
Universités Paris 1, Paris 12 & CNRS, Meudon 92195, FRANCE

Our talk provides new and original data on the analysis of obsidian artifacts from Iran. It focuses on the sourcing of obsidian artifacts collected at different archaeological sites dated from the Pre-pottery and Pottery Neolithic sites of Kalek Asad Morad (KAM), Qasr e Ahmad (QeA), Rahmat Abad (RA), Choghabur (ChB), Qaleh Asgar (QA); and the Bronze Age site of Kohne Tepesi (KT). These sites are located in the central (KAM) and southern Zagros (QeA & RA), along the Persian Gulf (ChB), in the central Alborz (QA), and in southern part of the Araxes River basin (KT).

The aim of this paper is to provide a diachronic perspective on the exploitation of obsidian sources and diffusion of its raw material in the area under investigation, from the Early Neolithic to Bronze Age. We demonstrate that obsidian originates mainly from the Taurus sources (Nemrut Dağ and region of Bingöl) during the Neolithic, and that a diversification of procurement appears during the Bronze Age, involving new obsidian sources, located in the south of Lake Sevan (Sjunik, Armenia), in the exchange processes. The spread of obsidian is considered as a suitable element for tracking the mobility and trade networks of prehistoric societies in the Near East. Current debates among archaeologists highlight the role of agropastoralists in the diffusion of obsidian.

Twenty-eight artifacts originating from these sites (KAM, n = 6; QeA, n = 10; RA, n = 3; ChB, n = 2; QA, n = 5; and KT, n = 2), have been analyzed using LA–ICP–MS. Their compositions were compared with different databases, and have benefited from new insights given by the GeObs Database which include more than 600 geological samples from the Anatolian volcanoes, precisely referenced. It thus became possible to assign the peralkaline obsidian from the Nemrut Dağ (KAM, QeA, ChB) to the obsidian flow of Sicaksu, while the other peralkaline obsidians can be assigned to obsidian outcrops located around Solhan in the Bingöl area (QeA). The calk-alkaline obisidians (RA, QA) were assigned to Alatepe, also located in the Taurus region (Bingöl area, Turkey), while data from the Kohne Tepesi site indicates different obsidian networks related to Sjunik source in Armenia (Sevkar outcrops). According to these preliminary results, we will examine changes in the dynamics of obsidian networks diachronically and geographically.

Transporting Kozushima Island Obsidian across the Pacific Ocean at the Beginning of Early Upper Paleolithic, Japan

Nobuyuki Ikeya
Center for Obsidian and Lithic Studies, Meiji University, Izunokuni City 410-2123; JAPAN
email: ikeoska@ka.tnc.ne.jp

This presentation focuses on the archaeological evidence for the sea crossings between Kozushima Island and the mainland Honshu Island during the Paleolithic of Japan based on obsidian source analysis. Kozushima is a small volcanic island located in the Pacific Ocean approximately 50 km southeast of the Izu Peninsula, southern coast of Japanese mainland.

Even during the coldest period of the Last Glacial Maximum this island was never connected to the present mainland; therefore, the existence of Kozushima obsidian on the mainland raises an extremely important question in world history regarding sea voyage and maritime transportation in the Paleolithic.

The Mount Ashitaka is a volcano located southeast of the Mount Fuji, and it is well known for the dense distributions of Early Upper Paleolithic (EUP or Phase I of Ashitaka–Hakone Paleolithic cultural chronology) sites on its southeastern foothills. One of the oldest obsidian artifacts unearthed in Idemaruyama site is dated to ca. 38,000 cal BP. Additionally, the date of the full-fledged spread of modern humans to Japanese Archipelago is being narrowed down to approximately 40,000 years ago.

The results of XRF analysis on obsidian artifacts from EUP industries have revealed that many of the obsidians were brought to the foot of Mt. Ashitaka from the sources on Kozushima Island. This is the oldest archaeological evidence of human beings repeatedly traversing the ocean.

The voyage between Kozushima source and the Izu Peninsula during the Upper Paleolithic would have been possible only if the three perquisites of ocean travel – knowledge, skill, and technology – were in place. The existence of Kozushima obsidian in the mainland Japan suggests that modern humans had reached a level of skill that incorporated these complex factors. This evidence of maritime travel brings a new perspective to questions related to the means and routes used by modern humans arriving to Japanese Islands.

This presentation will: 1) demonstrate the results of a recent examination of Kozushima Island obsidian artifacts based on XRF and NAA analyses; 2) examine the technological elements necessary for crossing the aforementioned strait; and 3) consider the relationship between modern human behavior and ocean–traversing technology.

Two Contrasting Provenances of Prehistoric Obsidian Artifacts in South Korea: Mineralogical and Geochemical Evidences

Yong-Joo Jwa

Gyeongsang National University, Jinju 660-701, REPUBLIC OF KOREA
email: jwayi@gnu.ac.kr

Seonbok Yi

Seoul National University, Seoul 151-742, REPUBLIC OF KOREA

In South Korea, obsidian artifacts are known at many prehistoric sites, if limited in quantity. All of the sites are open-air localities dated between ca. 25,000–30,000 BP and ca. 5000–6000 BP. Although some of the Pleistocene localities are claimed to have features related to human habitation such as hearths, they basically represent loose accumulations of artifacts over time in fluvio-colluvial sediments. Association between obsidian artifacts and such features is more pronounced for the Neolithic, although they are not reported in the context of tool-making or use. In Korea, obsidian is a rather rare rock to be found. The only known source of fine obsidian material is Mount Baekdusan (also known as Paektusan or Changbaishan) volcanic field close to the Sino-Korean border. On the other hand, the Kyushu volcanic field in southwestern Japan is well-known for many obsidian sources.

We examined the mineralogical and geochemical characteristics of the Baekdusan obsidians (hereafter, BO) and the Kyushu obsidians (hereafter, KO). Though obsidians are of glassy material, microliths are easily found in the matrix. Iron oxides are generally the most abundant microlith phase, with lesser amount of clinopyroxene, feldspar, and biotite. It is notable that the mode of occurrence and chemical composition of the microliths in the BO are quite different from those in the KO. Clinopyroxene in the BO occurs as oikocryst enclosing smaller Fe-oxides, and has the composition of hedenbergite to augite. On the other hand, clinopyroxene in the KO is compositionally of clinoferrosilite, and occurs as either individual crystals or overgrowths on Fe-oxides. Feldspar microliths in the BO are generally of sanidine to anorthoclase, whereas those in the KO of andesine to oligoclase. Lath-type biotite is often found in the KO, but absent in the BO.

In addition, there are prominent geochemical contrasts between the BO and the KO. At the similar SiO_2 range of 74 to 78 wt.%, the BO has higher contents of TiO_2, FeO, K_2O, Rb, Nb, Hf, Zr, Ta, Y, and rare earth elements than the KO. For Pb isotopic ratios, the BO shows higher values of $^{208}Pb/^{204}Pb$ and $^{207}Pb/^{204}Pb$ at a given $^{206}Pb/^{204}Pb$. The overall mineralogical and geochemical contrasts for the Baekdusan and Kyushu obsidians seem to reflect different parental magma composition and crystallization environment. This distinction can be used to discriminate the provenance of the obsidian artifacts from the prehistoric sites from Korean Peninsula as well as contiguous areas such as China, Japan, and Russia.

A Comparative Study of Non-destructive PGAA and XRF Used for Provenancing Archaeological Obsidian

Zsolt Kasztovszky
Centre for Energy Research, Hungarian Academy of Sciences, Budapest H-1121, HUNGARY
email: kasztovszky.zsolt@energia.mta.hu

Boglárka Maróti, Ildikó Harsányi, Dénes Párkányi, Veronika Szilágyi
Centre for Energy Research, Hungarian Academy of Sciences, Budapest H-1121, HUNGARY

Katalin T. Biró
Hungarian National Museum, Budapest H-1088, HUNGARY

At the Budapest Neutron Centre, Prompt Gamma Activation Analysis (PGAA) has been successfully applied in provenance research of Carpathian obsidians (Kasztovszky et al. 2008). The method is a unique bulk non-invasive technique for major elements as well as fingerprint-like traces of H, B, and Cl. Until now, around 180 Central European artifacts and 140 geological reference samples have been measured by PGAA.

In this study, we have compared the applicability of PGAA and Olympus Innov-X Delta type portable XRF equipment on a selected collection of geological reference samples that belong to the Lithotheca of the Hungarian National Museum. The selection was made in such a way to be representative for the major European–Mediterranean sources. For the discriminant analysis of PGAA data, concentrations of SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, CaO, Na_2O, K_2O, H_2O, Cl, B, Sm, and Gd have been determined. For the statistical analysis of XRF data, Si, Al, Ni, Ti, Fe, Mn, Ca, K, S, Cl, V, Cr, Co, Ni, Sb, Sn, Cu, Rb, Sr, Y, Zr, and 'light element' concentrations have been used, where 'light element' means the sum of the elements that are lighter than magnesium. The combined dataset is a result of a compilation using SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, CaO, Na_2O, K_2O, H_2O, Cl, B, Sm, and Gd concentrations measured by PGAA, and also V, Cr, Rb, Sr, Y, and Zr contents measured by XRF. On a limited set of 16 geological reference samples, the performance of Neutron Activation Analysis has been tested on the upgraded NAA system of the Budapest Neutron Centre.

All these three methods are appropriate, and can be effectively applied in provenance studies. The individual advantages and disadvantages of each method will be presented to suggest the best possible result with minimal damage to the samples, especially in fingerprinting long-distance trade items.

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Obsidian Sourcing in Southwest Arabia and the Horn of Africa: Implications for Human Mobility and Interaction in the Neolithic

Lamya Khalidi
CNRS / Université Nice Sophia Antipolis, Nice 06357, France
emails: lamya.khalidi@cepam.cnrs.fr; lamya.khalidi@gmail.com

Bernard Gratuze
CNRS / Université d'Orléans, Orleans 45071, FRANCE

Clive Oppenheimer
University of Cambridge, Cambridge CB2 3EN, UK

Edward Keall
University of Toronto, Toronto, CANADA

Jessie Cauliez
CNRS 5608 / Université Toulouse, Toulouse 31058, FRANCE

The last decade has seen significant advancement in the geochemical fingerprinting of obsidian sources and obsidian artifacts on both sides of the Red Sea Rift. Despite the presence of large numbers of obsidian-rich volcanoes, this region's sources are poorly known, and their exploitation by human groups minimally researched. Recent focused archaeological investigations on the prehistory of south Arabia and the African Horn have demonstrated the importance of this region for hominin dispersals, and for the forging of early human contact and interaction networks which accompanied major societal transformations such as Neolithization. This paper presents an overview of the results of obsidian sampling and sourcing carried out by the VAPOR program and its collaborators, and provides a first look at the way such results enable us to reconstitute inter-Arabian, Afro-Arabian, and inter-African human mobility and interaction and their relationship to the Neolithization of the region.

Obsidian from Archaeological Sites in Korea

Jong Chan Kim
Seoul National University, Seoul 151-742, REPUBLIC OF KOREA
email: marubosi@yahoo.co.kr

Although obsidian-producing volcanoes are rare in Korean Peninsula, especially in the southern part of it, numerous obsidian artifacts have been excavated at more than 100 archaeological sites, and this fact gives challenging opportunities for the study of prehistoric human mobility and exchange patterns in this region. Provenance studies, mainly based on geochemical analyses, show that these archaeological obsidians are derived generally from two major volcanic sources, e.g. the Paektusan Volcano (Mount Paektu at the North Korean/Chinese border), and the volcanoes on Kyushu Island (Japan).

The Paektusan obsidians were found mostly at Upper Paleolithic sites in Korea: ca. 80% of them are of the Paektusan origin. Sites such as Hopyung, Nulgery, and Hawhageri, which are located in the central part of peninsula, contained more than 1000 obsidian artifacts. At the Nulgery site, for example, one third of excavated artifacts was made of Paektusan obsidian. Obsidian was possibly brought here from the Paektusan source by direct exchange mechanism, so that people might have to travel the long distance of ca 500 km, covering the Taebaek Mountains range, which is the backbone of Korea Peninsula. On the other hand, 14 Paektusan obsidian artifacts are found at the Sinbuk Paleolithic site which is located in the southwestern end of Korean Peninsula, and this indicates a travel of straight distance of 1000 km from the Paektusan source. However, these obsidian items were most likely brought by a down-the-line exchange mechanism.

Prolific Japanese obsidians were found at the Neolithic sites in the southern coastal region of Korean Peninsula, and they are mainly from volcanic sources in Kyushu area. Although there are many other primary obsidian localities presently known in the Kyushu area, this raw material from two or three source, dominated by a high quality locality calls Koshidake, were brought to Korea. Therefore, it is likely that obsidian exchange took place systematically under the raw material exchange strategy.

The finding of seven Japanese obsidian artifacts at the Sinbuk Paleolithic site show the evidence of modest seafaring skill was existed to cross the Korea (Tsushima) Strait in the Paleolithic time, and also witnessed that cultural exchange between Korean Peninsula and Japanese Archipelago took place considerably earlier than Neolithic times, despite the fact that no boats older than the one from the Bibon-ni site (dated to ca. 6800 BP, or ca. 7600 cal BP) have been yet discovered.

Obsidian Provenance as a Tool to Study Human Movements in the Upper Paleolithic, Neolithic, and Paleometal of Northeast Asia: an Overview of Current Studies

Yaroslav V. Kuzmin
Institute of Geology & Mineralogy, Siberian Branch of the Russian Academy of Sciences, Novosibirsk 630090 RUSSIA; email: kuzmin@fulbrightmail.org

The aim is to present the current state-of-the-art in obsidian provenance studies for Northeast Asia, and to demonstrate how these data can be used to obtain solid evidence of prehistoric human migrations (for more details, see Kuzmin 2016a, 2016b). Northeast Asia constitutes the Japanese Islands, the Korean Peninsula, the Russian Far East, and Northeast China (Manchuria). Around 1600+ samples of both geological and archaeological obsidian were analyzed for its geochemistry in the last 25 years at the Archaeometry Laboratory, University of Missouri–Columbia. Several analytical methods were used, mainly NAA and XRF.

Based on obsidian source determinations, several exchange networks can be established. In the continental part of the region, consisting of Primorye (Maritime) Province and the Amur River basin of the Russian Far East, the Korean Peninsula, and Manchuria, the distances from primary sources to utilization sites often exceed 600–700 km, with a maximal range of around 800 km as the crow flies. This testifies to active human contacts and migrations in the Stone Age in continental Northeast Asia, beginning at ca. 25,000 BP on the Korean Peninsula, and at ca. 19,000 BP in the Russian Far East. In northern part of the insular Northeast Asia, two main source clusters on Hokkaido Island, Shirataki and Oketo, were the principal suppliers of obsidian to prehistoric populations. The distribution network of volcanic glass for these sources is extremely large and covers Hokkaido and Honshu islands, the Amur River basin, and the Kurile Islands, with distances sometimes exceeding 1000 km in a straight line.

The exploitation of obsidian by prehistoric people of Northeast Asia began in the Upper Paleolithic, ca. 34,000–25,000 BP, and continued until the Paleometal/Early Iron Age (ca. 3000–2000 BP; in some regions until ca. 800 BP and even later). Obsidian in Northeast Asia was most intensively used as a raw material in the Upper Paleolithic and Neolithic/Jomon/Chulmun times. The existence of several long-distance exchange networks (with ranges often exceeding 800–1000 km) gives us reliable information about very active human contacts and migrations in prehistoric Northeast Asia.

Using obsidian as a commodity to study human movements, it was possible to establish the crossing of open water spaces in several places within Northeast Asia, including straits between Hokkaido and Sakhalin islands, Kyushu Island and mainland Korean Peninsula, and the mainland Honshu Island and the smaller islands nearby. Based on these data, seafaring in Northeast Asia most probably began in the Upper Paleolithic, ca. 33,000–25,000 BP.

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Obsidian Provenance for Prehistoric Sites on Chukotka (Northeastern Siberia, Russia): First Results and Interpretations

Yaroslav V. Kuzmin
Institute of Geology & Mineralogy, Siberian Branch of the Russian Academy of Sciences, Novosibirsk 630090, RUSSIA; and Tomsk State University, Tomsk 634050, RUSSIA
email: kuzmin@fulbrightmail.org

Andrei V. Grebennikov
Far Eastern Geological Institute, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok 69022, RUSSIA

Michael D. Glascock
Archaeometry Laboratory, University of Missouri–Columbia, Columbia, MO 65211, USA

The Chukotka region of extreme Northeastern Siberia with abundant obsidian artifacts was poorly studied until recently due to lack of geological and geochemical data about the primary sources of obsidian, which were published previously in very preliminary fashion (e.g., Cook 1995). In 2005, we collected 114 obsidian artifacts from 30 Chukotkan sites, stored at Magadan, Russia, and analyzed them by NAA and XRF methods. In 2009, we conducted fieldwork on the Lake Krasnoe obsidian source in the Anadyr River basin, and performed various analyses of obsidians and volcanic rocks. As a result, both geological background and geochemical signature of the Lake Krasnoe obsidian source were securely established for the first time.

Upon comparison of geochemical data for the Lake Krasnoe primary source and artifacts from Chukotka, six obsidian groups were established. The major part (85% of the total) belongs to the Lake Krasnoe source (two groups, Cape Medvezhiy and Cape Ribachiy). It was exploited mainly in the Neolithic – Paleometal age (ca. 6000–500 BP), with distances between the source and utilization sites up to 510–690 km within the Chukotka region. Furthermore, the Lake Krasnoe obsidian was brought to Alaska, 820–1060 km from the source as the crow flies. The primary locality for one source group, Vakarevo (3.4% of the total), is still unknown. Three source groups are known from Kamchatka Peninsula (11.6% of the total) south of the Chukotka, with transportation distance s up to 1050–1100 km in a straight line, and possibly up to 1350–2100 km. If true, this would be the supra-long range distribution of obsidian in Northeast Asia.

The Lake Krasnoe obsidian source was one of the most important locales for prehistoric people to acquire the high quality raw material. After its geochemical composition is known, more work can be done in Northeastern Siberia and neighboring northern North America in terms of obsidian provenance.

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Obsidian Sources in the Democratic People's Republic of Korea (North Korea)

Yaroslav V. Kuzmin
Institute of Geology & Mineralogy, Siberian Branch of the Russian Academy of Sciences, Novosibirsk 630090 RUSSIA; email: kuzmin@fulbrightmail.org

Michael D. Glascock
University of Missouri, Columbia, MO 65211, USA

Jong Chan Kim
Seoul National University, Seoul 151-742, REPUBLIC OF KOREA

Clive Oppenheimer
University of Cambridge, Cambridge CB2 3EN, UK

Mi-Young Hong
Chosun University, Gwangju 501-759, REPUBLIC OF KOREA

Paektu [Paektusan] Volcano (also known as Changbaishan) is located on the border between China and the Democratic People's Republic of Korea (DPRK). It has been considered a source of high-quality obsidian associated with prehistoric tools found over a wide area in Northeast Asia. There does not appear to be good quality volcanic glass on the Chinese side of the volcano, and it has been assumed that the source must therefore be located on the DPRK side. Russian and Soviet geologists working on what is now the DPRK sector of the volcano in the 1890s and 1950s reported finding obsidian but no geochemical data were recorded, and specimens (if collected and archived) have not been found.

Working on other geological samples obtained indirectly from DPRK (collected on Chinese side of the Paektusan where they landed after large explosive eruption of volcano around 40,000 years ago) and archaeological specimens from Primorye Province of Russia and from the Republic of Korea (South Korea) (see Popov et al. 2005) did find a match for the archaeological obsidian found in Northeast Asia. However, the source position was not recorded. Our own fieldwork on the DPRK sector of Paektu Volcano failed to locate good quality obsidian. Only perlite was found, and it proves to be geochemically distinct from known obsidian groups PNK1–3 (e.g. Popov et al. 2005). This leaves the principal source of obsidian, widely exchanged in prehistoric Northeast Asia, still unknown.

We recently obtained good quality obsidian in Japan, imported from DPRK as a raw material. Its geochemical signature is a perfect match with the PNK1 group, which represents the majority of obsidian artifacts found across a vast region of the Korean Peninsula, Russian Far East, and Northeastern China. We understand that this obsidian was quarried from a site close to the port city of Chongjin in DPRK, about 160 km east of Paektu Volcano. We therefore tentatively conclude that Paektu Volcano has erroneously been identified as the source of the archaeological obsidian, and instead we should be looking in another part of the volcanic range to which Paektu Volcano belongs. We hope that this latest evidence will assist in pinpointing the source in future.

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Novel Investigations on the Mineralogy of Carpathian Mahogany Obsidian

Károly Lázár

Centre for Energy Research, Hungarian Academy of Sciences, Budapest H-1121, HUNGARY
email: lazar.karoly@energia.mta.hu

Viktória Kovács Kis

Centre for Energy Research, Hungarian Academy of Sciences, Budapest H-1121, HUNGARY

Adél Len

Wigner Research Centre for Physics, Hungarian Academy of Sciences, Budapest H-1121, HUNGARY

Zsolt Kasztovszky

Centre for Energy Research, Hungarian Academy of Sciences, Budapest H-1121, HUNGARY

András Markó & Katalin T. Biró

Hungarian National Museum, Budapest H-1088, HUNGARY

The obsidian pieces found in north-eastern Hungary and eastern Slovakia can be assigned into three macroscopic groups. In the northern part of the region, transparent or translucent obsidian occurs from several Slovakian outcrops, occasionally in large nodules (e.g. Viničky, Brehov). In Hungary, between the villages of Mád and Erdőbénye large blocks of grey or greyish-banded variants can be collected; in Tolcsva environs, non-transparent homogenous black obsidians are found in the form of maximum fist-sized nodules. This later source, very rarely, yielded also brown or red ('mahogany' type) obsidians. Archaeological pieces of mahogany obsidian were also identified and characterised by Prompt Gamma Activation Analysis (PGAA) in 2005. In 2007, the exact outcrop of the red variant located was found on the Szokolya hill (Tolcsva). It was especially interesting to know why different color variants occur on the same locality; therefore, novel methods of investigation were applied to know more about the mineralogical character of, basically, red obsidian. The Mössbauer spectroscopy (MS), transmission electron microscopy (TEM), and small-angle neutron scattering (SANS) were used on various samples.

For explanation of the different tints, determining role of oxidation state of iron present in the mineral was presumed. Hence, the MS was used to detect whether ferrous or ferric iron is present in the various specimens. Indeed, predominant presence of ferrous iron was observed in the black variant, similarly to other common occurrences. In contrast, the mahogany obsidian contained almost exclusively ferric iron, mostly in form of hematite.

The TEM observations verified the presence of hematite in the mahogany sample. The hematite crystals are embedded in the aluminosilicate glass matrix, they have tabular shape and their size ranges between 10–100 μm, however, larger hematite crystal with maghemite edge has also been found. The nanocrystals are randomly oriented and form irregular shaped groups in the amorphous matrix. According to TEM–EDS, the chemical composition of the aluminosilicate glass in the black and mahogany obsidians is similar, both contain only minor amount of iron (< 0.4 at.%).

The bulk nanostructure of ten different obsidian samples was investigated by SANS. Samples showing surface or volume fractal dimension were identified. Verifying the average nanopore size was possible in one case. Samples of greyish colour showed isotropy on the 2D SANS pictures, however in case of red type obsidians a considerable anisotropy in the bulk pore orientation was observed.

These new methods of analysis cannot be directly utilized in source characterization as yet but contribute essentially to the mineralogical cognizance of Carpathian obsidians.

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Obsidian from the Bronze Age Village of San Vincenzo – Stromboli: Provenance, Production, Function, Use and Distribution

Sara Tiziana Levi
City University of New York, New York, NY 10065, USA
email: sanvincenzostromboli@gmail.com

Diego Calliari
University of Ferrara, Ferrara 44121, ITALY

Valentina Cannavo'
University of Modena e Reggio Emilia, Modena 41125, ITALY

Andrea Di Renzoni
CNR, Montelibretti 00010, ITALY

Effie Photos-Jones
Scottish Analytical Services for Art and Archaeology, Glasgow G12 8JD, UK

The Bronze Age village at San Vincenzo, is located in the northeastern part of the volcanic island of Stromboli, the north-easternmost island of the Aeolian Archipelago. The village belongs to the Capo Graziano facies (Early-to-Middle Bronze Age 1–2), and is located on a steep-sided plateau, a large orographic unit, about 6 hectares in extent and 40–100 m a.s.l. It provides remarkable visual (perhaps also actual) control of the southern Tyrrhenian Sea.

The terrace upon which the village was built is mainly represented by a scoriaceous lava flow belonging to the last phase of Neostromboli. Preliminary paleomagnetic dating of the volcanic bedrock at the excavation site indicates an age of 6200 years, which is well constrained by the fact that the 'Secche di Lazzaro Pyroclastics', which locally cover the scoriaceous lavas, are considered to have been deposited at ≤ 6000 years ago.

Eruptions at Stromboli seem to have resumed only in the Greco-Roman period. The San Bartolo lava flows are palaeomagnetically dated to between 360 B.C. and AD 7, indicating a break in eruptions of the volcano during the Holocene, which might have coincided with the development of the Bronze Age occupation.

The site was partially excavated in the 1980s by Madeleine Cavalier, and re-opened by the current team in 2009. It was specifically the volcanic environment that inspired the interdisciplinary strategy of the project. The excavation area, comprising ca. 600 m^2, is located on an irregular sloping surface, which influenced the topographical organization of the dwellings on huge, stone-walled terraces. Radiocarbon estimations derived from 40 stratigraphic contexts across the village have provided a range of dates between 2300–1500 cal B.C., attesting to long occupation.

The most abundant finds are hand-made burnished pottery both locally produced and imported from other Aeolian Islands and Southern Tyrrhenian areas. Several Late Helladic I–II imports from the Aegean (17^{th} to 15^{th} centuries B.C.) are also attested. Obsidian is very abundant compared to other contemporary villages in central Mediterranean.

The ongoing study of the obsidian involves typological, technological, and functional characterization. Some p-XRF analyses were also performed in order to better define the provenance of the raw materials. We present here some preliminary results about the provenance (Lipari), the productive process (locally performed at Stromboli) and the function of the tools. The use of the artifacts is discussed in relationship with the topography and stratigraphy of the structures of the village (dwellings, fences, terraces).

We also present the general spatial distribution of all the obsidians (elaborated in GIS) compared with other finds as a fundamental step in the reconstruction of the site formation process and conservation.

Towards the Hyperboreans: Tracing out a Parabola of Sardinian Obsidian Exploitation and Distribution during the Neolithic

Carlo Lugliè

University of Cagliari, Cagliari 09124, ITALY; email: luglie@unica.it

François-Xavier Le Bourdonnec

Université Bordeaux Montaigne, Pessac 33607, FRANCE

In Sardinia (Central-Western Mediterranean), the Monte Arci obsidian source has been exploited for at least five millennia after its discovery, at the beginning of the Neolithic colonization of the island. Over 60 years of archaeological and archaeometric research revealed both the complexity of this source and its potential, in order to: 1) reconstruct patterns of socio-economic organization of obsidian supply and exchange; 2) assess the actual status of obsidian in different chronological, geographical, functional, and anthropological contexts; and 3) identify the role and relevance of obsidian exchange in the process of cultural evolution at a regional and interregional scale.

Building on a thorough geological sampling of the different (primary to secondary) ranks of raw material deposits, our team developed in the last 15 years an integrated and flexible research strategy which combines techno-typological and elemental (SEM–EDS, ED–XRF, pXRF, PIXE, etc.) characterizations of obsidian artifacts. In order to achieve a basic framework for further archeological interpretations, we analyzed complete lithic assemblages from selected Neolithic contexts of the Tyrrhenian region, ensuring a precise stratigraphical and chronological control.

Following the *chaîne opératoire* approach, we were able to identify the respective raw material economies within each studied lithic collection, and sketch out the role of the distinct obsidian sources.

In this paper, we present a state-of-the-art overview of the system of Sardinian obsidian exploitation, as it results from our fifteen-year comprehensive analysis. It stands out that Monte Arci obsidian procurement, reduction, and distribution dramatically shifted around the end of the 5^{th} millennium B.C. from a local "household" strategy to a mass craft production.

Accordingly, we may substantiate that the related structuration of exchange networks at an interregional scale may have driven the process of cultural fragmentation/differentiation of Sardinian Middle Neolithic groups.

Actually, the sphere of influence of Sardinian obsidian exchange is well-established northwards and, in this stage of consolidation of the Neolithization process, it is just the health of the island societies that gave birth to the "Sardinian black gold" myth.

Microstructure, Morphology and Magnetism of Monte Arci Obsidian

Valentina Mameli

University of Cagliari, Monserrato 09042, ITALY; email: valentina.mameli.87@gmail.com

Anna Musinu

University of Cagliari, Monserrato 09042, ITALY

Daniel Niznansky

Charles University, Prague 12843, CZECH REPUBLIC

Davide Peddis

National Research Council, Monterotondo Scalo 00015, ITALY

Guido Ennas & Andrea Ardu

University of Cagliari, Monserrato 09042, ITALY

Carlo Lugliè

University of Cagliari, Cagliari 09124, ITALY

Carla Cannas

University of Cagliari, Monserrato 09042, ITALY

Obsidian, also known as the "black gold", has been one of the most important raw material during the Neolithic, due to its mechanical properties and workability. Although the main component of obsidian is the glassy one, it is well-known that a low fraction of micro- and nanostructured crystalline phases, either occlusions or inclusions, co-exist with it. The amorphous–crystalline duality of its nature renders obsidian a very complex material to be studied. However, the presence of crystalline phases has been taken as an advantage in this work allowing the study of the microstructural and magnetic properties of Monte Arci (Sardinia) obsidian by a combined use of different techniques as X-ray diffraction (XRD) and Rietveld refinement, ^{57}Fe Mössbauer Spectroscopy, magnetic measurements, and Transmission Electron Microscopy (TEM and High Resolution TEM). Rietveld analysis on XRD data confirms the dual nature of obsidian, identifying, besides the main amorphous component, different crystalline phases and quantifying their content. Iron-containing phases like biotite, orthoferrosilite, and nanostructured spinel oxide phase, have been revealed. In this framework, ^{57}Fe Mössbauer Spectroscopy and DC magnetometry provide new insights into the iron-containing components responsible for a great variety of magnetic behaviors, including paramagnetism, antiferromagnetism, ferrimagnetism, and super-paramagnetism. The Goldanskii–Karyagin effect is proposed as the main responsible of the asymmetry of the Mössbauer doublet, alternatively to other interpretations proposed in the literature. Temperature dependence of magnetization, by zero field cooled (ZFC) and field cooled (FC) protocols, commonly employed for artificial nanostructured systems, are used, to the best of our knowledge, for the first time in the study of obsidian samples. Moreover, exchange bias phenomena, rarely observed in nature, are revealed for the first time in obsidians thus indicating the existence of antiferromagnetic/ferrimagnetic interfaces.

Finally, TEM and HR-TEM analyses allow us to associate this structural and magnetic complexity to the morphological properties (size and shape) and distribution of the crystalline phases into/over the glassy matrix.

Use of Obsidian during the Last Glacial Maximum: Case Studies from the Ságvárian Sites in Hungary

András Markó
Hungarian National Museum, Budapest H-1088, HUNGARY
email: markoa@hnm.hu

The few obsidian sources in the continental Europe are found in the Carpathian Basin: in eastern Slovakia, in north-eastern Hungary, and in the Trans-Carpathian Ukraine. In archaeological context, after the questionable data from the Lower Paleolithic, the use of this raw material is securely known from the last interglacial period.

During the last Würmian Pleniglacial and in a few millennia after it, large part of Central Europe was more-or-less depopulated: very few traces of human occupations are known from the areas north of the Carpathians and the Alps. In Hungary, however, important localities of the so-called Ságvárian industry with 20,000–19,000 BP are known. On the eponymous site, lying south of the Lake Balaton, two discrete artifact-bearing layers, at Mogyorósbánya site in the north-eastern Transanubia are three relatively well preserved settlement spots which were excavated. The artifacts from Szob site in the Ipoly Valley (northern Hungary) give supplementary data about the use of obsidian.

The studied artifacts are mainly of the Slovakian variant, imported from the source more than 200 km away; the Tolcsva and Mád obsidian types are represented only by single pieces. The majority of artifacts are linked to the bladelet production used as a blank for backed pieces. These bladelets were partly removed from cores, but burins of various forms are also considered as cores from the technological viewpoint. Finally, some larger pieces were seemingly imported to the sites as ready-made tools (convergent scraper and end scrapers).

Lipari Obsidian in the Late Neolithic: Artifacts, Supply and Function

Maria Clara Martinelli
Museo Archeologico Regionale "Luigi Bernabò Brea", Lipari 98055, ITALY
email: mariaclara.martinelli@regione.sicilia.it

Maria Rosa Iovino
Instituto Italiano di Paleontologia Umana, Rome 00197, ITALY

Robert H. Tykot
University of South Florida, Tampa, FL 33620, USA

Andrea Vianello
Sheffield S6 4QF, UK

In the cultural stratigraphic sequence of the Aeolian prehistory, the Late Neolithic is represented by the emergence of the Diana Culture. The largest diffusion of Lipari obsidian in the Italian peninsula is dated between 4000 and 3000 B.C. Since the 1950s, the archaeological excavations unearthed parts of a settlement in a plain near the sea, "contrada Diana". We shall discuss the technological and typometric study conducted on obsidian that was found in trenches XVII, XXI, and XXXVI. A series of pXRF analyses on obsidian were carried out to identify geological features and their potential correlation with the supply chain in Lipari. A selection of retouched and non-retouched artifacts were examined for the identification of use-wear traces, in order to identify their function. Contrada Diana stands out as an interesting site for the abundance of accessible natural obsidian. This situation has promoted the development of knapping technologies in Lipari sometimes more advanced than at sites where the obsidian was imported. We will discuss the main characteristics of this complex production and distribution system that focused on medium and small blades. We will present current hypotheses on the circulation of the finished or raw obsidian artifacts outside of the Aeolian Islands.

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The Neolithic Site of San Martino: Working and Circulation of Obsidian from Lipari

Maria Clara Martinelli
Museo Archeologico Regionale "Luigi Bernabò Brea", Lipari 98055, ITALY
email: mariaclara.martinelli@regione.sicilia.it

Tania Quero
Napoli Quarto 80010, ITALY

The settlement of San Martino was found in 2008 on the northern coast of Sicily (near the city of Spadafora, Messina). It is located on hill slope about 4 km from the coast of Tyrrhenian Sea. The excavations were conducted in area near an ancient river which today disappeared. The stratigraphy included two Neolithic levels: the oldest, of Stentinello Culture (middle Neolithic, 6^{th} – 5^{th} millennia B.C.); and the youngest, of Diana Culture (Final Neolithic, 4^{th} millennium B.C.). The San Martino's lithic assemblage consists of very important amount of obsidian knapping products. In both the phases of occupation, the lithic assemblages have microlithic dimensions.

In this paper, we examine the procurement, exploitation, and circulation of Lipari obsidian in central-southern Italy during the Neolithic period. It is possible to identify a diachronic change in the obsidian exploitation, from the Early Neolithic to the Late Neolithic, and long-distance circulation.

In the Stentinello Culture levels, lithic artifacts account for 402 pieces, and they are distributed this way: 21% – laminar blanks; 78% – flakes; and 1% – cores (polyhedral-shaped) which have been further exploited for flakes production.

In the Diana Culture levels, lithic artifacts account for 373 pieces, and they represent the following types: 45% – laminar blanks; 51.5% – flakes; and 3.5% – cores, with a remarkable standardization in shapes and dimensions. In this phase, laminar blanks are narrower and thinner than in the previous phase, and were obtained by the use of pressure technique.

As for the *chaîne opératoire*, almost all the stages (shaping, *plein debitage*, and re-sharpening) occurred at San Martino site. Both occupation periods show a remarkable amount of denticulated and scraper groups, and only few tools with abrupt retouch. In the early period, it is possible to highlight a greater frequency of *pièces esquillées*; maybe, some little residual cores were overexploited with a bipolar percussion.

Petrochemical analyses were carried out in the XRF Laboratory at the University of Ferrara on 12 samples from the levels of both phases; it was found that obsidian came from Lipari Island.

Considering these data, we suggest that San Martino site was a part of the Lipari obsidian exchange networks during the Neolithic because of its strategic location on the northern coast of Sicily, as a bridge to the Calabrian and Sicilian hinterlands.

Link between WD–XRF, ED–XRF and P-XRF for Archeological Obsidian Analyses

Hidehisa Mashima
Center for Obsidian and Lithic Studies, Meiji University, Nagawa 386–0601, JAPAN
email: hmashima@meiji.ac.jp

Trace element compositions of igneous rocks depend on their source materials such as the crust and/or the mantle of the earth. The composition of archaeological obsidian, therefore, is a powerful tool for their source identification. From the viewpoints of convenience, accuracy, and economic efficiency, X-ray Fluorescence (XRF) method is one of the most suitable techniquies for analysis of archaeological obsidian.

Analyses of archaeological obsidian from Japanese sites were carried out mainly using Energy Dispersive XRF (ED–XRF) method. Because of insufficient sensibilities of ED–XRF in the 1980s, intensity ratios of trace elements were used for source identification of archaeological obsidian. However, even if the same sample was analyzed, intensity ratios of trace elements could be different from machine to machine. It is therefore difficult to compare results of ED–XRF analyses obtained at different laboratories, and this obstructs the construction of a database of chemical composition for archaeological obsidian. In addition to this, because of the lack of analytical results presented by wt. % and/or ppm, it is also difficult for other laboratories to carry out additional test on samples previously analyzed. Recently, sensibilities of ED–XRF have progressed, and this enables us to determine the sources of archaeological obsidian more precisely. We, therefore, need to re-analyze archaeological obsidian to determine wt.% (or ppm) ratios of trace elements for source identification.

In the case of Japan, artifacts with high archaeological value are designated as important cultural properties, and this is why it is difficult to bring out them from storages. We, therefore, need to introduce portable XRF (P-XRF) for on-site analysis. Since P-XRF carries out determination under an atmospheric condition, one of major elements in obsidian, sodium (Na), with weak characteristic X-lay, could not be determined. Results of P-XRF analyses, therefore, could not be simply compared with those of ED–XRF for reference materials; and it is required to link ED–XRF and P-XRF results.

In order to resolves these issues concerning obsidian, Center for Obsidian and Lithic Studies (COLS) is now trying to link between Wave-length Dispersive XRF (WD–XRF), ED–XRF, and P-XRF. First, we calibrate WD–XRF with synthetic standard samples, in order to avoid systematic errors from uncertainties of recommended values for geochemical standard samples. Second, flux fused glasses of geological obsidian and sanukite (glassy andesite or dacite) are analyzed with WD–XRF, using calibration curves obtained from the synthetic standard method. Polished plates of these rocks samples are used as standard specimens for ED–XRF and P-XRF analyses. Third, ED–XRF and P-XRF are calibrated using the compositions of the standard rock plates. These methods reduce analytical differences between WD–XRF, ED–XRF and P-XRF. The methods also make inter-laboratory comparisons of analytical results, which could accelerate creation of international network for archaeological obsidian.

Spatial and Temporal Distributions of Exotic/Local Obsidians in the Aisén Region, Southernmost South America

César Méndez
Universidad de Chile, Santiago, CHILE
email: cmendezm@uchile.cl

Charles Stern
University of Colorado, Boulder, CO 80309–0399, USA

Amalia Nuevo Delaunay
Universidad Alberto Hurtado, Santiago, CHILE

Omar Reyes
Universidad de Magallanes, Punta Arenas, CHILE

Felipe Gutiérrez
Universidad de Chile, Santiago, CHILE

The Aisén region in western Patagonia is a key area for assessing long-distance procurement of the raw material since all high-quality obsidians used in the past by hunter-gatherers are exotic to this region. The systematic use of geochemical analyses for surface obsidians from archaeological locations in the Aisén and its comparison with data for known sources in Patagonia (Stern 2004) was used in discussion of the spatial distribution of these exotic lithic raw materials. In order to constrain their temporal distribution (Méndez et al. 2012), we sampled assemblages from archaeological deposits with known ^{14}C-based time frames.

This paper presents the results of ICP–MS analysis, considered to be precise to ± 10% at the concentration levels at which they occur (ppm), on 88 new samples with chronological contexts covering all the Holocene, which adds to 93 previously published analyses. These were obtained from 58 sites at 11 surveyed areas located along the coast, in Andean forests, and on the steppe of Aisén. The Chaitén volcano obsidian source materials dominate exclusively along the coastal fringe. Obsidian from the Pampa del Asador source (Santa Cruz, Argentina) largely dominates in the eastern steppes and on the forest/steppe ecotone. This broad distribution is explained by the presence of densely forested Andean mountain range extending north-to-south, which acts as a permeable biogeographical barrier. The only higher diversity of obsidians is documented in the middle and upper courses of the Cisnes River, probably because it is located closer to the northern sources of Telsen/Sierra Negra, Sacanana, and DesX/Piedra Parada (Chubut, Argentina), and it also because it hosts a local mid-to-low quality obsidian which occurs in very low abundance.

In this paper we discuss both the spatial distribution and antiquity in the use of different obsidian sources, and their presence in the archaeological record of Aisén. We include the analysis of fall-off curves based on the distance of sampled locations from the sources. These are combined with the use of least-cost paths (GIS) for providing the more likely procurement routes. Based on this, we discuss which lithic tool classes disappear with increasing distance, and the overall change in specific technological traits (cortex percentage, tool design, and retouch intensity). Various procurement behaviors are discussed, specifically direct procurement, exchange, or other acquisition modes proposed for Patagonia (Pallo and Borrero 2015).

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Consumption of Obsidian during the Middle Bronze Age: a Use-Wear Analysis of Obsidian from Kirrha (Phocis, Greece)

Marie-Philippine Montagne

Aix-Marseille Université, Aix-en-Provence 13094, FRANCE

email: marie.philippine.montagne@gmail.com

In Bronze Age Europe, when new technology, namely metallurgy, emerged, lithic industry was still in use. Indeed, stone technology continued to be used everywhere at least until the end of the Early Bronze Age, and even until the end of the Late Bronze Age in specific areas. This is especially true for Greece where lithic raw material and/or tool networks were still functioning during the whole period. Obsidian and good quality flint were largely used or at least found in different type of archaeological sites, residential or burial. This statement addresses the question for the necessity of use of obsidian instead of stronger or more modular material (flint or metal)? Why was this volcanic glass still used despite technological change (metallurgy was already developed), and what was its price in terms of knowledge and long-distance transportation?

These questions have already been addressed by R. Torrence and T. Carter, and several hypotheses have been proposed. My purpose here is to contribute to this debate through the use-wear analysis of obsidian tools. Obsidian tools from residential levels at the Middle Helladic site of Kirrha (Phocis, Greece) were examined. In this domestic-use context, bronze and flint were also found. The use-wear analysis was carried out on a sample with a binocular and a metallographic microscope, combining low and high power approaches. Main results of this study show an exclusive form and use of obsidian: bladelets used for cutting soft and siliceous vegetal matter, ruling out the possibility of harvesting activity. These results suggest a specialization of the lithic industry with respect to raw material, obsidian sharpness exploited for cutting activities, on soft and flexible materials, according to its relative brittleness, at least at Kirrha. Thus, among the numerous propositions concerning the maintenance of obsidian circulation during the entire Bronze Age, a functional (at least) use could be proven, if this observation was also made elsewhere in Greece.

Obsidian Source Selection in the Early Bronze Age Cyclades

Jessica A. Morgan
Pensacola Lighthouse & Museum, Pensacola, FL 32508, USA
email: jamorgan.inbox@gmail.com

Tristan Carter
McMaster University, Hamilton, ONT L8S 4L9, CANADA

Robert H. Tykot
University of South Florida, Tampa, FL 33556, USA

While the obsidian used by southern Aegean prehistoric communities has long been known to derive primarily from the Cycladic island of Melos, there has been little investigation into the relative importance of Melos' two quarries – Sta Nychia and Dhemenegaki. This study employed portable X-ray Fluorescence spectrometry as a means to address this question and begin to map regional traditions of obsidian source selection during the 3rd millennium B.C.

The study assemblage represents 11 Early Bronze Age Cycladic cemeteries (ca. 3000–2200 B.C.), with 713 total artifacts analyzed. Structurally, these assemblages are dominated by pressure-flaked blades manufactured for funerary consumption, but also include a small number of blade cores and pieces of flaking debris. Contextually, the assemblages reflect the social significance of body modification amongst these islanders, with the blades themselves likely used for depilation, scarification, and tattooing, and the cores reemployed as pestles in the grinding of pigments. Two additional assemblages from settlements on Crete were analyzed, one from a Late Neolithic cave site and another from a Late Minoan settlement. These assemblages served both to provide additional regional and temporal context for the Early Cycladic findings and to advance obsidian sourcing efforts in the Aegean as a whole.

The results display clearly that the Early Cycladic artifacts are overwhelmingly made from Melian obsidian, and approximately 88% derive from the Sta Nychia source. How far-reaching this procurement bias is throughout the Early Bronze Age Aegean is currently difficult to say, though contemporary data from previous studies, as well as the results obtained from the two Cretan assemblages in this study, seem to show a similar pattern. Future research integrating regional traditions of obsidian source selection with previously defined regional distinctions in pressure-blade technology is necessary in order to begin to map communities of practice across the broader Aegean.

Arslantepe (Eastern Anatolia): Procurement of Obsidian from Anatolian Geological Sources during the Chalcolithic and Middle Bronze Age

Damase Mouralis
Université de Rouen & CNRS, Mont-Saint-Aignan76130, FRANCE
email: damase.mouralis@univ-rouen.fr

Massimo Massussi
La Sapienza University, Rome 00185, ITALY

Ebru Akköprü
University of Van, Van 65080, TURKEY

Francesca Balossi
La Sapienza University, Rome 00185, ITALY

M. Korhan Erturaç
University of Sakarya, Sakarya 54187, TURKEY

Delphine Grancher
Universités Paris 1, Paris 12 & CNRS, Meudon 92195, FRANCE

Bernard Gratuze
CNRS / Université d'Orléans, Orleans 45071, FRANCE

Fatima Mokadem & Catherine Kuzucuoğlu
Universités Paris 1, Paris 12 & CNRS, Meudon 92195, FRANCE

Giulio Palumbi
Université Lyon 2 & CNRS, Lyon 69365, FRANCE

Anne-Kyria Robin
Universités Paris 1, Paris 12 & CNRS, Meudon 92195, FRANCE

Arslantepe is a *höyük* (i.e. tell), located within the fertile Malatya Plain, some 12 km from the right bank of the Euphrates River. The long sequence of the site covers several millennia, from at least the 6th millennium B.C. until the final destruction of the Neo-Hittite town. The archaeological site benefits of a more than fifty years of excavations by the Italian Archaeological Mission (La Sapienza University, Rome). Its long history reflects the changing relations and connections with various civilizations in the Near East (Frangipane 2011). During the earliest phases (Chalcolithic), Arslantepe is connected with the Syro-Mesopotamian world. However, during the Early Bronze Age Arslantepe's external relations are reoriented towards eastern Anatolia and Transcaucasia. During these periods, Arslantepe also had connections with Central Anatolia that grow during the 2nd millennium B.C. with the rising Hittite civilization.

This talk focuses on the sourcing of obsidian artifacts collected in Arslantepe. Four hundred artifacts, belonging to eight archaeological levels, from Late Chalcolithic to Middle Bronze Age, were analyzed. These analyzes include technological and typological study together with geochemistry using a portable XRF analyzer. The geochemical data have then been compared with the GeObs database which includes more than 600 geological samples, precisely positioned within space (latitude and longitude) and time (according to volcanic and stratigraphic settings).

This database includes 14 sources (i.e. volcanoes) and 34 sub-sources (outcrops with specific volcanic settings) from the Anatolian volcanoes.

This talk has three main scopes: 1) studying how the procurement of obsidian change according to the technological and typological kinds of artifacts; 2) understanding the changing external relations through time on obsidian procurement, using the very clear archaeological stratigraphy revealed at the Arslantepe; and 3) showing whether the obsidian procurement indicates same spatial and social connections than other artifacts; and presenting when the obsidian procurement show some different patterns.

The Effect of Latitude on Raw Material Transfers and Human Social Behavior: the Case of Paleolithic Obsidian

Theodora Moutsiou

University of Cyprus, Nicosia CY-1678, REPUBLIC OF CYPRUS

emails: dora81m@yahoo.com; tmouts01@ucy.ac.cy

A recent study on the Paleolithic use of obsidian has demonstrated that obsidian was a widely utilized raw material throughout the Paleolithic and in all the areas of the Old World where geological sources were available (Moutsiou 2014). Most importantly, the work showed that obsidian was utilized not only when locally available but also at great distances from source. Interestingly, obsidian movement ranges have been found to differ significantly when Africa and Eurasia are compared.

This paper addresses this issue and uses latitudinal/ecological differences as an explanatory model of the observed patterns. My hypothesis is that ecology, expressed through the proxy of latitude, will affect the distances over which obsidian is moved. My prediction is that when obsidian is found in low latitudes (Equatorial – East Africa) it will travel short distances, whereas when it is found in high latitudes (Northern – Central Europe) it will travel long distances. In order to test this hypothesis, I make use of the concept of effective temperature (ET) (Bailey 1960) presuming that ETs are a controlling factor of human mobility by controlling the productivity of ecosystems.

The comparative analysis of obsidian data between Africa and Eurasia shows that the scales of obsidian movement were responsive to the ecology of the two ecologically-varied regions. However, the results of the analysis indicate that ecology alone cannot account for the different trends in obsidian movement between Africa and Eurasia. Differences in obsidian movement ranges between the two regions could reflect shifting patterns of land use resulting from long-term social and behavioral changes rather than solely climatic pressure. The organizational responses of the hominins involved in the circulation of obsidian seem to have also been affected by more endogenous elements of the hominins themselves. Indeed, social behavior appears to play a big role in hominin decision-making regarding raw material movement too.

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Sourcing, Circulation, and Technology of Obsidian in the Neolithic of Apulia (Southeastern Italy)

Italo Maria Muntoni
Soprintendenza Archeologia della Puglia, Foggia 71121, ITALY
email: italomaria.muntoni@beniculturali.it

Francesca Radina
Soprintendenza Archeologia della Puglia, Bari 70122, ITALY

Sandra Sivilli
University of Salento, Lecce 73100, ITALY

Maria Clara Martinelli
Museo Archeologico Regionale "Luigi Bernabò Brea", Lipari 98055, ITALY

The paper aims to demonstrate data on the presence of obsidian at the Neolithic sites in Apulia (southern Italy). All Neolithic phases, from early to late one, are considered here, summarizing contexts, chronologies, and provenances, and providing quantitative, typological and technological data, with the goal of considering the circulation and production mechanisms of this raw material. A systematic review of provenance data, carried out with both destructive and non-destructive techniques, has also provided a well-defined outline of the various sources. This has confirmed the clear, sometimes exclusive, predominance of Lipari obsidian in all Neolithic phases, and a significant presence of Pontine obsidian, greater than it was previously thought. This overview allows proposing some hypotheses about the circulation model(s) of this raw material in an area that underwent significant development during the Neolithic.

Obsidian Sourcing and Characterization in the Celebes Region: an Initial Interpretation on the "Celebes Seafaring People"

Leee Anthony M. Neri
University of the Philippines, Quezon City 1101, THE PHILIPPINES;
emails: lmneri@up.edu.ph; leeeneri@yahoo.com

Obsidian materials have been archaeologically recovered in the Celebes Sea region dated to the Middle Holocene. These were found along the coast of northern Mindanao Island (Huluga, Daayata, Ilihan na Dako, and Calumat open-air sites), the Philippines; in Bukit Tengkorak, Sabah, Malaysia; and in Leang Tuwo Mane'e, Talaud Island, Indonesia. The results of study indicated that obsidians recovered from these sites are geochemically similar, and were procured from a single geological outcrop. This may suggest that prehistoric people have had acquired their raw materials in the same resource area, but its position is currently unknown.

Based on the theoretical principles on the process of acquisition as proxy data, the possible geological source of obsidian found along the Celebes Sea may have been located on Mindanao Island. The Middle Holocene people from Mindanao may have moved westward, crossing the Zamboanga Peninsula towards Sabah and Borneo, passing the Sulawesi Island, and may have moved back to southern Mindanao by crossing the Celebes Sea. The Middle Holocene people coined as "Celebes Seafaring People" from northern Mindanao, Talaud, and Bukit Tengkorak may have already been culturally associated and commercially connected in the past, ca. 6000–3000 BP.

This "Celebes Seafaring People" hypothesis is only anchored on the geochemical characterization of obsidian recovered from sites in the northern Mindanao, Bukit Tengkorak, and Leang Tuwo Mane'e. The idea of cultural interaction of the Celebes Sea coastal people must be further investigated on the similarities of assemblages and inferences between sites, and on the issue how they are linked to the Neolithic Lapita Culture.

The Impact of Obsidian Source Studies on Archaeology: a View from the Japanese Islands

Akira Ono
Center for Obsidian and Lithic Studies, Meiji University, Tokyo 101-8301, JAPAN
email: ono@tmu.ac.jp

A systematic provenance study of obsidian from Japanese archeological sites began in the early 1970s; initially, fission-track dating was applied to identify the sources of archaeological obsidian based on different times of volcanic eruption periods. In the 1980s, hand-in-hand with many excavations, obsidian sourcing projects shifted to using X-ray Fluorescence (XRF) analysis, and particularly the non-destructive Energy Dispersive X-ray Fluorescence (ED–XRF) analysis. In order to investigate the intra-site distribution of an archaeological obsidian assemblage, it is necessary to analyze all tools and not to pick up samples, with flakes and chips remaining at the site. Data from the non-destructive XRF method can be attained in a relatively straightforward manner, using scatter plots in conjunction with multivariate statistics.

The first consequence obsidian source analysis brought on was that it opened up the possibility to explore a wide range of human group movement in antiquity like “prehistoric pictures in action.” This came in stark contrast to usual practices adopted in Japanese archaeology in the immediate post-WWII period (mid-1940s – 1960s) where the cultural history paradigm saw human activities as rather static. The second major consequence was that the focus of prehistoric studies shifted from material culture to human behavior, providing a different interpretative angle. Thirdly, the source identification for artifacts found in distant locations from each other allowed us to pursue new horizons of research such as network analysis among the Japanese Islands in conjunction with tephrochronology. Fourthly, for the first time seafaring was proven beyond a doubt using the geochemical analysis of obsidian. The long-distance acquisition of obsidian had already been established during the initial phase of the Early Upper Paleolithic. The new methodology radically changed our epistemological presupposition of human abilities not only on land but also across the sea. Overall, obsidian sourcing studies have helped us to illustrate the movement of prehistoric peoples from macro-scale to micro-scale, especially when they are combined with fine stratigraphy and artifact chronology.

Risk and Opportunity at Nabro Volcano, Eritrea: a Deep Time Perspective

Clive Oppenheimer
University of Cambridge, Cambridge CB2 3EN, UK
email: co200@cam.ac.uk

Bernard Gratuze
CNRS / Université d'Orléans, Orleans 45071, FRANCE

Lamya Khalidi
CNRS / Université Nice Sophia Antipolis, Nice 06357, FRANCE

Bill McIntosh
New Mexico Tech, Socorro, NM 87801, USA

Nabro Volcano is located some 50 km from the coast in the southern Red Sea region of Eritrea. It reaches a maximum elevation of over 2200 m a.s.l. and has an 8 km-wide summit caldera with associated ignimbrites. Its first recorded eruption took place in 2011, displacing several thousand people who lived within the caldera. A field trip focused on understanding this event provided an opportunity to collect samples of older pyroclastic deposits and lavas, which have now been dated using the Ar–Ar method. Several large eruptions have occurred in the Middle to Late Pleistocene. Rhyolite coulees on the flanks of the volcano contained high quality obsidian. Worked obsidian pieces were present in abundance on the surface in various locations visited. The newly-quantified eruption history, along with the evidence for obsidian procurement and recent occupation of the volcano point to a complex relationship between humans and the volcano that has existed for many thousands of years.

Sourcing Obsidian Artifacts by LA–ICP–MS at the SOLARIS Platform

Marie Orange
Southern Cross University, Lismore, NSW 2480, AUSTRALIA
email: m.orange.10@student.scu.edu.au

François-Xavier Le Bourdonnec
Université Bordeaux Montaigne, Pessac 33607, FRANCE

Anja Scheffers & Renaud Joannes-Boyau
Southern Cross University, Lismore, NSW 2480, AUSTRALIA

As archaeological excavations progress, unearthing an ever increasing number of artifacts, new challenges arise for their geochemical sourcing, calling for new strategies. Characterization studies can indeed now include several thousands of samples while still being limited by deadlines, budgets, or sampling requirements.

In order to achieve an exhaustive analysis of these assemblages as well as to address numerous challenges faced in our discipline, our research group has been working towards the development and implementation of an analytical strategy involving some of the most efficient methods available to source the obsidian material. This panel comprises a range of strictly non-destructive, virtually non-destructive, and partially destructive techniques such as visual characterisation, ED–XRF, pXRF, PIXE, LA–ICP–MS, and SEM–EDS. Used in combination to source well documented and well dated assemblages, which typo-technological characteristics have also been studied and, in fine, paralleled with the geological origin, they allow to bring further insights on the obsidian economy of the region for the period considered (e.g. Lugliè et al. 2008; Le Bourdonnec et al. 2015).

Among those methods, the LA–ICP–MS is a key asset in the analytical strategy we chose to adopt, as it permits the analysis of the smallest and thinnest samples that cannot be analyzed with other techniques (Orange et al., in prep.). Moreover, its capability to process a hundred samples a day makes it a valuable advantage when the undergoing project has to meet a tight deadline, or when the availability of the machine is restricted. With the access to such state-of-the-art instrumentation at the SOLARIS platform at Southern Cross University (Australia), our team has been able to design and apply the optimized protocol presented here, building on methodological procedures reported in previous studies (Speakman and Neff 2005, *inter alia*) and specifically tailored for the analysis of Western Mediterranean obsidians.

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Obsidians in the Southern Caucasus between Cooking and Knapping: the Case of the Obsidian-Tempered Ceramics from Aratashen (Armenia) and Mentesh Tepe (Azerbaijan)

Giulio Palumbi
CNRS / Université Lyon 2, Lyon 69007, FRANCE
email: giuliopalumbi@hotmail.com

Denis Guilbeau
Université Paris Ouest / CNRS, Nanterre 92000, FRANCE

Laurence Astruc
CNRS / Université Paris 1, Paris, FRANCE

Bernard Gratuze
CNRS / Université d'Orléans, Orleans 45071, FRANCE

Bertille Lyonnet
CNRS, Paris, FRANCE

Christine Chataigner
CNRS / Université Lyon 2, Lyon 69007, FRANCE

Armine Harutyunyan
Institute of Archaeology and Ethnography, National Academy of Sciences, Erevan, ARMENIA

This research deals with the obsidian-tempered ceramics of the Chalcolithic period in the Southern Caucasus. Samples of obsidian-tempered ceramics from the sites of Aratashen (Armenia) and Mentesh Tepe (Azerbaijan) were analyzed by means of Laser Ablation High Resolution Inductively-Coupled Plasma Mass Spectrometry. These analyses have shown that obsidians which came from different sources were used as a ceramic temper for kitchen ware. The Aratashen site in the Ararat Plain, and Mentesh Tepe in the Kura River valley, are localized in very different ecosystems, and at a variable distance from the obsidian sources of the region.

Our aim is to compare the strategies of acquisition and use of obsidians at both sites as they are revealed by ceramic temper and lithics. This will allow a discussion of the organization of craftsmanship during the Chalcolithic in two fields of expertise, tool-making and ceramic production.

New Obsidian Sources and Late Pleistocene/Early Holocene Maritime Interaction in Southeastern Indonesia – East Timor

Christian Reepmeyer
James Cook University, Cairns QLD 4870, AUSTRALIA
email: christian.reepmeyer@anu.edu.au

Sue O'Connor
The Australian Nation University, Canberra, AUSTRALIA

Mahirta
Universitas Gadjah Mada, Yogyakarta, INDONESIA

Tim Maloney
Australian National University, Canberra, AUSTRALIA

This paper presents results of more than 2000 pXRF analyses on obsidian assemblages from four sites in the Lesser Sunda Islands of Indonesia and East Timor. These rockshelter sites, containing well-stratified deposits starting from around 42,000 cal BP throughout the Last Glacial Maximum (LGM) until the Late Holocene, show the utilization of local and off-island sources of obsidian. Contrary to the assumption that off-island resource use started during the LGM in relation to lower sea levels reducing distances between islands, obsidian exploitation appear to be only local up to the Late Pleistocene period. Off-island utilization and transport of obsidian raw material indicating initial maritime interaction seems to occur after around 12,000 cal BP, corresponding well with analyses in neighboring regions such as the central Philippines. Are these records indicative of developments of advanced maritime technology in reaction to rising sea levels?

Networks of Obsidian Use and Exchange in the Neolithic Eastern Fertile Crescent

Amy Richardson
University of Oxford, Oxford OX1 2PG, UK
email: amy.richardson@orinst.ox.ac.uk

C. Renfrew and colleagues' studies of obsidian in the 1960s highlighted the ways in which obsidian moved between communities across Southwest Asia. These exchanges opened up 'potential channels for the flow and interchange of ideas.' Since this time, substantial work has been conducted on identifying the provenance of obsidian from archaeological assemblages and sources. Integrating new portable X-ray Fluorescence data from Neolithic sites in Iraq and Iran, this paper highlights the complex operation of materials networks and exchange across the region. Through a review of the expanding analysis of obsidian and for material interactions across Iraq and Iran between the 10^{th} and 6^{th} millennia B.C., this research aims to identify emerging patterns for the flow and interchange of ideas, technologies, and people in the Neolithic landscape.

Changes in the obsidian repertoire mark a significant shift in the operation of materials networks across the eastern branch of the Fertile Crescent. From the Upper Paleolithic levels at Shanidar Cave, the earliest obsidian thus far known in the Eastern Fertile Crescent was recovered. Examples of the Nemrut obsidians are also known from Late Upper Paleolithic contexts in both the Zarzi and Palegawra caves, ca. 150 km south of Shanidar. This material would play a significant role in the tool repertoires of the Zagros region throughout the Neolithic, being passed along great swathes of mountainous territory. By the middle Neolithic, obsidian was present across almost all sites in the region, including small quantities of material which fail to correlate with the sources known to be in use at this time. Towards the end of the Neolithic, the volume and proportional representation of obsidian began to decline, there was a shift in the dominant source, and at sites such as Arpachiyah and Banahilk in the north, and Choga Mami in the south, obsidian was used for beads and necklaces, rather than functional tools. These changes in the obsidian repertoire mark a significant shift in the operation of materials networks across the Eastern Fertile Crescent; one which was already changing with the rise of ceramic technologies and early metallurgical innovations.

Throughout the Neolithic, people, things, skills, and technologies moved between settlements, weaving together cultural meshworks that connected widely spread communities. Across the Eastern Fertile Crescent, these networks covered hundreds of kilometers, connecting the remotest sites high in the Zagros Mountains of Iraq and Iran. Over the course of the Neolithic, simple and direct engagements with the material world evolved into more complex relationships. By the late Neolithic, these transforming societies were moving large quantities of materials around the landscape, consolidating relationships through new material ideologies. Obsidian forms a key piece of the evidence for this wide-ranging interchange of materials, embedded in cultural practices of exchange.

Identification and Characterization of a New Obsidian Source in the Nemrut Volcano (Eastern Anatolia, Turkey): the Sıcaksu Obsidian

Anne-Kyria Robin
LPG University Pantheon Sorbonne, Meudon 92195, FRANCE
email: anne-kyria.robin@lgp.cnrs.fr

Damase Mouralis
Université de Rouen, Rouen 76000, FRANCE

Ebru Akköprü
Yüzüncü Yıl University, Van 65000, TURKEY

Catherine Kuzucuoğlu
LPG University Pantheon Sorbonne, Meudon 92195, FRANCE

Bernard Gratuze
CNRS / Université d'Orléans, Orleans 45071, FRANCE

In the frame of GeObs project (http://geobs.univ-rouen.fr/), we started an exhaustive field study of obsidian lavas outcrops in the Nemrut Volcano (Eastern Anatolia, Turkey). We propose here to present results from analyses of the macroscopic facies and chemical characteristics of all sub-sources, and its comparison to each other. A first conclusive remark is that most Nemrut sub-sources are distinguishable using geochemical data (LA–ICP–MS). In addition, on the western flank of the volcano we identify and characterize (in the field as well as in the laboratory) two yet unknown obsidian outcrops (Kayacık and Sıcaksu) which are close to each other, with regard both to its geography and geochemistry. No previous research on obsidian sourcing around this volcano was able to identify these sub-sources.

Statistical treatments (classification and discriminant analyses) applied to a set of data composed of our results from both (i) all our sub-sources sampled in the Nemrut, together with (ii) the artifacts attributed by L. Khalidy et al. to the Nemrut Volcano, clearly connect the artifacts to the group formed by these newly found sub-sources.

Results of the combination of field work data, geochemical analyses, and statistical treatments comparing geological and archaeological obsidians, evidence the importance of two obsidian outcrops sampled by us on the western flank on Nemrut Volcano, which is the most up-to-date collection of samples from the Nemrut.

In further detail, only one of the two new sub-sources, the "Sıcaksu" obsidian, is particularly homogenous and suitable for chopping. Accordingly, Sıcaksu obsidian is now the best candidate for being the source addressed by Neolithic populations who collected raw material in the Nemrut Volcano for tool-making.

Emplacement of Obsidian Outcrops in Meydan and Obsidian Characteristics

Anne-Kyria Robin
LPG University Pantheon Sorbonne, Meudon 92195, FRANCE
email: anne-kyria.robin@lgp.cnrs.fr

Damase Mouralis
Université de Rouen, Rouen 76000, FRANCE

Ebru Akköprü
Yüzüncü Yıl University, Van 65000, TURKEY

Catherine Kuzucuoğlu
LPG University Pantheon Sorbonne, Meudon 92195, FRANCE

Bernard Gratuze
CNRS / Université d'Orléans, Orleans 45071, FRANCE

The volcanic complex of Meydan is located north to Lake Van (eastern Anatolia, Turkey) and comprises the Meydan stratovolcano and a rhyolitic dome Gürgürbaba. The Gürgürbaba extruded top on the western flank of the Meydan and flowed inside the caldera.

In spite of the presence of an obsidian workshop inside the caldera, few investigations on the sources have been made. Therefore, obsidian sources are not very well-known, and are generally attributed to Meydan Volcano itself. But our field investigations enhance the presence of several sources on Gürgürbaba dome but none on Meydan Volcano. The Gürgürbaba provides three types of obsidian outcrops: 1) very massive where obsidian is present as a "wall"; 2) massive obsidian occurs as bank; and 3) scattered obsidian is shown in blocks to gravel.

We aim to understand the mode of obsidian emplacement using field observation, chemical analyzes by LA–ICP–MS, and petrology study.

Obsidian walls are located at the front of two distinct flows; one is shown on the northeast near the village of Ulupamir the other is shown in the southern flank near the village of Düvenci. Bank of obsidian are manly in intermediary position on the slopes. Going to the summit obsidian bank tend to become thinner. Scattered obsidian is present at any location and present different size from blocks to gravel. Chemical results enhance four distinct obsidian clusters forming a trend. Obsidians from a same chemical cluster belong to the three types of outcrops wall, bank, and blocks to gravel. Therefore, it is possible to link the different formation and reconstruct the flow structure. Obsidians from Gürgürbaba are uniform black or brown, some present different pattern such as bands or motley. None of them contain phenocrysts. In thin section, obsidian are rich in microliths (six different types: globulites, margarite, prismatic microlith, acicular microlith, acicular trichites, and asteroidal trichites) but do not contain any microcrystals. Most of the obsidian, in thin section, presents bubbles and glass shards.

Until now, we can assume that Gürgürbaba emplaced in four stages, each stage provided obsidian. Obsidian is the consequence of welded ignimbrites emplacement.

Changes in Obsidian Use and Human Responses to the Last Glacial Maximum Climate Conditions in Central Japan

Kazutaka Shimada
Meiji University Museum, Tokyo 101-8301, JAPAN
email: moirai3sis2@gmail.com

The Upper Paleolithic hunter-gatherers settled in the Chubu–Kanto region of central Japan at ca. 38,000–16,000 cal BP, and intensively exploited obsidian sources located at the elevations of 1400–2000 m a.s.l. in the Central Highlands. The Upper Paleolithic industries, that used obsidian derived from the Central Highlands for lithic production, are distributed all over the Chubu–Kanto region. Previous archaeological studies have suggested that the last glacial maximum (LGM) might have impacted on human obsidian procurement in the source area because of its high altitude. However, the relationship between the impacts of the LGM and human responses in the source area based on convincing evidence from the paleoclimate, obsidian provenance data, and archaeology remains poorly understood.

To fill these gaps, this study examines the correlations among pollen record datasets from the past 30,000 years from the Central Highlands at the elevation of 1400 m a.s.l.; 86,525 pieces of obsidian from the Chubu–Kanto region for which provenance data are obtained; and the chronological sequence consists of 43 Upper Paleolithic industries in the Central Highlands. Through synthetic analysis, this study reconstructs historical changes in the human–environment interaction of the Central Highlands during the Upper Paleolithic.

The combined data shows that the exploitation of obsidian from the Central Highlands dramatically changed over time. The changes represent the early Last Glacial Maximum (LGM) during ca. 30,000–25,000 cal BP constraining the procurement activity at the sources; an increase in active human responses to the alpine landscape of the Central Highlands in the LGM cold phase during ca. 25,000–20,000 cal BP; and the re-organization of mobility ranges and the appearance of new lithic technology, with changing land use of the source area in the terminal LGM during ca. 20,000–19,000 cal BP. The historical changes in use of obsidian sources of the Central Highlands around 36° N suggest that human responses to the LGM conditions went through a complex process in this region.

Obsidian Sources and Distribution in Patagonia, Southernmost South America: a General Overview

Charles Stern
University of Colorado, Boulder, CO 80309–0399, USA
email: charles.stern@colorado.edu

Obsidian artifacts occur in some of the oldest known late Pleistocene Paleoindian archaeological sites in Patagonia, such as Pilauco (12,860–13,332 BP), south-central Chile, and Cerro Tres Tetas (10,260–11,560 BP), Santa Cruz, Argentina, and they are common in numerous early Holocene sites. The ICP–MS and XRF trace-element analysis of artifacts from these sites indicates long-distance (> 300 to > 1000 km) transport of obsidian from nine different sources.

Two of these sources, Chaitén (CH) and Nevadas de Sollipulli (NS), are associated with active Andean volcanoes in southern Chile. Six of them, Portada Covunco (PC), Cerro de la Planicies/Lago Lolog (CP/LL), Sacanana (S), Telsen/Sierra Negra (T/SC), Pampa del Asador (PDA), and Cordillera Baguales (CB), occur to the east in Argentina. One, Seno Otway (SO), occurs in the Miocene volcanic belt in the southernmost Andes. The relatively wide distribution of obsidian from each of these nine sources implies a considerable amount of material interchange among the prehistoric hunter-gatherers of Patagonia throughout the Holocene. A number of other obsidian sources have also been exploited, but only more locally. The nine main obsidian sources in Patagonia are all secondary, consisting of cobbles of obsidian distributed over relatively large areas by fluvial processes. Geologic ages of these obsidians range from 17.1 Ma (Seno Otway) to recent (Chaitén). The obsidian from each of these sources is chemically distinctive and generally homogeneous. Those from the Chilean Andes are subalkaline in composition, while those from the pampas of Argentina east of the Andes are alkaline and peralkaline. Grey obsidian from Chaitén is porphyritic, with ca. 1–3 vol.% of plagioclase crystals, while all the others are crystal-free. Chaitén obsidian occurs in marine culture sites along the Pacific coast as far as 400 km to the north and south of this volcano, and a few samples has been found > 1000 km to the southeast along the Atlantic coast, presumably transported there in a canoe. Green obsidian from Seno Otway was also exploited dominantly by Fuegan marine cultures, but also occurs in terrestrial hunter-gatherer sites in southernmost Patagonia such as Pali-Aike and Fell's caves, sites from which Junius Bird first reported, in 1938, obsidian artifacts in Patagonia. Based on their scarcity (< 1% of all artifacts) and small size, he correctly concluded obsidians in these two sites were not sourced locally. Distinctively black and red-banded obsidian from Portada Covunco has also been transported > 500 km east to the Atlantic coast, as well as west into Chile to the Pacific coast and coastal islands, perhaps because of its aesthetic appeal. Black alkaline obsidian from Pampa del Asador, which includes at least three chemically distinguishable types, has been distributed by terrestrial hunter-gatherers > 800 km northeast to the Atlantic coast and south to Tierra del Fuego, as well as west into Chile. A possible hiatus in the southward long-distance transport of PDA obsidian after 7000 BP may be related to catastrophic depopulation of southernmost Patagonia as a result of a large explosive eruption of the Hudson Volcano.

Obsidian in the Forest: Chemical Characterization of Archaeological Artifacts from Northwest Patagonia, Argentina

Charles Stern
University of Colorado, Boulder, CO 80309–0399, USA
email: charles.stern@colorado.edu

Mariana Carballido Calatayud & Cristina Bellelli
CONICET, Buenos Aires 1426, ARGENTINA

We present new data characterizing the trace-element geochemistry of obsidian artifacts from archaeological sites located in the mixed *Nothofagus* and *Austrocedrus* forests of northwest Patagonia, Argentina. These data increase the available information for this area, which allows us to discuss both the spatial distribution and circulation of obsidian in the interior of the forest and between this environment and the steppes to the east and Pacific coast to the west, and also to extend the temporal extent of this discussion back into the early Holocene.

We analyzed by ICP–MS the trace element composition of 35 archaeological obsidian artifacts, of which 23 were obtained from three sites near Cholila (Chubut) dated between 680 and 1870 BP; 11 artifacts from two sites from Manso River (Rio Negro) dated between 330 and 8230 BP, and one artifact from near El Hoyo (Chubut) of an age between 1330 and 1600 BP. The data for these samples have been combined with other already published data for samples from Cholila, and compared with the available information about the chemistry of obsidian from different sources in Patagonia.

Laguna La Larga, a primary source of obsidian, is the one located closest to the three localities sampled. However, it was exploited only very little, and this type of obsidian only occurs in the sites near Cholila, due possibly to its poor quality for fashioning tools, and/or the difficulty in accessing this source given its location in the interior of the forest. Obsidian sources from further away, but with abundant easily accessible and better quality obsidian, were exploited more frequently. The most utilized is located in Sacanana 230 km east of the sites near Cholila, and 350 km east from the sites near El Hoyo and El Manso. The sources close to Lacar and Lolog lakes (Cerro de las Planicies–Lago Lolog, Yuco, Paillakura, and Quilahuinto/Pocahullo) are 150 km north from El Manso and 260 km from Cholila. At 350 km northeast from El Manso is the Portada Covunco source, which based on previous results also provided obsidian to the sites near Cholila 430 km to the south. These data indicate north-south circulation of obsidian within the interior of the forest, and also east-west circulation between the steppes and the forest. No obsidian from sources west near the Pacific coast in Chile, such as Chaiten, has been found.

We have determined that for the last 2000 years at least eight different obsidian sources provided obsidian for the sites near Cholila and four for the sites near El Manso, all these being distant sources except for Laguna La Larga. We also found that one sample from El Manso, obtained in a level dated as 8230 BP, came from Sacanana, extending the exploitation of this source back into the early Holocene suggesting the importance of understanding the ancient use of this source.

Obsidian Hydration Dating of Late Pleistocene Deposits at Mochena Borago Rockshelter, Ethiopia

Christopher M. Stevenson
Virginia Commonwealth University, Richmond, VA 23284, USA
email: cmstevenson@vcu.edu

Steven A. Brandt
University of Florida, Gainesville, FL 32611, USA

Alexander Rogers
Maturango Museum, Ridgecrest, CA 93555, USA

Stanley H. Ambrose
University of Illinois at Urbana–Champaign, Urbana, IL 61801, USA

Mochena Borago rock shelter is located on the slopes of Mount Damota, a dormant volcano west of the Rift Valley in the southwest Ethiopian Highlands. The 2+ m of stratified late Pleistocene aeolian, fluvial, and volcanic deposits have revealed a geomorphologically complex depositional sequence. The three main stratigraphic groups contain over 15,000 late Middle Stone Age / early Late Stone Age artifacts, of which > 90% are obsidian. Fifty calibrated AMS ^{14}C dates on charcoal provide a stratigraphically consistent dating sequence ranging from > 50,000 cal BP to ca. 38,000 cal BP. Obsidian hydration dating of several artifact samples from each major stratum were undertaken to assess: 1) the reliability of this method in comparison to the AMS ^{14}C-dated sequence; and 2) its potential for dating deposits beyond the limits of ^{14}C dating.

Non-eroded hydration layers from internal impact fissures were isolated and optically measured. Laboratory diffusion coefficients were adjusted using paleo-temperature curves specific to the region to account for past climatic changes. Many of the obsidian hydration dates converge with the AMS ^{14}C dates. However, within some levels dates vary by a factor of two or more. We continue to investigate the cause(s) of this variability. Potential contributors to variation include recycling of older artifacts, and thermal alteration after deposition.

Provenance Study of Obsidian Artifacts from Hiroppara Site in Kirigamine, Central Japan

Yoshimitsu Suda
Nagasaki University, Nagasaki 852-8521, JAPAN
email: geosuda@nagasaki-u.ac.jp

Obsidian sourcing study was conducted on the artifacts excavated from the Hiroppara archaeological site located in the Kirigamine region, which is well-known as one of the major obsidian sources in central Japan. The result of quantitative analysis by WD–XRF method (destructive procedure) indicates that obsidian sources in this area are geochemically classified into 12 types or groups. Geochemistry of these types is characterized by the variations of Sr + Ti + Zr vs. Rb + Nb + Th contents. On the basis of these data, we performed the analysis of obsidian artifacts from the Hiroppara I site by the destructive procedure. Number of analyzed artifacts reached 40, and they are geochemically classified into six groups by the variation of Sr + Ti + Zr vs. Rb + Nb + Th contents.

Qualitative analysis by the ED–XRF method is one of the reasonable ways to perform the provenance study of obsidian artifacts by non-destructive procedure. Therefore, we further conducted the qualitative analysis of 30 specimens from obsidian sources that previously underwent geochemical classification by quantitative analysis. The results were plotted on the Mochizuki's (1997) diagram. Consequently, 12 types of geochemical groups identified by the quantitative analysis appeared in this diagram. Moreover, the validity of geochemical classification by this method is estimated to be 85% from the comparison of these results and quantitative analysis of 40 obsidian artifacts.

On the basis of these results, we conducted the qualitative analysis of 689 obsidian artifacts excavated from the Hiroppara I site. After that we were able to perform geochemical classification for about 414 obsidian artifacts (60%), while the rest of the artifacts (40%) are unclassified due to some analytical reasons. The Mochizuki's (1997) diagram is specialized for the identification of the wider territory of obsidian sources in the Kanto–Chubu region: Chubukochi (including Kirigamine), Kozushima, Hakone, Amagi, and Takaharayama. Therefore, if we would perform the provenance study of obsidian artifact within the Kirigamine area, we must propose the new method of classification to be applied to obsidian sources in all region.

Obsidian at Mesolithic Sites in Georgia

Ana Tetruashvili
Tbilisi State University, Tbilisi 0182, REPUBLIC OF GEORGIA
email: atetruashvili@yahoo.com

Obsidian as a raw material attracted the attention of prehistoric humans. Paleolithic people actively used obsidian, according to diverse tools nomenclature. More importantly, the use of obsidian in the Mesolithic and Neolithic periods increased. Thus, the aim of this paper is to present the importance of obsidian in Mesolithic humans' life.

Mesolithic sites in Georgia are located in gorges, mountainous places, and are always connected with the river basins. Mesolithic sites on the territory of Georgia (which we will present according to regional division) can be divided geographically into following regions: in the Black Sea – Yashtkhva, Kvachara, Jampali, Tsivi Mghvime, Apiancha, and Entseri (Samegrelo) sites; in Imereti – Sagvarjile, Chakhati, and Darkveti sites; in Racha – Tsona site; in Shida Kartli – Kveda, Kudaro, Gudaleti, Selo, and Jermukhi sites; and in Kvemo Kartli – Edzani and Zurtaketi sites.

The obsidian source in Georgia is located on the Javakheti Plateau. The obsidian mount of Chikiani is situated south of the volcanic plateau of the Javakheti mountain range in the northern part of the Paravani watershed. The height of the mountain is 2415 m a.s.l. The Paravani obsidian deposit occurs in a few types, mostly black with red spots and stripes.

One of the Mesolithic sites, Edzani Cave, with a large amount of obsidian artifacts indicates actuality of using obsidian as a raw material. Edzani is located in the extreme northern part of Tsalka Village, to the end of the eastern bank of the old gorge of the Khrami River, at an altitude of 25 m from the base of the gorge and at an altitude of 1600 m a.s.l. Archaeological excavations at the Edzani revealed the following sequence of layers: I – lawn (turf), 2–3 cm thick; II – blackish-brownish loam, 20–40 cm thick; III – burnt reddish-yellowish bedrock, 15–20 cm thick. The assemblage contains 21,628 items; 93.3% of it is made of obsidian, and the rest is flint and jasper. Only 1910 items are completed tools, which is 8.8% of the total amount, and the rest is debitage. Different obsidian tools indicate its quality. Large numbers of flakes, chunks, and chips indicate that the Edzani shelter represents a workshop.

In addition, use-wear analysis of a small collection (mostly obsidian geometrical forms) from the Edzani Cave shows activity of Mesolithic humans. Geometrical artifacts, which are indicators of the Mesolithic period, are considered as hunting tools, although according to the functional analysis they were used to cut meat, bones, and for working on leather.

To conclude, I would mention that the relationship between Chikiani Mount and Edzani Cave is defined by their location. They are situated in the same geographical zone. As we know, the beginning of the Mesolithic coincides with the end of the Pleistocene and the start of a new geological period, the Holocene, and this allowed hunter-gatherers to choose raw material such as obsidian.

Research into Characterization and Geochemical Provenance of Obsidian Artifacts from Pantelleria Island, Sicily (Italy)

Emiliano Tufano
Messigno 120, Pompei, 80045 ITALY. Email: emi.tufano@gmail.com

Sebastiano Tusa
Soprintendenza del Mare della Regione Sicilia, Palermo 90133 ITALY

Angela D'Amora & Marco Trifuoggi
Chemical Sciences, University Federico II, Naples, 80126 ITALY

The exploitation of the volcanic glass was a primary reason for the prehistoric occupation of Pantelleria, which is one of the four volcanic glass sources in Italy. A careful survey of the island territory allowed us to identify two unknown sources at Cala della Polacca and at the Faraglione di Dietro l'Isola, both located on the southern cliffs of Island.

Some instrumental and analytical characterizations on samples from the geological obsidian sources and on several obsidian artifacts from the Early Bronze Age site at Mursia and the Final Copper Age site at Lago di Venere, show interesting data about the sourcing, supply and selection of raw material on the island.

Obsidian Industry of Lago di Venere Settlement in Pantelleria

Emiliano Tufano
Messigno 120, Pompei, 80045 ITALY. Email: emi.tufano@gmail.com

Sebastiano Tusa
Soprintendenza del Mare della Regione Sicilia, Palermo 90133 ITALY

Pantelleria volcanic island lies in the Sicily Channel. Starting from the Early Neolithic, the exploitation of obsidian sources was a reason for the human Island's attendance. In the northeastern part of Lago di Venere area we found a prehistoric stratigraphy containing final Copper Age ceramics, and a great amount of obsidian tools that we studied using the Laplace's analytical method.

The obsidian industry results composed of about 673 pieces, 262 of them are retouched. Short and flat chips were preferred, and the most found tools were produced by simple retouches. Frequently the retouches didn't modify the chips edges. The large quantity of raw material available in Pantelleria allowed the production of tools paying low attention to the result accuracy. The tools were rapidly manufactured, and as much rapidly wasted.

Lipari Obsidian Sources and Distribution in the Prehistoric Central Mediterranean

Robert H. Tykot
University of South Florida, Tampa, FL 33556, USA
email: email: rtykot@usf.edu

The Aeolian island of Lipari, just north of Sicily, was a major geological source of high quality obsidian that was volcanically formed in the Late Mesolithic, followed by another major production in the 1st millennium AD, as well as on the neighboring island of Vulcano just a few centuries ago. A much earlier volcanic event on Lipari also produced some obsidian, but not of sufficient quality for tool production. A detailed geological survey in the early 2000s of the Lipari obsidian source areas, followed by elemental analyses using NAA, LA–ICP–MS, ED–XRF, and pXRF, shows that the different chronological groups may be distinguished from each other, as well as Gabellotto Gorge and Canneto Dentro, the two early Holocene sub-sources.

In the central Mediterranean, the initial use and long-distance movement of obsidian artifacts appears to coincide with the introduction of the “Neolithic package” of early agriculture, animal husbandry and ceramic production, and the year-round occupation of many islands in the late 7th/early 6th millennium B.C. Previous work done in Sardinia has shown that assigning obsidian artifacts to specific Monte Arci subsources is highly informative about prehistoric acquisition, production, and distribution of obsidian and significant changes over time. In order to address similar issues about the use of the Gabellotto Gorge and Canneto Dentro subsources on Lipari, thousands of Lipari obsidian artifacts from archaeological sites in the central Mediterranean have been analyzed, starting in 2008 with a non-destructive portable XRF which allowed analyses of large assemblages within museums and storage areas in Italy, Malta, and Croatia.

The data now available show that starting in the Early Neolithic period, multiple obsidian subsources were used on Lipari, and the other islands. For Lipari, most obsidian has been assigned specifically to Gabellotto Gorge, but artifacts made from the Canneto Dentro sub-source have been found too. In southern/western Sicily, and on Malta, Pantelleria obsidian was also used, while in southern Italy some obsidian from Palmarola and even Sardinia have been found. Obsidian from Lipari was used to create stone tools found at archaeological sites as far away as southern France, northern Italy, Croatia, Tunisia, and possibly Algeria.

Obsidian use appears to be affected by such factors as the availability of other stone tool material, changes in territorial access to the sources, the development of local production centers for export, and the transport of other materials. Yet further research is needed in certain areas and especially for specific time periods to assess the regularity of long-distance mobility and the maritime transport involved; the selected use of certain geological subsources on Lipari and the other islands based on quantity, quality, and accessibility; and regional and intra-site variation in source utilization. Integration of obsidian sourcing data with tool typology, use-wear, and other lithic materials can produce a better understanding of the production and exchange networks of prehistoric societies in the central Mediterranean.

Obsidian Access along the Adriatic: Sourcing Studies and Maritime Trade in Croatia

Robert H. Tykot
University of South Florida, Tampa, FL 33556, USA
email: rtykot@usf.edu

Stašo Forenbaher
Institute for Anthropological Research, Zagreb 10000, CROATIA

Damir Kliškić
Archaeological Museum in Split, Split 21000, CROATIA

Zlatko Perhoč
Rupprecht-Karls-Universität Heidelberg, Heidelberg 69120, GERMANY

Emil Podrug
Šibenik City Museum, Gradska vrata 3, 22000 Šibenik, CROATIA

Dinko Radić
Cultural Centre Vela Luka, Korčula, CROATIA

The geological sources of obsidian in the Mediterranean and Europe have been well-identified and can be distinguished using a variety of analytical methods. Fortunately, archaeological artifacts may be assigned to specific sources (and sub-sources) using non-destructive X-ray Fluorescence spectrometers, and in particular, with portable hand-held models. In this study, the use of a pXRF has facilitated analyses of prehistoric obsidian artifacts to be conducted at museums and other facilities in Croatia, thus overcoming limitations on destructive sampling and/or transport to external laboratories. The analysis of over 300 artifacts from Croatia for trace elements Rb, Sr, Y, Zr, and Nb, as well as Fe and other major elements, has revealed the use of obsidian from sources in the Carpathians of northeastern Hungary and Slovakia, and on the islands of Lipari, Melos, and Palmarola in the Mediterranean. This enables us to reassess long-distance contact and trade routes during the Neolithic period, ca. 6500–3500 BC, when the neolithic "package" of ceramics, domesticated plants and animals spread to Europe, and year-round settlements were established.

The obsidian artifacts tested come from more than 20 different archaeological sites, including several on the peninsula of Istria at the northern end of the Adriatic (Kargadur, Pupićina Peć, others), on islands in the central Adriatic (Palagruža, Korčula, Sušac), along the Dalmatian coast (Danilo, Krivače, Lok. Muša, Pokrovnik), and in northeastern Croatia (Samatovci, others). The analytical data were compared directly with those for geological samples from the Mediterranean/European sources and each artifact assigned to a specific source using standard statistical methods. The obsidian results may be compared with those from sites on the Italian side of the Adriatic, and integrated with studies done on flint and ceramics, to interpret likely maritime trade routes and transport capabilities, and the socioeconomic nature of raw material acquisition, artifact production and distribution, and usage.

Genesis of Internal Structure of the Shirataki Obsidian, Northern Hokkaido, Japan

Keiji Wada
Hokkaido University of Education, Asahikawa 070-8621, JAPAN
email: wada.keiji@a.hokkyodai.ac.jp

Kyohei Sano
Shirataki Geopark, Engaru 099-0111, JAPAN

Obsidian is an indispensable key material not only as archaeological provenance study but also for understanding the eruption process of silicic magmas for geological and petrological studies. The formation of dense obsidian is related to vesiculation, degassing, crystallization, viscosity, and magmatic temperature during effusive and flow history of silicic magmas (Fink 1983; Eichelberger et al. 1986; Stevenson et al. 1994). This study focuses on obsidian formation process during emplacement of obsidian–rhyolite magmas through the observation of internal structure of rhyolite lava from Shirataki, northern Hokkaido, Japan (Wada and Sano 2014; Sano et al. 2015).

The Shirataki obsidian–rhyolite field contains many outcrops of densely compact obsidian layers of excellent quality. Obsidian artifacts, belonging the Paleolithic and subsequent Jomon epoch, are widely spread throughout the Hokkaido Island, Sakhalin Island, southern Kurile Islands, and the northern Honshu Island, more than 500 km from this source. The Shirataki obsidian lavas (SiO_2 = 76.7–77.4 wt.%) were erupted 2.2 Ma ago, and formed a monogenetic volcano comprising ten obsidian–rhyolite lava units. Among them, Akaishiyama lava shows good exposures of internal sections from top to bottom, with thickness of about 250 m, and it comprises a surface clastic zone (not exposed); an upper dense obsidian zone (10 m thick); an upper banded obsidian zone (100 m thick); a central thick rhyolite zone (100 m thick); a lower banded obsidian zone (5 m thick); a lower dense obsidian zone (7 m thick); and a lower clastic zone (3 m thick). The upper banded obsidian zone includes many layers with concentration of spherulites (< 12cm in diameter); rhyolite blocks comprising innumerable spherulites; and tuffisite veins. The lower banded obsidian zone is characterized by alternating thin layers of vesicular rhyolite and obsidian. The dense obsidian is > 98% glass, containing a small amount of H_2O (< 0.1 wt.%) with magnetite microliths. Obsidian and rhyolite have similar bulk-rock compositions and amount of microliths, although the rhyolite contains glass with perlitic cracks and a large amount of crystalline material (spherulites and lithophysae). These geological and petrological features indicate that formation of obsidian and rhyolite layers was controlled mainly by the timing of the vesiculation and degassing of magmas, in addition to the cooling effect.

Notes