Obsidian Across the Americas

Compositional Studies Conducted in the Elemental Analysis Facility at the Field Museum of Natural History

Edited by

Gary M. Feinman and Danielle J. Riebe

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Front cover: Obsidian artifacts from Field Museum (Feinman and Nicholas) excavations at the Mitla Fortress and Lambityeco (Oaxaca, Mexico). Images taken by Linda M. Nicholas. Back cover: Obsidian preform CB07-41-0384 sourced to Alca-1 and recovered from the Sector A Palace Complex 41A-D2 on Cerro Baúl (drawing by J. Seagard).

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Chapter 1

Chipping Away at the Past: An Introduction

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Abstract

Key to the analysis of the archaeological and geological materials presented in this volume is the Elemental Analysis Facility (EAF) and the instruments housed in the EAF at the Field Museum of Natural History. This center has grown over the past twenty years becoming a leader in compositional studies of archaeological specimens. In particular, obsidian has been intensively analyzed by researchers using various compositional techniques. While many volumes have focused on the nature of obsidian and/or its use and circulation in the past, this volume uniquely presents the research conducted on obsidian, both geological and archaeological materials, from across the Americas using the equipment housed in the EAF at the Field Museum of Natural History. In so doing, it provides a snapshot into the current status and contributions of obsidian sourcing research toward understanding trade, exchange, and mobility in the precolonial American past.

Introduction

For the past two decades, the Field Museum of Natural History has been a leader in the analysis, conservation, and preservation of archaeological and museum collections. There are an immeasurable number of researchers who have walked the museum's halls, collaborated with museum scientists and curators, and advanced our understanding of the past and helped preserve the future through a diversity of research projects. However, of particular note are those researchers and projects that have relied on the Elemental Analysis Facility (EAF) at the Field Museum.

Beginning as a casual lunch conversation between Drs. Laure Dussubieux and Heather Walder about the growing number of unpublished EAF research, the discussion has resulted in the compilation of these analytical projects in the form of two volumes, with one more in the pipeline. The first volume, edited by Dussubieux and Walder (2022), focuses on the analysis of glass bead artifacts using the laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) laboratory at the EAF. This innovative volume included archaeological beads from around the world, and their analysis helped researchers reconstruct various chronological developments and human interactions. To build collaborative efforts, Dussubieux and Walder hosted a three-day workshop that allowed scholars to present their laboratory results, receive feedback from their colleagues, and incorporate the feedback into their final manuscripts. In a similar vein, the second volume, edited by Feinman and Riebe (this volume), started with a similar workshop on October 8, 2021, in which all authors presented their research in a "lightning-round" format and received feedback from the other participants and the editors. On February 4–5, 2022, a third workshop was held for the authors of the last publication that will focus on Andean ceramics and will be edited by Drs. Ryan Patrick Williams, M. Elizabeth Grávalos, and Luis Muro Ynoñán. Where the current volume differs from these other EAF compilations, however, are the materials studied and the analytical methods used. Obsidian, its origins, circulation, and use, are the focus of this volume, with most of the analyses conducted using the portable X-ray fluorescence (pXRF) devices in the EAF.

History of Elemental Analysis Facility

The origins of the EAF date to the early 2000's with Dr. Patrick Ryan Williams as the director. In 2005, the EAF became more firmly established as a leading analytical facility with the hire of research scientist and manager, Dr. Laure Dussubieux. Working together, Williams and Dussubieux have built the EAF labs – including the pXRF Lab, LA-ICP-MS Lab, and Optical Mineralogy Lab – through a series of granting initiatives from both internal sources (Negaunee Fund, Grainger Scientific

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Fund, Anthropology Alliance, Women's Board) and external sources (National Science Foundation: *BCS 0818401, BCS 1321731, BCS 1531394, BCS 0320903, BCS 1628026, BCS 2016729; BCS 1649742*). The growth of these laboratories and the investment in instrumentation has attracted researchers from all over the world, but it also has played a pivotal role in training and educating future scientists. The Field Museum and its curators and research scientists have close ties with the universities in the Chicago-land area, including Northwestern, the University of Chicago, and the University of Illinois at Chicago, and this uniquely positions interested students at these universities to learn about the different analytical techniques available in the EAF and to develop projects using these instruments and the collections at the Field Museum. Beyond training and working one-on-one with interested students, Williams and Dussubieux also developed and co-instruct a course, *Analytical Archaeology* (ANTH 494, UIC), that focuses on archaeometry and requires students to come up with a semester project utilizing one specific analytical technique.

Promotion of the EAF goes beyond the classroom to the public at large. The museum hosts a bi-annual event known as Museum Nights, and every year the EAF has a booth for the public to learn more about the benefits of the facility. Often the pXRF devices are on display, and interested people can have objects tested to determine their composition and sometimes their authenticity. In 2018, Dussubieux, along with Drs. Carla Klehm and Danielle Riebe, organized a formal workshop that was open to the public and presented a wide range of compositional research conducted in the EAF. Similar platforms for research dissemination are intended to be held in the future.

The EAF, and those running it, have sought to create more than just a research center, and as the EAF has grown, so too has its impact. Over the past twenty plus years, the EAF has been instrumental in building collaborations, educating the public, and training future scientists. By investing and developing the labs associated with the EAF, there has been increased opportunities and methods to better reconstruct and model the archaeological past.

Discussion of Instrumentation

As previously mentioned, the EAF labs consists of the LA-ICP-MS Lab, the pXRF Lab, and the Optical Mineralogy Lab. The former two labs have been highly instrumental in compositional studies of archaeological and geological specimens. Selection of the method used to analyze the materials often comes down to several variables, including sample size, portability of sample or exportability from country of origin, number of and/or specific elements necessary to generate a distinctive compositional signature, the need for minimally destructive vs. non-destructive technique, and cost. Since the early 2000s, when the EAF was first established, instrumentation has changed, and below details a brief description of those devices housed in the LA-ICP-MS and pXRF laboratories.

LA-ICP-MS

The first major instrumentation grant for the EAF was funded by the National Science Foundation (*BCS 0320903*) and secured in 2003 by Drs. Patrick Ryan Williams, Gary Feinman, Menakshi Wadwha, and Phil Janney for a mass spectrometer and a scanning electron microscope (SEM). The original mass spectrometer purchased for the lab was a Varian Ultramass Quadrupole LA-ICP-MS with a New Wave UP213 system. While the samples could be introduced to the system as a liquid, solid sample introduction relied on specimens approximately smaller than 5cm in order to fit in the analysis chamber. This greatly limited the materials that could be studied, so to expand the abilities of the equipment and to allow larger specimens to undergo solid state sampling, collaborative efforts were made to create a modified adaptable chamber that utilized a New Wave UP266 laser ablation system.

After receiving funding in 2015, in 2016 a new mass spectrometer was purchased to replace the original. The Thermo ICAP Q quadrupole ICP-MS continued to operate with the New Wave UP213 laser ablation system, and Dussubieux worked to ensure that results generated between the old and new mass spectrometers were comparable. As before, samples could be introduced into the ICP-MS either as a vaporized solid or in a liquid state.

The LA-ICP-MS analytical approach produced reliable measurements for over 50 elements. While considered a minimally destructive technique, solid ablation would result in sampling craters not visible to the naked eye. At the Field Museum, LA-ICP-MS has been used to analyze non-archaeological materials (Cook *et al.* 2006), but has been heavily relied upon to study archaeological materials (Dussubieux *et al.* 2016), including ceramics or other clay objects (Dussubieux *et al.* 2007; Golitko *et al.* 2016; Kreiter *et al.* 2014; Levine *et al.* 2013; Niziolek 2013; Piscitelli *et al.* 2015; Riebe 2021; Riebe and Niziolek 2015; Riebe *et al. in press*; Sharratt *et al.* 2009, 2015; Vaughn *et al.* 2011; Williams *et al.* 2019a, 2019b), pigments (Bonjean *et al.* 2015; Halperin and Bishop 2016), metals (Dussubieux 2007; Dussubieux *et al.* 2008), stone (Goemaere *et al.* 2013; Golitko and Terrell 2012; Speer 2014), and glass (Dussubieux *et al.* 2008, 2009, 2010; Robertshaw *et al.* 2009, 2010; Schibille 2011; Walder 2013; Walder *et al.* 2021).

pXRF

Throughout the operation of the EAF, a number of different pXRF devices have been purchased and used for both conservation and research purposes, with the first device being added to the EAF around 2007 with funding from the Grainger Scientific Fund. Later additional pXRF instruments would be secured with Negaunee funding. Generally, pXRF can reliably measure between 8–15 elements, however, the number and the specific measured elements vary depending on the instrument. The aspect that makes this device so appealing resides in its portability. This enables researchers to take the device to different countries and/or to the field, conduct analyses on materials *in situ*, and/or study those materials that cannot leave the country.

In total, four different pXRF devices have been housed in the EAF pXRF Laboratory, including an Innov-X, a Bruker TRAcER III-V, a Bruker TRAcER III-SD, and a Niton XL3t 950 GOLDD+. While these devices also have been used to study ceramics (Sharratt *et al.* 2019; Williams *et al.* 2012) and metals (Dussubieux and Walder 2015), a majority of the compositional studies utilizing the pXRF instruments in the EAF have focused on volcanic materials, such as basalt (Hastorf *et al. in press*; Janusek and Williams 2016; Janusek *et al.* 2012; Palumbo *et al.* 2015; Williams *et al.* 2015) and obsidian (Bélisle *et al.* 2020; Feinman *et al.* 2013, 2018, 2019a, 2019b; Golitko and Feinman 2015; Golitko *et al.* 2010, 2012; Meierhoff *et al.* 2010; Millhauser *et al.* 2011, 2015; Moholy-Nagy *et al.* 2013; O'Shea *et al.* 2021; Riebe 2018, 2019, 2021; Riebe *et al.* 2018, *in press*; Ruka *et al.* 2019).

Volume Contributions

The recent EAF-focused volume (Dussubieux and Walder 2022), as well as the current one, illustrate how integral the EAF has been in the lives and research of the contributors. Most of the chapters in this volume are co-authored with collaborators spanning the globe. Additionally, several of the authors (Chacaltana, Golitko, Reid, Riebe, and Sharratt) began as graduate students in the EAF and now are established research scientists. Overall, the Field Museum, its collections, and the EAF have offered researchers the opportunity to advance new lines of research, specifically as they relate to networks and the movement of people and goods. Many of the contributions in the volume highlight the reliance on existing collections at the Field Museum or other collaborating institutions, as well as the development of new investigatory methods. Together, the chapters explore a variety of regions, time periods, and topics, but all contribute to the advancement and development of anthropological research, focused on trade, exchange, and mobility, through compositional studies.

Specifically, this volume presents the results of compositional studies conducted in the pXRF Laboratory of the EAF at the Field Museum and focuses on geological and archaeological obsidians from across the Americas. Although numerous techniques are available for compositionally studying obsidian (see Chapter 2 for further discussion), pXRF is an expedient and efficient technique for sourcing the geological material. From utilitarian to ornamental, obsidian has been used by peoples for thousands of years. While the material is unique in terms of its composition as a volcanic rock, its acquisition, use, and alteration by people is truly what makes the silicious object of remarkable importance for archaeologists.

The volume is divided into three sections based on geography (North America, Mesoamerica, and South America), and the chapters cover a wide breadth of archaeological topics. Several chapters deal with obsidian procurement patterns in specific regions (see Nicholas *et al.* – Chapter 5; Williams *et al.* – Chapter 10) or across vast expanses of land (Golitko *et al.* – Chapter 3; Riebe *et al.* – Chapter 4; Feinman *et al.* – Chapter 8). Other chapters focus on individual sites to reconstruct changes in procurement patterns and intra-site material distribution (see Moholy-Nagy – Chapter 6), as well as highlight the role of marketplaces in the manufacture and distribution of finished goods (Cap – Chapter 7). Finally, several chapters focus on issues related to further developing archaeometric research through increased inter-laboratory collaborations (see Riebe *et al.* – Chapter 2) and the improvement of analytical techniques (see Reid *et al.* – Chapter 9). Together, the case studies in the volume explore the ways in which obsidian analyses have been used to investigate multi-scalar interactions, socio-economic exchanges, and socio-cultural developments in the past (see Chapter 11 for further elaboration). Several chapters (especially 4 and 8) highlight the great potential of expanded sample sizes that can be achieved through the use of pXRF. Large samples allow analysis to extend beyond presence-absence observations and to reveal more detailed patterns of quantitative variation. As technology continues to advance, so too will the methods used by researchers to study the archaeological record. In that sense, it is fascinating to view the tools of today as a means to study the tools of the past.

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