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International Association for Obsidian Studies

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NEWS AND INFORMATION

NEWS AND NOTES

Have news or announcements to share?
Send them to IAOS.Editor@gmail.com for
the next issue of the *IAOS Bulletin*.

CONSIDER PUBLISHING IN THE IAOS BULLETIN

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

CALL FOR NOMINATIONS

Rob Tykot has just begun his responsibilities as IAOS President, and Jeff Ferguson has stepped into the position of Past President for the coming year. That means that it's now time for nominations for our next IAOS President. Elections will be held this winter and the winner announced at the 2017 IAOS meeting at the SAAs in Vancouver. The winner will then serve as President-Elect for one year and begin the term of President in 2018. If you, or someone you know, would be interested in serving as IAOS President, please send a nomination to Rob Tykot at rtykot@usf.edu.

NOTES FROM THE PRESIDENT

Report on International Obsidian Conference on Lipari (Italy)

This international meeting was organized by Robert Tykot (USA), Yaroslav Kuzmin (Russia), Michael Glascock (USA), Akira Ono (Japan), and Maria Clara Martinelli (Italy), and held June 1-3 at the Regional Aeolian Archaeological Museum “Luigi Bernabò Brea” on the island of Lipari, just north of Sicily (Figure 1).



Figure 1. Castle area with Archaeological Museum, church and archaeological sites, with view also of harbor.

This location was sponsored by the Regione Siciliana Assessorato dei Beni Culturali e dell'Identità Siciliana and the director of the museum, Maria Amalia Mastelloni. The IAOS and the Society for Archaeological Sciences (SAS) provided some direct support, in addition to awards for student presenters. More than 80 people from 15 countries came to the conference which included more than 60 oral and poster presentations (Figure 2).



Figure 2. Conference participants in front of the lecture hall (photo by Yaroslav Kuzmin)

Located on the island of Lipari, a major source of obsidian for the central-western Mediterranean, a guided tour of the Gabelotto and Canneto Dentro subsources was done, and many of the participants were very happy to examine and collect some geological samples. One of the continuing issues for obsidian sourcing studies is having a statistically sufficient dataset for each potential source and subsource, ideally analyzed by the same instrument used for archaeological artifact analyses. For Lipari, we can chemically distinguish six subsources using INAA or LA-ICP-MS: Mt. Guardia is the oldest, but only has small-size pieces of usable obsidian; eruptions around 6700-6400 cal BC produced both the Gabelotto (Figure 3) and Canneto Dentro subsources, with trace element differences between the northern and southern parts of Gabelotto Gorge; and in the first millennium AD the Forgia Vecchia and Rocche Rosse sources were formed.



Figure 3. Conference participants visiting one side of the Gabelotto Gorge.

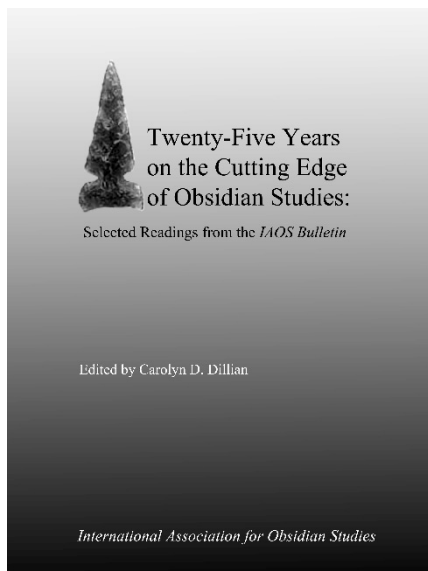
After a historical overview of Lipari studies by Maria Amalia Mastelloni, and some introductory comments by Colin Renfrew (pre-recorded), the conference began with a keynote presentation by Michael Glascock (University of Missouri, USA) on the use of analytical methods for obsidian studies; later were other keynote presentations by Clive Oppenheimer (Cambridge University, UK) and colleagues on an active obsidian-producing volcano in Eritrea and its historic

effects on the local residents, and by Akira Ono (Meiji University, Japan) on both macro- and micro-scale movement of people beginning in the Upper Paleolithic. For the regular oral and poster presentations, there were several focusing on the analytical methodologies, including elemental and magnetic methods and whether they are non-destructive, and many presentations focusing on specific geographic areas (Europe [Italy, Croatia, Greece, Hungary]; Western Asia [Turkey, Georgia, Armenia, Iran, Azerbaijan, Yemen]; Eastern Asia [Russia, Indonesia, Japan, North Korea, South Korea]; Africa [Djibouti, Eritrea, Ethiopia, Kenya, Saudi

Arabia, Yemen]; Americas [Argentina, Chile, Mexico]), and time periods.

Overall, the conference was a great success (as reported to me by many of the participants). The full program and abstracts may be found on the conference website: <http://rtykot.myweb.usf.edu/Obsidian%202016/index.html> while publication of the presentations are planned.

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Twenty-Five Years on the Cutting Edge of Obsidian Studies: Selected Readings from the IAOS Bulletin

Edited volume available for purchase online!

As part of our celebration of the 25th anniversary of the IAOS, we published an edited volume highlighting important contributions from the *IAOS Bulletin*. Articles were selected that trace the history of the IAOS, present new or innovative methods of analysis, and cover a range of geographic areas and topics. The volume is now available for sale on the IAOS website for \$10 (plus \$4 shipping to U.S. addresses).

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A CASE STUDY IN SITE FORMATION EFFECTS ON OBSIDIAN HYDRATION DATING

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Abstract

We report two methods of accounting for significant changes in burial depth in computing ages by obsidian hydration dating (OHD). We show by a numerical example that burial depth can have a profound effect on OHD age and must be taken into account. The example further shows the effects of uncertainty in the burial depth history: the artifact is assumed to have been recovered from a significant depth, but with indications the depth was not constant over time. Two computational methods are explored to compute age, referred to as time-averaging and level-averaging. Although the two methods are found to yield statistically indistinguishable results in this case, there are circumstances under which one method may be preferable to the other.

Introduction

The effective hydration temperature (EHT) that an obsidian artifact is exposed to a strong function of burial depth, and, for deeply buried artifacts, can significantly affect the age computed by obsidian hydration dating (OHD). Here we explore two methods for computing the age of deeply buried obsidian artifacts in which there are indications that burial depth was not constant over time.

As a numerical example, we assume an artifact which is geochemically sourced to the Coso West Sugarloaf source. The hydration rim is assumed to be 6μ , with a standard deviation of 0.1μ . The site is assumed to be in the California desert at an elevation of 4,000ft; and the burial depth of the artifact is assumed to be 1.0m, but with an active depositional environment suggesting the artifact was initially on the surface and subsequently buried by flooding.

Analysis Procedure: Age Computation

The computation of age is based on the measurement of hydration rim values by optical microscopy. Laboratory data (Rogers and Duke 2011; Stevenson and Scheetz 1989; Stevenson et al. 1998) indicate that the depth of the hydrated volume progresses into the obsidian proportional to t^n , where n is

approximately 0.5 within limits of experimental error. Thus the hydration dynamic model employed is:

$$r^2 = kt \quad (1)$$

where t is age in calendar years, r is rim thickness in microns, and k is the hydration rate (see e.g., Crank 1975; Rogers 2007a, 2012; Stevenson et al. 1989, 1998, 2004).

The hydration rate varies with EHT (see e.g., Hull 2001; Rogers 2007a; Stevenson et al. 1989, 1998, 2000, 2004), with relative humidity (Friedman et al. 1994; Mazer et al. 1991), and with intrinsic water concentration in the obsidian (Ambrose and Stevenson 2004; Friedman et al. 1966; Karsten and Delaney 1981; Karsten et al. 1982; Rogers 2008a; Stevenson et al. 1998, 2000; Zhang and Behrens 2000; Zhang et al. 1991). Relative humidity has a small effect in a practical sense, because the interstitial water content of even the driest sand is very high (Friedman et al. 1994), so the effect is generally ignored in practical analyses.

The hydration rate also varies by source flow within the Coso volcanic field. This study employs a rate for the Coso West Sugarloaf source of $18.14 \mu^2/1000$ yrs with a coefficient

of variation (CV) of 0.20 due to intrinsic water variations, at a reference temperature of 20°C. (Rogers 2011).

Temperature is the major effect which needs to be controlled in performing an obsidian analysis. Archaeological temperatures vary both seasonally and diurnally, and the hydration rate is a strong function of temperature. EHT is defined as a constant temperature which yields the same hydration results as the actual time-varying temperature over the same period of time. Due to the mathematical form of the dependence of hydration rate on temperature, EHT is always higher than the mean temperature. The mathematical derivation is given in Rogers 2007a and 2012.

EHT is computed by numerical integration of the temperature-dependent hydration rate over a modeled temperature history. The temperature history is modeled as the sum of a mean temperature (annual average temperature) and two sinusoids, one with 12-month period (seasonal temperature variation, which equals hottest-month mean minus coldest-month mean) and the other with a 24-hour period (mean diurnal variation).

Burial depth does not affect the annual average temperature, but it does affect the annual variation and the diurnal variation, the latter very strongly. For buried artifacts, V_a and V_d represent the temperature variations at the artifact burial depth,

$$V_a = V_{a0}\exp(-0.44z) \quad (2a)$$

and

$$V_d = V_{d0}\exp(-8.5z) \quad (2b)$$

where V_{a0} and V_{d0} represent nominal surface conditions and z is burial depth in meters (Carslaw and Jaeger 1959:81).

Once EHT has been computed, the measured rim thickness is multiplied by a rim correction factor to adjust the rims to the same EHT as the hydration rate, and ages are

computed by equation (1) (mathematical details in Rogers 2007a, 2012).

The temperature parameters for the hypothetical case were computed by regional temperature scaling for the upper Mojave Desert and desert mountains of eastern California. Details of the method are in Rogers 2008b. For an elevation of 4000ft amsl, the temperature parameters are as shown in Table 1.

| Parameter | At Surface | At 1.0 m depth |
|---------------------------------------|------------|----------------|
| Average annual temperature, T_a | 15.05 | 15.05 |
| Seasonal temperature variation, V_a | 21.14 | 13.61 |
| Mean diurnal variation, V_d | 15.80 | 0.0032 |
| Effective Hydration Temperature | 19.53 | 16.31 |

Table 1. Site temperature parameters, °C, 4000ft amsl. Note the depth of 1.0m reduces the diurnal variation to essentially zero.

Site Formation Processes

The effects of burial depth and site turbation on OHD dates have been discussed by Rogers (2007b). In the present case, site formation processes (Schiffer 1987) chiefly affect burial depth and its variation through time. In our model, the hypothetical artifact was recovered from a depth of 1.0m, but geological indications suggested it was initially on the surface and was subsequently covered with alluvium deposited by flash floods. Nothing can be inferred about duration of each phase. As a result, the value of burial depth (z) in equations (2a) and (2b) can range between 1.0m and zero (the ground surface). As can be seen from equations (2a) and (2b) and Table 1, burial depth reduces the temperature variation parameters and hence EHT – the deeper the burial, the lower the EHT. Furthermore, if an artifact is first on the surface and then buried, the hydration process is affected by the change in EHT. Two methods have been developed to deal with this uncertainty.

The first method is time-averaging, whose physical basis is that the overall hydration rate is the time-average of the instantaneous rate over the temperature history of the artifact (Rogers 2007a:658, eq. 7). Note that this is not the same as the hydration rate for the average temperature, nor the hydration rate for the average depth. Furthermore, it is immaterial whether the artifact is buried and then exposed or vice versa (Duke and Rogers 2013). The principle is to compute the hydration rate at depth and on the surface, and then compute a weighted average based on what fraction of its life the artifact was buried. For the present analysis, a fraction of 50% was assumed, since no other data are available. The weighted average rate is then used in computing age.

The second, simpler, method is level-averaging. The principle is to decide on two limiting cases, in this case $z=0$ and $z=1.0\text{m}$. Ages are computed for each limit, and a simple average computed as the best estimate of the age. In both methods, the standard deviation of computed age due to site formation is the difference of the two limiting ages divided by $\sqrt{12}$. Results of these two methods are presented below.

Results of Age Computation

Ages were computed by the two methods described above, and results are summarized in Table 2. The table shows the hydration rim as measured, the limiting age computed based on surface conditions, the limiting age based on conditions at 1.0m depth, the best estimate age computed by time averaging, the best estimate age computed by level averaging, and the standard deviation of the age uncertainty due to the unknown burial depth history.

| Source | R_m , μ | Surface age, yrs | Depth age, yrs | Mean TA age, cyb2k | Mean LA age, cyb2k | SF age uncertainty, yrs |
|--------|---------------|------------------|----------------|--------------------|--------------------|-------------------------|
| WSL | 6.0 | 2097 | 3065 | 2490 | 2581 | 279 |

Table 2. Ages for the hypothetical case, computed by obsidian hydration dating. All ages in calendar ages before 2000. WSL=West Sugarloaf; R_m =measured rim mean; TA=time-averaging; LA=level-averaging; SF=site formation.

Discussion

If the artifact had been on the surface for its entire life and was buried just before being discovered, the 6.0μ hydration rim would correspond to an age of 2097cyb2k; if the artifact had been buried at 1.0m depth the entire time, the age would be 3065cyb2k. This shows the profound effect burial depth can have on age computed by obsidian hydration methods. The actual value of the age must lie between these limits.

The two methods, time averaging and level averaging, yield slightly different estimates of the mean, as shown in Table 3.

| Statistic | Time averaging | Level Averaging |
|--|----------------|-----------------|
| Computed age, cyb2k | 2490 | 2581 |
| St. dev. of uncertainty due to site formation, years | 279 | 279 |
| N | 1 | 1 |

Table 3. Age summary. A t-test shows that the difference between the means is not significant at the 95% confidence level ($z = 0.23$, threshold = 1.96). Thus, one is justified in using either technique to estimate age in this case. Level averaging is more straightforward to implement in MS Excel, but both are simple in MatLab.

Age Accuracy

The primary sources of error, or uncertainty, are: obsidian rim measurement; errors in the hydration rate ascribed to a source; intra-source rate variability due to uncontrolled intrinsic water in the obsidian (Ambrose and Stevenson 2004; Rogers 2008a; Stevenson et al. 1993, 2000; Zhang et al. 1991; Zhang and Behrens

2000); and errors in reconstructing the temperature history, including site formation processes. The effects of these errors have been examined in detail, and the analysis is documented in Rogers 2010.

The standard deviation of the age estimate for any given specimen, σ_t , can be shown to be

$$\sigma_t = t \times \sqrt{\{4[CV_{rm}^2 + CV_{EHT}^2] + CV_{SF}^2 + CV_{ks}^2 + CV_{kw}^2\}} \quad (3)$$

where the variables are defined as follows: t is the age determined by equation (1), σ_r is the standard deviation of the hydration rim measurement, and is $\sim 0.1\mu$; r is the EHT-corrected hydration rim; CV_{EHT} is the coefficient of variation of EHT due to temperature modeling uncertainties; CV_{SF} is the coefficient of variation of age caused by the uncertain burial depth history; CV_{ke} is the coefficient of variation of the hydration rate ascribed to the obsidian source, and is typically ~ 0.05 ; and CV_{ks} is the coefficient of variation of the intra-source rate variations due to water content, which is ~ 0.20 for West Sugarloaf. For this numerical example these values give an overall uncertainty in age of 662 years.

Conclusions

First, it is clear that burial depth can have a profound effect on age computed by OHD, particularly for deeply buried artifacts. Computing age based on surface conditions and ignoring the effects of burial depth will invariably yield an age which is too young. On the other hand, if the burial conditions have varied significantly over time, computing age based on the deepest burial depth will yield ages which are too old. We have outlined two methods of accounting for changes in burial depth: time averaging and level averaging. Level-averaging can be conveniently performed by an Excel spreadsheet, but time-averaging is best performed by MatLab or a similar application.

Time-averaging is more complex computationally, but is closer to the actual

physics of the hydration process, while level-averaging is a simplifying short cut. In a case where there are no data to suggest the time-phasing of the site formation, either is adequate. However, if geoarchaeological or other contextual data are available such that timing of the phases of the burial process could be estimated, then the time-averaging method is preferable.

Both averaging methods yield essentially the same ages and age uncertainties for this numerical example. The convergence of results is caused by the fact that no data were available on the timing of the burial events: how long on the surface and how long at 1.0m. The simplifying assumption of "half its life on the surface and half at 1.0m depth" is roughly equivalent to taking the average of the ages. For our test case, the best estimate for the age of the artifact, including all error sources, is between 2490 ± 662 and 2581 ± 662 calendar years before 2000, or the Middle Newberry period.

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FUNDAMENTALS OF DIGITALLY IMAGING ARTIFACTS

Nicole Birney, Lucas R. Martindale Johnson, and Kathleen Montgomery
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Introduction

In archaeology, there is an increasing need to document as much as possible using quick, accurate, and economical methods. Artifacts may need to be documented in the field, because some or all cannot leave the site or host country. In California, there have been repeated situations where artifacts will be repatriated to indigenous groups after processing in a remote field lab. These artifacts are not taken to a permanent lab for additional analysis nor on to a curation facility or repatriation. Therefore, how can researchers economically document as much of a collection as possible in the shortest amount of time? Also, which method is the most accurate, requires the least knowledge, and uses the smallest amount of special equipment?

Realizing that academics and professional researchers alike are often tasked with not just research and writing, but also graphics, formatting, and report production, we present a few imaging and formatting pointers. We have put together suggestions on project planning, image-capture techniques, and equipment (e.g., hardware and software) for documenting obsidian and other artifacts. File management, storage, and image-editing guidelines for preparation of professional-quality images follow.

Our goal is to share what we believe is a best-practice approach for documenting obsidian artifacts of various types (e.g., cores, bifaces and projectile points, and flake tools) for reproduction in high-quality technical reports, public presentations, and academic research manuscripts. Although we use obsidian as a case-study, these methods may be used on other kinds of materials.

Project Planning

Choosing the right image-capture method, preparing your equipment, and making decisions that support your project objectives will save time and effort. What are the goals, scope, and final format requirements? Are you submitting to a client or journal, self-publishing, or creating a digital presentation? What hardware and software will you need, and which file formats and storage are best for your short- and long-term needs?

Time, Skills, and Equipment

There are several ways to capture and document images of artifacts, including scientific illustration, three-dimensional (3D) scanning, photography, and flatbed scanning. Each method has advantages, disadvantages, and dramatically different costs of time investment, required skills, and necessary equipment.

Scientific Illustration: Technical or scientific illustration of flaked stone artifacts is extremely time consuming, and the quality will vary greatly depending on the skill of the artist. Since most studies of flaked stone objects are concerned with knapping technique and metric attribute data, studies typically include a scaled sample of finely illustrated black-and-white line drawings. These illustrations highlight flaking scars and directions of force, and therefore represent the sequential, controlled actions by a craftsperson. There are a number of good guides to illustrating flaked stone (e.g., Addington 1986; Martingell and Savile 1988), and others that discuss the illustration of archaeological finds in general (for example, Dillon 1985; Griffiths and Jenner 2002; Steiner 2005). Of particular importance with the illustration of flaked stone (and ground stone) objects is the

need to control the style of pen-and-ink drawings to best represent the texture of a surface while keeping in mind the light source and shading method. Obsidian is glassy, in contrast to more coarse or fine-grained basalt or even coarser materials, like sandstone.

Learning to control the flow and thickness of technical ink pens may take hundreds of hours, and specialized pens, drawing paper, and tracing velum are required. Artifacts have to be drawn in pencil, then inked, scanned, and incorporated into a document. These representations are very useful in some cases where color prints are not possible, where gray scale digital images may obscure detailed flaked scars, or where an author wishes to show the nuances and particulars of flake removal from the face of an artifact. Some studies or illustration guides make use of contrasting lines on top of digitally imaged flaked stone objects (Dryer and Mazierski 2009; Titmus and Woods 2003:135, Figure 9.3). This method can be used together with the flatbed scanning method described below using an illustration software program to actually draw vector lines over the ridges between flake scars.

Technical illustration will always be an important method in archaeological representation of flaked stone artifacts as well as other artifacts; however, creating these images can be time consuming and costly, and might require specialized illustration staff. However, used on a small sample of artifacts, in conjunction with the methods described here, this technique can certainly be valuable.

Three-dimensional Scanning: 3D scanning has great potential for image capture and modeling of objects, though the process can be time-consuming and prone to error with the technology that is currently available and affordable. For most objects, a single scan will not produce a complete model. Multiple scans, even hundreds, from many different angles are usually required to document all sides of the subject. Light and reflection/refraction distortions that come from shiny objects can be

minimized by scanning in a dark environment. Another means to limit unwanted reflection/refraction is to dust the artifact with a light, non-abrasive powder such as cornstarch or baby powder. There is also a ready-made product that serves this purpose that is available under different names, including “dust spray,” “developer spray,” and “laser scanning anti-glare spray.” These are easily wiped away with a dry cloth and will not harm the surface of the object. “Chalk spray” is another possibility, but beware! There are types of chalk spray on the market that are permanent. If you have the time to experiment with 3D scanners and modeling technology, the results can be rewarding.

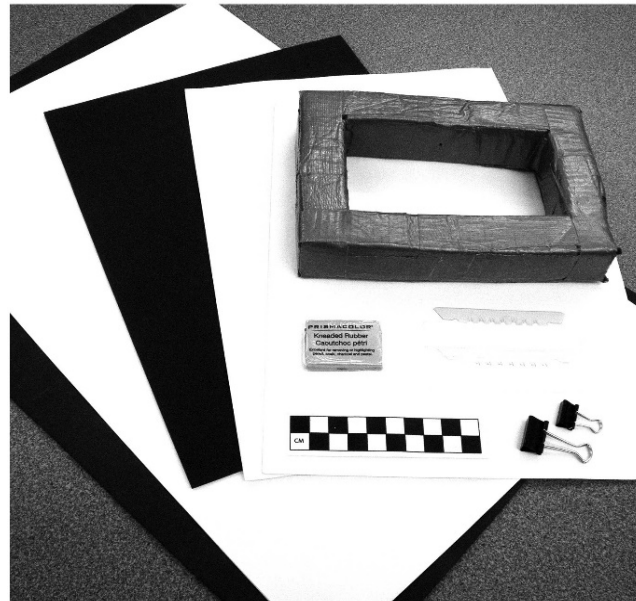
Photography: A traditional approach for illustrating small objects is macro-photography, which is the process of taking close-up pictures of a very small subject. Use of a traditional macro lens and film can be technically complex and require expensive specialty equipment. Alternatively, most digital cameras have the technical features needed to capture high-quality images of small subjects. Although the camera itself may have reliable settings for close-up photography, you’ll still need to find the right proximity to the object, keep a steady hand (set up a tripod, copy stand, or some other means of stabilization), and control the quality of light. For example, if the camera is not perpendicular to the subject or the distance to the subject is too close or too far, image distortion will occur; without stabilization, the image will be blurry. Incandescent, florescent, and natural light all have different effects on the color and shadows that are cast on the artifact, creating additional visual “noise” and inconsistencies. The learning curve for managing these variables, or the time spent compensating for poor execution, can be significant. Kelby (2015) details techniques for taking professional-quality photos and provides excellent how-to strategies.

Flatbed Scanning: Though a flatbed scanner is typically used for documents and photos, it is a very good tool for scanning thinner three-dimensional items (approximately three centimeters thick or less). We have found that the flatbed scanner is the best option for quick, accurate image capture. Many of the variables influencing quality are inherently controlled by the scanner itself: the image is scanned at 100% scale, the light source is consistent from one scan to the next, and the shallow depth of field minimizes background noise, bringing focus to the artifact's surface details and edges. Unlike the other methods mentioned above, flatbed scanning takes just a few seconds for image capture and once mastered, generally requires no more than five to 15 minutes to produce a publication-ready image.

Some popular manufacturers of flatbed scanners include Epson, Cannon, and HP, and these can be purchased for about \$100 and up. Any scanner should have adjustable settings that will allow you to specify the resolution of your image and file type at the time of scanning. Image editing software generally comes with your scanner, or you may prefer to use image editing specialty software such as Adobe Photoshop[®], Photoshop Elements[®], or Lightroom[®], to name a few. We've provided image-editing essentials below. Although we primarily use Photoshop[®], the tools and actions described here are fairly standard across different brands of editing software. Additionally, there are several instructional guides (Kelby 2003; McClelland 2016; Tally 2011) with easy to follow instructions explaining the bells and whistles of various software programs.

In addition to the scanner and editing software, it's helpful to have a few simple props at hand. Props are used to help control shadows, provide contrasting backgrounds, and hold artifacts in place when trying to capture a tricky profile or non-uniform artifact. Props that we find helpful include foam blocks, thick sheets of black and white paper, binder clips, and a

kneaded eraser (Figure 1). Plastic modeling clay can also be used, but do not use greasy traditional modeling clay. It will leave smudges on you, your artifact, and your scanner that are not easy to clean. Also, a piece of clear glass can be placed on the scan bed surface to protect against the any sharp edges that can scratch it.



Scanning props include foam blocks, thick sheets of black and white paper and neoprene, binder clips, clear plastic tabs, and kneaded eraser

Figure 1. Common props used while scanning artifacts on a flatbed scanner.

File Types and Management

Although each journal will have unique guidelines, they typically require high resolution (300-600 dots per inch [dpi] and higher) image files. Digital files imbedded within a Microsoft environment (e.g., MS Word, PowerPoint, Excel) are generally not accepted. If you are submitting files to a professional publication, it is best to send native files such as TIFF (Tagged Image File Format) or EPS (Encapsulated PostScript).

File Types: Both TIFF and EPS files work well for professional publications and archival copies. TIFF files can be saved in uncompressed form, producing a file that is relatively large but true to the original image. EPS files can contain transparencies, two-dimensional vector

graphics, text, and bitmap images. They can also be opened across multiple operating systems.

When saving an image as a JPEG (Joint Photographic Experts Group), an algorithm compresses it. Because of this, files are generally much smaller than the comparable files saved in other formats. The compression generally does not cause a noticeable loss to image quality, but there is some loss, which is why professional printers prefer not to use JPEG files. They do work well for the web, non-professional printing, e-mail, and digital presentations.

GIF (Graphics Interchange Format) files are widely used for web graphics, because transparency is possible. These files are generally compressed, have lower-quality color settings, and are smaller.

PNG (Portable Network Graphics) files are also common for online use. This file type was created to update and replace GIF images, since it can retain more colors than GIFs and can also be transparent while simultaneously being slightly smaller in size.

Adobe Photoshop[®] Document files (indicated by a .psd extension on the file name) can only be opened by a few programs, including Photoshop and the Macintosh's Preview[®] application. PSD files are generally much larger than JPEG, GIF, and even TIFF counterparts, because no compression occurs, and other data are stored in the file. These may include information on layers, paths, and other Photoshop-specific information. PSD files are good for "master" copies when you may want to edit and change portions of the image file later and save as some other format.

Color Spaces: Choice of color "space" (Cyan-Magenta-Yellow-Black [CMYK] or Red-Green-Blue [RGB]) is another variable that will be determined by how you are using the final files—print or digital media. CMYK color space is defined by the printing inks, which are made up of dyes and pigments. This is the color space used by commercial printers. RGB color

space is defined by light. This is the color space you see on your monitor and is used for web graphics and digital presentations.

File Management and Storage: Another critical project planning component to consider is where to store the scanned images. Internal and external hard drives, a cloud, flash drives, and CD/DVDs are all current options for saving files. Decisions on which media to use will be determined by the capacity needs and period of time you want to save them. Because each type of media is subject to decay and obsolescence, it is good practice to save project files to more than one type of media and in multiple file formats if you need long-term storage.

Finally, decisions on how to name the files should be made before any scanning is done. Each should have a unique identifier, such as batch name-date of scanning-batch number. This format would appear as "Batch Name-YYYYMMDD-nnn" or "Projectile Points-20160308-005." There are any number of file formats you may chose, and in archaeology it may be useful to embed some provenience and description information within a file name, especially for sharing with a colleague who does not have access to a full artifact catalogue.

Preparation and Publication

Scanning Instructions: Here is a technique we find useful. Place the artifact surface you wish to capture face-down on the scan bed and oriented perpendicular to the direction of the scanner's light path. Often it's helpful to keep the scanner lid open or remove it completely and cover the artifact with a thick piece of paper or neoprene in a color that contrasts with the object you are scanning. The greater the contrast between the background and the artifact, the easier it will be to select the background during image editing. We use a foam box frame covered with thick white paper to create a small box. When the object is scanned, the light

reflects off the background and the inside of the box, creating a soft lighting effect.

Obsidian artifacts can be especially challenging to scan depending on their degree of transparency, thickness, reflective quality, and color. The scanning process can create multi-colored reflections on the scanned image that do not represent the artifact's true color and texture. The box can help to mitigate these optical problems, and any additional corrections can be made using color and saturation adjustments during editing.

Normally scanner software will let you "preview" your image before scanning and saving. The "preview" button will warm-up the scanner and prepare the lamp to scan. Crop close to the artifact to designate the area you want to scan (Figure 2). Set the resolution to a minimum of 300 dpi. If you're working with a particularly small artifact that you will want to enlarge by 200% or more, scan to the maximum resolution, as you can reduce the resolution when you are satisfied with the image formatting. By scanning at 600 dpi or higher, you can crop the image a great deal and still have a well-defined image that is suitable for printing and submission to a professional journal. Beyond cropping and

selecting the resolution, the scanner auto settings often work fairly well for the initial capture of most artifacts. You will have more editing options and control using your image-editing software later.

Image Editing: Below is a list of essential editing adjustments, sequenced for the most efficient workflow. Not all steps are necessarily required for all images. For example, there are instances when the exposure is ideal, so you won't need to adjust the tonal range.

Step 1. Save As: Before any image editing, use the Save As command and rename the file to preserve the original raw capture. A pre-determined name convention can be used at this point, or simply annotating the file name with "edited" will identify it as something altered from the original scan.



(a) A foam box was used to create soft light and capture the translucency of artifact; the scan on the left will need to be straightened; the profile on the right was scanned while holding the artifact securely with a kneaded eraser



(b) This initial scan shows blue and gold reflections not present in actual artifact; these will be removed with image editing



(c) Scan of obsidian core four centimeters thick shows how the receding edges are out of focus and the scale of the object is distorted. Also, the scans show the multi-colored reflections that can occur with a glassy surface. These images can be edited to bring out and illustrate edge detail, but would also be photographed to convey proper scale.



Figure 2. Initial raw image captures that require editing.

Step 2. Straighten and Crop: Most scans can benefit from straightening the orientation and cropping the image. Add vertical and horizontal centerline guides to reference when straightening the image. Using the Crop tool, click and drag the box into position, and then fine-tune the crop by dragging the small box on each side. Hover over and select any corner of the box to rotate and straighten the image as needed.

Step 3. Remove Background: This step is not always necessary but can add a professional look. Use a Selection tool with a pixel size that is small enough to select pixels close to the edge of the artifact without grabbing pixels from the artifact itself. To insure the integrity of the edge shape and detail, tightly zoom-in on the image so you can clearly see what the selection tool is grabbing. Once the background has been selected, delete it so just the artifact remains. If there is dust or scratching that needs to be cleaned up, do so during this step using an Eraser tool, Healing Brush, or Clone tool.

Step 4. Adjust Levels, Brightness, and Contrast: To boost contrast, brighten highlights and darken shadows. In the Levels window, drag the white arrow toward the end of the histogram to lighten highlights, and drag the black arrow to darken the shadows. This step expands the tonal range, helps sharpen edges, and can add a crisp, clear appearance to the image. Beware of overexposing or washing out the artifact. Like most adjustments, it is best to keep changes to a minimum.

Step 5. Adjust Color and Saturation: If the scanning process has produced multi-colored reflections on the artifact, or the light source has cast a hue over the image that is not true to the artifact itself, desaturation and color adjustments are in order. The master color scheme or individual colors can be adjusted in the Hue/Saturation window. If there are still a few spots of color after initial desaturation

adjustments, use the Sponge tool to pick up the residual unwanted bits of color.

Step 6. Sharpen: Most digital images can benefit from sharpening. The exact settings will depend on whether you are going to view the image on-screen or in print, but you should always apply the minimum amount needed to avoid adding unwanted digital noise.

Step 7. Compare: Keep the original artifact close at hand while editing the image and compare. Notice if the editing process has caused the image to lose character or important attributes due to over-correction.

Step 8. Name File and Save: Verify that the resolution and image dimensions are set to a minimum of 300 dpi at 100% scale. Save the image with a descriptive name and as a file type appropriate for the project.

Step 9. Proofing: Proofing formatted images for accuracy and consistency is the last step before page composition. We recommend printing the images and evaluating both the hard copy and digital versions of your work. Below is a checklist that will help you assess the quality of your edited images.

- Is there any distortion due to the thickness of the artifact?
- Are the image orientation and cropping consistent from image to image?
- Has the image been straightened properly?
- Does the image have adequate contrast and brightness to convey surface texture?
- If your subject is obsidian, have the multi-colored reflections been removed from the image?
- Does the overall color accurately represent the artifact?
- Does the image have unwanted speckles or visual “noise”?
- Is there any character drop-out or over-correction from image editing?

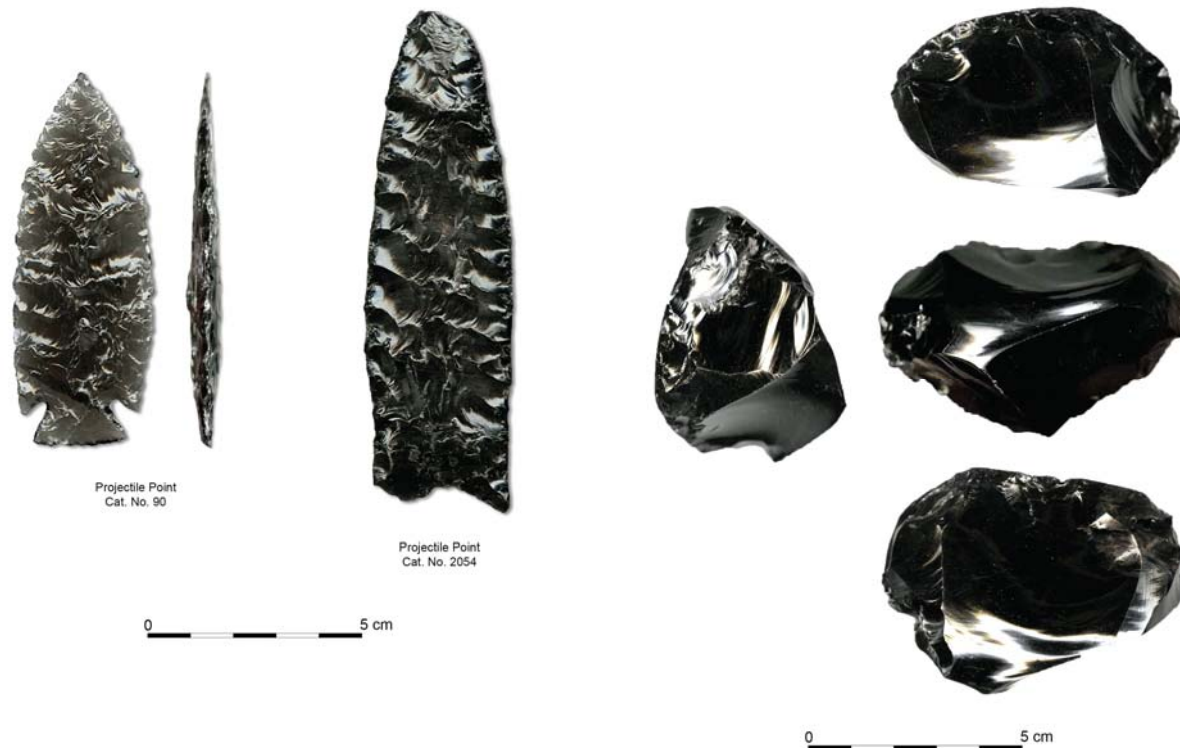


Figure 3. Composed figures using edited images.

Page Composition: A good composition (Figure 3) is one that is not only pleasing to look at but also effectively conveys the message of the text and graphics to your audience. There are certain tried and true elements of page composition that can help insure a successful layout. Place each element (text or graphic) on the page so that they have a visual connection to each other. Use horizontal or vertical alignment, align objects along the same edge, or center them. “Eyeballing” the arrangement can work, but for complicated layouts, a grid is helpful. If using multiple images, keep them connected both through alignment and proximity—grouping the images so that they form a single visual unit and aligning them in a similar fashion. Creating the right balance is about both the number of text and graphics elements and how they are arranged on the page. Odd numbers tend to create a more dynamic layout; symmetrical balance or the use of even elements produces a formal, more static layout. Just as important as the text and graphics on the page is the empty

space. Cramming too much on the page can ruin a composition. The page needs visual “breathing room.” The best place for white space is around the edges of the page (margins) and the edges of text or graphic elements. Increased paragraph, line, and letter spacing can also improve a layout. While some aspects of page composition involve things that are the same – the same alignment, consistent use of color – it is also a good idea to employ hierarchy by using contrasting elements including color, alignment, and font styles.

As with the individual scanned images, it is important proof the completed page composition. Review and consider of the following:

- Have you included a scale on the page?
- Are there descriptive labels on the figure?
- Is the figure cross-referenced in the text?
- Are the images distributed evenly on the page?

- Are the margins balanced on the page and consistent from one figure to the next?
- Is there enough visual “breathing room,” or are the objects crowded on the page?
- Does the composition need additional hierarchy to prioritize page elements?

Summary

Choice of which tools and techniques to use for digitally imaging artifacts is strictly driven by project objectives. Here our aim was to identify the approach and tools that provide the biggest bang for your digital-imaging buck! Taking the time to think through variables that will affect the quality of the end result, selecting and preparing equipment, and evaluating results under specific quality control criteria such as those provided in this article will set you up to produce professional-quality images.

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

1. Develop standards for analytic procedures and ensure inter-laboratory comparability.
2. Develop standards for recording and reporting obsidian hydration and characterization results
3. Provide technical support in the form of training and workshops for those wanting to develop their expertise in the field
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