Obsidian consumption in Chalcolithic Sardinia: a view from Bingia ‘e Monti

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This study represents a contribution towards an understanding of the nature of obsidian exploitation in Sardinia during the Chalcolithic (ca. 3200–2200 cal B.C.). A total of 154 obsidian artifacts from Bingia ‘e Monti in south-central Sardinia was techno-typologically characterized. Of these, 146 were elementally analyzed employing energy-dispersive X-ray fluorescence (EDXRF) as a means of sourcing the raw materials. It is argued that the community’s residents obtained obsidian directly from Sardinian source areas, then reduced the material on-site for the production of lunates and expedient flake tools. By contextualizing the study within a broader consideration of obsidian distribution and use within Sardinia, it is shown that obsidian exploitation at this time differs from earlier periods, arguably related to a reconfiguration of socio-economic interaction spheres and exchange networks.

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1. Introduction

This paper explores obsidian consumption on the Italian island of Sardinia during the Chalcolithic (ca. 3200–2200 B.C.) through the analysis of 154 obsidian artifacts from Bingia ‘e Monti in south-central Sardinia (Fig. 1). While the circulation of Sardinian obsidian in the Neolithic is well documented (Hallam et al., 1976; Le Bourdonnec et al., 2010; Lugliè et al., 2007, 2008; Tykot, 1996 inter alia), the use of these raw materials in the Chalcolithic has received far less attention in what appears to be an important transitional period characterized by the decline of long-distance Neolithic exchange networks.

While there are four obsidian sources in the West Mediterranean (Fig. 1), only obsidian from the four subsources of Monte Arci is known to have been exploited by people on the island itself. Despite the presence of Mesolithic populations on Sardinia (see Table 1 for a list of relevant time periods and dates), it is not until the beginning of the Neolithic that we see the first evidence of obsidian use by the islanders (see Lugliè et al., 2007, 2008; Tykot, 1996) and the long-distance procurement of Sardinian raw materials by populations on Corsica and mainland Italy (Ammeman and Polglase, 1993; Bigazzi and Radi, 1998; Léa, 2012; Tykot et al., 2003 inter alia). While the long-distance procurement of Sardinian obsidian continues into the Chalcolithic, used by communities on Corsica and mainland Italy (see Bigazzi and Radi, 1998; Hallam et al., 1976; Randle et al., 1993), there is a sharp fall-off in the number of sites at which obsidian has been reported. The declining use of Sardinian obsidian in the Chalcolithic mirrors the diminished exploitation of other West Mediterranean sources in the 3rd millennia B.C. in that obsidian consumption becomes a much more local phenomenon, largely restricted to populations within the immediate vicinity of the various sources.

Through the integration of raw material sourcing and techno-typological analysis, this broad-based artifact characterization study uses the analysis of the Bingia ‘e Monti assemblage as a means of undertaking a more general consideration of obsidian consumption in Chalcolithic Sardinia. The resultant data allows it to be argued that the community’s residents obtained obsidian directly from the source areas, then reduced the material on-site for the production of lunates and expedient flake tools. It is further posited that the nature of obsidian exploitation on Sardinia during the Chalcolithic differs from that of the Neolithic, a change in
tradition that is related to a larger reconfiguration of interaction spheres and exchange networks.

2. Site background

Bingia ’é Monti is located in south-central Sardinia (Fig. 1). The site was excavated in the years 1983–1985 and 1988–1990, originally led by Dr. Giorgio Murru and later by Dr. Enrico Atzeni and Dr. Alessandro Usai. Its earliest occupation dates to the Monte Claro phase of the Chalcolithic (ca. 2700–2200 B.C.). This initial phase of occupation is represented by two circular residential stone structures that underlay later Nuragic Bronze Age construction (Fig. 2). A Chalcolithic burial was also found approximately 180 m northwest of the settlement (Atzeni, 1996). The site is dated on the basis of its characteristic ceramic assemblage, the Monte Claro pottery differing from the preceding Abealzu–Filigosa phase of the Chalcolithic in that they are decorated and well-fired, often resembling the form and decoration of Beaker pottery from mainland France (Webster, 1996: 52). Although copper artifacts are found at many Monte Claro phase sites throughout Sardinia (Melis, 2000), Bingia ’é Monti produced no metal objects.

Approximately 500 chipped stone artifacts were recovered from the Monte Claro strata at Bingia ’é Monti, of which about 85% was obsidian. The remaining artifacts were made of black/gray rhyolites of likely local origin (see Tykot, 1997: 469–470) and a small number of chert flakes. Fig. 3 shows some examples of the obsidian artifacts.

3. The Bingia ’é Monti obsidian study

Obsidian is an igneous rock and a type of volcanic glass that is usually black in color. It is an excellent raw material for the flaking of stone tools and was widely exploited by prehistoric peoples on the island of Sardinia from the Neolithic onwards (Tykot, 1996). The obsidian source at Monte Arci in west-central Sardinia is often classified as a single ‘source’, but researchers have identified at least nine chemically distinct outcrops (Tykot, 1997), four of which are commonly reported in the literature as compositional groups, namely: SA, SB1, SB2, and SC. While geo-archaeological studies have documented the existence and exploitation of primary in situ outcrops, secondary SC obsidian deposits have also been identified by Lugliè et al. (2006) south of the main SC conglomerate (Fig. 4). The differentiation between these subsources is archaeologically relevant because it has been shown that there are differences in the exploitation of these subsources through both time and space.

While it has long been recognized that obsidian is present at many Chalcolithic sites in Sardinia (Puxeddu, 1958), only obsidian from nine of them has been elementally analyzed (see Table 2). Such studies are informative in that they determine where the products of the four obsidian subsources were distributed; however, they have tended to focus on one aspect of obsidian consumption, i.e. the raw materials involved, without considering the specific forms in which the obsidian circulated (nodule, core, end-
Since it was necessary to catalogue and photograph the entire assemblage before export, it can be confirmed that the selected material is representative of the whole in that the assemblage is mainly composed of flakes as well as highly cortical cores and angular waste. Out of this selection, eight artifacts were too small to be run by EDXRF (cf. Davis et al., 1998), but were nevertheless included in the typological analysis as their presence in the assemblage has important implications.

5. Analytical procedures

The artifacts were analyzed non-destructively at the McMaster Archaeological XRF Laboratory (MAX Lab) using a Thermo Scientific ARL Quant’X EDXRF spectrometer. Before analysis, each piece was given a unique ‘Mac’ number and subsequently cleaned in an ultrasonic tank with distilled water for ten minutes following the analytical protocols and methods devised by Shackley (2005: appendix).

The spectrometer is equipped with an end window Bremsstrahlung, air cooled, Rh target, 50 W, X-ray tube with a ≤ 7.6 micron (0.3 mil) beryllium (Be) window, an X-ray generator that operates from 4 to 50 kV in 1 kV increments (current range, 0–1.98 mA in 0.02 mA increments), and an Edwards RV8 vacuum pump for the analysis of elements below titanium (Ti). Data is acquired with a pulse processor and analog to digital converter. In this case, the samples were run under two analytical conditions. The samples were first run under a Mid Zb analysis condition with the X-ray tube operated at 30 kV using a 0.05 mm (medium) Pd filter in an air path for 200 s livetime to generate X-ray intensity Kz-line data for elements iron (Fe), zinc (Zn), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). The second was a High Zb analysis condition with the X-ray tube operated at 50 kV using a 0.63 mm (thick) Cu filter in an air path to detect the element barium (Ba). These elements have already been shown to be successful in distinguishing between the various West Mediterranean sources and subsources (see Crisci et al., 1994; Francaviglia, 1988; De Francesco et al., 2008; Freund and Tykot, 2011).

Trace element intensities were converted to concentration estimates by employing a least-squares calibration line ratioed to the Compton scatter established for each element from the analysis of international rock standards. These comprise AGV-2 (andesite), BCR-2 (basalt), BHVO-2 (hawaiite), BIR-1a (basalt), GSP-2 (granodiorite), QLO-1 (quartz latite), RGM-2 (ryholite), SDY-1 (mica schist), STM-2 (syenite), TLM-1 (tonalite), and W-2a (diabase) from the US Geological Service [USGS], plus JR-1 and JR-2 (both obsidian) from the Geological Survey of Japan. In turn, the USGS standard RGM-2 is analyzed during each sample run to check machine calibration and accuracy. The data was then translated directly into Excel for Windows software for manipulation and analysis. Artifacts displaying anomalous values were re-run to ensure accuracy and precision. The quantitative results were ultimately compared with data generated from geo-referenced in situ geological samples of obsidian using the same instrumentation. Qualitative spectral overlays were also used to confirm the quantitative sourcing discrimination.

In addition to elemental characterization, each artifact was analyzed techno-typologically. This included recording attributes pertaining to flaking type (platform, bulb, lip etc.), to understand how the blanks had been knapped. Artifacts were also categorized as nodules, cores, flakes, blades, or angular waste, data that along with presence of cortex (divided into distinct percentage categories) allowed for the reconstruction of the obsidian reduction sequences. Only the percentage of dorsal cortex was recorded on the flake categories. This in turn allowed for the identification of the various forms in which obsidian entered the site prior to its
reduction. Finally, any form of deliberate modification in the form of retouch was documented as a means of describing Chalcolithic tool types.

6. Results

Using the data from Table 3, a bi-variate plot of the elemental ratios of rubidium (Rb) and strontium (Sr) to niobium (Nb) was produced to discriminate the various Sardinian source products (see Freund and Tykot, 2011), and to then to allocate each artifact to the source from which it originated (Fig. 5). Of the 146 artifacts analyzed, 138 were shown to be made of obsidian that came from the SC subsource. Seven artifacts were made of SA obsidian, while only a single artifact’s raw material matched the chemistry of geological samples from the SB2 subsource. No SB1 obsidian was present in the studied assemblage. The percentage of SC obsidian is especially high when compared to other Chalcolithic sites near the SC subsource, although the Bingia ‘e Monti data is not radically different from the general trend of the predominance of SC obsidian in archaeological assemblages in southern Sardinia. The abundance of SC obsidian at the site is likely a reflection of Bingia ‘e Monti’s proximity to the source, less than 15 km distant, compared to 18 km and 20 km, from the SA and SB source regions respectively (Fig. 1). The analyzed artifacts comprise the full range of reduction debris related to the manufacture of flakes by direct percussion; in contrast to the Neolithic, blade technology was absent. The entire assemblage (n = 154) weighed 0.9 kg and contained one raw nodule, 20 cores, 118 flakes, and 15 pieces of angular waste. Fifty-five percent of artifacts had at least some cortex. When divided by source, the SC assemblage was composed of one nodule, 18 cores, 107 flakes, and 12 pieces of angular waste. Twenty SC artifacts displayed more than 80% cortex. Two of the seven artifacts made of SA obsidian were cores and the other five were either flakes or angular waste (see Fig. 3c, d). Both cores contained cortex, one between 60% and 80% and the other between 1% and 20% cortex. The sole artifact of SB2 obsidian was in the form of a retouched flake and displayed no cortex. The range of blank types suggests that the SA and SC obsidian was worked on-site, with the high occurrence of cortical debris indicating that these raw materials were procured in the form of raw nodules, the raw material having likely been procured by the inhabitants of Bingia ‘e Monti direct from the source, only some 18 km and 15 km away (SA and SC respectively).

Just under a third of the artifacts were modified (n = 44), mainly in the form of simple marginal retouch. This included 29% (n = 40) of the SC artifacts and 29% (n = 2) of the SA artifacts. The sole SB2...
artifact was a retouched perforator. While most of these artifacts can be considered the products of a low-skilled technology that were subsequently modified for the task at hand, there is one particular tool type in the assemblage that deserves further attention, the lunate (Fig. 3b). Lunates are best defined as small elliptical flakes with a natural or artificially backed margin. All of the eight lunates present in the assemblage were made of SC obsidian. Four SC lunate flake cores were also present (bottom right of Fig. 3a).

An important distinction must be made here with regard to reduction sequences surrounding lunate technology. While small elliptical backed pieces can be produced through an unspcialized manner of direct percussion, another method of production was also utilized. The Kombewa reduction strategy described and

<table>
<thead>
<tr>
<th>Site</th>
<th>Period</th>
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<th>SA</th>
<th>SB</th>
<th>SC</th>
<th>Method</th>
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</table>

**Table 2**

Results from previous sourcing studies on obsidian from Chalcolithic Sardinia (SA, SB and SC — sources; LN — Late Neolithic).
illustrated by Inizan et al. (1999: 68–71) occurs when a generally convex, semi-circular flake is removed from a core and subsequently used as a flake-blank for the creation of regularly shaped thin flakes. Lunates of this type typically have an obtuse platform angle and are traditionally associated with the Nuragic phases of the Bronze Age (see Freund and Tykot, 2011; Loci, 2004), where functional analysis has shown that they were often used for paint processing (Humphreys, 1992). At Bingia ‘e Monti, two Kombewa lunates were recovered (Fig. 3d). As such, this study pushes back the initial appearance of Kombewa technology in Sardinian obsidian assemblages to at least the Monte Claro phase of the Chalcolithic, although more evidence from additional sites is needed to confirm this assessment.

7. Discussion

The results from the Bingia ‘e Monti study suggest that the residents of the site obtained obsidian directly from the SA and SC source areas. These two raw materials were mainly reduced on-site in exactly the same way using a relatively unskilled percussive technique for the manufacture of simple flake tools. In contrast, SC obsidian was the sole raw material used for the creation of lunates,
which is similar to lunate production in the Bronze Age Nuragic period (Freund and Tykot, 2011: 161).

The reduction strategies at Bingia ‘e Monti contrast with the earlier Middle and Late Neolithic periods of Sardinia, where SC obsidian workshops produced core blanks that were circulated amongst populations on Sardinia and Corsica, while SA obsidian was specifically prepared as polyhedral blade cores for export to Corsica and further afield to populations in southern France (Lugliè, 2009; Lugliè et al., 2011; Vaquer, 2007). While the dominance of SC obsidian at Bingia ‘e Monti (95%) is in line with general trends in Sardinia that began in the Late Neolithic (Tykot et al., 2008) and subsequently continued into the Nuragic phases of the Bronze Age (Freund and Tykot, 2011; Michels et al., 1984), the prevalence of SC obsidian in Chalcolithic assemblages is not universal. Indeed, previous analyses of obsidian at other Chalcolithic sites show that SA material was also commonly used (see Table 2). One must note, however, the dubious dating of many Chalcolithic sites.

To understand these differences, it is necessary to consider these sites’ locations. Fig. 6 shows a map of Chalcolithic sites where at least eight obsidian artifacts have been elementally or visually characterized, displaying the portions of the subsources represented at each. Note that other studies do not make the distinction between the SB1 and SB2 subsources and have thus been lumped together as just ‘SB’. The map makes it apparent that there is a spatial patterning to the consumption of SA and SC obsidian. In general, sites to the north of the Monte Arci obsidian sources have more SA obsidian while assemblages to the south are mainly composed of SC material.

The end of the universal dominance of SC obsidian in Sardinia from the Late Neolithic to the Chalcolithic could be related to the concomitant collapse of organized obsidian workshops near the source areas (Lugliè, 2003). Without these workshops in place – crafting areas conceivably organized by specialists who also structured the materials’ subsequent distribution – the entire network of obsidian circulation could have been reconfigured to more local modes of procurement. While broad similarities in both the composition of obsidian assemblages and in the reduction of the raw materials in the Late Neolithic have led scholars to posit that these objects were obtained through a model of down-the-line exchange (e.g. Tykot et al., 2008: 182), it is not known whether this is the case in the Chalcolithic. While we do know that Sardinian raw materials were procured at distance during the Chalcolithic at sites on mainland Corsica and Italy (Bigazzi and Radi, 1998; Hallam et al., 1998).

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**Fig. 5.** Bi-variate plot of the elemental ratios of rubidium (Rb) and strontium (Sr) to niobium (Nb) in parts per million (ppm).

**Fig. 6.** Map of the spatial distribution of the various subsources in Chalcolithic archaeological assemblages with eight or more analyzed artifacts.
8. Conclusions

This study represents an initial step towards a more comprehensive understanding of the nature of obsidian exploitation in Chalcolithic Sardinia (ca. 3200–2200 BC). Through a multi-facettated analysis of 154 obsidian artifacts from Binga ‘e Monti in southern central Sardinia, this paper argues that the site’s residents obtained readily available SA and SC obsidian directly from the source areas and reduced the material on-site. While most of these artifacts can be considered the products of a largely unskilled and unstandardized technology that used both SA and SC obsidian, SC obsidian was specifically selected for the production of backed lunates. This is also the first documented case of Kombewa lunates in the Chalcolithic. By integrating these results within broader patterns of Chalcolithic obsidian distribution and use, it is further shown that obsidian exploitation at this time differs from earlier periods, possibly related to a reconfiguration of larger interaction spheres, where communities became more isolated and/or individually empowered, and more local traditions emerged.

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