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Considering the Source: The Importance of Raw Material Characterization and Provenance in Obsidian Use-Wear Studies

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Riassunto

Il motivo per la scelta di un tipo specifico di ossidiana per fabbricazione dell'attrezzo è presupposto generalmente per essere collegato con la posizione della fonte, l'apparenza del materiale e/o i rapporti sociopolitici che possono limitare la relativa acquisizione, piuttosto che le qualità inerenti del tipo di ossidiana. Questa ricerca esamina l'uso dell'ossidiana di Monte Arci (tipi SA e SC) tecniche di potere basso e macroscopiche. Da questi due tipi di ossidiane, un insieme sperimentale degli attrezzi è stato fatto ed usato stato sui materiali disponibili in Sardegna durante la preistoria. I risultati dei tipi differenti di questa esposizione comparativa di esperimento di ossidiane hanno modi di usura dissimili e variano nell'efficacia una volta usati sullo stesso materiale. Questi informazioni si sono applicate all'analisi degli attrezzi conveniente fatti, informali, piccoli, sfaldati dell'ossidiana scavati dal luogo neolitico di Contraguda e dai duo Nuraghes. Le interpretazioni sono fatte circa la funzione del luogo ed il ruolo di ossidiana nei periodi di tempo differenti.

Abstract

The reason for the choice of a specific type of obsidian for tool manufacturing is generally assumed to be related to the location of the source, the appearance of the material, and/or the sociopolitical relationships that may restrict its procurement, rather than the inherent qualities of the type of obsidian. This research examines the use of Monte Arci obsidian (types SA and SC) using macroscopic and low power techniques. From these two types of obsidian, an experimental set of tools was made and used on materials available in Sardinia during prehistory. The results of this comparative experiment show different types of obsidian have dissimilar wear patterns and vary in effectiveness when used on the same material. This information was applied to the analysis of expediently

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made, informal, small, flaked obsidian tools excavated from the Neolithic site of Contraguda, and from Duos Nuraghes. Interpretations are made about site function and the role of obsidian in different time periods.

1. The choice of a lithic material

Archaeologists have researched the function of lithic artifacts for over a century. In order to identify the purpose of these artifacts, conclusions have been drawn based upon the form of the tool, ethnographic studies, residue analysis, and use-wear research. Functional studies are frequently used to obtain clues about the activities that occurred at a site and explore prehistoric lifeways. The results from functional studies not only contribute to the understanding of the choices prehistoric people were making regarding the materials used for lithic tools, but they also give ideas to others conducing use-wear research.

While the use of a tool has long been accepted as one link in the *chaîne opératoire* model, which is used to understand human decisions, this research demonstrates the importance of considering the other links when forming experimental designs and answering research questions. Without the correct identification of the source of the lithic material (at least in the case of obsidian) used by prehistoric people, and the inclusion of this factor in the experimental design, one is in danger of forming incorrect interpretations of the use of the tool, function of a site, and general human behavior.

Although the properties of the individual raw materials must have led to the deliberate selection of these resources, little research has been done on the relationship between use and other attributes, such as flaking properties and raw material variability. For example, Greiser and Sheets (1979) compared the wear patterns of different lithic materials, such as variations between flint and obsidian; however, they did not research the differences between physicochemically varying obsidian.

Others, such as Kamminga (1978, 1982), have found considerable mechanical variation within some types of rock, such as quartzite, yet little variability in other lithic materials, including obsidian, which has a limited range of usefulness due to its fine texture and brittle nature (Hayden 1979). Schiffer (1979) noted that materials from a single source vary physicochemically, and experimental studies should produce results that are applicable to all lithic materials. However, Spear (1980) concluded that in general the wear on obsidian was quite similar to that of chert and he found that it is quite possible to determine the direction of use, as well as if the tool was used on hard or soft contact materials.

This research (Setzer 2004; Setzer and Tykot 2005) examines the use of obsidian tools from the sites of Contraguda and Duos Nuraghes. In particular, this research addresses the question of variability in Sardinian A (SA) and Sardinian C (SC) obsidian from Monte Arci and the usefulness of the two types when performing certain tasks. Observations were also made regarding the wear patterns occurring on these obsidians.

2. Contraguda

The open air site of Contraguda sits on a hill in the Coghinas Valley of Sardinia, about 20 km from the north coast of Sardinia and 3 km north of the town of Perfugas in Sassari. Used during the Late Neolithic, or the Ozieri period, Contraguda extends over several hectares and is the largest Ozieri settlement known on Sardinia. Not only is the site one of the largest open-air sites from this time, but it is also one of the only open-air sites with obsidian artifacts. While most of the contemporaneous sites that have produced obsidian artifacts on Sardinia have been almost exclusively rock shelters and caves, Contraguda provides archaeologists with a different perspective on the lifeways during the Late Neolithic on Sardinia.

This site was first identified in 1980 during an archaeological survey that was conducted to identify and catalog archaeological features at the site. In 1992, Boschian et al. (2000-2001) conducted a systematic investigation of Contraguda. Five radiocarbon dates obtained from this site place it in the middle of the fourth millennium BC, with the calibrated dates ranging between 4050 and 3770 BC. However, the samples that provided these dates were not from the same context as the obsidian tools, which appear to be from later in the Ozieri period.

The tools examined in this research were found at this site outside of a feature, called Structure A-B. This structure is composed of a series of small, interrelated walls, which form rooms. Structure A-B is of unknown purpose, and the quality of the construction varies. One hundred ninety-two obsidian tools were found in strata beneath the plow zone associated with this structure.

3. Duos Nuraghes

Duos Nuraghes is part of the Borore Group of sites, which is an elliptically shaped cluster of sites occupying about 40 sq km of Borore and the adjacent Birori communes. Long noted for its fertile volcanic soils and numerous springs, the region has a long history of mixed farming with a reliance on sheep. Research at Duos Nuraghes (Webster 2001) has uncovered ceramic jars, vessels, metal tools, and approximately 300 pieces of obsidian. Obsidian hydration dates (Stevenson and Ellis 1998) suggest that obsidian was re-used throughout the occupation of the site and that some contextual disruption of the site has occurred. Obsidian hydration dates from this site range from the late 35^{th} century BC to the early second century AD. Due to the destructive nature of obsidian hydration dating, the tools examined in this study were not dated, and are addressed by their deposition into various strata.

4. The experiment

The goal of the experimental portion of this research was to produce a set of tools comparable to the artifacts found at Contraguda and Duos Nuraghes, use them to process various materials that were likely used in prehistoric times at the sites, examine the wear patterns on the experimental set, and compare the use wear on the experimental tools to those found on the assemblages from the sites, thus allowing the function of the prehistoric tools to be interpreted. In addition, the experiment addressed the possibility of the choice of a type of obsidian based upon variation in function. The tools used in this experiment, as well as those analyzed from the site of Contraguda and Duos Nuraghes, are expediently made, flaked tools without retouch.

First, both *in situ* and secondarily deposited samples of obsidian were obtained from the Monte Arci region for this research. Type SA obsidian was collected from the Conca Cannas region of the western side of Monte Arci, and SC obsidian was collected on the eastern side of Monte Arci. One large nodule of SC obsidian and two smaller pieces of SA obsidian were selected for the production of experimental tools. One hundred fifty experimental tools were produced using direct hard hammer percussion methods. From this set, 80 were selected based on attributes such as size, sharpness of edges, and morphology. In other words, the pieces that resembled tools from the artifact assemblages were selected.

This sample set was divided into SA and SC obsidian tools. These experimental tools were numbered and classified by type, based on definitions taken from Andrefsky (1998). The types used in this study were flake, flake shatter, non-flake debitage, and blades. These tools were numbered and the type of obsidian was noted, along with topographic features, edge morphology, and both macro- and micro-edge wear. The topography included the general nature of the edge (e.g., flat, undulating, or ridged) as well as other attributes that were present on the edge, such as percussion ripples and feathering. Morphological features of the used edge were also recorded. These features included the angle, length, thickness, profile, and shape of the edge. The angle measurement of the used edge was taken at the midpoint of the used edge 1 mm back from the edge of the tool using a goniometer. The length of the used edge was measured using a pliable piece of wire as a guide. The measurement of the thickness of the tool was also taken from the midpoint of the used edge. The profile is a measurement of the plan of the use edge, which could be convex, straight or concave. This measurement is a ratio of the perpendicular distance of the working edge and its chord, or linear distance between the extremities of the working edge.

Sixty of these tools (30 made from the SA obsidian and 30 made from the SC obsidian) were used in a controlled experiment, while volunteers in a blind experiment used the other 20 tools (ten made from SA and ten made from SC obsidian) in order to assess how accurately the use-wear patterns were interpreted. The use-wear materials were chosen based on the categories outlined by Shea and Klenck (1993), who categorized them in terms of yielding and resistance (Table 1).

Table 1: The general categories of the materials worked and the materials used in this experiment (based on Shea and Klenck 1993)

Hardness of materials worked	Soft	Medium	Hard
Animal	Meat Hair	Fish Animal hide Dried meat Feathers	Bone (wet and dry)
Vegetal	Leaves	Cork	Dried oak wood
Inorganic	Tropical grass	Clay	Ceramics

The yielding classes are soft, medium (semi-rigid), and hard (rigid), while the resistance categories were animal (non-siliceous), vegetal (moderately siliceous), and inorganic (highly siliceous). The aim of this portion of the experiment was to produce wear patterns that could be compared to those on the artifacts allowing for the function of the prehistoric tool to be attributed to one of these categories, rather than a specific plant, animal or other material. The materials processed by the obsidian tools were chosen based on their availability during the Neolithic in the Contraguda region. First, the control set was used and analyzed. Macroscopic and microscopic use wear was recorded on these tools. For the purposes of this analysis, macroscopic wear is that which is seen without any magnification, and microscopic wear is that which is seen at 50x magnification. The identification of the most likely function of the tool was based on the type of use wear, its frequency, size, and distribution. In addition, processes such as edge rounding were also considered to aid in diagnosing tool function.

Next, to test the accuracy of the interpretations, a blind experiment was conducted. Volunteers were recruited from the Anthropology Department at the University of South Florida. The volunteers were directed to use a tool for a minimum of five minutes on a specific material, while noting the motions and methods used to work the material. They also noted how well the tool worked, how long it could be used effectively, and if any breakage occurred. The forms that the volunteers used were filed and not reviewed until interpretations were made on the experimental tool set. The interpretation of the use of the tools in the blind portion of the experiment produced mixed results. For example, with the SC obsidian, wear was attributed correctly (that is, the material worked was within the top two most tallied groups based on the wear analysis in either type of obsidian) to the exact category of the material worked 90% of the time. However, with the SA obsidian, the wear was correctly attributed to the exact category of the material worked (e.g., soft meat, medium meat, hard meat) 60% of the time. Overall, the category was correctly identified 75% of the time. The class of material (e.g., meat, vegetal, inorganic) was identified 90% of the time for the SC obsidian and 80% of the time for the SA obsidian. The wear patterns on the tools used in the blind set were compared to wear patterns on both types of obsidian. When compared solely to the wear patterns on the same type of obsidian, the materials worked were correctly identified 70% of the time with the SC obsidian, and 50% of the time for the SA obsidian. When compared solely to the other type of obsidian, the materials were identified 50% of the time for the SC tools used in the blind experiment, and 40% of the time for the SA tools used in the blind experiment.

5. Experimental results

During the experiments, users observed that the SA and SC obsidian varied in effectiveness for working certain materials. For example, when processing soft animal products, the SC obsidian cut the meat in clean cubes, while the SA obsidian was not as effective, leaving the meat to appear torn or shredded. In contrast, hard animal products (wet and dry bone) were processed more effectively when using SA tools (Figure 1). Medium hardness animal products were processed effectively using both types of obsidian; however, specific materials classified in the medium hardness animal category, such as animal hide, fish, and feathers were processed more effectively with specific types of obsidian (see Setzer 2004 for the detailed findings). There was no difference noted between the two types of obsidian when processing vegetal and inorganic products.

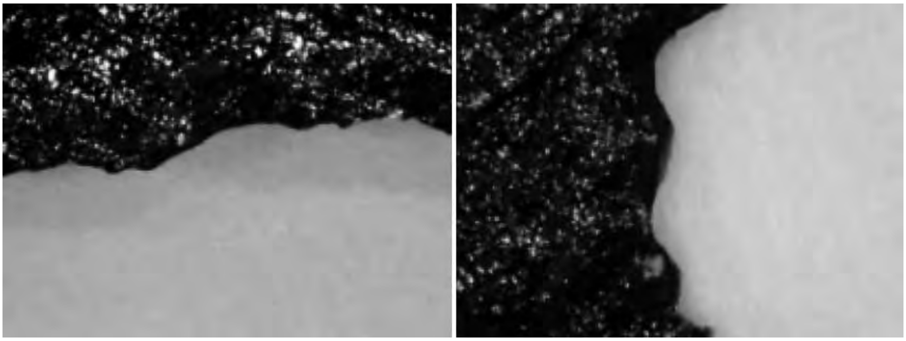

Fig.1: Experimental tools used to process hard animal products for 15 minutes (SA on the left and SC on the right). Note the variation in the size and distribution of the use wear.

The same factors were recorded for both macroscopic and microscopic wear. Macroscopic wear could be present on a tool without microscopic wear being present. The first factor analyzed was the location of the wear. The ventral and dorsal sides of the tool were studied to determine if wear was present. If there was no wear, this was noted. If wear was present, the sides with damage were noted. Macroscopically, the wear was recorded as being absent, occurring at a rate of < 5 fractures per 10 mm, or occurring at a rate of ≥ 5 fractures per 10 mm. Microscopically, use-wear fractures were recorded as being absent, occurring at a rate of < 5 fractures per 5 mm, or occurring at a rate of ≥ 5 fractures per 5 mm. In both instances, these fractures were classified as flakes (or conchoidal fractures), snaps, or steps. The predominant fracture types were recorded for each tool, as was the distribution of the wear. The wear distribution was classified as either random, having no regular pattern, intermittent, displaying a regular pattern on some areas of the edge but not others, and regular, which is a consistent display of wear along the edge. The minimum and maximum sizes of the wear fractures' widths were measured and noted. Finally, the amount of edge rounding was examined. Recording on the observance of edge rounding is heavily subjective. In this research it was either noted as absent, light, or heavy. Macroscopically, heavy rounding is characterized by a rounded edge that can be easily seen with the unaided eye and felt with the finger. Light rounding is more difficult to define, and the assignment of this rating is usually made after a more detailed observation. Microscopically, edge rounding was rated as heavy if an obviously blunt edge was observed, and light if it was more questionable. Typically, with macroscopic examination, the more the edge rounding that was present, the more difficult it was to focus the edge of the tool when viewing it laterally.

Due to the highly subjective nature of edge rounding, and the variety of angles produced when manufacturing lithic tools, it is probably more beneficial to use this as supporting evidence for the presence of wear rather than as a primary indicator.

The wear patterns observed on the SA and SC obsidians were significantly different in nine out of eleven observed parameters, as well. In some instances, the use of one type of obsidian would not produce wear on the macroscopic level. This was noted on some of the SC obsidian tools that were used to process soft animal and soft and medium organic products, and on some of the SA obsidian tools used to process soft and medium animal, soft and medium inorganic, and medium vegetal products. Overall, the SC obsidian demonstrated more evidence for macroscopic wear. For this comparison, the non-parametric Kolmogorov-Smirnov test was used, as the data are non-continuous. The results reflect a comparison of the distribution of the measurements between the SA and SC obsidian tools used in the controlled portion of the experiment (Table 2). The individual categories used to interpret wear were compared, rather than the individual use categories, as this provides a larger sample size.

Table 2: Results of the Kolmogorov-Smirnov test compare use-wear attributes between the SA and SC tools in the experimental set. The results indicate there is a significant difference in the way these two types of obsidian wear ($p < .001$) in nine out of the eleven attributes measured

Feature	Two-sided large sample K-S statistic	Approximate p value
SA and SC macrowear type	1.27	0.08
SA and SC macrowear distribution	1.78	< 0.005
SA and SC macrowear frequency	1.91	< 0.005
SA and SC microwear type	1.78	< 0.005
SA and SC microwear distribution	2.54	< 0.005
SA and SC microwear frequency	3.56	< 0.005
SA and SC macrorounding	3.43	< 0.005
SA and SC microrounding	2.54	< 0.005
SA and SC minimum fracture size	2.29	< 0.005
SA and SC maximum fracture size	1.02	0.25
SA and SC fracture size range	0.89	0.41

6. The interpretation of the archaeological assemblages

The tools in the assemblage from Contraguda, and therefore the experimental set, were composed of expediently made, informal, unretouched, small, flaked tools (Figure 2).

Fig. 2: Ventral and dorsal sides of a sample of tools excavated from Contraguda.

According to Binford (1979), these types of tools are situational in purpose, not produced with a specific use in mind, and made with little regard to form. The expedient nature of their manufacturing and short period of use are interpreted as being wasteful when compared to formal tools which are used for long periods of time and retouched for subsequent use. Informal tools, such as the ones in the Contraguda assemblage, are thought to be indicative of sedentism (Parry and Kelly 1987). While mobile groups generally utilize formal tools because these tools are multifunctional, modifiable, and easily transported, sedentary populations are not as affected by raw material availability. Therefore, sedentary populations do not need the formal tools, as they can manufacture, use, and discard the tool as the need arises (Andrefsky 1998).

The analysis of the obsidian artifacts from Contraguda provides information about activities occurring at this site during the Late Neolithic, or Ozieri period. Recent research has shown that 70 percent of the obsidian artifacts from Contraguda are attributed to the SC source (Lai et al. 2006; Tykot et al. 2010). However, the reason for this preference is not clear. Both sources are on the same mountain with no significant difference in distance from Contraguda. The reasons for this distribution could range from access to the raw materials to preference due to workability when manufacturing tools or functionality when using them. The results of this specific use-wear analysis indicate that the SC was used for processing more hard inorganic materials than SA, while SA was used to process more medium hard inorganic materials. The distribution of tools near Structure A-B could indicate this structure may have been used for the storage of obsidian, hafted tools, or processed goods, such as pottery. Due to the ceramic and flint finds at Contraguda, it is also possible that this structure was used for the heat treating of flint or as a kiln for the manufacturing of pottery; the latter use could be indicated by the presence of slumped sherds or residues on the structure. The remainder of the obsidian tools was found with wear patterns consistent with the processing of animal and vegetal materials. This indicates that humans have been utilizing this region for similar activities throughout the Late Neolithic. A study of the use-wear patterns on the flint tools found at Contraguda can complement the information found from analyzing the use of the obsidian. For example, it may be possible that the variety of materials the flint was used to work could be quite different than those worked with obsidian, which could indicate a preference based on the qualities of the two lithic media. In addition, the proportion of obsidian relative to flint can provide information about the accessibility and possibly usefulness of these materials. The stratum disturbed by agricultural activities, containing artifacts from the Late Neolithic that were used for similar activities, provides a means for understanding the subsistence traditions of the people of Sardinia and their changing technologies.

Obsidian hydration dates (Stevenson and Ellis 1998) suggest that obsidian was re-used throughout the occupation of Duos Nuraghes and that some contextual disruption of the site has occurred. One hundred and fifty pieces of obsidian from Duos Nuraghes have now been analyzed by pXRF and attributed to specific Monte Arci subsources (Tykot and Freund 2009). Due to the destructive nature of obsidian hydration dating, the tools examined in this study were not dated, and are addressed by their deposition into various strata. The analysis of these tools supports the hypothesis of re-use, as more tools were found in later strata, and fewer in the early deposits. An examination of the tools found in the structures demonstrates the common use on soft inorganic materials, such as clay, within the structures, as well as variations in function (e.g., hard inorganic material, and vegetal and animal processing). The processing of inorganic materials, such as ceramics, is shown throughout the occupation, while variations in animal and vegetal processing are also demonstrated.

Use-wear analysis can provide a means for understanding the activities occurring in different areas of a site over time. At Duos Nuraghes, the re-use of the tools demonstrates the value of this material at a time when obsidian tools were being replaced with those made of metal. Although previous analytical techniques limited the size of the sample of tools being studied, this research represents nearly one-third of the total obsidian assemblage excavated from Duos Nuraghes. Additional research, such as residue analysis, may provide more insight into the function of this important material at Duos Nuraghes.

7. Conclusions

This experiment was conducted with two types of obsidian used to make artifacts at the site of Contraguda to control for this variable. Even though there was no study found during this research that specifically compared the use-wear attributes of two types of obsidian, it was expected that there would be some variation between the usefulness of the types and the wear patterns on the tools due to variations in chemical composition, inclusions, and brittleness. This research demonstrates that some variation does occur that appears to be related to the type of obsidian used. These results also indicate that using obsidian from a different source as a reference when conducting use-wear experiments can reduce the number of correct interpretations made when analyzing artifacts.

The use-wear experiment produced results that are noteworthy for this research, as well as the design of other obsidian use-wear studies. These include the variation of the effectiveness of working the material based on the type of obsidian, as well as the production of different wear patterns on these obsidians.

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References

ANDREFSKY, Jr.W.
1998 *Lithics: macroscopic approaches to analysis*. Cambridge: University Press.

BINFORD, L.
1979 Organization and formation processes: looking at curated technologies, *Journal of Anthropological Research* 35: 255-273.

BOSCHIAN, G., BRILLI, P., FALCHI, P., FENU, P., MARTINI, F., PITZALIS, G., SARTI, L. e TOZZI, C.
2000-01 Prime ricerche nell'abitato neolitico di Contraguda (Perfugas, Sassari), *Rivista di Scienze Preistoriche* LI: 235-287.

GREISER, S.T. and SHEETS, P.D.
1979 Raw material as a functional variable in use-wear studies, in Hayden, ed.: 289-299.

HAYDEN, B. ed.
1979 *Lithic use-wear analysis*. New York: Academic Press.

HAYDEN, B.
1979 Discussion: Inferring worked materials, in Hayden ed.: 283-287.

KAMMINGA, J.
1978 *Journey into the microcosms: a functional analysis of certain Australian prehistoric stone tools*. Sydney: University of Sydney.
1982 Over the edge: functional analysis of Australian stone tools. In *Occasional Papers in Anthropology* vol. 12. Brisbane: University of Queensland.

LAI, L., TYKOT, R.H. e Tozzi, C.
2006 Nuovi risultati sulla provenienza dell'ossidiana del sito neolitico recente di Contraguda (Sardegna), in *Materie prime e scambi nella preistoria italiana*, Atti della XXXIX Riunione Scientifica dell'Istituto Italiano di Preistoria e Protostoria (Firenze, 25-27 Novembre 2004): 598-602.

PARRY, W.J. and KELLY, R.L.
1987 Expedient core technology and sedentism, in J.K. Johnson and C.A. Marrow, eds., *The organization of core technology*. Boulder: Westview Press.

SCHIFFER, M.B.
1979 The place of lithic use-wear studies in behavioral archaeology, in Hayden, ed.: 15-25.

SETZER, T.
2004 *Experiments with Sardinian obsidian: determining its function in the Neolithic*. M.A. Thesis. Tampa: The University of South Florida.

SETZER, T. and TYKOT, R.H.
2005 Obsidian use during the Bronze Age: an experimental analysis of obsidian artifacts from Duos Nuraghes, Sardinia (Italy). 70th Meeting of the Society for American Archaeology. Salt Lake City, Utah.

Shea, J.J. and Klenck, J.D.
1993 An experimental investigation of the effects of trampling on the results of lithic microwear analysis, *Journal of Archaeological Science* 20:175-194.

Spear, R.L.
1980 A brief discussion of obsidian use-wear experiments, *Lithic Technology* IX, 2: 38-39.

Stevenson, C.E. and Ellis, J.G.
1998 Dating sardinian archaeological obsidian, in M.S. Balmuth and R.H. Tykot, eds., *Sardinian and Aegean Chronology: Towards the Resolution of Relative and Absolute Dating in the Mediterranean*: 17-24. Oxford: Oxbow Books.

Tykot, R.H. and Freund, K.J.
2009 Bronze Age obsidian trade in Sardinia (Italy): the use of Monte Arci subsources at Duos Nuraghes and other sites. Presented at the 110th Annual Meeting of the Archaeological Institute of America, Philadelphia, PA, January 8-11.

Tykot, R.H., Lai, L. and Tozzi, C.
2010 Intra-site obsidian subsource patterns at Contraguda, Sardinia (Italy), in Proceedings of the 37th International Symposium on Archaeometry (Siena, Italy, May 12-16, 2008). Forthcoming.

Webster, G.S.
2001 *Duos Nuraghes: a Bronze Age settlement in Sardinia*. British Archaeological Reports, International Series 949. Oxford: Archaeopress.