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# Obsidians in the Rio Saboccu (Sardinia, Italy) campsite: Provenance, reduction and relations with the wider Early Neolithic Tyrrhenian area

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**Abstract**

Technologic analyses of Neolithic obsidian assemblages are quite rare in Sardinia, like in the wider Western Mediterranean. Such an approach is presented here in conjunction with a visual/instrumental provenance study for the Rio Saboccu Early Neolithic (EN) site, which yielded more than 1000 obsidian artefacts. It is shown that this mostly expedient industry was realized from a non-opportunistic exploitation of the four obsidian types of the nearby Monte Arci (Sardinia) volcanic massif. The choice of the raw materials was chiefly guided by their intrinsic knapping qualities and in function of the maximum size of the expected final products; hence some selection in the (primary and/or secondary) sources exploited. The obsidian industries of EN sites from the northern Tyrrhenian area present clearly some affinities with that of Rio Saboccu and of other EN Sardinian sites, mainly those located in its vicinity. This suggests a regional influence of the EN communities settled in the proximity of the Monte Arci. ***To cite this article: C. Lugliè et al., C. R. Palevol 7 (2008).***


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**Résumé**

**Les obsidiennes du site de Rio Saboccu : provenances, réduction et relations avec le Néolithique ancien de la zone tyrrhénienne.** Très peu d'analyses technologiques ont été effectuées sur des assemblages d'obsidiennes du Néolithique ancien sarde et, plus généralement, de Méditerranée occidentale. Une telle approche est présentée ici, en association avec une étude visuelle/instrumentale de provenance, pour le site Néolithique ancien de Rio Saboccu (Sardaigne), où plus de 1000 artefacts ont été collectés. Il est montré que cette industrie, pour l'ensemble peu investie, a été réalisée à partir d'une exploitation non opportuniste des quatre types d'obsidiennes du massif volcanique voisin du Monte Arci. Le choix de la matière première a principalement été guidé par la dimension des produits finaux espérés et les aptitudes à la taille, d'où la détermination de lieux d'exploitation spécifiques (sources primaires et/ou secondaires). Les industries en obsidienne des sites du Néolithique ancien de la zone Nord-Tyrrhénienne présentent des affinités certaines avec celles de Rio Saboccu et d'autres sites voisins. Il semblerait donc que les communautés proches du Monte Arci aient pu, à cette époque, exercer une certaine influence régionale. ***Pour citer cet article : C. Luglié et al., C. R. Palevol 7 (2008).***



*Keywords:* Obsidian provenance; PIXE; SEM-EDS; *Chaînes opératoires*; Early Neolithic; Rio Saboccu; Sardinia

*Mots clés :* Provenance d'obsidienne ; PIXE ; MEB-EDS ; Chaînes opératoires ; Néolithique ancien ; Rio Saboccu ; Sardaigne

## Version française abrégée

### *Introduction*

C'est au Néolithique ancien que la Sardaigne a été colonisée durablement, après peut-être quelques incursions au Paléolithique [1,3–5,16]. On connaît actuellement quelque 74 sites datant de cette période [11]. Le site de Rio Saboccu est l'un des dix sites du Néolithique ancien récemment découverts sur une terrasse alluviale située au sud-ouest du massif volcanique du Monte Arci [9] (Fig. 1).

Bien que plusieurs îles de Méditerranée occidentale offrent de l'obsidienne (Fig. 2), celle des sites néolithiques de Sardaigne est d'origine exclusivement locale [7,14,24]. Elle provient du Monte Arci, où elle affleure en position primaire, mais elle est également présente en position secondaire dans les plaines environnantes, sous forme de blocs et galets de dépôts fluviatiles [10,13]. Quatre types principaux d'obsidiennes ont été produits dans le Monte Arci, qui diffèrent par leurs propriétés physicochimiques [22,23,25,27] et souvent par leur aspect optique [11,26,29]. De plus, elles présentent un cortex plus ou moins développé en source secondaire [11,14].

Le site de Rio Saboccu, implanté à proximité de sources secondaires exploitables d'obsidiennes, renferme plus de 1000 artefacts lithiques, essentiellement en obsidienne.

### *Le site de Rio Saboccu*

Ce site, en bordure de lagune, a été révélé par l'érosion régressive d'une terrasse fluviatile ancienne sous l'action des vagues d'une lagune côtière. Il se présente en coupe, sur le talus terminal de cette terrasse, sous la forme de deux profondes fosses, S1 et S2, de sédiments anthropisés homogènes. Leur sommet se situe à environ 30 cm sous la surface actuelle de la terrasse et elles atteignent des profondeurs de respectivement 0,9 et 1,3 m, pour une extension latérale de 9,5 m pour la plus grande (S2). Quelques fragments de poterie et des restes de faune et de flore terrestres accompagnent un abondant mobilier lithique. L'homogénéité du sédiment suggère une formation rapide, renforcée par le remontage de pièces à partir de fragments collectés à des profondeurs différentes (voir Fig. 7 dans [15]). Le site est daté au carbone-14 sur des fragments charbonneux de la base de S2 à respectivement $6662 \pm 48$ BP et $6230 \pm 60$ BP. Âges $^{14}C$ et poteries dateraient le contexte de Rio Saboccu de la phase III du Néolithique ancien sarde, vers la fin du VI$^{e}$ millénaire avant notre ère.

### *La série lithique*

Elle comporte 1058 pièces, dont 1047 obsidiennes, le reste se composant de *cherts* et de calcédoines. La plus grande partie des artefacts en obsidienne provient de débitages. La présence de tous les stades principaux de réduction étant attestée, on peut admettre que le façonnage de l'obsidienne a été réalisé presque entièrement sur place. Les artefacts qui présentent des restes de surfaces corticales montrent que la matière première a été exploitée en position primaire ou subprimaire, mais aussi en position secondaire à proximité du site. Un nombre conséquent de nucleus montre que l'échantillonnage de la matière première était orienté vers des blocs ou des galets de petit module (longueur initiale de 80 mm tout au plus). La réduction était opérée par percussion directe à la pierre tendre pour l'obtention principalement d'éclats unipolaires, avec décalage récurrent du plan de frappe. Les 31 nucleus témoignent d'une utilisation maximale. Les supports laminaires, surtout les lamelles, ne représentent que 12 % de l'assemblage. Il s'agit essentiellement d'une production techniquement peu investie, obtenue selon une méthode de débitage simple, où peu d'outils à morphologie bien définie peuvent être identifiés. Parmi ces derniers**,** la catégorie la plus standardisée est celle des pièces géométriques, tandis que les autres, principalement burins et racloirs, montrent une grande variabilité, dans la mesure où ils étaient produits à partir de supports de tailles et de morphologies très variables (Fig. 5).

### *Provenance des matières premières lithiques et stratégies d'approvisionnement*

L'aspect macroscopique des obsidiennes de Méditerranée occidentale permet de reconnaître de quelle île-source provient la matière première d'un artefact (voir par exemple, [26],) et le plus souvent de distinguer les quatre types sardes, SA, SB1, SB2 et SC [11,14,26,28]. Cependant, en raison de faciès de convergence, en particulier entre les types SA et SB2 [28], il est nécessaire, pour 15 à 30 % des obsidiennes du Monte Arci, de recourir à des déterminations instrumentales [15,26]. À Rio Saboccu, toutes les obsidiennes sont d'origine locale, mais l'origine de quarante d'entre elles a dû être déterminée à partir de leur composition élémentaire.

Douze de ces artefacts ont été analysés en mode non destructif par *particle-induced X-ray emission* (PIXE) et 26 autres, de même que 47 obsidiennes du Monte Arci, à partir de sections polies. Les teneurs élémentaires en Na, Al, Si, K, Ca, Ti, Mn, Fe, Zn, Ga, Rb, Sr et Zr ont été obtenues selon des modes opératoires et traitements de données exposés précédemment [2,14,15,17,19] (Fig. 3). Les teneurs élémentaires en Na, Al, Si, K, Ca et Fe ont été obtenues par SEM-EDS à partir de sections polies sur deux autres artefacts. Elles avaient été également déterminées sur 80 échantillons géologiques du Monte Arci [8] (Fig. 4).

Au total, il s'avère que les artefacts ont été presque uniquement obtenus sur des obsidiennes SA, SB2 et SC, dans respectivement 56,2, 28,9 et 14,4 % des cas. L'obsidienne SB1 n'a été relevée que pour quatre objets. Alors que les obsidiennes SA et SB1 proviennent de localisations primaires à subprimaires, situées respectivement à quelque 16–17 km à l'est et au nord-est de Rio Saboccu, celles du type SB2 ont été prises à la fois dans ces types de sources, à 14 km au nord-est, mais aussi dans des sources secondaires plus proches, vers 9 km dans la même direction. Les obsidiennes SC, comme en témoignent leurs pièces corticales plus arrondies et avec des cortex évolués, proviendraient uniquement des sources secondaires situées à proximité immédiate de Rio Saboccu. L'exploitation de l'obsidienne apparaît donc largement comme non opportuniste, entre autres parce que les variétés SA, plus vitreuse et transparente et SB2, dont les sources sont plus lointaines, ont cependant été plus utilisées que celles, plus proches, du type SC. Les contraintes techniques ne semblent pas être intervenues dans ce choix, étant donné la similitude de dimensions des pièces initiales et des pourcentages des produits finaux. Tout au contraire, la rareté des artefacts réalisés avec les obsidiennes SB1, riches en phénocristaux, pourrait être due à de moins bonnes qualités de taille, comme le suggère l'expérimentation.

Les *cherts* et calcédoines, dont les sources primaires sont situées 25 km à l'est, sont à peu près aussi abondants que les obsidiennes dans la terrasse de Rio Saboccu. Ces roches siliceuse, très peu employées, présentent des aptitudes à la taille très diverses et une exploitation opportuniste ne peut dans leur cas être exclue.

### *Rio Saboccu dans le Néolithique ancien de Méditerranée occidentale*

La sélection des matières premières et les modes de réduction observés à Rio Saboccu sont aussi caractéristiques des sites voisins de Pauli Putzu, Orri et Sa Punta (Fig. 1) [9,11]. L'utilisation de matériaux bruts de dimensions restreintes, alors que blocs et galets de tailles supérieures sont aussi fréquents, résulte donc d'un choix technologique. De là résulte le faible pourcentage de lames dans les assemblages du Néolithique ancien de Sardaigne et, plus généralement, de la région tyrrhénienne [11,20]. Les tendances générales décrites dans l'industrie de Rio Saboccu, y compris le faible pourcentage d'obsidiennes SB1, se retrouvent dans les sites du Néolithique ancien de Méditerranée occidentale. Ces similitudes suggèrent l'existence de relations sociales structurées entre des communautés caractérisées par un haut niveau d'échanges par voie marine, comme en témoigneraient aussi de grandes analogies dans la technique de fabrication et de décoration de la céramique [12,18]. Ainsi, au Néolithique ancien, les groupes proches du Monte Arci auraient pu, en ce qui concerne l'obsidienne, influer à leur insu sur les groupes humains de la zone nord-tyrrhénienne. Des travaux en cours sur d'autres séries lithiques pourraient permettre de tester, dans un futur proche, la validité de cette hypothèse.

## 1. Introduction

After rare and still debated human incursions during the Palaeolithic [1,3–5,16], the island of Sardinia (western Mediterranean) was permanently populated only from the VIth millennium BC onward with the arrival of Early Neolithic (EN) men, first bringing the impressed cardial ware pottery. There are now up to 74 EN sites that are known all over the island [11]. Whilst evidence of the use of obsidian in pre-Neolithic contexts is still missing, like in the wider western Mediterranean region, it has been observed in a sizeable fraction of EN sites lithic industries, especially near to the Monte Arci volcanic complex. The few exceptions concern EN sites of northern Sardinia, where good lithic materials like flint offer an alternative to obsidian. During the last twenty years, ten open-air EN sites were discovered in the alluvial plains southwest of the Monte Arci massif, along Quaternary alluvial terraces of the Rio Mannu and Rio Mogoro rivers, with an average frequency of one per 4.5 $km^2$ [9] (Fig. 1). Their lithic implements are almost exclusively composed of obsidian.

Earlier studies have shown that the Sardinian 'archaeological' obsidians came exclusively from the Monte Arci, in spite of other natural occurrences in the Tyrrhenian island of Palmarola, the Eolian archipelago island of Lipari and in the southernmost Pantelleria, between Sicilia and Tunisia ([7,13,24], among others; Fig. 2). However, provenance studies have to take into account four types of Monte Arci obsidians, differing both by their elemental compositions [25,27], their physical properties [22,23], and also partly by their visual characteristics [11,26,29]. They have also to consider that obsidian was available to prehistoric men not only in 'primary sources' in their parent-rocks inside the Monte Arci or in their immediate proximity as dismantled materials, but also in 'secondary sources' in its surrounding plains as decimetric and pluri-decimetric cobbles [10,13]. Differences in macroscopic properties (size, shape, presence or not and characteristics of a cortex) of obsidian from primary to secondary sources may be used to refine provenance studies [11,14].

Rio Saboccu is one of the EN sites of the coastal plain southwest of Monte Arci, where obsidian of workable

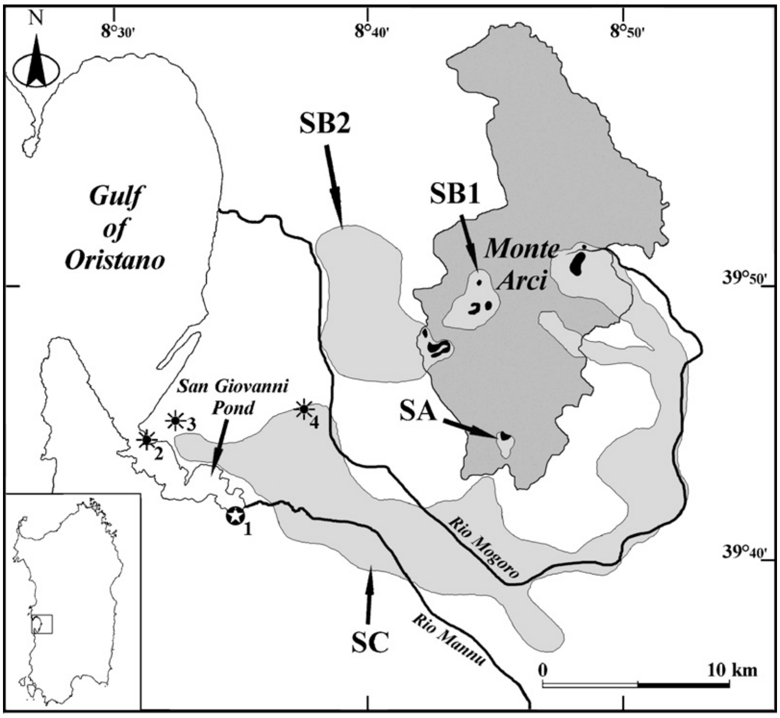


Fig. 1. Schematic map of the Monte Arci region (Sardinia) (adapted from [13]). The secondary obsidian sources are distributed in the light-gray areas and the primary sources, all located inside the Monte Arci massif, are indicated in black. Star symbols refer to the localisation of the Rio Saboccu site and of the other Early Neolithic sites cited in the text. **1**: Rio Saboccu; **2**: Sa Punta; **3**: Orri; **4**: Pauli Putzu.

Fig. 1. Carte schématique de la région du Monte Arci (Sardaigne), (modifiée d'après [13]). Les sources secondaires d'obsidienne sont situées dans les zones grisées et les sources primaires, toutes localisées sur le Monte Arci, sont reportées en noir. Les étoiles indiquent la position du site du Rio Saboccu et des autres sites mentionnés dans le texte. **1** : Rio Saboccu ; **2** : Sa Punta ; **3** : Orri ; **4** : Pauli Putzu.


Fig. 2. Map of the Western Mediterranean, showing the localisation of the obsidian island-sources.

Fig. 2. Carte de la Méditerranée occidentale, montrant la localisation des îles-sources d'obsidienne.

quality is still dispersed in nearby secondary sources. Its more than 1000 collected lithic artefacts are almost only made of obsidian, which offers a unique opportunity to investigate one procurement–reduction–use system elaborated by the first inhabitants of the island in the vicinity of raw material sources. After the Early Neolithic site of Su Carroppu [13], Rio Saboccu is the second Sardinian Neolithic assemblage whose industry is investigated with an integrated provenance/*chaîne opératoire* approach.

## 2. The Rio Saboccu site

The Rio Saboccu site is located on a low elevation terrace dominating the San Giovanni Pond, at 4.5 km from the actual southern shoreline of the Gulf of Oristano (Fig. 1). This terrace, which extends from the foot of the Monte Arcuentu to the coastal pond, presents an average elevation of 6 m a.s.l., slowly decreasing northwestward. It ends abruptly by a 3-m-high scarp dominating the pond. This abrupt morphology results from the erosive action of the pond waters when blown toward the terrace by a strong regional wind (Mistral). It is in this way that the Rio Saboccu archaeological sites, situated on this scarp, were unveiled. This was not totally unexpected, as in its immediate vicinity, on some 10,000 $m^2$, modern ploughing dispersed on the terrace surface many lithic artefacts. The Rio Saboccu site is composed of two deep dug-out structures, S1 and S2, filled with a homogeneous anthropogenic dark-brown soil rich in organic remains, including charcoal fragments. They extend from the depth of about 0.3 m underneath the surface of the terrace to depths of respectively, 0.9 and 1.3 m. The apparent lateral expansion of the structures reaches no more than 9.5 m (S2). The uniformity of the filling suggests a fast formation process.

The S1/S2 structures contained a large number of lithic artefacts, but very few pottery fragments. The sherds present very simple shapes, mostly hemispheric bowls; their surfaces are not decorated. Anthracological analysis carried on charcoal from the bottom of the S2 structure profile indicates a partially wooded land with *Buxus Sempervirens* and *Juniperus* sp. The few animal remains are limited to terrestrial fauna, particularly goats. Two concordant radiocarbon dates of 6266 ± 48 BP (5341–5066 cal 2$\sigma$, AA-58899) and 6230 ± 60 BP (5320–5027 cal 2$\sigma$, Ly-3010) were respectively obtained from charcoals collected at the base of the S2 structure (calibration from the routine dataset intcal04.14c [21]). Therefore, they date the Rio Saboccu sites to phase III of the Sardinian EN, by the end of the VIth millennium BC.

At this stage of the excavations, is not possible to ascertain that the surface artefacts concentrations scattered upon the Rio Saboccu site area are related or not to its S1/S2 structures, in spite of great techno-typological affinities of the respective lithic assemblages and of their almost total absence of pottery. In any case, at the time of its EN occupation, the sea level was still lower than today and the Rio Saboccu campsite more extended in the direction of the pond. Thus, we can only observe now the remnant fraction of the terrace occupied by EN men.

## 3. The lithic collection: technology and typology

The assemblage collected at Rio Saboccu S1 and S2 structures amounts to 1058 chipped-stone artefacts, among which 1047 are obsidians and the remainder are local cherts and chalcedony. The technological analysis of the entire collection clearly shows that obsidian reduction was almost entirely performed in situ, given the presence of all the main stages of the reduction sequence. The greatest part of the obsidian assemblage is debitage. A number of pieces showing portions of cortical surfaces bear evidences of the exploitation of obsidians both from primary and from sub-primary (close to the original geological context) deposits and from secondary alluvial deposits. A relatively high number of cores found in the site reveal that sourcing strategies were oriented in both cases towards little angular blocks or small rounded pebbles (maximum length of less than 80 mm). As revealed by the generalized plain type of butts with no or minimum preparation, reduction was carried out with the direct percussion technique with a soft stone and aimed mainly at producing flakes with a unipolar method and a recurrent shift of the striking platform. This strategy was usually performed through one or multiple 90° rotations of the piece. The 31 exhausted cores show a tendency to intensive and extreme raw material exploitation, until reaching the technical limits for further reduction. The laminar blanks (mainly bladelets) are rare and their general frequency keeps below twelve percent of the total lithic collection. Given the main character of expedient production that well describes the Rio Saboccu assemblage, very few formal tools can be recognized. Among them, the more standardized category is the one of geometric pieces, whilst other formal tools, mainly backed and double backed pieces, burins and scrapers, show a high variability, as they were produced from flake blanks of very different sizes and morphologies (Fig. 5).

## 4. Obsidian provenance

For practical reasons, it is not possible to source by instrumental means all obsidians of large lithic series. By chance, in the western Mediterranean, the number of obsidian sources to consider is limited and it is relatively easy to identify the source-island of any archaeological obsidian to the naked eye (see, e.g., [26]). It could be determined in this way that at Rio Saboccu, as for other Sardinian Neolithic sites, all obsidians are of local origin. The distinction between the Monte Arci obsidian types, SA, SB1, SB2 and SC can also mostly be accomplished by visual observation [11,13,14,26,28]. However, due to some facies convergences, mostly between the SA and SB2 types [28], it is necessary to call for a complementary instrumental way of characterization, typically from 15% to more than 30% of a site series [15,26]. At Rio Saboccu, 40 obsidians were of dubious origin from the point of view of their optical properties and, therefore, their provenance had to be determined by means of their elemental composition.

Thirty-eight artefacts [15] and 24 Monte Arci obsidians [14,15,19] were analyzed by particle-induced X-ray emission (PIXE) at the AGLAE extracted-beam facility of the 'Centre de recherche et de restauration des musées de France' (Paris). Two other sets of respectively, sixteen [14] and seven (Table 1) geological samples were also analyzed by PIXE using the nuclear microprobe lines of a Van de Graaff accelerator and of the new AIFIRA facility of the 'Centre d'études nucléaires de Bordeaux–Gradignan (CENBG)'. Twelve artefacts were measured in a non-destructive mode, the others and the geological samples from polished sections.

At AGLAE and AIFIRA, proton beams of 3 MeV and 1 nA were used to analyse an obsidian surface of about 0.5 $mm^2$. The fluorescence X-rays emitted by the samples were simultaneously collected by two Si(Li) detectors, respectively for the low-energy (Na, Al, Si, K, Ca,Ti, Mn, Fe) and high-energy (Mn, Fe, Zn, Ga, Rb, Sr, Zr) parts of the spectrum. As at the other nuclear microprobe of CENBG, only one detector was available; the 'light' and 'heavy' element contents were successively obtained from proton beams of 1.5 and 2.7 MeV, respectively [14]. To insure internal consistency, one Monte Arci obsidian ('ARC-URS') was analyzed in all runs. Data treatments were performed by the 2000 version of the GUPIX software [2,17]. It appears that only three Monte Arci obsidian types, SA, SB2 and SC, are present in the set analyzed by PIXE (Fig. 3).

The major element compositions (Na, Al, Si, K, Ca, Fe) of two other artefacts [15] and of 80 geological samples [8] were determined from polished sections

Table 1
Elemental compositions of Monte Arci (Sardinia) obsidians as determined by PIXE
Tableau 1
Composition élémentaire de quelques obsidiennes du Monte Arci (Sardaigne) déterminées par PIXE

| Sample | $Na_2O$ | $Al_2O_3$ | $SiO_2$ | $K_2O$ | CaO | $TiO_2$ | MnO | $Fe_2O_3$ | Zn | Ga | Rb | Sr | Zr | Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SB-106 | 3.2 | 13.4 | 76.2 | 4.9 | 0.58 | 0.133 | 0.031 | 1.23 | 39 | 21 | 250 | 53 | 120 | SB2 |
| SB2–50B | 3.1 | 13.5 | 76.2 | 4.9 | 0.55 | 0.114 | 0.031 | 1.17 | 47 | — | 229 | 47 | 104 | SB2 |
| 191 | 3.0 | 14.6 | 73.5 | 5.2 | 1.03 | 0.250 | 0.029 | 1.59 | 54 | 22 | 163 | 166 | 275 | SC |
| 193 | 3.1 | 14.3 | 73.5 | 5.3 | 0.87 | 0.252 | 0.031 | 1.63 | 58 | 24 | 191 | 141 | 271 | SC |
| SCgp1 | 3.0 | 14.3 | 73.6 | 5.4 | 0.87 | 0.253 | 0.031 | 1.67 | 62 | 23 | 179 | 144 | 267 | SC |
| SCgp2 | 2.9 | 14.4 | 74.0 | 5.2 | 0.88 | 0.257 | 0.029 | 1.55 | 59 | 26 | 175 | 139 | 291 | SC |
| SCgp3 | 3.0 | 14.4 | 73.8 | 5.3 | 0.89 | 0.245 | 0.029 | 1.58 | 59 | 24 | 173 | 144 | 259 | SC |

Contents in oxides are in percentage weight and contents in elements in µg/g (ppm).
Les teneurs en oxydes sont en pourcentage massique et les teneurs en éléments en µg/g (ppm).

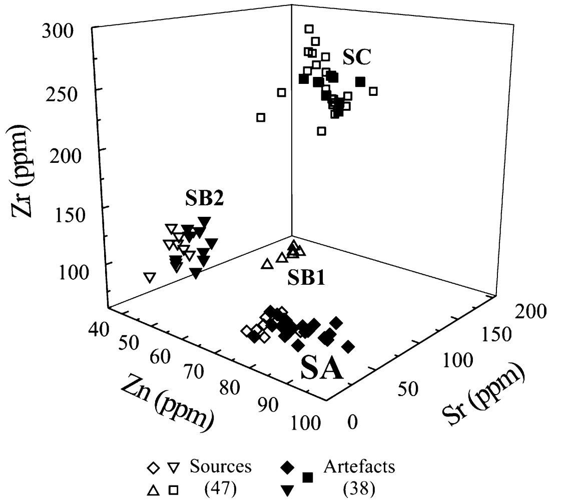


Fig. 3. 3D PIXE diagram comparing the contents in Zn, Sr and Zr of 38 Rio Saboccu obsidian artefacts [15] and of 47 Monte Arci geological samples (data from Table 1, [14,15,19]).

Fig. 3. Diagramme PIXE en 3D comparant les teneurs en Zn, Sr et Zr de 38 artefacts en obsidienne de Rio Saboccu [15] et de 47 échantillons géologiques du Monte Arci (sources des données : Tableau 1, [14,15,19]).

by energy-dispersive X-ray spectrometry with a JEOL scanning electron microscope (SEM-EDS) operating at 20 kV at the 'Centre de recherche de physique appliquée à l'archéologie' (Bordeaux). Data treatment followed a Phi-Rho-Z approach. Binary plots of Al–Fe and Al–Ca contents show that these two artefacts are of the SB1 type (Fig. 4).

Finally, from visual and instrumental determinations, 56.2, 28.9 and 14.4% of the artefacts belong to the SA, SB2 and SC types, respectively. Apparently, SB1 obsidians, with only four artefacts (0.5%), were nearly not used at Rio Saboccu (Table 2).

## 5. The Rio Saboccu obsidian procurement and reduction strategies in their wider sub-regional context

As demonstrated elsewhere [6,15], the obsidian collection from Rio Saboccu S1–S2 structures can be considered a well-homogeneous complex as regards the technological features. The presence of conjoining/refitting pieces lying at different depths confirms the sedimentologic and pedologic impression of a brief formation time of the deposit. Thus, the collected assemblage allows us to get insights into the lithic sourcing strategies applied by the Rio Saboccu EN human group. From a general standpoint, all the lithotypes exploited at Rio Saboccu should be considered as local. The cherts and chalcedony can easily be found in the skeleton

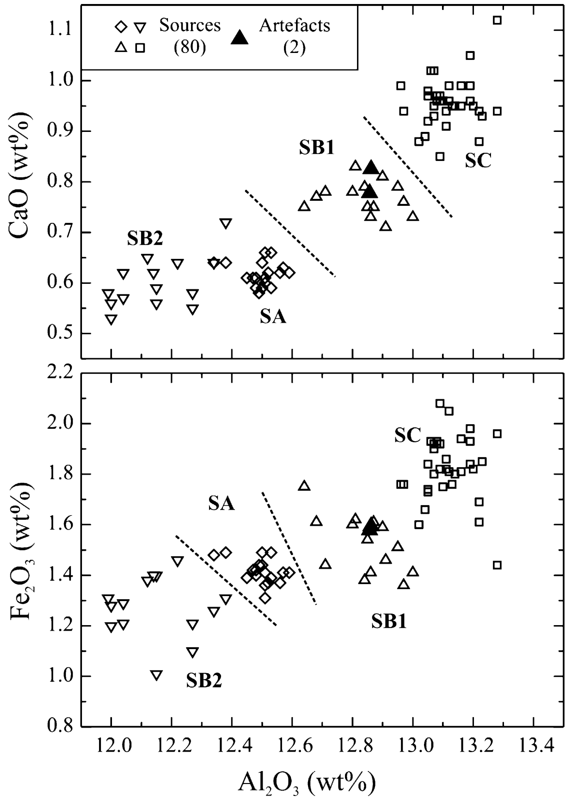


Fig. 4. Binary diagrams comparing the Al, Fe and Ca contents of two Rio Saboccu obsidian artefacts (this work) and of 80 Monte Arci geological samples [8] as determined by EDS with a scanning electron microscope.

Fig. 4. Diagrammes binaires comparant les teneurs en Al, Fe et Ca dans deux artefacts en obsidienne de Rio Saboccu (ce travail) et de 80 échantillons géologiques du Monte Arci [8], déterminées en microscopie électronique à balayage par EDS.

of the alluvial sediments around the site. They were formed during the Miocene post-Aquitanian diagenetic phase associated with the outcrop of underwater volcanic formations of the Masullas region, some 25 km eastwards from the site. The four obsidian types characterised at Rio Saboccu come from various deposits. Very rare pieces of SB1 type were occasionally gathered in their primary and sub-primary deposits, located in an inner area of the Monte Arci massif, at a minimum distance of about 17 km to the northeast. Among the other geochemical types, the most abundant SA obsidians were systematically acquired at their primary deposit of Conca'e Cannas, 16 km eastward, whilst the SB2 secondary and primary/subprimary deposits were closer, 9 km and 14 km northeastward, respectively. On the contrary, secondary deposits of SC obsidians occurred up to the site position and in its immediate vicinity and were (although but less intensively than the other types)

Table 2
Distribution of the Rio Saboccu obsidians among the four Monte Arci petrochemical types, according to the method of determination
Tableau 2
Répartition des obsidiennes de Rio Saboccu parmi les quatre types pétrochimiques du Monte Arci, selon la méthode de détermination utilisée

| Method | SA | SB1 | SB2 | SC |
|---|---|---|---|---|
| Visual | 568 | 2 | 294 | 143 |
| Instrumental | 21 | 2 | 9 | 8 |
| Total | 589 | 4 | 303 | 151 |

the only ones exploited, as indicated by the incidence of well-rounded and evoluted cortical surfaces in SC pieces.

All these aspects bear evidence of a mostly non-opportunist exploitation of obsidian. In spite of the *in situ* availability of SC obsidians and of nearby SB2 obsidians, there is a marked preference for the more transparent and vitreous SA type, whose exploitation required however a major energy investment, given the greater distance of its source from the site. Apparently, it was not technical constraints that have guided the obsidian types' selection, given the similar percentages of blade(let)s production and the homogeneous morphological–dimensional characters of the selected blocks and cobbles. To the contrary, the quasi-absence of SB1 obsidians, rich in phenocrysts and internal flaws, might be accounted for by its lower knapping qualities, as shown by present-day experimentation.

Cherts and chalcedonies, which exhibit quite variable knapping attitudes, are about as frequent as obsidian on the Rio Saboccu terrace. These raw materials, probably because they were less adapted to the EN men's needs, were however much less frequently used. We cannot exclude for them an opportunistic behaviour.

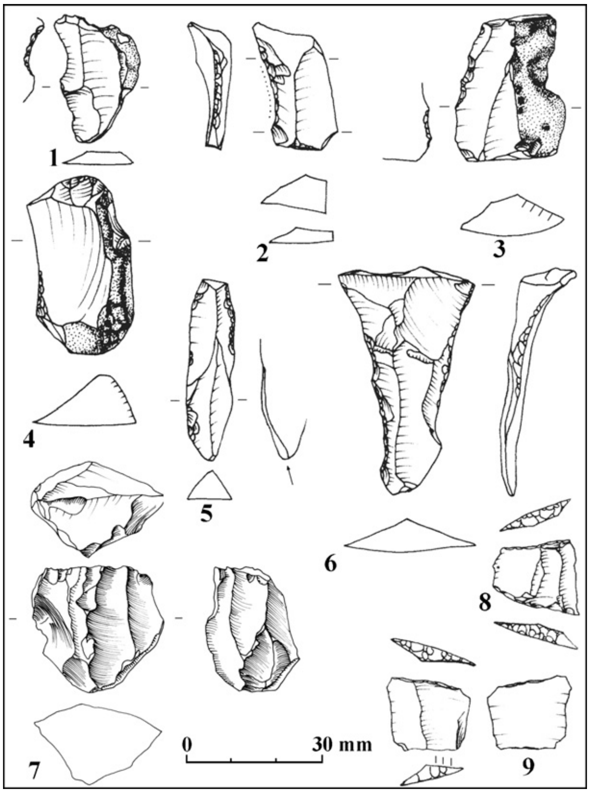


Fig. 5. Rio Saboccu S2 obsidian artefacts (SA: **1**, **7–9**; SB**2**: **2–5**; SC: **6**): notched piece (**1**), side scraper (**2**), denticulate scraper (**3**), end scraper (**4**), side burin (**5**), double backed piece (**6**), core (**7**) and geometrics (**8–9**).
Fig. 5. Artefacts en obsidienne de la fosse S2 de Rio Saboccu (SA : **1**, **7–9** ; SB**2** : **2–5** ; SC : **6**) : encoche (**1**), racloir latéral (**2**), denticulé (**3**), grattoir (**4**), burin (**5**), lame outrepassée à retouches abruptes sur les deux bords (**6**), nucleus (**7**) et géométriques (**8–9**).

## 6. From Rio Saboccu to the EN of the western Mediterranean

The raw material selection and the chipping reduction in practice at Rio Saboccu were shared by the other EN sites southwest of Monte Arci, as in the open-air sites of Pauli Putzu, Orri and Sa Punta (Fig. 1) [9]. SA, SB2 and SC obsidians are also well represented there, whilst SB1 obsidians are very rare to absent [11], and an intensive exploitation of secondary alluvial deposit is common, especially for the SC quality. The small size of the selected raw materials is a culturally-oriented choice, given the presence of a wide range of dimensions of pebbles and blocks both in primary and in secondary sources. The selection of small raw material units is in good agreement with the low percentage of blade production, which is a general tendency of the EN assemblages in Sardinia and in the wider Tyrrhenian region [11,20]. All the above-mentioned aspects and mainly the consistent percentage of SB2 among the small obsidian assemblages in the EN contexts of the western Mediterranean suggest the presence of structured social interactions between communities characterized by high levels of on-sea mobility, as supported by the close technological and decorative affinities in the pottery production [12,18]. Thus, in the composite distribution of Sardinian obsidians in the EN assemblages from the northern Tyrrhenian region, the human groups settled close to the Monte Arci source could have acted (although probably unwittingly) as a 'filter'. Further studies coupling visual/instrumental sourcing with technological/typological determinations on obsidian artefact series from other EN sites of the western Mediterranean might allow us to test the reliability of this hypothesis.

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