FROM THE PERSPECTIVE OF THE SOURCE. NEOLITHIC PRODUCTION AND EXCHANGE OF MONTE ARCI OBSIDIANS (CENTRAL-WESTERN SARDINIA)

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Abstract: The paper deals with the modes of Neolithic obsidian exploitation on the Sardinian source of Monte Arci, according to an integrated typo-technological/provenance approach. It focuses on the main changes in raw material selection and distribution criteria. Whilst from Early to Middle Neolithic they seem to have been influenced by technological and cultural factors, in Late Neolithic a dramatic shift in production behaviour is recorded. Then increased production rates are reflected in the appearance of a true structured exchange network which exerts bidirectional cultural and technological influences in the Northern Tyrrhenian region.

Keywords: Obsidian, Monte Arci, Sardinia, exchange networks, reduction technology.

Résumé: *Cette étude concerne les modalités d'exploitation de l'obsidienne en proximité de la source du Monte Arci pendant le Néolithique, suivant une approche integrant l'analyse typo-technologique et la provenance de la matière première des artefacts. On prend en examen les modifications principales dans les critères de sélection et de diffusion de la ressource. Tandis que à partir du Néolithique Ancien jusqu'au Moyen il semble que des facteurs technologiques et culturels ont determiné ces critères, à partir du Néolithique final on observe un changement abrupt au sein des méchanismes de la production. À cette époque l'augmentation du volume de la production marque l'apparition de véritables reseaux d'échange organisées qui exercent des influences culturelles et technologiques bidirectionnelles dans le domain Nord-Tyrrhenién.*

Mot clés: *Obsidienne, Monte Arci, Sardinia, reseaux d'échange, chaînes opératoires.*

Introduction

The traditional approach to the study of Neolithic in Sardinia has customarily been employing the type analogy, mostly within the field of ceramic production, as a heuristic tool in the identification of migratory processes or interchange phenomena among different Neolithic communities of the Mediterranean West. With regard to this issue – beyond the recently perspectives resulting from the involvement and the application of molecular biology techniques onto anthropic, palaeo-faunistic and palaeobotanic remains – another way to trace the interaction vectors among communities facing the different Mediterranean shores results from the characterization and the studies on the provenance of specific raw materials, integrated in the analysis of the related technical production systems. Under such perspective, obsidian is certainly one of the most efficient raw materials. Unlike in the Aegean area, the earliest distribution of obsidian in the western Mediterranean can most evidently be correlated with the advance of colonizing waves of the early Neolithic pioneers. Starting from the beginning of the 6th millennium cal B.C., indeed, obsidian had begun to circulate from the source-islands of Pantelleria, Lipari, Palmarola and Sardinia, originating in time the institution and consolidation of exchange networks, mainly following a coastwise and sub-coastal development, rarely penetrating into continental territories for more than 200 km (Lugliè 2009a). Beyond the key indicator represented by this volcanic glass, more structured processes of cultural interaction at a long distance may be perceived, entailing not only the handling of raw materials and artefacts, but also a significant technology and ideological transfer. These guiding principles in interregional relationships would apparently endure throughout the Copper Age, although with a lesser intensity, even when obsidian circulation clearly kept a substantially local value, limited to the source areas.

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Sardinia in the Neolithic colonization flow

Based on currently available data, the arrival of Neolithic communities along western Mediterranean coastlines is considered as the final step of an arhythmic, "leapfrog" distribution process, most likely starting from western Greece. The chronology of the earliest moments of such distribution process is relatively short, especially when referring to the Tyrrhenian area, where they may be probably set between 5900 and 5700 cal B.C. (Manen and Sabatier 2003).

Narrowing down the analysis field to Sardinia only, similarly to other western regions the phenomenon of Neolithic transition must have followed a true colonization process, since according to the currently known framework the island appeared most likely uninhabited during the early Atlantic period (Lugliè 2009b). Indeed, few pre-Neolithic sites in Sardinia supply a poor, fragmentary evidence about coastal or sub-coastal settlements, discontinuous and temporary, in the absence of elements highlighting the start of a process involving the familiarization with the hinterland, as well as its occupation and territorialization (Lugliè 2009c). Moreover, a *hiatus* of about 500 years still persists between the latest Mesolithic sites and the earliest attestation of a first Neolithic presence in the island. Also, strong discontinuities between the two phases are most evident, either on the occupation mode (temporary camps/permanent settlements) and on the socio-economic structure levels (small groups and predation or gathering activities/numerically significant groups and production activities with the introduction of domestic species), without neglecting the technical system level.

Within the lithic production, in particular, the antinomy between the two phases is evident, even considering the mere raw material selection behaviours: obsidian is totally absent in pre-Neolithic series, all created by employing local rocks, even of a low quality, whilst it almost immediately appears in Early Neolithic sites. Contextually, it is from this very moment that a non-anecdotic circulation of the lithic raw material occurs, either on a supra-local and supra-regional scale (fig. 1).

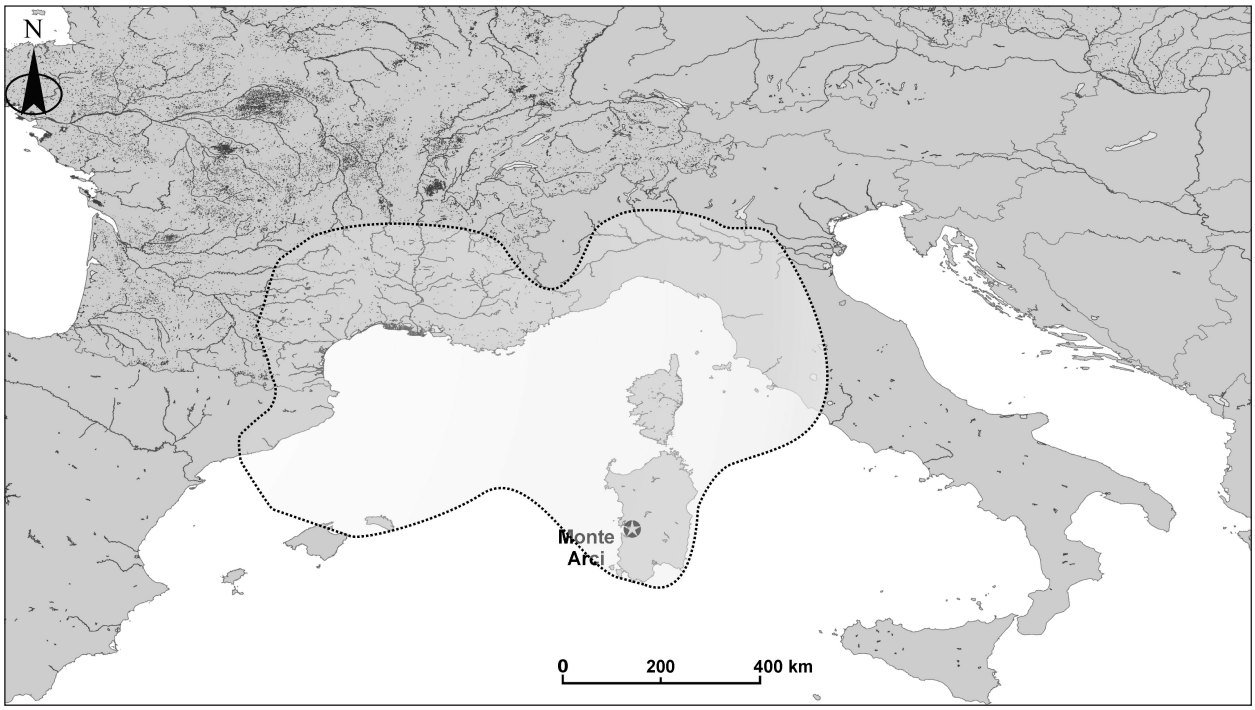

FIGURE 1. Schematic map showing the intensity of Monte Arci obsidians Neolithic distribution.

Monte Arci source: studies on the procurement area

In the past, studies on the provenance of obsidian were almost exclusively focused on an ever-increasing number of collections, coming from sites distant from the key area represented by the source on the volcanic massif of Monte Arci, in the hinterland region of central-western Sardinia. Only recently was the significance of acquisition area duly emphasized, in view of the comprehension about the distribution and potential availability of the resource, of the selection strategies and the raw material acquisition modes. The full integration of non-destructive characterization techniques and visual determination of the material with the technological analysis of complete series of obsidian artefacts, besides, has paved the way for a correct interpre-

tation of the production systems and their diachronic variability (Poupeau *et al.* 2010).

Defining the selection and reduction strategies implemented by Neolithic groups in the source region was of a paramount importance, enframing them comparatively on the background of the distribution phenomena inside and outside Sardinia, to the purpose of formulating hypotheses on interregional integration dynamics. Under this aspect, an area for the direct procurement of the resource was identified, where obsidians could be collected during daily expeditions, regardless of their specific orientation. Consequently, a 'contact zone' was identified to circumscribe the region where procurement may have likely occurred through exchange mechanisms.

In Sardinia, the existence of four obsidian varieties, named SA, SB1, SB2 and SC, of a discrete geochemical composition, has been progressively taking shape throughout the latest 40 years (Mackey and Warren 1983; Tykot 1996, 1997). More recently, the respective macroscopic properties and their specific localization on Monte Arci were systematically categorized with the aim of understanding the variations in the selection behaviours occurred in the course of the Neolithic. A distinction among these four obsidian varieties may be made by reason of their different elementary composition; yet, for the majority of artefacts, the provenance source of the raw material may also be determined to the naked eye by an expert observer, on the basis of a few macroscopic parameters.

Therefore, today, following a detailed mapping of the volcanic complex of Monte Arci and because of its particular morphology and relative ancientness of obsidianaceous formations, at least three categories of outcrops may be hierarchically differentiated, scattered over a surface covering about 270 square kilometres (Lugliè *et al.* 2006).

Primary deposits are defined those where obsidian was emplaced at the origin, as a consequence of effusive and/or explosive volcanic phenomena. These sources are entirely displaced inside the volcanic massif, at different altitudes comprised between 100 and 600 m asl. Sub-primary deposits are directly related to primary ones, since they result from the disaggregation of original outcrops and their consequent rolling and accumulation into colluvial slope deposits. Finally, secondary deposits are constituted by obsidian cobbles of different size, comprised within alluvial deposits formed at a greater or lesser distance from the volcanic massif, as a result of the different transport actions by weathering waters. In all probability, prehistoric communities were able to identify this latter form of obsidian in fluvial incisions of alluvial terraces. It still keeps fully exploitable physical properties for the manufacture of artefacts, even at a distance greater than 35 kilometres from the corresponding original primary deposit inside the massif.

An analysis of the distribution map of Monte Arci geochemical varieties of the volcanic glass shows that SC-group secondary deposits are by far the most extensive. Starting from the related primary deposits cropping out in different places at the eastern margin and at latitudes higher than 500 m, in the territory of Pau, they stretch as far as the southern end of the volcanic massif, until reaching the facing slope on the opposite mountainside. The secondary deposit of SB2-group ranks second for its extension and is distributed immediately northwards, skirting the western profile of the mountain (Lugliè *et al.* 2006).

On the other hand, secondary deposits of SB1 and SA groups are more restricted, being largely influenced by the low elevations, by the related primary outcrops sited in proximity to the plain and, most of all, by the presence of geo-morphological obstacles. The SA-group secondary deposit, more recently identified, partly overlaps the limits of SC and SB2 groups, at a short distance from the primary outcrop of Conca 'e Cannas, where it originated (Fanti and Lugliè 2010).

Exploitation and distribution modes: the Early Neolithic

The main archaeometric aspects of the investigation on the raw material, with special reference to the theoretical and technical approach to the compositional analysis of Monte Arci obsidians, have already been exhaustively illustrated elsewhere (Tykot 1997; Poupeau *et al.* 2004). The creation of a distribution map of Monte Arci geo-chemical groups (Lugliè *et al.* 2006) may be considered an archaeological tool of fundamental importance, to be integrated in the model analysis of their archaeological distribution, as defined by the increasing series of sites examined, in order to suggest a punctual interpretation of the diachronic variations in lithic flake production. Below are defined the salient features starting from the Early Neolithic (6th mill. cal B.C.).

Considering the status of early cultural horizons of Tyrrhenian impressed pottery and its progressive consolidation, a comparison between the distribution models of the different obsidian varieties employed in the direct procurement and contact areas shows no substantial differences. Indeed, SA, SB2 and SC groups are always well-represented, with a sharp prevalence of SA over the other two. On the other hand, SB1-type obsidians, quite rarely employed even in close proximity to the source, seem to be completely absent. By examining the nature of the exploited deposits, obsidian from SB2 and SC groups in direct procurement area sites largely comes from secondary deposits, closer to the settlements located in the plain, while in sites distant from the source area obsidians identified in a secondary position are almost totally absent.

In all of the Early Neolithic settlements systematically analyzed so far, obsidian occurred in the form of cobbles and tool blanks or just tested blocks. Apparently, the whole sequence of the *chaîne opératoire* primary processing – *débitage* and production of artefacts – would occur entirely in situ, in the same inhabited areas where the daily use of tools would take place (Lugliè *et al.* 2011). Considered the minor statistical incidence of SC-obsidians collected in secondary deposits available at a short distance from sites in the direct acquisition area, it is clear that raw material procurement was not ruled by the law of the minimum effort, being in fact influenced by specific selection criteria (fig. 2).

Even when primary and sub-primary deposits of SA and SB2 varieties were characterized by a large availability of blocks of a far bigger size and by a wide choice of forms, strategies to procure the lithic resource were exclusively aimed at collecting small-sized raw material units, in any case never exceeding the maximum length of 100 mm. The low interest aroused by the raw material more readily available in secondary deposits leads to theorize that its selection was rather conditioned by technologic and/or cultural (and/or symbolical?) imperatives. Indeed, obsidian collection has always followed absolutely non-opportunistic criteria, with reference either to the quality and the size of the raw material.

The opportunity to perform integrated visual and chemical-physical determinations in order to characterize obsidian deposits exploited for the manufacture of full artefact collections has allowed to estimate the minimum number of units introduced in the sites for each source and to define the raw material economy. This was confirmed by two main *chaînes opératoires*. The most commonly reported uses all obsidian varieties indifferently and is meant for the production of flakes marked by an irregular, aleatory morphology; its use as undifferentiated tools is a clear evidence of a much more opportunistic behaviour and represents the general rule at all sites. A second reduction sequence, minor in respect of quantity, was oriented to the production of blades and, above all, bladelets – chiefly by direct percussion with soft-stone hammers – employing mainly SA and SB2 types. Subsequently, making the object of a higher technical investment, these pieces were employed in the production of standardized formal tools such as geometrics and backed points, categories that, except for a few sites having a clear functional specialization, represent the far lesser component in the toolkits.

Broadening the scope to the available information on source distribution in sites of the same phase, in the Tyrrhenian central-northern region, where Monte Arci obsidian is distributed in the Early Neolithic, the trend is almost analogous to that of the source area. Indeed, SA-, SB2- and SC-type obsidians prevail, in a virtually total absence of SB1 type. Nevertheless, outside Sardinia, a certain asymmetry was reported due to the considerable relative increase of SB2-type obsidians, inversely correlated to a marked decrease in the occurrence of SC obsidians coming from secondary deposits at a long distance. Taking into account the significant settlement intensity referable to the Early Neolithic in the direct procurement area, such remark may be interpreted as the result of some form of control over the access to the resource, exerted by local communities, and of particular exchange modes, such as the more or less deliberated selection of specific obsidian types put into circulation and/or transported, in rather frequent transfers, especially during the pioneering expansion phase of impressed-pottery groups.

Moreover, in time, the general impression of a strong cultural affinity within the framework of the northern Tyrrhenian basin is corroborated by the technological shape of lithic series during the cardial and epicardial phases, up to the so-called *facies* of incised Tyrrhenian pottery, at the end of the 6th millennium. Such affinity may also be explained as the consequence of Early Neolithic peoples' high mobility rate by sea in the western Mediterranean. This, in turn, may account for the relatively low occurrence of Monte Arci obsidian outside Sardinia, sometimes contemporary to that of Palmarola in distant sites (Briois *et al.* 2009), contrasting with the result expected on the basis of a well-structured exchange network. In other words, the circulation of Monte Arci obsidian in this phase may be interpreted as the effect of group movement dynamics; this may also have had a distinctly symbolical, rather than exclusively functional significance (Vaquer 2007).

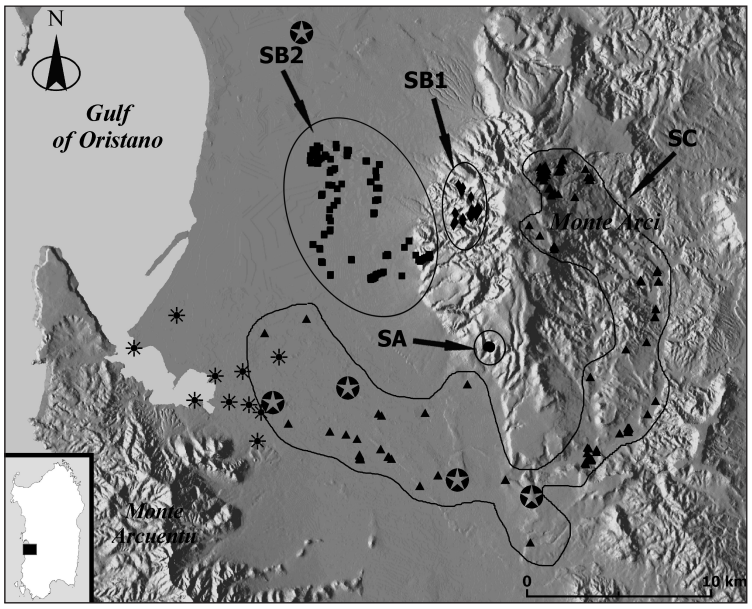

FIGURE 2. Map showing the secondary deposits distribution of the four archaeologically relevant Monte Arci obsidians geochemical groups. Little stars indicate Early Neolithic sites, whilst the bigger ones make reference to the larger Middle Neolithic campsites.

Towards a specialization of production? The Middle Neolithic

Despite of the fact that the general level of knowledge related to the obsidian reduction system in Sardinian Middle Neolithic is still rather deficient, the few sites providing an analysis at least allow to report the progressive emergence of a specialized production, with a general increase in the percentage of blades and bladelets as in the distribution of the pressure flintknapping technique (Lugliè 2004a).
Such phenomena may be associated to a progressive drift of cultural features, a subsequent original reworking and a definitive consolidation, entailing a marked regionalization of Bonu Ighinu Culture communities in Sardinia. In it, moreover, the occurrence of social differentiation processes is suggested by the appearance of prestige grave goods, further characterized by the adoption of specific funerary rituals (Santoni 1999). The poor occurrence of extra-insular feedbacks, starting from the neighbouring Corsica, does not even allow to define in detail the distribution modes of Monte Arci obsidian overseas; on the whole, they do not seem to have undergone any special changes in the general organization compared to the final phases of the Early Neolithic.
Such process of marked cultural identities, homogeneous on the territorial level, seems to be much more evident in the second half of the 5th millennium B.C., during the B-Middle Neolithic of San Ciriaco di Terralba *facies*. In this phase, a progressive increase in population growth is indicated by the rise in the number and size of open-air villages (Usai 2009). The correspondent, abrupt change reported either in the extent and the modes of obsidian production, in addition to the statistical distribution of the different composition groups in lithic series, appears as the effect of changed obsidian distribution modes at the island level, but also, and especially, outside Sardinia.
In addition, it should be pointed out that such modes are still largely indefinite. What has still to be ascertained, in particular, is the form under which obsidian was acquired by overseas peoples. In Corsica, indeed, despite the incontrovertible evidence of the locally implemented obsidian reduction practice – at some sites, at least (Le Bourdonnec *et al.* 2010) – cores are generally lacking, or very poorly represented, in the majority of series considered reliable on the context level (Costa 2006). This may be the result of local strategies associated to an intensive reduction, of the presence of specialist flintknappers/travelling distributors, or it may reveal the existence of procurement modes for already partially or totally worked products by these communities. Nor may it be excluded that, in such phase, where an organized exchange network was being created, different obsidian circulation modes could exist.
Indeed, a concentration of twelve natural or just tested blocks, belonging to SA and SC chemical-composition groups, found at few sites in south-western Corsica, has recently supplied a clear evidence of a possible raw material circulation/storage mode at the end of the 5th millennium B.C. (Le Bourdonnec *et al.* 2011). In Sardinia, at the same time, primary reduction and shapening specialized activities were confirmed even within settlements located outside the direct procurement area, such as in the case of Torre Foghe, Tresnuraghes - OR (Tozzi and Dini 2004). In that site, as generally observed at a distance from the local area surrounding Monte Arci, the obsidian varieties employed are essentially restricted to two types, SA and SC, while on the volcanic massif, in proximity of their main outcrops, lithic workshops were installed, aimed at increasing production volumes (Tanda *et al.* 2006; Lugliè and Lo Schiavo 2009).

Towards a mass production: the Final Neolithic

In the time span between the 5th and the 4th millennium B.C., in conjunction with the origin of Ozieri Culture, the early stages in the obsidian reduction process in Sardinia seem to have been definitively transferred in close proximity to the primary outcrops of SA and SC groups, where the raw material is abundant and ensuring the widest diversity of form and size.
Then, big processing workshops develop onto these deposits, essentially focused on the reduction of blocks and the creation of preforms of polyhedral cores, to be input in the now consolidated exchange networks.
Whilst in the direct procurement area an opportunistic attitude towards the raw material leads to occasionally maintain the exploitation of the SB2 type, this variety reports a sudden lack in extra-insular collections. The phenomenon is in line with the parallel general increase of Monte Arci obsidians – yet only with regard to SA and SC types – in Corsica, continental Italy and southern France. This seems to occur as a direct consequence of the full production capacity of ateliers operating at primary outcrops, in particular those of Conca 'e Cannas in Masullas and those of Sennixeddu and Fustiolau in Pau. They almost exclusively report sequences to prepare preforms for laminar débitage (fig. 3) (Lugliè 2004b; Tanda *et al.* 2006). These preforms are further worked in sites of regional and interregional areas, where they arrive following well-defined distribution routes. An evidence is given by the numerous cores prepared for the full laminar débitage, sometimes of a large size, found in inhabited centres related to Ozieri Culture, in different Sardinian districts. These cases are significantly associated with two cores detected offshore in the Strait of Bonifacio, on a sea bottom at a depth of about 70 metres (fig. 4): their large size and the circumstance of the discovery reveal the

technological level achieved and the development of forms through which the raw material is distributed.
The statute of the circulating raw material, at this point, is no longer ruled exclusively as a function of the distance from the source, but rather from the involved partnerships. While in Sardinia and Corsica obsidian arrives as preforms, or already started cores, usually exploited locally in sites following débitage tournant or semi-tournant styles, in continental areas obsidian is likely received as preform, whose reduction is managed in line with local technological customs. Emblematic is the case of the Chassey site of Le Terres Longues, in Trets (Bouche-du-Rhône) (Léa *et al.* 2010): reduction performed in accordance with the most represented style for bedoulien flint, submitted to thermal treatment, in relation to the so-called Trets type, may justify the marked preference for the importation of obsidian of the most glassy and homogeneous SA variety, allowing the highest levels as to pressure flint-knapping control. Therefore, within the framework of strong technological influences resulting from a high craftmanships, such as those operating within the Chassey range, it seems that impulses are generated towards a selective exploitation, increased from a quantity point of view, of specific raw material sources.

The subsequent local processing in a continental area, in sites probably rising to the rank of redistributing centres, triggers the further circulation of obsidian, mostly in the form of bladelets, sharing the flint distribution circuits organized by Chassey communities (Vaquer 2007; Léa *et*

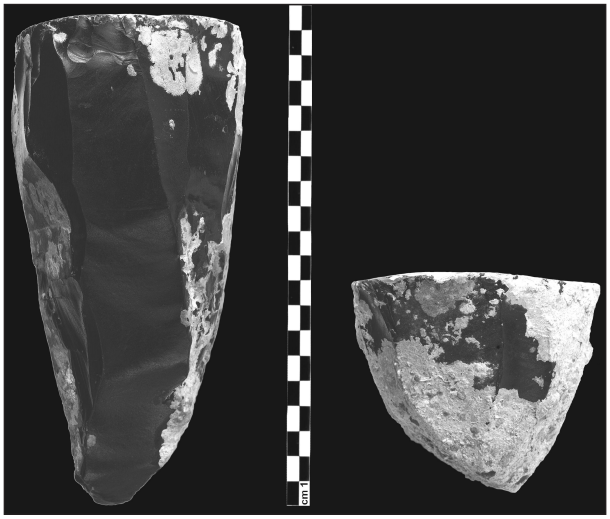

FIGURE 4. Two big-size SA obsidian blade core preformes found in the seabed of the Bocche di Bonifacio strait, between Sardinia and Corsica.

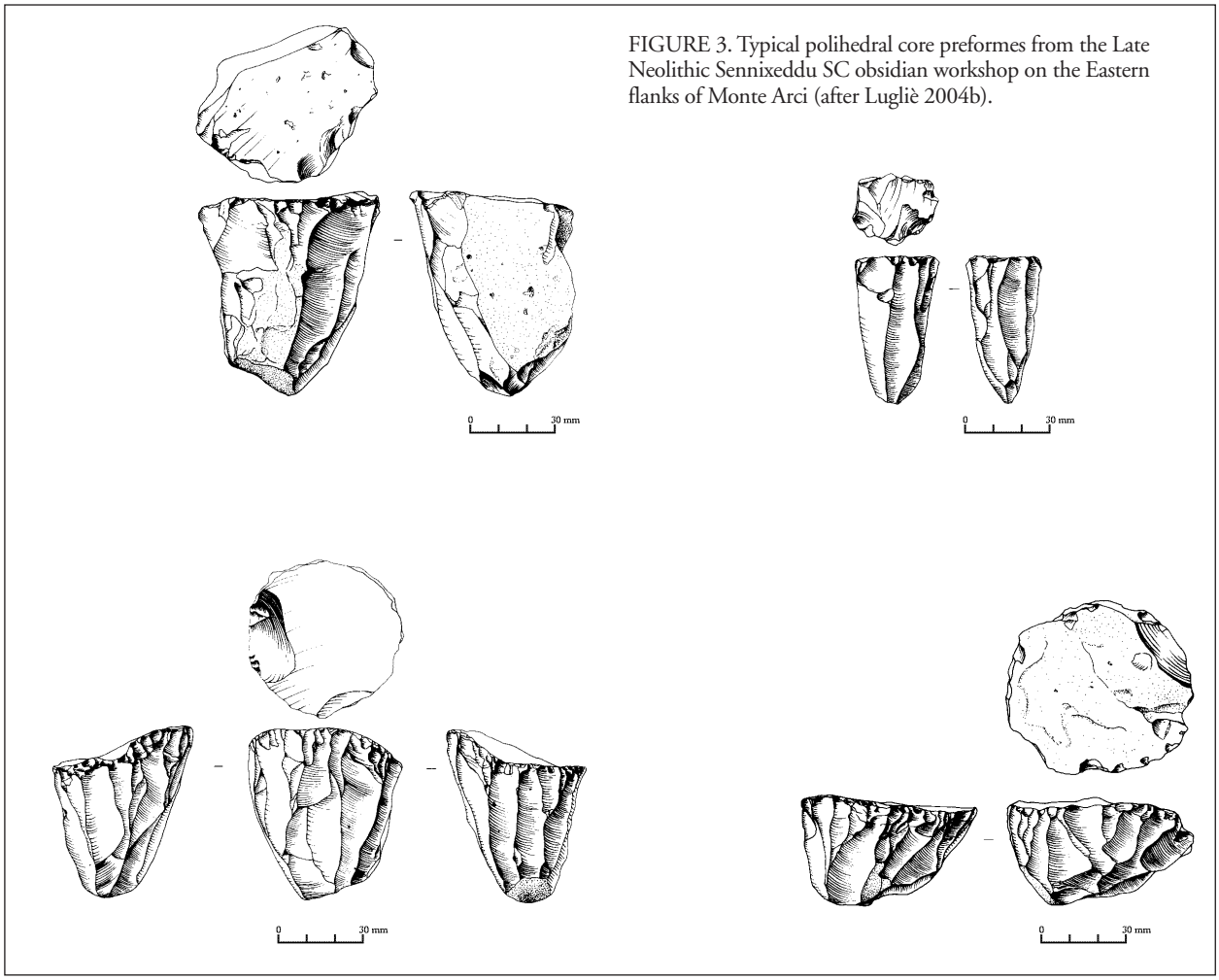

FIGURE 3. Typical polihedral core preformes from the Late Neolithic Sennixeddu SC obsidian workshop on the Eastern flanks of Monte Arci (after Lugliè 2004b).

al. 2010; Bosch *et al.* 2010). Thus, the obsidian distribution scheme over a long distance seems to be more structured and complex than what was formulated by the principle of monotonic decrease, down the line exchange model (Renfrew 1984; Tykot 1996; Tykot *et al.* 2008). Actually, it would have been influenced by catalyzing centres represented by the local availability of sought-after raw materials, as suggested by Vaquer (2007), or by the presence of groups endowed with particularly high technical specialization levels.

Conclusions

In conclusion, it is evident that, during about three millennia of exploitation, the production and the distribution of Monte Arci obsidian have changed their statute, even significantly. As it has been shown, following a systematic analysis of an increasing number of collections, the procurement and the distribution throughout the Early Neolithic would have been ruled by the forms of control over the resource exerted by groups settled in direct procurement areas. The aspects characterizing Sardinian obsidian circulation forms in this early phase seem to escape the logic of organized exchange networks, to be rather dependent on the traits of high mobility and close interdependence of groups settled over broad distances, as confirmed in other sectors of the technical system, such as pottery production.
After a possible gestation phase, possibly identifiable in the early Middle Neolithic, authentic, organized exchange circuits would start operating at the end of the 5th millennium, initially connecting Sardinia to Corsica and northern Italy, in the cultural circle of the 2nd and 3rd Square Mouthed Pottery (SMP) phase. Such circuits would apparently consolidate in time, due to the role carried out by San Ciriaco and Ozieri cultures in the control and development of obsidian production systems, including its distribution towards the spheres of influence of late-SMP and classic Chassey groups, which will certainly and reciprocally entail cultural and technological transfer effects on the island scene.
Further confirmation of this preliminary interpretation of the phenomenon is expected, in the near future, from the broadening of integrated studies on obsidian lithic production in the source area.

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