Chert exploitation and production in Sardinia during the Neolithic: Review and data synthesis

Barbara Melosu, Carlo Lugliè

University of Cagliari, LASP (Laboratory of Sardinian Antiquities and Palaeoethnology). Piazza Arsenale 1, 09124, Cagliari, Italy. Email: Melosu: barbara.melosu@gmail.com

Abstract:

This research deals with the modes of chert exploitation in Sardinia during the Neolithic, combining information on major chert sources identified across the island with the technological analysis on several stratigraphic reliable series. It focuses on the changes in raw material selection and on the evolution of technological behaviours between the 6th and the 4th millennium BCE. The data collected in this work allowed us either to shed a light on the role this lithic resource played in the production systems of Neolithic communities in Sardinia, and to catch differences in the modes of procurement, depending on the chronology and location of the sites. During the Early Neolithic, lithic raw material circulation in Sardinia did not occur through organized networks, but it seems to have relied on the high mobility of the local groups. It is only at the end of the 5th millennium BCE that well-organized exchange circuits started operating. These involved mainly obsidian and this raw material apparently consolidated in time, due to the role carried out by San Ciriaco and Ozieri Middle to Late Neolithic cultures in the control and development of the Monte Arci obsidian supply. Chert was never involved in these networks and was mainly exploited locally and opportunistically. However, from the end of the Neolithic, some outcrop in the Oligo-Miocene basin of Perfugas was exploited on a supra-local scale and for a relatively short period.

Keywords: chert; Sardinia; exploitation; techno-economy; Neolithic

1. Introduction

Due to its complex geological history, Sardinia provides a variety of lithic raw materials useful for knapping. Among them, obsidian was by far the most exploited lithic resource since the first stages of the Neolithic colonization of the island (first half of the 6th millennium cal. BCE) (Lugliè 2014; 2018). From the sole source of Monte Arci obsidians circulated in the whole island and, especially since the second half of 5th millennium cal. BCE, in the wider north-wester Mediterranean (Lugliè 2009; 2012; Tykot 1996).

Research on obsidian provenance, integrated in the analysis of the technical production systems, developed in Sardinia in the last decades (Lugliè 2006: 14-15; 2009; 2012). Conversely, studies on chert kept disregarded for long time, especially because of the heterogeneity of their potential origins and, alongside, because of the lack of good reference

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source samples. However, in the last few years major chert sources have been identified in the northern Sardinian Oligo-Miocene basin of Perfugas and, also, in the surroundings of the Montiferru volcanic massif in the west of the island (Bressy *et al.* 2007; Lugliè 2006: 76-78). This research, in parallel with the recent generalized adoption of a techno-economic approach in lithic studies, provided more information on Sardinian Neolithic industries and, more specifically, on chert production.

Currently, we have an overall perception of the role that chert played in the production system of Neolithic communities in Sardinia. Therefore, we can trace an evolution of this raw material procurement, according to both the chronology and the location of the receiving sites. However, our reconstruction is affected by the incomplete nature of the documentation, especially from the oldest excavations (and studies) where the lithic industries in general, and particularly those in chert, have often been neglected.

The first purpose of this work is to stress the evolution of the Neolithic chert acquisition strategies and behaviours on the island, compared to obsidian; the second objective is to describe the variation in the techno-economy which affected the Sardinian lithic industries between the 6th and the 4th millennium BCE. In this paper we present a regional synthesis of both these aspects, under a diachronic perspective.

2. Geological background

Lithic raw material provenance studies in Sardinia focused especially on Monte Arci obsidians; chert resources characterization, on the other hand, poorly developed until the last few years, when different areas have been intensively surveyed (Bressy-Leandri 2014: 15-17; Bressy-Leandri *et al*. 2019: 19-20; Leandri & Fernandes 2020), stressing on specific sectors where previous literature claimed about chert bearing formations. Systematic surveys interested particularly the Miocene Perfugas Basin, in the Anglona region (northeast Sardinia) (Figure 1), well known for the abundance of good quality chert (Boschian *et al.* 2002; Costa & Pelegrin 2004; Falchi *et al.* 2012). This area is linked to the geological formation which extends towards the coast as far as Castelsardo and further south, up to the Usini region (Soula Costa & Guendon 2010). Recently, among a hundred samples collected in the Perfugas area, nearly 60 different lithotypes were characterized (Leandri & Fernandes 2020). Among those facies, some are very specific to the Perfugas outcrops: this is the case of a banded chert, variable in colour and of waxy appearance, which bears very good knapping properties. These lithotypes have been widely exploited in Sardinia, especially since the Late Neolithic. In Perfugas area it has also been recognized, even if it is not exclusive of this sector, a calcedonious (translucent) facies which is highly variable in colour (Leandri & Fernandes 2020).

Our surveys (Figure 1), chiefly addressed to the Perfugas and Laerru sectors (Rio Minore Formation), had a main objective to identify the major chert source areas defining their extent and, likewise, to record the characteristics of collected chert in terms of quality, abundance, morphology, and knappable characteristics. All this information established the possible evaluation of the interest in these materials by the prehistoric communities.

In the surveyed sectors we collected 49 geological samples scattered in 12 locations, in both primary and secondary position. For each of these we recorded the position and some data concerning their aspect (colour, structure, opacity, cortex, *etc*.).

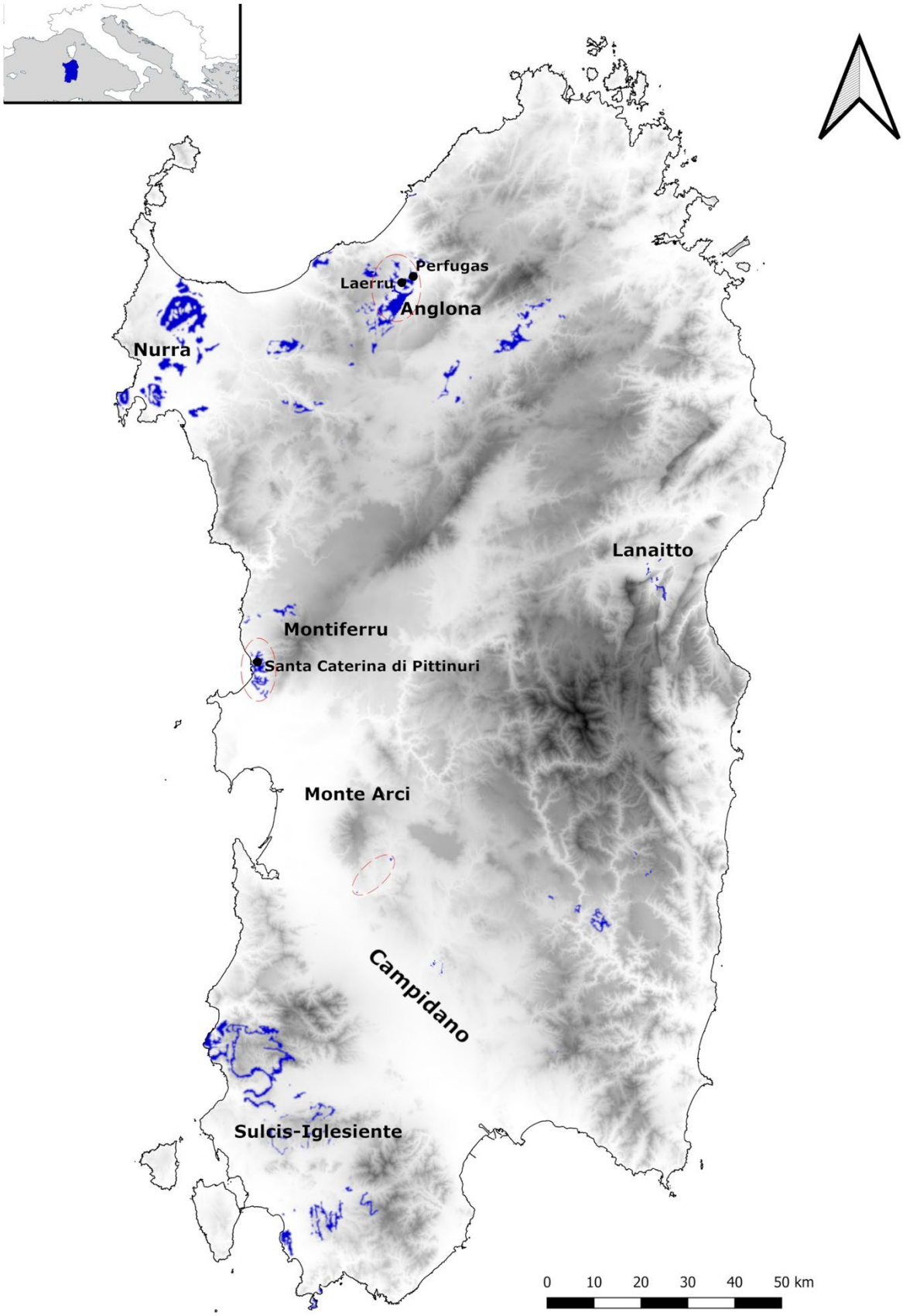

Figure 1. Sardinia chert bearing formations (data source available online). In red, surveyed areas.

Chert outcropping near the Perfugas and Laerru villages is mostly fine-grained and very homogeneous. This material can be easily found either in individual bands or layers ranging in thickness from one to several centimetres, or within colluvial/alluvial deposits in the form of pebbles up to about ten centimetres in diameter and more than twenty centimetres in length (Figure 2). Both banded and calcedonious cherts varieties occur frequently even in lithic assemblages coming from local sites; however, these materials have also been widely exploited in nearby Corsica.

Figure 2. Banded chert in primary position at Sa Rocca Rutta, Laerru (left); chert in secondary position along Rio Coghinas bed, Perfugas (right). (photograph by B. Melosu).

In central-west Sardinia, several locales between the shore around Santa Caterina di Pittinuri and the Montiferru massif were also surveyed (Santa Caterina di Pittinuri Formation), where previously chert horizons related to Miocene hydrothermal and volcanic activity have been observed (Palomba *et al.* 2006). In this area chert can be exclusively collected in secondary position, in the plain sediments surrounding the massif slopes and along the riverbeds, in the form of well-rounded pebbles and nodules (Figure 3). Throughout our surveys we collected 61 geological samples in 5 locations.

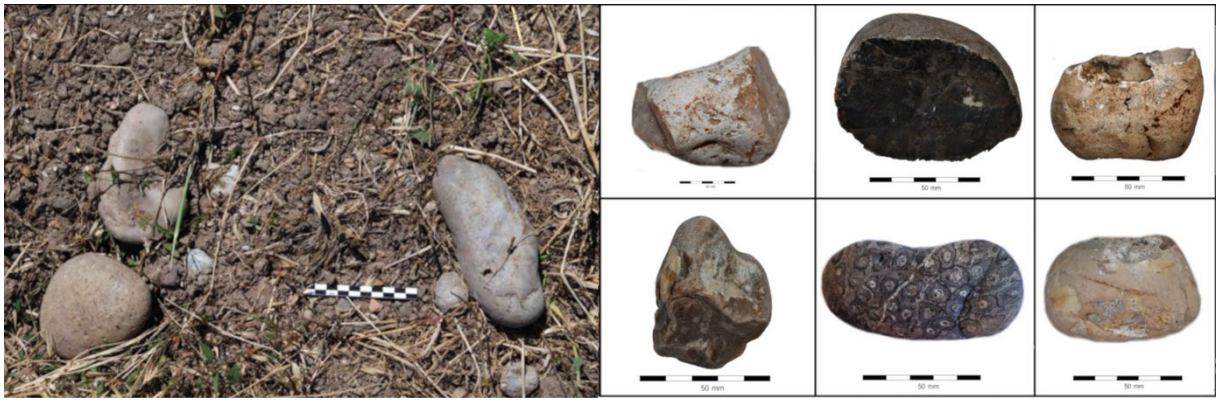

Figure 3. Chert cobbles in secondary position (loc. Concas, Cuglieri) (photograph by B. Melosu).

These materials, bearing a high colour variability (from white to red to grey), morphology (from blocks to flakes or weathered nodules, typical of alluvial deposits), and size (ranging from 3 to 25 cm), is very easy to supply because of its abundance.

A calcedonious (translucent) facies, highly variable in colour, with a calcareous cortex, is the most widespread variety in the whole surveyed area. This raw material is mostly fine-grained and highly homogeneous.

Further chert formations are also documented in Sardinia, even if in some cases they mainly provide low-quality chipping material (Bressy-Leandri 2014:21-22; Lugliè 2006: 77; Mussi & Melis 2002); among these, the best-known outcrop in the southeast of Monte Arci

Massif (Figure 1). Surveys performed in this area and specifically along the northern and middle Oligo-Miocene Campidano valley (Marmilla Formation) allowed us to identify a primary source and several alluvial secondary deposits, containing geological chert of various sizes (5-20 cm) and morphology (from blocks to weathered nodules) (Figure 4). We sampled 20 specimens in 5 locations.

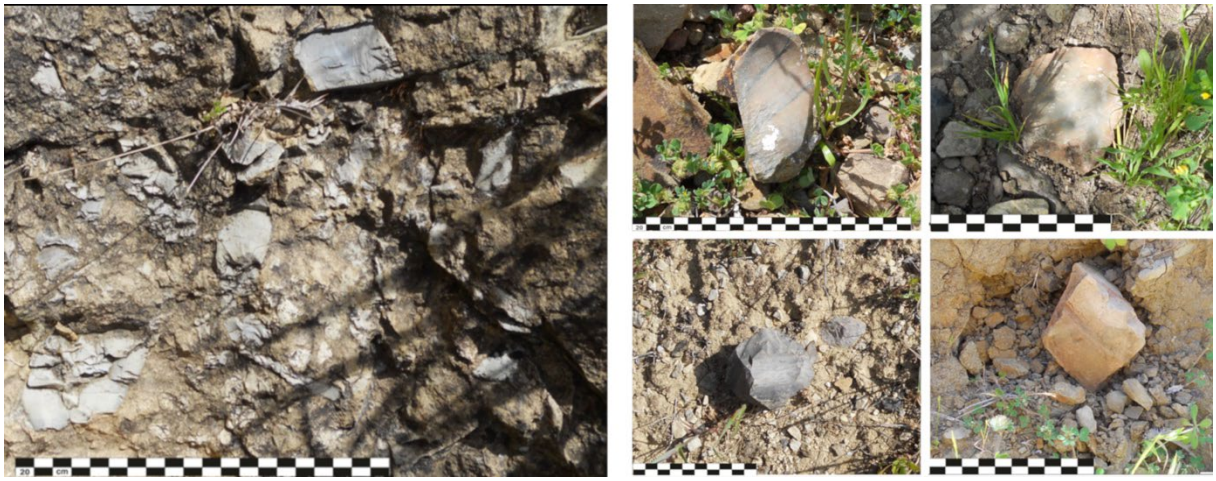

Figure 4. Chert nodules in primary position (left); chert blocks in secondary position at Rio Laccus region, Morgongiori (right) (photograph by B. Melosu).

Chert coming from this area frequently appear of medium-grained, poorly homogeneous and with low knappable qualities.

Finally, previous literature and the available geological maps also indicate chert-bearing formations in other areas of the island: Logudoro, Sulcis-Iglesiente (Carta Geologica di base della Sardegna, 2008), Nurra (Chabrier & Mascle 1975; Fauré & Peybernès 1983) and Lanaitto (Azéma *et al*. 1977; Bressy-Leandri 2014: 21-22) (Figure 1). Actually, no published reports are available suggesting any possible prehistoric exploitation of these source areas.

3. Materials and methods

In Sardinia, about eighty Neolithic sites providing chert artefacts are known, variously scattered from a topographic and chronological standpoint. Considering the limited extent and stratigraphic reliability of some of these, the uneven documentation especially for the oldest excavations, and the scarcity of chert elements, in this work we considered just a small number of sites, ranging from the Early Neolithic (EN) to the Final Neolithic (FN). For some of these, we performed the direct analysis of the lithic collections (Table 1) following a techno-economic approach. Starting from macroscopic observations, we recorded colour, structure and opacity of the exploited lithic materials, as well as the occurrence and type of cortex and patina. In addition, for chert artefacts, we also detected, by using a stereomicroscope (magnifications between 10x and 60x), the presence of clasts, iron oxydes, and evidence of organic elements. We recorded the same data on the geological chert specimens collected during our surveys.

As to the other series, currently unavailable, it was necessary to make reference to already published data. Sometimes, this provided useful information as to the general features of the lithic collections, but less often gave specific details on raw material acquisition methods and on the techno-economic nature of the industries.

Table 1. Descriptive list of the considered sites and series (all the FN artefacts are long blades). Abbreviations: Map ref.: map references; Site types: DS - dwelling structure OAS - open air site (generic); B - burial; RS - rock shelter; Str - structure. Chrono-cultural attribution: IW - Impressed ware; CW - Cardial ware; EC - Epicardial; MNA - Middle Neolithic A; MNB - Middle Neolithic B; FN - Final Neolithic. Analysed lithic elements - lithic elements analysed in this work (where the number of lithic implements is lacking, this is because for the majority of the cited sites just global information and not quantitative data are available).

Map ref.	Site (city)	Type	Chrono-cultural attribution	Context reliability	Radio-carbon dates (2σ cal. BCE)	Exca-vations	Analysed lithic elements (n)			References
							chert	obsidian	other	
EARLY	**NEOLITHIC**									
1	Cala Corsara, Spargi	RS	CW	**	-	yes	-	-	-	Ferrarese Ceruti & Pitzalis 1987
2	Sa Korona di Monte Majore, Thiesi	RS	CW IW	**	-	yes	-	-	-	Foschi 1982; Foschi Nieddu 1987; Lo Schiavo 1976
3	Filiestru, Mara	RS	CW Epi	***	5731-5491 5702-5390 5616-5343 5545-5316 5216-4859 4932-4620	yes	-	-	-	Trump 1983: 44-46; Lugliè 2018
4	Su Coloru, Laerru	RS	CW Epi	***	5895-5570 5965-5322 5965-5322	yes	-	-	-	Pitzalis *et al*. 2004; Lugliè 2018
5	Su Paris de Sa Turre, Santa Caterina di Pittinuri	AS	CW	***	-	no	6889	3538	34	Lugliè 1998; Dini 2007; Tykot 2007
MIDDLE	**NEOLITHIC**									
3	Filiestru, Mara	RS	MNA	***	4932-4620 4609-4342	yes	-	-	-	Trump 1983: 47-50
6	Sa 'Ucca de su Tintirriolu, Mara	RS	MNA	***	4942-4179	yes	-	-	-	Loria & Trump 1978: 13
7	Cuccuru is Arrius - S. 422, Cabras	DS	MNA	***	4780-4494 4686-4368 4591-4341	yes	57	630	18	Sebis *et al.* 2012
8	Su Molinu Mannu - S. 2, Terralba	OAS	MNB	***	unpublished	yes	221	7783	0	Ucchesu *et al*. 2017; Fanti *et al*. 2018
9	Torre Foghe, Tresnuraghes	OAS	MNB	***	-	yes	-	-	-	Dini 2007; Dini *et al.* 2004
10	Li Muri, Arzachena	B	MNB	***	-	yes	4	-	-	Puglisi 1942; Puglisi & Castaldi 1964; Antona 2003
11	Contraguda, Perfugas	OAS	MNB	***	4358-4073 4358-4073	yes	-	-	-	Falchi *et al.* 2012; Costa & Pelegrin 2006

Map ref.	Site (city)	Type	Chrono-cultural attribution	Context reliability	Radio-carbon dates (2σ cal. BCE)	Exca-vations	Analysed lithic elements (n)			References
							chert	obsidian	other	
FINAL	**NEOLITHIC**									
12	Monte d'Accoddi, Sassari	S	FN	**	3971-3530 3895-3636 3772-3530 3763-3373	yes	17	-	-	Contu 1953; Traverso 2008; Melis 2009
11	Contraguda, Perfugas	OAS	FN	***	4046-3806 3964-3778	yes	-	-	-	Falchi *et al.* 2012; Costa & Pelegrin 2006
13	Anghelu Ruju, Alghero	B	FN	**	-	yes	17	-	-	Taramelli 1904; Demartis 1986:12-14
6	Sa 'Ucca de su Tintirriolu, Mara	RS	FN	***	3985-3767 3906-3637 3761-3521	yes	8	-	-	Loria & Trump 1978: 23
2	Sa Korona di Monte Maiore, Thiesi	B	FN	**	-	yes	8	-	-	Lo Schiavo 1976; Foschi 1982; Foschi Nieddu 1987
14	Su Pranu Mannu, Cabras	OAS	FN	*	-	no	70	-	-	Baiocchi 1992
7	Cuccuru is Arrius, Cabras	OAS	FN	***	-	yes	74	-	-	Melosu 2019
15	Is Cirquittus, Laconi	Str	FN	***	-	yes	7	-	-	Atzeni 2004
16	Puisteris, Mogoro	OAS	FN	**	-	yes	15	-	-	Puxeddu 1962; Atzeni 1978
17	Pranu Mutteddu, Goni	B	FN	***	-	yes	3	-	-	Atzeni & Cocco 1989
18	San Benedetto, Iglesias	B	FN	***	3961-3709 3941-3647 3942-3655 3942-3533	yes	12	-	-	Maxia & Atzeni 1964; Atzeni & Floris 2001
19	San Gemiliano, Sestu	OAS	FN	**	-	no	14	-	-	Atzeni 1958
20	San Michele, Ozieri	RS	FN	***	-	yes	5	-	-	Taramelli 1915

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In this research we also tried, through the analysis of a selected number of assemblages and their comparison to the closest potential areas of chert supply, to highlight the main characteristics and variability of raw material selection strategies, especially compared to obsidian. Our information on chert sources is based on the research literature (Bressy *et al.* 2007; Bressy-Leandri *et al*. 2019: 7; Leandri & Fernandes 2020) and, as well, on direct surveys we conducted in specific areas (Anglona, Montiferru, and Campidano) to evaluate raw material availability and quality. We also described the techno-typological features of the analysed Neolithic toolkits highlighting, when possible, the traits of continuity and discontinuity over three millennia. Therefore, the total number of artefacts analysed per site is quite variable (Table 1). In this work this distribution can be defined by using some adjectives referring to the chert percentage on the totality of raw materials exploited (few: ≤ 5%; considerable ≥ 5%; important or high ≥ 30%); when it was not possible to directly analyse the lithic collections, these definitions refer to the information or remarks available in the literature.

We excluded from our analysis the contexts with poor stratigraphic reliability, for which, namely, it was not possible to establish a sound chrono-cultural sequence (and as a result, a chronological attribution); however, the information concerning these sites might be taken into account to reconstruct at least a general picture of the raw material selection criteria.

3.1. The Early Neolithic: Predominance of opportunistic behaviour in raw material exploitation

During the EN (5800-5000 BCE) chert consumption was generally secondary in the island. However, this evidence varies depending on the geographical location of the sites: in some locales of North Sardinia, in fact, this material was widely exploited, and the proportion of other lithic materials is always minor. minor. According to the literature, this is the case for the sites of Cala Corsara (Ferrarese Ceruti & Pitzalis 1987), the caves of Sa Korona di Monte Majore (Foschi Nieddu 1987), Filiestru - trench D (Trump 1983: 25), and Su Coloru F-I levels (Pitzalis *et al*. 2004). The greater proximity of these settlements to significant chert outcrops than the obsidian ones, must have influenced the local supply strategies (Figure 5), even if the exploitation of this ready-to-pick material was never exclusive. Indeed, if the resource procurement seems to be generally ruled by the law of minimum effort, sometimes other qualities of chert coming from long-distance deposits, such as those identified in Anglona, have also been sought after, like happened for the Monte Arci obsidians (Ferrarese Ceruti & Pitzalis 1987; Sarti *et al*. 2012; Trump 1983: 71).

The most reported uses of all chert varieties are addressed to the production of irregular and aleatory flakes. A minority parallel production was oriented to the manufacture of blades and bladelets, mostly by exploiting high quality materials like Anglona chert (and obsidian); these blanks could have been mainly employed in the production of standardized formal tools such as geometrics. This kind of artefacts of higher technical investment is by far the smaller component of all the assemblages (Ferrarese Ceruti & Pitzalis 1987; Sarti *et al*. 2012; Trump 1983: 76-78).

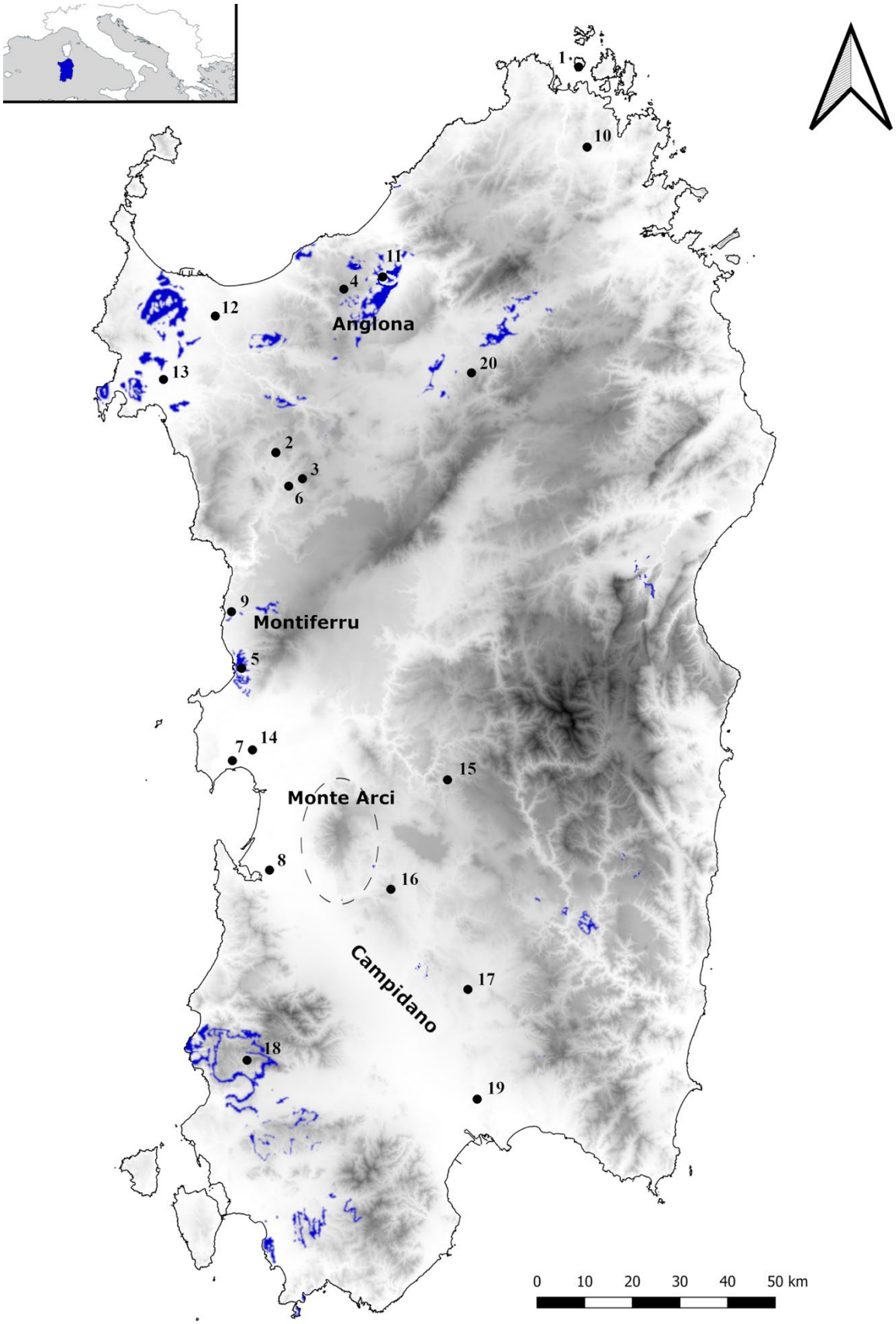

Figure 5. Map of Sardinia showing the chert-bearing formations, the Monte Arci obsidian direct procurement region, and the sites quoted in the text (site numbers correspond to the first column in Table 1).

An opposite trend in raw material selection criteria was observed in central and southern Sardinia. In this area the proportions of obsidian are higher than other siliceous materials: chert was almost exclusively employed as a minority complement of a production system mainly based on the exploitation of the volcanic glass. Only the Su Paris de Sa Turre settlement, located on the northern shore of Oristano (Figure 5), diverges from this trend, revealing specific raw material procurement behaviours, since it exhibits a high proportion of chert (66% in number, 80% in weight) and a low proportion of obsidian (20% in weight) (Dini 2007; Lugliè 1998). The high percentage of chert documented in this open-air site may be related to its geographical position near the outcrops of the Montiferru district of Santa Caterina di Pittinuri (Dini 2007; Lugliè 1998). In this area chert nodules and cobbles have been easily collected in a nearby secondary position. For the obsidian, different geochemical groups were exploited at Su Paris de Sa Turre, notably SB2, SA et SC (Dini 2007). All of these were available in secondary deposits located to the south and east of Monte Arci Massif, 45-60 km from the site (Lugliè 2012).

The typo-technological analysis of the Su Paris de Sa Turre lithic collection shows that the entire reduction sequence occurred in situ in the same occupation area, as reveals by the presence of cores, cortical surfaces on a number of elements, and technical pieces. The *débitage* of chert (and obsidian) at Su Paris de Sa Turre was mostly oriented towards unspecialized flake production, marked by irregular and aleatory morphology (Figure 6).

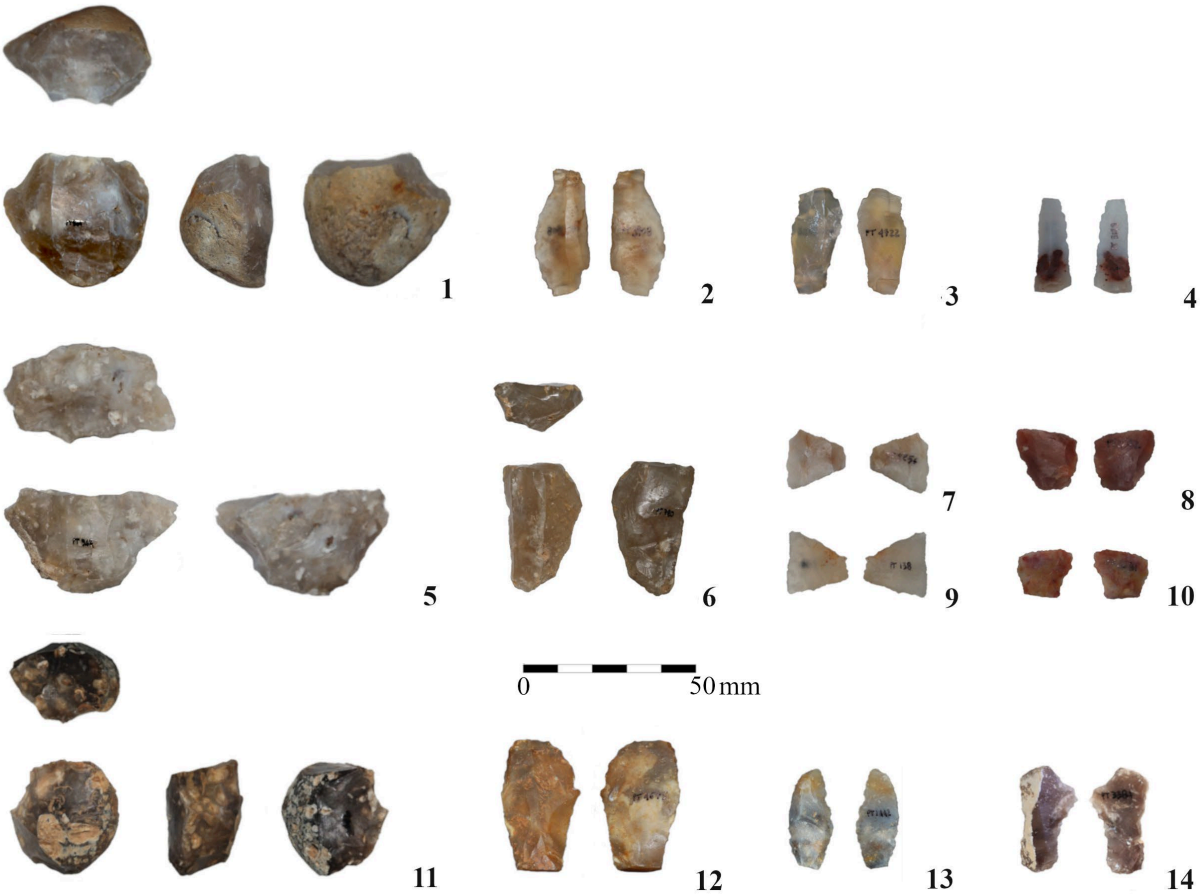

Figure 6. Chert lithic assemblage from the EN site of Su Paris de Sa Turre, Santa Caterina di Pittinuri. Cuglieri (OR) (mid of the 6th millennium BCE). Bladelet core (1, 5) and bladelet core side (6) with a single striking platform; flake core with multiple striking platforms (11); blade(let)s (2-4) and flakes like bladelet (12-14); truncations (8, 10) and geometrics (7, 9) (photograph by B. Melosu).

Blanks were obtained mainly through unipolar core exploitation, mostly by direct percussion. The reduction scheme was based on the recurrent reorientation of the core, allowing further reduction from platforms either orthogonal or opposed to the original one. The generally small size of the cores suggests an intense exploitation of the raw material units, even if most of them were discarded before being completely exhausted. This trend does not seem related to the size of the pebbles: it occurs, in fact, in the exploitation of the raw material units of ≤ 6 cm, as in the larger ones.

Blades and bladelets were generally manufactured using high quality chert or obsidian. These elements, obtained even by indirect percussion, were frequently transformed into truncations, geometric armatures, and backed points.

3.2. The Middle Neolithic: The increase of raw material exchange and distribution networks

During the Middle Neolithic (MN: 5th millennium BCE) a major decrease in the use of chert in favour of Monte Arci obsidian becomes evident: currently available data on knapped industries belonging to the Bonu Ighinu (MN A) and the San Ciriaco (MN B) Cultures illustrates this trend. Among the MN sites, only a few have been excavated to date and, concurrently, yielded according to the literature and our observations a considerable number of chert implements: this is the case for Filiestru (Trump 1983: 71) and Sa 'Ucca de Su Tintirriolu (Loria & Trump 1978: 44) caves, for the Structure 422 of Cuccuru is Arrius (Sebis *et al.* 2012) and the other open-air settlements of Contraguda (Falchi *et al*. 2012) and Torre Foghe (Dini 2007; Dini *et al.* 2004). The quantity of chert considerably varies depending on the context, but in most cases, it is limited; according to Falchi *et al.* (2012) only Contraguda provides a large number of chert implements; even so, the use of obsidian is still recorded.

As already noted, a general and significant increase in both proportions and quantities of this volcanic glass is reported on the island from the second half of the 5th millennium BCE. This seems to be a direct consequence of the full production capacity of obsidian workshops, operating near the primary outcrops on the slopes of the Monte Arci massif (Lugliè 2003; 2007; 2012; Lugliè & Lo Schiavo 2009; Tanda *et al*. 2006). Obsidian distribution modes changes, and this material becomes largely available to the whole island and to overseas regions (Lugliè 2012). Conversely, the exploitation of siliceous lithic resources keeps at a local level and conditional on the availability of the raw material in the immediate vicinity of the sites. The procurement of this resource was always expedient opportunistic, mostly without any reference either to quality or size of the collected geological units. Data on lithic assemblages coming from the MNA 422 structure of Cuccuru is Arrius and from the MNB open air sites of Torre Foghe and Su Molinu Mannu S2, exemplify these procurement strategies.

At Cuccuru is Arrius structure 422, only 8% of the 705 knapped elements currently available, are made on chert. The analysis of this representative series of the entire collection shows that the production processes occurred entirely in situ, as the presence of several cortical flakes and technical elements shows.

Regarding chert, the procurement strategies were exclusively aimed at collecting small material pebbles from secondary deposits, never exceeding the maximum length of 100 mm., although having a wider range of sizes among the geological units. The interest aroused by the raw material available in deposits closer to the settlement (south and west of the Montiferru Massif, 20 km away), considering the small number of artefacts, leads to the conclusion that chert supply was rather opportunistic and likely the result of occasional collection during embedded strategies of other resources exploitation (Figure 5).

The chert *débitage* (and to a lesser extent obsidian) was aimed towards the production of irregular flakes, chiefly by direct percussion (Figure 7). The reduction scheme was mainly based on the exploitation of small cores, essentially through a unidirectional *débitage* with frequent reorientation and creation of multiple platforms for new exploitation surfaces.

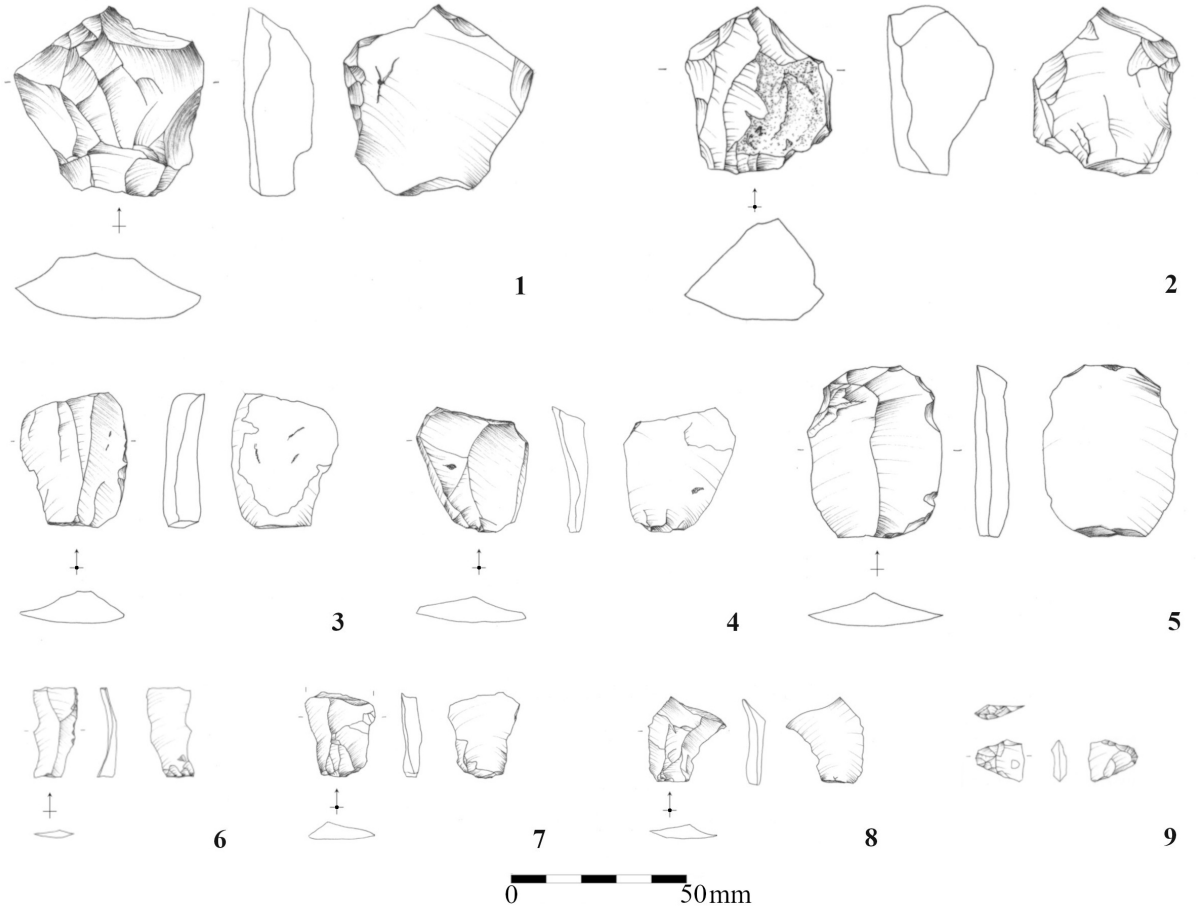

Figure 7. Chert lithic assemblage from the MNA site of Cuccuru is Arrius, Structure 422, Cabras (OR) (first half of the 5th millennium BCE). Rejuvenation flakes detached from cores with multiple striking platforms to remove a step fracture (1-2); flakes (3-5); flake like blade (8); blades (6-7), and microlithic geometric (9) (drawing by B. Melosu).

In this MN assemblage, the products of higher technical investment, like blade(let)s, were mainly produced either by direct or indirect percussion, on obsidian (particularly of the SA and SB2 qualities) and, far less frequently, on fine-grained chert available between the shore around Santa Caterina di Pittinuri and the Montiferru massif (Figure 3). These blanks were sometimes shaped to produce standardized formal tools.

As to the contemporary contexts of Filiestru and Sa'Ucca de Su Tintirriolu caves, our information is only based on the published data. These shows that chert played a part in the knapped industries of these sites but does not allow us to infer as far in terms of procurement and exploitation strategies, even if some local provenance of the used chert is claimed (Loria & Trump 1978: 44; Trump 1983: 76).

Regarding the later MNB lithic industries, our general level of information is still rather deficient; however, more data than for older phases are now available.

The few assemblages analysed for this study allowed us to detect a progressive emergence of a specialized production and a general increase in obsidian exploitation. This material is by far the most widely used lithic resource in the region, even in the settlements located outside the direct procurement area, namely where obsidian could be collected during

daily expeditions (Lugliè 2012). The selection strategies and the raw material acquisition modes at Su Molinu Mannu site fit into this pattern. This open-air settlement, currently under excavation, exhibits a very high proportion (n = 7783; ≈ 97,2 % of the lithic material) of obsidian implements with a minor number of chert elements (n = 250; ≈ 2,7 % of the lithic material). Chert varieties exploited at Su Molinu Mannu are available less than 20 km from the site, in the area located to the south-southeast of Monte Arci which constitutes the main supply region of this lithic resource (Figure 5). However, these materials could have also been found in the close vicinity of the settlement, in the alluvial deposits along the Rio Mogoro riverbed where small nodules and cobbles could be easily picked. Regarding the obsidian, the SC geochemical variety is by far the most exploited; its acquisition, even direct, was quite easy because both primary and secondary deposits spread within a radius of less than 20 km from the site (Lugliè 2006: 71).

At Su Molinu Mannu, independently of the raw material, the reduction knapping process was strongly oriented to flakes production. The reduction scheme was mainly based on the recurrent reorientation of the core, which allowed its exploitation from orthogonal or opposed platforms with respect to the original one. Blades and bladelets were almost always made on obsidian, frequently by indirect percussion or, less often, by pressure-flaking from a single platform. These elements were frequently transformed into truncations and geometric elements, or single-sided retouched tools (Figure 8).

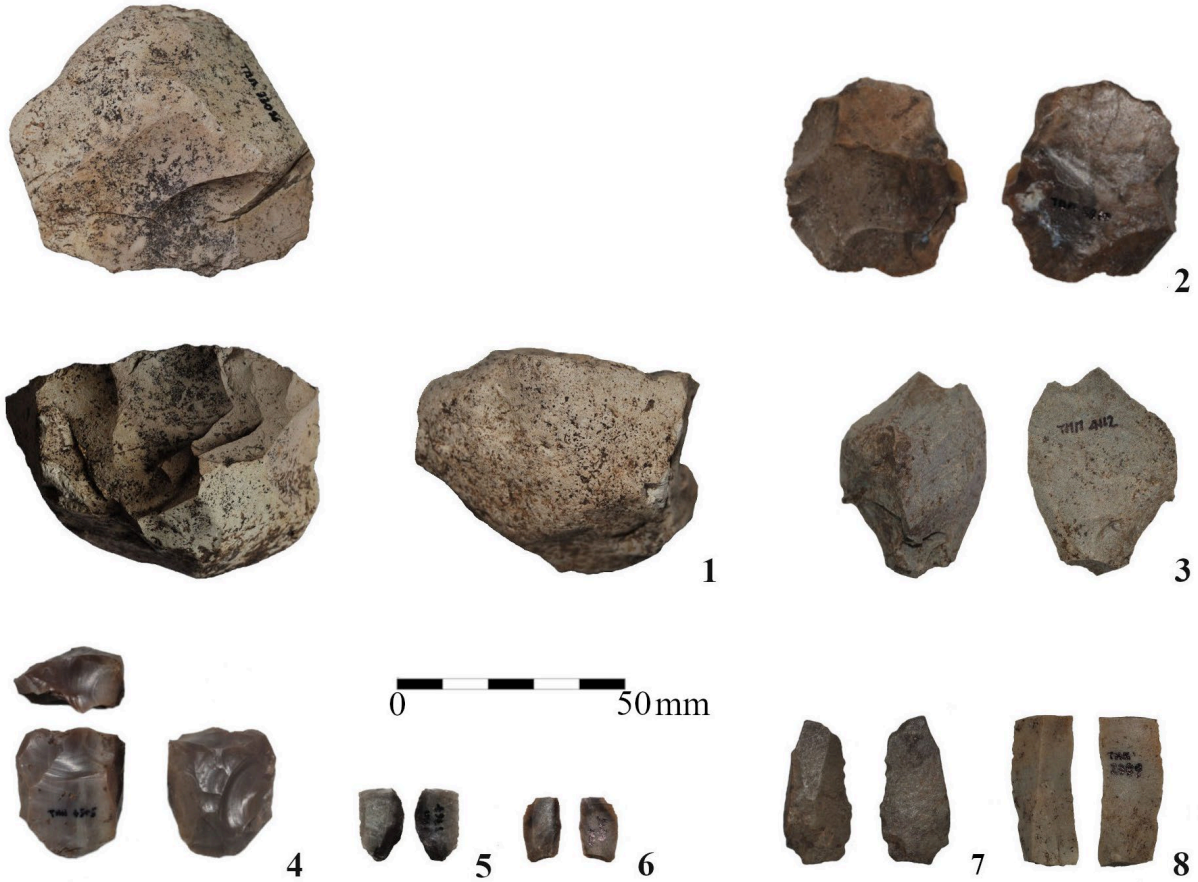

Figure 8. Chert lithic assemblage from the MNB site of Su Molinu Mannu, Terralba (OR) (second half of the 5th millennium BCE). Flake core with single striking platform (1); flake core with multiple striking platforms (4); cortical flakes (2, 3, 7); blade(let)s (5, 6, 8) (photograph by B. Melosu).

Even the lithic assemblage of the Torre Foghe settlement reveals some similarities in terms of procurement strategies and production schemes (Dini *et al*. 2004). At this site it was

possible to recognize two different procurement methods, for obsidian and for chert, respectively. The former raw material, mainly from SC quality (91%), comes both from primary deposits along the east side of Monte Arci (about 60 km away from the archaeological site) and from secondary deposits 50 km away (Lugliè & Lo Schiavo 2009; Tanda *et al*. 2006). Chert acquisition, instead, is performed on a sub-local scale: the raw material varieties exploited in this settlement can be collected, in fact, from the secondary deposits south of the Montiferru massif, less than 20 km away from the site (Figure 5). Although more readily available, and even though it is predominantly of good quality, this material was exploited alternatively to obsidian, which widely circulated throughout the island.

A different trend characterizes the MNB levels of Contraguda, a few kilometers North from Perfugas: 95% of the lithic artefacts dated to this chrono-cultural phase are, in fact, made from chert (Sarti *et al*. 2012); its acquisition is performed exclusively on a local scale, the sources being located in close proximity to the site. It is evident that, in this case, raw material procurement was ruled by the law of minimum effort, especially because of the good quality of the chert.

3.3. The Late to Final Neolithic: The development of a mass-production system

In Sardinia at the end of Neolithic, in the first half of the 4th millennium BCE, the lithic assemblages relied almost exclusively on the intensive exploitation of Monte Arci obsidian. At that time, this volcanic glass seems to have achieved the state of ordinary raw material for most of the Sardinian groups, who were able to easily obtain it through well-structured exchange networks (Lugliè 2012).

While obsidian largely circulated over the whole island, a complementary circuit involved the good-quality chert from Anglona, which was exchanged only in the form of long blades and was possibly requested like a true valuable good (Guilbeau 2010: 168; Lugliè 2009). These artefacts, despite being used for ordinary tasks, were possibly objects of high consideration, given their rarity, their high standardized manufacture, and the curated technology, true realm of craftsmanship (Figure 9).

In fact, just one case bears the best evidence of a specialized workshop for these technologically invested artefacts: it was identified at the site of Contraguda, a few kilometers north of Perfugas, settled from the end of the 5th to the middle of the 4th millennium cal. BCE (Falchi *et al.* 2012). The FN assemblage of Contraguda shows that different chert varieties were exploited; nevertheless, for the long blade production either a beige, brown, or even a gray-banded flint from the nearby outcrops was selected (Costa & Pelegrin 2004). Many long blades, found both in domestic and funerary sites away from Contraguda, were made of flint using other good-quality types available from the Perfugas-Laerru basin as well (Melosu & Lugliè 2017). It is safe to assume that other workshops had to exist, and operated, maybe at once, in this region. None of the long blades bearing sites show any evidence of flint reduction *in situ*; thus, it is possible to state that blades entered the consumer sites in the form of already finished products.

As to the technical features of these artefacts, it is evident that both cobbles and tabular flints were employed to their production; the second one seems to be preferred for this specialized production among the available natural shapes. About the raw material reduction, different techniques have been detected in these artefacts: indirect percussion and simple/lever pressure as well (Costa & Pelegrin 2004). Regarding the latter, no evidence has been recorded thus far in the San Ciriaco lithic assemblages; this technique, particularly when performed by a lever (sometimes with a copper point), is regularly employed in the FN to produce these blades and represents a real novelty in the regional chipped lithic technology. The

introduction of this innovation may be linked to the presence in Sardinia of a closed group of specialized craftsmen, perhaps foreign people who mastered this technique. If a workshop could be identified for the above-mentioned blades, this is not the case for some other high-curated artifacts made with the same raw material -namely a small number of daggers- found in some older excavations, especially funerary hypogea (Atzeni & Cocco 1989).

Figure 9. Long blades made of Anglona flint from the Final Neolithic site of Cuccuru is Arrius, Cabras (OR) (photograph by B. Melosu).

Parallel to this, an ordinary industry based on the exploitation of locally available low-quality chert is also documented during the FN. Its use is clear evidence of opportunistic behaviour, without much care for quality. This material was mostly employed within the framework of low-invested production, mostly composed of flakes without any care for formal standardization; laminar blanks were regularly made on obsidian, and during this phase the volcanic glass circulated mostly as polyhedral cores shaped for blade production.

4. Discussion and conclusions

This study dealt with the modes of chert exploitation in Sardinia during the Neolithic, combining the information on major chert sources identified across the island with the technological analysis of a series of reliable archaeological series. It focused on the main changes in raw material selection and on the evolution of technological behaviours between the 6th and the 4th millennium BCE.

The results obtained show that, during the EN, Sardinia was divided into two parts, North and South, in terms of chert procurement habits. In North Sardinia, the amount of chert in archaeological assemblages is often important, while in the South this raw material is scarcely attested. As it has been noted, chert procurement was ruled by the availability of this resource in the vicinity of the sites, where it was collected either by direct procurement or, likely, during occasional trips. For obsidian, its earliest procurement and distribution seems to not have developed into organized exchange circuits, and to have been rather linked to the high mobility and close interdependence of earliest Neolithic colonists settled over broad distances (Lugliè 2012).

At that time, this raw material crossed regional borders, probably transported by early foreign explorers, reaching the continent and neighbouring Corsica. Abroad, obsidian had a wider diffusion than flint which, likely due to its vicinity and because of possible economic and cultural imperatives, was above all transported in Corsica. Chert, and in particular the best facies of the Perfugas basin, was introduced to sites from northern Corsica mainly as end-products, while blanks predominate in southern settlements, probably because of direct contact with local communities settled close to the Anglona outcrops (Leandri & Fernandes 2020). These materials with valued knapping properties were employed to produce artefacts according to a higher standardization, like blades and bladelets.

In the 5th millennium BCE, concurrently with the emergence of well-defined cultural identities and the increase of social differentiation, the earlier uncontrolled and generalized direct raw material procurement shifted to a veritable organized mass-production system of worked elements made in obsidian, to be exchanged both inside and, especially, outside Sardinia (Corsica, Northern Italy, southern France). This is due, on the one hand, to the full production capacity of the Monte Arci workshops and, on the other hand, to the possible set up of specialized obsidian procurement and exchange networks (Lugliè 2012). Chert exploitation, instead, kept being mainly local, and knapping activities were mostly oriented, as before, to the production of flakes, with rare occurrence of standardized formal tools and blade(let)s; obsidian of SC and SA qualities was, in fact, almost always preferred to produce these artefacts (Lugliè 2012).

At the end of the 5th millennium BCE, due to the role carried out by San Ciriaco and, later and apparently without interruption, by the Ozieri cultures in the control and development of the Monte Arci obsidians production system, lithic assemblages were clearly grounded almost exclusively in the intensive exploitation of this resource. During this epoch, obsidian seems to have reached the status of ordinary material for the groups settled on the island, who were able to easily receive it through the branching of regional exchange networks. On the other hand, overseas Monte Arci obsidian continued to be considered an extra-ordinary and exotic material, whose value likely increased with the distance from its source (Melosu & Lugliè 2017).

Flint was never entangled in these distribution circuits, and it continued to be used almost exclusively at the local level, to produce a rather expedient lithic industry. A different consideration deserves some specific qualities of chert coming from the Perfugas outcrops, which seem to have achieved the status of a rare raw material. However, this different perception does not seem to depend on the material in itself, rather on the added high value

assigned to the artifacts produced with it. The occurrence of these specialized implements was documented almost exclusively on a regional scale, although very few Sardinian chert long blades are known outside the island: in fact, three specimens were found in Corsica (Leandri & Fernandes 2020) and one in Tuscany (Guilbeau 2010: 204). This scant quantity suggests that these chert long blades travelled occasionally abroad, possibly through already existing exchange and (or) circulation routes: it seems that neither these curated products, nor this raw material aroused a great interest outside Sardinia, where such artifacts had long been appreciated. At the beginning of Copper Age (the last centuries of the 4th millennium), chert's use gradually decreased until it disappeared, while obsidian remained in use throughout the Bronze Age, even though the assemblages were technically simpler and less structured than before.

A further validation for this scenario is expected in the near future. New data are still needed on the Neolithic knapped industries, through the analysis of additional collections performed by combining a tecno-economic analysis and a detailed mapping of chert outcrops and (or) lithotype variability. This approach should provide new insights on this relevant subject.

Data accessibility statement

The authors confirm that the data supporting the findings of this study are available within the article.

The data source for Figure 1 is available online at https://www.sardegnageoportale.it/areetematiche/

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Exploitation du silex et productions en Sardaigne au Néolithique : Bilan et synthèse des données

Barbara Melosu, Carlo Lugliè

Université de Cagliari, LASP (Laboratoire d'Antiquités Sardes et de Paléoethnologie). Piazza Arsenale 1, 09124, Cagliari, Italie. Email: Melosu: barbara.melosu@gmail.com; Lugliè: luglie@unica.it

Abstract:

La Sardaigne néolithique offre une grande richesse en vestiges en pierre taillée qui, à l'heure actuelle, reste plutôt sous-exploitée, même si ces dernières années, on assiste à un regain d'intérêt pour ces matériaux. Malheureusement ces tentatives restent encore peu fréquentes et se limitent, en général, à un gisement ou à plusieurs sites proches, réduisant les possibilités d'intégrer l'industrie étudiée dans un cadre de réflexion plus large. De plus, ces recherches se focalisent, le plus souvent, sur un lithotype en particulier : l'obsidienne du Monte Arci (Oristano), tandis que les matières siliceuses n'ont suscité qu'un faible intérêt. L'historique des recherches montre, en fait, la presque absence, jusqu'à ces dernières années, de travaux portant sur l'ensemble des matériaux siliceux de Sardaigne qui, même si utilisés plus faiblement que l'obsidienne, peuvent néanmoins nous renseigner sur les comportements et les habitudes techniques des gens qui ont habité l'île au cours du Néolithique.

Ce travail vise donc, d'un côté, à éclaircir les modalités de gestion et les logiques d'approvisionnement des matériaux siliceux - en particulier par rapport à l'obsidienne - et, de l'autre côté, à décrire les vestiges lithiques sous l'aspect techno-typologique. À travers cette approche techno-économique, il a été possible de mettre en évidence, en succession diachronique, les critères évolutifs de continuité et (ou) de discontinuité caractérisant les séries en pierre taillée examinées et, également, de décrire la transformation des comportements et des choix des groupes préhistoriques par rapport aux ressources lithiques exploitées.

Ainsi, pour le Néolithique ancien (VIème millénaire), le recours au silex semble varier en fonction de la disponibilité de ce matériau aux alentours des sites consommateurs. Parfois cette roche était utilisée de préférence et dans ces cas, la proximité était un argument de choix primant sur l'aspect qualitatif.

Pendant le Vème millénaire, un des principaux faits marquants des séries lithiques sardes est l'emploi prépondérant de l'obsidienne du Monte Arci qui, surtout avec l'avènement de la culture de San Ciriaco, commence à circuler de façon systématique dans la région ; le silex, en revanche, reste confiné à une utilisation exceptionnelle et, en même temps, à une production techniquement peu investie et souvent expédiente. Dès le début du IVème millénaire, on observe finalement, dans les collections lithiques sardes, la nette prépondérance de l'obsidienne, qui représente désormais le lithotype le plus largement utilisé dans l'île. À cette époque on constate d'une part, la recherche d'une variété spécifique de ce matériau (celle des sources oligo-miocènes localisées en Anglona, Nord Sardaigne), ayant vraisemblablement valeur de bien exotique, qui est utilisée pour des productions à haut investissement technique et, d'autre part, le recours à des silex ordinaires repérés à proximité des sites consommateurs.

En Sardaigne la place du silex dans les assemblages lithiques néolithiques apparaît donc varier sur base chronologique, mais aussi géographique ; en effet, pendant le Néolithique ancien le recours à ce lithotype est assez fréquent au nord, tandis que dans les régions du sud et du centre l'obsidienne est employée majoritairement. Le rôle prépondérant de cette roche sera plus net pendant le Néolithique moyen et elle deviendra dominante au Néolithique récent, quelle que soit la région considérée.

Keywords: silex ; Sardaigne ; exploitation ; techno-économie ; Néolithique