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Non-Flint Raw Material Use in Prehistory

Old prejudices and new directions

L'utilisation préhistorique de matières premières lithiques alternatives

Anciens préjugés, nouvelles perspectives

Edited by

Farina Sternke, Lotte Eigeland
and Laurent-Jacques Costa

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OBSIDIAN ECONOMY IN THE RIO SABOCCU OPEN-AIR EARLY NEOLITHIC SITE (SARDINIA, ITALY)

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***Abstract**: Integrated provenance/typo-technologic/chaînes opératoires studies on obsidians from Early Neolithic (EN) assemblages are still quite exceptional in the western Mediterranean region. The Rio Saboccu S1-S2 EN dwelling structures (Central-western Sardinia) ^{14}C dated to the last three centuries of the VIth millennium BC provided us with an opportunity to apply such an approach. A comprehensive provenance study of its 1.114 obsidian artefacts was realized through a combined visual/instrumental approach. Elemental compositions were determined mostly by ion beam analysis (PIXE) and by electron microprobe (SEM-EDS).*

The S1-S2 structures are situated inside the so-called supply zone of the Monte Arci volcanic complex. A technological analysis of the implements revealed a non-opportunistic behaviour in relation to obsidian procurement among the four (SA, SB1, SB2, SC) Monte Arci types locally available in various contexts (from primary to secondary sources). A comparison with other Sardinian EN sites suggests that the human groups settled near the Monte Arci sources might have acted as a 'filter' in the first stages of the diffusion of obsidians in Sardinia and possibly elsewhere in the northern Tyrrhenian area.
***Keywords**: obsidian provenance, PIXE, Early Neolithic, Rio Saboccu, Sardinia*

***Résumé**: Les études intégrées de provenance/typo-technologie/chaînes opératoires d'obsidiennes de séries Early Neolithic (EN) sont encore exceptionnelles en Méditerranée occidentale. La structure d'habitation S1-S2 de Rio Saboccu (Centre-ouest Sardaigne), datée par ^{14}C des trois derniers siècles du IIIème millénaire BP a offert une telle opportunité. Une étude de provenance de ses 1114 pièces d'obsidienne a été menée par une approche combinée visuelle/instrumentale. Les déterminations de composition élémentaire ont été réalisées par analyses sous faisceaux d'ions (PIXE) ou par microsonde électronique (MEB-EDS).*

Les structures S1-S2 sont situées dans la zone d'approvisionnement direct des obsidiennes du complexe volcanique du Monte Arci. Une analyse technologique du matériel a révélé des comportements non-opportunistes dans la collecte des quatre (SA, SB1, SB2, SC) types d'obsidiennes du Monte Arci, disponibles localement en diverses situations (gîtes primaires à secondaires). Une comparaison avec les autres sites EN de Sardaigne suggère que les choix des groupes humains installés à proximité du Monte Arci auraient pu constituer une sorte de 'filtre' et exercer une influence sur les premiers stades de la diffusion de l'obsidienne en Sardaigne et au-delà, dans la zone nord-tyrrhénienne.
***Mots clés**: provenance d'obsidienne, PIXE, Néolithique ancien, Rio Saboccu, Sardaigne*

INTRODUCTION

During the last twenty years, intensive archaeological surveys between the shoreline of the Gulf of Oristano and the nearby Monte Arci volcanic complex of Sardinia yielded an entirely unexpected presence of Early Neolithic (EN) settlements. In this area, previously considered in the past as an unpopulated region during this period, no less than nine open-air sites with ages estimated to the VIth millennium BC were discovered. Among those is the Rio Saboccu campsite which was discovered in the 1980s (Lugliè 2004). Obsidian, whose Sardinian sources are all linked to the Monte Arci massif, counts for almost the total of all lithic assemblages from these sites, which suggests that the EN populations in this coastal plain may have played an important role in the exploitation and the diffusion of this lithic raw material.

Earlier studies have shown that Sardinian obsidians have their primary sources (as inclusions in their volcanic parent rocks) in the Monte Arci volcanic massif. Four types, SA, SB1, SB2 and SC can be distinguished from each other for provenance studies on the basis of their elemental compositions (Hallam – Warren – Renfrew 1976; Tykot 1997) or their physical properties (Scorzelli *et al.* 2001; Stewart *et al.* 2003). More subtle subdivisions between these types (Francaviglia 1986; Tykot 2002) are only of

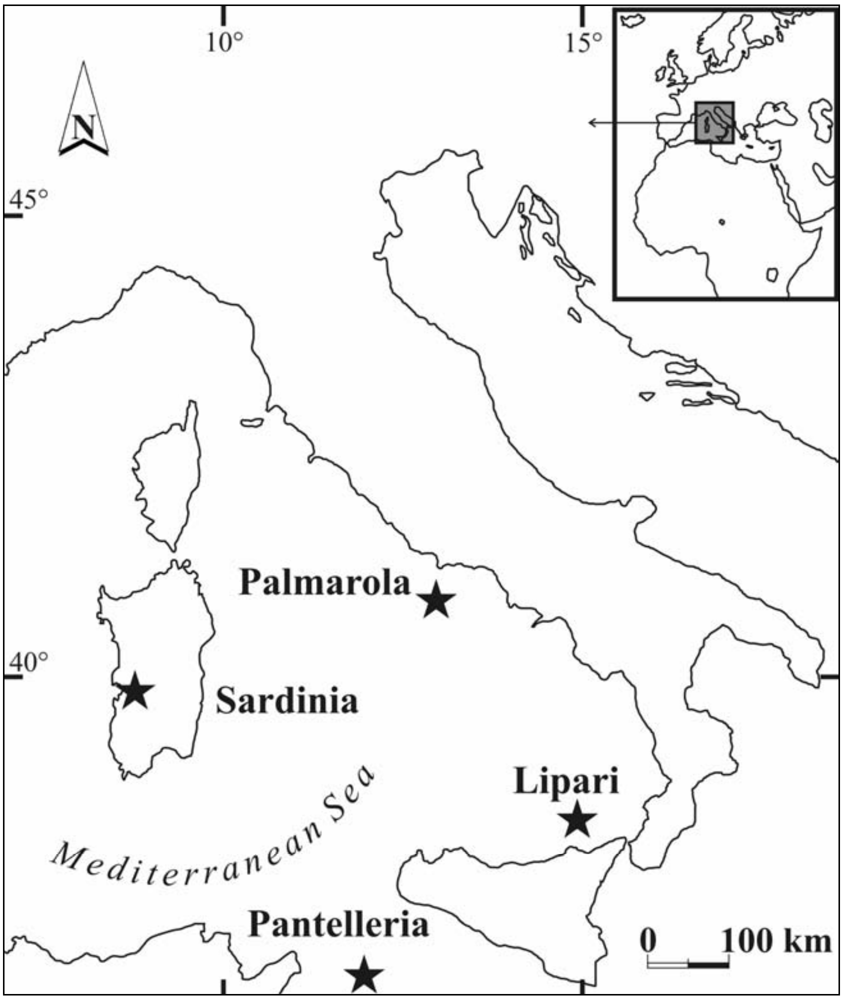

Fig. 21.1. Schematic maps of the Western Mediterranean showing the obsidian source-islands Lipari, Palmarola, Pantelleria and Sardinia

interest in volcanologic studies. Some of us have recently shown that the occurences of these obsidians were not limited to their primary sources, but could be much more extended, especially for SB2 and SC obsidians in 'secondary' sources as blocs and cobbles as the result of erosion and transportation by natural agents (Lugliè *et al.* 2006). Although Sardinian obsidians may present various compositions, they are easily distinguished from other western Mediterranean obsidians (Fig. 21.1) through their major and trace element contents (Le Bourdonnec – Poupeau – Lugliè 2006).

So far, provenance studies of EN obsidians in Sardinia involved only very few sites (see Lugliè *et al.* 2007) and were often limited to a small fraction of the available material. Only in the Su Carroppu case (SW Sardinia) this kind of investigation was comprehensive and associated with study of the *chaîne opératoire* of production (Lugliè *et al.* 2007). In this paper, we present a similar approach of the Rio Saboccu obsidians, including sourcing, typo- and technological descriptions and an attempt to identify the particular *chaînes opératoires* followed by local knappers.

THE RIO SABOCCU SITE IN HIS CONTEXT

The Rio Saboccu site is situated less than 5 km away from the shoreline of the Gulf of Oristano on the northern edge of a Würmian terrace dominating the San Giovanni-Marceddì lagoon (Fig. 21.2). Over an area of about 10.000 m^2, the terrace surface contains several obsidian concentrations which were uncovered by present agricultural activities. At an altitude of about 5 m above sea level, the site itself is on a steep scarp created by rising lagoon waters under the influence of a strong wind ('Mistral') coming at times from the north-west. It is the regressing erosion of this terrace which brought to light the natural stratigraphic profiles of two artefact-bearing structures, S1 and S2, at only 3 m from the bank of the lagoon. This phenomenon possibly started with the eustatic sea-rise accompanying the latest phases of the Tardiglacial.

These structures, partially dug out into a gravelly soil some 30 cm below the actual eroded terrace surface, are backfilled by a dark-brown anthropogenic soil with charcoal, faunal remains and artefacts. Both, the great

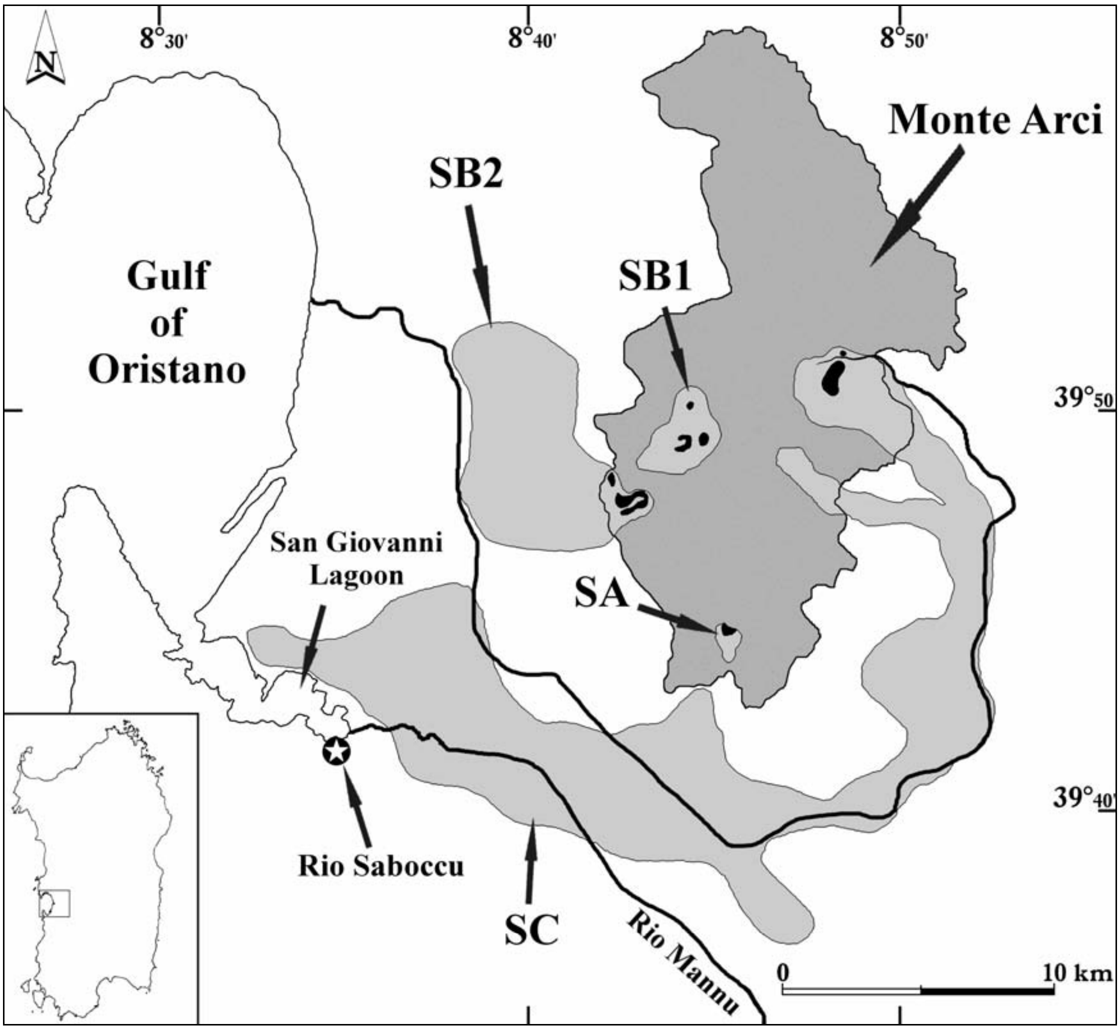

Fig. 21.2. Location of the Rio Saboccu S1-S2 site and of the Monte Arci volcanic complex in Sardinia. The secondary obsidian sources are shown as light grey areas and the primary sources, all located inside the Monte Arci massif, are indicated (in these areas) in black (adapted from Lugliè *et al.* 2006a)

homogeneity of this soil and the fact that artefacts collected at different depths can be refitted together suggest a short formation time of the structures. Several integral systematic collections of artefacts exposed in the profiles yielded a handful of small and thick potsherds with coarse non-decorated surfaces of indeterminate typology (mainly simple bowls with rounded rims), as well as more than 1.000 lithic artefacts. Two radiocarbon dates on charcoal of *Arbutus unedo L.* sampled from the lower layer of the larger structure S2 (9.5 m long x 1.3 m deep) provided calibrated ages for this context slightly older than the VIth millennium BC, namely 6266±48 BP (5341-5066 cal 2σ, AA-58899) and 6230±60 BP (5320-5027 cal 2σ, Ly-3010) respectively (calibrations from the routine dataset *intcal04.14c*, Reimer *et al.* 2004). This corresponds to the late EN, or the Phase III of the Sardinian EN Foschi 1982; Atzeni 1987; Tanda 1988; Tanda 1998.

Among the faunal remains some terrestrial species like goat were identified. Marine species which are predominant in the nearby (4 km NW) coeval Neolithic dwelling structure of Sa Punta-Marceddì (Terralba) are absent at Rio Saboccu. Based on palaeontological and sedimentological data, the paleoenvironment of the site can be described as one of an alluvial terrace covered by xerophil Mediterranean woodland and maquis with *Juniperus* sp. on the border of river-streams. Geomorphological evidence of old river bed meanders clearly indicates a time-decreasing flow energy which might be related to a prograding sea-level. In such a landscape, human subsistence might have been oriented more towards hunting and ovi-caprines rearing activities than cultivating.

THE LITHIC COLLECTION: RAW MATERIALS

1.058 chipped stone artefacts have been collected exclusively from the stratigraphic profiles of the S1 and S2 structures, 1.047 of which are obsidians. The artefacts look generally fresh, with a low degree of weathering of

Tab. 21.1: Absolute and relative distribution of raw materials at Rio Saboccu S1-S2

	obsidian					chert	chalcedony
	SA	SB1	SB2	SC	undetermined*		
number	585	4	300	146	12	8	3
%	55.2	0.3	28.3	13.7	1.1	0.7	0.2

*Chemical compositions not yet determined

the flaked and retouched surfaces which strengthens the hypothesis of a rapid formation of the stratigraphic deposits. On rare occasions, evidence of thermal alteration is ascribed to accidental exposure to fire.

Based on the presence of almost all the stages of the reduction sequence, an *in situ* obsidian flaking activity is inferred. Other rocks, such as chert and chalcedony also appear to have been exploited for tool production (Table 21.1). All these raw materials are easily accessible locally in secondary alluvial deposits and putative volcanic primary sources are known in the Monte Arci (Fig. 21.2).

The obsidian provenance is discussed below. Among the other raw materials, chert and chalcedony are most probably of a local origin, as they are readibly available in secondary alluvial deposits in the plain surrounding the site and the San Giovanni lagoon. They owe their formation to a miocenic post-aquitanian diagenetic process linked to underwater volcanism (pillow-lavas) which occurred during the early stages of the Monte Arci development and whose major traces lie in the Morgongiori-Masullas area some 25 km East from Rio Saboccu.

OBSIDIAN PROVENANCE

Nearly all obsidians were visually assigned to one of the four geochemical Monte Arci types. Forty artefacts of ambiguous macroscopic determination were also fingerprinted based on their elemental composition.

The contents of elements Na, Al, Si, K, Ca, Ti, Mn, Fe, Zn, Rb, Sr, Y, Zr and Nb were determined on 38 Rio Saboccu obsidians through particle induced X-ray emission (PIXE) at *Centre de Recherche et de Restauration des Musées de France* (Paris). The analyses were carried out using the 'extracted' beam line of the AGLAE facility (Calligaro – Macarthur – Salomon 1996; Calligaro *et al.* 2002), where element contents are determined simultaneously using two Si(Li) detectors (Le Bourdonnec *et al.* 2005). Twenty six samples were derived from polished sections and twelve artefacts analysed non-destructively. The results are presented in Table 21.2. It appears from a Zr *vs.* Rb content diagram that the only possible origin of these obsidians is Sardinia (Fig. 21.3). Type attributions (last column on right) were determined from the data obtained on forty geological samples under the same conditions. Analytical data are given for thirteen of these samples in Table 21.3 and for materials analysed previously in Lugliè *et al.* (2007) and Poupeau *et al.* (2000). All geological samples were analysed in the form of polished sections. Twenty one artefacts are of the SA type and nine and eight of the SB2 and SC types respectively, as shown in a Zn-Sr-Zr diagram (Fig. 21.4).

In two other archaeological pieces, the major element Na, Al, Si, K, Ca and Fe contents were obtained from polished sections at the Bordeaux laboratory using the energy dispersive spectrometer of a scanning electron microscope (SEM-EDS). A comparison between the element contents in these samples and in 99 geological samples analysed under the same conditions (Le Bourdonnec – Poupeau – Lugliè 2006) shows that they belong to the SB1 clan.

Among the forty obsidians classified both, visually and instrumentally the former determination was correct in only 67 percent of the cases. This is a 'success' rate equivalent to that achieved by Tykot (2002) and Tykot – Ammerman (1997) for various Sardinian sites and lower than the 85 percent obtained by Lugliè *et al.* (2007) for the Su Carroppu EN Sardinian site. If one takes into account the forty instrumental determinations and the visual attributions on the other Rio Saboccu obsidians, 56 percent of the obsidians are of the SA type, 29 percent of the SB2 type, and fourteen percent of the SC type. As is common on Neolithic sites, obsidians of the SB1 type are almost totally absent (less than one percent).

TECHNOLOGICAL CHARACTERISTICS OF THE OBSIDIAN ASSEMBLAGE

The overall distribution of the typo-technological categories in the obsidian assemblage is dominated by debitage, followed by retouched pieces and cores (Table 21.1); surprisingly despite careful screening, less than five percent of debris and shatter under 10 mm in size were recorded inside the S1-S2 structures, which raises the problem of the location of flaking activities on the campsite. Debitage is mainly represented by flakes (57.4 percent) and less frequent blade(let)s (together 7.1 percent). The first stages of the reduction sequences are present as shown by the large number of cortical upper surfaces preserved on the retouched pieces (a total of 386 implements or 37 percent). Cortical remains belonging to the four Monte Arci obsidian types were identified which implies that core preparation took place *in situ* on blocks

Tab. 21.2: PIXE chemical compositions of Monte Arci obsidians

Sample	Na_2O	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	MnO	Fe_2O_3	Zn	Ga	Rb	Sr	Y	Zr	Nb	Type	*
SAB5	2,91	15,26	72,65	5,43	0,99	0,31	0,02	1,77	68	21	176	138	27	223	29	SC	ND
SAB20	3,10	14,32	73,84	5,40	0,86	0,27	0,03	1,68	60	21	182	144	27	244	30	SC	D
SAB24	3,02	14,38	73,87	5,42	0,83	0,28	0,03	1,75	59	20	189	129	23	249	34	SC	D
SAB44	3,03	14,30	73,55	5,33	0,98	0,32	0,03	1,90	62	22	185	153	31	248	34	SC	D
SAB85	3,29	13,71	75,87	4,83	0,60	0,10	0,05	1,18	72	22	219	31	34	63	45	SA	ND
SAB92	3,12	13,49	75,58	5,11	0,60	0,16	0,03	1,45	46	19	236	65	21	129	28	SB2	D
SAB93	3,05	14,66	72,96	5,51	0,99	0,33	0,03	1,88	62	21	182	189	29	238	40	SC	D
SAB97	3,19	13,61	76,11	4,85	0,60	0,09	0,05	1,15	73	24	254	44	27	80	52	SA	D
SAB104	3,26	13,75	75,71	4,87	0,61	0,10	0,05	1,29	82	25	252	31	37	77	55	SA	ND
SAB108	3,41	14,12	75,46	4,72	0,64	0,09	0,05	1,20	77	24	259	39	35	84	58	SA	D
SAB131	3,19	14,01	75,18	4,91	0,65	0,10	0,06	1,51	90	27	276	36	41	81	56	SA	ND
SAB133	3,25	13,65	75,67	4,92	0,61	0,10	0,05	1,36	92	29	307	42	45	92	64	SA	ND
SAB138	3,27	13,83	75,79	4,76	0,62	0,09	0,05	1,27	75	24	256	38	34	74	61	SA	D
SAB139	3,17	13,48	75,65	5,09	0,60	0,15	0,03	1,43	46	20	245	60	23	121	32	SB2	D
SAB161	3,25	13,77	75,64	4,82	0,58	0,10	0,05	1,44	82	25	261	28	39	76	64	SA	D
SAB176	3,04	13,27	75,36	4,89	0,55	0,13	0,03	2,42	52	21	247	47	24	111	27	SB2	D
SAB203	3,19	13,78	75,80	4,81	0,57	0,10	0,05	1,36	80	24	263	34	36	85	61	SA	D
SAB244	3,14	13,70	75,99	4,81	0,57	0,09	0,05	1,33	80	24	262	34	39	85	55	SA	D
SAB276	3,15	13,75	75,58	4,82	0,58	0,10	0,05	1,61	87	24	273	31	31	85	66	SA	D
SAB317	3,09	13,39	76,13	5,11	0,58	0,14	0,03	1,16	45	19	248	54	22	117	30	SB2	D
SAB373	3,15	13,73	75,95	4,85	0,58	0,08	0,05	1,26	80	25	257	36	41	78	58	SA	D
SAB378	3,02	13,25	76,39	4,99	0,55	0,11	0,03	1,30	47	20	267	34	20	104	37	SB2	D
SAB388	3,11	14,24	74,87	4,88	0,61	0,11	0,05	1,66	97	28	277	34	39	82	58	SA	ND
SAB459	3,03	13,67	75,92	4,95	0,60	0,09	0,05	1,28	89	27	298	31	41	92	60	SA	ND
SAB481	3,34	13,84	75,71	4,74	0,59	0,09	0,05	1,30	81	24	262	33	35	82	60	SA	D
SAB552	3,20	14,23	75,19	4,80	0,66	0,10	0,05	1,30	91	27	289	38	45	84	61	SA	ND
SAB569	3,11	14,46	73,61	5,31	0,96	0,27	0,03	1,73	60	22	178	161	26	247	36	SC	D
SAB707	3,32	13,96	75,17	4,88	0,63	0,11	0,06	1,45	86	26	267	34	43	82	54	SA	ND
SAB755	3,09	13,38	76,18	5,07	0,58	0,14	0,03	1,19	43	18	244	57	21	121	36	SB2	D
SAB767	3,29	13,78	75,69	4,81	0,61	0,09	0,06	1,33	84	26	267	36	35	84	61	SA	D
SAB769	3,14	13,47	75,49	5,06	0,61	0,16	0,03	1,72	51	22	253	58	24	115	29	SB2	D
SAB800	2,98	14,57	73,46	5,38	0,94	0,30	0,03	1,78	63	22	177	159	26	225	35	SC	D
SAB872	3,19	13,75	75,83	4,81	0,59	0,09	0,05	1,28	85	26	253	29	46	72	60	SA	D
SAB902	3,04	13,78	75,04	5,28	0,62	0,16	0,03	1,41	51	19	223	49	24	102	25	SB2	ND
SAB903	3,15	13,12	75,99	5,09	0,57	0,13	0,04	1,50	53	21	259	35	23	98	30	SB2	ND
SAB948	3,19	13,94	75,23	4,94	0,60	0,10	0,06	1,55	92	26	265	33	44	82	55	SA	D
SAB968	3,10	14,51	73,49	5,41	0,92	0,28	0,03	1,80	62	21	187	146	29	233	27	SC	D
SAB992	3,25	13,63	75,82	4,90	0,58	0,09	0,05	1,28	82	26	279	32	41	83	57	SA	ND
MDL	0,05	0,09	0,04	0,03	0,03	0,01	0,001	0,01	1	1	5	2	11	6	5		

Contents in oxides are in wt% and contents in elements in ppm.

MDL indicates the mean detection limit.

ND: non-destructive analysis; D: partially destructive analysis.

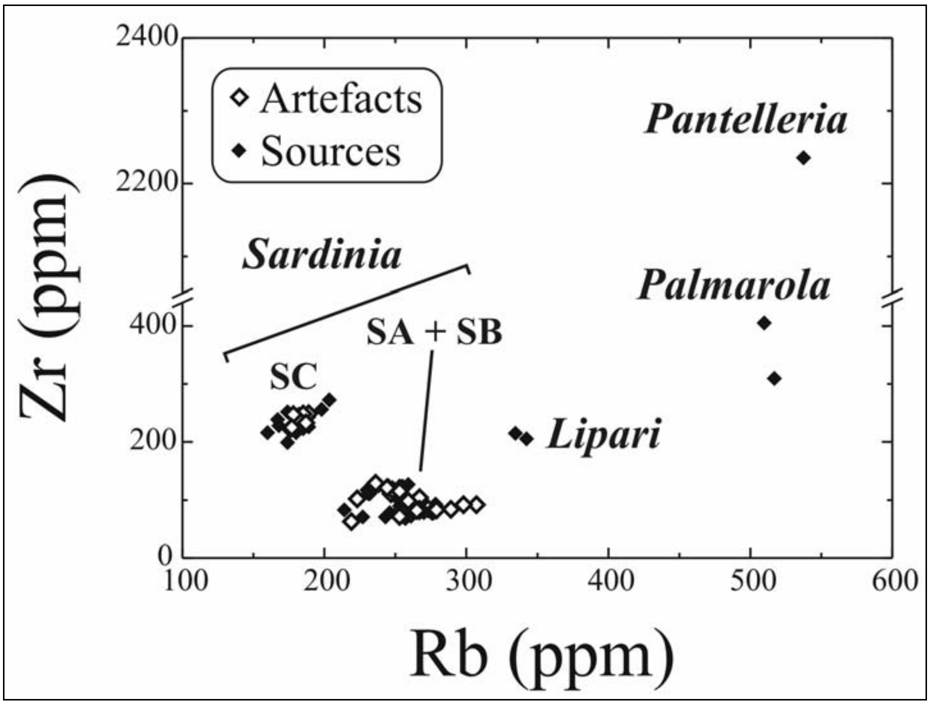

Fig. 21.3. Binary diagram comparing the Rb and Zr contents in obsidians of the Rio Saboccu S1-S2 structures and from the western Mediterranean source-islands. The Sardinian obsidians are separared into two groups with the SC and SA+SB sample types respectively (SB = obsidians of the SB1+SB2 types). Data on obsidian from sources, this work (Table 21.3), Poupeau *et al.* (2000) and Lugliè *et al.* (2006a)

Tab. 21.3: PIXE chemical compositions of obsidians from the Rio Saboccu S1-S2 structures

Sample	Na_2O	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	MnO	Fe_2O_3	Zn	Ga	Rb	Sr	Y	Zr	Nb	Type
428	3,13	14,45	73,58	5,30	0,94	0,31	0,03	1,79	64	21	180	150	25	216	34	SC
429	3,11	13,85	75,66	4,89	0,59	0,10	0,06	1,42	86	25	267	28	37	85	57	SA
430	3,00	14,46	73,57	5,45	0,94	0,30	0,03	1,81	62	22	185	155	21	226	30	SC
431	3,14	14,62	73,10	5,26	1,09	0,36	0,03	2,00	65	23	182	195	23	230	31	SC
432	2,98	14,50	73,57	5,42	0,91	0,30	0,03	1,81	63	22	180	151	22	229	28	SC
433	2,99	14,33	73,65	5,40	0,85	0,32	0,03	1,97	68	21	189	148	27	226	32	SC
435	3,07	14,49	73,53	5,42	0,91	0,30	0,03	1,77	62	21	187	152	22	229	32	SC
436	3,12	14,55	73,50	5,30	0,97	0,28	0,03	1,76	62	22	185	154	24	223	34	SC
437	2,96	14,41	73,71	5,47	0,86	0,28	0,03	1,78	64	21	185	138	23	241	30	SC
438	3,15	14,53	73,51	5,04	1,06	0,29	0,03	1,88	62	21	168	174	22	228	35	SC
442	3,24	13,27	76,04	4,92	0,55	0,12	0,03	1,46	48	20	251	30	26	104	25	SB2
444	3,10	14,08	73,85	5,45	0,86	0,32	0,03	1,65	56	20	174	148	26	252	29	SC
449	3,47	14,28	73,21	5,07	1,23	0,34	0,03	1,72	60	21	174	148	25	199	32	SC
MDL	0,05	0,06	0,03	0,02	0,03	0,01	0,001	0,01	2	2	5	3	13	8	5	

Contents in oxides are in wt% and contents in elements in ppm.

MDL indicates the mean detection limit.

and cobbles. Different cortical surface typologies in debitage products and cores fall into two broad categories, (i) either as in most cases, one with angular and sub-angular shapes and only slight or no surface weathering, consistent with an origin in primary and/or sub-primary geological contexts (65.5 percent) or (ii) less frequently, another one with rounded to well rounded and highly crenulated surfaces, typical of cobbles gathered from

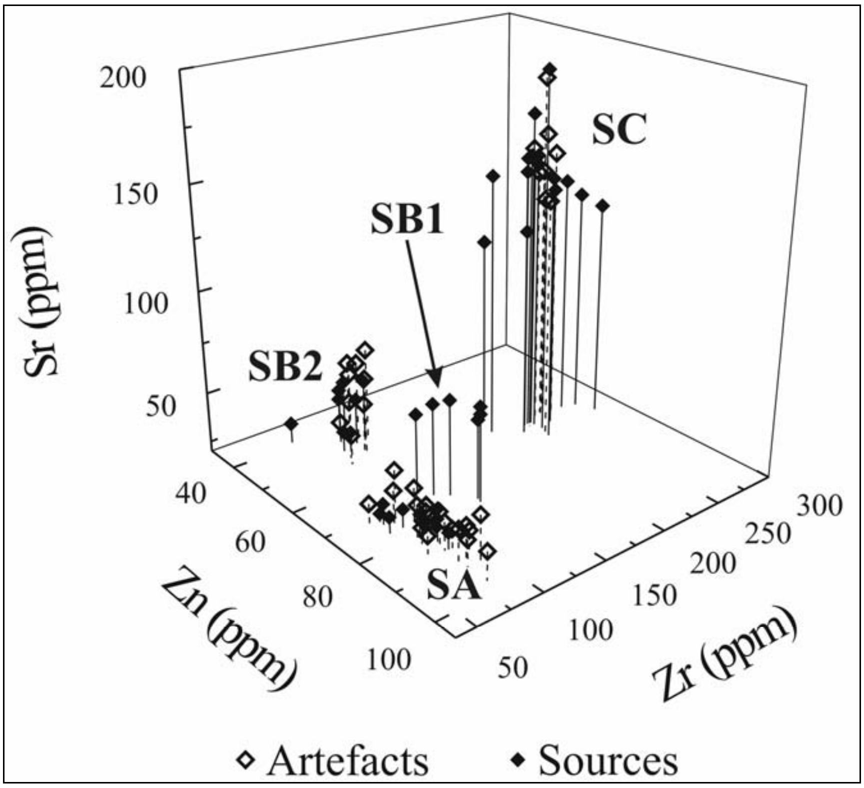

Fig. 21.4. Ternary diagram comparing the Zn, Sr and Zr contents in obsidians from the Rio Saboccu S1-S2 structures and from the Monte Arci. Data on obsidian from sources, same as in Figure 21.3

Tab. 21.4: Absolute and relative distribution of technological categories at Rio Saboccu S1-S2

	pebbles /blocks	retouched pieces	cores	debitage		
				flakes	blade(let)s	debris/shatters
number	2	292	31	608	76	49
%	0.2	27.6	2.9	57.4	7.1	4.6

Tab. 21.5: Distribution of butt typologies among different technological categories at Rio Saboccu S1-S2

butt	**technological categories**							
	flakes		blades		bladelets		retouched pieces	
	n	%	n	%	n	%	n	%
cortical	42	13.25	1	4.76			17	13.82
plain	171	53.94	12	57.14	11	61.11	56	45.52
punctiform	33	10.41	3	14.28	5	27.77	16	13.01
dihedral	25	7.88	1	4.76	1	5.55	6	4.87
facetted	26	8.2	3	14.28	1	5.55	22	17.88
retouched	20	6.31	1	4.76			6	4.87
total	317	99.99	21	99.98	18	99.98	123	100

secondary plain deposits (among them 63 percent of the SC type).

Butt typologies are usually plain and only among the more specialized pieces such as blade(let)s show a slightly higher preparation of the platfom (Table 21.5). The bulbs of percussion are rarely pronounced (twelve percent) and in general show a high frequency of bulb scars (53 percent). The technological features of debitage products suggest an almost exclusive application of direct

Tab. 21.6: Distribution of upper face patterns among debitage and retouched pieces at Rio Saboccu S1-S2

upper face patterns	**debitage**				**retouched pieces**					
	flakes		blade(let)s		flakes		blade(let)s		indeterminate	
	n	%	n	%	n	%	n	%	n	%
unidirectional	403	68.77	72	92.3	193	82.12	41	95.34	11	91.66
bidirectional	49	8.36	5	6.41	23	9.78	2	4.65	1	8.33
multidirectional	7	1.19			6	2.55				
indeterminate	127	21.67	1	1.28	13	5.53				
total	586	99.99	78	99.99	235	99.98	43	99.99	12	99.99

Tab. 21.7: Absolute and relative distribution of platfom core typologies at Rio Saboccu S1-S2

	core platform typology			total*
	natural	plain	prepared	
n	1	10	3	14
%	7.1	71.4	21.4	99.9

Tab. 21.8: Absolute and relative distribution of obsidian core morphologies at Rio Saboccu S1-S2

	general core morphology				total
	polyhedral	pyramidal	sub-discoid	discoid	
n	7	3	3	3	16
%	43.75	18.75	18.75	18.75	100

percussion techniques, regardless of the obsidian type exploited. The scars observed on the upper faces of 954 flaked pieces reveal a marked preference for the single-platform flaking method, whilst very rare patterns from double opposed platforms are possibly related to the maintenance of the flaking surface of the cores (Table 21.6). This typical behaviour is also attested in all obsidian types and other raw materials including chert through the presence of several technical pieces such as intentional plunging flakes/blades and one core tablet, which all deal with the optimization of inclination and *cintrage* of generally short core flanks and small platforms.

The main tendency of the Rio Saboccu industry is towards a high, in some cases extreme, raw material exploitation, which occasionally led to the use of large and thick flakes as flake-cores. One can recognize this behaviour even in the debitage economy, where unspecialized blanks are usually exploited to produce scrapers and other expedient and informal tools, irrespective of formal and dimensional standardization (for instance, plunging blades and the single core tablet are similarly retouched).

In comparison with the available data for Sardinian EN sites, the relatively high number (31) of cores found at Rio Saboccu allowed a detailed analysis of the reduction methods with the purpose of identifying the main aspects of the *chaînes opératoires*. Nine cores are fragmented, two exhausted and six are shaped from core tablets. The others show the earlier or the final stages of exploitation respectively, thus offer opportunities to identify the sizes and morphologies of the initial pieces. The relative frequencies of obsidian types are not very different compared to those found for the whole assemblage, with SA at 50 percent, SB2 at 33 percent and SC at seventeen percent. From cortical surface remnants on the cores, a maximum dimension of about 80 mm of the initial blocks/pebbles can be inferred. This approximate limit is confirmed by the medium length of both, the total debitage and toolkit from Rio Saboccu S1-S2. Regarding the initial morphologies, blocks and chunks are dominant in SA/SB2 cores (average 65 percent), whilst sub-rounded and rounded shapes, less present in these types, are exclusive in the SC obsidians. Flat core platforms are dominant as well as cores mainly reduced with a polyhedral shape, partly depending on the nature of the raw materials (Tables 21.7 and 21.8).

Given the small size of the initial raw material pieces and/or the generalized use of the direct percussion technique which limits the maintenance of the optimal flaking surface, the orientation had to be changed during the reduction process. Such technical gestures involve a shift of the striking platform, whose sequence shows one,

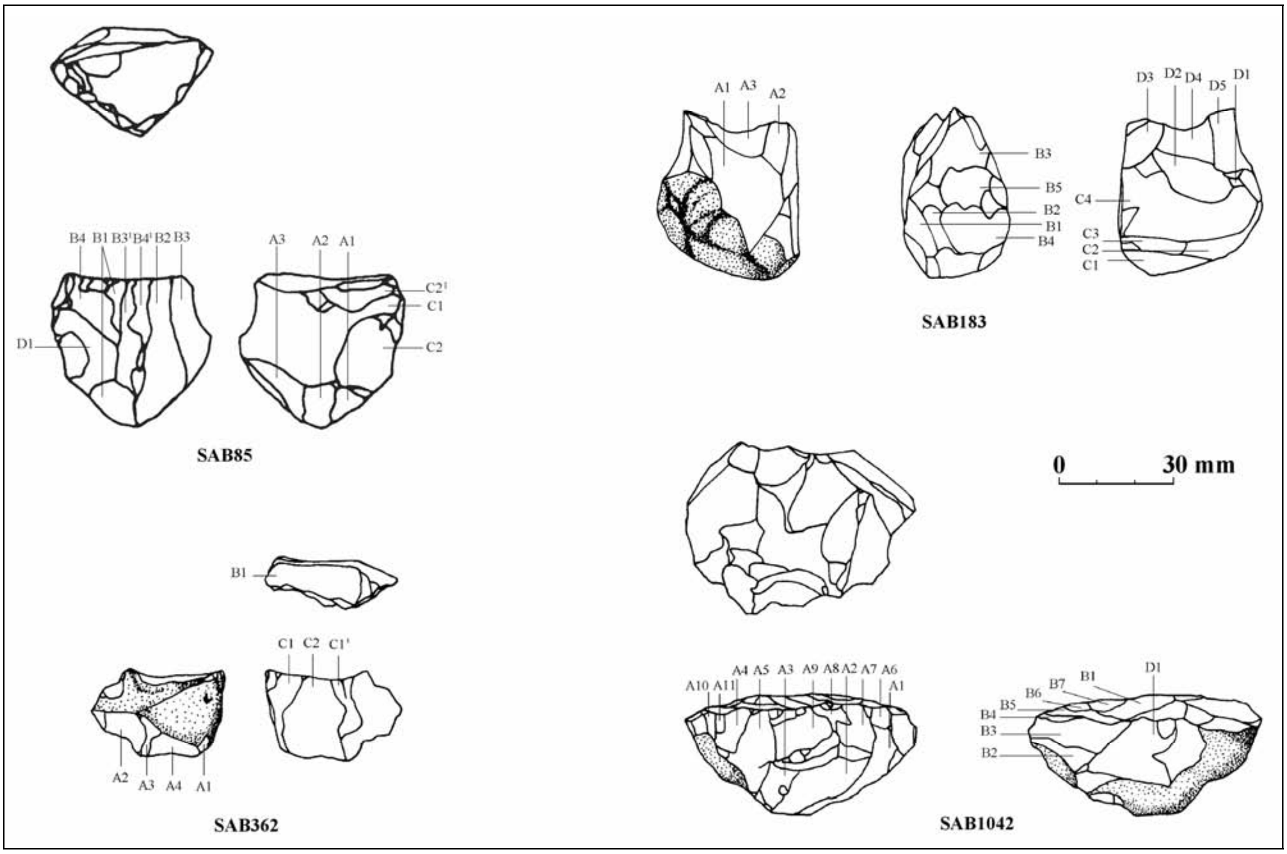

Fig. 21.5. Obsidian cores with poli-orthogonal rotation during the reduction sequence

Tab. 21.9: Distribution of the method of debitage among Rio Saboccu S1-S2 obsidian cores

	method of debitage				total
	unidirectional	90 degrees platform rotation		multidirectional	
		single rotation	multiple rotations		
n	5	4 (40%)	6 (60%)	2	17
%	29.41	58.82		11.76	99.99

two or more rotations of 90 degrees in the opposite or in several different directions (Fig. 21.5). In these cases, a new platform did not need to be created, as the scar of a side removal of the previous sequence functioned as a new platform. Sometimes, this was done after a rough adaptation of the overhang which is helpful when a soft stone hammer is used. Less frequently, the reduction method was carried out on a single striking platform with a complete uniaxial rotation of the core (debitage *tournant*) (Table 21.9). When the core size reached its smallest dimensions and the use of the direct percussion technique became impossible without using an immobilization tool, the last stages of reduction were carried out using a bipolar percussion on an anvil, as evident in the typical scaled detachments opposite the last striking platform. Following core exhaustion, generally indicated by several reflected strikes or the unexpected appearence of flaws in the raw material, some cores were subsequently retouched and used as expedient tools before their ultimate discard.

OBSIDIAN TOOLKIT TYPOLOGY

The final products of obsidian reduction sequences are present in the Rio Saboccu S1-S2 assemblage in the form of very few formal tool categories (Fig. 21.6). Among them, geometrics are somewhat more standardized despite the heterogeneity of the blanks, the majority being flakes (64.3 percent), imposes a variety of shapes and dimensions onto them. In regard to the raw material type, SA obsidians are almost exclusively used for the production of geometrics (up to 93 percent) which show abrupt retouch on both truncations. They are generally produced on flakes or blade(let)s with a small notch on a side on which a transverse fracture is succesfully obtained

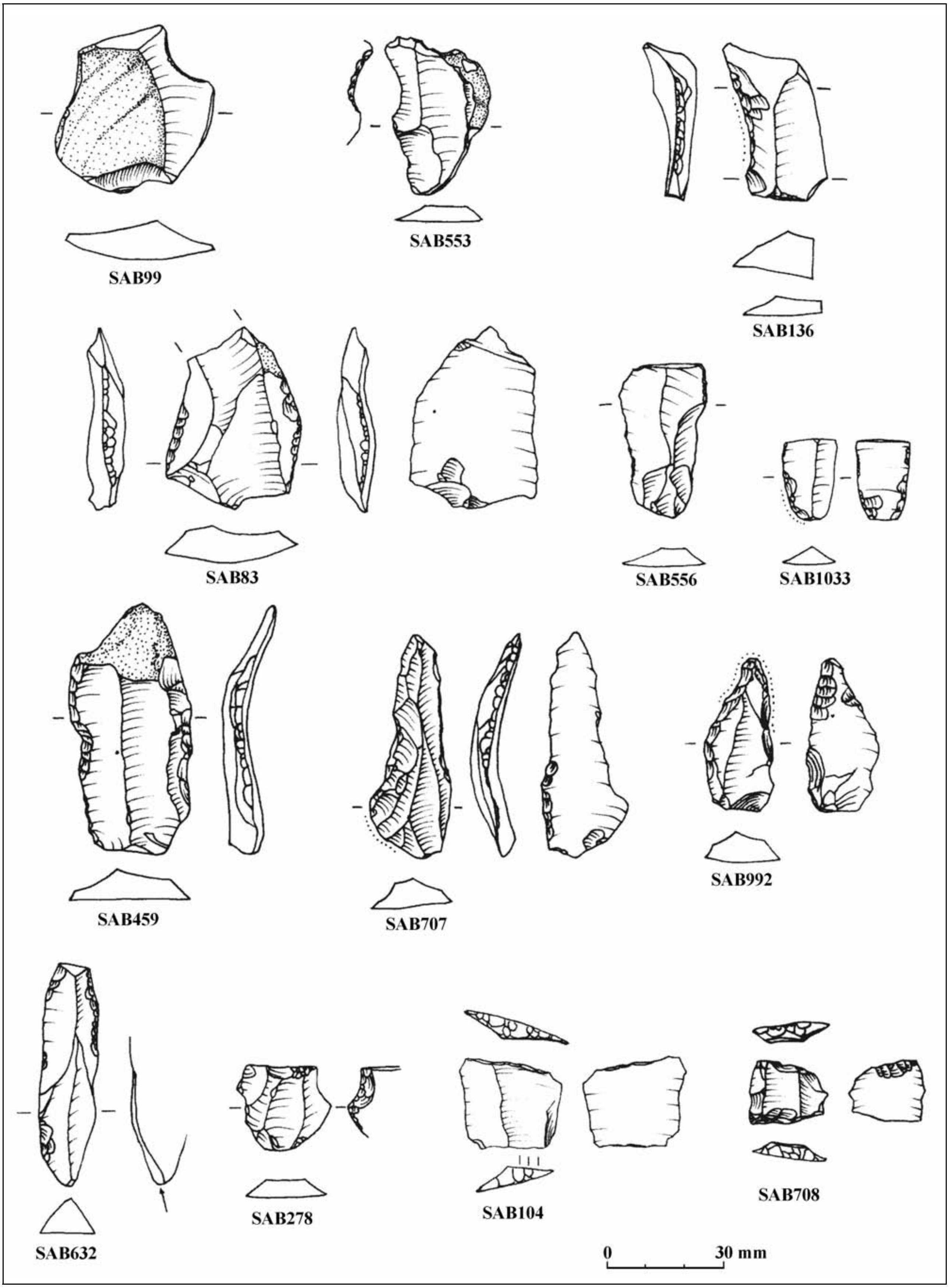

Fig. 21.6. Formal obsidian tools. *Enchoches* (SAB99, 553), side scrapers (SAB136, 83), truncations (SAB556, 1033), side abrupt piece (SAB459), backed pieces (SAB707, 992), side burin (SAB632), notched piece (SAB278) and geometrics (SAB104, 708)

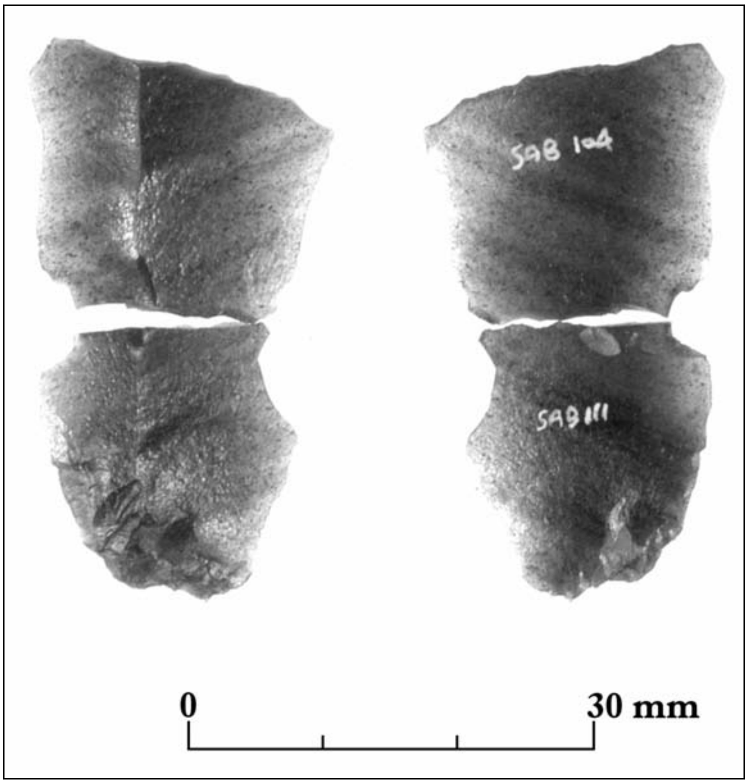

Fig. 21.7. Refitting of a geometric tool in SA obsidian type to the proximal part of a truncated flake

by flexion. This process is evident through the refitting of a geometric to the truncation of the proximal portion of a flake (Fig. 21.7) and in the high number of notches joined to a transverse simple truncation (51.9 percent of all the indentions found in the site).

All other formal tools such as backed and double backed pieces, burins and scrapers are almost exclusively produced on flakes with almost the same distribution of sources as seen in the whole assemblage. However, a slight dominance of SB2 use is observed among the scrapers (42.3 percent), while SC obsidians always seem to be less numerous (eleven percent). Among the blades, SC obsidians are more frequently met (circa 20 percent of all blade(let)s) than in the other technological categories. One possible explanation for this would be that SC tool production was performed in this area, while the tools were subsequently used elsewhere. The remainder of the retouched pieces are all expedient tools, made essentially on a variety of flakes with a relative distribution of sources as previously seen among formal tools. In general, a relatively low technical investment could be considered as a characteristic of the entire lithic production at Rio Saboccu.

CONCLUSION: OBSIDIAN ECONOMY AND PRODUCTION STRATEGIES

The technological characteristics of the Rio Saboccu lithic industry give a general impression of homogeneity regarding both the reduction strategies or the typological aspects of the toolkit. This might reflect the supposedly short occupation span of the site. However, a full interpretation of the assemblage is not possible considering the size of the contexts analysed (two stratigraphic profiles) and the lack of a detailed excavation of this partially eroded campsite.

The S1-S2 site is virtually situated on the nearest SC secondary deposit, only about 9 km from SB2 secondary deposits and 16 km from the SA source (Lugliè 2004; Lugliè 2006a, 2006b; Tanda *et al.* 2006) (Fig. 21.2). This makes the fact that 55 percent of the S1-S2 toolkit is made of SA obsidian highly significant (Table 21.1), revealing a non-opportunistic procurement strategy.

There is also a tendency for the production of the more standardized formal tools in the use of SA obsidians. At least four other sites, San Giovanni, Pauli Putzu, Bau Angius and Sa Punta, less than 6 km from Rio Saboccu and with quite similar archaeological features can be attributed to the Phase III EN (Lugliè 2003, Lugliè 2006b). Such a density of virtually contemporary sites suggests that they were inhabited by the same community or distinct human groups with high affinities. However in both cases, they had most probably a different economic specialization.

Similar to that of Rio Saboccu, the other EN communities in Sardinia generally appear to have used a low technical investment in core-shaping, a low incidence of blade(let)s and a low degree of blank standardization, a high frequency of expedient technologies and the dominant use of direct percussion techniques (often on anvil) with a core reduction strategy that implies several sequential rotations of the striking platforms. Another aspect of the Rio Saboccu obsidian reduction technology that is frequently shared with other EN obsidian assemblages in Sardinia concerns the deliberate selection of small pebbles and blocks of the different Monte Arci types to the near-exclusion of SB1 obsidians, in spite of the easy availability of larger natural samples mainly exploited in primary deposits.

As at Rio Saboccu, a composite raw material procurement strategy is very common in the plains to the south and to the west of the Monte Arci with a very prominent exploitation of secondary alluvial deposits (almost exclusive for SC obsidians). Similarly, the relatively high frequency of SB2 obsidians as at Rio Saboccu S1-S2 is a character common to virtually all EN sites in Sardinia, Corsica and the wider North Tyrrhenian region, where Monte Arci obsidian was distributed.

The procurement strategies of the EN Sardinian Neolithic communities were therefore clearly controlled by cultural criteria rather than by natural constraints (Lugliè 2006b). This phenomenon, which is even more emphasized in the direct procurement region, led us to suggest that the communities settled inside this area could possibly have acted as a 'filter' in the system of obsidian exchange within and around Sardinia. Such a hypothesis needs to be tested by way of collecting more qualitative and quantitative data from a larger number of sites of this region. The integrated visual and compositional fingerprinting approach applied to the whole assemblage of several EN settlements could be an effective tool in future research regarding the interpretation of the nature and of the importance of a possible intermediary role played by the EN communities around the Monte Arci region in the obsidian distribution process.

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