

Obsidian Procurement and Distribution in the Central and Western Mediterranean

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Abstract

Obsidian has long been recognized as an indicator of long-distance, maritime-based exchange networks in the Neolithic central and western Mediterranean. Earlier studies have identified and chemically characterized the major island sources, but few subsequent efforts have been directed at determining the provenance of significant numbers of artefacts from secure archaeological contexts. This paper presents new interpretations of obsidian procurement and distribution based on the chemical and visual sourcing of more than 2700 artefacts from island and mainland sites in France and Italy, and discusses the spatially and temporally dynamic economic and social role of obsidian. Finally, it is suggested that long-distance prestige exchange of obsidian and other materials was an important way of maintaining ethnic or kin connections in increasingly sedentary Neolithic societies.

Introduction

Archaeologists commonly use the concepts of 'trade' and 'exchange' to explain the presence of non-local raw materials or artefacts on archaeological sites. With the introduction of instrumental methods of chemical analysis and their successful application to archaeological provenance studies of materials like obsidian (Cann and Renfrew 1964), it became possible to define an object not only as an 'import', but also to identify the specific source of its raw material components. This established both beginning and end points in the lithic chaîne opératoire, and opened the possibility of examining the intermediate behaviors in greater detail.

Interpreting the social context of various modes of exchange in prehistoric societies

has been the subject of considerable research for some decades (e.g. Clark 1952), and the possibility of equating certain modes of trade with particular levels of social complexity (Service 1962) became a central interest of processual archaeology and its goal of achieving higher levels of inference from static archaeological data (Renfrew 1972; Sahlins 1972; Wilmsen 1972; Adams 1974). It seemed apparent that exchange could only be fully understood within both social and economic contexts relevant to the society in question, constructs which nevertheless remain difficult to establish without historical or ethnographic data (Polanyi 1957a, 1957b; Dalton 1975, 1977; Akalu and Stjernquist 1988).

Many studies in the 1970s and 1980s made use of generalizing, heuristic mathe-

mathematical models to interpret artefact distribution patterns. Among the best known are the gravity model (Bradley 1971; Chappell 1986), used to describe interaction zones in which different sources 'compete' for market share, and fall-off curves (Hodder 1974, 1978; Hodder and Orton 1976; Renfrew 1975, 1977; Warren 1981) of artefact frequency versus increasing distance from their source. The shape of the fall-off curve is determined by particular exchange mechanisms, and the slope by factors such as demand, transportation costs, and the availability of alternative materials.

There are a number of inherent problems in these models. Ammerman (1979; Ammerman *et al.* 1978; Ammerman and Andrefsky 1982), in particular, has noted that these models assume exchange was not sporadic, was not disrupted, and that they do not take into consideration temporal variations in behavior, population growth, changes in settlement size, and the heterogeneity of 'dropping rates' (Ammerman and Feldman 1974, 1978). There are also variables such as differential participation in exchange networks, seasonal activities, and the likelihood that several exchange mechanisms were in effect at the same time, that need to be taken into consideration. Objects may have moved alone (by trade or gift exchange); along with individuals (traders, craftspeople, brides); or with groups of people (migration, colonization, war, foraging). Local variation in resources, transportation, population density, and social organization would have produced regionally distinct situations which may be amplified by differences in archaeological fieldwork methods, sampling strategy and sample size (Clark 1979; Hodder 1980; Knapp 1985). Lastly, the problem of equifinality, that different exchange mechanisms may have resulted in

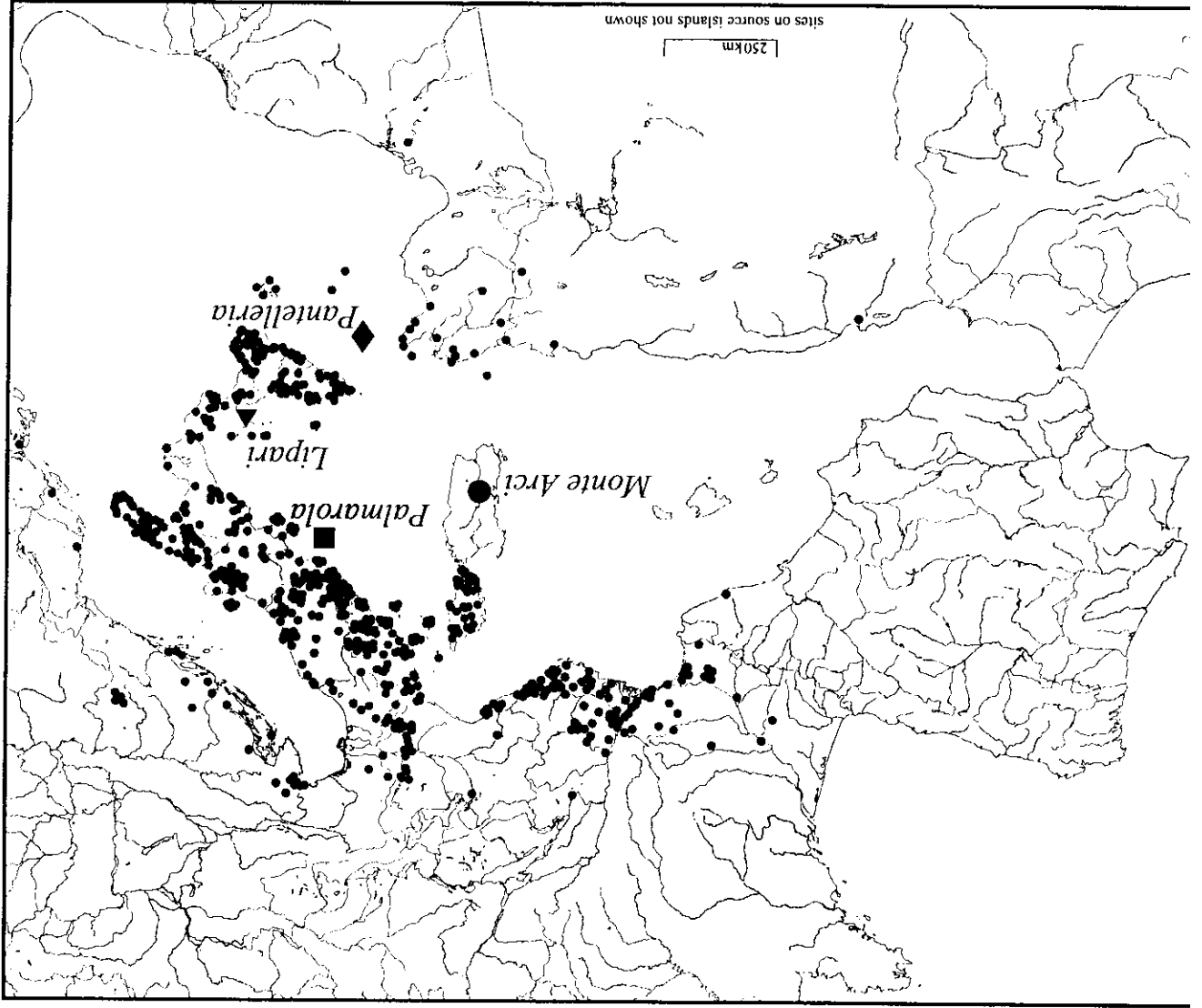
the same distribution of artefacts, has also been recognized. Despite these considerations, few have made an explicit interpretive connection between Polanyi's oft-cited modes of exchange (reciprocity, redistribution, and market exchange), the multiple mechanisms characteristic of each, and their manifestations in the archaeological record (Sheridan 1982).

These problems, along with the uneven quality of most archaeological data, led Bietti Sestieri (1985: 115) to suggest that the quantification of existing data was a higher priority than the elaboration of theoretical models:

...one should do no less than ask whether, in reality, the more fruitful application of mathematical methods to archaeology is in the elaboration of data on a quantitative and statistical basis, independently of the degree of formalization of the model.

This criticism is particularly relevant to obsidian in the central and western Mediterranean, where the sources themselves were until recently not well characterized, and where few provenance studies examined significant numbers of artefacts — many from insecure or inappropriate archaeological contexts which precluded the application of mathematical models. Perhaps because of limited capabilities in producing quantifiable exchange data, many recent Mediterranean lithic studies have emphasized procurement and production (e.g. Ammerman and Andrefsky 1982; Torrence 1981a, 1981b, 1982, 1983, 1984, 1986), and use (e.g. Hurcombe 1992a, 1992b; Vaughan 1985, 1990), rather than distribution of artefacts (e.g. Pollmann 1993).

The quantification and interpretation of obsidian provenance data is the focus of the work that follows (see Tykot 1995a).



Obsidian sources (large symbols) and archaeological sites (small circles) with obsidian in the central and western Mediterranean. (Nearly all of the mainland sites are Neolithic.)

The application of new analytical methods permits the construction of statistically significant geographic and chronological patterns of obsidian source exploitation, and new interpretive schemes re-establish exchange as critically important for understanding all stages of the chaîne opératoire. As the most visible indicator of Neolithic interactions, obsidian use is also relevant to discussions of the earliest settlement of the Mediterranean islands, the transition from hunting and gathering to an agricultural way of life, long-distance exchange networks, craft specialization, and the development of social differentiation and other precursors of more complex Copper and Bronze Age societies.

Mediterranean Obsidian Sources

In the Mediterranean region, the existence of a limited number of obsidian sources suitable for the production of stone tools has been known for quite a long time. Virtually all obsidian artefacts found at archaeological sites in the central and western Mediterranean come from four Italian island sources: Lipari, Palmarola, Pantelleria, and Sardinia (Figure 1). The Carpathian sources in southeast Slovakia and northeast Hungary (Williams–Thorpe, Warren and Nandris 1984, 1987; Biró *et al.* 1986; Bigazzi *et al.* 1990) are responsible for a few artefacts found in northern Italy, presumably others in Dalmatia (Martinelli 1990), and some as far east as Greek Macedonia (Kilikoglou *et al.* 1996). Obsidian from Melos has been confirmed at but a single site west of the Balkan peninsula (Bigazzi *et al.* 1986) and a few pieces of Anatolian obsidian have been identified in Eastern Europe and Greece (Renfrew and Aspinall 1990). The converse also appears true: as yet, not a single piece of central Mediterranean obsidian has been docu-

mented east of the southern tip of the Italian peninsula, despite the claims for Sardinian obsidian in Bosnia made a number of years ago in a conference paper (Rasson *et al.* 1977; cf. Williams–Thorpe 1995: 231).

Lipari

Lipari, located some 30 km north of the northeastern part of Sicily, is the largest of the Aeolian Islands at ca. 38 km². Transparent, black obsidian of excellent quality may be found today in several localities on Lipari, but the Forgia Vecchia and Rocche Rosse (including Punta Castagna) flows, and the Fossa cone on the nearby island of Vulcano, are from historic eruptions and were thus unavailable for prehistoric exploitation (Buchner 1949; Pichler 1967, 1980; Keller 1967, 1970; Bigazzi and Bonadonna 1973; Cortese *et al.* 1986; Gillot and Cornette 1986; Lefèvre and Gillot 1994). While older obsidian flows exist at Acquacalda, Vallone Gabelotto (including Papesca beach and the Pomiciazzo–Lami flow), and Monte della Guardia (including Praia di Vinci), fission-track dates on 66 artefacts of Lipari obsidian from archaeological sites in Italy (Arias–Radi *et al.* 1972; Bigazzi and Radi 1981; Bigazzi *et al.* 1982; Arias *et al.* 1984, 1986) indicate that Gabelotto was the primary source used in antiquity. Chemical analyses of samples from both recent and prehistoric flows conclusively demonstrate that there are negligible differences in their elemental composition (Belluomini and Taddeucci 1971; Francaviglia 1986; Tykot 1995a, 1995b).

Palmarola

Palmarola is the westernmost of the Pontine Islands, located west of Naples in the Gulf of Gaeta, about 35 km from the

mainland. Obsidian flows are found to the south of Monte Tramontana in a domal crust that transects the island, and along the east coast of Palmarola down to its southeastern tip at Punta Vardella where it is found in fist-sized, black, opaque blocks (Buchner 1949; Barberi *et al.* 1967; Herold 1986). Although analyses have not turned up any chemical differences in obsidian from the different source localities on Palmarola (Herold 1986), making it impossible to determine whether Punta Vardella was the only source utilized, the small size of the island (less than 3 km²) renders this distinction of minimal archaeological significance.

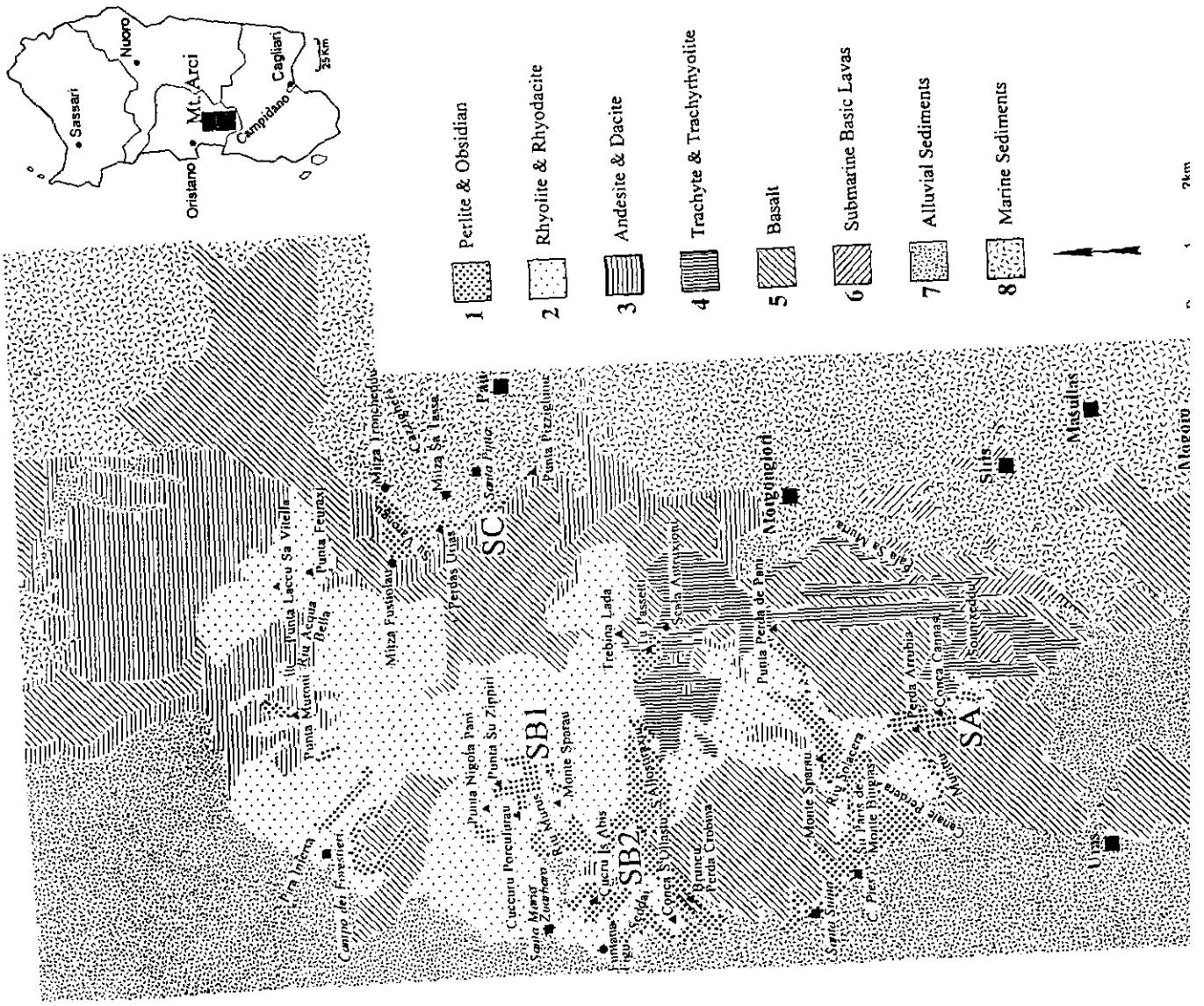
Pantelleria

Pantelleria, a small pear-shaped island of about 8 by 13 km, lies in the Strait of Sicily, about 90 km east of Cap Bon, Tunisia. Pantelleria is the type locality for peralkaline rocks, in particular its Na- and Fe-rich greenish obsidian known as Pantellerite (Foerstner 1881; MacDonald and Bailey 1973). Pantellerian obsidian is thus readily differentiable from other western Mediterranean sources on a visual basis (e.g. Cann and Renfrew 1964). Francaviglia (1988) has isolated five chemical source groups on Pantelleria: three vertically-differentiated sources exposed at Balata dei Turchi; Gelkhamar; and Lago di Venere. Chemical analyses of artefacts from Pantelleria, Malta, Sicily and the mainland demonstrate that the upper (i.e. more recent) Balata dei Turchi flows were most commonly used, but that pitchy (and more recent still) Gelkhamar obsidian was also employed — even in Sicily (Francaviglia 1988; Francaviglia and Piperno 1987; Tykot 1995a, 1995b). The large variation in fission-track dates on archaeological artefacts (Arias-Radi *et al.* 1972; Arias *et al.*

1984) also suggests the use of multiple source flows, but these dates cannot be correlated as yet with Francaviglia's chemical source groups. Like Palmarola, Pantelleria was not settled during the Neolithic, and neither differential access to the sources nor organized extraction of obsidian is likely to have existed.

Sardinia

Sardinia, unlike all other Mediterranean islands with obsidian sources, is a large landmass with an area of 24,000 km² and a history of occupation dating back to the Upper Paleolithic (for a detailed review, see Tykot 1995a, 1997b). Obsidian beds in the Monte Arci volcanic complex were first described by della Marmora (1839–40) and later by Washington (1913); a comprehensive survey of the Monte Arci zone was undertaken by Puxeddu (1958) as part of his thesis in archaeology at the University of Cagliari. This seminal contribution includes a detailed description of obsidian sources and archaeological sites in the Monte Arci region. In a zone of about 200 km² which today includes 19 towns or hamlets, Puxeddu found 246 locations with obsidian, including four which he classified as sources. The later realization that at least three chemical groups (SA, SB, SC) were represented among analysed archaeological material raised questions about which sources were being utilized, since only one geological source (Conca Cannas) had been analysed (Cann and Renfrew 1964; Hallam *et al.* 1976), and both translucent and opaque obsidian had long been recognized in archaeological assemblages. Following detailed geological surveys of the entire Monte Arci complex (Beccaluva, Deriu *et al.* 1974; Beccaluva, Maccioni *et al.* 1974; Assorgia *et al.* 1976), several attempts were made to chemically characterize the multi-



ple obsidian outcrops. Although all were successful in this regard, the only available information from the first study comes from a very brief conference paper (Mackey and Warren 1983); an independent effort by Francaviglia (1986), also not fully published, provides no details about the obsidian deposits themselves; and the unpublished dissertation by Herold (1986) makes no attempt to match chemically-defined geological source groups with archaeological materials. More recently, my own survey of the Monte Arci zone (Figure 2) located the SC source *in situ* for the first time, and geological material from the five sources (SA, SB1, SB2, SC1, SC2) represented among archaeological artefacts

has been fully described and chemically characterized (Tykot 1992, 1995a, 1997a).

Most importantly, it was demonstrated that all archaeologically-significant distinctions among Mediterranean obsidian sources (Lipari, Palmarola, Pantelleria, SA, SB1, SB2, SC, Melos, Giali) can be made on the basis of major/minor element composition, permitting quantitative yet inexpensive and minimally-destructive analysis using the electron microprobe (with wavelength dispersive X-ray spectrometers) of hundreds of archaeological artefacts from Neolithic sites in the central Mediterranean (Table 1). Furthermore, it was discovered that the frequency of each obsidian source represented in a lithic assemblage could be

	SA	SB1	SB2	SC
SiO ₂	74.72 ± 0.25 (74.02-75.63)	73.87 ± 0.35 (73.22-74.59)	75.08 ± 0.27 (74.33-75.72)	72.72 ± 0.35 (71.74-73.77)
Al ₂ O ₃	13.40 ± 0.15 (12.86-13.83)	13.63 ± 0.10 (13.46-13.84)	12.97 ± 0.14 (12.60-13.30)	13.92 ± 0.19 (13.18-14.83)
TiO ₂	0.09 ± 0.01 (0.05-0.12)	0.17 ± 0.03 (0.13-0.25)	0.13 ± 0.02 (0.10-0.20)	0.27 ± 0.03 (0.17-0.37)
Fe ₂ O ₃	1.25 ± 0.09 (1.01-1.59)	1.33 ± 0.20 (0.81-1.68)	1.15 ± 0.09 (0.92-1.44)	1.52 ± 0.19 (1.01-2.06)
MgO	0.08 ± 0.01 (0.05-0.13)	0.12 ± 0.04 (0.06-0.21)	0.11 ± 0.02 (0.06-0.15)	0.20 ± 0.06 0.06-0.38
CaO	0.59 ± 0.03 (0.52-0.71)	0.74 ± 0.03 (0.69-0.83)	0.57 ± 0.02 (0.53-0.67)	0.87 ± 0.08 (0.67-1.19)
Na ₂ O	3.45 ± 0.11 (3.05-3.82)	3.38 ± 0.10 (3.22-3.58)	3.36 ± 0.06 (3.11-3.48)	3.31 ± 0.12 (2.81-3.84)
K ₂ O	5.24 ± 0.14 (4.93-5.92)	5.55 ± 0.20 (5.12-6.10)	5.46 ± 0.11 (5.23-5.86)	5.89 ± 0.18 (4.84-6.43)
P ₂ O ₅	0.08 ± 0.01 (0.02-0.10)	0.10 ± 0.02 (0.07-0.13)	0.08 ± 0.01 (0.06-0.12)	0.14 ± 0.01 (0.09-0.18)
MnO	0.06 ± 0.01 (0.04-0.08)	0.04 ± 0.01 (0.03-0.06)	0.04 ± 0.01 (0.02-0.07)	0.03 ± 0.01 (0.01-0.07)
BaO	0.02 ± 0.02 (0.00-0.08)	0.05 ± 0.02 (0.01-0.10)	0.02 ± 0.02 (0.00-0.07)	0.11 ± 0.02 (0.03-0.18)
n	207	26	130	341

Table 1 Compositional analyses of obsidian from Monte Arci, Sardinia. (Means ± one standard deviation are given for n geological and archaeological samples analysed, with the range in parentheses below. All data are given as percentages, with totals normalized to 99.00%.)

reasonably estimated by non-destructive visual examination of the whole assemblage; the reduced accuracy of the visually determined source frequencies may be less significant than the sampling error commonly associated with chemical analysis of selected numbers of artefacts (Tykot 1995a).

Distribution Patterns

Obsidian artefacts have been identified at over 1000 archaeological sites in the central and western Mediterranean, including virtually every site on Sardinia and Corsica, and many if not most Neolithic sites in Sicily, the Italian peninsula, and Mediterranean France (Figure 1). Few sites with obsidian finds are known to the north of the Po River, on the eastern side of the Adriatic, or in North Africa. Obsidian tools are particularly abundant on or near the source islands, accounting for up to 100% of lithic assemblages, while the plethora of distant sites with obsidian masks the actual paucity of artefacts in that material found at most sites. In stark contrast to the eastern Mediterranean (see Perlés 1987, 1990), obsidian use is strictly associated with pottery-using agropastoralists, beginning in the Early Neolithic period. In the following discussion, I combine the results of my own research with previous analyses in order to describe the exploitation and distribution of Sardinian obsidian in particular, as well as the more general chronological and geographic patterns apparent in central and western Mediterranean obsidian use (Figure 3).

Sample Selection

The imprecise nature of the archaeological record presents many problems for the interpretation of obsidian distribution

patterns. Excavations, like publications, are of uneven quality, and those sites excavated may be unrepresentative of settlement patterns in their location, chronology or site type (e.g. emphasis on cave sites vs. open-air settlements). For the Neolithic period, we are currently limited to placing site-contexts within a timespan of a few centuries at best (Tykot 1994), so that describing 'contemporary' obsidian use at multiple sites is likely to conflate many generations of human activity and homogenize short-term patterns that may actually be heterogeneous (either intentionally or randomly). Lithic assemblages from older collections underrepresent small pieces of débitage, while increasing the probability that each artefact collected represents a different reduction event. Furthermore, obsidian artefacts in museum collections may not be a random selection of the population of tools used at a site. Finally, some sites have small numbers of artefacts analysed making it impossible to conclude much about their distribution pattern with any statistical confidence, although some attempt is made here to pool the results for multiple sites, and in some cases by combining preliminarily the distributional evidence from Neolithic, Copper and Bronze Age sites before specifically examining each age or culture period in detail.

Sardinia

Within Sardinia, it appears that a distinction can be made between an Oristano area supply zone, where lithic assemblages are comprised entirely of obsidian which most likely was acquired directly from its source, and the rest of the island, where obsidian probably was obtained indirectly through exchange (for terminology, see Renfrew 1969, 1977) and may even be less

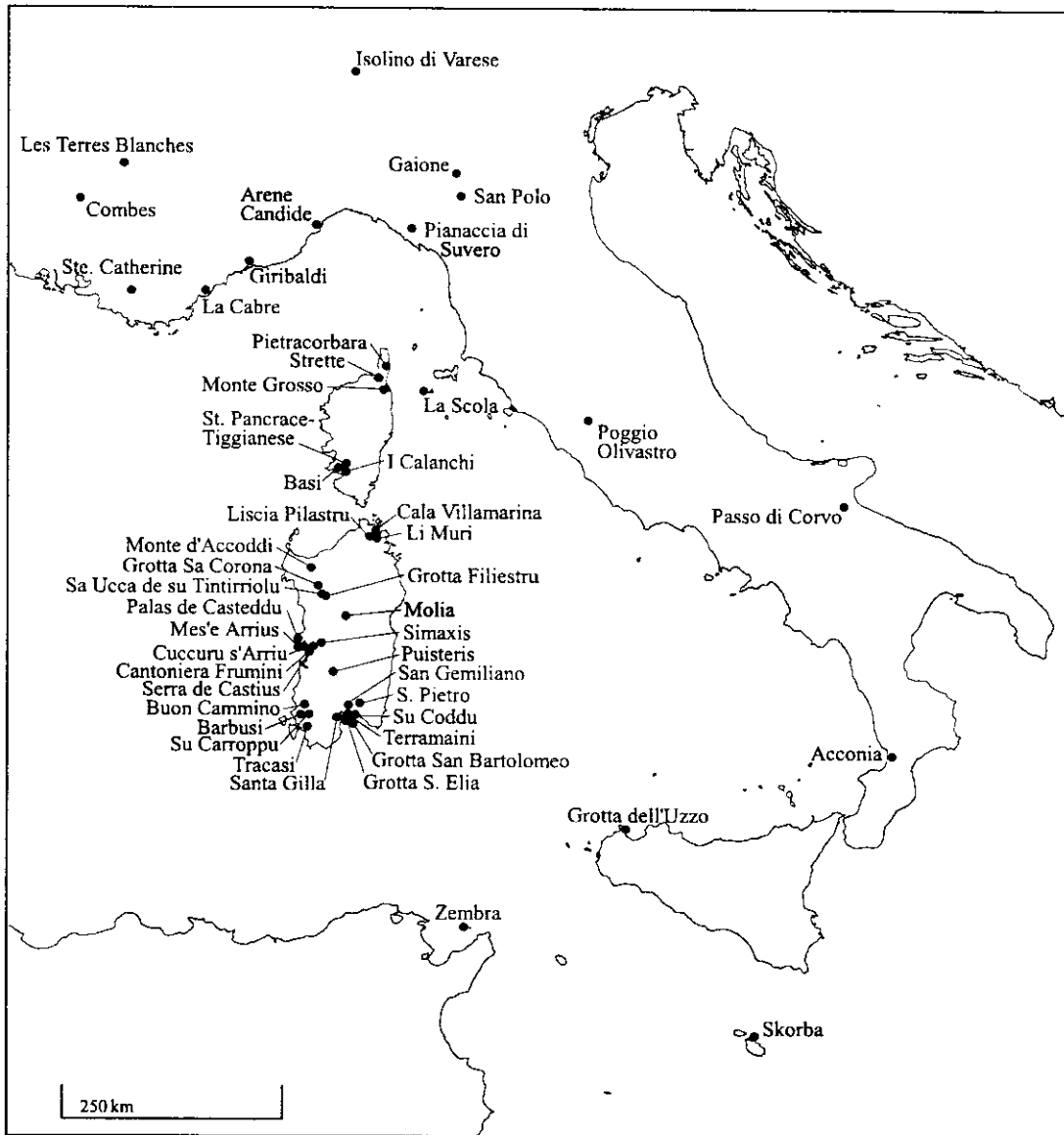


Figure 3 Neolithic sites with 10 or more obsidian analyses.

frequent than flint, quartzite or other lithic materials. Surface collections of many thousands of obsidian tools from sites in the Oristano–Campidano area and including the Monte Arci zone itself illustrate the ready availability and exploitation of this material in prehistoric Sardinia (Contu 1990–91; Atzeni 1992). Puxeddu (1958) in fact identified 11 collection centers and 74 reduction sites on Monte Arci, based on the lithic forms (cores, trim, flakes, blades) found at each. Unfortunately, there is no associated material to date these procurement and production activities, although the quantity and type of artefacts that Puxeddu collected suggests that they are primarily Neolithic.

Obsidian continued to be the most important lithic raw material used in Sardinia during the Copper, Bronze and Iron Ages (Contu 1990–91), but its ubiquitous presence from earlier use precludes knowing whether or not fresh obsidian was obtained from geological sources or was recycled from earlier site occupations. Hydration dating of obsidian from Sardinian sites has frequently identified reused or redeposited artefacts (i.e. those with ages much older than their context) (e.g. Michels *et al.* 1984; Stevenson 1989; Dyson *et al.* 1990; Stevenson and Ellis n.d.).

Chemical and visual analyses of obsidian from 61 sites in Sardinia indicate that all four Monte Arci sources were utilized at Neolithic sites in the Oristano region, but that types SA and SC obsidian were most commonly exploited (Tykot 1995a). The availability of considerable quantities of type SC obsidian on the west–central coast of Sardinia suggests that the ‘value’ (flaking quality plus less tangible factors) of type SC obsidian at least equaled that of type SA, since the procurement cost (time and effort) for type SC was probably somewhat greater than for type SA. Type SA obsidian

has always been considered to be of finer quality than type SC, but the roughly equal use of type SC in the Oristano region suggests that at least the local craftspeople did not make a big distinction on that basis.

In Sardinia, preliminary examination of obsidian relative use frequencies by province of the multiple Monte Arci sources reveals significant geographic differences (Figure 4). In southern Sardinia (Cagliari province), SB obsidian is hardly used at all (< 5%), whereas in northern Sardinia (Sassari province) it accounts for 33% of the obsidian tested; type SA is twice as frequent in southern Sardinia as in the north (36% vs 19%). Since the frequency of type SC is fairly constant, this distribution can be explained best by the relative proximity of the SB sources to northern sites, and of the SA source to southern sites. Surprisingly, type SB is less common at the Oristano province sites, for which the SB sources are the closest.

Looking at individual sites in Sardinia with 10 or more chemically analysed artefacts, greater heterogeneity in obsidian use patterns appears than in the provincial comparison above. In southern Sardinia, type SB is noticeable only at Tracasi; although much more common overall among tested samples from northern Sardinia, it is in fact not represented at all at three of the six sites there with 10 or more analyses. The chronology of the sites appears to be at least part of the explanation. Molia (Tanda 1980, 1984) and Liscia Pilastru (G. Pitzalis, unpublished) are Late Neolithic (Ozieri) sites, and Monte d'Accoddi (Tinè and Traverso 1992) is Final Neolithic/Chalcolithic, whereas most of the artefacts from Grotta Filiestru (Trump 1983) are Early and Middle Neolithic, as are those from Monte Maiore (Foschi Nieddu 1982, 1987) — both sites where type SB represents more than 45%

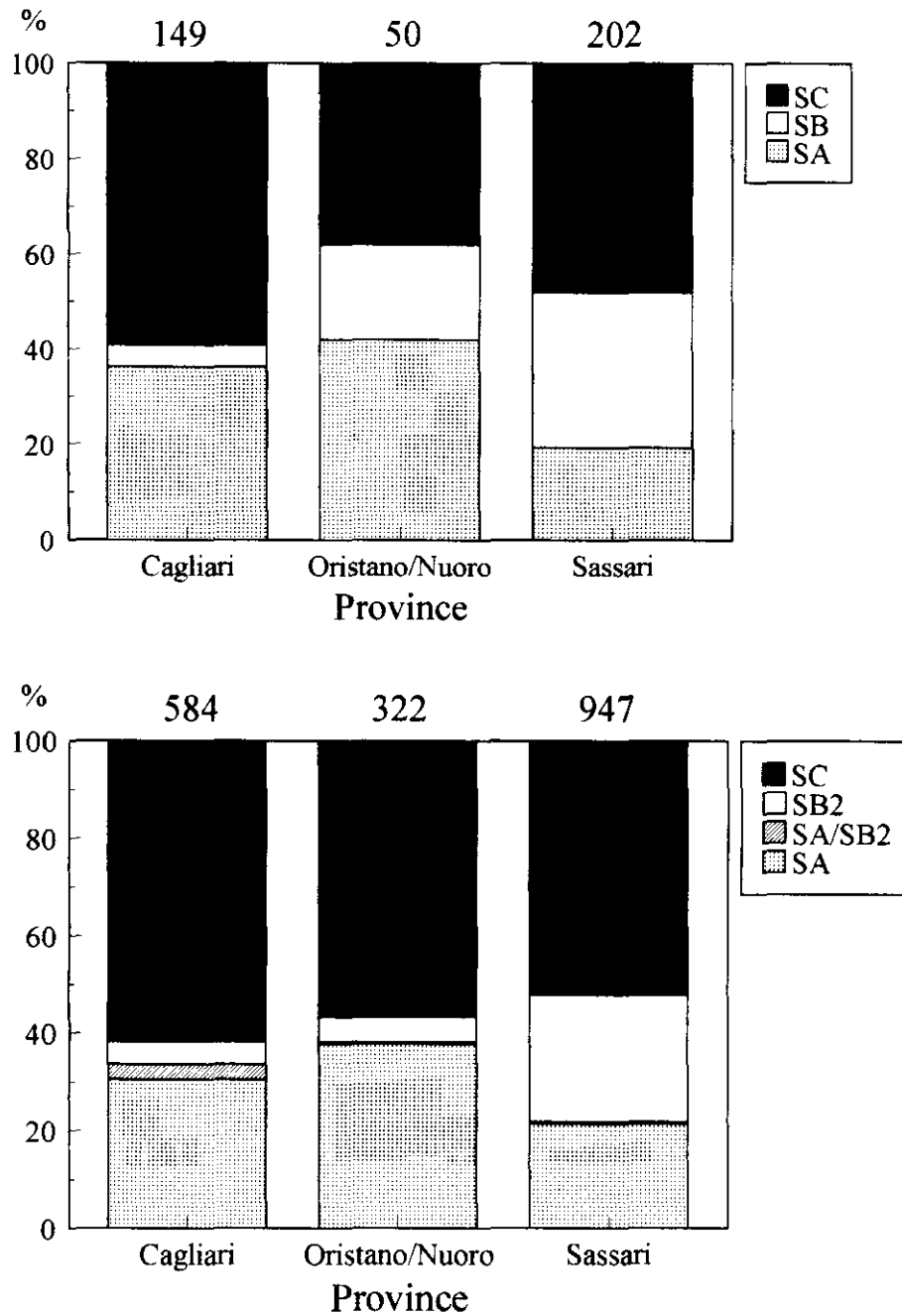


Figure 4 Obsidian source frequency in Sardinia, by province. Top: combined results from chemical analyses (Cann and Renfrew 1964; Hallam *et al.* 1976; Mackey and Warren 1983; Francaviglia 1986; Michels *et al.* 1984; Tykot 1995a); more than two-thirds of the artefacts represented are Neolithic. Bottom: results of visual assessment (Tykot 1995a); more than 90% of the artefacts represented come from Neolithic sites. Numbers of artefacts represented are at the top of each bar.

of the obsidian assemblage. Sa 'Ucca de su Tintirriolu (Loria and Trump 1978), with nearly 20% type SB obsidian, is Late Neolithic, but is right next door to Filiestru in the Bonu Ighinu Valley, so that the reuse of locally available type SB cannot be ruled out. Visual determinations also revealed no type SB obsidian at Molia among 63 artefacts examined (in addition to the 20 chemically analysed), and only 14 (out of 189 = 7%) type SB artefacts at Li Muri (also Late Neolithic; Puglisi 1941–42). 11% of 114 Middle Neolithic obsidian artefacts from Cala Villamarina (Lilliu 1959) were visually identified as type SB.

At Grotta Filiestru, the only site in Sardinia with all four Neolithic periods in stratigraphic succession, 86 randomly selected obsidian artefacts were chemically analysed, and an additional 581 were visually provenanced (Figure 5). Together, nearly all of the obsidian found at the site — constituting a steady 20–30% of the lithic assemblage (Trump 1983) — was examined. Both sets of data indicate that the use of type SB obsidian steadily decreased over time, to be replaced primarily by type SC obsidian. This situation is paralleled at Monte Maiore–Thiesi, where 58% of 26 Early Neolithic (Filiestru phase) and only 36% of 11 Middle Neolithic samples analysed are of type SB2 obsidian.

Corsica and the Tuscan Archipelago

The problem of sample size is best illustrated by the earlier work of Hallam *et al.* (1976), which indicated that type SB obsidian was particularly well represented in Corsica, especially at Curacchiaghju–Levie where 8 of the 9 analysed artefacts were from that source. In contrast, chemical analyses now of several hundred artefacts suggests that type SB accounts for less than

20% of the obsidian in Corsica, and even less in the southern part of the island (Figure 6). I wrote several years ago (Tykot 1992: 65) that the SB obsidian sources were readily accessible to sea-borne travelers to the Gulf of Oristano and that this could account for such high percentages in Corsica when its use in Sardinia was minimal. In fact, SB turned out to be much more significant in northern Sardinia than previously thought (33% instead of 6%) and the question is now reversed: why does type SB constitute only 12% of obsidian assemblages from southern Corsica? In addition, why is type SB twice as common in northern Corsica than in the south?

If we look at the data for individual sites, chronology again appears to provide some of the answer. Curacchiaghju (Lanfranchi 1987), Pietracorbara (Magdeleine 1991) and Strette (Magdeleine and Ottaviani 1986) are Early Neolithic or have Early Neolithic components (Lanfranchi 1993), making the low frequency of SB obsidian at Basi (levels 7–6) (Bailloud 1969a, 1969b) the exception among Early Neolithic sites. Furthermore, type SB obsidian appears more frequently in Early Neolithic (65%) than in later Neolithic (26%) levels at both Pietracorbara and Strette. Among the other sites, only the Chalcolithic dolmen of Cardiccia (P. Nebbia and J.-C. Ottaviani, unpublished) has more than a single piece of type SB obsidian. As noted above, tomb contexts are more likely to reflect single (or at least short-term) production events, and the size of the artefacts certainly does not exclude the possibility that all of the SB obsidian may have come from a single core. As in northern Sardinia, then, type SB obsidian is of major significance in the Early Neolithic but declines in frequency in the Middle and Late Neolithic. The quantity of obsidian imported to northern

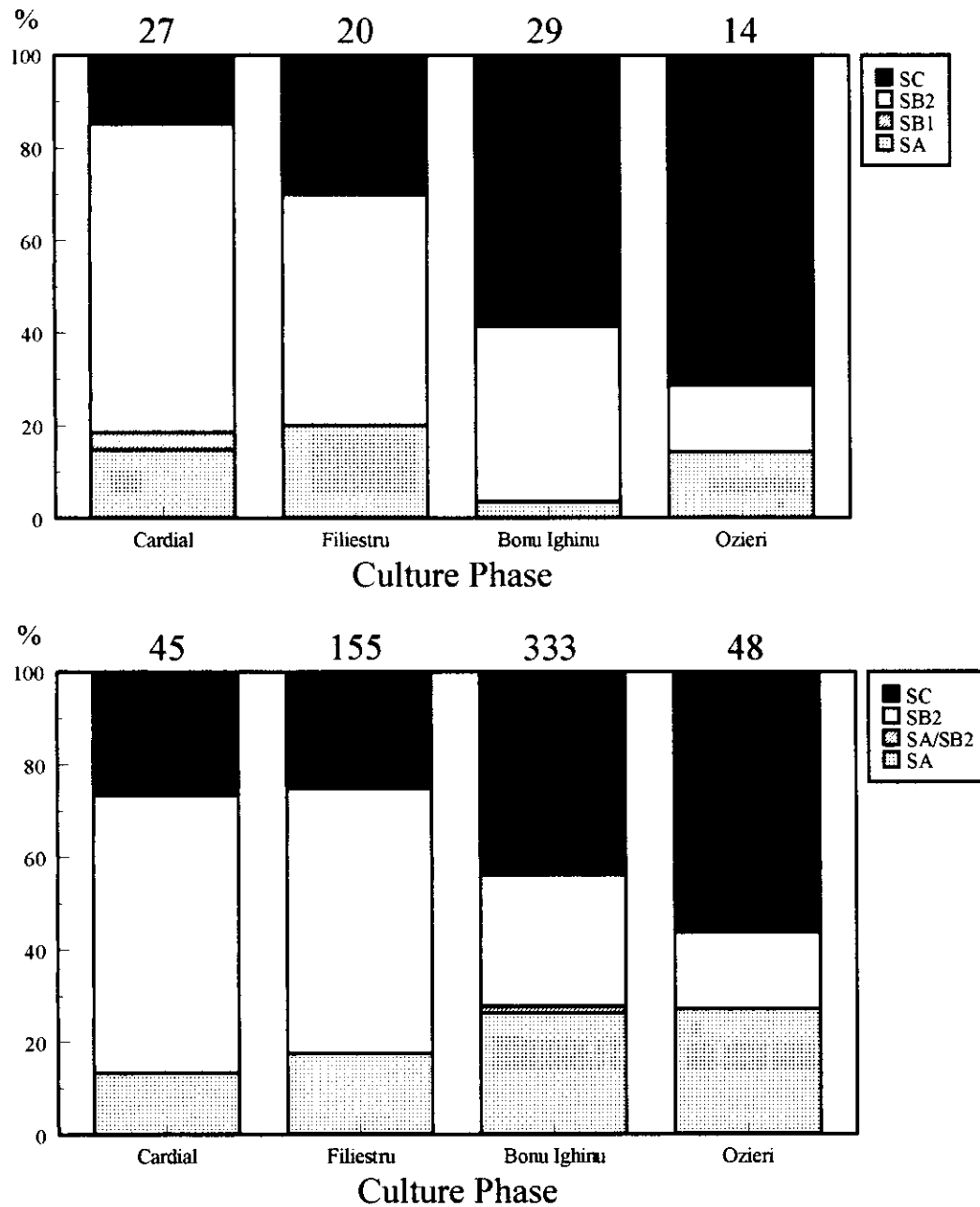


Figure 5 Obsidian source frequency for four Neolithic cultural phases at Grotta Filiestru. Cardial and Filiestru are Early Neolithic; Bonu Ighinu is Middle Neolithic; and Ozieri is Late Neolithic. Top: samples analysed by electron microprobe (Tykot 1995a), plus 4 Ozieri artefacts analysed by NAA (Mackey and Warren 1983). Bottom: samples attributed by visual assessment. Numbers of artefacts represented are at the top of each bar.

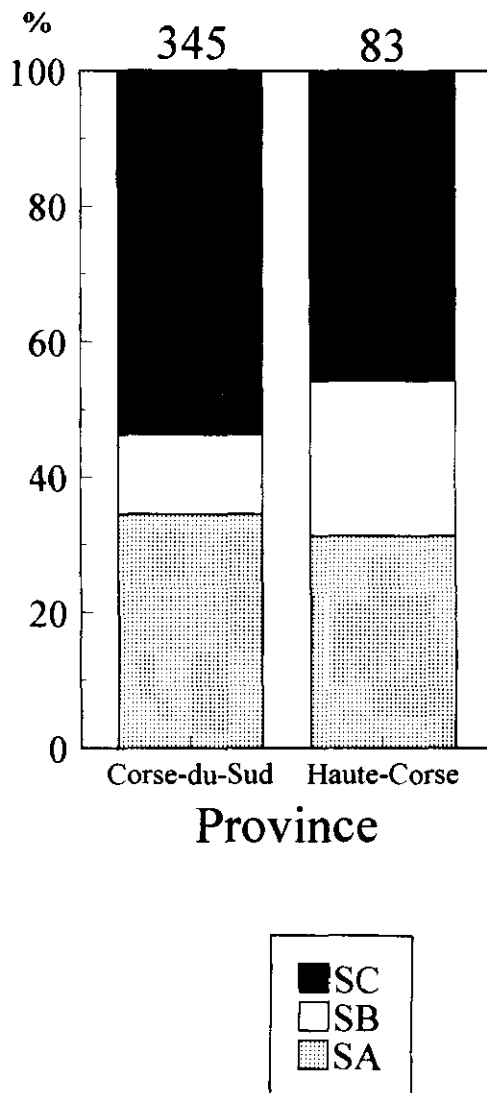
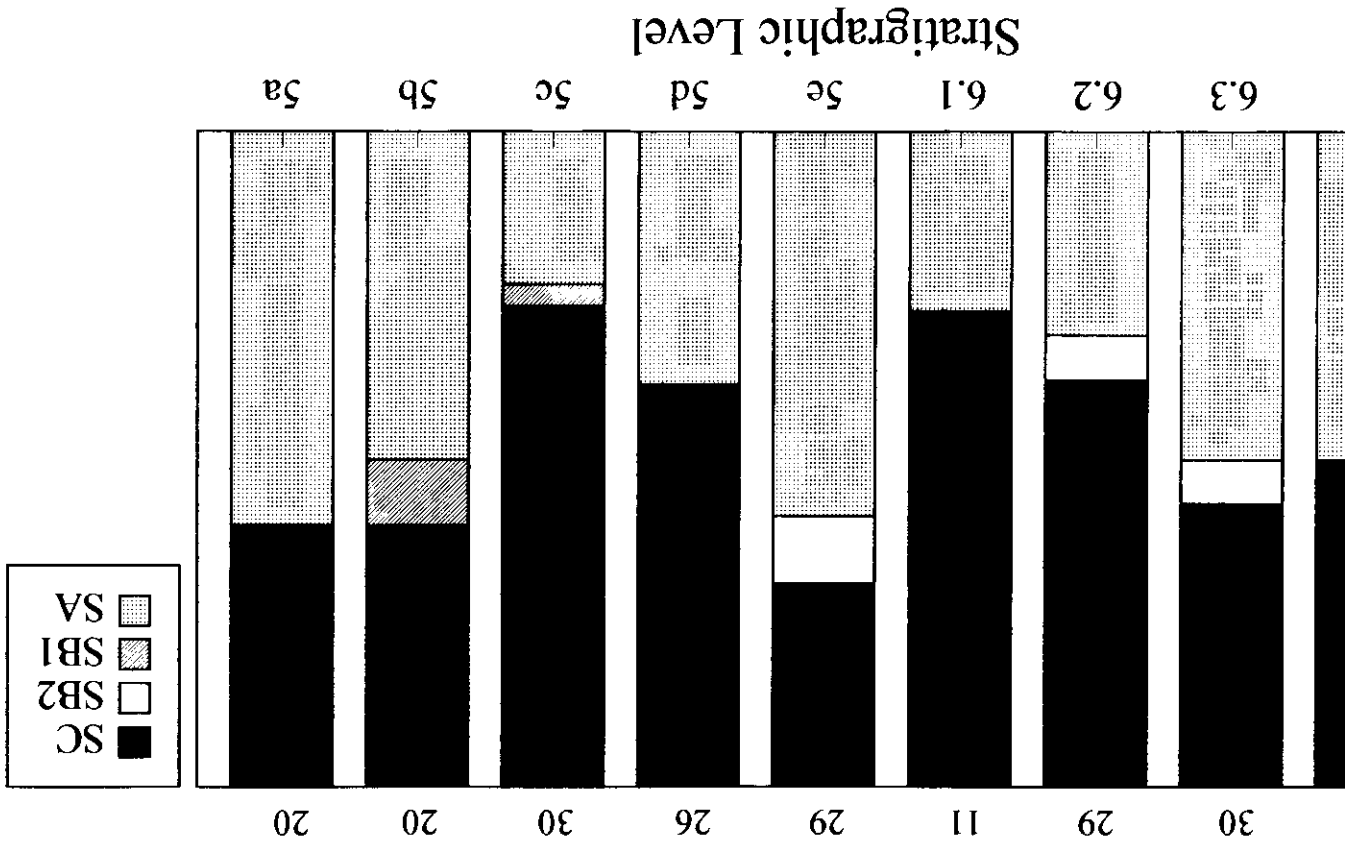


Figure 6 Obsidian source frequency in Corsica, by province. All but one of the analysed sites are Neolithic. All attributions are based on chemical analyses (Hallam *et al.* 1976; Crisci *et al.* 1994; Tykot 1995a). Numbers of artefacts represented are at the top of each bar.

Corsica also appears to increase over time: it accounts for just 6% of the lithic assemblage at Early Neolithic Strette (Magdeleine and Ottaviani 1986), while at nearby Late Neolithic/Chalcolithic Monte Grosso, 85% of the stone tools are in obsidian (Magdeleine 1973).

Two hundred and fourteen obsidian artefacts from Basi have been analysed, 197 of them from specific stratigraphic contexts (Figure 7), the most analyses from any site in the western Mediterranean. Although a chi-square test of source frequency for each of nine stratigraphic levels indicates some relationship between the two variables, no chronological pattern is evident despite the millennium-long hiatus in occupation between the Early Neolithic (Cardial) and Late Neolithic (Basien) levels. Furthermore, even though some of the excavated contexts actually contained mixed material (Lewthwaite 1983: 153; Camps 1988: 78), it is still surprising that type SB2 obsidian is so rare. Both SA and SC obsidian are well represented in every level (each a minimum of 25%), while both SB1 and SB2 are never very significant (maximum of 10% total). The two SB obsidian types are nevertheless present in five of the eight levels with more than two analyses. In the early Cardial contexts at Basi only a few percent of the stone tools were of obsidian, most of the lithics being in imported (Sardinian) flint; in the Basien period, however, obsidian accounted for 56–78% of the lithic assemblage, the rest made of quartz and other local rocks (Bailloud 1969a, 1969b). Similarly, at Longone-Bonifacio only imported flint tools are present in the first Cardial phase of the Early Neolithic (Lanfranchi 1993).

It has been taken for granted that Sardinian obsidian made its way to the mainland via Corsica and the Tuscan



Obsidian source frequency at Basit. Levels 7 and 6 are Early Neolithic; Level 5 is later Neolithic (Basien). All analyses represented by microprobe (Tykoc 1995a). Numbers of artefacts represented are at the top of each bar.

archipelago, minimizing the open-water distances traveled (e.g. Phillips 1975; Hallam *et al.* 1976: 99; Bagolini 1980: 42; Williams-Thorpe, Warren and Courtin 1984: 141). In fact, obsidian has been found on the islands of Elba, Capraia, Pianosa and Giglio. All 14 artefacts that I analysed from the Cardial Impressed Ware site of La Scuola on Isola Pianosa (Ducci and Perazzi 1991) are from Sardinia and include five of the SB2 type, emphasizing again the importance of this source in the Early Neolithic. Two artefacts from Elba are also Sardinian (Hallam *et al.* 1976), while both Lipari and Monte Arci obsidian have been documented on Capraia, albeit without any real context (Arias *et al.* 1984; Bigazzi *et al.* 1986). None of the extensive Early Neolithic finds from Le Secche on Isola del Giglio have been analysed, although the excavator attributes them to Lipari (Brandaglia 1985: 59–60). Lipari obsidian was not extensively distributed so far north in the Early Neolithic, however, and the presence of cores and reduction debris suggests to me that Sardinian and/or Palmarolan obsidian might account for a sizeable portion of the Le Secche assemblage.

Southern France, Northern and Central Italy

In Europe and the Mediterranean regions, obsidian appears to have been distributed as part of a few almost mutually exclusive systems: Anatolia and the Levant; the Aegean and Greece; central Europe; and the central/western Mediterranean. The only sure examples of Melian obsidian west of the Balkans are three pieces from Grotta del Leone–Agnano from an insecure context (Bigazzi *et al.* 1992b, 1986; Bigazzi and Radi 1981); their significance should not be over-estimated. Only two pieces of Carpathian obsidian have been

identified in Italy (one each at Grotta della Tartaruga–Trieste and Sammardenchia di Pozzuolo–Udine), although visual analysis suggests that more may be present at Fornace Cappuccini–Faenza (Randle *et al.* 1993; Polglase 1989; Antoniazzi *et al.* 1990: 55). Five analysed, but unattributed, samples from Le Crestair–Mornas and Beauvallon–Valence in France may also come from Carpathian sources (Crisci *et al.* 1994), but this needs to be confirmed by quantitative analyses. Finally, two unidentified pieces from Bellori–Verona and Misano Adriatico–Forlì have extremely low Na and very high Fe (Williams-Thorpe *et al.* 1979), compositions inconsistent with obsidian.

A few pieces of obsidian have been found at sites north and west of Toulouse along the Garonne and its tributaries (Villeneuve-sur-Lot, Condom, St. Michel-du-Touch, Capdenac-le-Haut), on both sides of the southern Alps (Pierre Chatel–Belley in France, and Isolino di Varese in Italy), and even in Spain near Barcelona (Guilaine and Vaquer 1994; Pollmann 1993; Courtin 1989). Several of these sites are about 200 km from the Mediterranean coast, but only the obsidian from Isolino di Varese (ca. 150 km north of Genoa) has been analysed (Hallam *et al.* 1976; Williams-Thorpe *et al.* 1979). The number of sites now with analysed obsidian in the western Mediterranean is actually quite considerable, including 37 in France and over 100 in Italy and Sicily, and the list of Neolithic sites with 10 or more analyses is growing (Figure 3). Nevertheless, only five excavated sites outside Sardinia and Corsica have more than 20 chemical analyses.

In southern France, obsidian from Early Neolithic sites is extremely rare, and the one piece analysed from Peiro Signado–Portiragnes comes from Lipari (Crisci *et al.* 1994). Obsidian is found more regularly —

but still in very small quantities — at French Middle Neolithic (Chasseen) sites in the form of blades, flakes and cores. At Giribaldi–Nice, the 58 obsidian artefacts found comprise only 0.5% of the lithic assemblage; the number of pieces found at this site is surpassed only by the 70 from La Cabre/Le Grenouiller–Agay (Binder and Courtin 1994). Provenance determinations of 143 obsidian artefacts from French sites show them to be predominantly of Sardinian origin. Only 24 analysed artefacts are from Lipari, and most of them appear in earlier rather than later Neolithic contexts, providing a contrast to the increasing quantities of Sardinian obsidian. At the Chasseen site of La Cabre/Le Grenouiller–Agay, 37 of 41 analysed obsidian artefacts are Sardinian, as are all 22 pieces analysed from the Late Chasseen site of Sainte Catherine–Trets (Hallam *et al.* 1976; Crisci *et al.* 1994). Since Monte Arci is considerably closer to southern France than is Lipari, the predominance of Sardinian obsidian (by whatever mechanism and route it took) is not surprising; what is shocking is that 110 of the 117 artefacts of Sardinian obsidian, from 27 different sites in southern France, are specifically of type SA. This regional emphasis on a single Monte Arci source is unparalleled and deserves explanation.

Sardinian obsidian could have reached southern France by several routes: directly from the Monte Arci supply zone; via Corsica; or via Tuscany and Liguria. The first and second choices would suppose much greater confidence and capability in open-water crossings than most scholars are willing to credit to Neolithic sailors, even if the ships hugged the western coast of Corsica before crossing 150 km of open sea to the Côte d'Azur. Interaction between southern France and northern Italy is documented by the distribution of jadeitite

and eclogite axes from western Alpine sources in Liguria and Piedmont (Ricq-de Bouard *et al.* 1990; Ricq-de Bouard 1993; Ricq-de Bouard and Fedele 1993). The obsidian at southern French sites could therefore also be derived from the northern Italian regions, transported over inland, riverine or coastal routes along with animal or plant products too (Phillips 1982: 27–30, 43). The distribution pattern of obsidian closely resembles that of the eclogites, which Ricq-de Bouard and Fedele (1993) argue were not distributed by coastal routes. Honey-colored flint, from sources in the Rhône valley, and glaucophane schists, from alluvial sources in the lower Durance valley, were widely distributed on a more regional level. Hallam *et al.* (1976: 103), using an exponential fall-off curve model, argue that the density of obsidian finds in northern Italy and southern France supports a down-the-line reciprocal exchange mechanism. They conclude that Provence was the last in a network series from Sardinia to Corsica to Tuscany to Liguria, and perhaps over the Alps into Provence from the Po Valley (Hallam *et al.* 1976: 99; see also Williams–Thorpe, Warren, and Courtin 1984: 141). The small quantities reaching Provence indicated that direct trade with Sardinia, with or without middlemen, was very unlikely. Bloedow (1987), however, is particularly critical of the evidence for 'trade' in the Neolithic Mediterranean, since there is no proof that goods were exchanged. For the western Mediterranean, he specifically argues that parties from individual settlements may have travelled to the sources, if not exclusively, at least in many cases (Bloedow 1987: 114).

Since obsidian from at least two if not three Monte Arci sources are commonly found at sites in northern Italy (see below), Corsica, and even in the Oristano area, the

concentration on type SA obsidian in southern France can only be explained by (1) conscious selection of that type (1a) during acquisition from their neighbors' 'supply' (in a down-the-line sense) and/or (1b) by procurers in the supply zone; or by (2) deriving the obsidian finds at so many sites ultimately from just a few 'shipments' (by any of the above routes) to the area which happened to be all of type SA obsidian. While type SA obsidian has been found at many sites in northern Italy, there is no evidence there of its selection over the other Sardinian varieties, either at the site or regional level, and since the indigenous Sardinians did not select type SA over the other varieties either, it seems unlikely that Sardinian sailors would have carried only type SA with them on their voyages. Selection, therefore, of type SA obsidian by 'merchants' from southern France (whether in northern Italy, Corsica, or even visiting Neolithic settlements in the Cabras-Oristano area) would have been a peculiarly French phenomenon. Specific rock types were intentionally selected for ground stone implements with widely different frequencies in neighboring areas of France, indicating that the availability and quality of the raw materials were not the only factors influencing selection (Ricq-de Bouard and Fedele 1993: 16), circumstances which could equally well apply to obsidian (translucent vs opaque, with most of the available translucent obsidian of type SA, especially in the Middle-Late Neolithic). The second hypothesis seems highly unlikely (too many sites with obsidian, at least a 1500-year time span), and the other, also unlikely, alternative appears to be direct procurement from Monte Arci by sailors from southern France who only knew about the SA source and who passed around directions to Conca Cannas for generations.

No obsidian from Palmarola has been identified yet in France, but two exceptional pieces of obsidian from Pantelleria are known from a Final Neolithic dolmen tomb at San Sebastien (Williams-Thorpe, Warren and Courtin 1984), nearly 850 linear km from their source. The absence of Palmarola obsidian among the many artefacts that have now been analysed from southern France, considering its widespread (but modest) use in northern Italy, lends additional support to the hypothesis of French selection of translucent obsidian and/or frequent procurement via Sardinia/Corsica rather than Tuscany/Liguria.

In Northern Italy, obsidian is still only a minor part of lithic assemblages, with flint from southern Alpine sources the primary raw material used during the Neolithic (Ferrari and Pessina 1994; Barfield 1987, 1981). Of the obsidian present, all three Sardinian obsidian sources (SA, SB, SC) are almost equally well represented. In contrast to more-distant southern France, Lipari and Palmarola are also significant contributors. In fact, the usual case seems to be for at least two if not three island sources to be represented at each site in northern and western Italy where more than a few artefacts have been analysed. At the Italian Middle Neolithic (VBQ) site of Gaione-Parma, obsidian from Sardinia (SC), Palmarola and Lipari is present, and the strong tendency towards blades being of Lipari obsidian and cores and trim of Sardinian obsidian suggests source-based differences existed in the forms produced and circulated (Ammerman *et al.* 1990; Polglase 1990). The underlying motivation for circulation of different forms of obsidian (cores = utilitarian, reduced on-site; blades = prestige, little-used?) emphasizes the complexity of Neolithic exchange systems and our difficulty reconstructing them.

More definitive evidence comes from Arene Candide–Savona, where 53 obsidian artefacts from several Neolithic stratigraphic contexts have been analysed (Ammerman and Polglase 1993, 1996). In the Early Neolithic, obsidian comprises about 5% of the lithic assemblage at Arene Candide, and comes equally from Sardinia and Palmarola. All three Sardinian varieties are represented, with type SB by far the most important. In the Middle Neolithic, obsidian from Lipari replaces much of the Sardinian SA and SB contribution (the frequency of opaque [Palmarola + SC] obsidian remains constant), and by the Late Neolithic, nearly all obsidian artefacts are finished blades of Lipari obsidian. Ammerman and Polglase (1993, 1996) link this shift to the high quality of Lipari obsidian and its circulation as a prestige item in the later Neolithic. One must note, however, that they analysed only eight Late Neolithic artefacts from Arene Candide, and Sardinian obsidian is actually better represented than Lipari among Late Neolithic artefacts from other sites in northern Italy (combined analyses of Williams–Thorpe *et al.* 1979). Furthermore, visual examination of 99 obsidian artefacts from Gaione (Polglase 1990) suggests equal use of Lipari and other sources during the Middle Neolithic, while visual examination of 334 obsidian artefacts from Fornace Cappuccini–Faenza (Polglase 1989) may indicate that non-Lipari obsidian was more common there from the Early Neolithic through the Chalcolithic. Finally, my visual provenancing of 213 artefacts from Poggio Olivastro–Viterbo (Bulgarelli *et al.* 1993) revealed only 4 of Lipari obsidian in Late Neolithic levels. As usual, more analyses from more stratigraphically-controlled sites are warranted.

Some obsidian from Monte Circeo–

Latina, in southern Latium, was indicated to be of type SA (Hallam *et al.* 1976: fig. 4), presumably making it the most southerly occurrence of Sardinian obsidian on the mainland, but no analysis was reported and a later distribution map also produced by scholars at Bradford University shows only Palmarola obsidian from that site (Crummett and Warren 1985: fig. A1.2). Obsidian from Palmarola has been identified at a number of sites in central peninsular Italy, as well as in the Foggia area of the Tavoliere, and as far south as the Gulf of Taranto at Grotta Sant'Angelo–Cosenza (Hallam *et al.* 1976). Obsidian found at S. Domino in the Tremiti Islands was also reported to be from Palmarola (Cornaggia Castiglioni *et al.* 1962, 1963), but this attribution should not be taken for granted (e.g. Crummett and Warren 1985; Bigazzi *et al.* 1992a) since the analysis may be unreliable. Of no small significance is the single piece of Pantellerian obsidian identified in an Early Neolithic context at Villa Badessa–Pescara, on the Adriatic coast of central Italy (Bigazzi *et al.* 1992b).

Sardinian obsidian seems not to have made it to the eastern shores of Italy, although it accounts for all but one of 25 analysed samples from the Lake Region north of the Po River. In the Trieste area at the head of the Adriatic, most of the obsidian is from Lipari, and a few pieces are from Palmarola and Carpathian sources. Obsidian has been found at several coastal sites in Dalmatia, accounting for up to 2–3% of Danilo lithic assemblages (Martinelli 1990). No analyses of this material have been published, although it had been reported that some artefacts from Bosnia were of Sardinian origin (Rasson *et al.* 1977), a conclusion unsupported by the distributional evidence and perhaps due to trace element similarities between Sardinian and Anatolian obsidian (Williams–

Thorpe 1995: 231). A couple of pieces of Anatolian obsidian have been reported in Greece and eastern Europe (Renfrew and Aspinall 1990), but Carpathian sources are more likely to account for most of the Dalmatian finds. Obsidian is found more sporadically in Albania, where it may be Melian in origin (K.M. Petruso, pers. comm. 1994).

Southern Italy, Sicily, Malta and North Africa

In southern Italy, the Lipari source accounts for virtually all of the obsidian analysed to date. In Calabria, obsidian is particularly plentiful (90% of lithic assemblages at sites on the west coast), since alternative lithic raw materials were not available locally (Ammerman 1985a). Even though sites may be more than 100 km from the Lipari source, cores were discarded at an earlier stage of reduction than in northern Italy where they would be even more precious (Ammerman 1979, 1985b; Ammerman and Polglase 1993). Strong Early–Middle Neolithic (Impressed Ware and Stentinello) ceramic parallels between Calabria and Sicily and the Aeolian Islands link these regions in a single cultural unit, separate from Puglia and other areas of southern Italy (Ammerman *et al.* 1978: 191). Obsidian from Passo di Corvo–Foggia has been cited as Melian in origin (Perlés 1992: 145–146), but in fact the ESR analyses performed by Mello (1983) could not distinguish between Melos, Monte Arci, and Palmarola — the last being the most likely possibility. To date, not a single piece of central Mediterranean obsidian has been identified east of Italy's heel.

All the obsidian found in Malta comes from Lipari and Pantelleria, not Melos (Cann and Renfrew 1964; Hallam *et al.* 1976; contra Cornaggia Castiglione *et al.*

1963). Visual identification of 300 artefacts from Skorba indicate that more than 85% come from Lipari (Cann and Renfrew 1964), indicating that Malta's socio-economic affiliation was primarily to the north, certainly a much shorter open-water distance than to Pantelleria and North Africa. In Sicily, obsidian is largely presumed to be from Lipari, but few sites have been analysed. Nearly 40% of 152 obsidian artefacts from Grotta dell'Uzzo, however, come from Pantelleria (Francaviglia and Piperno 1987), a surprising amount if obsidian were the only resource obtained after such a large open-water crossing. Pantellerian obsidian has also been identified in Bronze Age contexts at Monte Cofano–Trapani (Francaviglia and Piperno 1987), and on the island of Ustica to the north (Tykot 1995b). Along with the sporadic finds at Villa Badessa and San Sebastien, it appears that Pantellerian obsidian was more widely distributed to the north than on the North African mainland. The distribution pattern for Pantellerian obsidian is clearly significant for our interpretation of the western spread of domesticates from the eastern Mediterranean during the Early Neolithic. A coastal North African route (Lewthwaite 1986a, 1986b, 1989) could have ultimately supplied domesticated animals and plants to Sicily and the Italian peninsula, with an open-water crossing of about 150 km between Cap Bon and southwest Sicily. If regular crossings did take place, however, one would expect that Pantelleria (100 km from Capo Granitola–Sicily) would have been visited often as well, resulting in the distribution of a significant quantity of obsidian (southward, if Sicilians travelled to North Africa; northward, if North Africans went to Sicily).

Pantelleria, only 90 km from the Tunisian coast, is presumed to have been

the source of most obsidian found in North Africa. Obsidian is being identified at more and more sites, although rarely in significant quantity (Camps 1964, 1974; and the multiple volumes in the series *Atlas Préhistorique de la Tunisie*, Collection de l'École Française de Rome 81: 1985, 1987, 1989, 1992). Not a single analysis of obsidian found at North African sites has been published, however, even though several samples were analysed in 1976 (unpublished data; Williams-Thorpe 1995: 229). These few analyses have been cited by Crummett and Warren (1985: 108), whose map (fig. A1.2) indicates that Lipari is the source of obsidian from an inland site (Tebessa?), while Pantelleria is the source of material from a site in the Bizerte region. The proximity of Pantelleria to the Tunisian coast makes it the most likely source of obsidian, since Lipari is considerably further away (ca. 400 km), and there is no evidence that material from Tibesti in northwestern Chad ever reached the Mediterranean coast nearly 1800 km to the north. Some obsidian artefacts reported from Tunisian and Algerian sites have been assigned a provenance on a visual basis (Camps 1964, 1974), but are insufficient in number to establish the relative contributions of Lipari and Pantelleria to North African lithic assemblages. I examined 34 pieces of obsidian collected during surface surveys and excavation on the small island of Zembra, and found all to be green in transmitted light and thus from Pantelleria (Tykot and Vigne n.d.).

Discussion

Procurement

During the Early Neolithic (Cardial and Filiestru periods), there appear to have been few settlements in the Gulf of

Oristano area, permitting unhindered access to Monte Arci and its obsidian resources. In extant traditional societies, lithic raw materials are often acquired in the course of other activities such as seasonal transhumance, in other words as an embedded strategy (Binford 1979). Shepherds, farmers, hunters, or fishermen passing through the Campidano plain to the west of Monte Arci would have found it particularly easy to locate type SB2 obsidian in secondary geological contexts on the western flanks of Monte Arci and *in situ* deposits right nearby. I suspect that the more concentrated Conca Cannas obsidian flow was less visible to the casual observer, particularly non-local prospectors coming even from adjacent regions. More distant visitors arriving by boat in the Gulf of Oristano would have been closer to the SB2 source, and even if they entered the coastal lagoons south of Arborea, would still have been 13 km from the Conca Cannas source. While they might have been able to get somewhat closer if the Mannu or Mogoro rivers were navigable, obsidian otherwise was transported by human hands, since the only animals (cattle) capable of carrying a load of obsidian nodules must have been extremely rare in the Early Neolithic. Residents of areas east of Monte Arci could have come across type SC obsidian in secondary deposits without having to ascend the steep ridge to Punta Pizzighinu.

In the Middle Neolithic (Bonu Ighinu), the settlement of the Cabras and Oristano area meant that residents of neighboring and/or distant communities could obtain obsidian without going to Monte Arci themselves. Agricultural intensification may have led to fewer seasonal rounds, long distance hunting trips, etc., ultimately resulting in less embedded procurement of obsidian. In any case, ethnographic data

suggest that direct procurement from raw material sources in another community's territory is rare, in part because the repeated reciprocal exchanges that typically characterize privileged expeditionary relationships between communities obviates the need for such trips (Féblot–Augustins and Perlés 1992). Nevertheless, both agriculturalists in California and hunter–gatherers in Australia were able to quarry in their neighbors' territory freely or in exchange for small gifts (Bryan 1950; Gould *et al.* 1971). In such cases, a sequential production strategy is often employed to produce utilitarian items from the raw materials back at their own village; luxury goods are more likely to be completed at the quarry or in its immediate area by local residents (Ericson 1981).

The Oristano province locals, certainly knowledgeable about all the available obsidian sources, apparently preferred types SA and SC over SB2, but passed on all types (including SB1) to Corsica and the mainland, mostly in unfinished form (preform cores or raw nodules). Lilliu (1989) writes that *oro nero sardo* was transported to the mainland by local merchants from the Gulf of Oristano, and even suggests that the manufacture of ground-stone objects may have been centered in the Monte Arci zone because of stimulation from obsidian workshops there (Lilliu 1986). It is uncertain, however, to what extent specialists were involved in the procurement, production or transport of obsidian from Monte Arci. In the Early Neolithic, the island's low population density and the incipient level of newly-introduced domestic food production would seem to make full-time lithic specialists unlikely for socioeconomic reasons, in contrast to the Middle Neolithic when increases in settlement numbers and more intensive agropastoralist activities are

accompanied by innovative exploitation and production of ground stone vases and figurines in addition to widespread obsidian distribution (see Tykot 1997b for a detailed review of the Neolithic periods). Excavation and analysis of lithic quarries and workshops would provide direct information on raw material selection, extraction and reduction technology, and knapping behavior, as well as chronological change in production, exchange and technology (Ericson 1984). No workshop sites in Sardinia have been excavated, nor detailed studies done to determine lithic reduction skill and efficiency. There is some evidence, however, that knapping was better controlled and forms more standardized in the Middle Neolithic than in the Early Neolithic levels at Grotta Filiestru (Hurcombe and Phillips *n.d.*), while use-functions of individual tools were also more specific in the later period (Hurcombe 1992a, 1992b). This is consistent with a general impression of progressive typological standardization and maximization of core material by the Late Neolithic (Garibaldi 1993).

Labor specialization must have existed in the central Mediterranean in the Early Neolithic, judging from the technological expertise represented in the extensive flint mine complex of Defensola–Vieste in the Gargano peninsula, which may have been worked year round (di Lernia *et al.* 1990–91). Likewise, Leighton (1992) argues that raw materials for ground stone tools were taken from local sources in southern Italy and worked at nearby settlements, ultimately being exchanged to adjacent communities as finished objects. The involvement of particular communities with procurement and manufacturing — village craft specialization — would naturally have been favored when raw material resources were only locally available.

Finally, it has been suggested that access to the Monte Arci sources may have become restricted by the Bronze Age, based on the presence of only one type of obsidian at some sites (Michels *et al.* 1984). As noted above, the likelihood of most site collections representing multiple generations of human activity, and the strong possibility of reuse of locally available obsidian in the Bronze Age, makes it extremely difficult to test this hypothesis. Obsidian artefacts from tomb contexts may well be from a single source, but are also more likely the result of reduction from a single core, as are artefacts from residential sites where core trim and debitage are also found. Differentiating between direct procurement from a single source, and acquisition of obsidian of a single type from intermediaries is virtually impossible.

Distribution

A now substantial number of analyses continues to support the notion of minimal overlap in obsidian exchange between Neolithic Europe, the western Mediterranean, the Aegean, and the Near East. The limits of obsidian distribution probably also applied to the movement of other materials and ideas, and may reflect cultural or ethnic boundaries. It should also be understood that these distribution patterns represent cumulative actions over long periods of time; it may have taken generations for some obsidian to travel from its geological source to its findspot (Williams–Thorpe 1995).

Provenance determinations of more than a few artefacts each from an increasing number of Neolithic sites in the central and western Mediterranean have contributed greatly to our understanding of obsidian distribution from each island source, although the number of analysed speci-

mens from the mainland, especially peninsular Italy, remains inadequate (Figure 3). Obsidian from Monte Arci is found in Early Neolithic contexts throughout Sardinia, as well as in Corsica, the Tuscan archipelago, and northern Italy, although there is some evidence that not much if any obsidian reached southern Corsica in the very first phase of the Early Neolithic (Lanfranchi 1993) and few excavations elsewhere have produced fine enough distinctions within the Early Neolithic to address this possibility. Obsidian from Lipari, Palmarola, and Pantelleria was also distributed in the Early Neolithic, with long-distance circulation of obsidian from all four islands peaking during the Middle–Late Neolithic in southern France (Chasseen) and northern Italy (VBQ and Lagozza). Courtin (1967: 105, fig. 5) implied long ago that Sardinian obsidian reached southern France directly and independently of Tuscany and Liguria, while Camps (1976a, 1976b) specifically indicated that Monte Arci obsidian probably passed along the west Corsican coast and then across the open sea to Provence, near St. Tropez. The presence of Pantellerian obsidian in Early Neolithic levels at Grotta dell'Uzzo in Sicily is direct evidence of open-water crossings of at least 100 km, to a tiny island destination, and attests to the navigational skills of early seafarers. The open-water distance between Corsica and southern France is of the same order of magnitude (150 km), indicating that such trips could well have taken place on a regular basis during the Neolithic. Phillips (1992, 1986, 1982) more reasonably suggests that obsidian probably reached southern France by several routes, including directly from Sardinia, but also by cabotage along the Ligurian coast and overland from the Po Valley.

Regional differences in form and fre-

quency of the multiple obsidian sources present at individual sites are apparent even when the obvious factors of relative source distance, quality and abundance are taken into account (Figure 8). High quality translucent obsidian from Lipari predominates throughout southern Italy, Sicily, and Malta, overshadowing the more limited quantities of opaque Palmarolan and Pantellerian obsidian circulating in the same areas and ultimately reaching the same or even more distant distributional endpoints in North Africa, Languedoc, and Trieste. Three major varieties of Monte Arci obsidian are exclusively found in Sardinia and Corsica, predominate in southern France, and 'compete' with Lipari and Palmarola obsidian in northern Italy. Hurcombe and Phillips (n.d.) have observed that type SA obsidian may have reached Grotta Filiestru in northern Sardinia in finished form, whereas abundant evidence for the reduction of type SC exists at the cave site. The large quantity of blade cores and debitage in southern Corsica indicates tools of Sardinian obsidian were produced there too, and six workshop sites have been identified in southern France (Phillips 1982, 1992; Binder 1987) even though the amount of flaked material was small. In northern Italy, Sardinian obsidian also appears to have arrived as cores rather than finished blades, in contrast to obsidian from Lipari (Ammerman *et al.* 1990; Ammerman and Polglase 1993). At Arene Candide, blades of Sardinian or Palmarolan obsidian are also noticeably larger than those from more distant Lipari (Ammerman and Polglase 1996).

The relative use frequency of the different Sardinian sources is particularly significant for our understanding of procurement and distribution activities, and raises questions about the differential functional

quality of the various obsidian sources as well as their aesthetic characteristics. Type SA — and some SB2 — obsidian is quite translucent and glassy and thus similar in appearance to Lipari obsidian, while type SC is opaque, less glassy, and resembles Palmarola obsidian (and Pantelleria too except for thin pieces in which the green color is more readily apparent). Glassy obsidian is considered too brittle for certain tasks, and generally dulls quickly; in those cases flint would actually be the preferable stone tool material. Knapping experiments and use-wear analysis of obsidian assemblages will be necessary to determine whether types SA and SC obsidian were best suited — and employed — for different tool forms and use-functions.

The distributional evidence indicates that types SA, SB2 and SC obsidian were all used at Neolithic sites in central and northern Sardinia, with type SB2 the least frequent of the three, and rarely found in southern Sardinia. In the Early Neolithic, however, it seems that type SB2 obsidian was much more commonly used and even predominates in some assemblages, not only in Sardinia but also in northern Corsica, the Tuscan archipelago, and northern Italy (Figure 9). This could result from its ready accessibility in a sparsely populated area of the island. By the Late Neolithic, types SA and SC are the only sources regularly found at individual sites, with type SC obsidian actually accounting for a greater percentage of most assemblages. For the most part, the relative frequencies of the multiple Monte Arci obsidian sources represented in northern Sardinia are quite close to those in Corsica and northern Italy. Southern France is the notable exception, where more than 95% of the Sardinian obsidian for the entire Neolithic is type SA. The most parsimonious explanation for the presence of almost

exclusively type SA obsidian in southern France, for a period spanning more than a millennium, is particular selection of that translucent variety for reasons unimportant or not applicable to their neighbors at Arene Candide and elsewhere in northern Italy where a diversity of sources is represented. If Sardinian (and/or Corsican) boats travelled to southern France or northern Italy, they likely would have carried obsidian from multiple Monte Arci sources and left it all behind before returning home, probably laden with mainland products. Since mostly type SA is found in southern France, and the current in the Ligurian Sea runs counterclockwise (i.e. northern Italy would probably have been visited before southern France by Sardinian/Corsican sailors), it is more likely that French merchants specifically selected type SA obsidian over the other varieties available, whether that was at ports of call in Liguria, Corsica, or even Sardinia. Lipari obsidian, when available so far from its source, was also apparently acceptable, but Palmarolan obsidian — even though it is well attested at Arene Candide — was not. Differences in obsidian selection criteria between southern France and northern Italy may also be related to the availability of alternative lithic materials, or evolved cultural preferences or ethnic ties dating from the beginning of the Early Neolithic; in southeastern France, neolithisation involved the acculturation of Cardial characteristics by Castelnovian (Late Mesolithic) peoples, whereas in Liguria there seem to have been no Late Mesolithic antecedents (Binder 1987, 1989; Vaquer 1990; Biagi *et al.* 1989).

Obsidian continued to be used in Sardinia and Corsica after the Neolithic, judging from its regular presence at Copper, Bronze and even Iron Age sites (Contu 1990–91) and from obsidian

hydration dating studies (Michels *et al.* 1984; Dyson *et al.* 1990; Stevenson and Ellis n.d.). There is also growing evidence of its continued use (at diminished levels) at contemporary mainland sites, and although this may represent recycling of locally available material, there is other evidence that contacts between Sardinia and Tuscany were maintained after the Neolithic (Vigliardi 1980).

Exchange

In reconstructing prehistoric exchange systems, Renfrew (1993a) has emphasized the consideration of the full range of human interactions, and the possibility that these interactions may have been characterized by 'communication' rather than 'trade' if the acquisition of goods played a secondary or minor role. What has become strikingly clear is that multiple, distinct systems of production and exchange operated simultaneously in Neolithic Mediterranean societies, pertaining to different categories of material goods (Perlès 1992; Skeates 1993). Cardial ceramics, for example, were also being exchanged in the Early Neolithic, although the distances involved were on the order of 50–70 km rather than the hundreds traveled by obsidian (Barnett 1990a, 1990b). We also have evidence for Neolithic trade of flint, greenstone, and various kinds of fine ceramics up and down the Italian peninsula, along the Po Valley, and across the head of the Adriatic to Dalmatia. It should be no surprise that topography played an important role in the routes these materials followed; cabotage along either the Tyrrhenian or Adriatic shoreline made more sense than transport across mountainous inland areas — although this occurred in the Alps in the case of flint and greenstone, and across the Appenines in

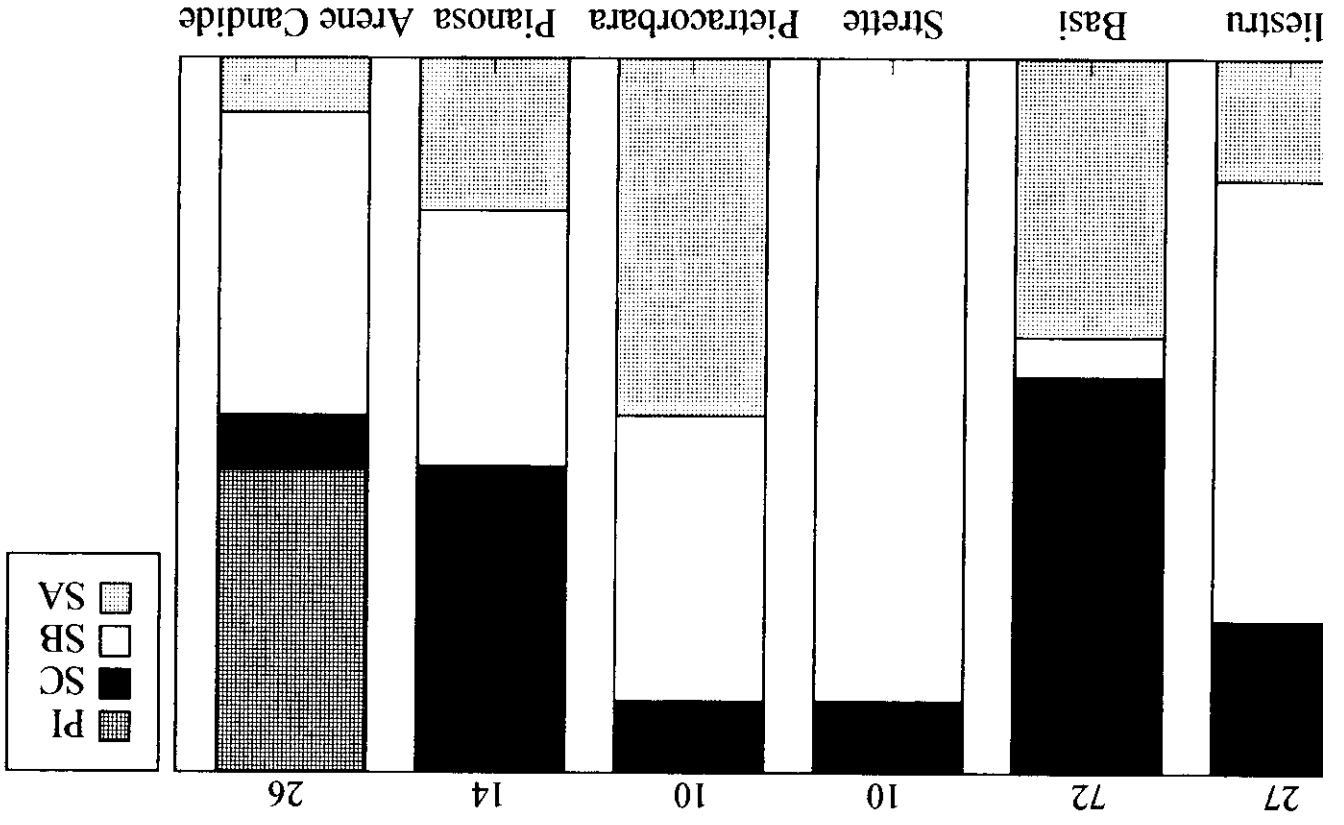
the case of Ripoli trichrome pottery. Finally, we know that Near Eastern domesticates were introduced to the central Mediterranean during the Neolithic (Tykot 1995a, 1997b; Donahue 1992; Lewthwaite 1986a; Costantini 1989), and along with other potential trade goods like salt, basketry and textiles which are not particularly visible in the archaeological record, would have formed the basis for the Neolithic economic system. We must therefore consider that the distribution of obsidian not only is linked to the circulation of other material goods of similar utilitarian, social, and/or symbolic significance, but that the particular exchange system it belonged to probably depended upon dynamic factors such as local custom and the availability of the material which were likely to change over time.

In the central and western Mediterranean, obsidian was not used during the Upper Paleolithic or Mesolithic, despite the likelihood that its sources were known to the pre-Neolithic residents of Corsica, Sardinia, and Sicily, and its presence falls off sharply after the Late Neolithic in mainland Italy (Lagozza) and southern France (late Chasseen). This situation parallels the use of amber in Britain, where it was a high prestige item in the Early Bronze Age Wessex culture, but is almost archaeologically invisible in the preceding Neolithic and the succeeding Middle Bronze Age (Beck and Shennan 1991). In the eastern Mediterranean, pre-Neolithic trade has been considered an incentive for the adoption of agriculture and the production of surplus wealth to acquire non-local goods (Runnels and van Andel 1988; cf. also Tangri 1989; Runnels 1989). But in the central and western Mediterranean obsidian distribution coincides with the expansion of village farming, and is more likely the consequence of this new

sedentism. The dramatic shift in the subsistence economy is accompanied by the development of craft specialization — evident not only in the skilled knapping of obsidian and flint tools, but also in ceramic production and other activities — but craft specialization is certainly not a prerequisite for obsidian exploitation, particularly near its source. In its 'supply zone' obsidian was likely to have been primarily utilitarian in function, whereas at greater distances its diminished availability added a prestige component to its use. Jadeitite and eclogite axes found in northern Italy and southern France appear well used and less perfectly finished than more finely-made, lightly-used axes found in southern Italy which probably served a non-utilitarian or ornamental purpose (Leighton 1992). While it would be tidy to link the southward distribution of 'jadeite' from the western Alps to the northward dispersion of Lipari obsidian, this cannot be assumed since they may have belonged to different exchange system categories depending on a site's location relative to the two opposing sources, and because interaction between groups may not have been symmetrical (Renfrew 1986; Champion 1989). Likewise, the circulation of Sardinian obsidian, flint, nephrite, steatite, and salt cannot be considered within a single exchange category (Garibaldi 1993; Lilliu 1986).

The relative quantity of obsidian found at sites of differing distances from its source has been used to define fall-off curves which may be characteristic of certain exchange mechanisms of sociopolitical systems. The quantification of obsidian frequency, by number or mass of tools, debitage, and cores relative to other chipped stone tools or other measures of site size, is still theoretically desirable (Ericson and Baugh 1994), although often

bsidian source frequency at several Early Neolithic sites. All determinations by chemical analysis (Tykot 1995a; mmerman and Polglase 1993, 1996 for Arene Candide). Numbers of artefacts represented are at the top of each bar.



difficult to apply given the considerable variation in reported excavation data in the last century (see Guidi 1987). Such systematic data are necessary for diachronic and spatial analysis of obsidian use, and an admirable effort has been made recently for the central and western Mediterranean by Pollmann (1993) who confirms the empirical hypothesis that obsidian use was greatest during the Italian Middle–Late Neolithic (VBQ, Ripoli, Serra d'Alto, Lagozza, Diana; Chasseen in southern France), with presumed transportation routes and geographic barriers significantly influencing the quantities found. The identification of centers of redistribution should be made cautiously, however, since the quantity of obsidian found at Pescale in northern Italy (950 pieces) is no longer unusual, or surprising. Hundreds of obsidian artefacts have been found at Fornace Cappuccini–Faenza (Polglase 1989; Antoniazzi *et al.* 1990; Montanari *et al.* 1994), Podere Uliveto and La Puzzolente–Coltano (Cocchi Genick and Sammartino 1983; Sammartino 1986), and extrapolation from the surface finds at Gaione suggests that thousands may be present there in just the plough-zone levels (Ammerman *et al.* 1990).

While privileged access to non-local goods may have enhanced the prestige of local elites — by both the exotic nature of the material and any accompanying exotic or secret knowledge (Renfrew 1993a; Helms 1988) — there is little evidence at present to indicate that obsidian fulfilled such a role in prehistoric Italy. According to the structuralist, prestige-goods economy model, elite sociopolitical status is characterized by control of commodities which are scarce, require specialist production, and/or are associated with more powerful social systems (Baugh and Ericson 1992: 10). During the Early and

Middle Neolithic, however, social differentiation within culture groups was minimal, as was any political hierarchy between groups, and it is only in the Late Neolithic (Lagozza, Late VBQ, Diana) — after the zenith of obsidian distribution — that agricultural intensification and an increase in the variety and quantity of material goods in circulation signify the growth of ranking and increased emphasis on prestige goods (Phillips *et al.* 1977; Barker 1981; Shennan 1982; Phillips 1993).

Conclusion

The typology, relative quantities and archaeological contexts in which obsidian is found in the central Mediterranean suggest that it was primarily utilitarian in function, but that its presence was the result of social and multi-level economic interactions including prestige exchange, both of which probably had particular local characteristics. The basic exchange systems that existed may be understood as intertwined local networks rather than as a whole world system (Renfrew 1993a: 7), and in combination with some direct long-distance contacts — mostly via coastal maritime routes — resulted in the distribution of mainly raw materials and utilitarian products, although their 'prestige' value would have been enhanced at great distances from their source. In the Neolithic, domesticated sheep, goat and cattle, and their secondary products, were among the most likely commodities exchanged, especially so for the islands of Sardinia and Corsica where they must have been intentionally introduced and were a necessary dietary supplement to the limited indigenous fauna (see Lewthwaite 1981). Again, specifically linking extra-insular exchange of Sardinian obsidian with incoming domesticates is tidy, but impossible to

82.	Torre Testa (Brindisi)	42.	Grotta Belia (Monticcasstrilli)	41.	Isolino di Varese	1.	habert (Saint-Eulalie)
83.	Torre S. Sussanna	43.	Ripoli (Corropoli)	2.	Grotta Follera (Savona)	2.	s (Ventenac-Cabardès)
84.	Masseria S. Gaetano (Guagnano)	44.	Poggio Olivastro (Vulci)	3.	Arne Candide (Finale Liguria)	3.	assonne)
85.	Laghi Alimini (Otranto)	45.	Valle Orara (Cittaducale)	4.	Planaccia di Suvro	4.	de-Roquefortongue
86.	Campi Latini (Catalone)	46.	Castignano (La Separa)	5.	Monte Covolo (Brescia)	5.	do (Portiragnes)
87.	Grotta della Trinità (Ruffano)	47.	Villa Badessa (Rosciano)	6.	Rocca di Manerba	6.	Fonlatine (Congénies)
88.	Grotta Grande di Latronico (Potenza)	48.	Ponte Peschio (Genzano)	7.	Riparo Valenesi (Manerba)	7.	saint-Loup (Tresques)
89.	Grotta del Romito (Papasidero)	49.	Palidoro (Roma)	8.	Bellori (Grezzana-Verona)	8.	: Orange)
90.	Grotta Sant'Angelo (Cassano Jonio)	50.	Setteville (Tivoli)	9.	Grotta G. Perrin (Sengia Bassa)	9.	es Roches (Piolenc)
91.	Acconia	51.	Via Pontina (Roma)	10.	Sammardenchia di Pozzuolo	10.	(Mornas)
92.	Beviacqua (Acconia)	52.	Palermo (Avezzano)	11.	Grotta della Tararuga (Trieście)	11.	(Chateaufort-du-Rhône)
93.	Prestarona (Canolo)	53.	Fossaccia (Chieti)	12.	Vašca Jama (Trieście)	12.	(Valence)
94.	Isola di Filicudi	54.	Batteria (Monte Circeo-Roma)	13.	Riparo di Monrupino (Trieście)	13.	tomaire
95.	Isola di Lipari	55.	Campo Mezzomonte (Roma)	14.	Grotta degli Zingari (Sgonico)	14.	en-Djols)
96.	Castelaro Vecchio (Lipari)	56.	Isola di Ponza	15.	San Quirino (Trieście)	15.	Bianches (Menglon)
97.	Lipari Castello	57.	Grotta delle Felci (Capri)	16.	Grotta Lonza (Monrupino)	16.	'Olivier (Istres)
98.	Isola di Ustica	58.	Isola di Capri	17.	Grotta dell'Ansa (San Pelagio)	17.	- (Grans)
99.	Monte Corfano (Trapani)	59.	Pompeii	18.	Gaione (Parma)	18.	eres (Verrières-Cazan)
100.	Grotta dell'Uzzo (Trapani)	60.	La Panellaria (Lucera)	19.	Razza di Campagne	19.	ambesc)
101.	Santa Panegia (Siracusa)	61.	Lucera	20.	San Polo d'Enza	20.	: (Vauvenargues)
102.	Arenella (Siracusa)	62.	Casone (San Severo)	21.	Ciotta (Scandiano)	21.	(Minc)
103.	Mursia (Panelliera)	63.	Monte Aquilone (Manfredonia)	22.	Villa Agazzotti (Formigine)	22.	erne (Trets)
104.	Isola di Panelliera	64.	Grotta Scoloria (Manfredonia)	23.	Cava Nuova (Fiorenza)	23.	Baune (Gdémens)
105.	Cala Pisana (Lampidusa)	65.	Passo di Corvo (Foggia)	24.	Pescate (Prignano)	24.	na (La Londe-les-Maures)
		66.	Masseria Leconessa (Melfi)	25.	Spiamberto (Modena)	25.	gliche Supflicure
		67.	Bari	26.	Formace Cappuccini (Farenza)	26.	sur-Verdon)
		68.	Pulo di Altamura (Bari)	27.	Misano Adriatico (Riccione)	27.	asse)
		69.	S. Candida (Bari)	28.	Grotta del Leone (Agnano)	28.	: (Villicroze)
		70.	Serra d'Alto (Matera)	29.	Piazza della Sigioria (Firenze)	29.	(Toumour)
		71.	Fonte di Villa (Matera)	30.	Podere Ulliveto (Livorno)	30.	(Ramatuelle)
		72.	Grotta Funeraria (Matera)	31.	Isola di Capraia	31.	en (Plan-de-la-Tour et
		73.	Murgaccia (Matera)	32.	Isola d'Elba	32.	ime)
		74.	Murgia Timone (Matera)	33.	La Scioia (Isola Pianosa)	33.	saint-Tropez)
		75.	Grotta del Pipistrelli (Matera)	34.	Grotta del Fontino (Vallefortana)	34.	ontouge
		76.	Pizzica Pantanello (Metaponto)	35.	Pienza	35.	ael, Agay)
		77.	Torre Sabea (Taranto)	36.	Cava Barberi (Pienza)	36.	res (Saint-Raphaël, Agay)
		78.	Torre Canne (Fasano)	37.	Grotta del Beato Benincasa (Pienza)	37.	: Grenouiller
		79.	Torre Bianca (Fasano)	38.	Grotta dell'Orso (Sartano)	38.	ael, Agay)
		80.	Fontanelle (Osuni)	39.	Santa Maria in Selva (Teta)	39.	Carros)
		81.	Grotta Morelli (Osuni)	40.	Argentario (Grosseto)	40.	ice)
				41.	Ischia di Castro (Viterbo)	41.	ice)

ALGERIA

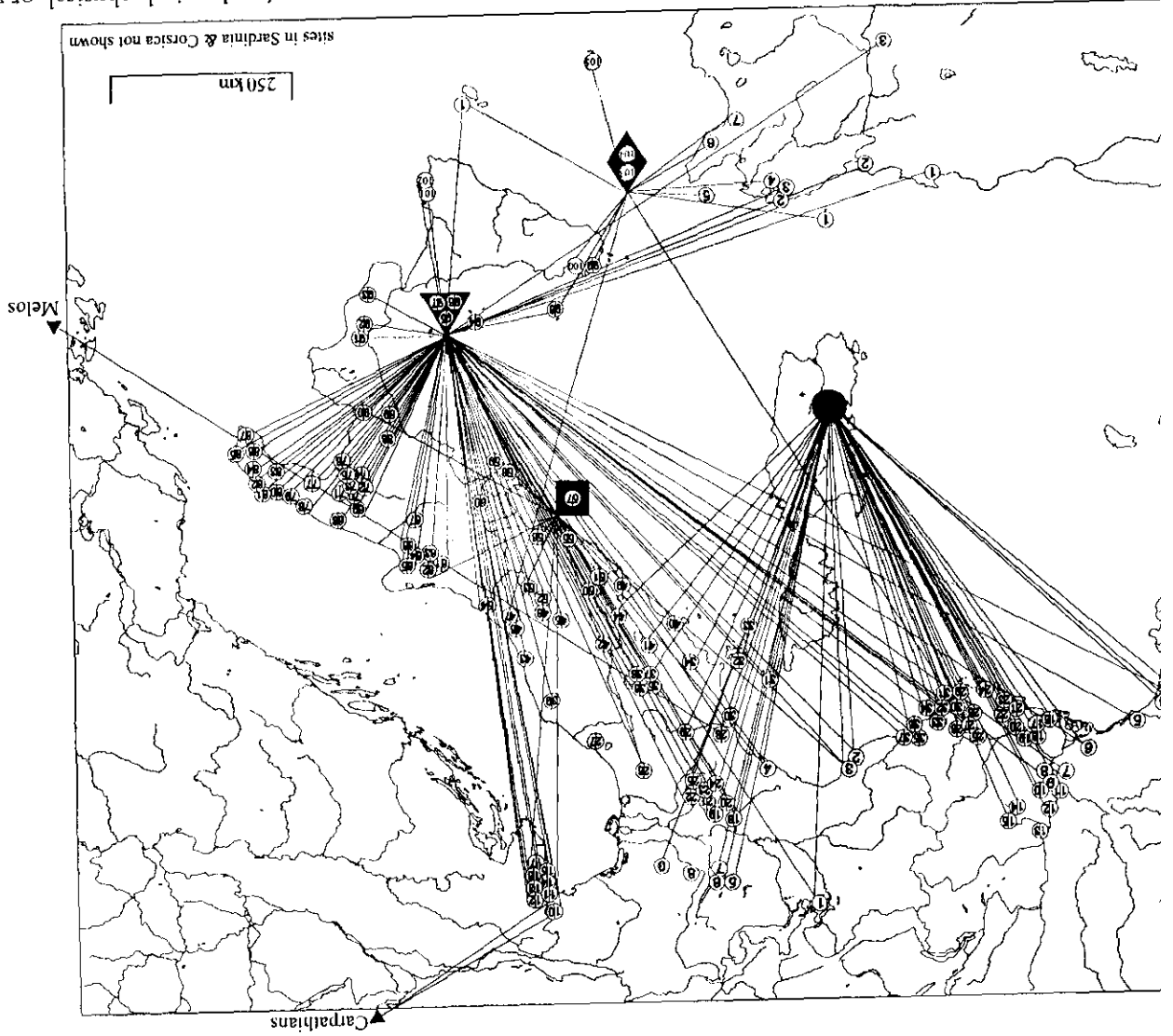
TUNISIA

MALTA

ITALY

Obsidian Procurement and Distribution in the Central and Western Mediterranean

sidian distribution in the central and western Mediterranean: source determinations by chemical, physical, or visual tests. In Italy, sites 7, 17, 34, 60, 94, 98, and 103 are post-Neolithic.)



demonstrate archaeologically. Nevertheless, a similar proposal has been posited for the exchange of cattle and obsidian at Çatal Hüyük in Turkey (Sherratt 1982).

Simultaneously, ethnicity and the maintenance of kin connections are likely to have been significant factors in the creation of preferential social exchange partners, and the importance of alliances and ceremonial behavior in the functioning of exchange networks cannot be underestimated. Fine ceramics, shell and other exotic materials are commonly found in ritual or ceremonial contexts, and these are just the Neolithic commodities that are archaeologically visible (Skeates 1993; Malone 1985). Such occasional ceremonial events may also have provided the main context for the social exchange of obsidian, ground stone axes and other less spectacular materials. Group identity and the maintenance of kin relations would have become important social issues with the changes in mobility due to agricultural sedentism in the Early Neolithic, and widespread exchange networks would have integrated dispersed communities through the common behaviors associated with the exchanged items, especially decorated ceramics and the eating and drinking habits associated with them (Chapman 1988).

Chronological change in prestige-type material goods in the central and western Mediterranean may be described in terms of three phases:

(i) In the Early Neolithic, ceramic production was an innovative technology, so that highly decorated Cardial wares were especially prized, and were produced in multiple workshops spread across much of the region. The great stylistic similarity may have served to maintain social affiliations among groups, while local modifications may have operated as boundary maintenance symbols and defined particu-

lar social groups.

(ii) In the Middle and Late Neolithic, we see the addition to the northern mainland repertoire of obsidian, a material available only in restricted, island localities, and only sparsely available on the mainland in the Early Neolithic. The generally small quantities found at large numbers of individual sites surely implies its social rather than economic importance, and the transparency of obsidian from certain sources might have been its most sought after feature (Barker 1981). The best way to model long-distance obsidian exchange in this period may be as multiple small-scale movements like those demonstrated by Barnett (1990a, 1990b, 1995) for fine ceramics.

(iii) The third stage begins with the appearance of metal artefacts at later Neolithic and Chalcolithic sites, both on the islands and on the mainland. It is at this time that elaborate chambered tombs appear in much of the central Mediterranean region (Whitehouse 1981; Jousaume 1985; Guilaine 1992), but obsidian is noticeably absent in them except for those on Sardinia and Corsica. Also, metal did not replace stone as the material most commonly used for tools in the Chalcolithic or even the Early Bronze Age for most of Italy; the absence of obsidian in lithic assemblages must mean then that its prestige value declined, not that exchange with the source islands was abandoned.

In modeling distribution and exchange systems, it is necessary to go beyond the simple dispersion diagrams showing the geographic extent of a single material's distribution (Figure 10), and consider the chronology, quantity and quality of the material circulated, the economic and social context(s) in which obsidian and other products were acquired or exchanged, and the particularistic factors of

transportation methods and routes, differential use–function and value pertaining to individual prehistoric communities.

In conclusion, while we must be cautious in our extraction of economic and social information from lithic distribution patterns, this remains a worthwhile endeavor. Characterization alone is not enough; the derivation of structured models that integrate social and utilitarian function fully within specific exchange systems is necessary to interpret ‘trade’ in ancient societies. The extent and significance of obsidian distribution from the central Mediterranean sources are still being refined, but it is clear that comprehensive sourcing of obsidian assemblages provides a different yet clearer picture of source exploitation, production and exchange than does selective analyses of small numbers of artefacts. Analyses of large numbers of artefacts permits chronological control at least at the site level, and therefore insight into dynamic changes in obsidian source selection. The integration of source data, form, function, and reduction sequence for whole assemblages of obsidian artefacts from well–dated archaeological contexts will ultimately provide a more complete understanding of prehistoric socio–economic systems and human behavior in the central and western Mediterranean.

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