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The Sources and Distribution of Sardinian Obsidian

Robert H. Tykot

Introduction

The following paper summarizes the history of obsidian studies pertaining to Sardinia, and assesses our current knowledge of the geological sources in Sardinia, and of the 'trade' of archaeological obsidian around the island, to Corsica, Elba and mainland Italy and France. The pattern and chronology of obsidian distribution have the potential to increase our understanding of the extent of interaction between insular and extra-insular populations, and of Neolithic and Bronze Age social and economic organization. With sufficient data, it should be possible to infer the parallel movement of more perishable goods (e.g. plants, animals and animal products), cultural ideas, and technological information, and their significance in the cultural development of prehistoric Sardinia (Tykot forthcoming). The long history of obsidian studies in Sardinia reflects the realization of this potential, and current efforts continue to build upon the foundation established by previous research.

History of Research

The presence in Sardinia of geological sources of obsidian, a volcanic glass frequently used to make stone tools because of its superior conchoidal fracture, is not a new discovery. Count Alberto de la Marmora (1839–40) made the first substantial contribution to our geological knowledge of the island in general, and in particular of the Monte Arci region where obsidian is found, more than a century ago (Fig. 1). De la Marmora (1839–40: 499-501) describes rhyolites of various types, including black obsidian, in the narrow valleys (*concas*) on the southwestern side of Monte Arci; he found obsidian *in situ*, as dikes or beds between rhyolite flows, in only a few places, however, although he does mention scatters so abundant that they could have come from a glass bottle factory. De la Marmora (1839–40: 153, 479, 489, 532, 583, 631) also mentions several minor sources of obsidian, at Tacco Ticci (Seulo), in the

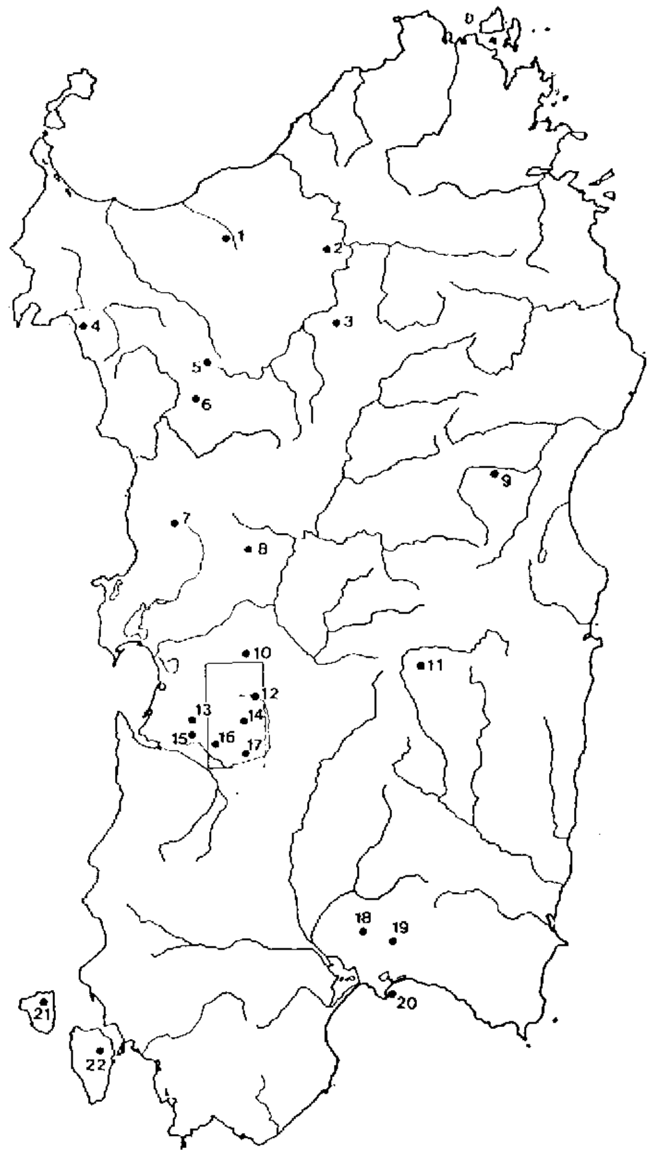

Fig. 1 Map of Sardinia showing Monte Arci zone (rectangle) and sites mentioned in text.
1. Osilo; 2. Tula; 3. Ozieri; 4. Alghero; 5. Monte Traessu; 6. Filiestru-Mara; 7. Cuglieri; 8. Losa-Abbasanta; 9. Corbeddu-Olièna; 10. Villaurbana; 11. Seulo; 12. Pau; 13. Marrubiu; 14. Morgongiori; 15. Terralba; 16. Uras; 17. Mogoro; 18. Sestu S. Gemiliano; 19. Settimo S. Pietro; 20. S. Bartolomeo-Cagliari; 21. S. Pietro; 22. S. Antioco.

Sarcidano, on the islands of S. Pietro and S. Antioco, in the altopiano of Sassu between Ozieri and Tula, at Muros (Villaurbana) and at Monti Urtigu (Cuglieri).

The first archaeological mention of Sardinian obsidian was by Giovanni Spano (1870: 19) in his notice about the prehistoric site of Monte Urpinu (CA). This site would come to the attention of mainland officialdom a decade later (Pigorini 1879: 45), was fully excavated by Edoardo Mannai in 1901, and was published on his behalf by Romualdo Loddo (1903). Significantly, two distinct types of obsidian, translucent and opaque, were recognized at Monte Urpinu, and attributed to sources on Monte Arci and Monte Trebina (Loddo 1903: 47). Meanwhile, the discovery by Melosi of a rock-shelter near Alghero with arrowheads of obsidian, quartz, agate and jasper had been reported (Spano 1873: 20-22); and Pio Mantovani (1875: 84) had discovered near Osilo (SS) an obsidian and flint workshop about 200 m wide, which was explored further by D. Lovisato (1875: 82; 1879: 18) and Filippo Nissardi (1886: 467). By 1903 a number of other prehistoric sites with obsidian had been discovered, including S. Gemiliano (Sestu) (Pigorini 1903), Settimo S. Pietro, and the Grotta di S. Bartolomeo (Cagliari), and it became clear that obsidian was an extremely important raw material for the prehistoric inhabitants of Sardinia.

Henry Washington (1913), a geologist with the Carnegie Institution, visited Sardinia in 1905 and spent two days studying the western flanks of Monte Arci. He confirmed de la Marmora's observation that Monte Arci consists of a domal core of feldspathic rhyolites, covered by a later mantle of trachyte, dacite, andesite and basalt flows. Washington (1913: 590-82) cites highly vitreous ash-gray perlites and black obsidians, usually intercalated with lithoidal rhyolites, near Uras in the Canale Perdera, above Conca s'Ollastu and at Conca Cannas; some small pieces of reddish-brown obsidian with black streaks are reported from the Rione Prassueda east of Conca s'Ollastu.

It thus became apparent by the early 1900s that obsidian from Monte Arci was to be found at nearly all prehistoric and protohistoric sites in Sardinia. Zanardelli (1899: 109-77), for example, lists 25 sites in the Campidano around Oristano from which he collected some 6661 pieces of obsidian; Taramelli (1926) summarizes his own extensive finds, and those of Lovisato, Ardu-Onnis, Zanardelli, Pischedda, Orsoni, Cara, Nissardi, Loddo and Mannai. Puxeddu (1958: 10-20), in a publication resulting from his thesis work at the University of Cagliari, was the last to compile this obsidian-site information, adding sites reported by Luigi Congiu (1947), Carlo Porru (1947), and Giovanni Lilliu, who has described obsidian as '*oro nero*'. Puxeddu's major contribution was in the location and description of the Monte Arci obsidian sources, and the incorporation of that geological/geographical information into an archaeological framework for the interpretation of prehistoric sites with obsidian artifacts.

In a zone of about 200 km^2 which today includes 19 centers of habitation, Puxeddu reports 35 Roman sites, 93 nuraghi, and 246 locations with obsidian. The latter are classified as: sources (4); collection centers (11); workshops (74); and stations (157). Puxeddu (1958: 24, 33-37, 46, 48) found abundant *in situ* material at Roia Cannas near Uras, cites de la Marmora's finds of obsidian veins at Sonnixeddu, and notes probable sources at Tzipanéas in the territory of Marrubiu, and at Perdas Urias near Pau.

Puxeddu (1958) also reported some green, red and hazel-brown obsidians from the Monte Arci zone, but these are actually jasper (Francaviglia 1984: 314). Monte Arci obsidian can have red streaks, however, and a few samples of blue obsidian have been reported (Francaviglia 1984: 314).

By the time of Puxeddu's research, numerous sites with obsidian artifacts were known not only in Sardinia, but also in Corsica, on Elba and other islands in the Tuscan archipelago, in Liguria and southern France, and elsewhere on the Italian peninsula (cf. Buchner 1949). It was also recognized that the Mediterranean sources were limited to Pantelleria (Pa), Lipari (Li), Palmarola (Pl), Monte Arci in Sardinia, Melos, and the mountains of Hungary and Transylvania. It is therefore not surprising that the obsidian in central and northern Italy was attributed to Sardinian and Liparian sources (Bernabò Brea 1947; Bernabò Brea and Cavalier 1956).

It was in the early 1960s that chemical methods of analysis were first applied to the question of obsidian provenience. Cornaggia Castiglioni *et al.* (1962–63) tried using ordinary wet chemical analysis of major elements to distinguish between the Palmarolan, Liparian, Melian and Pantellerian sources, with the surprising (and erroneous) result that obsidian artifacts in Malta were thought to be mainly of Melian origin.

The first successful application of chemical analysis relied instead on trace elements, measured by optical emission spectroscopy, to characterize the Mediterranean obsidians (Cann and Renfrew 1964). Using the trace elements barium, zirconium, niobium and yttrium, they were able to differentiate many of the sources in the Mediterranean region. Among those sources which could not be differentiated were Lipari and Palmarola (their group 4a), and only two of the Sardinian sources (2a and 6a) were represented among the four Sardinian specimens analyzed.

Hallam, Warren and Renfrew (1976) followed up on this initial study with a more detailed examination of the western Mediterranean obsidians. Of the 148 samples analyzed, 63 were Sardinian: these fell into three chemical groups, suggesting that there were three Sardinian sources, all presumably in the Monte Arci region of the island. Only 7 were geological specimens, however, all from a source near Uras, which was now labelled as the SA source, and was equivalent to the 2a group from Cann and Renfrew's earlier study (Hallam *et al.* 1976: 88). Type SB archaeological material was tentatively identified as coming from the northern part of Monte Arci, while the source of type SC artifacts was considered to be possibly near the SA source in the Roja Cannas area east of Uras (Hallam *et al.* 1976: 95). This study also revealed an extensive distribution of Sardinian obsidian to Corsica, southern France, and northern Italy (Fig. 2a), with different patterns of individual source utilization. In order to explain this variation, it became urgently necessary to locate and characterize the SB and SC sources.

It was also considered unusual for such chemically disparate obsidians (SC is calcalkalic to tholeiitic; SA is more alkaline) to occur together in the same volcanic center (Hallam *et al.* 1976: 95), but tectonic plate movement over a few million years can substantially change lava composition (Tykot 1982). Although calcalkalic obsidian of Oligocene-Miocene age (K-Ar date of 16.8 mya) has been reported in the rhyolitic massif of Monte Traessu west of Giave in northwestern Sardinia (Coulon 1971; Coulon *et al.* 1974), this material was never considered a possible source of the SC archaeological material found near Monte Arci (Dixon 1976: 291), although the obsidian of Monte Arci was attributed to an early phase of the Oligocene-Miocene by earlier scholars (cf. Lauro and Deriu 1957; Dixon 1976: 290-91). In any case the Monte Traessu obsidian is highly localized and unsuitable for tool use (personal observation), perhaps because of its great age.

The potassium-argon dating of Italian obsidians by Belluomini *et al.* (1970) included a vertical series of 8 samples in the Uras quarry which showed that flow to be about 3.0 ± 0.2 million years in age; the obsidians from Palmarola (1.6 ± 0.2) were significantly younger, and those from Lipari and Pantelleria were so young as to be unmeasurable by this technique. Fission-track dating by Bigazzi and his colleagues (Bigazzi *et al.* 1976; Bigazzi *et al.* 1971; Bigazzi and Bonadonna 1973) initially confirmed the age of the Uras and Palmarolan obsidians, and provided ages of about 11,000 BP for Liparian and 135,000 BP for Pantellerian obsidian; thus the individual island obsidian sources could be differentiated by their geological age as well as their chemistry. It was later realized that a correction factor had to be applied to these dates to account for argon loss in the rhyolitic flows, so that the Uras obsidian should be dated to about 5 million years (Bigazzi *et al.* 1976). Dating by potassium argon of obsidian samples from Conca s'Ollastu and Riu Murus (near Monte Sparau North) (di Paola *et al.* 1975); and by fission-track of two specimens each from a quarry at Perdas Urias and at Pira Inferta (to the northwest of Monte Arci) (Bigazzi *et al.* 1976: 1568), showed these obsidian deposits to be of the same age as the Uras material. Thus, Bigazzi and Radi (1981) were unable to individuate the Sardinian sources in their analysis of archaeological material, which included 7 (of 13) artifacts from Tuscany found to be of Sardinian origin.

It was only in 1976 that a complete geological and petrographic study of Monte Arci was published, including a detailed 1: 50,000 map of the region (Assorgia *et al.* 1976; cf. also Beccaluva *et al.* 1974). This research illustrates the wide distribution of acidic lavas in the Pliocene levels of Monte Arci, where they frequently appear as massive, strongly vesiculated flows, often grading into a perlitic facies where obsidians are likely to occur (Assorgia *et al.* 1976: 383). Areas of prevailing perlites and obsidians include a small zone around Conca Cannas; a large area around Su Paris de Monte Bingias, reaching northwest to Santa Suina and northeast to Punta Perda de Pani; an equally large but more diffuse zone on the western side of Monte Arci, encompassing Bruncu Perda Crobina and s'Allostiraxiu, Conca s'Ollastu, Seddai, Cucru Is Abis, the western flanks of Monte Sparau North, Cuccuru Porcufurau, and Punta Su Zippiri; the isolated pockets of Tu Passetti at the center of Monte Arci, and several to the northwest including Pira Inferta; and a zone stretching northwest from Punta Pizzighinu to Su Varongu, west of Pau (Fig. 3).

Pyroclastic deposits, for example at Pala Sa Murta (southwest of Morgongiori) and Fustiolau (north of Perdas Urias), also tend to have obsidian and perlite mixed with pumice (Assorgia *et al.* 1976: 380-81), and obsidian-perlite volcanics have been reported in the Riu Acqua Bella valley, at Punta Feuraxi and at Laccu Sa Vitella to the northwest of Fustiolau (Bigazzi *et al.* 1976: 1557). Rarely do the geological studies specifically mention the size or extent of the obsidian outcrops, and whether the obsidian is of workable quality.

It should also be noted that glassy, peralkaline comendites are found on the islands of S. Antioco and S. Pietro off the southwest coast of Sardinia (Araña *et al.* 1974), and an artifact made of this material has been found on the surface at Nuraghe Losa (Abbasanta) by Francaviglia (1984: 316). These comendites are, however, chemically distinguishable from the obsidians (Hallam *et al.* 1976: 95).

Meanwhile, additional archaeometric studies of western Mediterranean obsidian were being done in the late 1970s/early 1980s by Noël Gale at Oxford, by Stanley Warren at Bradford (with several colleagues), by Vincenzo Francaviglia at CNR-Rome, by a group at CNR-Cagliari, and by Joseph Michels at Penn State. These studies included attempts at using strontium isotopes, Mössbauer spectroscopy, magnetic parameters, and X-ray fluorescence to characterize source material, and the neutron activation and atomic absorption analysis of archaeological material from northern Italy, southern France, and Sardinia.

Gale (1981) demonstrated that it was possible using a combination of strontium isotopes and elemental measurements of strontium and rubidium to separate all of the Mediterranean sources; all five geological samples from Sardinia, however, were from a single source. The two Sardinian artifacts analyzed did not match this group, and suggested the existence of additional sources.

Only the SA type of Sardinian obsidian has been tested by Mössbauer spectroscopy (Longworth and Warren 1979; Aramu *et al.* 1983), and it is differentiable from Liparian obsidian; this method cannot, however, differentiate the Liparian and Palmarolan sources. The use of magnetic parameters was also not entirely successful, as it separated Pantellerian, Liparian and Palmarolan obsidian, but the Sardinian groups overlapped with all of these sources (McDougall, Tarling and Warren 1983). This technique can, however, differentiate the SA, SB and SC sources, and two archaeological samples and one geological specimen from the Perdas Urias zone fell into a fourth group, called SD (McDougall *et al.* 1983: 448).

The analysis of 57 artifacts from northern Italy (Williams Thorpe *et al.* 1979) and 10 pieces from southern France (Williams Thorpe *et al.* 1984) supplemented Hallam *et al.*'s (1976) original study. In northern Italy, the primary use of both Liparian (22 of 68 overall) and Sardinian SA (32) sources was confirmed, while in southern France type SA was by far the most common source material (15 of 21 analyses overall). While the quantity of obsidian found at mainland sites is small, it is significant that this imported material is found at so many sites (40 in northern Italy, 50 in southern France).

The actual location of the Monte Arci obsidian sources and their relationship to archaeological artifacts was addressed at this time by Maria Mackey for her doctoral dissertation in geology at the University of Nottingham. Unfortunately, her work was temporarily abandoned, and when she finally submitted her thesis, it was turned down. The only available information comes from a brief conference paper (Mackey and Warren 1983), which is summarized here. Mackey was able to locate, in addition to the Conca Cannas source, ***in situ*** outcrops with medium-sized obsidian nodules towards the summit of Monte Sparau North, with small 1 cm nodules at higher levels of Cucru Is Abis, and with sub-millimeter specks of obsidian in a hard perlitic matrix at Le Trebine and Monte Sparau South (Mackey and Warren 1983: 421). Neutron activation analyses of 'relatively small' numbers of geological samples were able to differentiate the Conca Cannas (SA), Perdas Urias (SC), Monte Sparau North, and Cucru Is Abis sources; all 51 archaeological artifacts (from 12 Ozieri sites and 1 Nuragic site) analyzed could be attributed to one of these four groups. The original SB group matched most closely, but not exactly, the Cucru Is Abis source.

Another geochemical study of the Monte Arci sources was done independently by Vincenzo Francaviglia (1984), as part of a Mediterranean-wide survey using classical methods. Using X-ray fluorescence, a total of 172 geological specimens from Sardinia were analyzed for both major/minor and trace elements. Unfortunately, little information about the deposits themselves is given for the five localities tested: the quarry at Conca Cannas (77 samples), Funtana Figu (next to Cucru Is Abis) (30), Mitza Sa Tassa (near Perdas Urias) (27), S. Pinta (18), and Cave della Ceca (Morgongiori) (20) (Francaviglia 1984: 314). The most significant results were that the Cave della Ceca material actually consisted of a mixture of Conca Cannas and Funtana Figu-type obsidian in a detrital deposit; the western Mediterranean sources (Li, Pl, Pa, SA, SB, SC) could be differentiated using just major/minor element composition; and that the Mitza Sa Tassa and S. Pinta collections, both near Perdas Urias, were perhaps partially distinguishable using trace elements.

Finally, Michels *et al.* (1984) analyzed 104 artifacts from 10 sites in southern Sardinia using

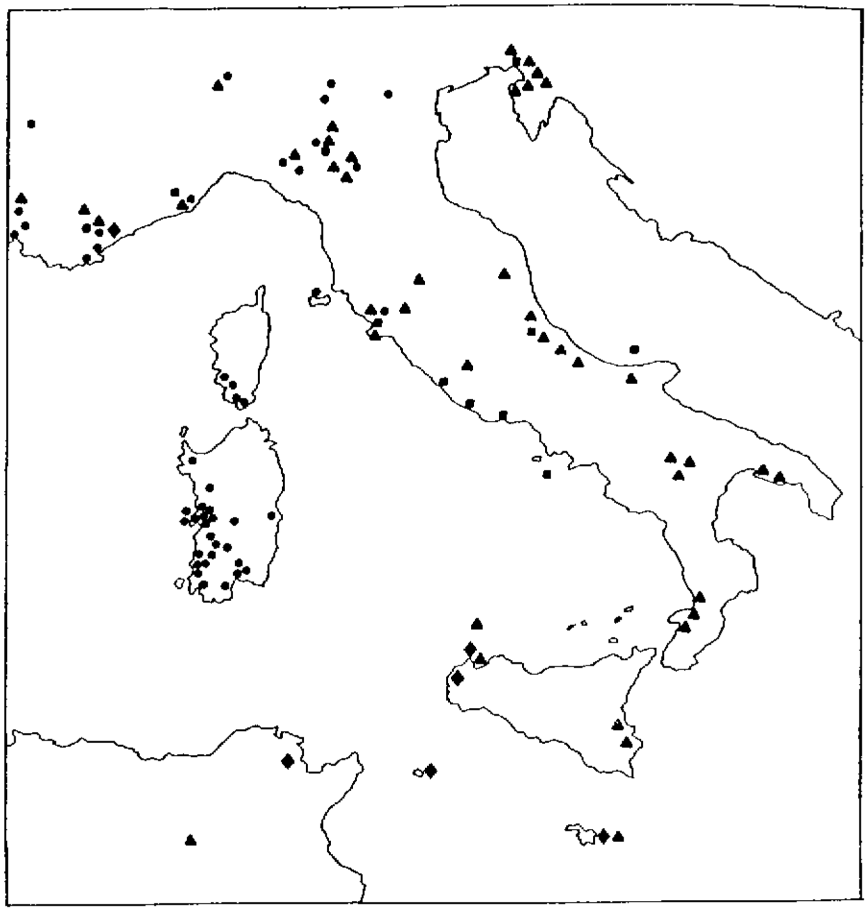

Fig. 2a Map of western Mediterranean sites with obsidian tested by means of chemical analysis (after Crummett and Warren 1985; with additions). Circles = Sardinian (Monte Arci) obsidian; triangles = Liparian obsidian; squares = Palmarolan obsidian; and diamonds = Pantellerian obsidian.

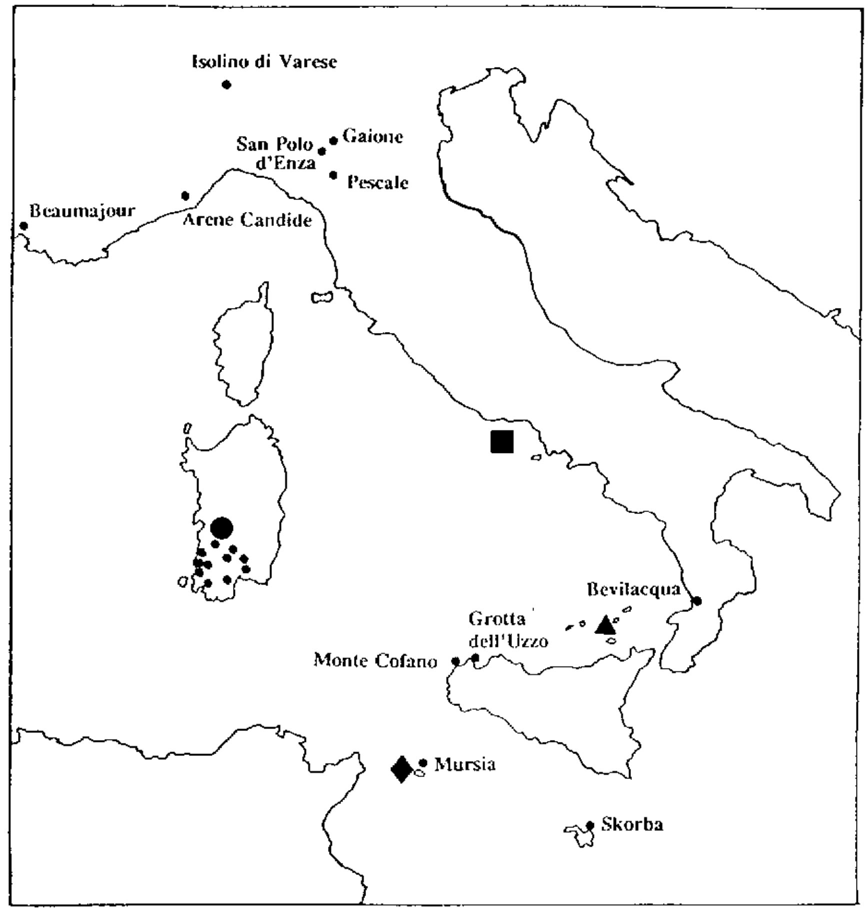

Fig. 2b Map of western Mediterranean sites with more than 5 pieces of obsidian tested. Sources: Monte Arci (circle); Palmarola (square); Lipari (triangle); and Pantelleria (diamond).

atomic absorption, in conjunction with an obsidian hydration dating program. The number of artifacts analyzed, in addition to those previously reported, greatly enhanced our knowledge of *Sardinian* use of Monte Arci obsidian, and alerted us to the potential chronological changes in source exploitation.

Current Research

Despite the numerous research efforts outlined above, there still remained a number of problems regarding the sources and usage of Sardinian obsidian. While the SA source seems well characterized, the SC source had not been located *in situ*, and the type SB archaeological artifacts analyzed did not match exactly with either of the Santa Maria Zuarbara localities tested by Mackey and Warren. The research by McDougall *et al.* (1983) and Francaviglia (1984) suggested that additional source groups may also have existed. Furthermore, while obsidian from about 100 western Mediterranean sites had been analyzed (Fig. 2a), most sites were represented by only a few samples, many from unscientific excavations. Only a fraction of these sites had more than five analyses (Fig. 2b), and only four had more than ten; one of these is Gaione in northern Italy, where Ammerman *et al.* (1990) recently found 3 of the 17 pieces tested to be of Sardinian type SC obsidian. Skorba in Malta is the only site where we can look at chronological change in source utilization.

My own research into the problems of Sardinian obsidian comprises three parts: (1) the location and characterization of the geological sources; (2) the provenience analysis of archaeological material; and (3) the interpretation of the resulting distribution patterns at various levels of inference. The results of the chemical analysis, by electron microprobe and ICP mass spectrometry, will be reported elsewhere (Tykot forthcoming); a description of the geological survey (cf. also Tykot 1991) and some preliminary interpretations of the archaeological data follow.

My fieldwork at Monte Arci began in 1987 with a survey of the zones previously identified as containing acidic lavas, and hence possibly obsidian (Fig. 3). Obsidian is usually formed under rapid cooling conditions from lavas that would otherwise form granitic rocks such as rhyolite and trachyte. If too much water is present, pumice or tuff can also be produced. After formation, obsidian can hydrate, turning into perlite, so that few obsidian sources are older than 10 million years.

Some quantity of obsidian was in fact found in most of these zones, although often as millimeter-sized pieces in a rock matrix. For each locality, the presence of obsidian was noted as *in situ* (found in geologically-formed strata), float (large, naturally produced blocks found on the surface or in secondary deposits), scatter (unworked obsidian found in loose soil, presumably naturally transported), or archaeological (worked artifacts and/or flaking debris). The exact position, including altitude, and extent of each locality was recorded, along with the range and average size of the obsidian finds. Physical properties such as color, glassiness, translucency, and the presence of phenocrysts were also described. Approximately 600 specimens were selected from more than 30 localities and, with the permission of the Soprintendenza Archeologica per le Provincie di Cagliari ed Oristano, taken to the United States for analysis.

The most well-known source is located below the peak of Conca Cannas, northeast of Uras, where obsidian occurs in an abandoned perlite quarry along with rhyolite and trachyte. Obsidian is frequently found as small specks within a perlitic matrix along the Riu Cannas, and rising up to Conca Cannas itself (elevation 382 m a.s.l.). No trace of obsidian was found near Perda Arrubia. One can find rather small, unworkable nodules of obsidian in a broad area to the south and east of the quarry, while fist-sized obsidian nodules are abundant in a more restricted area. These nodules average 10-15 cm in diameter, and can reach nearly 40 cm in length (cf. also Lanfranchi and Weiss 1973: 124). Conca Cannas obsidian is generally quite glassy, black but often so translucent that individual particles of colorant can be seen by eye. The particles are sometimes oriented so as to represent the original flow structure. Very occasionally the obsidian will contain red streaks.

The zone where type SB obsidian occurs is located near the church of Santa Maria Zuarbara but often at much higher elevations. A few kilometers northeast of the church, obsidian may be found *in situ* on the slope of Cuccuru Porcufurau, in bombs up to 30 cm in length; 3-5 cm nodules of obsidian occur at Punta Su Zippiri, at an elevation of 500 m. And it occurs along the Riu Murus near Monte Sparau North, in workable-sized blocks.

The Cucru Is Abis source appears to begin at an elevation of 230 m and flows down to the west near Funtana Figu, where large blocks may be found in a modern gravel quarry below the Seddai cliff-face (cf. also de Michele 1975: 172-73; Exel 1986: 78). Material still in the quarry measures up to 1 m in length; interestingly enough, hardly

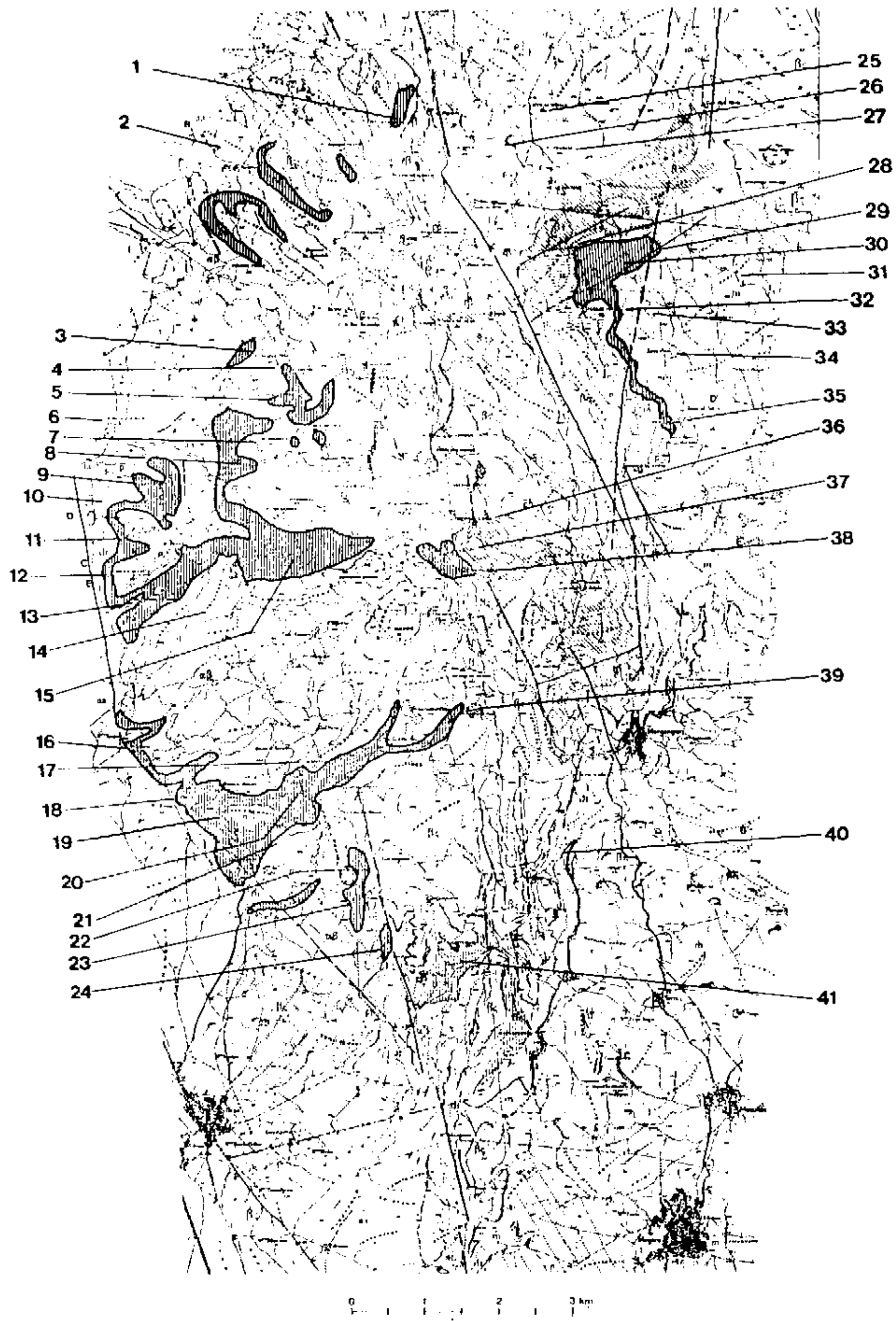

Fig. 3 Monte Arci: location of geological obsidian samples (probable obsidian-bearing lavas in outline, after Assorgia *et al.* 1976).

1. Punta Muroni; 2. Pira Inferta/Campo dei Forestieri; 3. Punta Nigola Pani; 4. Punta Su Zippiri; 5. Cuccuru Porcufurau; 6. Santa Maria Zuarbara; 7. Monte Sparau (North); 8. Riu Murus; 9. Cucru Is Abis; 10. Funtana Figu; 11. Seddai; 12. Conca s'Ollastu; 13. Bruncu Perda Crobina; 14. Rione Prasuedda; 15. S'Allostiraxiu; 16. S. Suina; 17. Monte Sparau (South); 18. C. Pies; 19. Su Paris de Monte Bingias; 20. Riu Solacera; 21. Canale Perdera; 22. Perda Arrubia; 23. Conca Cannas; 24. Uras Quarry; 25. Punta Laccu Sa Vitella; 26. Riu Acqua Bella; 27. Punta Feuraxi;; 28. Fustiolau; 29. Mitza Troncheddu; 30. Su Varongu; 31. Cazzighera; 32. Perdas Urias; 33. Mitza Sa Tassa; 34. Santa Pinta; 35. Punta Pizzighinu; 36. Trebina Lada; 37. Tu Pasetti; 38. Scala Antruxioni; 39. Perda de Pani; 40. Pala Sa Murta/Cave della Ceca; 41. Sonnixeddu.

any obsidian occurs in another quarry less than 1 km to the north.

Obsidian-bearing deposits continue to the south, along the western flanks of Monte Arci. *In situ* obsidian bombs 15-17 cm in length can be found on the slope of Bruncu Perda Crobina, beginning at an elevation under 100 m in the west, and up to an elevation of perhaps 400 m to the northeast. Scatters of unworked obsidian are common in the low plain to the west of Cucru Is Abis and Conca s'Ollastu.

No obsidian was observed between Santa Suina and C. Pies, but small pieces of *in situ* obsidian can be found even further south, near the peak of Su Paris de Monte Bingias, and near Monte Sparau South as specks within a perlitic matrix. Quarries have been operating in both locations for about 30 years, and according to the manager only small pieces have been found. Francaviglia (1984: 314), however, reports pieces several tens of centimeters in size along the Canale Perdera and the Riu Solacera.

Obsidian from the western flanks localities is frequently as glassy as the Conca Cannas material, but may be less translucent and grayer in color. This obsidian also is often broken up by white spots of crystalline material which can make the fracture sub-conchoidal. Not all pieces have white spots however, and visual techniques of source identification are not entirely accurate.

On the northeastern side of Monte Arci lies the Perdas Urias source zone, which is actually a large ridge running north-northwest from Punta Pizzighinu to the plateau of Su Varongu. *In situ* material has been located for the first time, in a perlitic matrix at about 600 m altitude, near Punta Pizzighinu, and includes specimens up to 17 cm in length. Abundant material also occurs in secondary contexts at lower altitudes. Natural blocks up to 30 cm may be found redeposited near Santa Pinta, just below the actual peak of Perdas Urias, near Mitza Troncheddu to the north, and in the low hills of Cazzighera to the east. The nearby site of Sa Tassa has been called a lithic production center, but this needs to be investigated. It appears that if a concentration of large obsidian nodules like that found near Conca Cannas exists, it is mostly overlain by later geological deposits. Thus, although there clearly exists considerable geological material—and the archaeological evidence proves that this source was exploited to a great extent—it must have required greater effort to collect raw material than at the SA and SB sources. Certainly, the landscape in the Perdas Urias zone is much more mountainous than the western side of Monte Arci; with parts reaching altitudes over 800 m a.s.l., no roads cross Monte Arci from east to west.

Obsidian from the Perdas Urias zone exhibits a great range in physical appearance. Some material is highly devitrified and weathered on its surface, while other pieces are glassy and have no evidence of flow banding. The type SC obsidian tends to be more opaque than both types SA and SB, but again it is difficult to visually distinguish archaeological artifacts.

Lastly, near Pala Sa Murta south of Morgongiori, some obsidian is found in the Ceca quarry, which Francaviglia (1984) had reported as being of two types. Elemental analyses are currently in progress, but in any case the only *in situ* obsidian I found was never greater than 1 cm in diameter, and there were no surface scatters of natural or flaked obsidian to suggest human activity there. Regarding other zones with the geological potential for obsidian formation, only the most meager surface scatter was found in the localities adjacent to the Campo dei Forestieri, near where Bigazzi *et al.* (1976) took a sample for fission-track dating; and no material was found near Punta Muroni, also to the northwest of Monte Arci. The locality of Tu Passetti/Scala Antruxioni was not visited.

To summarize the geological source data, we can say that: (1) large quantities of type SA obsidian occur near Conca Cannas; (2) equally large quantities of workable-size material occur in diffuse localities along the western flanks of Monte Arci, and the source at Cucru Is Abis has been shown chemically to be close, but not identical with the archaeologically-determined SB group; (3) large quantities of type SC obsidian are available at several localities in the Perdas Urias zone; and (4) small pieces of unworkable-sized obsidian may be found *in situ* at several additional localities, in either a perlitic or pyroclastic matrix. The extent to which all these sources were exploited at various period in prehistory can be easily estimated by testing archaeological material, but the dynamic behavior resulting in individual sources being favored, and some even ignored, will be more difficult to reconstruct.

Interpretation

Obsidian exploitation must be considered in chronological perspective, from the Neolithic to the end of the Bronze Age; we must also differentiate between local, regional and inter-regional levels of exchange, and the different economic and social mechanisms governing each. Settlement patterns, land routes and water crossings will also affect how raw source material ended up at various archaeological sites.

Although only part of the analytical data is now available, a few things can be said about regional interaction. A simple calculation of the relative usage of the different west Mediterranean obsidian sources shows that within Sardinia, type SA accounts for 37% of the artifacts analyzed, type SC 58%, and type SB, only 6% (Table 1). In Corsica, however, type SB (42%) is nearly as common as type SC (53%), with very little SA (5%); yet on the mainland, type SA (76% in northern Italy, 94% in southern France) is by far the most common type of Sardinian obsidian used. These frequencies are statistically different (at a 95% confidence level) than those for the Sardinian sources within Sardinia, and require a cultural explanation (among the possibilities, simply chronological variation in the sites tested so far). Whether these patterns will hold up after more material has been analyzed remains to be seen, but the current data imply that in the Neolithic—which most of the analyzed artifacts represent—different exchange mechanisms existed between Sardinia, Corsica and the mainland.

The routes taken by Mesolithic and Early Neolithic colonists of Corsica and Sardinia may be reflected in the directional distribution of obsidian finds. For example, obsidian from a Cardial site on Pianosa Island, between Elba and Corsica, is of Sardinian type C (unpublished data), and shows that there was bi-directional interaction in the Early Neolithic between the mainland and Sardinia.

Examination of the relative quantities of obsidian at sites in Tuscany and Liguria suggests that early navigators hugged the coasts and traveled from island to island. Specifically, it is proposed that long-distance traders may have transported the readily-accessible type SA obsidian directly to the Gulf of Oristano, where ships sailed north past Corsica to the Tuscan coast (cf. also Cocchi Genick and Sammartino 1983). Type SC obsidian, occurring on the eastern side of Monte Arci, may also have been carried to the Gulf, but was mainly distributed through an extensive land-based network. Type SB, used only locally in Sardinia, was nevertheless readily accessible to sea-borne carriers, and this may account for its increased representation in Corsica. Mechanical and visual properties of the obsidian sources cannot be discounted as influential in the selective exploitation of individual sources. The large quantities of obsidian at mainland sites like Pescale and Faenza, and the sheer number of sites where obsidian is present, show that this exchange was at least socially, if not economically, significant.

The fact that Sardinian obsidian was widely distributed in the Early Neolithic, yet is not found in the pre-Neolithic levels of Corbeddu Cave (cf. Hofmeijer and Sondaar and Martini this volume), certainly does not help the case for Pleistocene settlement of Sardinia.

Continuity or change in the distribution pattern established in the Early Neolithic may parallel other economic or technological developments (e.g. the introduction of animal domesticates and cereal agriculture in the Neolithic, or improvements in maritime technology); once again the direction of importation may also be reflected in the obsidian distribution pattern. Of particular interest is the possibility that the Near Eastern neolithic 'package' was introduced to Sardinia and Corsica from Sicily and North Africa, rather than from the European continent; this hypothesis would be supported if Sardinian obsidian were present in Tunisian assemblages, e.g., that of Zembra Island (J.-D. Vigne, pers. comm.).

Finally, I will test Michels's hypothesis that by the Middle Bronze Age access to obsidian sources had come under the control of local communities, which had specific trading relationships with their neighbors. For most Sardinian sites, it appears that variety in obsidian sources is the rule in the Neolithic and Early Bronze Age (and Gaione in northern Italy also has 3 types present), but that in the Middle and Late Bronze Age obsidian from only one source at a time was used at a particular site (Table 2). For example, the assemblage from Nuraghe Antigori on the Bay of Cagliari is entirely of type SC obsidian, a composition which is statistically different from the island-wide figure of 58%; in fact, the only sites which are statistically different are Nuragic in date. When territorial control emerged is important for our understanding of the function of the nuraghi. If access to obsidian sources were restricted prior to the earliest nuraghi, the latter could then be interpreted as having military significance from their inception; if territorial control came later, alternative explanations for the protonuraghi must be found (cf. Trump; Bonzani; and Ugas, this volume). Again, this suggestion is based on minimal data, and we will see if this pattern holds up after more sites have been examined.

In conclusion, we must be cautious in our extraction of information from lithic distribution patterns, but it is certainly a worthwhile endeavor. This is especially true for Sardinia, the only Mediterranean island source where distribution patterns on that island itself can be studied. The collection of appropriate data in the course of geological and archaeological survey and excavation, and the determination of the sources of the raw materials, are only the first steps in this direction.

Table 1

Regional use of Sardinian obsidian in the western Mediterranean

Region	*Source*	*Number analyzed*	*Percent*	*p̄*	*Var*	*z value*
W. Mediterranean	SA	122	43.9			
	SB	28	10.1			
	SC	128	46.0			
Sardinia total:		178				
	Li	80	–			
	Pa	11	–			
	PI	16	–			
Sardinia	SA	67	37.0			
	SB	10	5.5			
	SC	104	57.5			
total:		181				
France	SA	15	93.75	0.42	0.017	-4.36*
	SB	0	0	0.05	0.003	1.00
	SC	1	6.25	0.53	0.017	3.93*
Sardinia total:		16				
	Li	3	–			
	Pa	2	–			
N. Italy	SA	32	76.2	0.44	0.007	-4.68*
	SB	3	7.1	0.06	0.017	-0.12
	SC	7	16.7	0.50	0.007	4.88*
Sardinia total		42				
	Li	34	–			
	PI	6	–			
Corsica	SA	1	5.3	0.34	0.013	2.78*
	SB	8	42.1	0.09	0.005	-5.28*
	SC	10	52.6	0.57	0.014	0.41
total:		19				

$\bar{p}$, Var, and z are statistical values which are used to test for the difference between two sample proportions; here the Sardinian use of each source is compared with regional percentages of each type. Regional z-values with asterisks (*) are significantly different from the Sardinian pattern:

the probability of $/z/ < 1.96$ is 95%
the probability of $/z/ < 1.65$ is 90%

$\bar{p}$ = total successes/$(n_1 + n_2)$ n = # analyzed for each region

$\mathrm{Var}\,(p_1\text{-}\bar{p}_2) = \bar{p}(1\text{-}\bar{p})(1/n_1 + 1/n_2)$

$z = (p_1\text{-}\bar{p}_2)/\sqrt{\mathrm{Var}}$

Calculation comparing type SA in France and in Sardinia:

$\bar{p} = (67 + 15)/(181 + 16) = 0.42$
$\mathrm{Var} = (0.42)(.58)(1/181 + 1/16) = 0.017$
$z = (0.37\text{-}0.938)/\sqrt{0.017} = -4.36^*$

Table 2

Chronological use of obsidian within Sardinia (sites with more than 5 analyses)

Site	*Source*	*Number analyzed*	*Percent*	*Date*	*p*	*Var*	*z value*
Su Carroppu	SA	6	46.0	E Neo	0.38	0.019	-0.65
	SB	1	8.0		0.06	0.004	-0.40
	SC	6	46.0		0.57	0.020	0.81
Buon Cammino	SA	5	42.0	M Neo	0.37	0.021	-0.35
	SB	0	0.0		0.05	0.004	0.87
	SC	7	58.0		0.58	0.022	-0.03
Tracasi	SA	5	50.0	L Neo	0.38	0.025	-0.82
	SB	2	20.0		0.06	0.006	-1.87
	SC	3	30.0		0.57	0.026	1.71
Barbusi	SA	2	18.0	L Neo	0.36	0.022	1.28
	SB	0	0.0		0.05	0.005	0.78
	SC	9	82.0		0.59	0.023	-1.62
San Benedetto	SA	3	60.0	L Neo	0.38	0.048	-1.05
	SB	0	0.0		0.05	0.010	0.55
	SC	2	40.0		0.57	0.050	0.78
C. Craboni	SA	5	38.0	EBA	0.37	0.019	-0.07
	SB	0	0.0		0.05	0.004	0.87
	SC	8	62.0		0.58	0.020	-0.32
Serra Cannigas	SA	3	25.0	EBA	0.37	0.021	0.85
	SB	0	0.0		0.05	0.005	0.78
	SC	9	75.0		0.59	0.022	-1.18
Antigori	SA	0	0.0	Nuragic	0.35	0.019	2.68*
	SB	0	0.0		0.05	0.005	0.78
	SC	13	100.0		0.60	0.020	-3.01*
Domu Beccia	SA	10	100.0	Nuragic	0.40	0.025	-3.98*
	SB	0	0.0		0.05	0.005	0.78
	SC	0	0.0		0.54	0.026	3.57*
Ortu Comidu	SA	16	41.0	Nuragic	0.38	0.007	-0.48
	SB	0	0.0		0.05	0.001	1.74
	SC	23	59.0		0.58	0.010	-0.15

References

Ammerman, A., A. Cesana, C. Polglase & M. Terrani
1990 Neutron activation analysis of obsidian from two neolithic sites in Italy. *Journal of Archaeological Science* 17(2): 209-20.

Aramu, F., V. Maxia, S. Serci & I. Uras
1983 Mössbauer study of Mount Arci (Sardinia) obsidian. *Lettere al Nuovo Cimento* 36(5): 102-104.

Araña, V., F. Barberi & R. Santacroce
1974 Some data on the comendite type of S. Pietro and S. Antioco islands, Sardinia. *Bulletin Volcanologique* 38(3): 725-36.

Assorgia, A., L. Beccaluva, G. di Paola, L. Maccioni, G. Macciotta, M. Puxeddu, R. Santacroce & G. Venturelli
1976 Il complesso vulcanico di Monte Arci (Sardegna Centro-Occidentale). Nota illustrativa alla carta geopetrografica 1: 50.000. *Bollettino della Società Geologica Italiana* 95: 371-401.

Beccaluva, L., L. Maccioni, G. Macciotta & G. Venturelli
1974 Dati geologici e petrochimici sul massiccio vulcanico di Monte Arci (Sardegna). *Memorie di Società Geologica Italiana* Supplemento 2(13): 387-405.

Belluomini, G., A. Discendenti, L. Malpieri & M. Nicoletti
1970 Studi sulle ossidiane italiane II. Contenuto in 40Ar radiogenico e possibilità di datazione. *Periodico di Mineralogia* 39: 469-79.

Bernabò Brea, L.
1947 Commerci e industrie della Liguria neolitica. *Rivista di Studi Liguria Italiana* 13: 3-16.

Bernabò Brea, L., & M. Cavalier
1956 Isole Eolie e Milazzo. *Bullettino di Paletnologia Italiana* 1956.

Bigazzi, G., & F. Bonadonna
1973 Fission track dating of the obsidian of Lipari Island (Italy). *Nature* 242(5396): 322-23.

Bigazzi, G., & G. Radi
1981 Datazione con le tracce di fissione per l'identificazione della provenienza dei manufatti di ossidiana. *Rivista di Scienze Preistoriche* 36(1-2): 223-50.

Bigazzi, G., G. Belluomini & L. Malpieri
1971 Studi sulle ossidiane Italiane IV. Datazione con il metodo delle tracce di fissione. *Bollettino della Società Geologica Italiana* 90: 469-80.

Bigazzi, G., F. Bonadonna, L. Maccioni & G. Pecorini
1976 Research on Monte Arci (Sardinia) subaerial volcanic complex using the fission-track method. *Bollettino della Società Geologica Italiana* 95: 1555-70.

Buchner, G.
1949 Ricerche sui giacimenti e sulle industrie ossidianiche in Italia. *Rivista di Scienze Preistoriche* 4(3-4): 162-86.

Cann, J.R., & A.C. Renfrew
1964 The characterization of obsidian and its application to the Mediterranean region. *Proceedings of the Prehistoric Society* 30: 111-33.

Cocchi Genick, D., & F. Sammartino
1983 L'ossidiana utilizzata nelle industrie preistoriche del livornese. *Quaderni del Museo di Storia Naturale di Livorno* 4: 151-61.

Congiu, L.
1947 Saggio di Catalogo Archeologico della Carta d'Italia, Foglio 225, Quadrante IV, Tavolette SE-NE. Tesi di Laurea, Anno Accademico 1946-47, Università di Cagliari.

Cornaggia Castiglioni, O., F. Fussi & M. D'Agnolo
1963 Indagini sulla provenienza dell'ossidiana in uso nelle industrie italiane. *Atti della Società Italiana di Scienze Naturali e del Museo Curcio di Storia Naturale in Milano* 102: 310.

Coulon, C.
1971 La genèse du massif rhyolitique du Mont Traessu (Sardaigne septentrionale): Evolution de son dynamisme volcanique. *Bollettino della Società Geologica Italiana* 90: 73-90.

Coulon, C., A. Demant & H. Bellon
1974 Premières datations par la methode K/Ar de quelques laves cenozoiques et quaternaires de Sardaigne nord-occidentale. *Tectonophysics* 22: 41-57.

Crummett, J.G., & S.E. Warren
1985 Appendix I. Chemical analysis of Calabrian obsidian. In A. Ammerman (ed.), *The Acconia Survey: Neolithic Settlement and the Obsidian Trade*, 107-14. Institute of Archaeology Occasional Publication 10. London: Institute of Archaeology.

de la Marmora, A.
1839–40 *Voyage en Sardaigne*. Turin: J. Bocca.

de Michele, V.
1975 *Guida Mineralogica d'Italia*. Novara: Istituto Geografico De Agostini.

di Paola, G., M. Puxeddu & R. Santacroce
1975 K-Ar ages of Monte Arci volcanic complex (central-western Sardinia). *Rendiconti della Società Italiana di Mineralogia e Petrografia* 31: 181-90.

Dixon, J.E.
1976 Obsidian characterization studies in the Mediterranean and Near East. In R.E. Taylor (ed.), *Advances in Obsidian Glass Studies. Archaeological and Geochemical Perspectives*, 288-333. Park Ridge, NJ: Noyes Press.

Exel, R.
1986 *Sardinien: Geologie, Mineralogie, Lagerstatten, Bergbau*. Sammlung geologischer Fuhrer, Bd. 80. Berlin: Borntraeger.

Francaviglia, V.
1984 Characterization of Mediterranean obsidian sources by classical petrochemical methods. *Preistoria Alpina* 20: 311-32.

Gale, N.H.
1981 Mediterranean obsidian source characterisation by strontium isotope analysis. *Archaeometry* 23(1): 41-51.

Hallam, B.R., S.E. Warren & A.C. Renfrew
1976 Obsidian in the western Mediterranean: Characterisation by neutron activation analysis and optical emission spectroscopy. *Proceedings of the Prehistoric Society* 42: 85-110.

Lanfranchi, F. de, & M.-C. Weiss
1973 *La Civilisation des Corses. Les origines*. Ajaccio: Cyrnos et Méditerr.

Lauro, C., & M. Deriu
1957 Il vulcanismo cenozoico in Sardegna; le manifestazioni 'oligoceniche'. *Congresso Geologico Internazionale XXe session, Mexico 1956* (2): 469-86.

Loddu, R.
1903 Stazione neolitica del Monte Urpino (Cagliari). *Bullettino di Paletnologia Italiana* 29: 45-52.

Longworth, G., & S.E. Warren
1979 Mössbauer spectroscopy and the characterisation of obsidian. *Journal of Archaeological Science* 6(2): 179-93.

Lovisato, D.
1875 Una pagina di Preistoria Sarda. *Atti della R. Accademia dei Lincei* 4: 82.
1879 Gita inaugurale della sezione di Sassari al Club Alpino Italiano. *Bullettino di Paletnologia Italiana* 6: 18.

Mackey, M., & S.E. Warren
1983 The identification of obsidian sources in the Monte Arci region of Sardinia. In A. Aspinall & S.E. Warren (eds.), *Proceedings of the 22nd Symposium on Archaeometry, University of Bradford, Bradford, U.K. March 30th—April 3rd 1982*, 420-31.

Mantovani, P.
1875 Una stazione dell'età della pietra in Sardegna. *Bullettino di Paletnologia Italiana* 1: 81-90.

McDougall, J., D. Tarling & S.E. Warren
1983 Magnetic sourcing of obsidian samples from the Mediterranean. *Journal of Archaeological Science* 10(5): 441-52.

Michels, J., E. Atzeni, I.S.T. Tsong & G.A. Smith
1984 Obsidian hydration dating in Sardinia. In M.S. Balmuth and R.J. Rowland, Jr (eds.), *Studies in Sardinian Archaeology*, 83-114. Ann Arbor: University of Michigan.

Nissardi, F.
1886 *Sardinia-XXI. Sassari. Notizie degli Scavi* 1886: 467.

Pigorini, L.
1879 *Bullettino di Paletnologia Italiana* 5: 45.
1903 Stazione neolitica di S. Gemiliano di Sestu (Cagliari). *Bullettino di Paletnologia Italiana* 29: 42-43.

Porru, C.
1947 Saggio di Catalogo Archeologico della Carta d'Italia, Foglio 225, Quadrante I, Tavolette NE-SE. Tesi di Laurea, Anno Accademico 1946-47, Università di Cagliari.

Puxeddu, C.
1958 Giacimenti di ossidiana del Monte Arci in Sardegna e sua irradiazione. *Studi Sardi* 14-15(1955-1957) Parte I: 10-66.

Spano, G.
1870 *Scoperte Archeologiche in Sardegna 1870*. Cagliari.
1873 *Scoperte Archeologiche in Sardegna 1873*. Cagliari.

Taramelli, A.
1926 La ricerca archeologica in Sardegna. In *II Convegno Archeologico in Sardegna, Reggio Emilia, giugno 1926*, 9-80.

Tykot, R.
1982 Problems in obsidian: Nuragic manufacture and use. Paper read at the Fourth Annual Colloquium on Sardinian Archaeology, Tufts University

1991 Survey and analysis of the Monte Arci (Sardinia) obsidian sources. *Old World Archaeology Newsletter* 14(2-3): 23-27.

forthcoming Prehistoric trade in the western Mediterranean: The sources and distribution of Sardinian obsidian. PhD dissertation, Department of Anthropology, Harvard University.

Washington, H.
1913 Some lavas of Monte Arci, Sardinia. *American Journal of Science* 36: 577-90.

Williams Thorpe, O., S.E. Warren & L.H. Barfield
1979 The distribution and sources of archaeological obsidian from Northern Italy. *Preistoria Alpina* 15: 73-92.

Williams Thorpe, O., S.E. Warren & J. Courtin
1984 Sources of archaeological obsidian from Southern France. *Journal of Archaeological Science* 11(2): 135-46.

Zanardelli, T.
1899 Stazioni litiche del Campidano d'Oristano. *Bullettino di Paletnologia Italiana* 25: 109-77.

Riassunto

L'ossidiana, un vetro vulcanico frequentemente utilizzato per fabbricare utensili di pietra, è un importante indicatore del commercio nell'area mediterranea antica. Nel Mediterraneo occidentale, l'ossidiana è stata spesso ritrovata a centinaia di chilometri dai giacimenti insulari di Lipari, di Palmarola, di Pantelleria, e della Sardegna.

I giacimenti e la distribuzione di ossidiana sono stati esaminati dettagliatamente. Importanti contributi a questo proposito sono stati fatti da numerosi studiosi sardi tra cui de la Marmora nell'Ottocento e da Puxeddu alla metà del Novecento. Puxeddu ha compiuto un'indagine dettagliata nella zona di Monte Arci in Sardegna, dove già si sapere che l'ossidiana era presente *in situ*. Puxeddu ha identificato quattro giacimenti, undici centri di raccolta, settantaquattro officine, e centocinquantasette stazioni.

All'inizio del 1960 sono state sviluppate tecniche analitiche capaci di trovare il giacimento geologico corrispondente ad un materiale archeologico. Ricerche compiute da Renfrew e dai suoi colleghi, mostrano che è possibile trovare ossidiana sarda presso siti archeologici in Corsica, nell'Elba, nella Penisola Italiana, e nella Francia meridionale, e che esistono almeno tre giacimenti sardi. Ci sono state numerose speculazioni riguardo l'esatta posizione di questi giacimenti, ma soltanto all'inizio del 1980 sono stati raccolti campioni provenienti dai giacimenti geologici per farli corrispondere con quelli provenienti dai siti archeologici.

I geologi Mackey e Francaviglia, lavorando indipendentamente, hanno raccolto ed analizzato campioni di ossidiana provenienti dalla Sardegna, ma i risultati di queste ricerche sono stati pubblicati solo brevemente. Più recentemente l'Autore ha condotto una ricerca più estensiva nella regione del Monte Arci, e per la prima volta egli ha trovato ossidiana di tipo SC in situ. Sono in corso le analisi chimiche sia del materiale geologico che dei campioni archeologici provenienti da più di 50 siti in Sardegna e in Corsica.

Le informazioni sui giacimenti e sulla distribuzione di ossidiana possono essere riassunte così:

1. Il tipo di ossidiana SA si presenta *in situ* presso Conca Cannas, a nord-est di Uras ed è associato con perlite. L'ossidiana è nera e vetrosa e appare in forma di noduli (con il diametro medio di cm 10-15). In Sardegna questo tipo di ossidiana è quello del 40% dei materiali fino ad ora analizzati. In Francia e nell'Italia settentrionale, il tipo di ossidiana SA è decisamente il tipo di ossidiana sarda più comune (85%), ma in Corsica esso rappresenta meno del 5% dell'ossidiana analizzata.
2. Il tipo di ossidiana SC si trova *in situ* a Punta Pizzighinu, a sud di Perdas Urias, a circa 600 m s.l.m. Questo tipo appare più comunemente in depositi secondari ad altitudini più basse vicino a Santa Pinta, sotto Perdas Urias, e probabilmente anche a nord e ad ovest di Su Varongu. L'ossidiana di tipo SC è nera, spesso non è così vetrosa come quella di tipo SA, ma appare in blocchi di cm 30. È il materiale più comune in Sardegna ed in Corsica, e anche se è stato ritrovato nel continente, è presente in quantità minori dell'ossidiana di tipo SA.
3. Il tipo di ossidiana SB, originariamente identificato solo da campioni archeologici, può essere trovato sui pendii occidentali del Monte Arci, vicino a Santa Maria Zuarbara. Materiale lavorabile è stato ritrovato *in situ* presso numerose località che includono le zone del Monte Sparau Nord, Cucru Is Abis, Cuccuru Porcufurau, Punta Su Zippiri, Bruncu Perda Crobina e Su Paris de Monte Bingias. Sono stati osservati blocchi di m 1, ed entrambi i giacimenti di Cucru Is Abis e Bruncu Perda Crobina contengono noduli di cm 15-20. L'ossidiana di queste zone è nera e tende ad essere vetrosa come quella di tipo SA, ma forse meno traslucida e spesso con accenni di grigio. Alcuni pezzi hanno delle caratteristiche macchie bianche, ma generalmente non è possibile dif-

ferenziare ad occhio nudo l'ossidiana proveniente dai giacimenti sardi.
Nonostante i numerosi giacimenti locali di ossidiana, sembra che il tipo di ossidiana SB sia stato usato raramente in Sardegna, visto che rappresenta solo il 5% degli oggetti analizzati. Analisi preliminari suggeriscono che il giacimento di Cucru Is Abis corrisponde ai pochi campioni archeologici analizzati.

4. L'uso diverso dei diversi tipi di ossidiana in Sardegna, in Corsica, e nel continente, è statisticamente significativo e suggerisce che esistevano diversi meccanismi di scambio locale, regionale e con il continente. È possibile che i commercianti del Mediterraneo occidentale possano aver trasportato il tipo di ossidiana SA direttamente nel Golfo di Oristano dove navi hanno navigato verso Nord, passando per la Corsica verso la costa toscana. Il tipo di ossidiana SC presente sulla parte orientale del Monte Arci potrebbe essere stato trasportato verso il Golfo, ma è stato distribuito principalmente attraverso un estensivo network sulla terraferma. Anche se il tipo di ossidiana SB era usato solo localmente in Sardegna era accessibile ai commercianti marittimi e probabilmente per questo motivo l'uso di questo tipo di ossidiana è aumentato in Corsica. Le proprietà meccaniche e visuali dei giacimenti di ossidiana potrebbero aver influenzato lo sfruttamento dei giacimenti individuali.

5. I cambiamenti cronologici della distribuzione di ossidiana sono esaminati attraverso l'analisi di materiale archeologico che include siti con lunghi periodi di occupazione. Il cambiamento di certi modelli a livello regionale e nel Mediterraneo occidentale è contemporaneo ad altri cambiamenti, per esempio all'introduzione di animali domestici e di piante, e alla circolazione di nuove idee architettoniche e credenze religiose. È stato ipotizzato che a livello locale entro l'Età del Bronzo Medio, l'accesso ai giacimenti di ossidiana era sotto il controllo di comunità locali.