Prehistoric Trade in the Western Mediterranean: The Sources and Distribution of Sardinian Obsidian

A thesis presented

by

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to

The Department of Anthropology

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

in the subject of

Anthropology

Harvard University

Cambridge, Massachusetts

October, 1995

HARVARD UNIVERSITY

THE GRADUATE SCHOOL OF ARTS AND SCIENCES

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THESIS ACCEPTANCE CERTIFICATE

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Prehistoric Trade in the Western Mediterranean:
The Sources and Distribution of Sardinian Obsidian

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ABSTRACT

Obsidian sources exist on four islands in the western Mediterranean, one of which is Sardinia. The distribution of obsidian from several sources in the Monte Arci area of west-central Sardinia was an important aspect of the indigenous economy and is an indicator of extrainsular communication. Archaeologists use the concept of "trade" to explain the presence of non-local artifacts, but the behaviors responsible for obsidian procurement, transport, production, use and disposal were complex and are no longer observable. Previous efforts to describe and quantify the distribution of obsidian from the western Mediterranean sources - and to make inferences about Neolithic (ca. 6000-3000 BC) socio-economic systems - were limited by small or flawed archaeological data sets, and incomplete description and characterization of the multiple Sardinian obsidian sources.

For this study, geological specimens were collected from several dozen source localities, and trace element analysis of over 200 samples by inductively coupled plasma - mass spectrometry and X-ray fluorescence indicated that 9 chemically-differentiable sources exist. The exploited sources include the well-known Conca Cannas flow (source SA); multiple localities on the west side of Monte Arci which fall into two source groups (SB1 and SB2); the Perdas Urias source (SC1), located *in situ* for the first time; and an extremely similar chemical subgroup (SC2) found with SC1 in secondary deposits. Distinctions between all four archaeologically-important sources can be made on the basis of major element composition, and thus the rapid, minimally-destructive electron microprobe technique could be employed to determine the provenance of over 600 archaeological artifacts from Sardinia, Corsica, and Tuscany. The provenance of an additional 2100 artifacts was determined using visual characteristics.

The Sardinian sources were differentially exploited in ways not explainable by the quality or accessibility of the raw material, and in patterns which differed chronologicaly and geographically. We must consider that the distribution of obsidian not only was linked to the circulation of other goods of similar utilitarian, social, and/or symbolic significance, but that multiple exchange systems were in all likelihood operating simultaneously. The integration of source data, form, function, and reduction sequence for whole assemblages of obsidian artifacts from well-dated archaeological contexts will ultimately provide a more complete understanding of human behavior during the Neolithic in the western Mediterranean.

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PREFACE

This dissertation has its roots in a course project I undertook as an undergraduate student at Tufts University under the supervision of Miriam S. Balmuth. Although that work was presented at a conference in 1982, it was five years before I decided on the problem of Sardinian obsidian as the subject of my PhD thesis. Parts of the next five years were spent surveying the geological sources in Sardinia, and in acquiring archaeological material for provenience analysis. A Pfeiffer Traveling Fellowship (1987), a GSAS Travel Grant (1990), an award from Sigma Xi, The Scientific Research Society (1991), and several Teschemacher Awards (1987-1991) supported the field research associated with this dissertation; the laboratory analyses were funded by a grant from the American School of Prehistoric Research (1993).

Some of the ideas in this dissertation were initially presented in conference papers at the Annual Tufts University Colloquia on Sardinian Archaeology (Tykot 1982; 1986; 1990a; 1993); the Annual Meeting of the Archaeological Institute of America (Tykot 1989; 1991d; 1992c; 1994c); the Annual Meeting of the Society for American Archaeology (Tykot 1991b; 1992b; 1994b; 1995b; Tykot & Hartshorn 1995); the Annual Meeting of the American Anthropological Association (Tykot 1990b); the American Chemical Society National Meeting (Tykot & Young 1995); and at the international conferences "Archaeological Stone: Scientific and Technical Studies," British Museum (Tykot 1991c); "Science and Archaeology: Towards an Interdisciplinary Approach to Studying the Past," Harvard University (Tykot & Hartshorn 1994); and "Sardinian Stratigraphy and Mediterranean Chronology," Tufts University (Tykot 1995a). Two preliminary reports on the geological survey have been published (Tykot 1991a; 1992a), as has an article on radiocarbon dating in Sardinia and Corsica (Tykot 1994a; updated in Tykot 1995a). Two additional articles on obsidian will appear shortly (Tykot 1995c; 1996), as will one on ICP-MS applications in archaeology (Tykot & Young 1996).

Geological obsidian samples from Monte Arci in Sardinia were collected with the permission of the Soprintendenza Archeologica per le Provincie di Cagliari e Oristano (Dott. Vincenzo Santoni, soprintendente); some geological specimens came from the Geological Museum of Harvard University (Dr. Carl Francis, director), from Professor Joseph Michels (The Pennsylvania State University), and from Dott. Cornelio Puxeddu (Mogoro, Sardinia). Archaeological samples from Sardinia and Italy were generously provided by the Soprintendenza Archeologica per le Provincie di Cagliari e Oristano, the Soprintendenza Archeologica per le Provincie di Sassari e Nuoro (Dott.ssa Fulvia Lo Schiavo, soprintendente), the University of Cagliari (Professor Enrico Atzeni), the Soprintendenza Speciale al Museo Nazionale Preistorico ed Etnografico "L. Pigorini" (Dott. Giovanni Scichilone, soprintendente), the Soprintendenza Archeologica per la Toscana (Dott. Francesco Nicosia, soprintendente), and Brown University (Professor R. Ross Holloway). Dr. David Trump gave permission to analyze the material from his excavations at Grotta Filiestru and Sa 'Ucca de Su Tintirriolu in northern Sardinia, as did Professor Miriam S. Balmuth for the

obsidian from Nuraghe Ortu Còmidu in southern Sardinia. I thank Dott.sse Luisanna Usai, Donatella Salvi, Francesca Galli, Vanna Canalis, Paola Perazzi, and Grazia Bulgarelli, and Dott. Rico Pellegrini for their help in accessing the various collections. Dr. Joseph Cesari (Direction des Antiquité Préhistoriques de Corse) provided most of the Corsican material, including many samples from recent excavations by Dr. Jacques Magdeleine. Additional obsidian from Corsican sites came from the University of Cagliari (Professor Enrico Atzeni). Archaeological samples from Tunisia were supplied by Jean-Denis Vigne (CNRS, Paris).

I thank Dave Lange (Harvard University), and also Steve Recca (MIT), for assistance with microprobe analyses; Dr. Ron Pflaum (then at Harvard, now at University of Hawaii) for help with ICP-mass spectrometry; and Ray Kunselman of the University of Wyoming for doing the XRF analyses. Karen Hartshorn, whose senior thesis on obsidian was supervised by Professor Nikolaas J. van der Merwe and me, assisted greatly in the preparation and microprobe analysis of many samples from Corsica.

Thanks are due to my thesis committee, Professors Nikolaas J. van der Merwe, Miriam S. Balmuth, Ofer Bar-Yosef, and Richard Meadow, for their advice and suggestions; I am especially grateful to Professor van der Merwe for the opportunities he provided me as a Teaching Fellow and as a Manager of the Archaeometry Laboratories while working on my dissertation.

Finally, I thank my family for their patience and understanding over the long haul that resulted in the work presented here.

CHAPTER ONE: INTRODUCTION

> Exchange is not simply an economic transaction but a series of transactions involving social relationships that form the central component of the action. From an archaeological perspective, these social ties can be measured in terms of content, magnitude, directionality, and the diversity of items being traded through time and space (Baugh & Ericson 1992:4).

> A meaningful explanation of the origin and development of systems of interregional exchange is not the same thing as a synchronic account of their subsequent functioning (Adams 1974:243).

> Characterization alone is not enough (Renfrew 1993a:15).

> What has to some extent been lacking is a more sustained analysis of the role of each commodity, of each class of traded material or finished object within the society in question...It may be enough to ask some new questions in a fairly straightforward way, and to seek to answer them in adequate detail. It is because we have been overlooking the use of artefacts as agents of communication that our analyses have sometimes seemed excessively utilitarian. It is this aspect of 'action at a distance' which requires much closer consideration (Renfrew 1993a:8).

Obsidian in the Western Mediterranean

The research presented here is an attempt to address several problems in the prehistory of the western Mediterranean, a region not studied nearly as much as the eastern Mediterranean and Near East, by examining the sources and distribution of obsidian during the Neolithic period, ca. 6000-3000 BC. Many questions may be asked about obsidian exploitation in the western Mediterranean, where all of the sources are located on islands:

1. Where is obsidian found?
2. Who collected/transported/distributed/used obsidian?

3. How much and how often was obsidian obtained?
4. What maritime capabilities existed and what routes were taken?
5. What were obsidian artifacts used for?
6. Did obsidian have a special social or economic significance?
7. Were other items exchanged along with obsidian?
8. Did obsidian use patterns vary geographically?
9. Did obsidian use patterns change chronologically?
10. What do these differences tell us about neolithic societies?

My research focuses specifically on obsidian from Sardinia, one of four sources in the western Mediterranean. With an area of 25,000 Km^2 and its own distinct cultural sequence pre-dating the earliest obsidian use, Sardinia offers a unique opportunity to study obsidian exploitation within a single cultural and geographic unit. Contrasts may then be made with contemporary cultures on nearby Corsica, and on the mainland where obsidian from several island sources was used simultaneously. The approach I have taken is quantitatively and qualitatively, rather than theoretically, innovative; the number of artifacts examined from good archaeological contexts exceeds that of all prior studies combined and overcomes the interpretive limitations previously caused by small or inappropriate data sets. The differential use of the multiple Sardinian sources, rather than their fall-off in frequency with distance, is emphasized in my reconstruction of obsidian distribution mechanisms. There are two explicit hypotheses about Sardinian obsidian use that I test using this approach:

1. Differential regional exploitation of certain Sardinian obsidian types existed, perhaps because of specific cultural preferences or alliances, rather than distance to source and quality of the raw material.
2. Territorial control of the Sardinian obsidian sources did not exist in the Early Neolithic period, but probably developed by the Bronze Age.

Several "problems" need to be addressed first (Tykot 1982). When I began this research, the location of the Sardinian sources was not yet established, although a limited number of analyses of archaeological artifacts indicated that at least three existed (Hallam et al. 1976). The geological sources needed to be located and characterized in terms of their chemical composition not only so that the provenance of archaeological artifacts could be determined, but also in order to produce proper obsidian hydration rates for dating purposes. Only then could data on the distribution of archaeological obsidian be produced, and diachronic and geographic patterns revealed.

Trade and Exchange

Archaeologists commonly use the concepts of "trade" and "exchange" to explain the presence of non-local raw materials or artifacts on archaeological sites. In formal economics, trade may be defined as "the mutual appropriative movement of goods between hands" (Polanyi 1957b:266). In the archaeological record, however, it is the movement of the goods themselves, rather than their ownership or possession, which is immediately recognizable (Renfrew 1993a), and somewhat broader definitions have often been adopted, e.g., "reciprocal traffic, exchange, or movement of materials or goods through peaceful human agency" (Renfrew 1969:152) or "procurement of materials from a distance, by whatever mechanism" (Renfrew 1977:72). Anthropologists ultimately require a methodology for establishing a cultural biography for goods starting with the procurement of their raw materials and ending only with their final disposal.

Interpreting the social context of various modes of exchange in prehistoric societies has been the subject of considerable research in recent decades, beginning with Grahame Clark's (1952) work on prehistoric Europe, and blossoming after the publication of Karl Polanyi's (1957a) influential work which emphasized a substantivist (institutionally determining) rather than formalist (individually optimizing) approach. Specifically, Polanyi argued that disembedded market trade as we know it only emerged in classical Greece, and even then only to a limited extent; primitive exchange was embedded in the nature of the particular prehistoric society (Polanyi 1957b). The possibility of equating certain modes of trade with particular levels of social complexity (Service 1962) was of central interest to the "new" processual archaeology and its goal of achieving higher planes 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 (Dalton 1975; 1977; Akalu & Stjernquist 1988; Plattner 1989; Meijer & van Nijf 1992).

In the past two decades, scholarly interest in trade and exchange has remained keen, especially since technical advances have made it possible to determine the source of materials such as pottery, jade, turquoise, amber, marble, copper, lead, and obsidian. Numerous works have been devoted to this subject (cf. individual articles in edited volumes by Polanyi et al. 1957; Sabloff & Lamberg-Karlovsky 1975; Earle & Ericson 1977; Fry 1980; Ericson & Earle 1982; *The Ancient World* 10(1-2), 1984; Knapp & Stech 1985; Brumfield & Earle 1987; Hårdh et al. 1988; Ericson & Baugh 1992; Oates 1993; Scarre & Healy 1993; and Baugh & Ericson 1994). In addition to specific case studies, the literature includes a number of essays which discuss the nature of production, trade and exchange, and review the history of their archaeological interpretation (Earle & Ericson 1977; Hodder 1980; Earle 1982; Ericson 1984; Knapp 1985; Earle 1985; Brumfiel & Earle 1987; Baugh & Ericson 1992; Renfrew 1993a; Ericson & Baugh 1994; Earle 1994).

Many studies in the 1970s and 1980s made use of generalizing, heuristic mathematical models to interpret artifact 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 & Orton 1976; Renfrew 1975; 1977; Warren 1981) of artifact frequency vs. 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. Sidrys (1977), for example, found a strong correlation between obsidian frequency and ranking of Maya centers, while Fulford & Hodder (1974) identified mode of transport as the prime factor in determining the percentage of Oxford pottery at Romano-British sites.

There are a number of inherent problems in these models. Ammerman (1979; Ammerman et al. 1978; Ammerman & 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 dynamic time behavior, population growth, changes in settlement size, and the heterogeneity of "dropping rates" (Ammerman & 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). In some cases, the idea alone, rather than the physical object, may have been transmitted (Olausson 1988). 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 artifacts, 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:

> "...non si può fare a meno di chiedersi se in realtà l'applicazione più fruttuosa di metodi matematici all'archeologia non consista proprio nell'elaborazione dei dati su basi quantitative e statistiche, indipendentemente dal grado di formalizzazione del modello."

More recent studies have turned their focus to procurement (Torrence 1983; Jeske 1989; Kuhn 1989; Morrow & Jefferies 1989; Bamforth 1990; Shackley 1990; Montet-White & Holen 1991; Andrefsky 1994) and production (e.g. Ammerman & Andrefsky 1982; Ericson & Purdy 1984; Gibson 1986; Torrence 1981a; 1981b; 1982; 1984; 1986; Andrefsky 1991; Shafer 1991; Arnold 1992; Bradley & Edmonds 1993; Carr 1994), rather than distribution of artifacts. Use of lithic raw materials by hunter-gatherers is frequently determined to have been economizing in a formalist sense, while embedded in subsistence-related activities. For production, the social constraints of economic behavior are directly explained using the *chaîne opératoire* approach (Leroi-Gourhan 1964; 1965; Lemonnier 1976; 1990; Cresswell 1983; Schlanger 1994). The subsequent behaviors involved in exchange, use and deposition are much more variable, particularizing, and difficult to infer from the archaeological record.

Lithic materials are among the most common artifacts in the archaeological record, and are the product of several distinct behaviors: acquisition of the raw material; preparation of a core for flaking; primary trimming; secondary trimming and shaping; use; maintenance or modification; disposal (Collins 1975). Gero (1989) has defined five axes of variability which must be controlled for in order to understand the social processes involved: the rarity of the raw material; the size of artifact produced; the number of production stages necessary; the restrictiveness of production; and the longevity of the item. Some of these activities may have been part of rather complex behaviors. Raw nodules, pre-formed cores, or finished tools were acquired from distant sources, and labor specialization may have been involved in these processes. Finally, the movement of the lithics found in the archaeological record may have been non-economic in purpose, or have been secondary to the movement of primary resources including animals and animal products, agricultural produce, salt, etc., of which there would be little trace in the archaeological record.

Obsidian distribution is the focus of the work that follows. The identification of the geological source of obsidian artifacts establishes both beginning and end points in the *chaîne opératoire*, while the analysis of geographic and chronological patterns of obsidian source exploitation complements lithic reduction and use-wear studies in elucidating the intervening behavioral links and in answering the questions about obsidian exploitation listed above. 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 complex Bronze Age societies.

CHAPTER TWO: THE WESTERN MEDITERRANEAN SETTING

> The persistent myth that Corsica and Sardinia are isolated by virtue of being islands may be challenged not only on the historical record but through the archaeological facts of the great antiquity of their settlement and their participation in such wide-ranging cultural phenomena as that of the Impressed Ware sphere of the Early Neolithic and of the sphere of a precocious Copper-Bronze Age '*incastellamento*' (Lewthwaite 1988:180).

> It would have been less difficult than we might imagine to transport a few skins of water, some baskets of fruit and sacks of smoked meat along with a few lambs, which could have simply been hobbled and placed in the bottom of the boat. Like pottery, which made it possible to cook stews and soups, like obsidian, which could cut so well, sheep, even very young ones, were a valuable product that was offered to Mesolithic tribes fully ready to fall under the sway of the charms of Neolithic culture. We need only imagine the astonishment of the Western barbarians when offered meat on the hoof that did not have to be hunted in order to comprehend the rapid spread of domestic sheep, come from the sea (Camps 1986:44-45).

> L'ossidiana...fu, forse, la causa principale della venuta dell'uomo primitivo in Sardegna, che si serviva di quella materia per farne armi e utensili e la commerciava largamente all'interno e all'esterno dell'Isola. L'ossidiana era una sorta di *oro nero* dell'antichità (Lilliu 1967:6).

> Se è vero che la cronologia non può essere lo scopo primario della ricerca archeologica ma uno degli elementi di essa, è vero altresì che senza un'ordito cronologico non si può costruire la trama dei fatti e quindi della Storia (Contu 1982:91).

It is only in the last twenty-five years that the island of Sardinia has been recognized as having had a rich indigenous culture dating from at least the Early Neolithic period, if not earlier. Our knowledge of Sardinian prehistory has benefitted in the past three decades from an explosion of archaeological research (cf. Balmuth 1992), and the application of absolute dating methods. Of the 200

Neolithic sites known today, only 47 were known in 1963, and 46 of them were considered Chalcolithic (Lilliu 1963:28-29). In fact, the only real evidence that the island had been inhabited early on came from the finds of obsidian, assumed to be from Sardinia, associated with Early Neolithic ceramics at sites outside of Sardinia such as Arene Candide in Liguria, and Basi in Corsica. As Lilliu (1967) suggested in the quotation above, obsidian may have played a significant role in the settlement and Neolithic economy of Sardinia.

A detailed synthesis of central Mediterranean prehistory is beyond the scope of this work. Comprehensive accounts are available elsewhere for Sardinia (Lilliu 1988) and Corsica (Camps 1988), as are brief but up-to-date summaries such as *Sardegna Archeologia. Roma, S. Michele 4 Dicembre 1990 - 4 Gennaio 1991* (Rome: Ministero dei Beni Culturali e Ambientali, 1990) and *Corse des Origines. Guides archéologiques de la france* (Paris: Ministère de la Culture et de la Francophonie, 1994). In-depth coverage of Italian prehistory may be found in *Italia Preistorica* (Guidi & Piperno 1992) and in the *Atti della XXVI Riunione Scientifica, "Il Neolitico in Italia"* (Firenze: Istituto Italiano di Preistoria e Protostoria, 1987). Equally good for France are *Ancient France: Neolithic Societies and their Landscapes 6000-2000 bc* (Scarre 1983), *Le Néolithique de la France* (Demoule & Guilaine 1986), and *Mesolithique et Néolithisation en France et dans les Régions Limitrophes. Actes du 113^e^ Congrès National des Sociétés Savantes* (Thevenin 1991). Phillips (1975), Guilaine (1981), and Guilaine et al. (1987) focus on the early western Mediterranean, and Demoule & Perlès (1993) on Greece, while broader surveys of the Mediterranean and Europe include Trump

(1980); Phillips (1980); Barker (1985); Whittle (1985; 1990); Aurenche & Cauvin (1989); Maggi et al. (1991-92); Guilaine & Settis (1993); and Cunliffe (1994). A short outline for Sardinia and Corsica is given below, to provide a contextual background for interpreting the exploitation of obsidian.

The tri-partite Neolithic chronology for Italy developed by Bernabò Brea from his excavations at Arene Candide soon after World War II is still widely used, but regional cultures do not all necessarily begin or end simultaneously (Table I). This is only one of the interpretive limitations of this study. Radiocarbon dates are presented here as "cal BC" ranges calculated by the Calib 3.0.3 program using the standard intercept method (Stuiver & Reimer 1993). The probability distributions for the same dates are illustrated graphically and provide a better visual idea of the chronology suggested by the relatively limited number of determinations. A complete compendium of dates from Sardinia and Corsica has been published elsewhere (Tykot 1994a), although some of the interpretations are superseded here.

Paleolithic

The question of when Sardinia and Corsica were first settled has been the subject of some debate in the last several years, with "Clactonian" lithic assemblages from the area of Perfugas in northern Sardinia reported as Middle Pleistocene in age (Martini & Pitzalis 1981; 1982; Arca et al. 1982a; 1982b; Martini 1992; Bini et al. 1993), but contested by Cherry (1984; 1990; 1992) and others (e.g. Vigne 1988b; 1989; 1990) who note the peculiarity of the tools

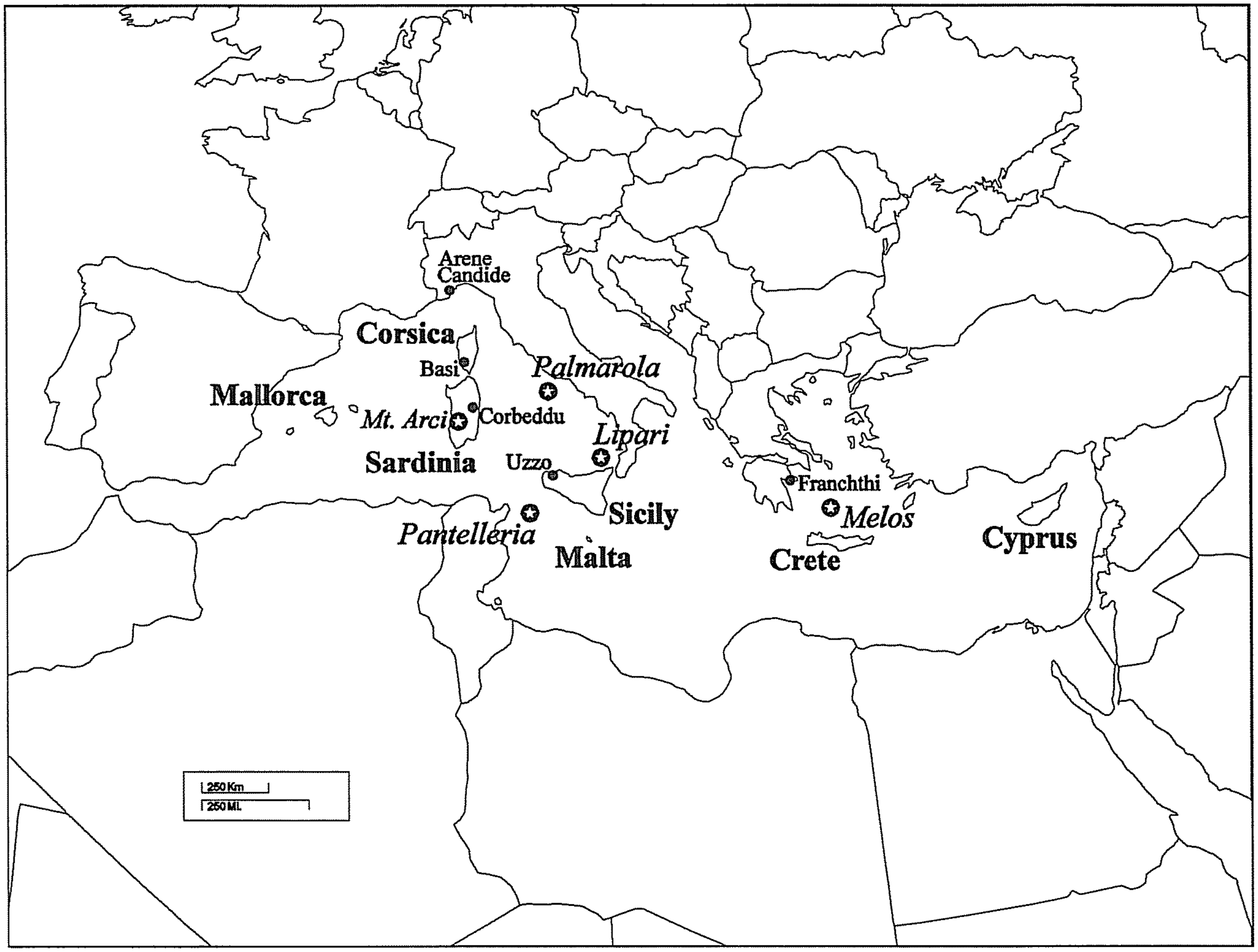
Table I Central Mediterranean cultural chronology. The contemporaneity of individual cultures is not always well established.

	SARDINIA	CORSICA	S. FRANCE	N. ITALY	C. ITALY	S. ITALY	SICILY	MALTA	N. AFRICA
Upper Paleolithic	Corbeddu	---	Solutrean Magdalenian	Epigravettian	Epigravettian	Epigravettian	Epigravettian	---	Ibero-maurusian
			Azilian						
Mesolithic	Corbeddu	Preneolithic	Sauveterrian Tardenoisian	Sauveterrian Castelnovian	Sauveterrian Castelnovian	Sauveterrian Castelnovian	Sauveterrian Castelnovian	---	Capsian
Early Neolithic	Impressed	Impressed	Impressed	Impressed	Impressed	Impressed	Impressed	Ghar Dalam	Impressed/ Neolithic of Capsian Type
	Filiestru	Curasièn		Fiorano	Sasso	Stentinello	Stentinello		
		Presian					Trichrome		
Middle Neolithic	Bonu Ighinu		Chasséen	VBQ/Chiozza	Ripoli	Serra d'Alto	Serra d'Alto	Grey Skorba	Middle NCT
	San Ciriaco	Basien							
Late Neolithic	Ozieri	Terrinien	Verazien/ Ferriéres Couronnien	Lagozza	Diana	Diana	Diana	Red Skorba	Upper NCT
	sub-Ozieri		Treilles Fontbuisse					Zebbug	
Chalcolithic	Filigosa Abealzu Monte Claro		Gourgasien St. Ponien	Remedello	Rinaldone	Gaudo	Piano Conte	Ggantija	
							Castelluccio	Tarxien	Beaker

themselves, the absence of palaeontological context and chronometric dates, and the uniqueness of the Sardinian situation relative to the known pattern of human colonization of the Mediterranean islands. Recent excavations at La Coscia (Macinaggiu-Rogliano) in Cap Corse have also turned up evidence of Middle Paleolithic occupation (Bonifay 1994), so it cannot be excluded that bias in the archaeological record and the extent of modern efforts have shaped this situation. The prevailing evidence appears to indicate that preneolithic occupation of islands is exceptional in the Mediterranean (Figure 1), with the limiting factors relating more to subsistence and "attractiveness" (Cherry 1990) than the basic maritime capabilities necessary to get there (Tzalas 1989; 1993). The exceptions include the large islands of Sardinia, Corsica, Cyprus (Simmons 1991a; 1991b; 1991c), and perhaps Mallorca (Ensenyat Alcover 1991; Gómez Bellard 1995).

The settlement of the Aegean islands, and the exploitation of obsidian from Melos, provide a sharp contrast to the western Mediterranean situation. Melian obsidian has been found beginning in Upper Paleolithic levels at Franchthi Cave (Perlès 1979; 1987), indicating that some maritime capabilities existed by at least 10,000 cal BC. The earliest sites on Melos date to the late 5th millennium BC, however, and the earliest settlements only appear in the Early Bronze Age (Cherry 1979; 1980; Cherry & Torrence 1982; Torrence 1982). In fact, settlement of the Aegean islands in general was quite sporadic during the Neolithic (Cherry 1979; 1980; 1981; 1984; 1990). Since colonization did not coincide with the introduction of agriculture, lack of larger-scale transportation may have been the

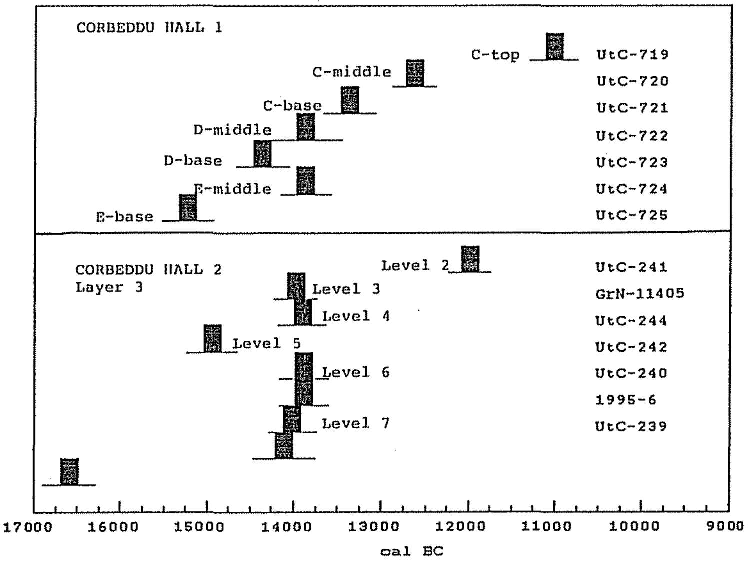
Figure 1. Mediterranean islands and sites mentioned in the text.



limiting factor in both island settlement and socioeconomic interaction prior to the late 4th millennium BC (Cherry 1985).

The earliest evidence for island occupation anywhere in the Mediterranean comes from Corbeddu Cave (Olièna) in Sardinia, where a human phalanx has recently been found in a layer dated approximately 20,000 BP (Sondaar et al. 1995). An interdisciplinary team has excavated the Late Pleistocene/Early Holocene deposits of Corbeddu Cave since 1982, and revealed a stratigraphic sequence documented by more than 36 radiocarbon determinations (Klein Hofmeijer & Sondaar 1992; Klein Hofmeijer et al. 1989; 1987; Sondaar et al. 1984; 1989; 1995) (Table II). In 1993, new excavations immediately adjacent to the main excavation area of previous years in Hall 2 exposed a pit more than 6 meters deep, divided into 53 distinct levels. The human fossil, apparently associated with bones of the now-extinct endemic deer *Megaloceros cazioti*, was found in Level DEF-27 (depth 343.0 - 336.5 cm), and is bracketed by radiocarbon dates of 30,700 BP (at 425 cm in the same pit) and 15,700 BP (<300 cm in the main pit). The pollen spectra for the layers between 310 and 380 cm are suggestive of a highly glacial period, and hence an approximate date of 20,000 BP (Sondaar et al. 1995).

Layer 3 in Hall 2, dated by a series of 9 radiocarbon measurements from 15,700 to 12,000 BP, contains a remarkable accumulation of deer bones including several mandibles seemingly used as cutting or scraping tools (Klein Hofmeijer & Sondaar 1992; 1993). Some remains of the small canid *Cynotherium sardous* and the ochotonid lagomorph *Prolagus sardus* were also recovered from Layer 3



SITE	CONTEXT	LAB. NO.	^{14}C AGE	ERROR	2σ CALIBRATED AGE RANGE	REFERENCE
SARDINIA						
Corbeddu Cave	Hall 2 Layer 3, >550 cm		42000	± 3000		Sondaar et al. 1995
Corbeddu Cave	Hall 2 Layer 3, 425 cm		30700	± 1200		Sondaar et al. 1995
Corbeddu Cave	Hall 1 Quadrant R07	UtC-243	25700	± 400		*RC* 31(3)1989: 988
Corbeddu Cave	Hall 1 Layer F	UtC-718	17700	± 200	cal BC 19757 (19145) 18475	*RC* 31(3)1989: 988
Corbeddu Cave	Hall 2 Layer 3		15700	± 200	cal BC 17073 (16645) 16234	Sondaar et al. 1995
Corbeddu Cave	Hall 1 Layer E-base	UtC-725	14600	± 200	cal BC 16002 (15532) 15047	*RC* 31(3)1989: 988
Corbeddu Cave	Hall 2 Layer 3 level 5	UtC-242	14370	± 190	cal BC 15730 (15274) 14798	Klein Hofmeijer et al. 1987
Corbeddu Cave	Hall 1 Layer D-base	UtC-723	13900	± 200	cal BC 15224 (14722) 14180	*RC* 31(3)1989: 988
Corbeddu Cave	Hall 2 Layer 3		13700	± 250	cal BC 15103 (14473) 13766	Sondaar et al. 1995
Corbeddu Cave	Hall 2 Layer 3 level 7	UtC-239	13620	± 180	cal BC 14853 (14371) 13843	Klein Hofmeijer et al. 1987
Corbeddu Cave	Hall 2 Layer 3	GrN-11405	13590	± 140	cal BC 14729 (14332) 13904	Sondaar et al. 1984
Corbeddu Cave	Hall 2 Layer 3 level 4	UtC-244	13530	± 170	cal BC 14722 (14253) 13738	Klein Hofmeijer et al. 1987
Corbeddu Cave	Hall 2 Layer 3 level 6	UtC-240	13510	± 180	cal BC 14720 (14226) 13680	Klein Hofmeijer et al. 1987
Corbeddu Cave	Hall 2 Layer 3		13510	± 180	cal BC 14720 (14226) 13680	Sondaar et al. 1995
Corbeddu Cave	Hall 1 Layer D-mid	UtC-722	13500	± 300	cal BC 14982 (14213) 13287	*RC* 31(3)1989: 988
Corbeddu Cave	Hall 1 Layer E-mid	UtC-724	13500	± 190	cal BC 14731 (14213) 13636	*RC* 31(3)1989: 988
Corbeddu Cave	Hall 1 Layer C-base	UtC-721	13100	± 190	cal BC 14221 (13644) 12956	*RC* 31(3)1989: 988
Corbeddu Cave	Hall 1 Layer C-mid	UtC-720	12500	± 150	cal BC 13241 (12699) 12217	*RC* 31(3)1989: 988
Corbeddu Cave	Hall 2 Layer 3 level 2	UtC-241	11980	± 140	cal BC 12461 (12018) 11641	Klein Hofmeijer et al. 1987
Corbeddu Cave	Hall 1 Layer C-top	UtC-719	11200	± 170	cal BC 11546 (11158) 10819	*RC* 31(3)1989: 988

Table II. Radiocarbon dates from Corbeddu cave. Paleolithic dates are listed with their context, laboratory number (when known), uncalibrated age, error, and calibrated age range at 2σ determined with the intercept method (Stuiver & Reimer 1993). Three early dates are beyond calibration range. The relative probabilities of the calibrated dates for Layer 3 of Hall 2 and Layers C-E of Hall 1 are illustrated at top.

in Hall 2. Several stone tools, described as "very elementary" and "complementing the more widescale use of naturally flaked material," have also been reported from Levels C-E of Hall 1 (Martini 1992); seven radiocarbon dates indicate that Levels C-E were broadly contemporary with Layer 3 of Hall 2. Six of the dates from Layer 3 (spanning levels 3 through 7), fall within an interval of less than 200 years, however, suggesting that most of the Layer 3 deposits were laid down over a relatively short span of time (Table II). The Hall 1 radiocarbon dates, in contrast, indicate depositional continuity over several thousand years. It is difficult then to relate the alleged lithic industry of Hall 1 with the deer bone accumulation of Hall 2, and the human involvement in each deposit should be judged independently. If the dubious status of the lithics or the deer mandibles can be resolved, by disproving the hypothesis that they could be the result of non-human processes (cf. Cherry 1992), then it would appear that Corbeddu Cave was frequently occupied for the latter half of the Upper Paleolithic. Late Upper Paleolithic sites are known throughout the Italian mainland and Sicily (Bietti 1990), especially in Latium and Tuscany where the island populations may have originated.

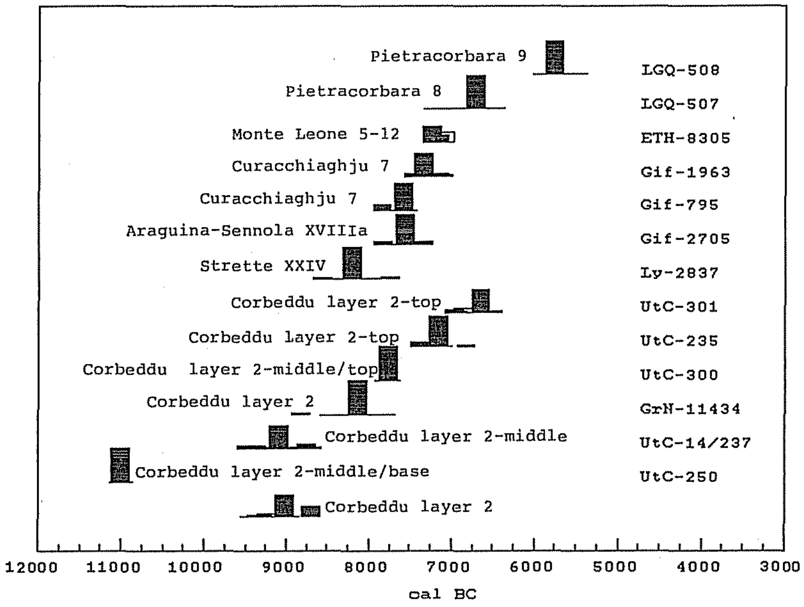
The maximum regression of sea level during the last ice age was about -120 m at 18,000 BP, linking Sardinia with Corsica and opening up extensive coastal plains east of Tunisia and in the north Adriatic (Shackleton et al. 1984). At that time Corsica was still separated, however, from the Tuscan archipelago by a strait at least 300 m deep, although only 15 Km wide. While Conchon (1976) has shown that more recent tectonic subsidence could have submerged a possible isthmus between Corsica and Tuscany, the endemic nature of the island fauna virtually proves that such a connection did not exist. Besides *Megaloceros cazioti*, *Prolagus sardus*, and *Cynotherium sardous*, the indigenous Pleistocene fauna of Sardinia and Corsica were limited to a large soricid insectivore (in Sardinia, *Episoriculus similis*; in Corsica, *E. corsicanus*), a large vole (*Tyrrhenicola henseli*), a large field mouse (*Rhagamys orthodon*), probably the otter (*Cyrnaonyx majori*), possibly the fox (*Vulpes vulpes* L.), and an assortment of birds and frogs (Vigne 1988a; 1990; 1992a; 1995; Vigne & Desse-Berset 1993). The strong size increase of both the hare and the field mouse throughout the Pleistocene suggests weak predation pressure, and therefore minimal human presence on the islands (Vigne 1988a; 1990). *Megaloceros cazioti* remains, however, have normal (undwarfed) proportions, unlike their counterparts on Crete and elsewhere (Sondaar 1977; 1986), which has been interpreted as further evidence of human presence and predation (Sondaar et al. 1984; 1986; 1989).

We may thus draw the following preliminary conclusions about the nature of the human occupation of Sardinia (and Corsica?) in the Upper Paleolithic: whenever they arrived, they came by boat, signifying at least rudimentary maritime capabilities; population density was probably very low, and occupation perhaps discontinuous; obsidian was not used on the islands or transported to the mainland.

Mesolithic

By the beginning of the Mesolithic in Italy, sea-levels had risen significantly, to about -35 m by 8000 cal BC, putting coastlines near to their present location, and separating the islands of Sardinia and Corsica (Shackleton et al. 1984; van Andel 1989; 1990). Subsequent rise was slow, but Mesolithic and Neolithic sites right on the shoreline are likely under water now. Settlers from the mainland must have crossed at least 33 Km of open water from Elba to Capraia (plus 25 Km between Capraia and Cap Corse), or 42 Km from Pianosa (plus 15 Km from Elba). These sorts of distances must have been traveled in the Aegean too, based on finds of obsidian (Perlès 1990a) and bluefin tuna (Jameson et al. 1994) at Franchthi Cave, although Rose (1994; 1995) correctly notes that a vessel sufficient for transporting small quantities of obsidian may have been insufficient for bulky (and perishable) fish which probably could have been caught relatively close to shore. While the quantities of both obsidian and tuna are never abundant, by the Upper Mesolithic they are significantly more frequent than in the Upper Paleolithic, indicating increased maritime travel if not improved capability.

In Sardinia, the anthropogenic origin of the deposits in Layer 2 of Hall 2 in Corbeddu Cave are undisputed, since two human cranial fossils are associated with the butchered bones of *Prolagus sardus*, in a sequence with 7 radiocarbon dates between 11,000 to 7900 BP (Table III). Both finds, a temporal bone and a left maxilla, have morphologies outside the range of modern human variation, and which have been explained as the result of endemism in an isolated population



SITE	CONTEXT	LAB. NO.	^{14}C AGE	ERROR	2σ CALIBRATED AGE RANGE	REFERENCE
			SARDINIA			
Corbeddu Cave	Hall 2 Layer 2 mid/base	UtC-250	11040	± 130	cal BC 11283 (11005) 10736	Klein Hofmeijer et al. 1987
Corbeddu Cave	Hall 2 Layer 2 mid	UtC-14/237	9820	± 140	cal BC 9812 (9044) 8539	Klein Hofmeijer et al. 1987
Corbeddu Cave	Hall 2 Layer 2, >200 cm		9790	± 160	cal BC 9835 (9038) 8477	Sondaar et al. 1995
Corbeddu Cave	Hall 2 level 2 (60-85)	GrN-11434	9120	± 380	cal BC 9053 (8088) 7428	Sondaar et al. 1984
Corbeddu Cave	Hall 1 Layer B-base	UtC-726	8960	± 110	cal BC 8321 (8018) 7705	*RC* 31(3)1989: 988
Corbeddu Cave	Hall 2 Layer 2 mid/top	UtC-300	8750	± 140	cal BC 8039 (7877, 7812, 7710) 7497	Klein Hofmeijer et al. 1987
Corbeddu Cave	Hall 2 Layer 2 top	UtC-235	8160	± 130	cal BC 7486 (7192, 7189, 7134, 7127, 7049) 6652	Klein Hofmeijer et al. 1987
Corbeddu Cave	Hall 2 level 1b	UtC-22	8040	± 180	cal BC 7480 (7008) 6462	Klein Hofmeijer et al. 1987
Corbeddu Cave	Hall 2 Layer 2 top	UtC-301	7860	± 130	cal BC 7043 (6617) 6418	Klein Hofmeijer et al. 1987
Filiestru Cave	Trench D, Layers 7-9	BM-2139R	7760	± 130	cal BC 7006 (6544) 6267	*RC* 32(1990): 76
			CORSICA			
Strette II	Layer XXIV	Ly-2837	9140	± 300	cal BC 9015 (8091) 7538	*RC* 27(1985):437
Curacchiaghju	Level 7	Gif-795	8560	± 170	cal BC 7967 (7543) 7106	*RC* 13(1971):221
Araguina-Sennola	Hearth, level XVIIIa	Gif-2705	8520	± 150	cal BC 7923 (7535) 7105	*RC* 28(1986):20
Curacchiaghju	Layer 7	Gif-1963	8300	± 130	cal BC 7546 (7412, 7363, 7313) 7007	*RC* 16(1974):34
Monte Leone	Layers 5-12 (bone)	ETH-8305	8225	± 80	cal BC 7478 (7259, 7111, 7109) 7030	Vigne & Desse-Berset 1993
Pietracorbara	Layer 8	LGQ-507	7840	± 310	cal BC 7496 (6607) 6013	Vigne & Desse-Berset 1993
Pietracorbara	Layer 9	LGQ-508	6920	± 300	cal BC 6373 (5733) 5263	Vigne & Desse-Berset 1993

Table III. Radiocarbon dates from Mesolithic sites in Sardinia and Corsica. The relative probabilities of the calibrated dates are illustrated at top (UtC-22 and UtC-726 not shown). BM-2139R comes from a non-archaeological level at Grotta Filiestru.

(Spoor & Sondaar 1986; Spoor & Germanà 1987), an interpretation with much greater credibility given the recent phalanx find.

More importantly, contemporary settlement has been documented at six rock-shelter sites in Corsica (Figure 2): Curacchiaghju (Lanfranchi 1967; 1974; 1987a); Araguina-Sennola (Lanfranchi et al. 1973; Lanfranchi & Weiss 1977); Strette II (Magdeleine 1985; Magdeleine & Ottaviani 1986); Pietracorbara (Magdeleine 1991); Longone (Lanfranchi 1987b); and Monte Leone (Lanfranchi 1991a; Vigne 1992b). A preneolithic presence was also noted at Grotta Scritta by R. Grosjean but not well documented (cf. Camps 1988:25). Except for Curacchiaghju, all of these sites are located on coastal plains within a few kilometers of the sea. Monte Leone, still under excavation, is the only site with actual domestic structures (hearths), although burials have been found at Araguina-Sennola (Lanfranchi & Weiss 1977) and Pietracorbara (Magdeleine 1991). Associated lithic assemblages are largely idiosyncratic, and always made of local quartz and rhyolite. Typologically, they have been related to the Final Epigravettian and Sauvetterian of Tuscany (Tozzi 1995).

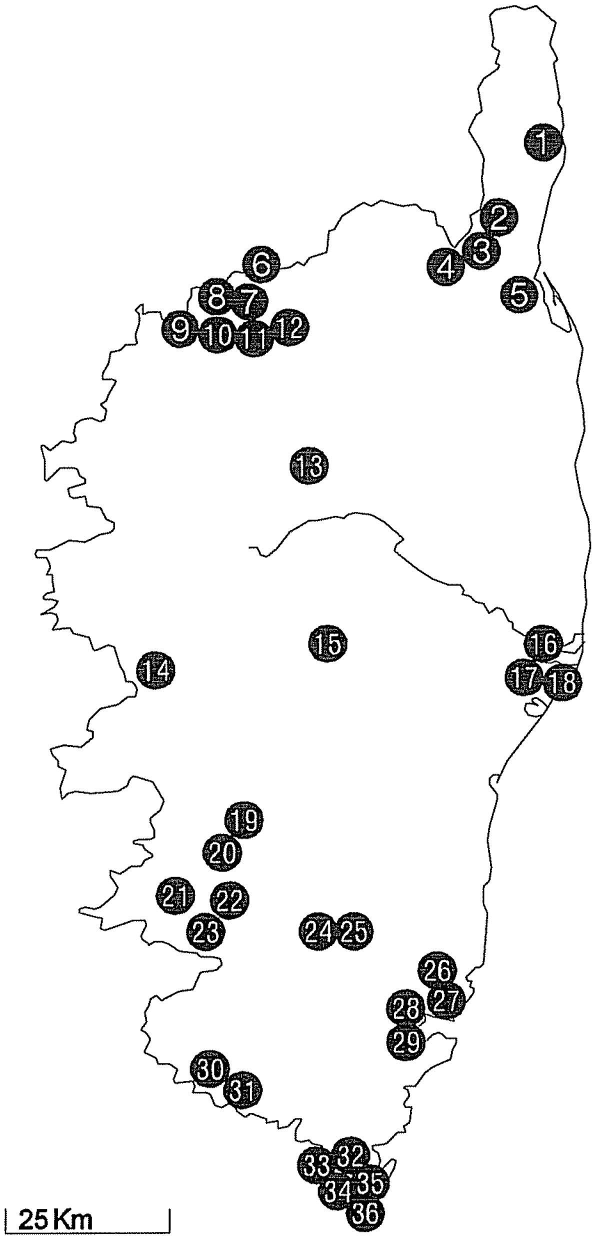
Faunal analyses of the Corsican sites (Vigne 1987b; 1988a; 1995) demonstrate the predominance of *Prolagus sardus* (> 78% by weight of edible matter for all sites), the presence of several small endemic mammals, shellfish, fish, and birds, and the absence of large game and domestic animals. *Prolagus* also dominates the faunal assemblage in Layer 2 at Corbeddu (Sondaar et al. 1984; 1989). Some *Megaloceros* remains were also found there, but it appears to have become extinct in Corsica by this time, presumably as a result of human

Figure 2. Mesolithic and Neolithic sites in Corsica.

CORSICA

Mesolithic and Neolithic Sites

1. Pietracorbara
2. Strette
3. Scaffa Piana
4. Grotta Scritta
5. Monte Grosso
6. La Pietra (Ile Rousse)
7. Carcu-Modria
8. Monte Ortu
9. Lumio
10. Revellata
11. Porto Vecchie Corsu
12. A Mutola
13. Abri Albertini
14. Monte Lazzu
15. Grotte Southwell
16. Terrina I
17. Casabianda I
18. Casabianda II
19. Pietroselle
20. Castellucciu
21. Basi
22. Filitosa
23. I Calanchi
24. Presa-Tusiu
25. Curacchiaghju
26. Tozze Bianche
27. San Ciprianu
28. Foce
29. Strappazola
30. Cala Barbarina
31. Punta di Murtoli
32. Saint-Julien
33. Abri du Goulet
34. Araguina-Sennola
35. Monte Leone
36. Longone



activity (although it is impossible to distinguish proximate from ultimate causation) (Vigne 1987a; 1990; 1992a). Marine resources appear to have been no more than 20% of the diet at best, despite the variety of fish and shellfish species represented. One seal bone (*Monachus monachus*) was identified at Araguina-Sennola, and the Early Neolithic site of La Pietra may have been a specialized seal hunting site (Vigne, in press). It remains possible that the currently known sites may have been specialized or seasonal hunting/trapping settlements, with complementary camps along the Mesolithic littoral now submerged or destroyed (Vigne & Desse-Berset 1993; Vigne 1995). In other areas of the western Mediterranean, subsistence intensification was similarly manifested in both hunting specialization and the diversified use of estuarine and marine resources (Lubell & Jackes 1985; Straus 1991a; 1991b; Bicho 1993; 1994; Zilhão 1993).

During the Mesolithic, then, it appears that human occupation of Sardinia and Corsica may have become more widespread. Nevertheless, there is no evidence of regular traffic between the islands and the mainland (the endemic human remains from Corbeddu suggest the opposite). No obsidian has been found at any of the preneolithic sites in Sardinia and Corsica, nor in Mesolithic levels at Grotta dell'Uzzo in Sicily, nor Arene Candide in Liguria. Although some obsidian was found associated with Mesolithic artifacts during a survey of the Salerno peninsula in southeast Italy (Milliken & Skeates 1989), the only example of western Mediterranean obsidian excavated from a preneolithic context comes from a Final Epigravettian layer at Arma dello Stefanin in Liguria, excavated between 1952 and 1962 (Leale Anfossi 1972), and which by all accounts was not contaminated (Williams-Thorpe et al. 1979; Barker et al. 1990). Obsidian was not found, however, during more recent excavations at Stefanin (Biagi et al. 1987), and at minimum cautions that the significance of the single scraper found in layer V not be over-interpreted (contra Cherry 1990:190-191). The geological source of this piece has not been determined (contra Camps 1986:37).

Early Neolithic

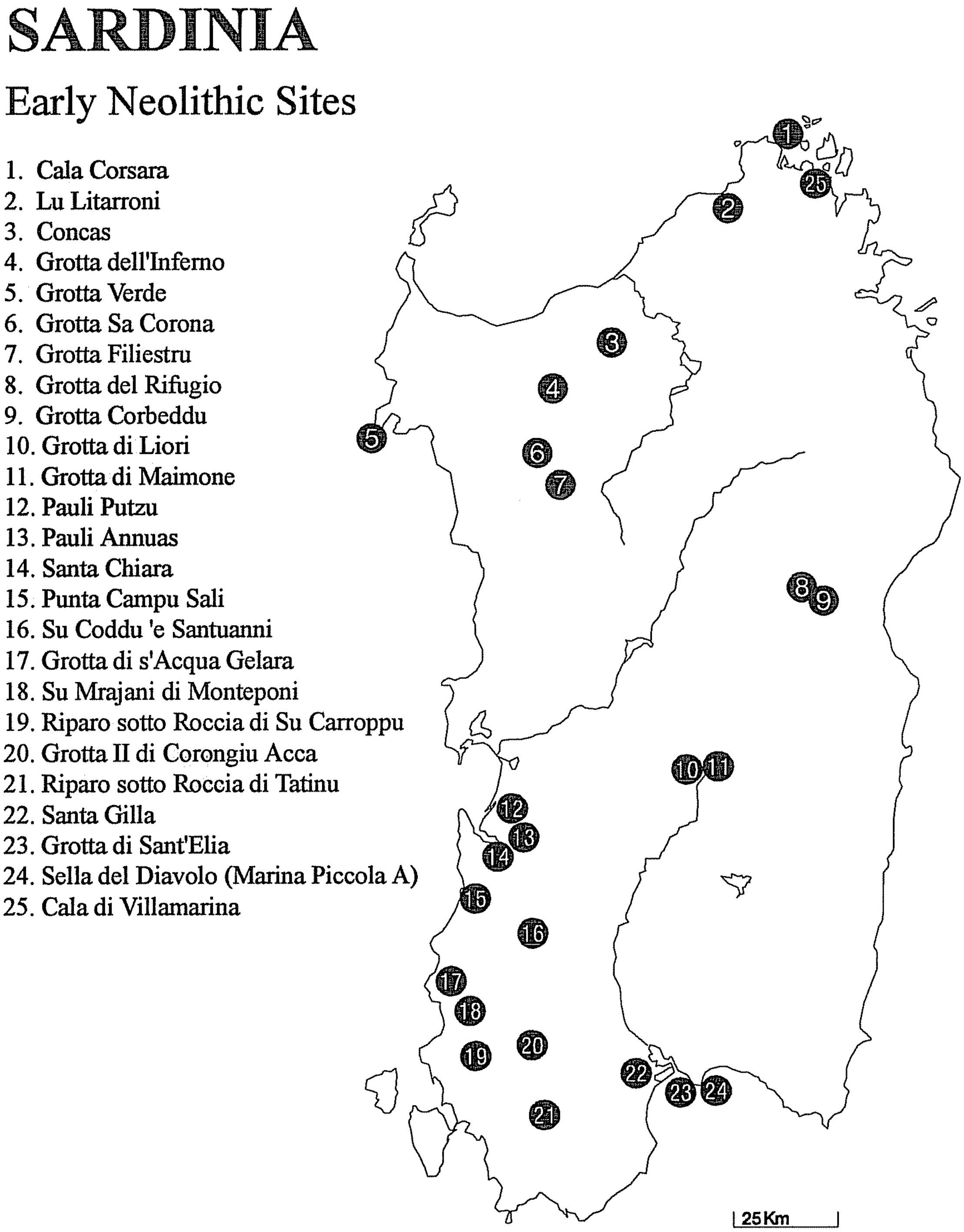
The Early Neolithic in the western Mediterranean is defined by the appearance of impressed ceramics, and domesticated animals and plants presumably with eastern Mediterranean origins. There is some evidence that not all of these elements of the "neolithic package" appeared simultaneously in the western Mediterranean, a situation which has complicated our interpretation of this transitionary phase. Three major hypotheses exist for the appearance of the neolithic: (1) adoption of neolithic elements through social and economic interaction between neighboring indigenous populations (Guilaine 1976; 1979; Lewthwaite 1981a; 1982a; 1982b; 1986a; 1986b; 1989; Zvelebil 1986; Bökönyi 1988-89; Binder 1989; Clark 1989; 1990; Chapman & Müller 1990; Donahue 1992; Barnett 1995); (2) demic diffusion of a growing farming population (Ammerman & Cavalli-Sforza 1973; 1984; Renfrew 1987; 1993b; Whitehouse 1987; Sokal et al. 1991; Cavalli-Sforza et al. 1994; Barbujani et al. 1995); and (3) long-distance migration/colonization by eastern agropastoralists (Arnaud 1982; Tinè 1983; Anthony 1990; Zilhão 1993).

Clearly, neither Sardinia nor Corsica were entirely unoccupied territories, so that the indigenous peoples must be considered in any acculturation or assimilation process, especially their potential motivation for a substantial change in their subsistence practices. Currently, the skeletal evidence is too meager to draw any conclusions about the ethnic/geographic origins of the preneolithic or neolithic island inhabitants (Germanà 1989; 1990; 1992). Since every known site of preneolithic type predates the neolithic, and most have subsequent Early Neolithic occupations, long-term continuity of a single population originating from and continuing to have interactions with the nearby mainland is more likely than two separate populations of indigenous hunter-gatherers and immigrant farmers from the east.

Twenty-five Early Neolithic sites have been identified in Sardinia (Figure 3), and an equal number in Corsica, including caves and rockshelters concentrated in the less mountainous parts of the islands or near the coasts, but including a few open-air sites as well (Atzeni 1981). Some are located well in the interior of the islands, away from fluvial systems. Inhumation burials are known from Grotta Verde (Alghero) in Sardinia (Tanda 1976; 1980a; Lo Schiavo 1987), and Araguina-Sennola and Saint-Julien in Corsica (Lanfranchi & Weiss 1994).

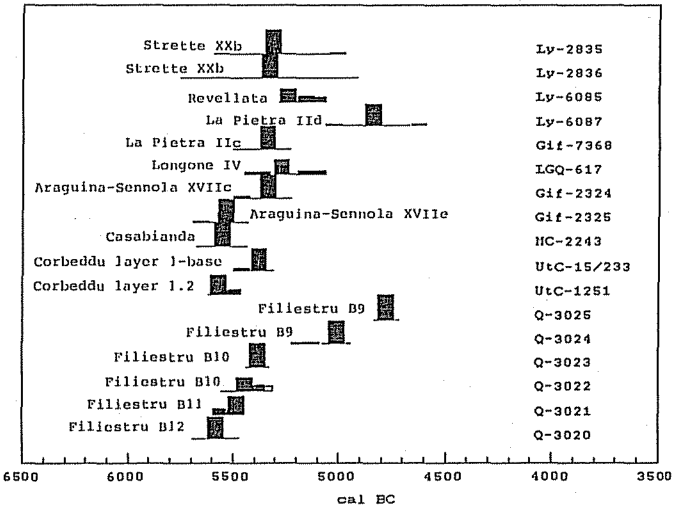
Stratigraphic excavations at Grotta Filiestru (Mara) (Trump 1983; 1985; 1986) and Sa Corona di Monte Maiore (Foschi Nieddu 1982; 1987) have provided the best sequence for Sardinia, with data from Corbeddu Cave still only preliminarily published (Sanges 1987). For Corsica, the Curacchiaghju stratigraphy is probably unreliable (Lewthwaite 1983:151; Lanfranchi 1987a), but

Figure 3. Early Neolithic sites in Sardinia.



good sequences come from Araguina-Sennola (Lanfranchi et al. 1973; Lanfranchi & Weiss 1977), Basi (Bailloud 1969a; 1969b), Strette I and II (Magdeleine & Ottaviani 1986), and Longone (Lanfranchi 1987b; 1992; 1993).

Radiocarbon dates from several sites suggests that the Early Neolithic in Sardinia and Corsica began no earlier than about 5700 cal BC (Table IV), a date supported by a series of 9 obsidian hydration dates (5550 to 4875 BC) from Su Carroppu de Sirri in Sardinia (Michels et al. 1984). If we exclude the three earlier dates from Curacchiaghju given the doubts about their context, the Basi date (Gif-1851) is 1000 radiocarbon years older than the remaining 17 Early Neolithic dates, and thus cannot be used by itself to mark the beginning of the period. A single determination from Corbeddu Cave (UtC-22: 8040 ± 180 BP), previously described as the earliest Cardial date anywhere in the Mediterranean (Lewthwaite 1989:546), has now been rejected by the excavators who suggest that bioturbation must have caused some upward movement of charcoal in the Hall 2 deposits since a new date (UtC-1251: 6690 ± 80 BP) from the same level is considerably later and is both internally and externally consistent (Klein Hofmeijer & Sondaar 1992:50). Most of the radiocarbon dates for mainland impressed ware sites also fall within the 7th millennium uncal. BP (Skeates 1994a; Bagolini & Biagi 1990; Evin 1987; Sargent 1985). Debate continues (cf. Rowley-Conwy 1995; Zilhão 1993; Lewthwaite 1981a; Guilaine 1979), however, over the critical acceptance of certain early dates and the rejection of others on taphonomic or stratigraphic grounds: some argue that the Early Neolithic appeared earlier in southern Italy and Dalmatia than in northern Italy (Chapman 1988; Chapman & Müller 1990; Skeates



SITE	CONTEXT	LAB. NO.	^{14}C AGE	ERROR	2σ CALIBRATED AGE RANGE	REFERENCE
			SARDINIA			
Filiestru Cave	Layer B(12)	Q-3020	6710	± 75	cal BC 5693 (5587) 5444	Switsur & Trump 1983
Corbeddu Cave	Hall 2 level 1b	UtC-1251	6690	± 80	cal BC 5687 (5579) 5440	Klein Hofmeijer & Sondaar 1992
Filiestru Cave	Layer B(11) spit 2	Q-3021	6615	± 75	cal BC 5607 (5561, 5557, 5522) 5350	Switsur & Trump 1983
Filiestru Cave	Layer B(10) spit 5	Q-3022	6515	± 65	cal BC 5570 (5437) 5290	Switsur & Trump 1983
Corbeddu Cave	Hall 2 Layer 1 base	UtC-15/233	6490	± 90	cal BC 5576 (5433) 5259	Klein Hofmeijer et al. 1987
Filiestru Cave	Layer B(10) spit 2	Q-3023	6470	± 65	cal BC 5521 (5430, 5394, 5386) 5269	Switsur & Trump 1983
Filiestru Cave	Layer B(9) spit 4	Q-3024	6120	± 55	cal BC 5218 (5051) 4870	Switsur & Trump 1983
Filiestru Cave	Layer B(9) spit 1	Q-3025	5900	± 50	cal BC 4906 (4783) 4629	Switsur & Trump 1983
			CORSICA			
Basi	Level 7, site 1	Gif-1851	7700	± 150	cal BC 7002 (6467) 6187	*RC* 16(1974):33
Curacchiaghiu	Layer 6c	Gif-1962	7600	± 180	cal BC 6994 (6419) 6038	*RC* 16(1974):34
Curacchiaghiu	Layer 6a	Gif-1961	7310	± 170	cal BC 6456 (6156, 6144, 6125, 6084, 6070) 5779	*RC* 16(1974):34
Curacchiaghiu	Level 6	Gif-796	7300	± 160	cal BC 6426 (6122, 6087, 6063) 5805	*RC* 13(1971):221
Casabianda	Hearth 1	MC-2243	6670	± 150	cal BC 5784 (5575, 5543, 5528) 5283	Camps 1979
Araguina-Sennola	Hearth, Level XVIIe	Gif-2325	6650	± 140	cal BC 5742 (5571, 5546, 5526) 5283	*RC* 28(1986):20
Strette	Layer XXb	Ly-2836	6480	± 430	cal BC 6172 (5432, 5390, 5390) 4460	*RC* 27(1985):437
La Pietra	Layer IIc	Gif-7368	6430	± 130	cal BC 5580 (5410, 5373, 5366, 5336) 5256	Lanfranchi 1995
Araguina-Sennola	Hearth F3', Level XVIIc	Gif-2324	6430	± 140	cal BC 5588 (5410, 5373, 5366, 5336) 5063	*RC* 28(1986):20
Strette	Layer XXb	Ly-2835	6420	± 300	cal BC 5923 (5332) 4712	*RC* 27(1985):437
Longone	Layer 4a2 (phase IV)	LGQ-617	6320	± 140	cal BC 5520 (5263) 4933	Lanfranchi 1995
Revellata		Ly-6085	6280	± 75	cal BC 5411 (5246) 5054	Lanfranchi 1995
La Pietra	Layer IId	Ly-6087	5945	± 160	cal BC 5228 (4823) 4460	Lanfranchi 1995

Table IV. Radiocarbon dates from Early Neolithic sites in Sardinia and Corsica. The relative probabilities of the calibrated dates are illustrated at top (Basi and Curacchiaghju dates not shown).

1994b), while others assert that the neolithic transition occurred more or less contemporaneously in the entire western Mediterranean, including southern France, Spain, and Portugal (Zilhão 1993). What is clear is that not enough data exists: currently, there are just too few sites with (a) stratigraphic contexts; (b) significant numbers of analyzed faunal remains; (c) analyses of plant, phytolith and pollen remains; and (d) series of contextually significant radiocarbon dates to resolve this issue.

In Sardinia, the Early Neolithic has been divided into three sequential phases based on stratigraphic and ceramic typological considerations (Tanda 1980a; 1982; Foschi Nieddu 1987; 1990): Cardial I (Filiestru trench B, levels 10-12; trench D, levels 7-9; Su Carroppu); Cardial II (Monte Maiore level 3, layers 4-6; Grotta Verde 1a-b); and Epicardial (Filiestru trench B, level 8; trench D, level 6; Monte Maiore level 3, layers 1-3; Grotta Verde recente). Although no absolute dates are available for the Cardial II phase, there is an apparent gap of a few centuries between the Cardial I and Epicardial (Trump's Filiestru phase) dates from Grotta Filiestru (*supra*, Table IV, top). In Corsica, the Early Neolithic has been divided into four phases, based on recent work at Longone (Lanfranchi 1992; 1993): Cardial I; Cardial II; Cardial III; and Punched (= Curasien). The last phase, with radiocarbon dates from the type-site clearly too early for the associated ceramics, is typologically similar to, and chronologically contemporary with, the Sardinian Bonu Ighinu culture, and is perhaps best considered as Middle Neolithic.

Early Neolithic sites are characterized by pottery frequently decorated with impressions of *Cardium edule* shells, a practice evident not only in Sardinia and

Corsica, but especially common in southeastern Italy, southern France, and both Mediterranean and Atlantic coasts of the Iberian peninsula. At Grotta Filiestru in Sardinia, for example, Cardial impressed bowls, plates, and jars comprise 7% of the ceramic assemblage (Trump 1983). Guilaine (1980) has subdivided the Cardial Impressed Wares into three regional facies: south Italian/Sicilian; Tyrrhenian; and Classic Cardial. An extremely important study of the provenance of Cardial wares, from six sites in the Aude region of southern France and one in Portugal, has demonstrated the existence of intra-regional, multi-directional interaction networks, with vessels found 50-70 Km from their production area (Barnett 1989; 1990a; 1990b; 1992). Overall, we may interpret the Cardial phenomenon as suggesting a common cultural base over much of the western Mediterranean, with broad inter-group interaction evidenced not only by the ceramics (Chapman 1988; Barnett 1995) but also by inter-regional movement of ground and chipped stone artifacts including obsidian. In Italy, other neolithic ceramic types are generally considered to be of local origin, although this has not been explicitly tested by thin-section or chemical characterization studies (cf. Skeates 1992).

Lithic assemblages are typically composed of geometric microliths, including rectangles, trapezes, lunates, triangles, and larger implements including scrapers, burins, and transverse tranchet arrowheads (e.g. Weiss 1990; Brandaglia 1985; Binder 1987). These tools were fashioned from flint, quartz, rhyolite, and above all obsidian. In Corsica, obsidian is rare (Basi layer 7, Curacchiaghju layer 6) or non-existent (Longone 4a3) in the Cardial I phase, although the flint from which most tools were made was imported from the Perfugas area in Sardinia (Lanfranchi 1980; 1993). In Sardinia, obsidian is found at all Early Neolithic sites, and accounts for 17% of the Cardial I lithic assemblage at Grotta Filiestru (Trump 1983). In Cardial II, obsidian becomes abundant at Corsican sites, although obsidian cores are small and rare, and arrowheads are infrequently made of obsidian. Lanfranchi & Weiss (1973) note that the obsidian can be opaque or translucent, and that there appears to be a drop off in obsidian frequency from south to north. Sardinian obsidian has been found in Early Neolithic contexts on Isola Pianosa between Corsica and the mainland, and at Arene Candide, Grotta Pollera, and Pianaccia di Suvero in Liguria. It is not possible at this time to say whether any obsidian comes from strictly Cardial I contexts at these sites. The impressed ceramics found on Isola del Giglio may be Cardial I, judging from reports of its similarity to material at Basi and Su Carroppu (Brandaglia 1991), and are associated with obsidian, some of which is probably Sardinian, despite the excavator's assumption otherwise (Brandaglia 1985).

The exchange of these materials is undoubtedly related to the introduction and spread of domesticated animals and the transition to an agricultural way of life (cf. Castelletti et al. 1987). The mouflon (*Ovis ammon musimon*), which doesn't appear in the archaeological record until the Late Neolithic (Vigne 1988a), is most likely a descendant of feral domestic sheep (Lauvergne 1977; Bunch et al. 1978; Poplin 1979; Nguyen & Bunch 1980; Poplin & Vigne 1983; Geddes 1985; Uerpmann 1987; Groves 1989), despite arguments that the evidence is not definitive (Ducos 1991). Likewise, the Corsican wild boar (*Sus scrofa* L.) is considered to be descended from feral domestic pigs (Vigne 1984; 1988a), although not all agree (Groves 1981; 1989; cf. Helmer 1987 and Rowley-Conwy 1992 for mainland pigs). Remains of sheep (*Ovis aries*) and pig (*Sus scrofa*) are present in Cardial levels at Basi, Strette and Araguina-Sennola in Corsica (Vigne 1984; 1987b; 1988a), and Filiestru (Levine 1983) and Corbeddu (Sanges 1987) in Sardinia. Goat (*Capra hircus*) has been identified in the same levels at Basi and Strette, and perhaps is represented among the indeterminate caprine remains at Araguina-Sennola. Domestic cattle (*Bos taurus*) appear in the Cardial Neolithic at Filiestru, but account for less than 2% of the domestic faunal remains. In Corsica, cattle are not present in the Cardial levels at either Basi or Araguina-Sennola, but do appear by the end of the Early Neolithic at Strette (Vigne 1984; 1987b; 1988a). When the modern practice of pastoral transhumance over geographically extensive, often non-contiguous land areas began, and what form(s) it acquired, are open questions (Lewthwaite 1984a; 1984c; 1991; Weiss 1991; Lanfranchi 1991b; Cleary & Delano Smith 1991).

Prolagus sardus continued to be an important food resource during the Neolithic, with remains found at Araguina-Sennola (Vigne et al. 1981), Monte Maiore (Foschi Nieddu 1987), Filiestru (Levine 1983), and Corbeddu (Sanges 1987). It declined in importance during the Roman period, but survived at least until the 18th century AD (Cetti 1777). Other wild foods included fish, mollusks, crustaceans, and snails. Incipient agriculture in the Early Neolithic is suggested by the finds of carbonized domestic grains (*Triticum monococcum*, *Triticum dicoccum*) at Filiestru (Trump 1983) and the presence of grinding stones at

Filiestru and Monte Maiore in Sardinia (Foschi Nieddu 1982), and Basi and Strette in Corsica (Lanfranchi 1993). These limited data are insufficient to address the issue of how quickly and to what extent agricultural produce replaced gathered foodstuffs; special effort must be made in current and future excavations to systematically retrieve archaeobotanical evidence from neolithic sites.

Neolithisation was based then on the adoption of ceramic technology of a widespread decorative type, the cultivation of already-domesticated plants and the raising of non-indigenous (and in most if not all cases already-domesticated) animals. This neolithic package was introduced by expanding mainland populations, or through local experimental adoption, especially in coastal and insular environments (Tusa 1985; Manfredini 1988-89). In all instances, this transition went hand in hand with an accelerated involvement of Sardinia and Corsica in Mediterranean interrelations (cf. Camps 1991). Although the density of known sites is much higher in the Early Neolithic than the Mesolithic, the rise in sea levels may bias an interpretation towards the significant influx of agriculturalists and subsequent population growth on the islands.

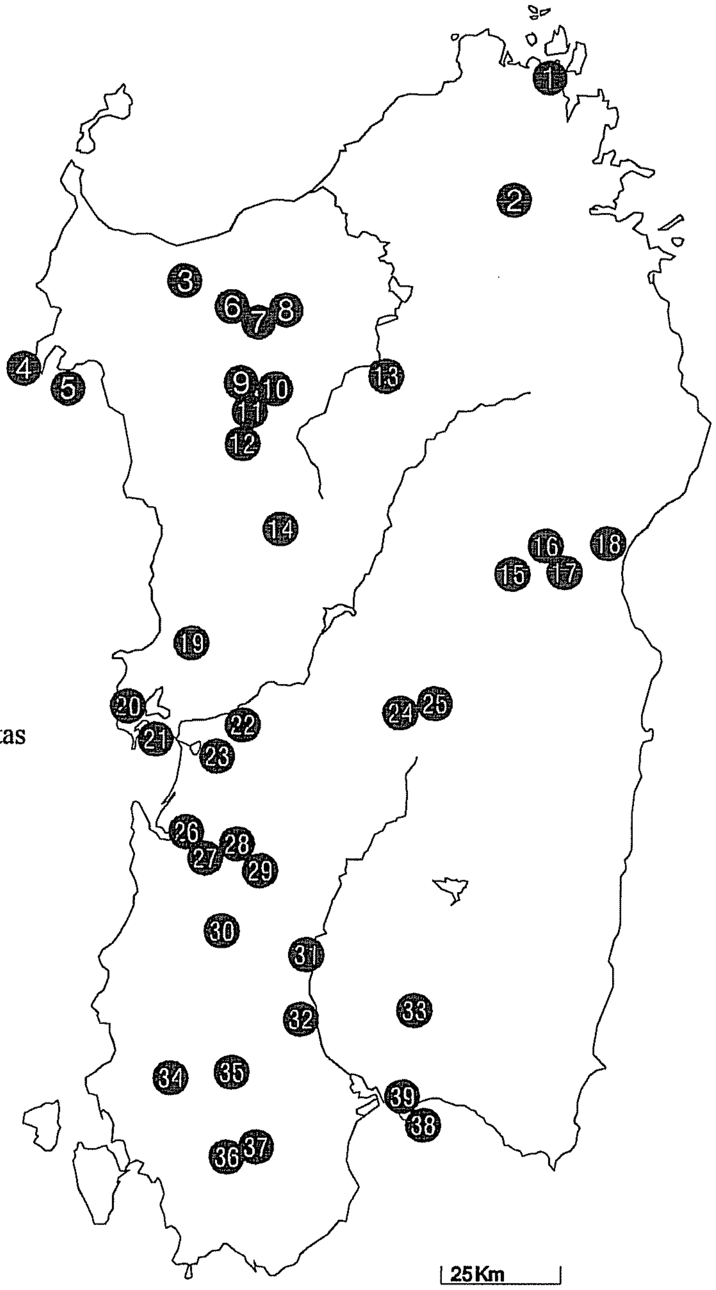
Middle Neolithic

The Bonu Ighinu culture was first recognized in 1971 with the excavation of the cave site Sa 'Ucca de Su Tintirriolu (Mara), where its distinctive ceramics were stratigraphically earlier than those of the already-familiar Ozieri culture (Loria & Trump 1978; Trump 1984a; 1984b). Bonu Ighinu material has been identified now at some 38 sites in Sardinia (Figure 4), with additional stratigraphic

Figure 4. Middle Neolithic sites in Sardinia.

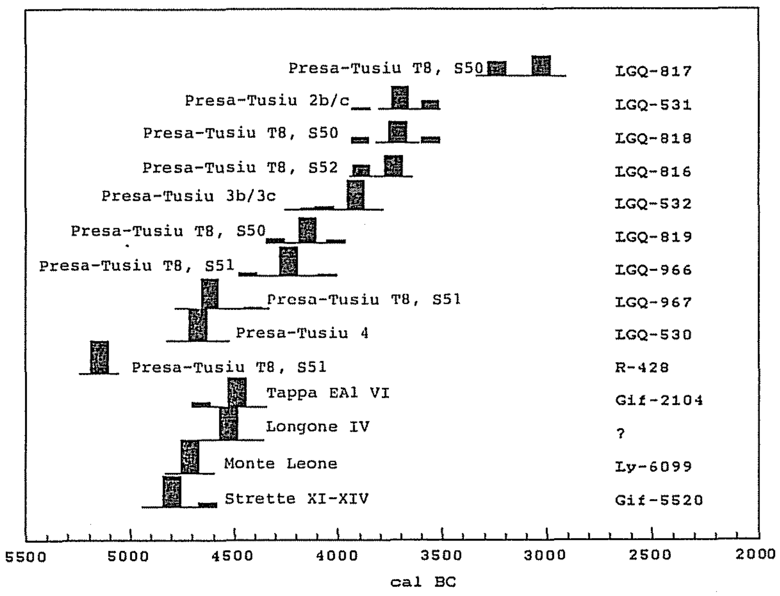
SARDINIA
Middle Neolithic Sites

1. Cala di Villamarina
2. S. Mariedda
3. Monte d'Accoddi
4. Grotta Verde
5. Grotta Dasterru
6. Grotta di Su Monte
7. Grotta dell'Inferno
8. Sa Binza Manna
9. Grotta Sa Corona
10. Grotta Ulari
11. Sa Ucca de su Tintirriolu
12. Grotta Filiestru
13. Grotta Barile
14. Grotta s'Adde
15. Orgosolo
16. Grotta del Rifugio
17. Grotta Corbeddu
18. Dorgali
19. Su Anzu
20. Conca Illonis
21. Su Cuccuru s'Arriu
22. Su Cungiau de is Fundamentas
23. Santa Giusta
24. Polu
25. Grotta di Pitzu e Pranu
26. S. Giovanni
27. San Ciriaco
28. Serra sa Furca
29. Puisteris
30. Terra e Zeddari
31. Sa Mandara
32. Su Cungiau de Marcu
33. Bingia Eccia
34. Grotta di Su Carroppu
35. Grotta II di Corongiu Acca
36. Grotta di Monte Miana
37. Grotta di Tatinu
38. Grotta del Bagno Penale
39. Cala Mosca



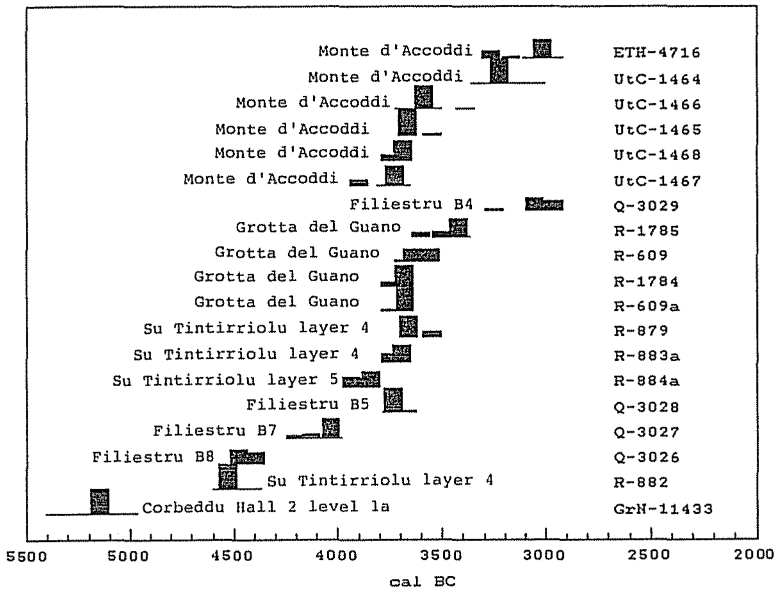
sequences coming from Filiestru (Trump 1983), Sa Corona di Monte Maiore (Foschi Nieddu 1987), Cuccuru s'Arriu (Santoni 1977; 1989; 1992; Santoni et al. 1982), and Corbeddu (Sanges 1987). The culture appears to be largely homogenous throughout the island, in contrast to Corsica where multiple Middle/Late Neolithic cultures have been defined (cf. Lewthwaite 1983 for a review). There, the Basien culture had been defined as Middle Neolithic (Camps 1988), but the recently identified Presian culture is apparently contemporary with both Bonu Ighinu and Curasien (e.g. Longone phase IV) cultures (Lanfranchi 1992; 1995). A series of dates from different contexts at the type-site, Presa-Tusiu, more than spans the 5th millennium cal BC (Table V), and full publication of this material is eagerly awaited. For Sardinia, just two radiocarbon dates from Sa 'Ucca de Su Tintirriolu (R-882) and Filiestru (Q-3026) calibrate to the mid-5th millennium cal BC, clearly more recent than the Filiestru culture yet several centuries earlier than the earliest Ozieri dates (Table VI). The recently defined San Ciriaco-Cuccuru s'Arriu facies, with ceramic parallels to the Corsican Basien (cf. Ugas 1990:87-92; Meloni 1993), is found stratigraphically between Bonu Ighinu and Ozieri levels at Cuccuru s'Arriu, and would fit well within this late 5th millennium BC gap (cf. also Ugas 1990:114-115, n. 65; Atzeni 1987a:392).

Although most Bonu Ighinu sites are caves and rock-shelters, village settlements dot the fertile Campidano plain which extends northwest from Cagliari to Oristano, and include five in the Cabras/Oristano area (Atzeni 1992). The Cabras lagoon open-air sites are the earliest known settlements in the Sinis area, despite a recent intensive field survey there (Lazrus 1992). In the Iglesiente



SITE	CONTEXT	LAB. NO.	^{14}C AGE	ERROR	2σ CALIBRATED AGE RANGE	REFERENCE
			CORSICA			
Presa-Tusiu	T8, S51, Layer 3c	R-428	6210	± 80	cal BC 5282 (5210, 5166, 5141) 4937	Lanfranchi 1995
Strette	Layer XI-XIV	Gif-5520	5910	± 130	cal BC 5194 (4787) 4466	Delibrias et al. 1987
Monte Leone	burial level (bone)	Ly-6099	5855	± 95	cal BC 4936 (4757, 4743, 4725) 4469	Lanfranchi 1995
Presa-Tusiu	allée, Layer 4	LGQ-530	5820	± 130	cal BC 4951 (4712) 4363	Lanfranchi 1992
Presa-Tusiu	T8, S51, Layer 3a	LGQ-967	5740	± 170	cal BC 4951 (4557) 4248	Lanfranchi 1995
Longone	Phase IV		5680	± 160	cal BC 4905 (4507) 4170	Lanfranchi 1992
Tappa	Layer VI, abri E A1	Gif-2104	5650	± 150	cal BC 4833 (4466) 4164	*RC* 16(1974):34-5
Presa-Tusiu	T8, S51, Layer 3b	LGQ-966	5430	± 180	cal BC 4681 (4323, 4281, 4262) 3812	Lanfranchi 1995
Presa-Tusiu	T8, S50, Layer 4	LGQ-819	5330	± 150	cal BC 4462 (4222, 4192, 4156) 3795	Lanfranchi 1995
Presa-Tusiu	allée, Layer 3b/3c	LGQ-532	5150	± 130	cal BC 4315 (3965) 3662	Lanfranchi 1992
Presa-Tusiu	T8, S52, Layer 3	LGQ-816	4980	± 140	cal BC 4070 (3772) 3383	Lanfranchi 1995
Presa-Tusiu	T8, S50, Layer 3	LGQ-818	4910	± 160	cal BC 4033 (3695) 3353	Lanfranchi 1995
Presa-Tusiu	allée, Layer 2b/2c	LGQ-531	4890	± 130	cal BC 3966 (3663) 3366	Lanfranchi 1992
Presa-Tusiu	T8, S50, Layer 3	LGQ-817	4430	± 160	cal BC 3616 (3075, 3067, 3040) 2618	Lanfranchi 1995

Table V. Radiocarbon dates from Presa-Tusiu and Middle Neolithic sites in Corsica. The relative probabilities of the calibrated dates are illustrated at top.



SITE	CONTEXT	LAB. NO.	^{14}C AGE	ERROR	2σ CALIBRATED AGE RANGE	REFERENCE
SARDINIA						
Corbeddu Cave	Hall 2 Level 1a	GrN-11433	6260	± 180	cal BC 5563 (5226) 4783	Sondaar et al. 1984
Su Tintirriolu	Layer 4 Trench C	R-882	5680	± 60	cal BC 4688 (4507) 4362	*RC* 1978(20): 91
Filiestru Cave	Layer B(8) spit 4	Q-3026	5625	± 65	cal BC 4592 (4461) 4343	Switsur & Trump 1983
Filiestru Cave	Layer B(7)	Q-3027	5250	± 60	cal BC 4233 (4038, 4015, 4006) 3957	Switsur & Trump 1983
Su Tintirriolu	Layer 5 Trench G	R-884α	5090	± 50	cal BC 3982 (3942, 3845, 3824) 3776	*RC* 1978(20): 91
Monte d'Accoddi	pavement of chapel	UtC-1467	4970	± 100	cal BC 3974 (3765) 3535	Tinè 1992
Filiestru Cave	Layer B(5) spit 2	Q-3028	4950	± 50	cal BC 3907 (3709) 3643	Switsur & Trump 1983
Su Tintirriolu	Layer 4 Trench G	R-883α	4930	± 50	cal BC 3892 (3702) 3638	*RC* 1978(20): 91
Monte d'Accoddi	pavement of chapel	UtC-1468	4920	± 50	cal BC 3793 (3698) 3635	Tinè 1992
Grotta del Guano	below stalagmite layer	R-609α	4900	± 50	cal BC 3784 (3692, 3670) 3547	*RC* 13(1971): 399
Grotta del Guano		R-1784	4900	± 60	cal BC 3793 (3692, 3670) 3538	Allegri et al. 1987
Monte d'Accoddi	Phase I of sanctuary	UtC-1465	4870	± 50	cal BC 3768 (3649) 3534	Tinè 1992
Su Tintirriolu	Layer 4 Trench F	R-879	4850	± 50	cal BC 3710 (3644) 3523	*RC* 1978(20): 91
Grotta del Guano	below stalagmite layer	R-609	4830	± 50	cal BC 3703 (3639) 3389	*RC* 13(1971): 399
Monte d'Accoddi	Phase I of sanctuary	UtC-1466	4810	± 80	cal BC 3767 (3634) 3372	Tinè 1992
Grotta del Guano		R-1785	4700	± 60	cal BC 3637 (3503, 3416, 3383) 3349	Allegri et al. 1987
Monte d'Accoddi	Phase II of sanctuary	UtC-1464	4540	± 90	cal BC 3509 (3336) 2921	Tinè 1992
Monte d'Accoddi	Str. III, menhir fall	ETH-4716	4440	± 85	cal BC 3361 (3085, 3061, 3043) 2887	Tinè 1992
Filiestru Cave	Layer B(4)	Q-3029	4430	± 50	cal BC 3333 (3075, 3067, 3040) 2915	Switsur & Trump 1983

Table VI. Radiocarbon dates from Middle and Late Neolithic sites in Sardinia. The relative probabilities of the calibrated dates are illustrated at top.

region in southwest Sardinia, all known Bonu Ighinu sites are caves or rockshelters, as were their Early Neolithic predecessors (Atzeni 1987b); in the Cagliari area, open-air and cave sites are known from both periods (Atzeni 1986). Insufficient data exist to assess the longevity and potential seasonality/functional specialization of the cave sites, but a limited number of obsidian hydration dates from several sites suggest discontinuous occupation (Michels et al. 1984), a pattern also noted in Medieval Sardinia (Day 1976a; 1976b; Lewthwaite 1988). In northern Sardinia, however, Trump (1983; 1984a; 1986) notes a change in the intensity of occupation at Grotta Filiestru, which he interprets as a shift to permanent settlement elsewhere with continued use of the cave by shepherds. Frequent finds of ground stone axes at Sardinian and Corsican sites suggest more intensive clearing of forests for cultivation, while grinding implements may have been used for cereal processing (Lanfranchi 1990). Faunal assemblages from Araguina-Sennola (XVI-XIV), Strette I (XIII), Cala Barbarina (III-II), and Filiestru (5) attest to the continued presence and dietary significance of cattle, pig, sheep, goat, and *Prolagus* (Vigne 1988a; Levine 1983).

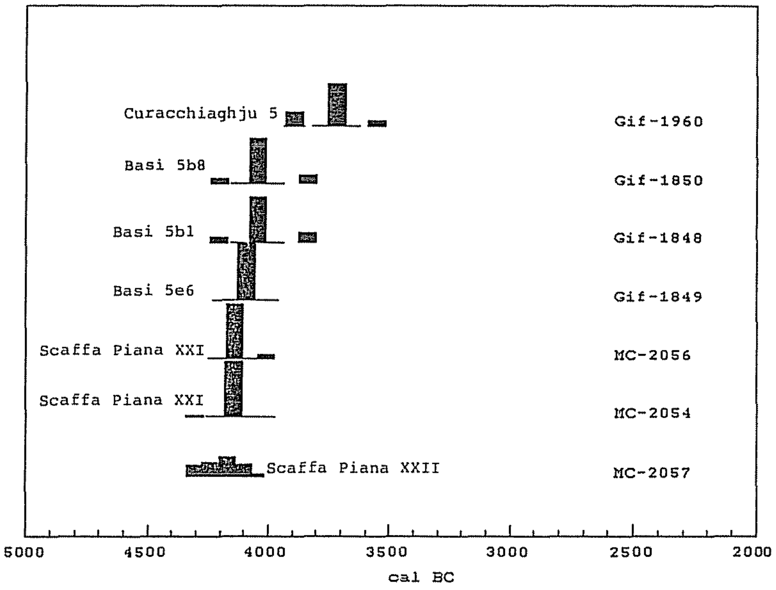
Bonu Ighinu ceramics exhibit a greater degree of craftsmanship in both their production and decoration than Early Neolithic pottery. A wide variety of hemispherical or carinated bowls, jars, flasks, and ladles, with distinctive necks and handles, are frequently decorated with original geometric designs, occasional human and animal figures, and characteristic borders of fine punchmarks. The forms are similar to those of the contemporary Curasien punched-ware tradition in Corsica, and the incised motifs are in some cases reminiscent of Ripoli and

Serra d'Alto wares from southern Italy (Atzeni 1987a). During the Middle Neolithic, considerable quantities of Sardinian obsidian were distributed inter-regionally, judging from finds at numerous Chasséen sites in southern France and Square Mouth Pottery (*vasi a bocca quadrata* = VBQ) sites in northern Italy. At Filiestru, it accounts for at least 30% of the lithic assemblage (Trump 1983). Other materials in circulation in Sardinia were shell, chlorite and aragonite beads, greenstone axes, and polished stone rings or bracelets. Greenstone axes, in particular those of jadeitite and eclogite, have a wide distribution on the mainland, from their western Alpine source to sites in southern France and northern Italy (Ricq-de Bouard 1993; Ricq-de Bouard & Fedele 1993), and to southern Italy and Sicily (Leighton 1992; Leighton & Dixon 1992). The stone rings are also widely distributed in central and northern Italy (Tanda 1977). No provenance study of the Sardinian stone material has yet been undertaken, but sources of nephrite and serpentinite apparently exist in northern Sardinia.

It has recently been argued that cults of secret knowledge, with activities focused on inaccessible caves, arose in Italy during the Middle Neolithic (Whitehouse 1990; 1992). In Sardinia, Sa 'Ucca de Su Tintirriolu has been interpreted as a ritual site, with its finds of pure ash, figurines, fine pottery, and a few human remains in a cave with only a 65 cm high entry (Loria & Trump 1978). 97% of the Bonu Ighinu ceramics are decorated, in contrast to 7% of the contemporary wares at the nearby Grotta Filiestru. Elsewhere in Sardinia, collective burials in caves are known (e.g. Grotta Rifugio: Agosti et al. 1980), while individual and group burials are also found in simple artificial hypogean tombs in cemeteries located near settlements. At Cuccuru s'Arriu, one buried individual lies on a bed of rocks, covered by red ocher, accompanied by a rich assemblage of ceramics, stone and bone tools, and shell, and holds in his right hand a stone figurine of the so-called mother-goddess type (Santoni et al. 1982; Germanà & Santoni 1992). Ten "*dea madre*" figurines have been found in the Cuccuru s'Arriu necropolis, and are well-known at other sites in Sardinia, in Liguria, and elsewhere on the mainland (Atzeni 1978; Gimbutas 1988).

Late Neolithic

The Late Neolithic in Sardinia is also characterized by a relatively homogeneous, island-wide culture, named after the type site of San Michele di Ozieri, with a regional variant in the northeast (Gallura) part of the island. Ozieri settlements, mainly open-air sites, are truly found everywhere on the island, in all ecological zones, but are concentrated in alluvial plains, lagoonal and coastal areas; more than three times as many sites are known than in the preceding Middle Neolithic period (Figure 5). Of the 137 habitation and burial sites shown, only 4 have radiocarbon dates (*supra*, Table VI). The Grotta Filiestru sequence is the most important, since the radiocarbon dates for the entire neolithic are sequential (Switsur & Trump 1983; Switsur 1990). The date for Filiestru layer B7 (Q-3027), which contains Ozieri material, provides a *terminus post quem* of ca. 4000 cal BC, and the post-Ozieri layer B4 (Q-3029) provides a *terminus ante quem* of ca. 2900 cal BC, although the latest date from an Ozieri context (Grotta del Guano: R-1785) is ca. 500 years earlier. The Ozieri culture is now commonly



SITE	CONTEXT	LAB. NO.	^{14}C AGE	ERROR	2σ CALIBRATED AGE RANGE	REFERENCE
CORSICA						
Scaffa Piana	Couche XXII	MC-2057	5360	± 100	cal BC 4435 (4228) 3969	Delibrias et al. 1982
Scaffa Piana	Couche XXI	MC-2054	5330	± 100	cal BC 4355 (4222, 4192, 4156) 3957	Delibrias et al. 1982
Scaffa Piana	Couche XXI	MC-2056	5320	± 100	cal BC 4352 (4220, 4195, 4151, 4111, 4107) 3953	Delibrias et al. 1982
Basi	Level 5e6	Gif-1849	5250	± 120	cal BC 4343 (4038, 4015, 4006) 3786	*RC* 16(1974):33
Basi	Level 5b1	Gif-1848	5200	± 120	cal BC 4328 (3986) 3716	*RC* 16(1974):33
Basi	Level 5b8	Gif-1850	5200	± 120	cal BC 4328 (3986) 3716	*RC* 16(1974):33
Curacchiaghju	Layer 5	Gif-1960	4930	± 140	cal BC 3990 (3702) 3372	*RC* 16(1974):34

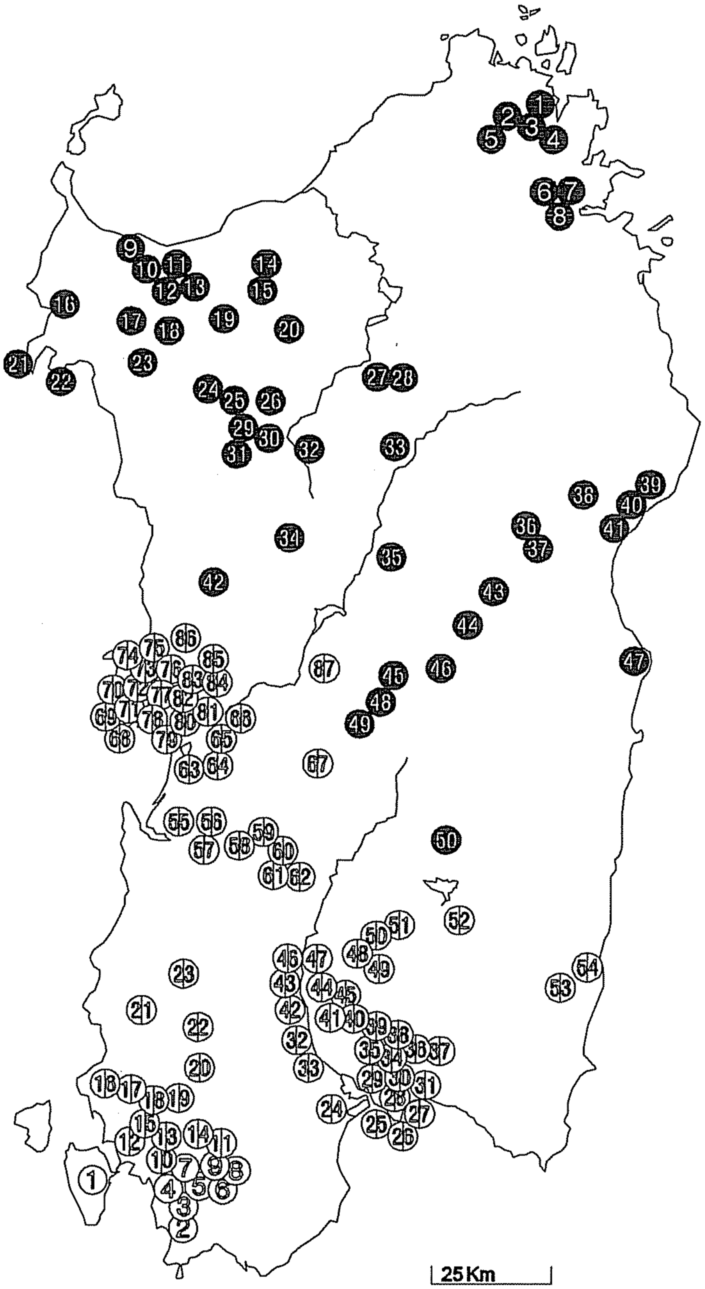
Table VII. Radiocarbon dates from Basien (Late Neolithic) sites in Corsica. The relative probabilities of the calibrated dates are illustrated at top.

Figure 5. Late Neolithic sites in Sardinia.

SARDINIA
Late Neolithic Sites

Sassari and Nuoro Provinces (solid circles)

1. Liscia Pilastru
2. Li Muri
3. Monte Incappiddatu
4. Macciunita
5. Punta Candela
6. San Pantaleo
7. Li Muracci
8. S. Mariedda
9. Su Crucifissu Mannu
10. Marinaru
11. Ponte Secco
12. Monte d'Accoddi
13. Monte d'Accoddi
14. Sas Laccheddos
15. Abealzu
16. Porto Ferro
17. Anghelu Ruju
18. Monte Domingu
19. Grotta dell'Inferno
20. Sa Binza Manna
21. Grotta Verde
22. Grotta Dasterru
23. Santu Pedru
24. Grotta di Sa Corona
25. Grotta di Su Idighinzu
26. Grotta Ulari
27. Grotta del Carmelo
28. Grotta di San Michele
29. Grotta di Sa Ucca
30. Grotta Filiestru
31. Grotta di Su Guanu
32. Grotta di Bonu Ighinu
33. Sas Furrighesos
34. S'Adde
35. Molia
36. Grotta Corbeddu
37. Grotta del Rifugio
38. Dolusorre
39. Grotta di San Giovannu
40. Grotta di Cala Gonone
41. Grotta di Perapala



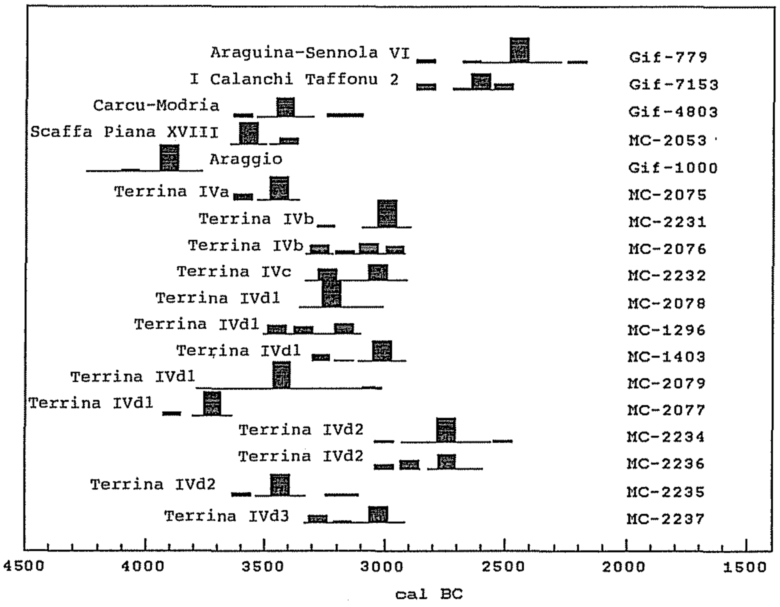
42. Serruggiu
43. Gorthene e di Locoe
44. San Michele
45. Ruinacchesos
46. Pitzu Tonni
47. Grotta di Su Marinaru
48. Polu
49. Asuni
50. Pizziogu

Cagliari and Oristano Provinces (open circles)

1. Grutt'Acqua
2. Porto Pino
3. Sant'Anna
4. Is Solinas
5. L'Acquedotto
6. Grotta di Monte Miana
7. Narboni Is Gannaus
8. Grotta di Su Benatzu
9. Pani-Loriga
10. Tracasi
11. S'Arriorgiu
12. Locci Santus
13. Monte Crobu
14. Montessu
15. Grotta A.C.A.I.
16. Nuraxi Figu
17. Barbusi
18. Poliambulatorio
19. Grotta dei Fiori
20. Grotta di Corongiu Acca
21. San Benedetto
22. Grotta di Monte Acqua
23. Terra 'e Zeddari
24. Santa Gilla
25. Grotta di San Bartolomeo
26. Grotta dei Colombi
27. Marina Piccola
28. Sa Duchessa, Via Basilicata, Monte Claro
29. Via Is Maglias
30. Cuccuru Serra
31. Su Coddu
32. Su Cungiau de Marcu
33. C.R.A.S.
34. Cuccuru Biancu
35. San Gemiliano I
36. Soleminis
37. San Pietro
38. San Gemiliano II
39. Monte Olladiri
40. Monte Zara
41. Crabai
43. Cuccuru Gibindia
44. Cuccuru Ambudu
45. Cresia Is Cuccurus
46. Sa Mandara
47. Cuccuru Pontis
48. S'Acqua Salida
49. Corongiu
50. S'Acqua Salida
51. Turriga
52. Pranu Mutteddu
53. Nuraji
54. Torre Murtas
55. San Giovanni
56. Santa Chiara
57. Santa Vittoria
58. Serra sa Furca
59. Perdixedda
60. Tombe di Mannias
61. Puisteris
62. Perdu Piras
63. Santa Giusta
64. San Quirico
65. Fenosu
66. Su Cungiau de Is Fundamentas
67. S. Antonio
68. San Salvatore
69. Conca Illonis
70. Grotta di Is Aruttas
71. Conca Illonis II
72. Costa Atzori
73. Ludosu
74. Sale Porcus
75. Serra Is Araus
76. Isca Maiori
77. Pauli Fenu
78. Cuccuru Arrius
79. S'Arrieddu
80. Bau 'e Porcus
81. Santa Vittoria
82. Su Pranu
83. Gribaia
84. Pauli Fenu
85. Perda Lada
86. Su Anzu
87. Campumaiore

described as "classic" or "late" (= sub-Ozieri), both to reflect its long duration and its continuity with the succeeding Chalcolithic cultures (Santoni 1992). In Corsica, the Basien culture may precede Ozieri by a century or two, judging by the handful of radiocarbon dates from Basi, Scaffa Piana, and Curacchiaghju (Table VII), while the Terrinien culture apparently belongs mostly to the 2nd half of the 4th millennium cal BC (Table VIII). Once again, it is anticipated that full publication of the Presa-Tusiu material will clarify that island's sequence and allow direct comparison with nearby Sardinia, independent from any typological considerations.

In Corsica, faunal assemblages from Araguina-Sennola (XIII-XI), Scaffa Piana (XXIII-XVIII), and Terrina IV document the importance of cattle, pig, sheep and goat, with cattle and then pig the most significant dietarily, and *Prolagus* least significant, based on their estimated meat and offal weight (Vigne 1984; 1987b; 1988a; 1992c; Jehasse 1980). At Filiestru (D4) in Sardinia, in contrast, sheep/goat continue to dominate the faunal assemblage, while the frequency of pig remains continued to decline relative to earlier Neolithic phases (Levine 1983). Since Filiestru appears to be a functionally specialized site, it would be unwise to conclude that differences existed between Sardinia and Corsica in terms of animal husbandry practices. Archaeobotanical remains are scanty, and it is mainly the density and location of settlements - many of them villages with several dozen wattle and daub huts, elliptical or elongated in shape with floors excavated to below ground level and averaging 7 m in diameter - which argues for a fully agricultural economy by this time. This interpretation is reinforced by the



SITE	CONTEXT	LAB. NO.	^{14}C AGE	ERROR	2σ CALIBRATED AGE RANGE	REFERENCE
			CORSICA			
Araggio	Hearth, room S	Gif-1000	5130	± 130	cal BC 4244 (3958) 3649	*RC* 13(1971):221
Terrina IV	Level d1	MC-2077	4950	± 90	cal BC 3958 (3709) 3535	Camps 1979
Scaffa Piana	Layer XVIII	MC-2053	4775	± 90	cal BC 3751 (3624, 3573, 3538) 3354	Delibrias et al. 1982
Terrina IV	Level d1	MC-2079	4720	± 300	cal BC 4220 (3508, 3400, 3387) 2621	Camps 1979
Terrina IV	Level a	MC-2075	4690	± 90	cal BC 3650 (3501, 3424, 3381) 3110	Camps 1979
Terrina IV	Level d2	MC-2235	4650	± 100	cal BC 3645 (3491, 3483, 3372) 3046	Camps 1979
Carco-Modria	Level 4	Gif-4803	4640	± 130	cal BC 3692 (3370) 2925	Delibrias et al. 1982
Terrina IV	Level d1 (shell)	MC-1296	4610	± 110	cal BC 3116 (2871) 256	Delibrias et al. 1982
Terrina IV	Level d1 (shell)	MC-2078	4530	± 90	cal BC 2938 (2831) 2499	Camps 1979
Terrina IV	Level b	MC-2076	4450	± 120	cal BC 3501 (3091, 3055, 3047) 2784	Camps 1979
Terrina IV	Level d3	MC-2237	4430	± 140	cal BC 3506 (3075, 3067, 3040) 2669	Camps 1979
Terrina IV	Level c	MC-2232	4430	± 160	cal BC 3616 (3075, 3067, 3040) 2618	Camps 1979
Terrina IV	Level d1	MC-1403	4420	± 100	cal BC 3364 (3036) 2788	Camps 1979
Terrina IV	Level b	MC-2231	4380	± 80	cal BC 3336 (3015, 2998, 2926) 2788	Camps 1979
Terrina IV	Level d2	MC-2236	4270	± 100	cal BC 3254 (2888) 2581	Camps 1979
Terrina IV	Level d2	MC-2234	4210	± 160	cal BC 3332 (2875, 2794, 2784) 2347	Camps 1979
I Calanchi	Taffonu 2	Gif-7153	4080	± 60	cal BC 2874 (2586) 2463	Cesari 1987
Araguina-Sennola	Hearth F3, Level VI	Gif-779	3980	± 140	cal BC 2886 (2468) 2041	*RC* 13(1971)220

Table VIII. Radiocarbon dates from Terrinien (Late Neolithic/Chalcolithic) sites in Corsica. The relative probabilities of the calibrated dates are illustrated at top.

numerous grindstones, mortars and pestles, storage vessels and pits, and even stone tools with sickle gloss that are known. In Corsica, less dynamic growth has been attributed to topographical/ecological limitations on the adoption of cereal-ovicaprine based subsistence (Lewthwaite 1983; 1984a; 1984b; 1985b).

Ozieri ceramics come in a rich variety of forms and decorations, including new types of bowls and cups with carinated rims, globular vases with tunnel handles, tripods and amphoras, with geometric and stylized figurative motifs impressed or incised in the clay and colored red or white. The find of Ozieri ceramics under the Piazza della Signoria in Florence (Booth 1989) demonstrates, for the first time, the extrainsular movement of something other than obsidian, although flint, salt, and metal ores have been proposed as additional candidates. The schematic figurines attributed to the Ozieri culture (Antona Ruju 1980) are apparently earlier than the well-known Cycladic types (produced mainly in the EC II period, ca. 3100-2400 BC; cf. Getz-Preziosi 1985), and therefore not imported; even the open-work type, perhaps of post-Ozieri, chalcolithic date, can then be understood as having developed from a long sequence of local prototypes. The Late Neolithic is also rich in the variety of its material culture, from flaked stone tools (new forms include foliate points and pedunculate triangles) in obsidian, flint and other stones, to greenstone axes, to bone tools, to decorated spindle whorls, to baskets (at Scaffa Piana: Magdeleine & Ottaviani 1983). The manufacture of textiles, apparently with an upright loom, is evident from the spindle whorls, loom weights and bone shuttles found. Copper and silver metal first appear in Late Ozieri (Lo Schiavo 1989) and Terrinien (Camps 1988:123-134) contexts.

The increase in the exchange of material goods during the later Neolithic in peninsular Italy has been linked to changes in burial practices (Robb 1994a). Presumably, prestige competition in the circulation of obsidian and other materials was manifested as well in agricultural intensification and the observed shift to formal cemeteries with simple tombs and grave goods. Gender inequalities may have resulted from changes in labor specialization and a male focus on secondary products (Robb 1994b; Sherratt 1981; 1982; 1983). The Sardinian sample of contextual burial remains, with only one tomb found intact (San Benedetto: Maxia & Atzeni 1964; cf. also Germanà 1990; 1992), is insufficient to statistically corroborate the mainland trend towards more burial goods (Robb 1994c), but elaboration of burial architecture with a presumed emphasis on kin relations is certainly evident in the hypogean rock-cut tombs known as *domus de janas* (house of the witches) which are found all over Sardinia, cut in rock outcrops, vertical rock faces, or on flat or sloping ground with long *dromos*-type entry passages. These tombs, found isolated or in clusters of up to 40, often are presumably modelled after Ozieri houses, with architectural details carved in the rock including the roof beams, support columns, doorways, windows, benches, niches and even hearths. Symbolic-religious motifs are also cut in bas-relief, especially the horns or silhouettes of bulls and rams (e.g. Su Littu: Ferrarese Ceruti 1992), commonly interpreted as having connotations of fertility (Tanda 1984a; 1985; 1989). Inhumations are primary and secondary, and accompanied by ceramics, arrowheads, small votive axes, and *dea madre* figurines.

Late Neolithic burial structures also exhibit some variety, for example the megalithic circle graves at Li Muri in Arzachena (Puglisi 1941-42), the corridor dolmen (*allée couverte*) at Motorra in Dorgali (Lilliu 1968), and the tumulus complex at Pranu Mutteddu in Goni (Atzeni 1989) associated with large concentrations of menhirs (Atzeni 1982; 1988). The megalithic phenomenon is also well-known in Corsica, with particularly close ties with northern Sardinia (Cesari 1992; Lanfranchi 1992; Lanfranchi & Weiss 1994). Whether the multiplicity of burial forms on the two islands represents different ethnic or social groups (hypogea for agriculturalists and megalithic tombs for pastoralists has been suggested), or just experimentation in mortuary elaboration is difficult to determine without contextual interments. The appearance and development of the Sardinian and Corsican tombs are paralleled by similar megalithic constructions in much of the central and western Mediterranean (Whitehouse 1981; Joussaume 1985; Guilaine 1992).

A most singular ritual monument is the 55 m long "altar" of Monte d'Accoddi, located between Sassari and Porto Torres in northwest Sardinia. Constructed on top of an early Ozieri village, a ramp leads up to a platform reconstructed into a ziggurat-like shape with a red-painted shrine at its center (Tinè et al. 1989; Tinè & Traverso 1992). There is not yet agreement on the ceramic sequence and the multiple construction phases of the monument, nor on its interpretation. Four statistically identical radiocarbon dates (*supra*, Table VI) suggest its initial construction at the end of the classic Ozieri period (Tykot 1994a:138, n. 2).

Chalcolithic

The Chalcolithic period in Sardinia is a still poorly understood millennium-long transition between the widespread and well-known Late Neolithic Ozieri culture and the Bronze Age Bonnanaro and Nuragic cultures (Atzeni et al. 1988). Currently recognized in five aspects - sub-Ozieri, Filigosa, Abealzu, Monte Claro, and Beaker - stratigraphic sequences come only from Monte d'Accoddi and La Tomba dei Vasi Tetrapodi in Santu Pedru (Contu 1966). Some consider Filigosa and Abealzu to be contemporary, Monte Claro has at least three regional variations (e.g. Noeddos I? cf. Trump 1990), and there are no solely Beaker settlement sites (Ferrarese Ceruti 1981a; Atzeni et al. 1988; Lewthwaite 1985a). The Beaker phenomenon in Europe is generally dated between ca. 2700 and 1900 cal BC (Harrison 1980; Ambers et al. 1992), with early and late phases known in the Balearic Islands (Waldren 1991). In Sardinia, Beaker material is found above or mixed with Monte Claro assemblages, and sometimes with Bonnanaro ceramics (Ferrarese Ceruti 1981b; 1988), perhaps divisible into an earlier decorated (Beaker A) and a later undecorated (Beaker B) phase as at Padru Jossu in Sanluri (Ugas 1982). A single date from an Abealzu context at Monte d'Accoddi (UtC-1464) calibrates to the late 4th/early 3rd millennium cal BC (*supra*, Table VI), while one from a Monte Claro burial context at Grotta dell'Acqua Calda in Nuxis (R-677, 3690 ± 60 BP) calibrates to the end of the 3rd millennium cal BC. Taffonu 6 at I Calanchi (Sollacaro) in Corsica has produced a single radiocarbon date from a context with Beaker ceramics (LGQ-279, 3910 ± 150 BP) which also calibrates to the later 3rd millennium cal BC.

As early as the Filigosa-Abealzu phase of this period, sites enclosed by megalithic walls are known, perhaps denoting a response to increased economic interests in prospecting and metallurgy and developing social tensions between groups. Other than the Beaker material, there is little direct evidence of extrainsular contacts, as little obsidian is found in mainland Chalcolithic contexts (but cf. Pollmann 1993) although it remains the most common lithic material in Sardinia until at least the Iron Age. It is likely that, at least in peninsular Italy and southern France, obsidian had somewhat more than a simple functional utility, and that this role was replaced by objects in metal.

CHAPTER THREE: WHAT IS OBSIDIAN?

Obsidian, named after the Roman Opsius who "discovered" it in Ethiopia (Pliny the Elder, *Naturalis Historiae* 36:196-197; de Romanis 1995), is a relatively rare type of volcanic rock, of little importance in the modern world, even to geologists. Obsidian is infrequently listed in the indexes of geology reference volumes, even those specifically on igneous rocks and their classification; there is virtually no mention of any of the four Italian sources in *Geology of Italy* (Squyres 1975).

Obsidian was, however, a material highly valued by prehistoric peoples for making stone tools. When flaked, it produces extremely sharp yet hard (5-5.5 on the Mohs scale) cutting edges, and is generally superior to chert, flint, jasper and other lithic materials for cutting softer materials including animal flesh and non-woody plants. Significant quantities of obsidian are often found at archaeological sites hundreds of kilometers away from its geological source, even when alternate materials were available at lesser distances, suggesting that its value was more than simply functional. Obsidian has a particularly special role in archaeological reconstruction of the past for several reasons: (1) obsidian can be easily identified as a non-local material; (2) it is relatively easy to determine the specific source of archaeological specimens through chemical analysis; (3) obsidian hydration dating can be used to directly date obsidian reduction and reuse events; (4) the broad spatial distribution of obsidian provides a means for investigating the interaction of different social or cultural groups, and to speculate on the parallel movement of materials which are not as well preserved in the archaeological record; and (5) the use of obsidian by prehistoric peoples throughout the Neolithic, and even into the Bronze Age and later, gives us the opportunity to examine chronological developments in and the dynamic nature of obsidian usage, and the economic and social conditions under which this usage occurred.

Definition and Description

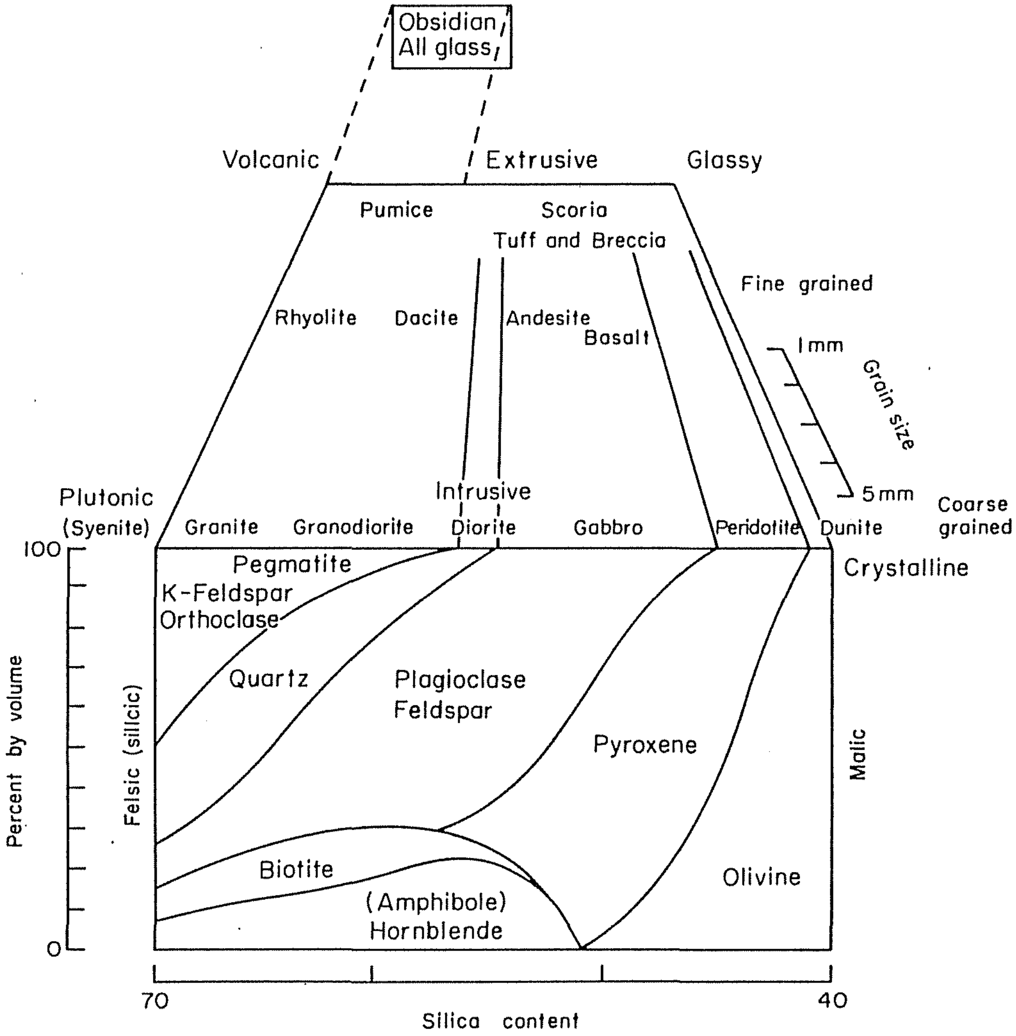
The terms **obsidian** and **glass** usually refer to the texture, rather than to a specific chemical or mineral composition, of the rock; thus, glassy rhyolites may also be called obsidian, but not all obsidians are necessarily of rhyolitic composition. There are also trachytic, andesitic, and phonolitic obsidians. A rock usually is identified as obsidian if it contains 80% or more glass (Streckeisen 1980:200; 1979); most archaeological obsidians, however, contain at least 95% glass (Cann 1983:229). Glass is defined as a non-crystalline phase composed mainly of silicon, but which can include other elements. Glass is actually a super-cooled liquid, with no directional properties; its characteristic conchoidal fracture is what makes ordinary broken glass so sharp, and obsidian a superior material for stone tools. Obsidian is an aphanitic rock, with individual grains (usually 1 to 100 μm in diameter) too fine to see with the unaided eye; this category also includes pumice (vesicular obsidian), scoria, tuff, and the finer-grained rhyolites, dacites, and andesites (Figure 6). Phaneritic rocks of similar chemical composition to obsidian include the coarser-grained granites and gabbros.

It should be noted that the chemical classification of rocks is an imperfect endeavor; the commonly used criteria of silica content and alkalinity (K and Na) may result in rather arbitrary divisions and not accurately reflect the gradation and continuity of different rock types (cf. Middlemost 1985:79-83). The silica-based scheme shown here illustrates the mineral composition of the major volcanic rocks, along with the relationship between coarse-grained, intrusive, plutonic rocks, and their fine-grained or glassy, extrusive, volcanic equivalents.

Rhyolite is the fine-grained chemical equivalent of granite. Alkaline rhyolites in their glassy state include obsidian (wholly glass), pitchstone (mostly glass, usually with a dull resinous lustre), and vitrophyre (glassy and porphyritic), as do calc-alkaline (high levels of Ca, K, Na) rhyolites; the latter also include the rarer hyalopsite and hraftinna (Wahlstrom 1947:282). Obsidian and pitchstone are usually differentiated not by their crystallinity, but their water content (obsidian usually has less than 1% water; pitchstone 4-10%) (Mackenzie et al. 1982:112; Middlemost 1985:143).

Rocks of syenitic (more alkaline than granite) composition may also be fine-grained (trachytes), and even occasionally include obsidians; rocks of the gabbro-basalt family rarely form obsidian, however (see explanation *infra*). In the past, various local names (e.g. pantellerite, liparite, toscanite, macedonite) were given to glassy rocks, despite only minor geological differences. Cann (1983:229) gives a complete list of those rock names synonymous with or related to obsidian, including those which are no longer in common use.

Figure 6. Classification of the igneous rocks according to mineralogy, silica content, and texture. After Carmichael (1989:8, fig. 6). Obsidian is volcanic, extrusive, and glassy, extremely fine-grained, and typically of the same composition as granites and rhyolites.



Geological Formation

Glassy rocks are always extrusive, found at or near the earth's surface as the outer layer of volcanic domes, as crusts on lava flows, or as pyroclastic deposits; in submarine environments; and in near-surface dikes. Pyroclastic material may be ejected and form fall deposits (ejecta, tephra); or flow out from a volcanic vent and move across the landscape (ash-flow tuffs, ignimbrites). Obsidian flows have several characteristic features: (1) small flows tend to produce restricted deposits in topographic lows, while larger flows are thickest over paleovalleys; (2) although volcanic flows usually have nearly-level upper surfaces, the high viscosity of obsidian-bearing flows often results in a dome-shaped flow, up to 200 m in height, several hundred meters in width, and one kilometer in length; (3) rock inclusions are unsorted, ranging from fine ash to large blocks; and (4) debris from the original ground surface will be incorporated in the deposit (Cann 1983:230; Best 1982:83). Rhyolitic flow deposits in general may also have a compositional and mineralogical gradient from base to surface, particularly in silica content (Middlemost 1985:147; Best 1982:86). Welding or compaction of individual glass particles can further alter flow deposits after emplacement, and loosely consolidated deposits are subject to redeposition up to several kilometers away by wind and water transport. The latter is of particular concern to archaeologists trying to pinpoint the exact location of obsidian procurement.

Inevitably, some crystals (occasionally, large phenocrysts, spherulites or snowflakes) will form, even during rapid cooling; this is due to the much greater physical stability of crystals than glass. The formation of fine microlite crystals, often of magnetite and hematite, during cooling may be patterned, such that their orientation and distribution can show the lava flow structure. These fine crystals give obsidian its color, with the opacity of the glass depending on the density of the microlites.

Larger phenocrysts in rhyolitic obsidian typically contain quartz, Fe-Ti oxides, and feldspars (Middlemost 1985:144). Devitrification of the obsidian surface begins after formation and is the basis for obsidian hydration dating. Perlite or perlitic glass, usually a lustrous, pearly gray color, is the long-term product of slow absorption of atmospheric or ground water (up to 10% by weight) and is characterized by nests of concentrically curved, inward growing fractures, in which small nodules of uncracked obsidian may still be found (Best 1982:65; Friedman et al. 1966). Because of this continuous devitrification process, most extant obsidians are younger than the Miocene (<25 million years).

Obsidians can occur in rock compositions from basalt through rhyolite to trachyte, while the elemental silicon content of obsidian can range from 35% to more than 80%. Rhyolitic obsidians (about 70-75% Si) are much more common, however, than basaltic or andesitic obsidian (about 50% Si), even though basalt is much more common in nature. This is probably due to the greater viscosity, and therefore stability, of the major rhyolitic minerals (orthoclase, albite and quartz) during cooling (Frye 1981:187). The release of gas on extrusion, and the inhibited flow of ions in the viscous siliceous magma, slow the growth of nuclei, and allow the super-cooled liquid to congeal without crystallizing. Experimental evidence has shown that rapid cooling is a major factor in preventing crystal growth (Hyndman 1985:50). Fluid, basaltic glass (sideromelane) is only formed under exceptional circumstances, such as underwater eruption, and even then rarely forms blocks large enough for prehistoric tool manufacture (Cann 1983:228). The comparative chemistry of peralkaline and subalkalic obsidians are discussed in detail, respectively, by MacDonald & Bailey (1973) and MacDonald et al. (1992).

Where is Obsidian Found?

Most (geologically) modern volcanic activity (and hence obsidian production) occurs along the tectonic plate boundaries of the earth's crust. The convergence of these plates may result in magmatic constructions on the underlying continental or oceanic crust. In the latter case, volcanic islands are typically formed (island arc volcanism), and it is not surprising therefore that many obsidian sources are located on islands. For various reasons, there are broad similarities in genesis and major-element chemical composition of volcanic series from island arcs: rhyolite (and obsidian) from island arc volcanism tends to be calc-alkaline, whereas continentally-derived rhyolites (e.g. Pantellerite) are mostly peralkaline ($Na_2O + K_2O > Al_2O_3$) (Hess 1989:150, 265). Such similarities often preclude the positive differentiation of archaeological specimens beyond these two rock suites using only macroscopic means of examination. Alkaline and calc-alkaline obsidians usually are translucent in colors ranging from black to grey, occasionally with some red; peralkaline obsidians are typically green or brown in transmitted light.

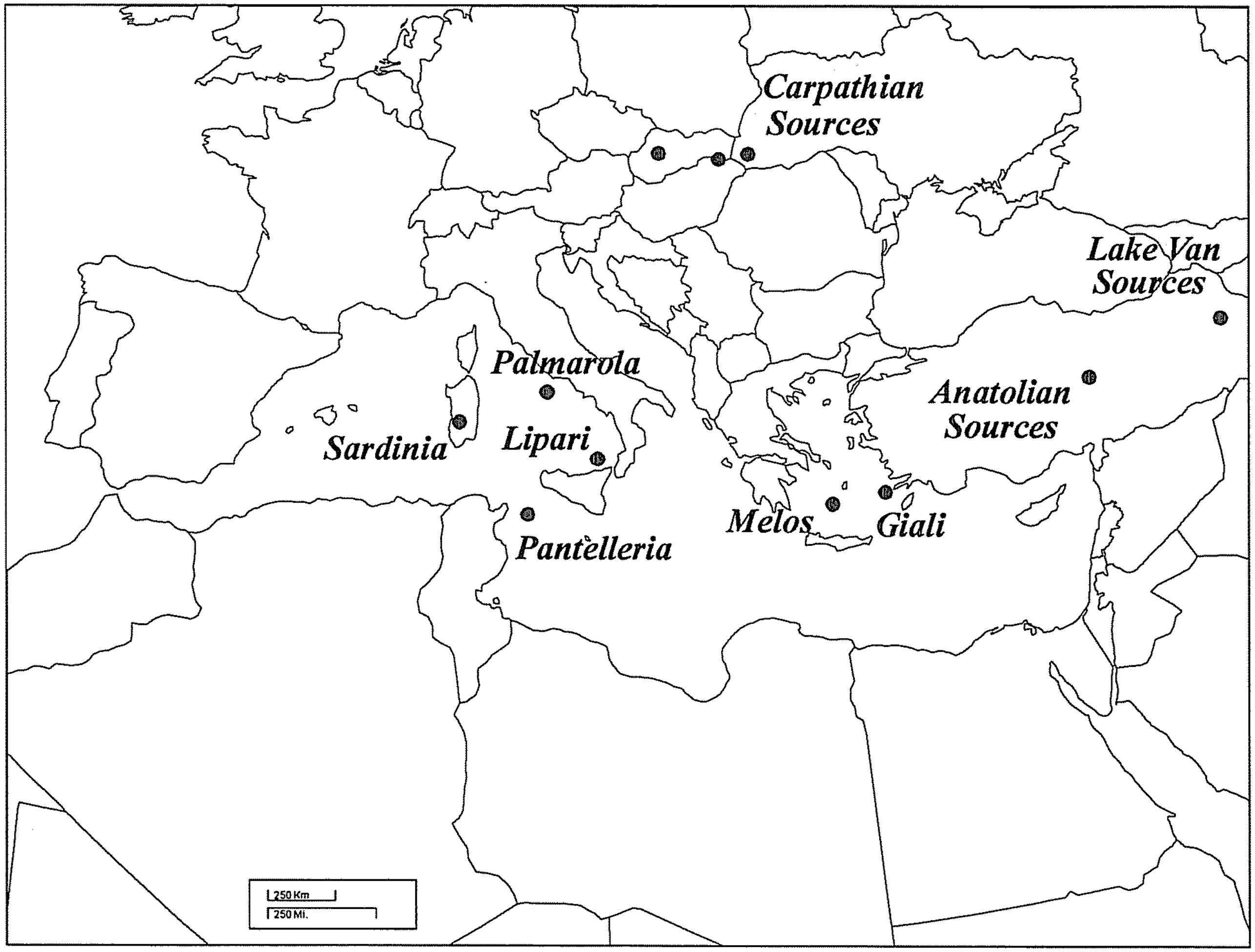
In addition to the western Mediterranean islands, obsidian sources are known virtually all over the world. Examples of regions with obsidian which have been the focus of archaeological research are the Aegean (Shelford et al. 1982; Torrence 1986); the Near East (Gratuze, Barrandon et al. 1993; Keller & Seifried 1990; Erçan et al. 1989; Blackman 1984; Renfrew & Dixon 1976; Wright 1969); the Red Sea region (Zarins 1989; 1990); central Europe (Williams-Thorpe, Warren & Nandris 1984; Biró et al. 1986); East Africa (Merrick & Brown 1984a; 1984b); New Zealand (Seelenfreund & Bollong 1989; Moore 1983; Reeves & Ward 1976); Japan (Suzuki 1973; 1974); Melanesia (Specht et al. 1988; Bird et al. 1988); the Pacific (Fullagar et al. 1991; Weisler 1990; Best 1987; Smith et al. 1977); Peru (Burger & Asaro 1978); Mexico (Cobean et al. 1991; Ericson & Kimberlin 1977); Guatemala (Braswell & Glascock 1992; Moholy-Nagy & Nelson 1991; Sheets et al. 1990); the southwest United States (Shackley 1990; 1988; Stevenson & Klimkiewicz 1990; Stevenson & McCurry 1990); California (Jackson 1986; Hughes 1986; Jack 1976; Ericson et al. 1976); and British Columbia-Canada (Fladmark 1984).

CHAPTER FOUR: OBSIDIAN SOURCES IN THE WESTERN MEDITERRANEAN

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 (Figure 7). Obsidian nodules from several localities near Auvergne in France are too small for flaking (<1 cm diameter) and/or do not exhibit conchoidal fracture; no archaeological finds resemble the small distinctive red obsidian pieces from the La Lusclade quarry (Williams-Thorpe, Warren & Courtin 1984). Minor outcrops also occur in several localities near Naples, at the Phlegrean Fields and on the islands of Ischia, Procida and Ponza: all are small and none are of workable quality (Buchner 1949). Obsidian from Antiparos, to the northeast of Melos in the Aegean, is also too small for flaking, and only a few small unworked lumps have been found in archaeological contexts at the nearby Neolithic site of Saliagos (Renfrew et al. 1965). Obsidian from Giali is quite crystalline (ca. 5% feldspar crystals) and was apparently used only for Minoan bowls in the Bronze Age (Renfrew et al. 1965). The "Carpathian" sources in central-western Slovakia are highly fractured and crystalline and were not exploited, while those in southwestern Ukraine have not been thoroughly investigated (Williams & Nandris 1977).

Glassy peralkaline comendites from the type site of La Comende on the island of San Pietro, and also from the island of Sant'Antioco, both off the southwest coast of Sardinia, contain about 10% phenocrysts and are unsuitable for tool manufacture (MacDonald & Bailey 1973; Araña et al. 1974), although a

Figure 7. Obsidian sources in the Mediterranean region. Sources which have not produced any worked obsidian are not shown (Auvergne, France; Phlegrean Fields, Procida, Ischia, Ponza, and Vulcano, Italy; Monte Traessu, Sardinia; Antiparos, Greece).



single specimen was found on the surface at Nuraghe Losa (Abbasanta) by Francaviglia (1984). The obsidian from Monte Traessu in northern Sardinia reported by Coulon (1971; Coulon et al. 1974) is apparently restricted to tiny beads in a pumice matrix (personal observation), and likewise is of no archaeological significance. Blue, green and other colored samples from Monte Arci (Puxeddu 1958), provided by Prof. Puxeddu, are in fact jasper and other fine-grained rocks (see my analyses of samples 284-291 in Appendix F), although Francaviglia (1984:314; cited also by Williams-Thorpe 1995:221) reports that Puxeddu provided him with an authentic sample of blue obsidian.

Finally, natural glass found in the part of southwest Egypt known as the Great Sand Sea should not be confused with obsidian, since it is 98% pure SiO_2 (Olsen & Underwood 1979). This unusual material, called Libyan Desert glass, varies from clear to green to black, and resembles tektites except that they do not appear meteoritic in origin (Giegengack & Assawi 1975). This glass was used for stone tools as early as the Lower Paleolithic (Oakley 1952; Roe et al. 1982), and most Neolithic sites in the immediate region have large quantities of glass flakes, blades and debitage (Olsen 1982). There is no evidence of its use farther afield.

In the western Mediterranean - defined here as including the territories of the former Yugoslavia, Italy, France, Spain, Morocco, Algeria, Tunisia and Libya west of Cyrenaica - virtually all archaeological obsidian artifacts come from four Italian island sources: Lipari, Palmarola, Pantelleria, and Sardinia. The Carpathian sources in southeast Slovakia and northeast Hungary (Williams-Thorpe, Warren & Nandris 1984; 1987; Biró et al. 1986; Bigazzi et al. 1990) are responsible for a few artifacts found in northern Italy, presumably others in Dalmatia (Martinelli 1990), and some as far east as Greek Macedonia (Kilikoglou et al. 1995). 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 & Aspinall 1990). The converse also appears true: as yet, not a single piece of western Mediterranean obsidian has been documented 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).

I will focus here on the western Mediterranean sources. A description of their origin and geochemical characteristics is given below, and blends information derived from the literature with results of my own research, mainly on the Sardinian sources. These descriptions are followed by a discussion of their chemical characterization for provenance purposes. The scope of some 70 papers on western Mediterranean obsidian analysis is summarized in Table IX. Previously published elemental data are reproduced in Appendix A, and K-Ar and fission-track dates in Appendix B.

Lipari

Lipari is the largest of the Aeolian Islands at ca. 38 Km^2 and is located ca. 30 Km north of the northeastern part of Sicily (Figure 8). All of the islands are volcanic in origin, and three have had eruptions in the historic era. Lipari was first formed ca. 150,000 BP, during the second of three major phases of Aeolian

Figure 8. Lipari and the Aeolian Islands (after Waltham 1987, with additions).

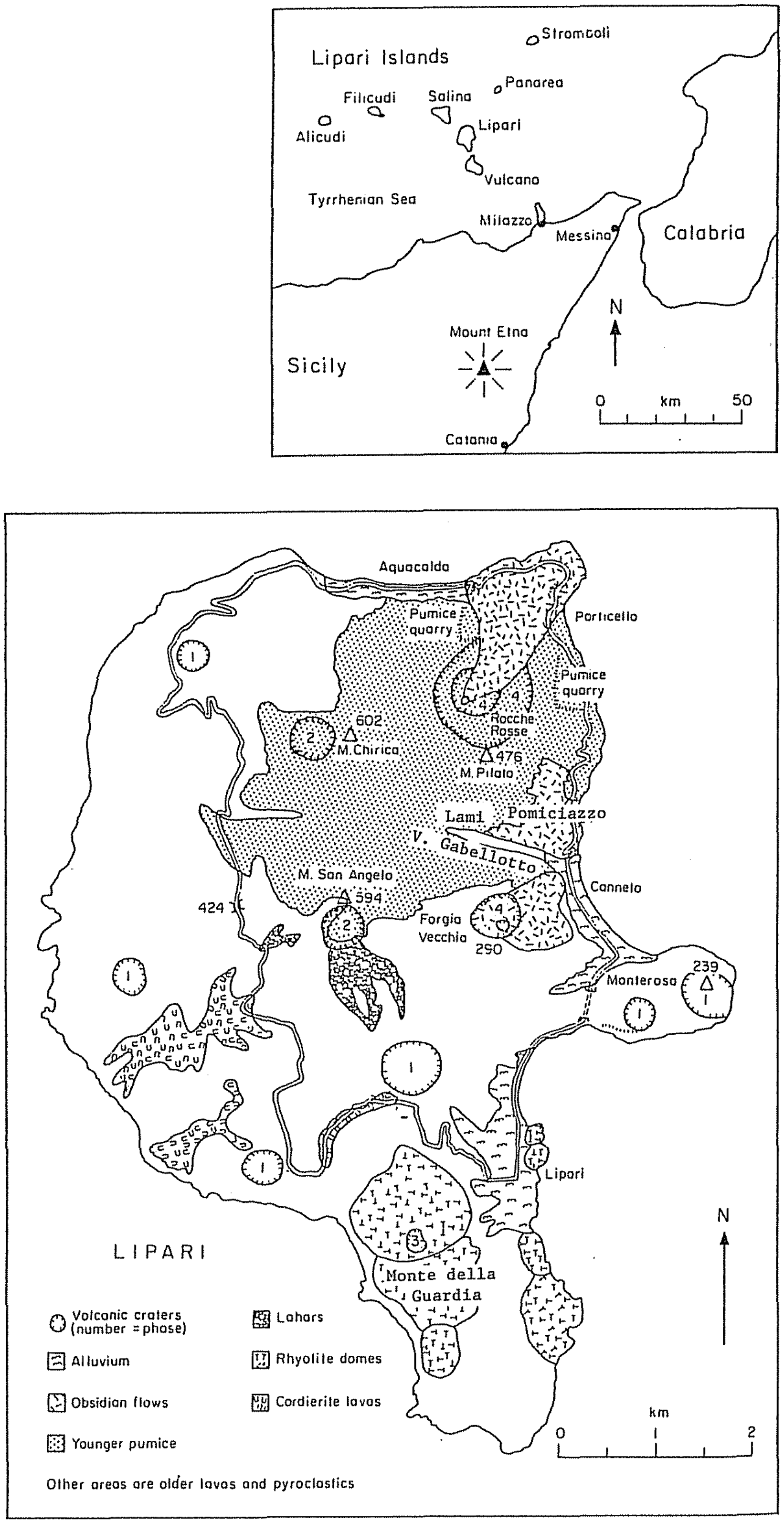


Table IX. Analytical studies of western Mediterranean obsidian. Numbers in parentheses refer to analyses reported in prior published or thesis work. Only studies explicitly using visual means of identification are listed under that method.

AAS	atomic absorption spectroscopy
BSE	backscattered electron petrography
CA	classical chemical analysis
ESR	electron spin resonance
FT	fission-track dating
ICP-AES	inductively coupled plasma - atomic emission spectroscopy
K-Ar	potassium-argon dating
LOI	loss on ignition (water content)
NAA	neutron activation analysis
OES	optical emission spectroscopy
OH	obsidian hydration dating
RI	refractive index
SEM-EDS	scanning electron microscopy - energy dispersive spectrometry
TL	thermoluminescence
XRF	X-ray fluorescence

Reference	Method	Geological Samples	Archaeological Artifacts
Abich 1841	CA	1	
Bergeat 1899	CA	1	
Washington 1913a	CA	1	
Washington 1913c	CA	1	
Washington 1920	CA	2 (+2)	
"	Density	2	
"	RI	3	
Chayes & Zies 1962	CA	1	
Cornaggia Castiglioni	CA	41 ?	
et al. 1963	Density	37 ?	16 ?
"	U content	2 ?	9 ?
"	Mn content	18 ?	14 ?
Cann & Renfrew 1964	OES	13	23
"	Visual		298
Chayes & Zies 1964	CA	1	
Von Platen 1965	CA	1	
Barberi et al. 1967	CA, K-Ar, Sr	1	
Noble & Haffty 1969	OES	2	
Belluomini et al. 1970	K-Ar	18	
Belluomini & Taddeucci 1970	U, Th isotopes	12	
Belluomini & Taddeucci 1971	OES, XRF	88	
Bigazzi et al. 1971	FT	8	
"	RI, density	46	
Arias-Radi et al. 1972	FT	1 (+3)	24
Baldanza et al. 1973	OES	4	
Bigazzi & Bonadonna 1973	FT	2	

Table IX (continued)

Reference	Method	Geological Samples		Archaeological Artifacts	
MacDonald & Bailey 1973	CA		(+2)		
"	OES		(+2)		
Beccaluva et al. 1974a	CA	1			
Beccaluva et al. 1974b	CA		(+2)		
Klerkx et al. 1974	XRF, Sr isotopes	1			
Williams 1975	NAA			51	
di Paola et al. 1975	K-Ar	2			
Bigazzi et al. 1976	FT	9			
Hallam 1976	NAA	29		119	
Hallam et al. 1976	NAA		(+29)		(+119)
"	OES			11	
Wagner et al. 1976	FT	1			
Rasson et al. 1977	OES, XRF	?		?	
Alciati 1978	OH			44	
Longworth & Warren 1979	Mössbauer	27		15	
Mosheim 1979	XRF	41			
Williams 1978	NAA			3	
Williams-Thorpe et al. 1979	NAA				(+54)
Pichler 1980	?	1			
Bigazzi & Radi 1981	FT	2		33	
Gale 1981	Sr isotopes	30		3	
Bigazzi et al. 1982	FT	3		42	
Cioni et al. 1982	XRF	5			
"	NAA, Sr isotopes	2			
Dostal et al. 1982	CA, XRF, NAA	1			
Friz 1982	RI, density	?			
Aramu et al. 1983	Mössbauer	?			
Gill & Warren 1983	XRF	?		?	
Mackey & Warren 1983	XRF, NAA	?		51	
McDougall et al. 1983	Magnetic	24		29	
Mello 1983	ESR			20	
Arias et al. 1984	FT	2	(+7)	16	(+72)
Biró & Pozsgai 1984	SEM-EDS	16			
Francaviglia 1984	XRF	309		5	
Michels et al. 1984	AAS, OH			104	
Williams-Thorpe et al. 1984	NAA			10	
Crummett & Warren 1985	NAA	2		46	
Michels 1985	OH experiment	9			
Arias et al. 1986	FT	3	(+9)	10	(+21)
Bigazzi et al. 1986	NAA	29		15	
Biró et al. 1986	SEM-EDS		(+16)		
"	SEM-XRF	7			
"	CA	2			
Gillot & Cornette 1986	K-Ar	7			

Table IX (continued)

Reference	Method	Geological Samples		Archaeological Artifacts	
Herold 1986	XRF	212			
"	NAA	30			
"	AAS	16			
"	LOI	21			
"	Density	73			
"	RI	39			
"	OT	23			
"	Mineralogy	11?			
"	TL	4?			
Mahood & Hildreth 1986	K-Ar, XRF	4			
Lanfranchi 1987a	NAA		(+2)		(+16)
Francaviglia & Piperno 1987	XRF, visual			90	
Michels 1987	OH			61	
Francaviglia 1988	XRF	66		77	
Heyworth et al. 1988	ICP-AES	16			
Polglase 1989	Visual			334	
Ammerman et al. 1990	NAA, visual	2		23	
Dyson et al. 1990	OH			83	
"	XRF			27	
Francaviglia 1990	XRF		(+66)		(+77)
Polglase 1990	Visual			76	(+23)
Bigazzi et al. 1992a	FT			?	
Bigazzi et al. 1992b	NAA			15	(+15)
MacDonald et al. 1992	CA		(+2)		
"	OES		(+4)		
"	Colorimetry, AAS	4			
"	XRF, NAA	5			
Meloni & Oddone 1992	NAA	35			
Ammerman & Polglase 1993	NAA			54	
Randle et al. 1993	NAA			9	
Crisci et al. 1994	XRF	60?		138	
Kayani et al. 1994	BSE	?			
Lefèvre & Gillot 1994	K-Ar		(+5)		
Montanini et al. 1994	XRF	3			
"	Sr/Nd isotopes	3			
"	ICP-AES	2			
Acquafredda et al. 1995	XRF	21			
"	SEM-EDS	30		5	
Ammerman & Polglase 1995	NAA, visual				(+54)
de Romanis et al. 1995	XRF			3?	
Stevenson & Ellis 1995	Density	53		23	
"	OH			21	
Kayani & McDonnell 1996a	BSE	?			
Kayani & McDonnell 1996b	BSE	?			

vulcanism. By 40,000 BP, the volcanic products had changed to an acidic type and include rhyolite, obsidian and pumice deposits of various ages in complex stratigraphic sequences (Cortese et al. 1986; Crisci et al. 1991). Obsidian may be found today in several localities on Lipari: Forgia Vecchia, Rocche Rosse (including Punta Castagna), Acquacalda, Vallone Gabellotto (including Papesca beach and the Pomiciazzo-Lami flow), and Monte della Guardia (including Praia di Vinci). Vulcano, just to the south of Lipari, features obsidian only from a 1739 AD lava flow from the Fossa cone, and was thus not a potential source during the Neolithic or Bronze Age.

By the end of the 19th century, a number of geological studies of Lipari had been undertaken. Abich (1841) was the first to chemically analyze obsidian from Lipari, while descriptions of the island's volcanic history include those of Cortese & Sabatini (1892) and Bergeat (1899). Washington (1920) specifically studied rhyolites and obsidians from Forgia Vecchia, Rocche Rosse, and Monte della Guardia. Buchner (1949) was the first to notice, however, that some prehistoric archaeological deposits were covered by the Forgia Vecchia and Rocche Rosse flows, which were therefore too recent to have been used during the Neolithic. Later field studies by Pichler (1967; 1980) and Keller (1967; 1970) placed the Gabellotto flow between 4800 and 13,000 BP based on radiocarbon dating of its stratigraphic context, and confirmed Buchner's findings on the recent flows, attributing them to the first half of the 6th century AD based on finds of underlying late Roman material, a single radiocarbon date (1220 ± 100 BP), and a local Christian legend about the fiery exploits of San Calogero, who lived on

Lipari from 524-526 AD. Others date this final volcanism to 729 AD when San Willibald observed explosive activity in the Rocche Rosse area (Bernabò Brea & Krönig 1979; Cortese et al. 1986).

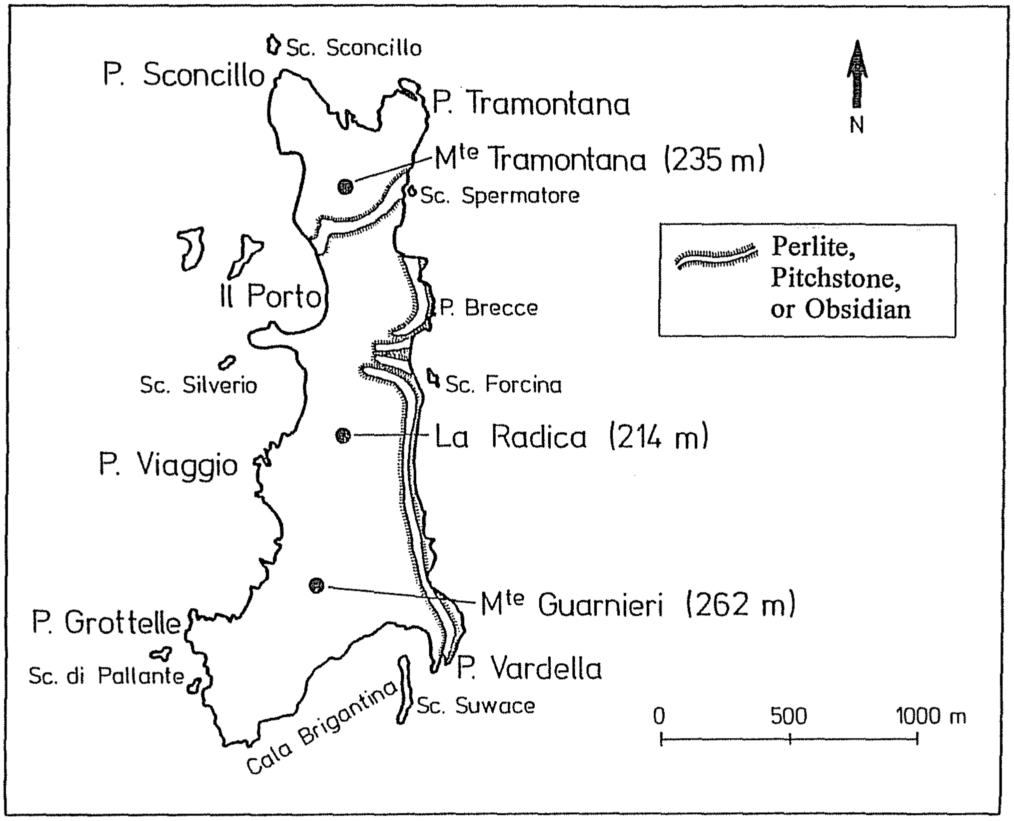
These stratigraphic/radiocarbon datings of the context of the Lipari flows are supported by fission-track dates (Appendix B, Table B2) on the obsidian itself, with single dates of 1400 and 1600 BP on the Rocche Rosse and Forgia Vecchia flows, respectively (Bigazzi & Bonadonna 1973), and by a series of 7 K-Ar dates (Appendix B, Table B1), using the new Cassignol technique for young materials, on Rocche Rosse obsidian which average 1500 BP (Gillot & Cornette 1986; Lefèvre & Gillot 1994). Additional fission-track measurements include three dates on Gabellotto obsidian which average a little older than 9000 BP, a single date on Acquacalda obsidian of approximately 21,000 BP, and three dates on Praia di Vinci (Monte della Guardia) samples which average 30,000 BP (Bigazzi et al. 1971; Arias-Radi et al. 1972; Bigazzi & Bonadonna 1973; Wagner et al. 1976; Bigazzi & Radi 1981; Arias et al. 1986). Fission-track dates on 66 artifacts (Appendix B, Table B3) of Lipari obsidian from archaeological sites in Italy (Arias-Radi et al. 1972; Bigazzi & Radi 1981; Bigazzi et al. 1982; Arias et al. 1984; 1986) include only one determination older than 12,500 BP, indicating that the Gabellotto obsidian was the primary source used in antiquity (contra Crummett & Warren 1985:109 who state that the exposed Gabellotto obsidian is not of workable quality). The older obsidian at Acquacalda is present as cobbles within the historic pumice layer, and may ultimately derive from a deposit inaccessible to prehistoric people. The Monte della Guardia outcrop has not been fully described, but is apparently not represented archaeologically, presumably due to inaccessibility or unsuitability for tool manufacture. A handful of fission-track dates between 3000 and 7000 BP on obsidian artifacts probably represent a resetting of the fission-track clock during a period of documented human activity.

Optical emission spectroscopy (OES) and X-ray fluorescence (XRF) analyses of many samples from both recent and prehistoric flows conclusively demonstrate that there are negligible chemical differences among the obsidians at both the major and trace element levels (Belluomini & Taddeucci 1971; Mosheim 1979; Friz 1982; Francaviglia 1984; Tykot 1995c and Appendix F, recent samples 306-308, and archaeological samples 506-511, 1715-1725), despite the spatially and temporally dynamic, complex mixing of mantle sources and crustal melts (Crisci et al. 1991; Esperança et al. 1992).

Palmarola

Palmarola is the westernmost of the Pontine Islands, located west of Naples in the Gulf of Gaeta, about 35 Km from the mainland (Figure 9). The island, less than 3 Km^2 in area, was first formed approximately 5 million years ago, with the intrusion of soda-rhyolitic lavas coming about 1.7 million years ago (Barberi et al. 1967). Obsidian-bearing flows are found to the south of Monte Tramontana, and along the east coast of Palmarola down to its southeastern tip at Punta Vardella. The domal crust of obsidian which transects the island from Il Porto to Scoglio Spermatore mostly contains devitrified nodules of massive obsidian with frequent inclusions, while the glassy perlites and pitchstones found along much of

Figure 9. Palmarola (after Herold 1986, with modifications).



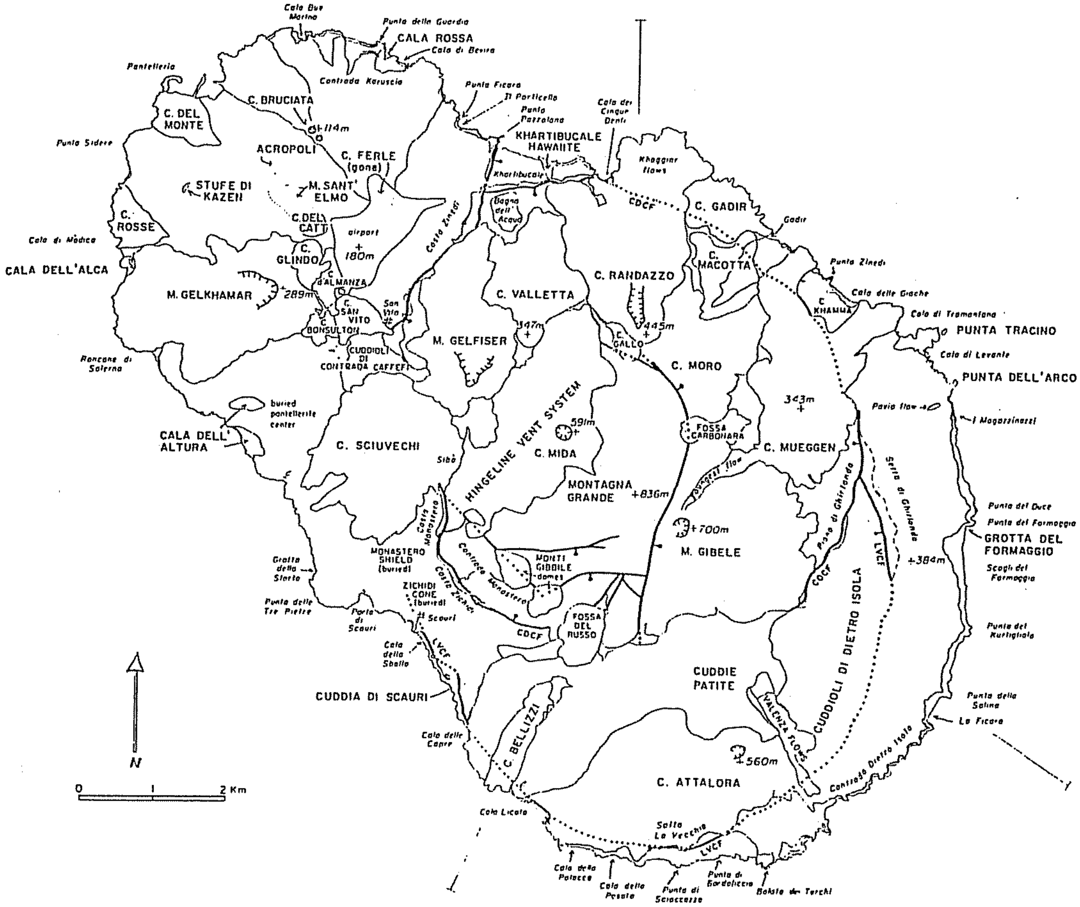
the east coast are unsuitable for toolmaking (Barberi et al. 1967; Herold 1986). The Punta Vardella material, however, found as fist-sized angular blocks in secondary geological deposits, was undoubtedly exploited in antiquity for stone tool production (Buchner 1949; Hallam et al. 1976). Dixon (1976) mistakenly reports that Monte Tramontana was the only source of usable material. Palmarola obsidian is grey to black and even brownish, and nearly opaque. Its surface can appear patinated, presumably due to weathering.

Two K-Ar dates and two fission-track dates on obsidian from Monte Tramontana all fall between 1.6 and 1.7 million years ago (Barberi et al. 1967; Belluomini et al. 1970; Bigazzi et al. 1971; Bigazzi & Radi 1981), and a handful of artifacts from Italian archaeological sites have equivalent fission-track ages (Arias et al. 1984). Although analyses have not turned up any chemical differences in obsidian from the different source localities on Palmarola (Appendix A, Table A6: Herold 1986), making it impossible to determine whether Punta Vardella was the only source utilized, the small size of the island and the lack of evidence for Neolithic settlement render this distinction of minimal archaeological significance.

Pantelleria

Pantelleria, a small pear-shaped island of about 8 x 13 Km, lies in the Strait of Sicily, about 90 Km east of Cap Bon, Tunisia (Figure 10). Pantelleria appears exceptional among the Mediterranean island obsidian sources in that its volcanic activity is not related to tectonic plate boundaries (Carmichael 1962) and

Figure 10. Pantelleria (after Mahood & Hildreth 1986).



it is the type locality for peralkaline rocks, in particular its Na- and Fe-rich greenish obsidian known as Pantellerite (Foerstner 1881; MacDonald & Bailey 1973). Pantellerian obsidian is thus readily differentiable from the other western Mediterranean sources on a visual basis (e.g. Cann & Renfrew 1964). Geological surveys by Washington (1913b; 1913c; 1914), Rittmann (1967) and Villari (1974) identified the multiple eruptive units on the island, while more recent geostratigraphic (Civetta et al. 1984; 1988; Mahood & Hildreth 1986) and analytical (Francaviglia 1988) investigations have resolved many questions about the sources and chronology of the obsidian flows.

Pantelleria was first formed about 325,000 years ago, but the modern landscape is dominated by the 6 Km wide Cinque Denti caldera and its associated Green Tuff (fine-grained pyroxene in devitrified matrix), both formed only 45,000 years ago. More recent eruptions produced a Pantelleritic lava flow at Monte Gelkhamar (Civetta et al. 1988). Older volcanics are principally exposed at the southern end of the island where erosion has left 200 m high cliffs. The fault zone of the La Vecchia caldera, exposed near Cuddia di Scauri, Salto La Vecchia, Costa Zinedi, Cuddia Khamma, and Grotta del Formaggio, is associated with a number of Pantellerite lava vents and flows dated ca. 124,000-189,000 BP. An obsidian sample from Cala dell'Altura was K-Ar dated to 159,000 ± 8000 BP (Mahood & Hildreth 1986), perhaps slightly older than obsidians from Balata dei Turchi which have fission-track dates between 127,000 and 141,000 BP (Bigazzi et al. 1971; Arias et al. 1984). Even older obsidian-rich lava flows have been K-Ar dated 239,000 ± 10,000 BP (Salto La Vecchia) and 303,000 ± 71,000 BP

(Cuddia di Scauri), while obsidian from Fossa della Pernice has been fission-track dated ca. 72,000 ± 8000 BP (Arias et al. 1984).

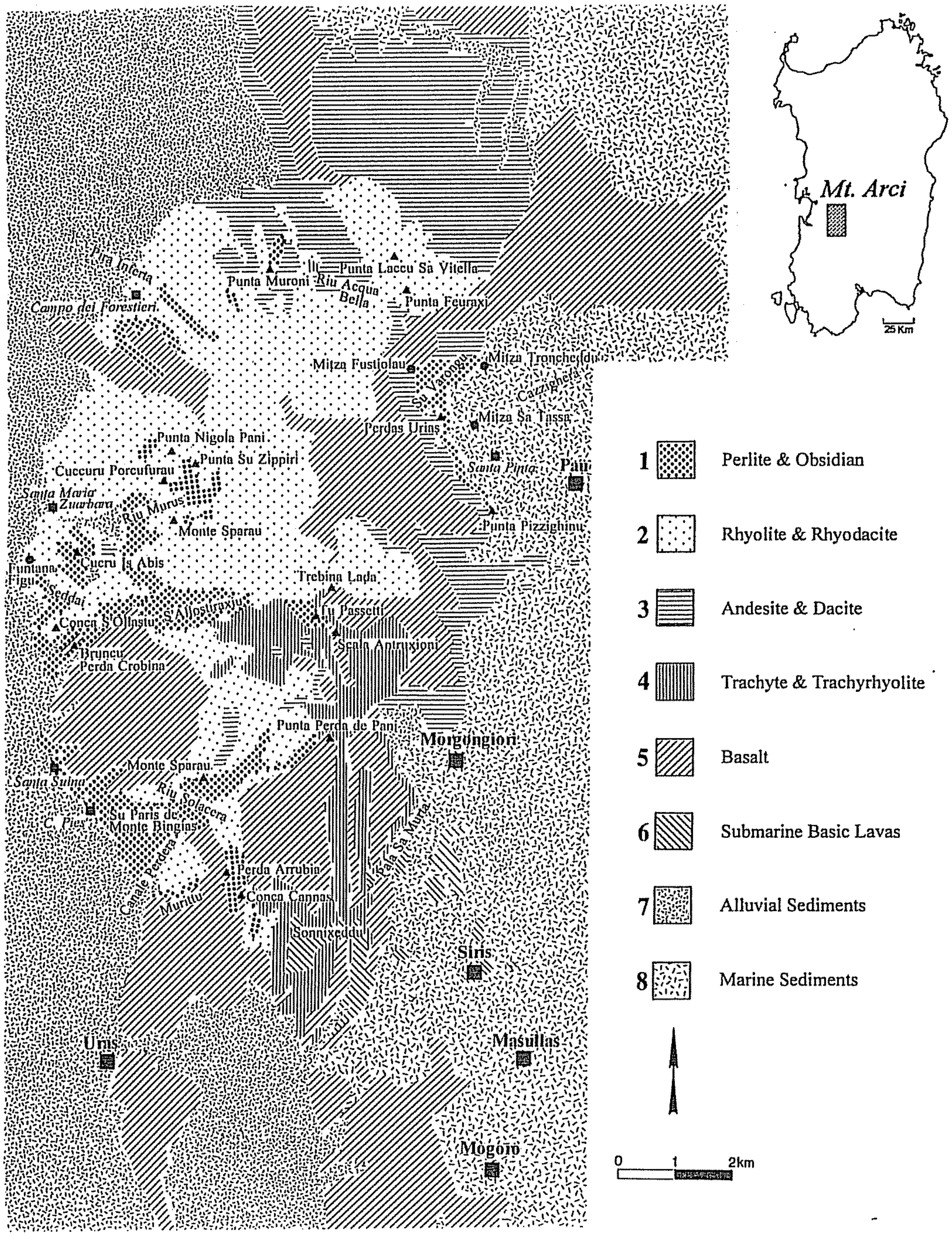
9 fission-track dates on archaeological artifacts fall between 204,000 and 122,000 BP (Arias-Radi et al. 1972; Arias et al. 1984), suggesting the use of multiple source flows. In a somewhat confusing paper which mixes XRF analyses of geological and archaeological samples, Francaviglia (1988) has isolated five chemical source groups on Pantelleria: three vertically-differentiated sources exposed at Balata dei Turchi; Gelkhamar; and Lago di Venere (=Bagno dell'Acqua, near Costa Zinedi in Figure 10). Analyses of nearly 150 artifacts 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 (but more recent?) Gelkhamar obsidian was also employed - even in Sicily (Francaviglia 1988; Francaviglia & Piperno 1987; Tykot 1995c and Appendix F, samples 513-516, 1726). Apparently, neither the lower Balata dei Turchi flow nor the Lago di Venere type - neither specifically dated - have been identified among archaeological samples (but see Francaviglia 1988:122). Fission-track dates on samples from Francaviglia's five source groups would conclusively correlate workable obsidian sources with particular geological flows. As with Palmarola, however, Pantelleria was not settled during the Neolithic, and differential access to the sources is unlikely to have existed. There is no indication of discrete quarry or workshop areas to signal even a minimal level of organized extraction or production.

Sardinia

Sardinia, unlike the other Mediterranean islands with obsidian sources, is a large landmass with an area of 24,000 Km^2 and a history of occupation dating back to the Upper Paleolithic. Count Alberto Ferrero della Marmora (1839-40) made the first substantial contribution to our geological knowledge of the island more than 150 years ago. He describes rhyolites of various types interspersed with dikes or beds of obsidian in the narrow valleys (*concas*) on the southwestern side of the Monte Arci volcanic complex (Camboni 1989; Barca et al. 1993), about 25 Km long from north to south and 7-8 Km wide with a maximum height of 812 m a.s.l. (Figure 11), and he also mentions loose scatters so abundant they could have come from a glass bottle factory. della Marmora (1840:153, 479, 489, 532, 583, 631) also noted other, minor sources of obsidian in Sardinia, including those discussed above which are of no archaeological significance. The prehistoric importance of obsidian in Sardinia became apparent during early research at several sites (Spano 1871; Mantovani 1875; Lovisato 1875; 1879; Orsoni 1879; Zanardelli 1899; Pigorini 1903), and it was quickly recognized that two distinct types - translucent and opaque - were represented, coming from different sources (Loddo 1903).

Washington (1913a) visited Sardinia in 1905 and spent two days studying the western flanks of Monte Arci. He confirmed della 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 (1913a:590-582) cites highly vitreous ash-gray perlites and black obsidians, usually

Figure 11. Monte Arci (Sardinia).



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 were reported from the Rione Prasuedda east of Conca s'Ollastu. A comprehensive survey of the Monte Arci zone was finally undertaken by Puxeddu (1958) as part of his thesis work in archaeology at the University of Cagliari. This singularly important contribution has been the starting point for all subsequent research, with its detailed description of the Monte Arci obsidian sources and archaeological sites in the vicinity. In a zone of about 200 Km^2 which today includes 19 towns or hamlets, Puxeddu found 246 locations with obsidian, which he classified as sources (4), collection centers (11), workshops (74), and stations (157). Site destruction through subsequent settlement growth, quarrying activity, and land clearing make this work an invaluable documentation of prehistoric activity. For the obsidian sources, Puxeddu (1958:24, 33-37, 46, 48) found abundant *in situ* material at Conca Cannas, notes probable sources at Tzipanéas (east of Santa Maria Zuarbara) and Perdas Urias (he did not find *in situ* material at either), and only cites della Marmora's finds of obsidian veins at Sonnixeddu.

The later realization that at least three sources (SA, SB, SC = Sardinia A, B, C) were represented among chemically analyzed archaeological material raised questions about which sources were being utilized, since the only geological source material yet analyzed came from Conca Cannas on Monte Arci (Cann & Renfrew 1964; Hallam et al. 1976). In fact, Hallam et al. (1976:95) considered it unusual for such chemically disparate obsidians (their type SC is calcalkalic to tholeiitic; their type SA [= Conca Cannas] is more alkaline) to occur together in the same volcanic center, suggesting that Sardinian sources besides Monte Arci may have been exploited, but it was also known that tectonic plate movement and changes in the magma source over a few million years could substantially alter lava composition (Tykot 1982). K-Ar dates from Conca Cannas (Belluomini et al. 1970), Conca s'Ollastu and Riu Murus (di Paola et al. 1975), and fission-track dates from Conca Cannas (Bigazzi et al. 1971; 1976; Bigazzi & Bonadonna 1973), Perdas Urias and Pira Inferta (Bigazzi et al. 1976), however, had shown these multiple obsidian deposits to all have uncorrected ages of about 3.2 million years (cf. Beccaluva et al. 1985 for a recent review).

Geological and petrographic studies (Beccaluva, Deriu et al. 1974; Beccaluva, Maccioni et al. 1974; Assorgia et al. 1976) show that a Miocene (ca. 15 mya) sequence of submarine calc-alkaline volcanics and calcareous sediments has been largely covered by Pliocene acidic lavas which frequently appear as massive, strongly vesiculated flows, often grading into a perlitic facies where obsidians are likely to occur. The acidic lavas are themselves covered by more recent dacitic and basaltic flows. This work, the basis for my Figure 11, identified outcrops with prevailing perlites and obsidians in 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. Pyroclastic deposits, for example at Pala Sa Murta (southwest of Morgongiori) and Fustiolau (north of Perdas Urias), also were found to have obsidian and perlite mixed with pumice (Assorgia et al. 1976), and obsidian-perlite volcanics were reported in the Rio Acqua Bella valley, at Punta Feuraxi and at Laccu sa Vitella to the northwest of Fustiolau (Bigazzi et al. 1976). Obsidian has even been reported in dacitic flows at Conca de Mesu, several Km north of Monte Arci (Beccaluva et al. 1977), and the differing chemistries of these simultaneous volcanic activities are now explained by variable crustal contamination rather than fractional crystallization (Savelli et al. 1979; Cioni et al. 1982; Dostal et al. 1982; Montanini & Villa 1993; Montanini et al. 1994). Rarely, however, do any of these geological studies specifically mention the size or extent of the obsidian outcrops, and whether the obsidian is of workable quality - crucial information for archaeologists interested in exploitation patterns. The ability to match the multiple chemical groups found among archaeological materials with specific geological sources remained, and has led to four independent efforts - including my own - to describe and characterize all of the Monte Arci obsidian sources.

The first study was done by Maria Mackey for her doctoral dissertation in geology at the University of Nottingham. Due to an unfortunate set of circumstances her thesis was not accepted, and the only available information comes from a very brief conference paper (Mackey & Warren 1983). Importantly, Mackey did locate *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). Neutron activation analysis (NAA) of "relatively small" numbers of geological samples was used to differentiate the Conca Cannas (SA), Perdas Urias (presumed SC source), Monte Sparau (north), and Cucru Is Abis sources, and the 51 archaeological artifacts analyzed could be attributed to one of these four groups. The SB group of Hallam et al. (1976) had similar, but not identical chemical characteristics to the Cucru Is Abis source.

Francaviglia (1984), apparently unaware of Mackey's efforts, also did a geochemical study of the Monte Arci sources as part of a Mediterranean-wide characterization program, analyzing by XRF 172 geological specimens from Sardinia. Unfortunately, no information about the deposits themselves is given for the five localities tested: the quarry at Conca Cannas (77 samples), Funtana Figu (30), Mitza Sa Tassa (27), S. Pinta (18), and Cave della Ceca (near Pala Sa Murta) (20). His most significant findings were that the Ceca material contained two differentiable obsidians mixed in a detrital deposit and that the Mitza Sa Tassa and S. Pinta collections, both near Perdas Urias, were distinguishable using trace elements. This confirmed the magnetic parameter data produced by McDougall (1978; McDougall et al. 1983) which suggested that there were two sources in the Perdas Urias zone, and in combination with Mackey's results indicated the existence of at least 7 differentiable obsidian sources in the Monte Arci region.

Finally, Herold (1986), without knowledge of the work of Mackey & Warren (1983) or Francaviglia (1984, but not actually published until 1986), conducted a thorough survey and analysis of the Sardinian sources for his [unpublished] doctoral dissertation in geological science at the University of Karlsruhe (and which I myself became aware of only from its citation in a 1990 publication by German authors; cf. also a conference paper abstract, Herold & Althaus 1987). Herold's analyses by XRF and NAA (reproduced in Appendix A, Table A6) are particularly important for their coverage of many minor outcrops, which belong to at least four chemical subgroups (Monte Sparau south; Scala Larga, Acqua Marzana, and Riu Mattiabis; Gora de Capudaquas; and Riu Ceddus, Riu Nieddu, and Maria Zuarbara), none yet recognized among archaeological material. The Perdas Urias source, however, still was not yet located *in situ*, and the problem remained of matching type SB artifacts to specific source localities.

Monte Arci Field Survey

Unaware at the time of either Herold's or Francaviglia's efforts, my own fieldwork at Monte Arci began in 1987 with a survey of the zones previously identified as containing acidic lavas, and hence possibly obsidian (Figure 11, *supra*). Some obsidian was in fact found in most of these areas, although often as millimeter-sized specks in a rock matrix. For each locality, the presence of obsidian was noted as *in situ* (found in primary geological strata), float (large, naturally produced blocks found on the surface or in secondary geological 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. A list of the geological samples collected and their findspots may be found in Appendix C (Table C1), while a description of the sources follows (cf. also Tykot 1991a; 1992a).

The best-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 (elev. 382 m a.s.l.). No trace of obsidian was found near Perda Arrubia, nor near Sonnixeddu. 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, but can reach nearly 40 cm in length and 7 kg in mass (cf. also the observations of Lanfranchi & Weiss 1973:124). Conca Cannas obsidian is generally quite glassy, black but often so translucent that microlite crystals can be seen with the unaided eye. The microlites are often directionally oriented, representing the original flow structure, but are never large enough to be classified as phenocrysts. Francaviglia (1984:314) reported obsidian blocks up to several tens of cm not only at Conca Cannas, but also along the Canale Perdera and Riu Solacera surrounding Su Paris de Monte Bingias; the obsidian I found in these localities was not this massive, and was neither plentiful nor *in situ*. Only loose material of workable size was found at Su Paris, and some of unworkable size at

Monte Sparau (south), despite the considerable exposures resulting from current gravel and perlite quarrying activity. Herold (1986), however, reported some blocks 10-20 cm in size from Monte Sparau. I found no obsidian near the ruins of C. Pies and S. Suina.

Obsidian-bearing deposits continue to the north, along the western flanks of Monte Arci. I found *in situ* obsidian 15-17 cm in length 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 Conca s'Ollastu, while a source at Cucru Is Abis appears to begin at an elevation of 230 m and flows down to the west near Funtana Figu. Obsidian may be found in a modern gravel quarry there, below the Seddai cliff-face, along with the rare minerals tridimite and osumilite (de Michele 1975:172-173; Exel 1986:78). The quarry is primarily basalt, but also includes trachyte and rhyolite, and I observed obsidian blocks up to 1 m in length. Hardly any obsidian occurs, though, in another quarry (mostly quartz) less than 1 Km to the north.

Obsidian also occurs in the area east of Santa Maria Zuarbara, usually at much higher elevations. A few Km northeast of the church, obsidian may be found *in situ* on the slope of Cuccuru Porcufurau, in blocks up to 30 cm in length at elevations 250-300 m a.s.l.; 3-5 cm nodules of obsidian occur abundantly at Punta Su Zippiri at an elevation of 500 m, and less frequently at Punta Nigola Pani at an elevation of 350 m. Workable blocks of obsidian also occur along the Riu Murus near Monte Sparau (north). Obsidian from these localities on the western flanks of Monte Arci is frequently as glassy as the Conca Cannas material, but may be less translucent and more gray in color. This obsidian also can features white phenocrysts 1-3 mm in diameter, which can make the fracture sub-conchoidal if frequent enough. Many pieces do not have any phenocrysts, however, and some are virtually transparent. Only the most meager surface scatter was found further north by the Campo dei Forestieri, near where Bigazzi et al. (1976) took a sample for fission-track dating, and no obsidian was observed near Punta Muroni.

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. I located *in situ* obsidian there, for the first time, in a perlitic matrix at about 600 m altitude near Punta Pizzighinu. The primary material includes specimens up to 17 cm in length, while secondary deposits are abundant at lower elevations. Natural blocks up to 30 cm were observed 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. Mitza Sa Tassa appears to be a large lithic reduction center, and should be investigated further. Given the presence of secondary obsidian deposits, it would not have been necessary for prehistoric people to collect raw material directly from its source. Perdas Urias obsidian exhibits a great range in physical appearance, although it is almost always black and opaque. Many nodules have distinct alternating black and grey bands, some material is devitrified and weathered on its surface, a few pieces have red streaks, and rare examples are beer-bottle brown with high translucency.

Lastly, some obsidian was found in the Ceca quarry near Pala Sa Murta, which Francaviglia (1984) had reported as being of two chemical types. The only *in situ* obsidian I found was never greater than 1 cm in diameter, and there weren't any surface scatters of natural or flaked obsidian to suggest human activity there. I did not visit the area of Trebina Lada and Tu Passetti.

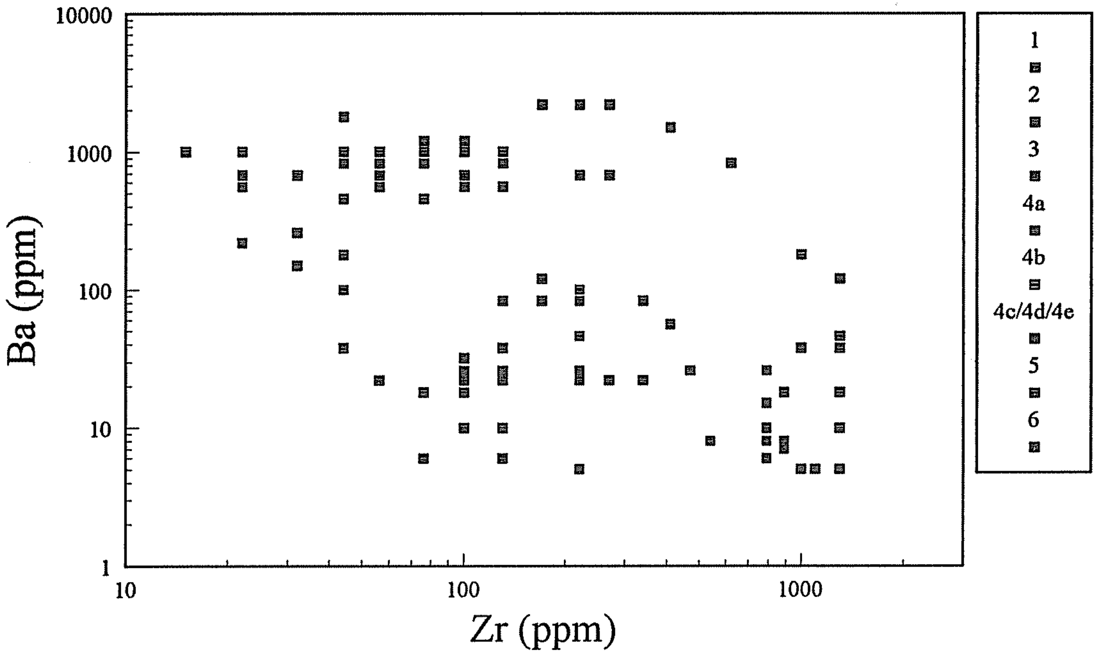
To summarize the Monte Arci source data, we can say that: (1) large quantities of type SA obsidian occur near Conca Cannas in accessible, primary geological deposits; (2) equally large quantities of workable-size material occur in diffuse localities (both primary and secondary) along the western flanks 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 in the Perdas Urias zone, mainly in secondary deposits; and (4) small pieces of unworkable-sized obsidian may be found *in situ* at several additional Monte Arci localities, in perlitic or pyroclastic matrices.

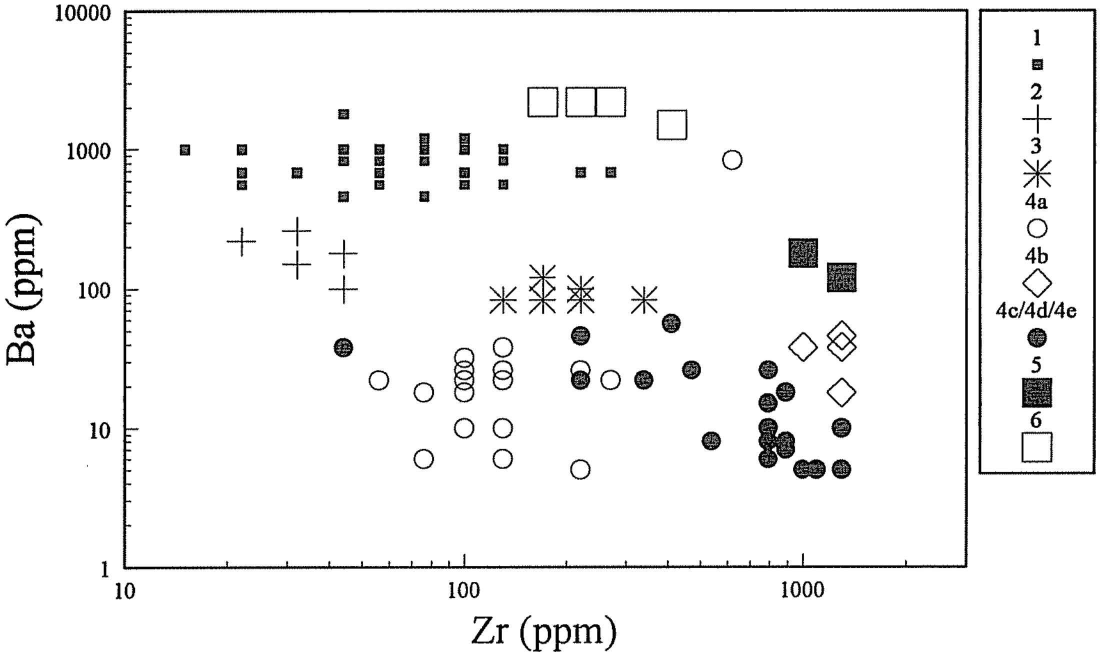
Characterization Studies

The chemical analysis of lithic raw materials is useful not only for petrological classification and reconstructing their geological history, but also as a means of identifying the source of specimens such as archaeological artifacts no longer found in their natural setting. The premise of all characterization studies, of course, is that greater differences exist between sources than within a single source. The first attempt at determining the provenance of archaeological objects using their trace element composition, a study of faience beads from Britain, was not entirely conclusive (Stone & Thomas 1956). Initial attempts at using trace elements to trace obsidian by Cornaggia Castiglioni et al. (1962; 1963) were promising, but their reliance on Mn content led to the erroneous attribution of obsidian found on Malta to sources on Melos, a connection which pervaded the archaeological literature for a long time (e.g. Bagolini 1980, fig. 19), and suggests that their other attributions - even if archaeologically reasonable - are unreliable.

Analysis of multiple trace elements, using OES, was successful though in differentiating many of the obsidian sources in the Mediterranean and Near East (Cann & Renfrew 1964; data reproduced in Appendix A, Table A1). The success of this and other obsidian characterization programs owes much to the homogeneity of the sources, of which there aren't very many when compared to other raw materials of archaeological interest (e.g. clay, iron, copper, marble), and the fact that composition is unchanged from source to artifact. In the Mediterranean region, Cann & Renfrew (1964) were able to sort the obsidian sources into 8 groups using the trace concentrations of Ba, Zr, Nb and Y, but could not differentiate between Palmarola and Lipari (their group 4a), and had samples representing only two of the Sardinian sources (their groups 2 and 6). It is important to recognize that even this would not have been possible based simply on the analytical results (Figure 12, top), as *a priori* knowledge of the source of many samples was required to establish source fields (Figure 12, bottom).

Figure 12. Plots of Ba and Zr content for Mediterranean obsidian sources. Top: source groups have same symbol. Bottom: groups have different symbols. Both axes use logarithmic scales. Data from Cann & Renfrew (1964).





Subsequent studies of geological specimens by Belluomini & Taddeucci (1970; 1971; data reproduced in Appendix A, Table A2), using a combination of isotope dilution/mass spectrometry, OES and XRF, were able to differentiate between all four western Mediterranean island sources, but included samples from only the Conca Cannas source in Sardinia.

NAA rapidly became the method of choice in the 1970's, since it had better precision than OES and the advantage of being non-destructive for artifact analysis. Hallam (1976; Hallam et al. 1976; Hallam & Warren 1971) applied this technique to western Mediterranean obsidians in his Master's thesis at Bradford University, successfully differentiating the four island sources as well as three Sardinian subsources using trace element ratios of La and Cs to Sc (Figure 13). Of the 148 samples analyzed, 63 were Sardinian: the three chemical groups represented suggested that there were three Sardinian sources, all presumably in the Monte Arci region of the island, but the 7 geological specimens tested were all from the Conca Cannas source. 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 (Hallam et al. 1976:95). This study, along with another Bradford Master's thesis (Williams 1975; Williams-Thorpe et al. 1979; Williams Thorpe, Warren, & Courtin 1984; data for all Bradford analyses reproduced in Appendix A, Table A3), revealed an extensive extrainsular distribution of Sardinian obsidian and it became urgently necessary to locate and characterize the SB and SC sources.

Figure 13. West Mediterranean source discrimination using trace element ratios of La and Cs to Sc. Data from Hallam et al. (1976).

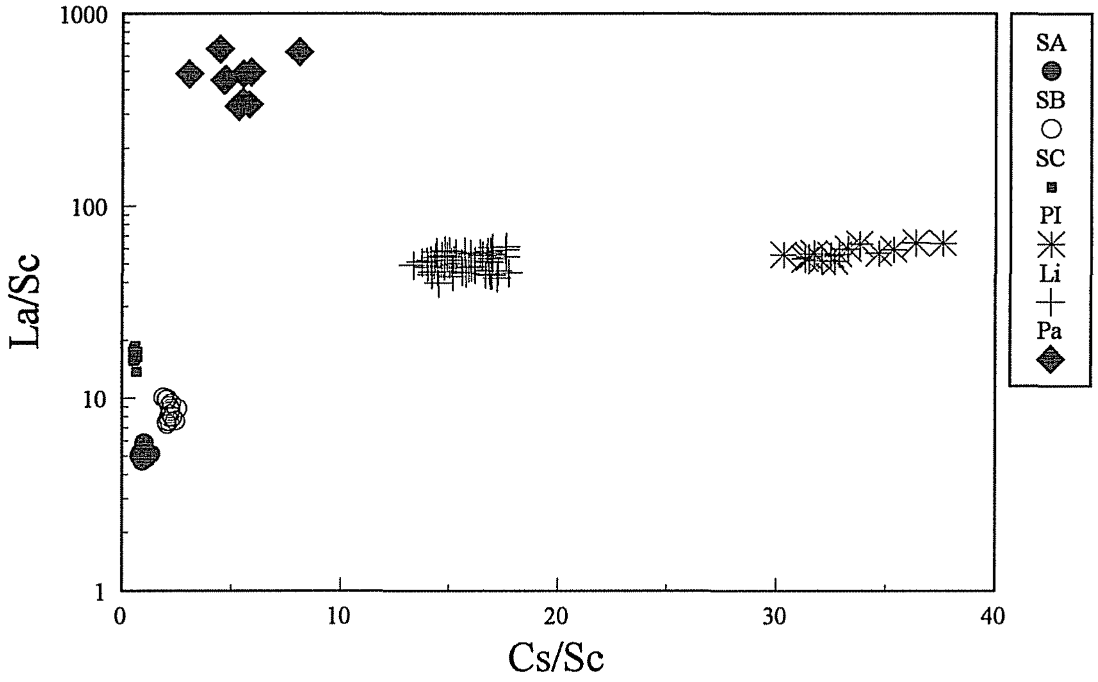
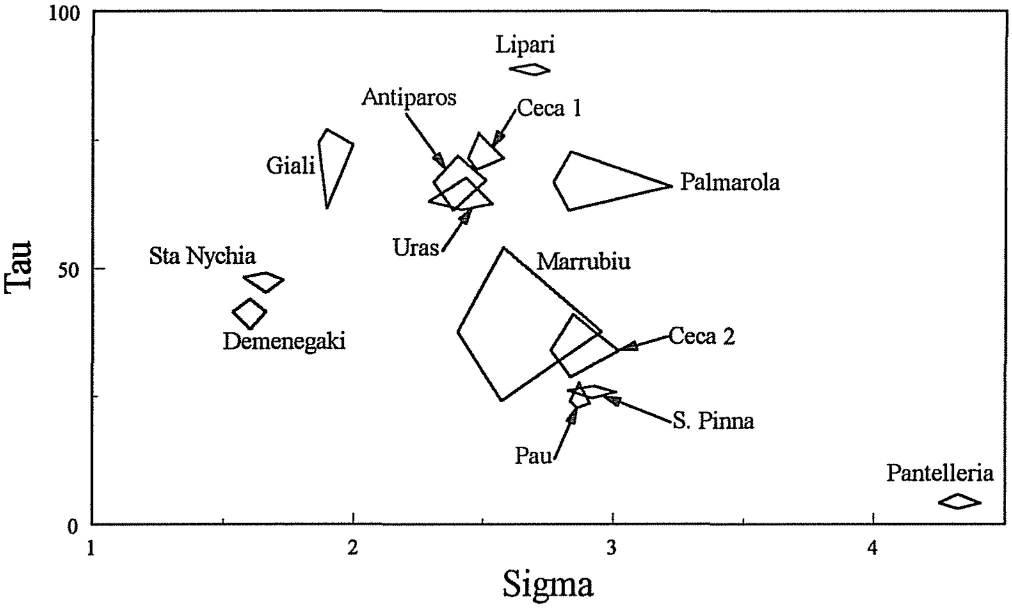


Figure 14. Mediterranean obsidian source discrimination using major element Rittman indices sigma (σ) and tau (τ). $\sigma = (Al_2O_3\text{-}Na_2O)/(SiO_2\text{-}43)$ and $\tau = (Na_2O + K_2O)^2/(TiO_2 + P_2O_5)$. After Francaviglia (1984).



This was, as discussed above, the subject of Mackey's dissertation work, with the only data available coming from that one conference paper (Mackey & Warren 1983) which does not report the number of samples analyzed nor their individual results although group means and standard deviations are provided. NAA of her hand specimens demonstrated the existence of four differentiable sources (Conca Cannas, Perdas Urias, Monte Sparau North, Cucru Is Abis), while XRF analyses of the first three revealed distinct differences in their major element chemistry. Bulk element composition was explicitly used by Michels et al. (1984), as part of an obsidian hydration dating project, to source 104 artifacts from several Sardinian sites. Using AAS, the artifacts were sorted into groups A, B and C, which are the equivalent of Hallam et al.'s (1976) SC, SA, and SB, respectively. The sample data for only 12 of these artifacts were published (reproduced in Appendix A, Table A4), but the attributions of the artifacts analyzed suggested the existence of chronological patterns of source exploitation within Sardinia, as well as differences between Sardinia, Corsica and the mainland (Tykot 1992a).

Francaviglia (1984), noting that previous studies were limited by the small numbers of geological specimens defining source groups, analyzed by XRF enough samples from all the Mediterranean sources to statistically assess intrasource variation and to graphically define multiple source fields. Analyses of 22 major and trace elements for 172 samples from 6 Sardinian sources (see above) provided a solid basis for determining the provenance of archaeological material, but only the means and ranges for each source are provided, and just 6 western Mediterranean artifacts were analyzed (data reproduced in Appendix A, Table A5). Using the Rittmann (1973) indices Sigma (σ) and Tau (τ), Francaviglia (1984) did demonstrate that major element analysis was sufficient for distinguishing among all the Mediterranean obsidian sources used for stone tool manufacture (Figure 14).

The efficacy of a number of other analytical methods has also been assessed over the years in an attempt to facilitate Mediterranean obsidian provenance studies. Refractive index, density, and other physical parameters may be characteristic of one or more sources, but are never sufficient to separate all of the island source groups (cf. Cornaggia Castiglioni et al. 1963; Bigazzi et al. 1971; Friz 1982; Herold 1986; Stevenson & Ellis 1995). Mössbauer spectroscopy can differentiate between Sardinia (only type SA has been tested) and Lipari, but not between Lipari and Palmarola (Longworth & Warren 1979; Aramu et al. 1983). The use of magnetic parameters was also not entirely successful, since the Sardinian analytical groups overlapped with those of the three other source islands (McDougall et al. 1983). This technique did, however, distinguish between SA, SB and SC, with three additional Sardinian samples forming a fourth group (SD), suspected to be from the Perdas Urias area (McDougall et al. 1983:448). Similarly, electron spin resonance analyses separated two subgroups each for Pantelleria and Lipari, but were unable to distinguish between Palmarola, Melos and Monte Arci (Mello 1983). Sr isotope ratios, in combination with Rb and Sr concentrations, appear effective (Gale 1981), but this approach is clearly too costly and time-consuming for the routine provenance analysis of artifacts.

Fission-track dating has been widely used to source western Mediterranean obsidians based on their differing geological ages (Bigazzi et al. 1971; Arias-Radi et al. 1972; Bigazzi & Radi 1981; Bigazzi et al. 1982; Arias et al. 1984; 1986; Bigazzi et al. 1992a), but cannot discriminate among the multiple Sardinian sources (Bigazzi et al. 1976). In addition, doubts are raised when the fission-track clock has been reset and attributions are based only on the induced track density, while the physical nature of some samples precludes their testing entirely. Recently, backscattered electron (BSE) petrography using a scanning electron microscope (SEM) has also proven successful in differentiating the four island sources (Kayani et al. 1994; Kayani & McDonnell 1996a; 1996b), but this technique is also unsuited for rapid characterization studies of large numbers of artifacts. Furthermore, although energy dispersive spectrometry (EDS), also using the SEM, has been shown to discriminate well between Melos, Lipari and Palmarola without removing a sample from small artifacts (Acquafredda et al. 1995), the Monte Arci sources cannot be distinguished from one another, nor from Lipari, using this technique.

I did a pilot study in 1985-86 to evaluate whether AAS (cf. Michels et al. 1984) could be utilized as a rapid and inexpensive means of sourcing large numbers of obsidian artifacts in order to produce a statistically significant dataset for archaeological interpretation. 300 mg samples from 27 artifacts recently excavated at the Bronze Age site of Nuraghe Ortu Còmidu (Balmuth 1986) were dissolved in concentrated HF, HCl, and HNO_3 in sealed polycarbonate bottles using a hot water bath (Farrell et al. 1980). Ba and Sr were determined using a

Perkin-Elmer 3030 atomic absorption spectrophotometer, calibrated against single-element standard solutions. The results clearly fell into three groups which I identified as SA (13 samples), SB (1 sample), and SC (13 samples). Although relatively inexpensive, the sample preparation time and the multiple solution concentrations necessary for producing quantitative results meant this technique was not optimal for the thousand samples I wanted to analyze, even if the analysis were limited to only a few elements.

The ability of NAA to produce quantitative results for many trace elements while being non-destructive to artifacts has thus resulted in its being by far the most common method employed in western Mediterranean obsidian provenance studies, despite its being neither rapid nor inexpensive. Analyses at Bradford by Warren and coworkers (Hallam et al. 1976; Williams-Thorpe et al. 1979; Mackey & Warren 1983; Williams-Thorpe, Warren, & Courtin 1984; Crummett & Warren 1985) have been followed by artifact-based efforts by Bigazzi et al. (1986; 1992b; data reproduced in Appendix A, Table A7), Ammerman et al. (1990; Ammerman & Polglase 1993; 1995; data reproduced in Appendix A, Table A9), and Randle et al. (1993; data reproduced in Appendix A, Table A11). Only Mackey & Warren (1983) and Herold (1986; data reproduced in Appendix A, Table A6) have focused on geological source material, but trace element analysis using NAA can clearly distinguish between all of the Mediterranean sources, including the important Sardinian subsources.

Quantitative analysis by XRF requires a flat polished surface to minimize geometric effects: samples are usually removed as powder and pelletized but only one study using this destructive method on excavated archaeological artifacts from the western Mediterranean has been published (Francaviglia & Piperno 1987; data reproduced in Appendix A, Table A8). Destructive sampling has also been used on archaeological surface collections in two instances (Francaviglia 1984 and Dyson et al. 1990; data reproduced in Appendix A, Tables A5 and A10, respectively). Of particular note are recent XRF analyses of selected elements by Crisci et al. (1994) on 138 whole artifacts, and my study (with R. Kunselman) on 36 whole samples (*infra*, chapter 5), which demonstrate the capability of this method in distinguishing among all Mediterranean sources in a non-destructive way. Crisci et al. (1994), however, rely on multiple plots of trace element ratios, rather than absolute concentrations, making their results difficult to compare with other studies, and precluding the use of multivariate statistics for both source characterization and probability testing of source attributions. The same holds true for energy dispersive XRF using an SEM (Gill & Warren 1983; Biró et al. 1986).

Advances in analytical instrumentation in recent years have added new techniques to the list of those appropriate for provenance studies, while improving the precision, accuracy and speed of well-known methods. Inductively coupled plasma - atomic emission spectroscopy (ICP-AES, also just ICP-S) is routinely used for the analysis of 35-40 elements (Walsh & Howie 1986; Hatcher et al. 1995), and its applicability to archaeological materials - including Mediterranean obsidian - has already been demonstrated (Heyworth et al. 1988). Beam techniques such as proton-induced X-ray emission (PIXE) are commonly employed for spot analyses (Duerden et al. 1986; Fleming & Swann 1988), which are more than satisfactory for homogeneous materials like obsidian. These and other methods can be successfully applied to Mediterranean provenance studies if analyses of geological obsidian samples from all potential sources define the groups to which unknowns are attributed, or if repeated analyses of reference materials demonstrate compatibility with data produced in other laboratories. For the western Mediterranean, very specific provenance information for the Sardinian sources would be extremely useful for the reconstruction of procurement behavior, since it could reflect organized and/or localized quarrying activities, restrictions on access to sources, and selectivity in the raw material chosen for tool manufacture. At minimum, artifacts of Sardinian obsidian should be attributed to one of three subgroups (SA, SB or SC), while the possibility that these multiple-locality sources could be further subdivided is investigated in the following chapter.

CHAPTER FIVE: ANALYSIS & CHARACTERIZATION OF OBSIDIAN SOURCES

Resolution is clearly the most important consideration in the characterization of western Mediterranean obsidian sources. In the case of Sardinia at least, a large island with its own indigenous population and culture, the differential exploitation of three source groups has already been noted, while obsidian outcrops have been found in multiple, discontinuous localities, especially along the western flanks of Monte Arci. Geological specimens collected during my survey of these source areas were chemically analyzed, to investigate whether additional geological subgroups could be defined, and subsequently to serve as references for the provenance attribution of archaeological samples. My intention of analyzing many hundreds of artifacts constrained the choice of analytical methods for reasons of time, expense, and the need to be minimally destructive to ancient materials.

Many trace elements in obsidian are related to the gross compositional makeup of the parent magmatic material because of their individual chemical volatility and solubility. Many "incompatible" elements are insoluble in solid magmatic phases, and have higher concentrations in the liquid magma (e.g. Sr, Ba, Rb, Cs, La, Ce, Y, Ti, Zr, P, Ta, Nb, Be, B and Li; cf. Cann 1983:238-239). The evolutionary nature of magmas, which continuously incorporate the surrounding crust while forming (crystallizing) new solid rock, results in changing patterns of absorption by different minerals in the solid phases. Both differential crustal contamination and fractional crystallization of the magmatic melt contribute to considerable differences in the concentrations of the incompatible elements in volcanic flows, and these elements are thus particularly useful for obsidian provenance studies. Although water percolating in rock deposits can exchange Sr, Na, K and other elements with volcanic glasses, this effect is much more pronounced in devitrified glass or volcanic ash than in obsidian (Hess 1989:223), and one need not worry about discrepancies between geological specimens and archaeological artifacts deposited under different environmental conditions for the last several thousand years.

Inductively Coupled Plasma - Mass Spectrometry

Inductively coupled plasma - mass spectrometry (ICP-MS) is a relatively new technique in which samples are usually introduced as liquids, atomized and ionized at extremely high temperatures, and the individual atomic species separated magnetically and measured by a detector. In this sense, ICP-MS is similar to ICP-AES, except that individual mass units are measured rather than the energy or wavelength of electromagnetic spectra. There are few mass spectral overlaps, and nearly all can be overcome by analyzing alternative isotopes, whereas overlaps in X-ray spectra, for example, frequently obscure or reduce the analytical precision for many components. ICP-MS can be used both to determine elemental concentrations as well as mass ratios, and several applications have already appeared in the archaeological literature (e.g. Young 1992; Angelini et al. 1993; Gratuze, Giovagnoli et al. 1993; Ulens et al. 1994; Miller et al. 1995; Young & Miller 1995; cf. Tykot & Young 1996 for a complete review). Although mass spectrometers were first used with an ICP source only a decade ago, details on its theoretical and practical aspects are readily available (Jarvis & Jarvis 1985; 1992; Hutton 1986; Potts 1987; Gray 1988; Jarvis 1988; Date & Gray 1989; Jarvis & Gray 1990; Jarvis et al. 1991; Holland & Eaton 1991; 1993; Totland et al. 1992). Only those features pertinent to obsidian studies are discussed further here.

When a sample solution is injected into the torch through a capillary tube, it is atomized and ionized into single-charged ions. Molecular and doubly-charged species are very few, reducing the otherwise significant problem of matrix effects well-known in other analytical techniques. The ions are then passed into a quadrupole mass spectrometer for separation and measurement. The entire mass range may be scanned by the detector in about one second, with an accumulation of 50 scans producing in a few minutes a simple mass spectrum, theoretically representing all elements (and their isotopes) in the periodic table except H, He, C, N, O, F, Ne, Cl and Ar. Unfortunately for the analysis of silicate materials, precision is somewhat reduced for Fe and Ca because of mass spectral overlaps with their major isotopes. For other elements, solution detection limits are much lower than for other analytical methods, typically on the order of 1 ppb for light elements, and 50 parts per trillion for heavy elements. Some ICP mass spectrometers are now equipped with graphite furnaces, lowering detection limits into the low parts per trillion range. Precision is on the order of ± 2-4% for most elements (Longerich et al. 1990; Jarvis & Jarvis 1992), and extensive analyses of U.S.G.S. basalt and andesite reference materials have accuracies better than 3% for 18 of 28 elements tested, with only 1 element differing by more than 7% from published values (Jenner et al. 1990). ICP-MS is therefore comparable to NAA and XRF in precision and accuracy, but can rapidly produce quantitative data for a greater number of major and trace elements (including rare earth elements, platinum group elements, Ag, Au, Th, and U) than any other single technique. The combination of small sample size (less than 100 mg are required for the analysis of homogeneous materials like obsidian) and low per sample cost allows assemblages of artifacts rather than individual objects to be analyzed, while the number of elements that can be determined makes ICP-MS particularly suitable for establishing source groups in provenance studies.

ICP-MS can also be used with a laser ablation device, which can remove from a solid specimen a tiny sample from a spot much less than 1 mm in diameter, sending it directly to the ICP source (Hutton 1986; Arrowsmith 1987). Although this method saves all the preparation time involved in dissolving a silicate sample, results are not nearly as precise, and detection limits are "only" in the ppm range, although the precision may be sufficient for provenance studies of homogeneous materials like obsidian (Gratuze, Giovagnoli et al. 1993). While the small amount of sample ablated makes this technique minimally destructive - an important consideration for archaeological materials - samples must nevertheless fit inside the ablation chamber, which is less than 4 cm in diameter.

Nearly 200 geological samples from more than 20 Monte Arci source localities, plus a number of archaeological specimens, were ultrasonically cleaned in distilled and deionized water, and dried at 60 °C. Each sample was then pulverized at liquid nitrogen temperatures for 2.5 minutes using a SPEX 6700 freezer mill. 100 mg of the powdered sample were weighed into the inner Teflon beaker of an acid digestion bomb (Parr Instrument Co., Moline, Illinois). 0.2 mL of aqua regia (1:3 concentrated nitric:hydrochloric acid) were used to wet each sample; 2.5 mL of hydrofluoric acid were added and the bomb sealed. Bombs were heated at 120 °C for 2 hours, increasing the internal pressure to several tens of atmospheres, causing minerals which are resistant to attack at normal pressures to decompose. After cooling, the digestion bombs were carefully opened, their contents quantitatively transferred to a 250 mL polypropylene volumetric flask already half-filled with twice-distilled and deionized water, and the sample solution brought up to volume. Samples of less than 100 mg were diluted proportionally so that solution concentrations were similar for all samples, with elements of interest present in concentrations of about 500 ppb or less. The Teflon containers were cleaned by soaking in a concentrated nitric acid bath for several hours before reuse.

Immediately prior to analysis, 100 μL of a 10 ppm ^{115}In solution were added to a 10 mL aliquot of each sample as an internal spike. All analyses were done using the Fisons PQ 2 Plus instrument located in the Department of Earth and Planetary Sciences at Harvard University. Since the purpose of these analyses was to determine the number of obsidian source groups which could be chemically identified, rather than their quantitative characterization, calibration curves were produced for only a few elements (using single and multi-element standards) and each sample was analyzed at a single concentration. Data were collected for ^{26}Mg, ^{44}Ca, ^{45}Sc, ^{48}Ti, ^{52}Cr, ^{55}Mn, ^{57}Fe, ^{58}Ni, ^{59}Co, ^{61}Ni, ^{64}Zn, ^{65}Cu,

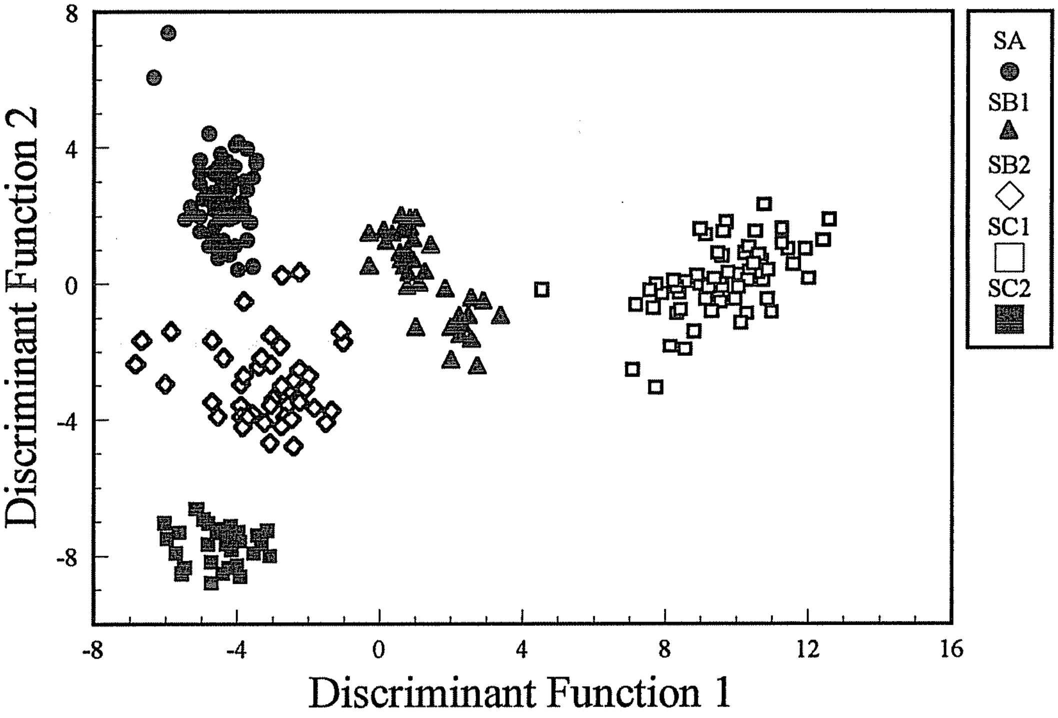
^{66}Zn, ^{75}As, ^{78}Se, ^{85}Rb, ^{88}Sr, ^{89}Y, ^{98}Mo, ^{109}Ag, ^{111}Cd, ^{137}Ba, ^{138}Ba, ^{139}La, ^{140}Ce, ^{141}Pr, ^{145}Nd, ^{147}Sm, ^{151}Eu, ^{157}Gd, ^{159}Tb, ^{162}Dy, ^{165}Ho, ^{166}Er, ^{169}Tm, ^{174}Yb, ^{175}Lu, ^{202}Hg, ^{208}Pb, ^{232}Th, and ^{238}U, and the uncorrected peak integrals for each sample solution were checked for consistency in the measurement of the indium spike, against which all other elements are corrected for detector drift. The average value of several acid blanks was then subtracted from that of all sample solutions, and the resulting solution concentration values were multiplied by the dilution factor (approximately 1:2500) to reproduce the elemental concentrations in the solid obsidian sample. The NIST standard obsidian SRM-278 (cf. Glascock 1991 for accepted values), prepared in the same way as the other samples, was also analyzed, and shows that the detector response was not linear over different concentration levels, and the data produced (Appendix D) should not be considered indicative of the actual composition of the samples although in most cases they are reasonably close. For true quantitative analysis, calibration curves for each element of interest must be produced, while the averaging of replicate samples (ideally at different concentrations) or the use of standard addition would significantly enhance precision.

The ICP-MS results are nevertheless useful for establishing the number of differentiable source groups present. Exploratory graphical and statistical analysis of the data, including cluster, principal components and discriminant analysis using the Statgraphics Plus (version 6) program, failed to reveal further meaningful subdivisions besides the five source groups already identified by Mackey & Warren (1983; SA, SC and two SB groups) and Francaviglia (1984; SA, SB and two SC groups). A bivariate plot of the first two discriminant functions (Figure 15) shows these groups to be quite distinct. The source localities of the geological samples are as follows: SA (Conca Cannas quarries plus surface finds from Su Paris de Monte Bingias and near Monte Sparau south); SB1 (Cuccuru Porcufurau, Punta Nigola Pani, Punta Su Zippiri, and Monte Sparau north); SB2 (Cucru Is Abis, Seddai and Bruncu Perda Crobina); SC1 (Punta Pizzighinu, plus secondary deposits near Perdas Urias, Mitza Sa Tassa, and Santa Pinta, and surface finds near Su Varongu and Mitza Troncheddu); and SC2 (secondary deposits near Perdas Urias and Santa Pinta). Not illustrated is a sixth group, Ceca 1 (Pala Sa Murta quarry), which was the only one of the four unworked sources identified by Francaviglia (1984) and Herold (1986) that I tested. The discovery that both SC1 and SC2 obsidian, with extremely similar chemical characteristics except for Sr concentration, can be found together in detrital contexts in the Santa Pinta area, suggests that the distinction between the two SC types is unimportant for archaeological purposes, since it would have been impossible to select one type over the other and both occur within the same area.

X-Ray Fluorescence (XRF)

Thirty-six geological obsidian specimens were quantitatively analyzed by X-ray fluorescence spectroscopy in order to confirm that the source groups determined above by ICP-MS were identical with those established by Mackey & Warren (1983), Francaviglia (1984) and Herold (1986). XRF (Williams 1987; Jenkins 1988) is a well-known geochemical technique in which incident X-rays

Figure 15. Discriminant analysis of ICP-MS data for Monte Arci (Sardinia) obsidian sources. The discriminant functions are derived from the elemental concentrations of Ba, Mn, Sc, Rb, Sr, Y, La, Ce, Pr, Nd, Eu, Gd, Tb, Dy and Ho.



directed at a sample remove an inner shell electron; when an outer shell electron fills the vacancy, secondary X-rays are produced. Since the energy levels for each shell and the differences between shells are characteristic of individual elements, the intensity of particular X-ray energies or wavelengths is proportional to the concentration of each element in the sample. Detection limits are in the low ppm range for most elements; with an evacuated sample chamber, elements with atomic numbers as low as 6 may be analyzed. The analyses reported here were performed by Ray Kunselman in the Department of Physics and Astronomy at the University of Wyoming.

Cleaned samples were analyzed whole for Rb, Sr, Y, Zr, Nb and Fe_2O_3 with Kα peak areas obtained relative to the Compton scattering produced from all the electrons in the sample material. The samples were excited for 20 minutes using L-series tungsten X-rays with a production tube current of 2 microamps. Where necessary, background Kβ peaks produced by other elements were subtracted from the raw counts for elements of interest, and detector efficiency conversion constants determined from the analysis of calibrated standards at each particular energy were used to convert the net counts into ppm concentrations (Appendix E). The statistical uncertainty for each measurement is 1% for Fe_2O_3; 2% for Rb, Sr and Zr; 4% for Y; and 5% for Nb. Systematic uncertainties are somewhat greater: ± 4 ppm for Rb and Sr; ± 6 ppm for Zr; ± 8 ppm for Y; ± 9 ppm for Nb; and ± 0.04% for Fe_2O_3. The combined absolute error (square root of sum of squares) for the Sardinian samples is, therefore, less than ± 7 ppm for Rb; ± 5 ppm for Sr; ± 10 ppm for Y and Nb; ± 9 ppm for Zr; and ± 0.04% for

Fe_2O_3. Precision is therefore of the same order as the standard deviation for the multiple samples analyzed and only a fraction of the reported values (Table X).

The trace elements analyzed here have been shown to be good obsidian source discriminators in other parts of the world (e.g. Kunselman 1991), and in the western Mediterranean in particular (Crisci et al. 1994). Discriminant analysis of the data for all six elements provides clear separation of the Sardinian subsources (Figure 16). Sr would likely have separated the two SC subsources (Francaviglia 1984; my ICP-MS data, *supra*) had both been present among the samples tested, although this is not an important distinction as discussed above. The average values for the Monte Arci sources analyzed compare favorably with published XRF data produced by other researchers (*infra*, Tables XVI-XXI) and demonstrates the equivalency of my source definitions with those previously determined.

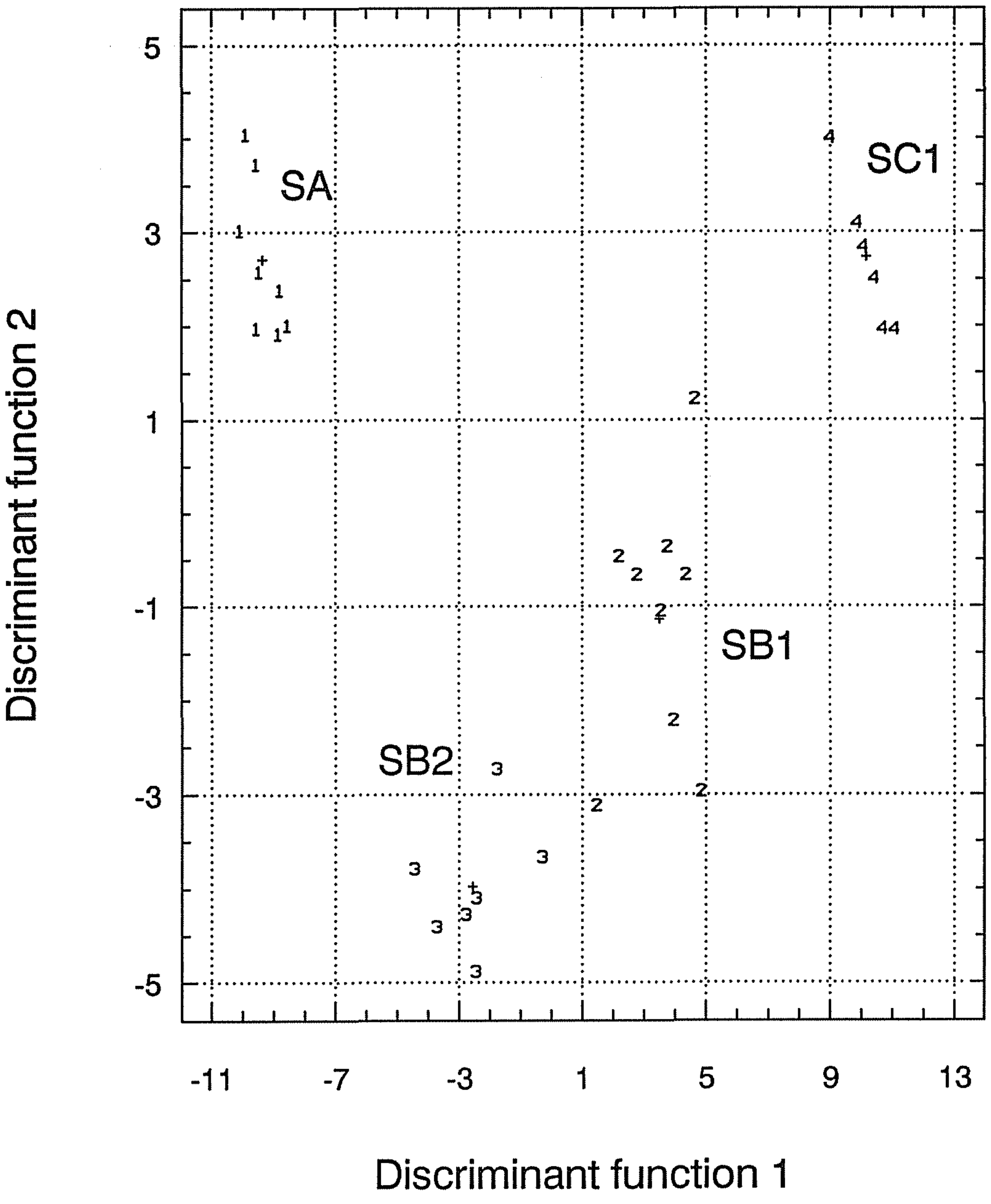
Electron Probe Microanalysis

Obsidians, by definition, have relatively limited ranges in their bulk element composition. Simple bivariate plots of major elements will not separate all of the recognized sources the way trace elements do, but Francaviglia (1984; 1988; Francaviglia & Piperno 1987) has successfully employed a multi-element transformation of major element data to differentiate not only the different island sources (Sardinia, Li, PI, Pa, Melos, Giali) but even several sub-sources on Pantelleria and both Sta Nychia and Demenegaki on Melos. Furthermore, the combined data of Mackey & Warren (1983), Francaviglia (1984), Michels et al.

Source		**Rb**	**Sr**	**Y**	**Zr**	**Nb**	**Fe_2O_3**
		ppm	ppm	ppm	ppm	ppm	%
SA	ave.	249	26	37	91	60	1.36
(n=8)	±	13	4	5	5	4	0.06
SB1	ave.	231	96	27	177	44	1.70
(n=9)	±	13	11	7	26	5	0.07
SB2	ave.	247	42	20	124	42	1.38
(n=7)	±	9	10	4	16	1	0.04
SC1	ave.	161	145	26	261	36	1.81
(n=6)	±	8	5	4	12	4	0.03
Cecal		292	0	53	231	82	1.40
(n=1)							
Li	ave.	288	8	43	185	38	1.71
(n=2)							
Pal		131	0	128	1559	233	8.01
(n=1)							

Table X. Summary of XRF Analyses for Sardinian Obsidian.

Figure 16. Discriminant analysis of XRF data for Monte Arci (Sardinia) obsidian sources. Discriminant function 1 = 7.52155 + 0.00884Rb + 0.20961Sr - 0.09268Y - 0.05286Zr - 0.19535Nb - 3.27185Fe_2O_3. Discriminant function 2 = -3.31924 - 0.09743Rb - 0.07656Sr + 0.13058Y + 0.02413Zr + 0.23566Nb + 8.08608Fe_2O_3.



(1984), and Herold (1986) indicated that major elements are sufficient to differentiate the 4 major Sardinian flows (SA, SB1, SB2, SC), so that at least in the Mediterranean all useful source distinctions can be made without resorting to trace element techniques. Electron probe microanalysis using wavelength dispersive X-ray spectrometers was selected as the method of choice for analyzing large numbers of archaeological artifacts since only a tiny 1-2mm sample needs to be removed, sample preparation is minimal, the precision of the microprobe is superior to laser ablation ICP-MS, and the per-sample cost is a fraction of the price of XRF or NAA (for similar reasoning, cf. Michels 1982; Merrick & Brown 1984a; 1984b; Biró & Pozsgai 1984; Biró et al. 1986; Keller & Seifried 1990). Although recent studies indicate that energy dispersive spectrometry can also produce excellent quantitative results for ancient glassy materials (Verità et al. 1994; Acquafredda et al. 1995), TiO_2, MgO, MnO, P_2O_5, and BaO are below the minimum detection limits of EDS systems, and at least TiO_2, MgO, and BaO are important discriminators among western Mediterranean obsidian sources.

Electron probe microanalysis is a technique widely used in the geological sciences to determine the major and minor element concentrations of selected areas of samples mounted in thin section (Loretto 1984; Potts 1987; Goldstein 1992). The polished surface of the sample, and the narrow diameter of the electron beam, allow for the quantitative analysis of individual minerals or grains in the sample, although the detection limits are 50-100 times poorer than those expected with X-ray fluorescence.

Cylinders one inch in diameter were made using Epotek two-part epoxy, and allowed to harden for 48 hours. Up to 18 holes 2mm in diameter and 3mm in depth were drilled in the flat surface of the hardened disk, fresh epoxy was poured into the holes, and the disk was evacuated to remove air bubbles. Obsidian samples, cut earlier with a fast-speed diamond saw if necessary, were inserted in the holes (filled with still-wet epoxy), and covered with an additional layer of wet epoxy. The entire disk was allowed to harden for 48 hours before a series of successively finer grit grinding papers were used to produce a flat surface in which all samples were visible. 10- and then 1-micron diamond paste were used to fine polish the surface. A one-eighth inch thick slice containing the polished obsidian samples was cut off using a slow-speed Isomet saw, and the excess epoxy cylinder discarded. All sample disks were carbon-coated prior to analysis to minimize local surface charging under the electron beam.

Samples were analyzed primarily using the Cameca MBX electron microprobe in the Department of Earth & Planetary Sciences at Harvard University. The Cameca MBX uses a Tracor Northern computer control system, and quantitative wavelength dispersive analysis is performed using a Harvard-modified version of Sandia TASK8. A small number of samples were analyzed using the JEOL Superprobe 733 in the Department of Earth, Atmospheric & Planetary Sciences at the Massachusetts Institute of Technology.

Samples were excited by a relatively wide (40 micron) 15 keV electron beam. Electrons from the beam interact with the sample atoms in a balloon-shaped volume of several hundred cubic microns. Some primary electrons are deflected as backscattered electrons, while others ionize sample atoms near the sample surface; the ionization of inner (K, L, M, N) orbital electrons, which ultimately fall back into their stable energy levels, results in the emission of X-rays of characteristic wavelength. It is the background continuum of X-radiation produced by deceleration of the primary electrons that limits the sensitivity of this technique to the detection of major and minor elements. The X-radiation was measured by wavelength dispersive spectrometry (WDS) using TAP (thallium acid phthalate), PET (penta-erythritol) and LiF (lithium fluoride) crystals, with counting times of 10-80 seconds per element. The measured X-ray intensities were corrected for matrix effects, absorption, and secondary fluorescence by the Bence-Albee correction program. All analyses were internally calibrated against international standards, and a laboratory reference material (hornblende) was repeatedly measured to insure consistency between analytical sessions (Appendix F, Table F1).

125 geological obsidian samples were analyzed for SiO_2, Al_2O_3, TiO_2, Fe_2O_3, MgO, CaO, Na_2O, K_2O, MnO, P_2O_5, and BaO. For quantitative bulk analysis of most rock samples, it would be necessary to pulverize the sample and fuse the powder into homogeneous glass beads. Obsidian, however, with no significant mineral growth, is already extremely homogeneous. Ten replicate analyses each of several Monte Arci samples (Appendix F, Table F2, samples 279-282 and 315) demonstrates this to be true for Sardinian obsidian. Nevertheless, at least three points per sample were tested, in case a phenocryst contributed to the analysis; it was necessary to purge the results of only a few of the 433

analyses (Appendix F, Table F2). Furthermore, the broad 40-micron beam minimized the influence of tiny microlite inclusions (typically high in iron) on the overall composition of the sample, as well as to prevent the heat-induced decomposition of alkali elements during analysis. For each sample, the three (or more) analyses were each normalized to total 99.00% (allowing 1% for water and trace elements) and then averaged (Appendix F, Table F3).

Type SA obsidian (Table XI) is characterized by relatively high concentrations of SiO_2, and lower concentrations of TiO_2, MgO, and K_2O than the other Monte Arci sources. Type SB1 obsidian (Table XII) has less SiO_2, and slightly more of the other elements analyzed, while type SB2 (Table XIII) is similar to type SA but has less Al_2O_3 and slightly more TiO_2, MgO, and K_2O. Type SC obsidian (Table XIV) has very low concentrations of SiO_2 and the highest concentrations of the other elements analyzed except Na_2O.

Comparison of the average values for the western Mediterranean sources (Table XV) reveals that K_2O concentration alone can often distinguish SA from SB from SC (5.24 ± 0.12; 5.48 ± 0.17; and 5.89 ± 0.34 %, respectively); SB1 has 1.2% lower SiO_2 and 0.7% higher Al_2O_3 than SB2; and type SC obsidian is distinguished from all other western Mediterranean obsidians by its high Al_2O_3 (13.9%), MnO (0.14%), and BaO (0.11%). All four of these types are easily distinguished from Lipari, Palmarola, and Ceca-type (unworked) obsidian by their Na_2O concentrations (<3.5 vs. >4%), while the peralkaline obsidian from Pantelleria is easily distinguished by its extremely low SiO_2, Al_2O_3, and CaO, and its extremely high Fe_2O_3 and Na_2O concentrations. Two of the Pantellerian sub-

Cat.	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MgO	CaO	Na_2O	K_2O	MnO	P_2O_5	BaO	Total
187	74.66	13.46	0.10	1.24	0.09	0.59	3.49	5.24	0.08	0.05	0.01	99.00
188	74.75	13.47	0.10	1.12	0.07	0.58	3.45	5.31	0.08	0.05	0.02	99.00
189	74.65	13.46	0.10	1.23	0.08	0.59	3.43	5.30	0.08	0.04	0.03	99.00
190	74.53	13.56	0.10	1.27	0.09	0.60	3.43	5.28	0.08	0.05	0.01	99.00
191	74.55	13.53	0.09	1.27	0.06	0.62	3.49	5.21	0.09	0.06	0.02	99.00
192	74.78	13.39	0.09	1.23	0.07	0.59	3.36	5.32	0.09	0.06	0.03	99.00
193	74.69	13.42	0.09	1.24	0.08	0.59	3.40	5.32	0.07	0.06	0.04	99.00
194	74.69	13.42	0.09	1.29	0.08	0.59	3.44	5.26	0.08	0.05	0.02	99.00
544	74.87	13.46	0.10	1.14	0.06	0.57	3.39	5.27	0.09	0.06	0.01	99.00
545	75.16	13.27	0.09	1.16	0.06	0.55	3.36	5.21	0.08	0.05	0.00	99.00
546	74.68	13.46	0.09	1.24	0.08	0.60	3.44	5.25	0.09	0.05	0.03	99.00
547	74.91	13.44	0.08	1.12	0.05	0.57	3.49	5.16	0.09	0.05	0.04	99.00
548	75.18	13.38	0.09	1.05	0.05	0.55	3.39	5.13	0.09	0.05	0.02	99.00
624	75.04	13.43	0.08	1.13	0.07	0.53	3.40	5.13	0.09	0.06	0.04	99.00
625	74.62	13.55	0.10	1.25	0.08	0.57	3.41	5.27	0.08	0.05	0.02	99.00
626	74.81	13.52	0.09	1.18	0.09	0.57	3.43	5.18	0.09	0.04	0.00	99.00
628	74.65	13.72	0.08	1.13	0.08	0.61	3.58	5.01	0.08	0.04	0.01	99.00
629	74.73	13.49	0.10	1.27	0.09	0.58	3.39	5.21	0.08	0.05	0.01	99.00
668	74.48	13.58	0.09	1.25	0.09	0.56	3.46	5.34	0.09	0.06	0.00	99.00
669	74.88	13.26	0.09	1.27	0.05	0.59	3.38	5.34	0.07	0.06	0.01	99.00
654	74.68	13.46	0.09	1.23	0.05	0.60	3.49	5.26	0.07	0.06	0.01	99.00
655	74.60	13.49	0.09	1.19	0.06	0.59	3.49	5.32	0.08	0.06	0.02	99.00
656	74.85	13.35	0.09	1.23	0.07	0.59	3.38	5.28	0.07	0.05	0.03	99.00
185	74.85	13.53	0.07	1.19	0.11	0.59	3.40	5.07			0.03	98.84
186	75.12	13.36	0.06	1.25	0.08	0.56	3.30	5.11			0.02	98.85
217	74.77	13.60	0.07	1.27	0.11	0.60	3.37	5.04			0.02	98.85
315	75.29	13.25	0.06	1.29	0.08	0.56	3.36	4.95			0.02	98.85
279	74.73	13.47	0.11	1.20	0.06	0.58	3.32	5.39				98.85
280	74.71	13.48	0.10	1.21	0.08	0.57	3.30	5.41				98.85
281	74.72	13.39	0.10	1.29	0.08	0.58	3.35	5.33				98.85
282	74.63	13.43	0.09	1.28	0.07	0.59	3.30	5.45				98.85
315	74.59	13.49	0.09	1.30	0.09	0.59	3.35	5.35				98.85
Ave	74.78	13.46	0.09	1.22	0.08	0.58	3.41	5.24	0.08	0.05	0.02	99.00
S.D.	0.19	0.10	0.01	0.06	0.02	0.02	0.06	0.12	0.01	0.01	0.01	

Table XI. Electron Probe Microanalysis Data for Type SA Obsidian.

Cat.	**SiO_2**	**Al_2O_3**	**TiO_2**	**Fe_2O_3**	**MgO**	**CaO**	**Na_2O**	**K_2O**	**MnO**	**P_2O_5**	**BaO**	**Total**
683	73.26	13.84	0.20	1.68	0.21	0.98	3.50	5.12	0.13	0.04	0.05	99.00
684	73.86	13.72	0.16	1.30	0.13	0.79	3.50	5.34	0.10	0.05	0.05	99.00
685	73.55	13.64	0.17	1.62	0.17	0.78	3.47	5.40	0.11	0.05	0.04	99.00
688	74.34	13.53	0.14	1.17	0.08	0.72	3.35	5.47	0.09	0.05	0.06	99.00
689	73.85	13.54	0.16	1.53	0.14	0.76	3.47	5.33	0.10	0.05	0.07	99.00
708	73.49	13.65	0.19	1.57	0.16	0.72	3.31	5.68	0.12	0.03	0.08	99.00
710	74.16	13.77	0.18	0.81	0.06	0.74	3.34	5.71	0.12	0.04	0.07	99.00
711	73.67	13.69	0.18	1.39	0.15	0.74	3.27	5.74	0.11	0.04	0.02	99.00
713	73.98	13.62	0.15	1.32	0.13	0.77	3.47	5.40	0.07	0.06	0.03	99.00
714	73.55	13.69	0.19	1.48	0.16	0.76	3.30	5.63	0.12	0.04	0.08	99.00
722	73.88	13.68	0.15	1.29	0.12	0.70	3.43	5.60	0.09	0.03	0.03	99.00
723	74.08	13.64	0.14	1.27	0.13	0.75	3.42	5.43	0.09	0.04	0.01	99.00
724	73.95	13.54	0.14	1.53	0.10	0.73	3.36	5.47	0.10	0.05	0.02	99.00
725	74.11	13.56	0.15	1.27	0.10	0.75	3.37	5.48	0.10	0.06	0.05	99.00
726	74.05	13.64	0.15	1.28	0.10	0.76	3.37	5.46	0.09	0.06	0.04	99.00
729	73.22	13.80	0.25	1.31	0.16	0.83	3.58	5.62	0.11	0.03	0.08	99.00
734	74.40	13.49	0.13	1.18	0.08	0.70	3.28	5.57	0.09	0.05	0.03	99.00
735	74.13	13.54	0.14	1.30	0.13	0.74	3.30	5.54	0.09	0.05	0.02	99.00
736	74.59	13.46	0.14	1.05	0.06	0.69	3.50	5.33	0.09	0.03	0.06	99.00
737	74.38	13.52	0.14	1.21	0.07	0.72	3.48	5.33	0.07	0.04	0.04	99.00
Ave	73.93	13.63	0.16	1.33	0.12	0.76	3.40	5.48	0.10	0.04	0.05	99.00
S.D.	0.37	0.10	0.03	0.20	0.04	0.06	0.09	0.15	0.02	0.01	0.02	

Table XII. Electron Probe Microanalysis Data for Type SB1 Obsidian

Cat.	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MgO	CaO	Na_2O	K_2O	MnO	P_2O_5	BaO	Total
310	75.48	12.94	0.11	1.12	0.10	0.54	3.28	5.23	0.11	0.07	0.03	99.00
311	75.34	13.06	0.11	1.10	0.10	0.54	3.33	5.27	0.10	0.04	0.02	99.00
312	75.47	12.99	0.12	1.06	0.10	0.56	3.22	5.29	0.12	0.06	0.02	99.00
313	75.47	12.99	0.12	1.06	0.10	0.56	3.22	5.29	0.12	0.06	0.02	99.00
314	75.19	13.07	0.12	1.09	0.14	0.59	3.37	5.25			0.03	98.85
742	74.99	13.02	0.13	1.25	0.10	0.56	3.39	5.42	0.08	0.04	0.02	99.00
743	75.08	12.98	0.11	1.29	0.09	0.57	3.34	5.41	0.08	0.04	0.01	99.00
745	74.71	13.16	0.15	1.21	0.13	0.60	3.40	5.49	0.08	0.04	0.03	99.00
747	74.08	13.56	0.13	1.32	0.13	0.67	3.37	5.54	0.09	0.06	0.05	99.00
756	75.12	13.05	0.14	1.06	0.12	0.59	3.33	5.47	0.07	0.03	0.02	99.00
757	74.44	13.22	0.16	1.25	0.14	0.65	3.27	5.73	0.08	0.03	0.03	99.00
759	74.66	13.23	0.15	1.02	0.10	0.60	3.39	5.68	0.09	0.04	0.04	99.00
760	74.63	13.24	0.15	1.14	0.13	0.62	3.30	5.63	0.08	0.04	0.04	99.00
761	74.45	13.22	0.15	1.24	0.14	0.60	3.19	5.86	0.07	0.05	0.03	99.00
821	75.01	13.00	0.13	1.17	0.12	0.59	3.32	5.52	0.08	0.03	0.03	99.00
822	74.84	13.06	0.14	1.35	0.11	0.60	3.30	5.46	0.07	0.03	0.04	99.00
823	74.73	13.09	0.14	1.24	0.12	0.60	3.41	5.51	0.08	0.04	0.04	99.00
824	74.94	13.08	0.13	1.23	0.11	0.59	3.30	5.51	0.07	0.03	0.01	99.00
825	74.96	13.03	0.13	1.23	0.11	0.60	3.31	5.49	0.08	0.05	0.01	99.00
Ave	74.93	13.10	0.13	1.18	0.12	0.59	3.32	5.48	0.09	0.04	0.03	99.00
S.D.	0.37	0.14	0.01	0.10	0.01	0.03	0.06	0.17	0.02	0.01	0.01	

Table XIII. Electron Probe Microanalysis Data for Type SB2 Obsidian

Cat.	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MgO	CaO	Na_2O	K_2O	MnO	P_2O_5	BaO	Total
195	72.65	13.89	0.28			0.81	3.19	6.07	0.11	0.07		98.90
205	72.73	13.90	0.25			0.79	3.35	5.90	0.11	0.03		98.90
206	72.41	14.06	0.29	1.81	0.30	0.87	3.21	5.76	0.12	0.06	0.11	99.00
212		14.10	0.28			0.80	3.34	5.82	0.11	0.05	0.12	99.00
901	72.57	13.84	0.29	1.71	0.26	0.85	3.24	5.93			0.14	98.85
902	72.97	13.78	0.26	1.39	0.16	0.85	3.24	6.12			0.09	98.85
936	72.65	13.91	0.29	1.52	0.21	0.84	3.31	5.95	0.14	0.03	0.12	99.00
946	72.44	14.09	0.28	1.50	0.25	0.93	3.34	5.92	0.14	0.03	0.10	99.00
947	72.27	14.08	0.29	1.67	0.29	0.89	3.28	5.96	0.13	0.02	0.11	99.00
948	72.32	14.02	0.29	1.64	0.29	0.86	3.28	6.03	0.13	0.03	0.10	99.00
949	72.36	14.06	0.28	1.57	0.24	0.95	3.29	5.96	0.15	0.03	0.11	99.00
950	72.80	13.95	0.24	1.50	0.21	0.81	3.24	6.01	0.13	0.03	0.08	99.00
967	72.58	14.03	0.29	1.39	0.22	0.87	3.23	6.09	0.15	0.02	0.14	99.00
968	72.54	14.00	0.29	1.52	0.22	0.87	3.36	5.95	0.14	0.03	0.08	99.00
969	72.40	14.08	0.29	1.72	0.27	0.89	3.32	5.79	0.13	0.03	0.09	99.00
970	72.45	13.97	0.28	1.78	0.26	0.86	3.24	5.89	0.14	0.04	0.09	99.00
971	72.04	14.21	0.31	1.80	0.27	0.94	3.26	5.91	0.13	0.03	0.09	99.00
974	73.00	14.14	0.18	1.12	0.11	0.90	3.60	5.62	0.17	0.03	0.14	99.00
976	72.45	14.09	0.29	1.49	0.09	0.91	3.18	6.15	0.18	0.04	0.14	99.00
977	73.34	13.89	0.23	1.11	0.08	0.82	3.27	6.00	0.13	0.03	0.09	99.00
978	72.75	14.00	0.25	1.31	0.13	0.88	3.37	6.07	0.14	0.01	0.09	99.00
979	73.28	13.81	0.22	1.43	0.13	0.75	3.18	5.91	0.13	0.05	0.11	99.00
986	72.71	13.86	0.28	1.51	0.23	0.89	3.32	5.93	0.13	0.03	0.10	99.00
991	72.57	13.92	0.28	1.55	0.24	0.89	3.21	6.05	0.14	0.02	0.12	99.00
992	72.33	14.20	0.30	1.46	0.23	0.88	3.26	6.07	0.15	0.04	0.09	99.00
993	72.30	14.20	0.29	1.42	0.28	0.98	3.31	5.90	0.15	0.02	0.16	99.00
994	72.29	14.14	0.29	1.54	0.25	0.98	3.33	5.89	0.14	0.03	0.13	99.00
995	72.09	14.11	0.28	1.86	0.33	1.18	3.67	5.22			0.10	98.85
996	72.69	13.74	0.29	1.66	0.21	0.87	3.29	6.03			0.08	98.85
997	72.53	14.20	0.27	1.60	0.28	1.31	4.50	4.05			0.12	98.85
1001	72.22	14.05	0.30	1.70	0.26	0.97	3.37	5.91			0.06	98.85
1002	72.63	13.87	0.29	1.49	0.20	0.90	3.37	5.96			0.14	98.85
1003	72.25	13.99	0.42	1.61	0.17	0.97	3.35	6.02			0.08	98.85
1004	72.57	14.02	0.28	1.40	0.17	0.98	3.30	6.05			0.08	98.85
1005	72.83	13.89	0.29	1.42	0.09	0.88	3.33	6.02			0.10	98.85
1006	72.54	13.75	0.29	1.73	0.24	0.86	3.28	6.04			0.12	98.85
1026	72.86	13.98	0.19	1.31	0.11	1.08	3.50	5.72			0.11	98.85
1027	72.58	13.80	0.28	1.69	0.26	0.89	3.33	5.90			0.12	98.85
1728	72.70	13.97	0.28	1.49	0.21	0.87	3.25	6.00	0.09	0.05	0.00	98.90
Ave	72.57	13.99	0.28	1.54	0.21	0.91	3.34	5.89	0.14	0.03	0.10	99.00
S.D.	0.28	0.13	0.04	0.17	0.06	0.10	0.21	0.34	0.02	0.01	0.03	

Table XIV. Electron Probe Microanalysis Data for Type SC Obsidian

Source		SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MgO	CaO	Na_2O	K_2O	MnO	P_2O_5	BaO	Total
SA	ave	74.72	13.40	0.09	1.25	0.08	0.59	3.44	5.26	0.08	0.06	0.02	99.00
	sd	0.26	0.15	0.01	0.09	0.01	0.04	0.16	0.22	0.01	0.01	0.02	
	n	207	207	207	207	207	207	207	207	60	60	202	
SB1	ave	73.87	13.63	0.17	1.33	0.12	0.75	3.38	5.55	0.10	0.04	0.05	99.00
	sd	0.35	0.10	0.03	0.20	0.04	0.06	0.10	0.20	0.02	0.01	0.02	
	n	26	26	26	26	26	26	26	26	21	21	26	
SB2	ave	75.05	12.97	0.13	1.17	0.11	0.57	3.34	5.51	0.08	0.04	0.02	99.00
	sd	0.33	0.15	0.02	0.17	0.02	0.02	0.22	0.35	0.01	0.01	0.02	
	n	130	130	130	130	130	130	130	130	81	81	130	
SC	ave	72.71	13.92	0.27	1.53	0.21	0.88	3.30	5.90	0.14	0.03	0.11	99.00
	sd	0.37	0.19	0.03	0.21	0.07	0.10	0.20	0.30	0.01	0.01	0.03	
	n	341	342	342	339	339	342	342	342	120	120	340	
Li	ave	74.51	12.75	0.08	1.63	0.03	0.72	4.03	5.13	0.05	0.06	0.01	99.00
	sd	0.22	0.14	0.01	0.08	0.01	0.04	0.10	0.09	0.05	0.01	0.01	
	n	20	20	20	20	20	20	19	19	9	9	20	
Pa1	ave	70.78	7.47	0.22	8.50	0.01	0.26	7.16	4.23	0.03	0.30	0.03	98.96
	sd	0.10	0.03	0.01	0.05	0.00	0.00	0.11	0.04	0.00	0.01	0.01	
	n	3	3	3	3	3	3	3	3	3	3	3	
Pa2	ave	66.23	10.17	0.61	8.90	0.15	0.53	7.56	4.56	0.05	0.35	0.02	99.00
	sd	0.15	0.70	0.00	0.57	0.02	0.04	0.09	0.16	0.00	0.00	0.01	
	n	2	2	2	2	2	2	2	2	1	1	2	
Ceca	ave	75.40	12.46	0.09	1.40	0.06	0.47	4.21	4.80	0.02	0.06	0.01	99.00
	sd	0.06	0.04	0.02	0.04	0.01	0.00	0.04	0.11	0.00	0.01	0.01	
	n	3	3	3	3	3	3	3	3	2	2	3	

Table XV. Summary of electron probe microanalysis data for geological and archaeological samples.

groups are distinguishable among the small number of samples I tested, with significant differences in SiO_2, Al_2O_3, TiO_2, MgO, and CaO. My Pa1 group corresponds to the Upper Balata dei Turchi flow near the southern coast of Pantelleria, while my Pa2 group corresponds with the less-frequently used pitchy obsidian from Gelkhamar. Multivariate discriminant analysis emphasizes the differences among the Monte Arci sources (*infra*, Figure 17), with the posterior probability of each geological sample belonging to a single source group exceeding 95% in nearly all cases. Unknown (archaeological) samples are similarly attributed to individual source groups with a high degree of statistical confidence.

Visual Sorting

Geological source samples were selected from those collected in the field with an eye towards diversity in appearance. The visual features of each major source group were intensively studied, and several characteristics were recorded for each piece with the hope that visual identification would prove to be of some use in sourcing archaeological material, at least on a preliminary basis. The parameters recorded were color (red, grey, black, clear, green, brown); translucency (a subjective scale from 1 to 5, with 1 = opaque and 5 = transparent); reflectivity (also subjective, with 1 = matte and 5 = shiny); fracture (conchoidal, irregular, pitchy); and the presence of flow banding or visible microlites and phenocrysts. The obvious problem encountered was that the varied thickness and shape of the specimens made it difficult to effectively compare translucency and matrix inclusions, which seemed to be the most important source attributes. My observations are as follows:

Monte Arci type SA has a high translucency index (4), but rarely as high as "non-spotted" SB2 (denser microlite crystals imparting black color in type SA). There is frequent flow banding of microlites, occasionally in very well-defined parallel bands, but phenocrysts are not present. The reflectivity index is also high (4), although there is some "graininess" to surface texture.

Monte Arci type SB1 has a low translucency index (1.5-2) and is usually indistinguishable from opaque type SC. An exceptional piece may be very transparent, while those only modestly translucent may have a mottled pattern of crystallites. The reflectivity index may be lower (2-3) than for type SC, but like type SC external banding can be present. Fortunately for visual identification purposes, type SB1 does not seem to have been used much archaeologically.

Monte Arci type SB2 comes in two visual varieties. The first is spotted, with 1-3 mm diameter phenocrysts, lower translucency index (2.5), high reflectivity (4), and frequent internal banding when visible. The second usually has no phenocrysts, a high translucency index (3-5) with many example virtually as clear as window glass. Some of the transparent type may be confused with SA as they too have some internal microlite flow bands. There are rare examples of opaque light-gray obsidian with very high reflectivity (4.5) and very fine surface texture. Occasionally type SB2 will appear mottled with a slight brownish tint.

Monte Arci type SC has the lowest translucency index (1), and is usually virtually opaque except in the thinnest edges. Its reflectivity index can be high

(3-4), but its surface texture is coarser than SA or SB2. Surface banding (sharply defined alternating grey and black stripes) is common, and occasionally internal flow bands are visible with alternating translucent bands. Rare examples have red streaks; several exceptional pieces are beer-bottle brown with high translucency.

Lipari obsidian has a high translucency index (4-5). It is grey to black in color, and phenocrysts may be very common. Its tint in transmitted light is distinctly different than the transparent Sardinian types SA and SB2.

Pantellerian obsidian is green in transmitted light, but its low translucency index (2) requires a thin edge to determine color.

Obsidian from Palmarola has a low translucency index (2-3). Its surface can appear patinated, shading toward grey and even brown rather than true black in color. Palmarola and the opaque Sardinian types SB1 and SC are the most difficult to distinguish of the island sources, but there are few areas where they are both likely to be found.

The visual characteristics of the western Mediterranean obsidian sources are summarized in the following chart:

Source	**Translucency**	**Reflectivity**	**Other Characteristics**
SA	4	4	visible microlites, flow banding
SB1	1.5-2	2-3	usually indistinguishable from SC
SB2	2.5-5	4-4.5	quite variable, phenocrysts
SC	1	3-4	surface banding frequent
Li	4-5	4-5	tinted; occasional phenocrysts
Pa	2	3-4	green in transmitted light
PI	2-3	3-4	patinated appearance

CHAPTER SIX: ANALYSIS AND CHARACTERIZATION OF ARCHAEOLOGICAL OBSIDIAN

Using the methods described in Chapter 5, I chemically analyzed 649 archaeological obsidian artifacts and visually provenanced an additional 2100 objects, mostly from site collections housed at the Museo Nazionale di Cagliari, the Museo Nazionale di Sassari "G.A. Sanna", the Museo Nazionale Preistorico ed Etnografico "L. Pigorini" in Rome, the Musée de Préhistoire Corse in Sartène, and the University of Cagliari. The many individuals who provided samples or assisted in access to the collections are acknowledged in the Preface.

Samples were examined from the following sites in Sardinia (*infra*, Figure 19): Corte Auda-Senorbì (Usai 1986); Cuccuru s'Arriu-Cabras (Santoni et al. 1982; Santoni 1989); Grotta Filiestru-Mara (Trump 1983); Grotta di San Bartolomeo-Cagliari (Atzeni 1962b); Li Muri-Arzachena (Puglisi 1940-41); Liscia Pilastru-Arzachena (recent excavation by G. Pitzalis); Molia-Illorai (Tanda 1980b; 1984b); Monte d'Accoddi-Sassari (Contu 1953; 1992); Monte Maiore-Thiesi (Lo Schiavo 1976; Foschi Nieddu 1982; 1987); Ortu Còmidu-Sardara (Balmuth 1986); Loc. Pirrotta-Simala (1986 surface collection by M. Piras); Puisteris-Mogoro (Puxeddu 1962); Sa 'Ucca de Su Tintirriolu-Mara (Loria & Trump 1978); San Gemiliano-Sestu (Atzeni 1962a); Santa Gilla-Cagliari (Atzeni 1986); Cala Villamarina-Santo Stefano (Lilliu 1959); San Pietro-Settimo (Atzeni 1958); Su Carroppu-Sirri (Atzeni 1972; 1977); Su Coddu-Selargius (Ugas et al. 1989); and Terramaini-Pirri (Usai 1987). With less certain archaeological contexts (and significance!) are obsidian artifacts from a dozen Sardinian site collections made many decades ago and now in the Pigorini Museum (Lo Schiavo 1980; cf. also Atzori 1960; Lugliè 1989).

Analyzed obsidian from Corsica came from Basi (Bailloud 1969a; 1969b; 1972); I Calanchi-Sollacaro (Cesari 1987; 1988); Campu Ventosu-Bastia (1990 surface collection by J. Magdeleine); Castellari-Rapale (Magdeleine 1974); Dolmen de Cardiccia-Sartène (1989 excavation by P. Nebbia & J.-C. Ottaviani); Filitosa (Atzeni 1966); Monte Grosso-Biguglia (Magdeleine 1973; 1979); Pietracorbara (recent excavations by J. Magdeleine); Saint Pancrace-Tiggianese (1984 survey by J. Cesari, G. & G. Janin; cf. Bonifay 1986); Sarra Cinescu-Castello di Rostino (1990 surface collection by J. Magdeleine); and Strette-Barbaghju (Magdeleine & Ottaviani 1986).

Also provenanced was obsidian from Pianaccia di Suvero (surface collection by R. Maggi); Pianosa-La Scola (Ducci & Perazzi 1991); Poggio Olivastro-Canino (Bulgarelli et al. 1993); Ustica (Holloway & Lukesh 1995); and Île de Zembra (recent excavations by J.D. Vigne). The specific archaeological site context of all the artifacts examined (when known) is given in the sample catalogue (Appendix C, Table C2), and the results of the analyses in Appendix H, Tables H1 and H2).

Inductively Coupled Plasma - Mass Spectrometry (ICP-MS)

In the course of my experimental work to determine the number of differentiable obsidian sources on Sardinia, 33 archaeological artifacts from

Nuraghe Su Para, Pianosa-La Scola, Basi and Filitosa were also analyzed (data in Appendix D).

Although it is possible to distinguish among all of the western Mediterranean obsidian sources using simple bivariate scatter plots, it is preferable to use multivariate statistical analysis of all elemental data to measure the fit of an archaeological specimen with a particular source group to insure proper attribution. It is possible for a variety of reasons (e.g. sample preparation error, dilution effects) for an obsidian sample to coincidentally have values characteristic of another source for a few elements, especially since the concentrations of many elements are geologically intercorrelated. Cluster analysis does not quantify the degree of separation between groups, nor does it allow for the classification of additional observations. Cluster analysis is therefore useful only in exploring what source groups exist, for example when geological sources have not yet been studied. The statistical technique most appropriate for geochemical data is discriminant function analysis (Baxter 1994a; 1994b; 1992; McLachlan 1992; Jobson 1992; Stevens 1992; Aitchison 1986), which has been used widely in archaeological provenance studies of metals (e.g. Stos-Gale & Gale 1992) and ceramics (cf. Pollard 1986 for problems with cluster and principal components analysis, and Beier & Mommsen 1994 and Leese & Main 1994 for use of the Mahalanobis distance). For each artifact analyzed here, stepwise discriminant analysis using the computer program BMDP 7M (version 7.0) was used to find the combination of concentration variables that best predicts the source group to which a case belongs, and to compute the Mahalanobis distance and the posterior probability of belonging to one of the five sources already defined by analyses of geological samples. All artifacts were assigned to a single source at a probability level greater than 99%.

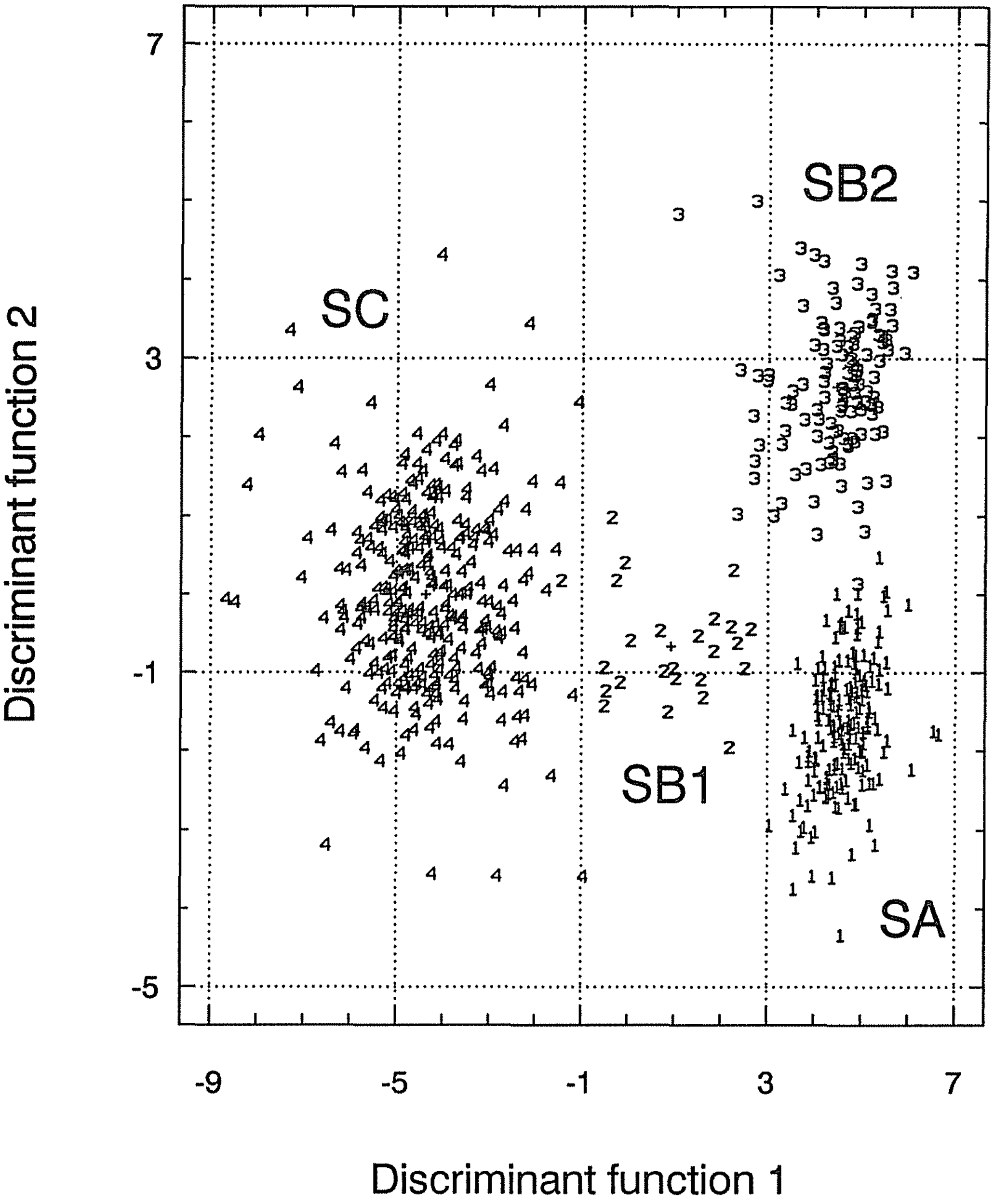
Electron Probe Microanalysis

Electron probe microanalysis was subsequently selected as the best method for determining the source of archaeological artifacts because it is minimally destructive, sample preparation is not difficult, and the cost of analysis is low. Tiny samples were removed from 616 archaeological artifacts either by flaking or using a high-speed diamond saw, and prepared and analyzed using the same protocols described above. Karen Hartshorn assisted with the preparation and analysis of many of the Corsican artifacts as part of her senior thesis. To further reduce time and costs, only two points per sample were analyzed, and MnO_2 and P_2O_5 were not measured since their presence was always close to the detection limits of the microprobe, and neither was necessary for a full discrimination of the Mediterranean obsidian sources (data in Appendix G, Table G1). A handful of samples with inconsistent point analyses were reanalyzed.

Sample data were normalized and the averages of the multiple analyses for each sample computed. Using these values (and those for the geological samples), source attributions were made using stepwise discriminant analysis and the statistical probability of belonging to each source group calculated (data and source attributions in Appendix G, Table G2). The equivalence of archaeological specimens with the geological source samples is illustrated in a plot of the first two discriminant functions for both data sets (Figure 17). All but a dozen artifacts were assigned to a single source at a probability level greater than 95% (most > 99%), and all attributions were individually cross-checked with expectations based on concentration ranges of single elements.

The elemental means and standard deviations of all samples (geological and archaeological) from each source group analyzed by the microprobe may be favorably compared with those produced by other methods (Tables XVI-XXI). Most of the observed discrepancies may be attributed to differences in analytical technique (e.g. microprobe analyses represent very small sample areas, and non-glassy phases were avoided, whereas XRF and NAA analyses are more representative of bulk composition). In all cases, differences in concentration values are systematically offset for all sources, and do not affect the separation distance between sources. Since nearly all of the reported major element analyses of Sardinian obsidian have been from geological samples (Mackey & Warren 1983; Francaviglia 1984; Herold 1986; the only large archaeological study - Michels et al. 1984 - doesn't report standard deviations or concentration ranges), my analyses serve to characterize the specific geological sources actually utilized for stone tool manufacture and to complement the trace element data already available. These data should also render additional analyses of source group material unnecessary for future provenance studies using either bulk or trace element methods.

Figure 17. Discriminant analysis of electron microprobe data for Monte Arci (Sardinia) obsidian. Both geological and archaeological samples are shown in a plot of the first two discriminant functions determined from the geological data alone. Discriminant function 1 = -186.178 + 2.39046SiO_2 + 0.53495Al_2O_3 - 21.7185TiO_2 + 1.45253Fe_2O_3 + 5.27939MgO - 0.94599CaO + 1.08222Na_2O + 0.36808K_2O -15.8771BaO. Discriminant function 2 = 8.06722 + 0.71373SiO_2 - 6.07939Al_2O_3 + 13.4917TiO_2 - 3.87966Fe_2O_3 + 11.1122MgO + 6.68697CaO + 1.94002Na_2O + 2.00936K_2O + 4.06974BaO.



Visual Identification of Provenance

Prior to chemical analysis, each artifact was attributed to a single Mediterranean island source strictly using its visual characteristics, based on my experience handling geological specimens. When compared with the actual source (based on chemical attribution), I found that I was 100% accurate in assigning samples to Lipari, Pantelleria, or Sardinia, and that the only errors were made distinguishing between the multiple Monte Arci sources (Table XXII). Furthermore, most of the discrepancies were between the highly transparent SA and SB2 groups. I was unsure about one-fourth of them (I attribute the artifacts to SA/SB2 or SB2/SA categories), and I was only correct about 73% of the time when trying to distinguish among the remaining three-fourths (including the securely-identified spotted SB2 variety). Mis-attributions between SA or SB and SC were infrequent (< 7%), indicating that a distinction between the east and west sides of Monte Arci can be confidently made (note that this is not the equivalent of opaque vs. translucent since both SB1 and SC are nearly always opaque and SB2 often is as well). Importantly, since the mis-attributions between SA and SB2 were bidirectional, the percentage of artifacts visually assigned to each source was quite close to the actual percentages (Table XXIII). It appears then that the frequency of each obsidian source represented in lithic assemblages can be reasonably estimated by non-destructive, low-cost visual examination. This permits the study of entire assemblages, while the reduced accuracy of the visually determined source frequencies may be less significant than the sampling error associated with chemical analysis of selected numbers of artifacts. Certainly,

	Cann and Renfrew 1964	Bradford Labs 1976-1984**	Mackey and Warren 1983	Francaviglia 1984	Michels et al. 1984	Pisa Group 1986**	Herold 1986
Geo. + Arch.	0 + 2	8 + 66	? + 0	77 + 1	0 + 40	0 + 1	8 + 0
Method	OES	NAA	XRF	XRF	AAS	NAA	AAS
% SiO_2			74.16 ± 0.63	74.30 ±	75.7 ±		
% Al_2O_3			13.98 ± 1.00	13.83 ±	13.68 ±		
% Fe_2O_3	*1.23 ± 0.14	*1.64 ± 0.19	1.47 ± 0.08	1.55 ±	1.28 ±	*1.60	
% MnO			0.07 ± 0.01	0.07 ±			
% MgO	*0.05 ± 0.01		0.07 ± 0.05	0.17 ±	0.12 ±		0.10 ± 0.00
% CaO	*0.62 ± 0.06		0.59 ± 0.03	0.58 ±	0.56 ±		
% Na_2O		*3.46 ± 0.45	3.65 ± 0.08	3.70 ±	3.32 ±		3.58 ± 0.04
% K_2O			5.19 ± 0.05	4.97 ±	5.18 ±		5.22 ± 0.03
% TiO_2			0.09 ± 0.02	0.09 ±	0.18 ±		
% P_2O_5			0.09 ± 0.01	0.07 ±			
Ba ppm	165 ± 21		136 ± 7.3	299 ±			
Subtotal			99.37	99.36	100.02		
Li	32 ± 0						
S				18.1 ±			
Cl				916 ±			
Sc		4.80 ± 0.48				3.21	
V	<5 ± 0			18.2 ±			
Cr			4.8 ± 0.8	0.5 ±			
Co		0.60 ± 0.38	4.2 ± 2.3	3.1 ±			
Cu			3.0 ± 2.0				
Zn				68.8 ±			
Ga	15 ± 4						
Rb	143 ± 25		255.4 ± 8.2	269 ±		266	

Sr	35 ± 0		27.0 ± 1.4	36.4 ±			
Y	20 ± 3			29.3 ±			
Zr	38 ± 9		104.6 ± 3.3	93 ±			
Nb	53 ± 10		51.0 ± 1.9	64.1 ±			
Mo	<3 ± 0						
Sn	<10 ± 0						
Cs		5.00 ± 0.72				3.45	
La	65 ± 21	23.8 ± 2.3	24.6 ± 2.4			20	
Ce		55 ± 11	45.2 ± 6.8			43	
Nd						37	
Sm		5.75 ± 0.79				17.0	
Eu		0.4 ± 0.1				0.50	
Gd						4.4	
Tb						1.65	
Dy						17.0	
Ho						1.75	
Tm						0.19	
Yb						10.5	
Lu						0.10	
Hf		3.7 ± 0.4					
Ta						2.36	
Pb	38 ± 0						
Th		18 ± 2	16.8 ± 4.2			16.7	
U		7.1 ± 1.2	6.2 ± 1.5			5.2	

Table XVI. Comparison of analytical data for type SA obsidian. * converted from element %. ** Bradford Labs = Hallam et al. 1976; Williams-Thorpe et al. 1979; Williams-Thorpe, Warren, & Courtin 1984.

	Herold 1986	Herold 1986	Dyson et al. 1990	Randle et al. 1993	Milan Group 1995**	Tykot 1995	Tykot 1995
Geo. + Arch.	3 + 0	56 + 0	0 + 10	0 + 1	0 + 3	8 + 0	32 + 173
Method	NAA	XRF	XRF	NAA	NAA	XRF	Microprobe
% SiO_2		74.56 ± 0.25	73.77 ± 0.57				74.72 ± 0.26
% Al_2O_3		13.84 ± 0.09	13.66 ± 0.53				13.40 ± 0.15
% Fe_2O_3		1.47 ± 0.01	1.40 ± 0.03		*1.57 ± 0.09	1.36 ± 0.06	1.25 ± 0.09
% MnO		0.06 ± 0.00	0.05 ± 0.01				0.08 ± 0.01
% MgO		0.13 ± 0.02					0.08 ± 0.01
% CaO		0.60 ± 0.00	0.66 ± .0.03				0.59 ± 0.04
% Na_2O		3.64 ± 0.06	4.59 ± 0.35		*4.45 ± 0.45		3.44 ± 0.16
% K_2O		5.22 ± 0.03	5.30 ± 0.12		*5.02 ± 0.82		5.26 ± 0.22
% TiO_2		0.11 ± 0.00	0.11 ± 0.01				0.09 ± 0.01
% P_2O_5		0.08 ± 0.00					0.06 ± 0.01
Ba ppm		145 ± 8	215 ± 43	238			160 ± 150
Subtotal		99.71 ± 0.23					99.00
Sc	4.1 ± 0.1			5.9	4.21 ± 0.06		
Co	0.3 ± 0.1			0.35			
Cu			22				
Zn		92 ± 1	60 ± 17				
Rb		247 ± 2	213 ± 10	278	296.2 ± 49.1	249 ± 13	
Sr		30 ± 1	31 ± 9			26 ± 4	
Y		36 ± 1	25 ± 18			37 ± 5	
Zr		105 ± 1	75 ± 14	<250		91 ± 5	
Nb		43 ± 1	39 ± 12			60 ± 4	
Sb	0.5 ± 0.1						
Cs	4.8 ± 0.4			4.7	4.75 ± 0.59		

La	17 ± 1			28	23.59 ± 0.10		
Ce	56 ± 2			51	47.1 ± 1.2		
Nd	32 ± 2						
Sm	6.7 ± 0.1			8	3.80 ± 0.15		
Eu	0.34 ± 0.02			0.41			
Gd							
Tb	1.2 ± 0.1			<1			
Dy							
Ho							
Tm							
Yb	3.3 ± 0.1			2.6			
Lu				0.39			
Hf				3.9	2.95 ± 0.43		
Ta	4.5 ± 0.1			5.5			
Pb			22 ± 16				
Th	18 ± 1			18.3	17.5 ± 1.1		
U	6.7 ± 0.8			4	4.71 ± 0.91		

Table XVI (continued). * converted from element %. ** Pisa Group = Bigazzi et al. 1986; Milan Group = Ammerman & Polglase 1995.

	Bradford 1976-83**	Mackey and Warren 1983	Mackey and Warren 1983	Francaviglia 1984	Michels et al. 1984	Herold 1986	Herold 1986	Tykot 1995	Tykot 1995
Geo. + Arch.	0 + 6	? + 0	? + 0	30 + 0	0 + 4	11 + 0	3 + 0	9 + 0	20 + 6
Source	SB1	M. Sparau	M. Sparau	Marrubiu	SB	SB1	SB1	SB1	SB1
Method	NAA	NAA	XRF	XRF	AAS	XRF	NAA	XRF	Microprobe
% SiO_2			73.41 ± 0.76	73.98 ±	73.5 ±	73.45 ± 0.18			73.87 ± 0.35
% Al_2O_3			14.00 ± 0.62	13.71 ±	13.34 ±	14.10 ± 0.06			13.63 ± 0.10
% Fe_2O_3	*1.74 ± 0.13	*1.70 ± 0.13	1.81 ± 0.07	1.71 ±	2.36 ±	1.86 ± 0.02		1.70 ± 0.07	1.33 ± 0.20
% MnO			0.05 ± 0.01	0.06 ±		0.05 ± 0.00			0.10 ± 0.02
% MgO			0.17 ± 0.03	0.26 ±	0.41 ±	0.28 ± 0.02			0.12 ± 0.04
% CaO			0.74 ± 0.04	0.71 ±	1.19 ±	0.81 ± 0.01			0.75 ± 0.06
% Na_2O	*3.59 ± .23	*3.22 ± .26	3.42 ± 0.09	3.63 ±	3.30 ±	3.55 ± 0.05			3.38 ± 0.10
% K_2O			5.62 ± 0.04	5.24 ±	5.47 ±	5.37 ± 0.03			5.55 ± 0.20
% TiO_2			0.21 ± 0.02	0.17 ±	0.47 ±	0.21 ± 0.01			0.17 ± 0.03
% P_2O_5			0.12 ± 0.01	0.10 ±		0.10 ± 0.00			0.04 ± 0.01
Ba ppm			459.8 ± 18.1	447 ±		331 ± 14			440 ± 210
Subtotal			99.60	99.61	100.04	99.83			99.00
S				18.9 ±					
Cl				776 ±					
Sc	3.83 ± 0.20	3.61 ± 0.30					4.0 ± 0.1		
V				27.6 ±					
Cr			3.8 ± 1.9	0.9 ±					
Co	1.0 ± 0.3	1.13 ± 0.20	3.6 ± 3.2	3.0 ±			1.1 ± 0.1		
Cu			3.0 ± 2.2						
Zn				60.7 ±		89 ± 2			
Rb			234.6 ± 7.9	253 ±		235 ± 2		231 ± 13	
Sr			78.6 ± 1.8	84.3 ±		70 ± 1		96 ± 11	

Y				19.6 ±		29 ± 1		27 ± 7	
Zr			177.0 ± 7.2	149 ±		144 ± 3		177 ± 26	
Nb			32.8 ± 2.5	40.6 ±		37 ± 2		44 ± 5	
Sb							0.5 ± 0.1		
Cs	6.9 ± 1.8	4.51 ± 0.89					4.3 ± 0.2		
La	37.3 ± 2.6	41.6 ± 1.5	39.8 ± 3.0				22 ± 0		
Ce	80 ± 3	90.2 ± 21.9	77.6 ± 8.4				74 ± 4		
Nd							39 ± 4		
Sm	5.2 ± 0.2						7.4 ± 0.2		
Eu	0.8 ± 0.2	0.78 ± 0.10					0.64 ± 0.03		
Tb							1.1 ± 0.1		
Yb							3.1 ± 0.3		
Hf	4.5 ± 0.5	5.46 ± 0.89					4.4 ± 0.2		
Ta							3.9 ± 0.1		
Th	23 ± 2	20.7 ± 0.3	24.0 ± 4.1				19 ± 0		
U	4.9 ± 1.3	4.6 ± 0.6	5.0 ± 1.6				5.5 ± 0.6		

Table XVII. Comparison of analytical data for types SB1 and SB2 obsidian. * converted from element %. ** Bradford Labs = Hallam et al. 1976; Williams-Thorpe et al. 1979; Mackey & Warren 1983. Standard deviations are estimates since Mackey & Warren (1983) only reported the average values for the two artifacts they analyzed.

	Bradford Labs 1976-1983**	Mackey and Warren 1983	Herold 1986	Herold 1986	Pisa Group 1986-1992**	Milan Group 1995**	Tykot 1995	Tykot 1995
Geo. + Arch.	0 + 18	? + 0	28 + 0	3 + 0	1 + 3	0 + 15	7 + 0	19 + 113
Source	SB2	Cucru Is Abis	SB2	SB2	SB?	SB	SB2	SB2
Method	NAA	NAA	XRF	NAA	NAA	NAA	XRF	Microprobe
% SiO_2			74.58 ± 0.22					75.05 ± 0.3
% Al_2O_3			13.46 ± 0.12					12.98 ± 0.16
% Fe_2O_3	*1.53 ± 0.11	*1.69 ± 0.09	1.50 ± 0.05		*1.54 ± 0.13	1.5 ± 0.10	1.38 ± 0.04	1.17 ± 0.17
% MnO			0.04 ± 0.05					0.08 ± 0.01
% MgO			0.21 ± 0.04					0.11 ± 0.02
% CaO			0.59 ± 0.03					0.57 ± 0.02
% Na_2O	*3.49 ± 0.14	*3.17 ± 0.12	3.54 ± 0.06			3.92 ± 0.32		3.34 ± 0.22
% K_2O			5.49 ± 0.07			5.43 ± 0.69		5.50 ± 0.35
% TiO_2			0.15 ± 0.02					0.13 ± 0.02
% P_2O_5			0.07 ± 0.01					0.04 ± 0.01
Ba ppm			234 ± 69					200 ± 140
Subtotal			99.65					99.00
Sc	3.61 ± 0.18	4.09 ± 0.16		3.2 ± 0.0	2.27 ± 0.10	3.11 ± 0.16		
Co	1.1 ± 1.0	1.40 ± 0.28		0.5 ± 0.1				
Zn			62 ± 3					
Rb			239 ± 8		282 ± 1	276.3 ± 88.5	247 ± 9	
Sr			46 ± 10				42 ± 10	
Y			22 ± 2				20 ± 4	
Zr			132 ± 9				124 ± 16	
Nb			24 ± 2				42 ± 1	
Sb				0.7 ± 0.1				
Cs	8.1 ± 0.7	4.42 ± 0.45		7.3 ± 0.1	2.5 ± 0.3	6.61 ± 0.96		

La	30.2 ± 1.9	33.0 ± 0.82		24 ± 1	42 ± 1	32.33 ± 3.02		
Ce	65 ± 6	68.1 ± 3.5		75 ± 3	63 ± 1	57.0 ± 8.6		
Nd				33 ± 1	35 ± 2			
Sm	4.9 ± 0.3			6.1 ± 0.2	11.4 ± 0.4	3.27 ± 0.27		
Eu	0.5 ± 0.1	0.61 ± 0.05		0.59 ± 0.03	0.39 ± 0.01			
Gd					4.8 ± 0.3			
Tb				0.7 ± 0.1	1.12 ± 0.12			
Dy					11.2 ± 0.4			
Ho					0.98 ± 0.10			
Tm					0.21 ± 0.01			
Yb				2.2 ± 0.1	9.1 ± 0.4			
Lu					0.15 ± 0.01			
Hf	4.1 ± 0.6	4.48 ± 0.29		3.9 ± 0.1		3.73 ± 0.52		
Ta				2.8 ± 0.1	2.7 ± 0.2			
Th	22 ± 4	18.7 ± 0.7		21 ± 0	17.7 ± 0.3	18.3 ± 2.2		
U	6.4 ± 0.7	4.6 ± 0.5		6.9 ± 0.3	5.8 ± 0.1	5.11 ± 0.65		

Table XVII (continued). *converted from element %. ** Bradford Labs = Hallam et al. 1976; Williams-Thorpe et al. 1979; Mackey & Warren 1983. Standard deviations are estimates since Mackey & Warren (1983) only reported the average values for the four artifacts they analyzed. Pisa Group = Bigazzi et al. 1986; 1992b. Milan Group = Ammerman & Polglase 1995.

	Cann and Renfrew 1964	Bradford Labs 1976-1983**	Mackey and Warren 1983	Mackey and Warren 1983	Francaviglia 1984	Francaviglia 1984	Michels et al. 1984
Geo. + Arch.	0 + 2	0 + 53	? + 0	? + 0	27 + 0	18 + 3	0 + 60
Source			Perdas Urias	Perdas Urias	Pau	S. Pinna	
Method	OES	NAA	NAA	XRF	XRF	XRF	AAS
% SiO_2				72.44 ± 0.98	72.48 ±	72.40 ±	73.7 ±
% Al_2O_3				13.76 ± 0.75	14.37 ±	14.34 ±	14.21 ±
% Fe_2O_3	*2.43 ±	*1.96 ± 0.16	*1.89 ± 0.11	1.95 ± 0.09	1.99 ±	1.96 ±	1.74 ±
% MnO				0.05 ± 0.01	0.04 ±	0.08 ±	
% MgO	*0.25 ±			0.27 ± 0.01	0.37 ±	0.32 ±	0.28 ±
% CaO	*1.05 ±			0.91 ± 0.04	0.93 ±	0.94 ±	0.83 ±
% Na_2O		*3.22 ± 0.24	*3.28 ± 0.26	3.25 ± 0.02	3.31 ±	3.58 ±	3.11 ±
% K_2O				5.73 ± 0.12	5.56 ±	5.65 ±	5.76 ±
% TiO_2				0.31 ± 0.01	0.32 ±	0.32 ±	0.38 ±
% P_2O_5				0.13 ± 0.01	0.10 ±	0.11 ±	
Ba ppm	2200 ±			1000.5 ± 79.9	933 ±	944 ±	
Subtotal				98.90	99.56	99.79	100.01
Li	18 ± 0						
S					19.6 ±	15.8 ±	
Cl					571 ±	563 ±	
Sc		3.72 ± 0.31	3.62 ± 0.19				
V	18 ± 4				45.5 ±	45.4 ±	
Cr				4.5 ± 4.9	2.3 ±	2.5 ±	
Co		1.5 ± 0.2	1.46 ± 0.24	2.0 ± 2.8	2.9 ±	2.8 ±	
Cu				6.5 ± 0.7			
Zn					61.6 ±	62.0 ±	
Ga	20 ± 4						

Rb	180 ± 28			177.5 ± 2.1	186 ±	184 ±	
Sr	190 ± 28			127.0 ± 5.7	214 ±	156 ±	
Y	15 ± 0				23.6 ±	19.7 ±	
Zr	195 ± 35			261.0 ± 25.5	281 ±	275 ±	
Nb	49 ± 16			28.5 ± 2.1	32.8 ±	31.1 ±	
Mo	<3 ± 0						
Sn	<10 ± 0						
Cs		2.4 ± 0.4	2.25 ± 0.27				
La	135 ± 21	64.7 ± 4.8	64.7 ± 3.9	60.5 ± 2.1			
Ce		130 ± 19	123.6 ± 9.8	123.5 ± 12.0			
Sm		7.3 ± 0.5					
Eu		1.3 ± 0.1	1.24 ± 0.09				
Hf		6.8 ± 0.8	6.78 ± 0.78				
Pb	41 ± 4						
Th		28 ± 3	25.7 ± 1.7	30.0 ± 5.7			
U		2.8 ± 0.7	3.2 ± 0.3	4.6 ± 1.5			

Table XVIII. Comparison of analytical data for type SC obsidian. * converted from element %. ** Bradford Labs = Hallam et al. 1976; Williams-Thorpe et al. 1979; Mackey & Warren 1983.

	Herold 1986	Herold 1986	Herold 1986	Dyson et al. 1990	Milan Group 1990-1995**	Randle et al. 1993	Tykot 1995	Tykot 1995
Number	8 + 0	3 + 0	22 + 0	0 + 17	0 + 7	0 + 3	6 + 0	40 + 302
Source	Perdas Urias	Perdas Urias	Perdas Urias				SC	SC
Method	AAS	NAA	XRF	XRF	NAA	NAA	XRF	Microprobe
% SiO_2			72.27 ± 0.27	72.86 ± 0.45				72.71 ± 0.37
% Al_2O_3			14.41 ± 0.06	13.79 ± 0.52				13.92 ± 0.19
% Fe_2O_3			1.92 ± 0.02	1.98 ± 0.40	*2.00 ± 0.19		1.81 ± 0.03	1.53 ± 0.21
% MnO			0.03 ± 0.0	0.04 ± 0.01				0.14 ± 0.01
% MgO	0.33 ± 0.01		0.38 ± 0.02	0.40				0.21 ± 0.07
% CaO			0.93 ± 0.01	1.07 ± 0.30				0.88 ± 0.10
% Na_2O	3.34 ± 0.03		3.49 ± 0.06	4.18 ± 0.58	*3.92 ± 0.49			3.30 ± 0.20
% K_2O	5.78 ± 0.02		5.84 ± 0.03	5.68 ± 0.27	*6.41 ± 0.36			5.90 ± 0.30
% TiO_2			0.31 ± 0.01	0.32 ± 0.07				0.27 ± 0.03
% P_2O_5			0.13 ± 0.00	0.31				0.03 ± 0.01
Ba ppm			955 ± 31	1218 ± 104		977 ± 12		960 ± 230
Subtotal			99.70	100.75				99.00
Sc		3.5 ± 0.1			3.38 ± 0.08	5.2 ± 0.2		
Co		1.1 ± 0.2				1.50 ± 0.13		
Cu				17 ± 8				
Zn			72 ± 3	59 ± 4				
As					1.75 ± 0.41			
Rb			173 ± 4	155 ± 11	196.6 ± 23.9	199 ± 7	161 ± 8	
Sr			129 ± 2	115 ± 27			145 ± 5	
Y			25 ± 2	34 ± 29			26 ± 4	
Zr			242 ± 1	206 ± 14		240 ± 8	261 ± 12	
Nb			26 ± 2	32 ± 8			36 ± 4	

Sb		0.1 ± 0.1						
Cs		2.4 ± 0.0			2.67 ± 0.97	2.4 ± 0.2		
La		46 ± 4			67.15 ± 1.94	63 ± 2		
Ce		136 ± 5			115.6 ± 3.8	132 ± 3		
Nd		64 ± 3						
Sm		10.3 ± 0.3			5.60 ± 0.25	11.6 ± 1.1		
Eu		1.28 ± 0.03				1.6 ± 0.2		
Tb		1.03 ± 0.05				1.29 ± 0.01		
Yb		2.7 ± 0.1				1.85 ± 0.12		
Lu						0.28 ± 0.01		
Hf		6.5 ± 0.2			6.16 ± 0.58	7.2 ± 0.2		
Ta		2.4 ± 0.1				3.1 ± 0.1		
Pb				33 ± 15				
Th		28 ± 0			26.6 ± 1.6	30.9 ± 0.6		
U		3.5 ± 0.3			2.98 ± 0.34	2.3 ± 0.1		

Table XVIII (continued). * converted from element %. ** Milan Group = Ammerman et al. 1990; Ammerman & Polglase 1995.

	Cann and Renfrew 1964	Mosheim 1979	Francaviglia 1984	Francaviglia 1984	Francaviglia 1984	Francaviglia 1984
Geo. + Arch.	9 + 12	41 + 0	30 + 0	20 + 0	10 + 0	11 + 0
Source			Papesca Beach	Pomiciazzo-Lami	Forgia Vecchia	Rocche Rosse
Method	OES	XRF	XRF	XRF	XRF	XRF
% SiO_2		73.6 ±	74.10 ±	74.17 ±	74.08 ±	74.28 ±
% Al_2O_3		13.0 ±	13.23 ±	13.11 ±	13.24 ±	13.12 ±
% Fe_2O_3	*1.26 ± 0.31	1.81 ±	1.83 ±	1.80 ±	1.87 ±	1.81 ±
% MnO			0.08 ±	0.08 ±	0.08 ±	0.08 ±
% MgO	*0.023 ± 0.012	0.05 ±	0.11 ±	0.10 ±	0.11 ±	0.11 ±
% CaO	*0.686 ± 0.087	0.66 ±	0.71 ±	0.70 ±	0.72 ±	0.71 ±
% Na_2O		4.03 ±	4.24 ±	4.12 ±	4.17 ±	4.11 ±
% K_2O		5.09 ±	4.86 ±	4.86 ±	4.90 ±	4.95 ±
% TiO_2		0.10 ±	0.07 ±	0.07 ±	0.07 ±	0.07 ±
% P_2O_5		0.05 ±	0.03 ±	0.03 ±	0.03 ±	0.03 ±
Ba	18 ± 9		314 ±	295 ±	290 ±	294 ±
Subtotal		98.39	99.29	99.07	99.30	99.30
Li	58 ± 21					
S			17.4 ±	18.2 ±	19.8 ±	33.4 ±
Cl			2324 ±	2341 ±	2270 ±	2399 ±
V	<5 ± 1		15.1 ±	15.5 ±	15.0 ±	15.7 ±
Cr			0.3 ±	0.3 ±	0.1 ±	0.0 ±
Co			2.9 ±	2.8 ±	2.8 ±	2.9 ±
Ni						
Zn			59 ±	57 ±	58 ±	58 ±
Ga	15 ± 4					
Rb	202 ± 41		329 ±	315 ±	324 ±	326 ±

Sr	<16 ± 7		19.7 ±	15.5 ±	20.1 ±	23.7 ±
Y	24 ± 3		38.3 ±	36.9 ±	40.3 ±	38.1 ±
Zr	113 ± 33		208 ±	202 ±	211 ±	206 ±
Nb	40 ± 8		46.6 ±	40.9 ±	46.6 ±	40.4 ±
Mo	4 ± 1					
Sn	<10 ± 0					
La	107 ± 31					
Pb	37 ± 6					

Table XIX. Comparison of analytical data for Lipari obsidian. * converted from element %.

	Bradford Labs 1976-1985**	Pisa Group 1986-1992**	Milan Group 1990-1995**	Randle et al. 1993	Tykot 1995	Tykot 1995	Acquafredda et al. 1995
Geo. + Arch.	16 + 114	3 + 16	1 + 32	0 + 5	0 + 2	3 + 17	11 + 0
Method	NAA	NAA	NAA	NAA	XRF	Microprobe	XRF
% SiO_2						74.51 ± 0.22	75.98 ±
% Al_2O_3						12.75 ± 0.14	12.68 ±
% Fe_2O_3	*1.96 ± 0.29	*1.14 ± 0.21	*1.76 ± 0.10		1.71	1.63 ± 0.08	1.95 ±
% MnO						0.05 ± 0.05	0.06 ±
% MgO						0.03 ± 0.01	0.00 ±
% CaO						0.72 ± 0.04	0.69 ±
% Na_2O	*4.07 ± 0.39		*4.54 ± 0.55			4.03 ± 0.10	3.82 ±
% K_2O			*5.33 ± 0.43			5.13 ± 0.09	4.74 ±
% TiO_2						0.08 ± 0.01	0.08 ±
% P_2O_5						0.06 ± 0.01	0.01 ±
Ba				230 ±100		70 ± 70	34 ±
Subtotal						99.00	
Sc	1.1 ± 0.1	0.58 ± 0.11	1.09 ± 0.11	1.3 ± 0.1			
V							1 ±
Cr							20 ±
Co	0.4 ± 0.1			0.4 ±0.04			
Ni							4 ±
As			18.93 ± 1.18				
Rb		167 ± 29	369.1 ± 35.8	300 ±24	288		300 ±
Sr					8		13 ±
Y					43		46 ±
Zr				220 ± 16	185		185 ±
Nb				0.9 ± 0.07	38		38 ±

Cs	19 ± 2	7.0 ± 1.2	16.36 ± 1.32	18.7 ± 2.0			
La	58 ± 6	111 ± 19	58.22 ± 2.34	67 ± 5			61 ±
Ce	132 ± 20	84 ± 12	101.1 ± 4.1	100 ± 10			115 ±
Nd		40 ± 6		36 ± 5			
Sm	7.2 ± 0.7	14.0 ± 1.9	4.91 ± 0.31	26.1 ± 32.2			
Eu	0.14 ± 0.06	0.47 ± 0.16		0.17 ± 0.02			
Gd		12.0 ± 1.6					
Tb		1.20 ± 0.65		1.34 ± 0.08			
Dy		5.3 ± 0.4					
Ho		0.85 ± 0.05					
Tm		0.29 ± 0.03					
Yb		8.1 ± 1.8		4.3 ± 0.4			
Lu		0.15 ± 0.05		0.6 ± 0.2			
Hf	7.5 ± 1.1		6.10 ± 0.58	6.2 ± 0.4			
Ta		1.0 ± 0.2		3.4 ± 0.2			
Th	60 ± 8	45.9 ± 7.5	50.1 ± 2.9	52 ± 4			
U	21 ± 4	14.3 ± 2.6	12.43 ± 1.12	11 ± 1			

Table XIX (continued). * converted from element %. ** Bradford Labs = Hallam et al. 1976; Williams-Thorpe et al. 1979; Williams-Thorpe, Warren, & Courtin 1984; Crummett & Warren 1985; Pisa Group = Bigazzi et al. 1986; 1992b; Milan Group = Ammerman et al. 1990; Ammerman & Polglase 1995.

	Cann and Renfrew 1964	Bradford Labs 1976-1979**	Francaviglia 1984	Herold 1986	Herold 1986	Pisa Group 1986-1992**	Milan Group 1990-95**	Acquafredda et al. 1995
Geo. + Arch.	2 + 2	4 + 12	36 + 1	3 + 0	31 + 0	1 + 3	1 + 20	10 + 0
Method	OES	NAA	XRF	NAA	XRF	NAA	NAA	XRF
% SiO_2			73.87 ±		73.63 ± 0.38			75.62 ±
% Al_2O_3			13.47 ±		13.48 ± 0.10			12.74 ±
% Fe_2O_3	*1.56 ± 0.89	*1.89 ± 0.13	1.83 ±		1.79 ± 0.04	*1.26 ± 0.17	*1.86 ± 0.09	2.02 ±
% MnO			0.11 ±		0.08 ± 0.00			0.08 ±
% MgO	*0.05 ± 0.07		0.11 ±		0.09 ± 0.02			0.00 ±
% CaO	*0.64 ± 0.20		0.47 ±		0.46 ± 0.02			0.49 ±
% Na_2O		*4.91 ± 0.16	4.66 ±		4.82 ± 0.05		*5.36 ± 0.42	4.36 ±
% K_2O			4.65 ±		4.96 ± 0.04		*5.11 ± 0.77	4.58 ±
% TiO_2			0.09 ±		0.10 ± 0.00			0.11 ±
% P_2O_5			0.04 ±		0.01 ± 0.00			0.01 ±
Ba	13 ± 9		336 ±		38 ± 12			28 ±
Li	78 ± 72							
S			20.4 ±					
Cl			1438 ±					
Sc		1.55 ± 0.10		1.4 ± 0.1		0.86 ± 0.13	1.51 ± 0.17	
V	<5 ± 0		18.9 ±					1 ±
Cr			0.4 ±					13 ±
Ni								2 ±
Co		0.9 ± 1.5	3.0 ±	0.2 ± 0.1				
Zn			56.3 ±		65 ± 2			
Ga	18 ± 3							
As							22.96 ± 0.77	
Rb	375 ± 125		496 ±		455 ± 10	280 ± 23	572.6 ± 49.1	466 ±
Sr	<10 ± 0		0.0 ±		5 ± 2			4 ±

Y	24 ± 2		43.3 ±		58 ± 2			64 ±
Zr	200 ± 70		325 ±		291 ± 9			310 ±
Nb	51 ± 11		73.0 ±		59 ± 2			71 ±
Mo	<3 ± 1							
Sn	<10 ± 0							
Sb				3.6 ± 0.1				
Cs		52.3 ± 3.9		51.4 ± 0.1		24.8 ± 4.9	46.5 ± 2.9	
La	125 ± 29	89 ± 4		67 ± 0		101 ± 14	90.39 ± 3.25	93 ±
Ce		175 ± 25		176 ± 2		143 ± 44	154.8 ± 9.5	175 ±
Nd				70 ± 3		45 ± 5		
Sm		9.1 ± 0.9		11.2 ± 0.2		20.6 ± 5.1	6.14 ± 0.37	
Eu		0.2 ± 0.1		0.6 ± 0.1		0.32 ± 0.03		
Gd						7.6 ± 2.8		
Tb				1.5 ± 0.1		1.49 ± 0.23		
Dy						4.9 ± 0.7		
Ho						0.95 ± 0.10		
Tm						0.36 ± 0.05		
Yb				7.9 ± 0.4		1.67 ± 0.31		
Lu						0.19 ± 0.05		
Hf				9.0 ± 0.1			9.5 ± 1.4	
Ta				5.7 ± 0.1		1.68 ± 0.22		
Pb	50 ± 16							
Th		81 ± 9		78 ± 2		42.2 ± 2.4	73.6 ± 4.0	
U		26 ± 5		28 ± 1		15.3 ± 1.5	16.08 ± 1.15	

Table XX. Comparison of analytical data for Palmarola obsidian. * converted from element %. ** Bradford Labs = Hallam et al. 1976 and Williams-Thorpe et al. 1979; Pisa Group = Bigazzi et al. 1986; 1992b; Milan Group = Ammerman et al. 1990 and Ammerman & Polglase 1995.

	Cann and Renfrew 1964	Bradford Labs 1976-1984**	Pisa Group 1986-1992**	Francaviglia 1988	Francaviglia 1988	Tykot 1995
Geo. + Arch.	2 + 5	1 + 11	2 + 4	31 + 0	0 + 11	0 + 2
Source				Lago di Venere	Gelkhamar?	
Method	OES	NAA	NAA	XRF	XRF	Microprobe
% SiO_2				69.45 ± 0.32	66.26 ± 0.21	66.23 ± 0.15
% Al_2O_3				10.94 ± 0.09	10.94 ± 0.12	10.17 ± 0.70
% Fe_2O_3	*0.76 ± 0.19	*9.53 ± 1.04	*3.59 ± 0.64	6.70 ± 0.57	9.27 ± 0.62	8.90 ± 0.57
% MnO				0.26 ± 0.01	0.31 ± 0.01	0.05 ± 0.00
% MgO	*0.033 ± 0.030			0.23 ± 0.01	0.20± 0.01	0.15 ± 0.02
% CaO	*0.42 ± 0.08			0.41 ± 0.02	0.64 ± 0.05	0.53 ± 0.04
% Na_2O		*6.79 ± 2.57		6.32 ± 0.07	7.04 ± 0.07	7.56 ± 0.09
% K_2O				4.70 ± 0.09	4.70 ± 0.06	4.56 ± 0.16
% TiO_2				0.51 ± 0.01	0.64 ± 0.02	0.61 ± 0.00
% P_2O_5				0.03 ± 0.00	0.04 ± 0.00	0.35 ± 0.00
Ba	36 ± 9			47.5 ± 22.4	18.6 ± 18.3	150 ± 120
Subtotal				99.56	100.04	99.00
Li	38 ± 24					
S				21.3 ± 1.0	31.3 ± 2.3	
Cl				1601.1 ± 51.9	1155.7 ± 87.9	
Sc		0.48 ± 0.07	1.17 ± 0.25			
V	<7 ± 4					
Cr				93.4 ± 36.7	76.2 ± 38.0	
Co		0.21 ± 0.18				
Zn				260.3 ± 7.1	241.8 ± 6.0	
Ga	32 ± 12					
Rb	145 ± 40		48 ± 3	120.9 ± 1.9	99.9 ± 4.6	

Sr	<10 ± 0			2.3 ± 1.1	1.9 ± 1.0	
Y	120 ± 40			259.3 ± 5.9	201.9 ± 10.8	
Zr	1260 ± 110			1413.4 ± 29.7	952.9 ± 75.3	
Nb	400 ± 65			396.0 ± 10.4	289.2 ± 25.0	
Mo	10 ± 3					
Sn	<10 ± 0					
Cs		2.56 ± 0.53	2.7 ± 0.2			
La	330 ± 80	219 ± 36	129 ± 32	210.5 ± 6.7	164.6 ± 9.6	
Ce		448 ± 78	81 ± 3	284.7 ± 11.0	227.4 ± 9.1	
Nd			50 ± 8	125.9 ± 8.9	105.8 ± 6.7	
Sm		24 ± 4	22.6 ± 1.7			
Eu		4.86 ± 0.73	4.93 ± 1.52			
Gd			19.4 ± 4.3			
Tb			2.20 ± 0.64			
Dy			22.5 ± 2.9			
Ho			2.23 ± 0.89			
Tm			0.61 ± 0.07			
Yb			15.5 ± 1.0			
Lu			0.21 ± 0.07			
Hf		49.1 ± 4.14				
Ta			3.7 ± 0.3			
Pb	27 ± 7			9.2 ± 2.3	7.4 ± 2.3	
Th		38.0 ± 3.5	27.1 ± 3.1	24.3 ± 2.6	16.9 ± 2.3	
U		34 ± 9	7.0 ± 0.7			

Table XXI. Comparison of analytical data for Pantelleria obsidian.

	Francaviglia 1984	Francaviglia 1988	Francaviglia 1988	Francaviglia 1988	Tykot 1995	Tykot 1995
Geo. + Arch.	30 + 0	35 + 0	0 + 18	0 + 48	0 + 1	0 + 3
Source	BdT	Lower BdT	Upper BdT-1	Upper BdT-2		
Method	XRF	XRF	XRF	XRF	XRF	Microprobe
% SiO_2	71.65 ±	70.35 ± 0.09	70.72 ± 0.31	70.83 ± 0.16		70.78 ± 0.10
% Al_2O_3	7.60 ±	7.86 ± 0.06	7.68 ± 0.07	7.72 ± 0.06		7.47 ± 0.03
% Fe_2O_3	9.46 ±	9.57 ± 0.85	9.07 ± 0.59	9.11 ± 0.52	8.01	8.50 ± 0.05
% MnO	0.28 ±	0.30 ± 0.00	0.29 ± 0.00	0.29 ± 0.00		0.30 ± 0.01
% MgO	0.09 ±	0.09 ± 0.01	0.09 ± 0.00	0.08 ± 0.01		0.01 ± 0.00
% CaO	0.30 ±	0.33 ± 0.01	0.29 ± 0.01	0.29 ± 0.02		0.26 ± 0.00
% Na_2O	6.86 ±	6.84 ± 0.12	6.91 ± 0.06	6.93 ± 0.06		7.16 ± 0.11
% K_2O	4.29 ±	4.38 ± 0.05	4.20 ± 0.04	4.25 ± 0.05		4.23 ± 0.04
% TiO_2	0.23 ±	0.25 ± 0.00	0.24 ± 0.01	0.24 ± 0.00		0.22 ± 0.01
% P_2O_5	0.03 ±	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.00		0.03 ± 0.00
Ba	614 ±	29.7 ± 19.3	13.9 ± 13.0	14.3 ± 14.5		230 ± 125
Subtotal	100.85	99.99	99.51	99.76		99.00
Li						
S	39.0 ±	30.0 ± 1.8	25.2 ± 2.1	25.7 ± 2.3		
Cl	3438 ±	2316.1 ± 168.5	2222.6 ± 35.7	2195.3 ± 37.5		
Sc						
V	32.7 ±					
Cr	5.5 ±	42.1 ± 15.5	133.2 ± 38.9	87.4 ± 35.6		
Co	0.0 ±					
Zn	244 ±	404.7 ± 16.2	398.8 ± 6.1	397.1 ± 10.0		
Ga						
Rb	195 ±	170.0 ± 1.7	164.7 ± 2.2	168.5 ± 1.9	131	

Sr	5.7 ±	4.0 ± 1.0	3.7 ± 1.1	4.0 ± 1.2	0	
Y	183 ±	403.9 ± 3.6	377.8 ± 7.2	399.9 ± 5.3	128	
Zr	1976 ±	1862.2 ± 16.8	1701.5 ± 22.2	1826.4 ± 15.0	1559	
Nb	441 ±	547.3 ± 5.9	486.2 ± 8.2	538.1 ± 5.4	233	
Mo						
Sn						
Cs						
La		309.0 ± 8.6	311.8 ± 8.5	310.3 ± 7.0		
Ce		423.0 ± 13.5	423.5 ± 11.7	419.6 ± 13.5		
Nd		201.1 ± 9.6	194.9 ± 9.2	198.7 ± 10.5		
Sm						
Eu						
Hf						
Pb		26.2 ± 18.3	13.0 ± 3.1	12.3 ± 2.9		
Th		32.7 ± 2.7	32.0 ± 1.9	32.4 ± 1.7		
U						

Table XXI (continued). * converted from element %. ** Bradford Labs = Hallam et al. 1976; Williams-Thorpe, Warren, & Courtin 1984; Pisa Group = Bigazzi et al. 1986; 1992b.

	Actual				
Visual	SA	SB1	SB2	SC	Total
SA	102		38	6	146
SA?			2	2	4
SA/SB2	30		9	3	42
SB2/SA	28		4	3	35
SB		1	2	8	11
SB1					0
SB2	15		41	12	68
SB2?			8		8
SB/SC		1	5	11	17
SC		4	2	244	250
SC?				3	3
SC/SA				1	1
SC/SB				7	
?				2	2
Total	175	6	111	302	594

Table XXII. Comparison of visual and actual (chemical) source attributions of Sardinian obsidian artifacts.

	SA	SB1	SB2	SB	SB/SC	SC/SA	SC
Visual	32.3	0.0	18.7	1.9	3.0	0.2	42.8
Actual	29.5	1.0	18.7	0.0	0.0	0.0	50.8

Table XXIII. Comparison of visual and actual (chemical) source attributions of Sardinian obsidian artifacts. By percentage of the 594 artifacts examined.

chemical analysis should be employed whenever there is any doubt in the visual attributions, or when the provenance of individual artifacts is important. All researchers must in all cases establish their own ability to visually identify obsidian sources with blind tests of material of known provenance.

The provenance of more than 2100 additional archaeological obsidian artifacts was determined by visual examination. These include all those samples listed in the archaeological catalogue (Appendix C, Table C2) that were not chemically analyzed by ICP-MS or microprobe, plus additional artifacts examined on-site at the Museo Nazionale di Cagliari, the Museo Nazionale di Sassari, the University of Cagliari, the Museo Archeologico in Chiavari, and the Museo Nazionale Preistorico ed Etnografico "L. Pigorini" in Rome. The results for each site examined are given in Appendix H, Table H2, along with those few from other visually-based studies. Those artifacts from Settimo S. Pietro, San Gemiliano-Sestu, and Cala Villamarina-Santo Stefano that were examined in the Cagliari Museum were mounted and their source attribution may be slightly less reliable. These 2100 visual identifications provide an important supplement to those determined chemically for interpreting the source exploitation and distribution of Sardinian obsidian.

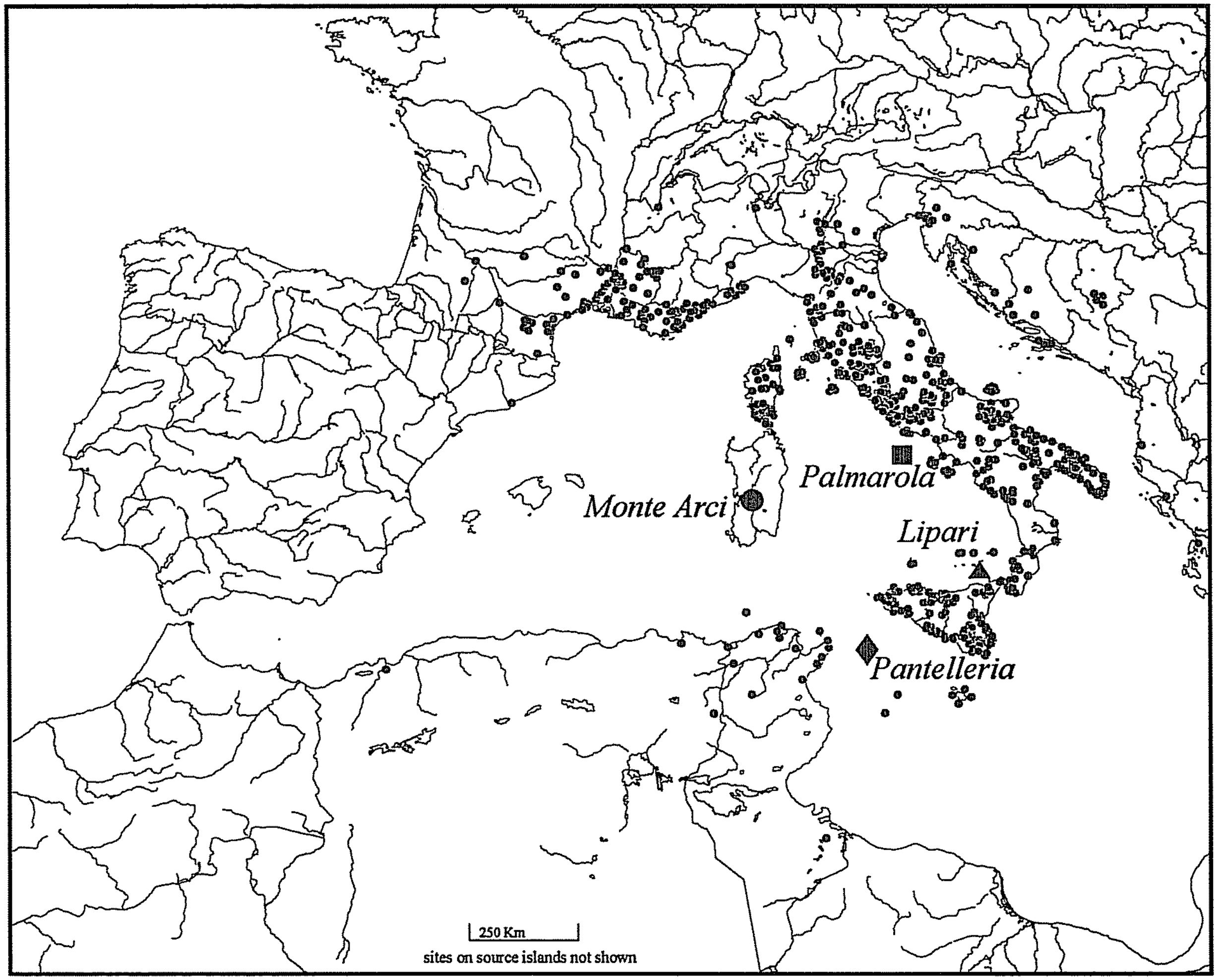
CHAPTER SEVEN: OBSIDIAN DISTRIBUTION PATTERNS

> La Sardegna costituì un punto alto, per così dire, di manovra economica del Mediterraneo, fondato sullo sfruttamento della risora dell'ossidiana, allora essenziale all'attrezzatura materiale e all'uso quotidiano (Lilliu 1989:13).

> Anzi è da credersi che (a parte quanto sappiamo già dal Mesolitico) la presenza di una fonte di ossidiana abbia avuto un peso determinante nella fitta colonizzazione neolitica della Sardegna e perciò nei suoi rapporti attivi o passivi con le zone oltremare. Più difficile risulta determinare, allo stato attuale degli studi e delle ricerche, se nel commercio dell'ossidiana, l'isola abbia avuto almeno in parte una funzione solo passiva, esportando cioè solo materiali e non cultura, dato che solo l'ossidiana ci garantisce sinora un movemento verso le lontane zone oltremare (Contu 1990-91:247).

Obsidian artifacts have been identified at over 1000 archaeological sites in the western Mediterranean, including virtually every site on Sardinia and Corsica, and most Neolithic sites in Sicily, the Italian peninsula, and Mediterranean France. Few sites with obsidian finds are known to the north of the Po River, on the eastern side of the Adriatic, and in North Africa (Figure 18). 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 artifacts in that material found at most sites. In stark contrast to the eastern Mediterranean, 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

Figure 18. Western Mediterranean sites with obsidian. The compilation of sites in Sicily and peninsular Italy is largely based on Pollmann (1993), and in France on Binder & Courtin (1994) and Guilaine & Vaquer (1994).



particular, as well as chronological and geographic patterns in western Mediterranean obsidian use.

Sample Selection, the Re-Use Problem, and Hydration Dating

The imprecise nature of the archaeological record presents many problems for the interpretation of obsidian distribution patterns. Excavations (and 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, 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 debitage, while increasing the probability that each artifact collected represents a different reduction event. Furthermore, in addition to obsidian artifacts in collections that may not be a random selection of the population of tools used at a site, I can only guarantee that artifacts from the Sassari, Pigorini, and University of Cagliari collections were truly sampled at random since I did not personally select the others. Finally, some sites have small numbers of artifacts analyzed 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.

Within Sardinia, a distinction can be made between an Oristano area supply zone, where obsidian most likely was acquired directly from the source, and the rest of the island, where obsidian probably was obtained indirectly through exchange (cf. Renfrew 1969; 1977). Surface collections of many thousands of obsidian tools from sites in the Oristano-Campidano area (Zanardelli 1899:109-177; Taramelli 1926; Congiu 1947; Porru 1948) and including the Monte Arci zone itself (Puxeddu 1958; 1975) illustrate the ready availability and exploitation of this material in prehistoric Sardinia. Puxeddu (1958) in fact identified 10 collection centers and 72 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 artifacts that Puxeddu collected suggests that they are primariily Neolithic.

Obsidian continued to be the most important lithic raw material used during the Copper, Bronze and Iron Ages, 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 artifacts (i.e. those with ages much older than their context) and led to some criticism of the method (e.g. Alciati 1978). At the Nuragic (ca. 1600-800 BC) village of Santa Barbara-Bauladu (Gallin & Tykot 1993), 9 of 19 artifacts tested produced dates between 5000 and 2000 BC (unpublished report by C.M. Stevenson, 1989), and similar reuse frequencies exist at Duos Nuraghes (7 of 21:

Stevenson & Ellis 1995). None of the 61 artifacts dated from Nuraghi Urpes and Toscono, however, have Prenuragic ages (Michels 1987), and along with a selection of artifacts from many Sardinian sites (Dyson et al. 1990) demonstrate at least the casual use of obsidian well into the Medieval era.

Dating archaeological contexts by obsidian hydration appears to be more promising for tomb contents (e.g. Cuccuru Nuraxi, Serra Cannigas, Cuccuru Craboni) where fresh artifacts may have been manufactured as burial goods, although tight clusters of dates have also been produced from domestic contexts (e.g. Nuraghe Domu Beccia, Nuraghe Antigori) (Michels et al. 1984). In all cases, soil temperature and obsidian composition are important factors in hydration rate determination (Michels 1985). Experimentally determined hydration rates for SA and SC obsidian (both 4.14 μ^2/1000 years) are 7.2% higher than for SB obsidian (3.84 μ^2/1000 years), as computed for an effective hydration temperature of 292.39 °K (unpublished report by J.W. Michels, 1989). More recent work (Stevenson et al. 1993; 1989) indicates that the compositional effect on the surface hydration rate is a function of the structural water content of the obsidian, with much greater heterogeneity within individual flows than previously realized. In addition to gathering soil temperature and humidity data for specific site contexts, precise density measurements of individual artifacts are now recommended, since a study of just 25 Sardinian artifacts produced hydration rates ranging from 3.0 to 5.3 μ^2/1000 years at 20 °C (Stevenson & Ellis 1995).

Sardinia

Chemical and visual analyses of obsidian from 61 sites in Sardinia (Figure 19; attributions summarized in Appendix H, Tables H1 and H2) 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. Recent reports of both translucent and opaque obsidian associated with Early and Middle Neolithic material at Punta Campu Sali-Arbus (Alba 1990) and Late Neolithic material at Cuccuru s'Arriu-Cabras (Depalmas 1991) also probably indicate the exploitation of multiple Monte Arci sources (SA and SC likely, but whose frequency can't be determined by this simple distinction since SB ranges from translucent to opaque). The availability of considerable quantities of type SC obsidian on the west-central coast of Sardinia suggests that the "value" (flaking quality + less tangible factors) of type SC obsidian at least equaled that of type SA, since the procurement cost (time + 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. Experimental knapping (L. Hurcombe, pers. comm.) and typological studies of provenanced artifacts (Hurcombe & Phillips 1995) may nevertheless reveal correlations between obsidian source and artifact type. The relative usage of translucent (SA, some SB2) and opaque (SB1, some SB2, SC) obsidian in Sardinia is reportedly similar in many instances all over the island, from S. Gemiliano-Sestu in the south (35% translucent: Atzeni 1962a) to

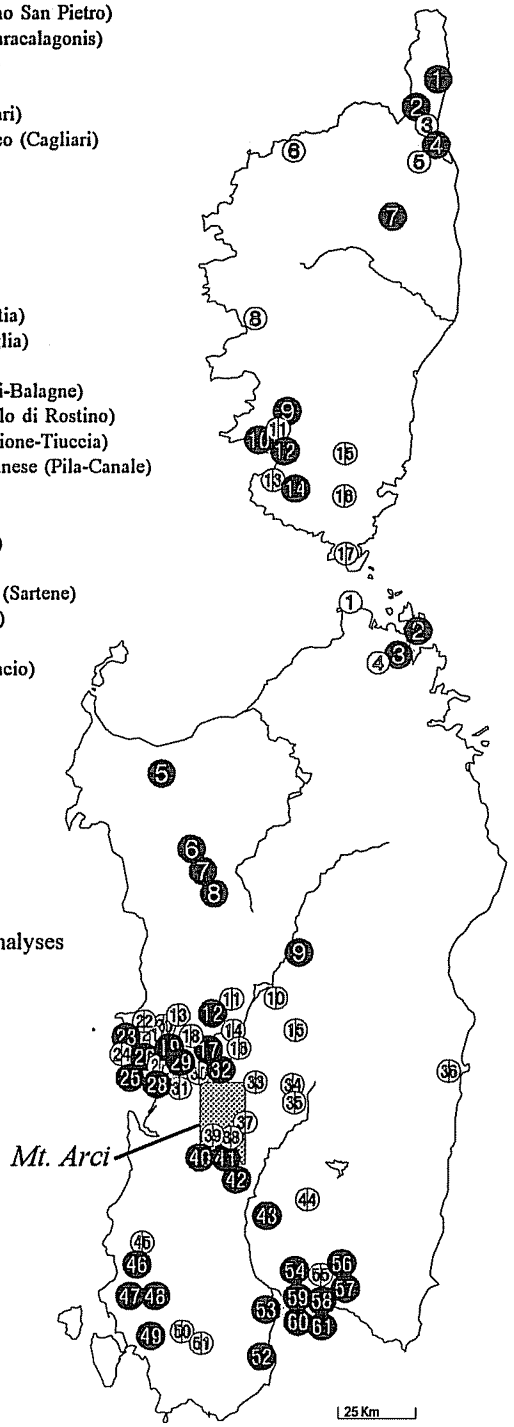
Figure 19. Sites with analyzed obsidian in Sardinia and Corsica. Analyses by chemical, physical, or visual methods. Results and references in Appendix H, Tables H1 and H2.

SARDINIA

1. Ile Monica (Santa Teresa di Gallura)
2. Loc. Liscia Pilastru (Arzachena)
3. Li Muri (Arzachena)
4. Monte d'Accoddi, Sassari
5. Monte Maiore (Thiesi)
6. Sa Ucca de su Tintirriolu (Mara)
7. Grotta Filiestru (Mara)
8. Molia (Illorai)
9. Lake Omodeo
10. Nuraghe Losa (Abbasanta)
11. Domus de Janas Triarzu (Paulilatino)
12. Perda Lada (San Vero Milis)
13. Nuraghe Santa Barbara (Bauladu)
14. Nuraghe Loddu (Fordongianus)
15. Ruinacchesos (Sorgono)
16. Su Casteddu Becciu (Fordongianus)
17. Simaxis
18. Santa Vittoria (Nuraxinieddu)
19. Nuraghe Nieddu (Oristano)
20. Gribaia (Nurachi)
21. Su Pranu (Solanas)
22. Ludosu (Riola Sardo)
23. Palas de Casteddu (Cabras)
24. Conca Illonis (Cabras)
25. Mes'e Arrius (Cabras)
26. Cuccuru s'Arriu (Cabras)
27. S'Arriedu (Cabras)
28. Cantoniera Frumini (Sili)
29. Serra de Castius (Sili)
30. Palmas Arborea (Oristano)
31. Lacumarense (Santa Giusta)
32. Nuraghe Tiria (Villaurbana)
33. Villa S. Antonio (Carabassa)
34. Grotta Lioru (Laconi)
35. Tomba di Masone Perdu (Laconi)
36. Tortoli (Ogliastra)
37. Loc. Pirrotta (Simala)
38. Nuraghe Su Para (Masullas)
39. Roja Cannas (Mogoro)
40. Nuraghe Domu Beccia (Uras)
41. Puisteris (Mogoro)
42. Nuraghe Ortu Cómidu (Sardara)
43. Serra Cannigas (Nuraminis-Villagreca)
44. Corte Auda (Senorbi)
45. San Benedetto (Iglesias)
46. Buon Cammino (Iglesias)
47. Barbusi (Carbonia)
48. Su Carroppu (Sirri-Carbonia)
49. Tracasi (Tratalias-Carbonia)
50. Crabi (Villaperuccio)
51. Monte Narcao (Villaperuccio)
52. Nuraghe Antigori (Sarroch)
53. Santa Gilla (Capoterra)
54. San Gemiliano (Sestu)
55. Cuccuru Nuraxi (Settimo San Pietro)
56. Loc. S. Pietro (Settimo San Pietro)
57. Cuccuru Craboni (Maracalagonis)
58. Su Coddu (Selargius)
59. Terramaini (Pirri)
60. Grotta S. Elia (Cagliari)
61. Grotta San Bartolomeo (Cagliari)

CORSICA

1. Pietracorbara
2. Strette (Barbaghju)
3. Campu Ventosu (Bastia)
4. Monte Grosso (Biguglia)
5. Castellari (Rapale)
6. Carcu-Modria (Catteri-Balagne)
7. Sarra Cinescu (Castello di Rostino)
8. Monte Lazzo (Casaglione-Tiuccia)
9. Saint Pancrace-Tiggianese (Pila-Canale)
10. Basi (Serra di Ferro)
11. Filitosa (Sollacaro)
12. I Calanchi (Sollacaro)
13. Tivolaggio (Sartene)
14. Dolmen de Cardiccia (Sartene)
15. Curacchiaghiu (Levie)
16. Vascolacciu (Figari)
17. Cap Pertusato (Bonifacio)



Cuccuru s'Arriu in the west (32%: Depalmas 1991) to Santo Stefano in the northeast (28%: Lilliu 1959). It is equally clear, however, that their relative frequency varies considerably, for example at Filiestru from about 30% in Ozieri levels to 70% in Cardial Neolithic levels (Trump 1983). The chronological linearity of the decrease at Filiestru perhaps even suggests that opaque obsidian (mostly SC?) was increasingly the preferred and/or more readily obtainable lithic raw material.

In Sardinia, examination of obsidian relative use frequencies by province (for all time periods) of the multiple Monte Arci sources, as determined by both chemical analysis (Figure 20, top) and by visual assessment (Figure 20, bottom), reveals significant geographic differences. 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 analyzed artifacts, greater heterogeneity in obsidian use patterns appear than in the provincial comparison above. In southern Sardinia (Figure 21, bottom), type SB is noticeable only at Tracasi, perhaps because only 10 artifacts were analyzed; although much more common overall among tested samples from northern

Figure 20. Obsidian source frequency in Sardinia, by province. Top: combined results from chemical analyses (Cann & Renfrew 1964; Hallam et al. 1976; Mackey & Warren 1983; Francaviglia 1984; Michels et al. 1984; Tykot, this work) for sites of all time periods. Bottom: results of visual assessment (Tykot, this work) for sites of all time periods. Numbers of artifacts represented are at the top of each bar.

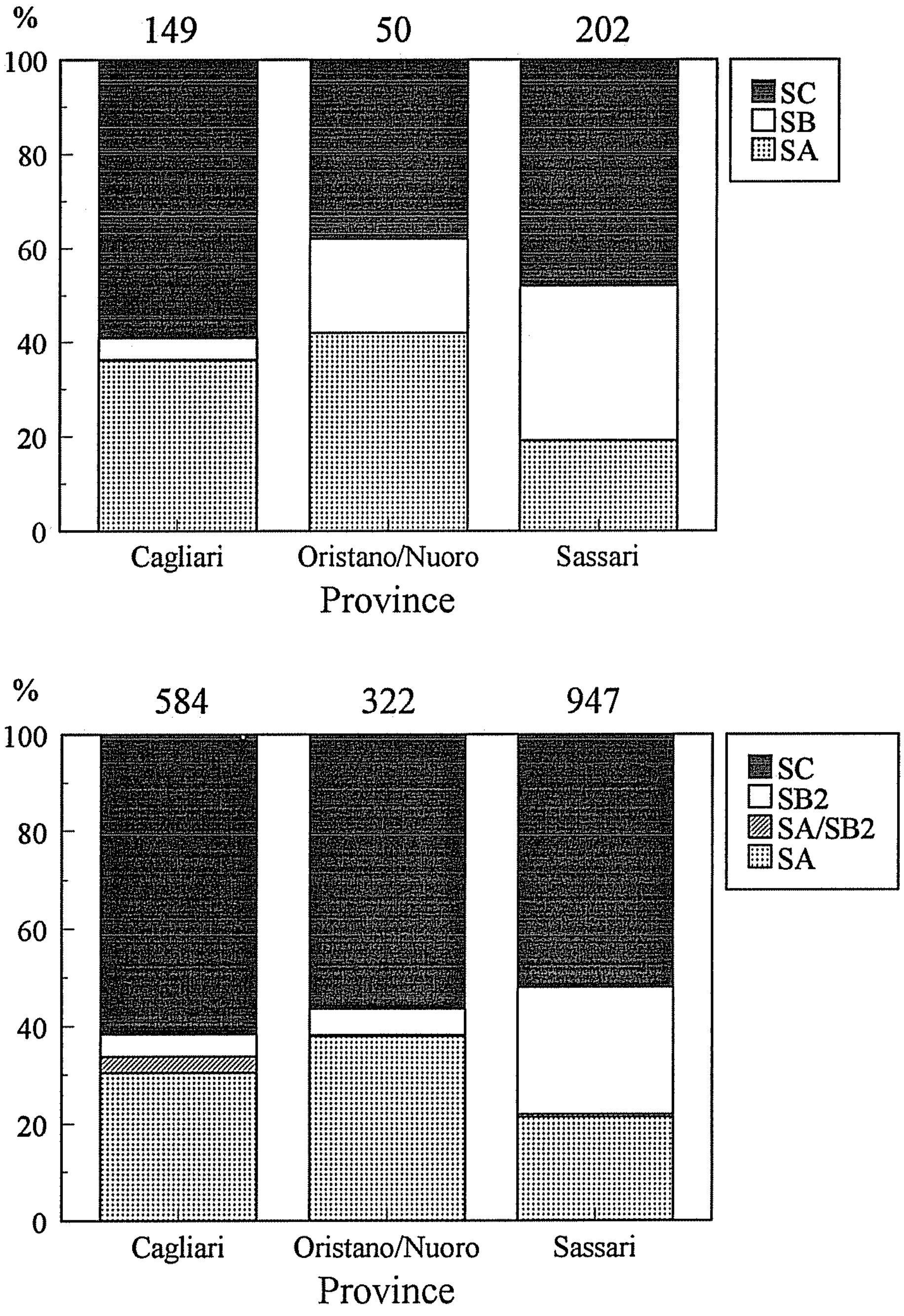
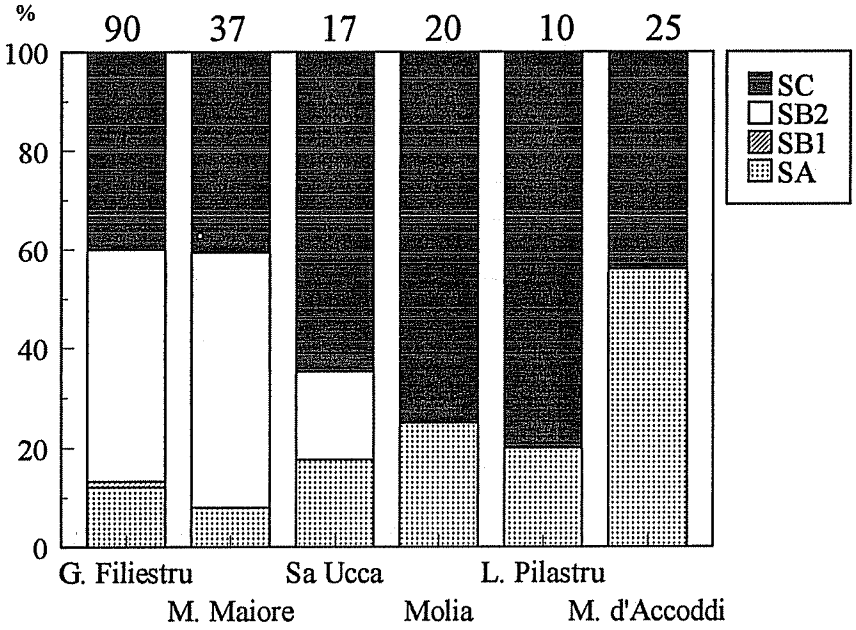
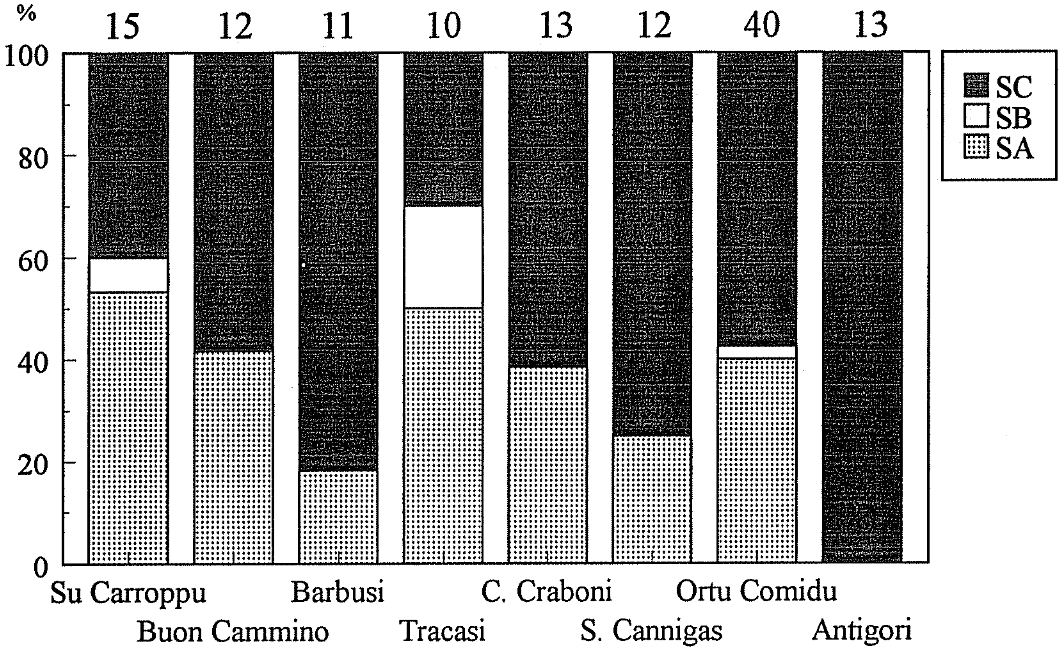


Figure 21. Obsidian source frequency at individual Sardinian sites. Top: sites in northern Sardinia, all but 6 analyses by microprobe (Tykot, this work). Bottom: sites in southern Sardinia, analyses by AAS (Michels et al. 1984; Tykot, this work) except for 13 from Ortu Còmidu (NAA: Mackey & Warren 1983). Sites are in chronological order (based on earliest occupation phase) with oldest sites at left. Numbers of artifacts represented are at the top of each bar.

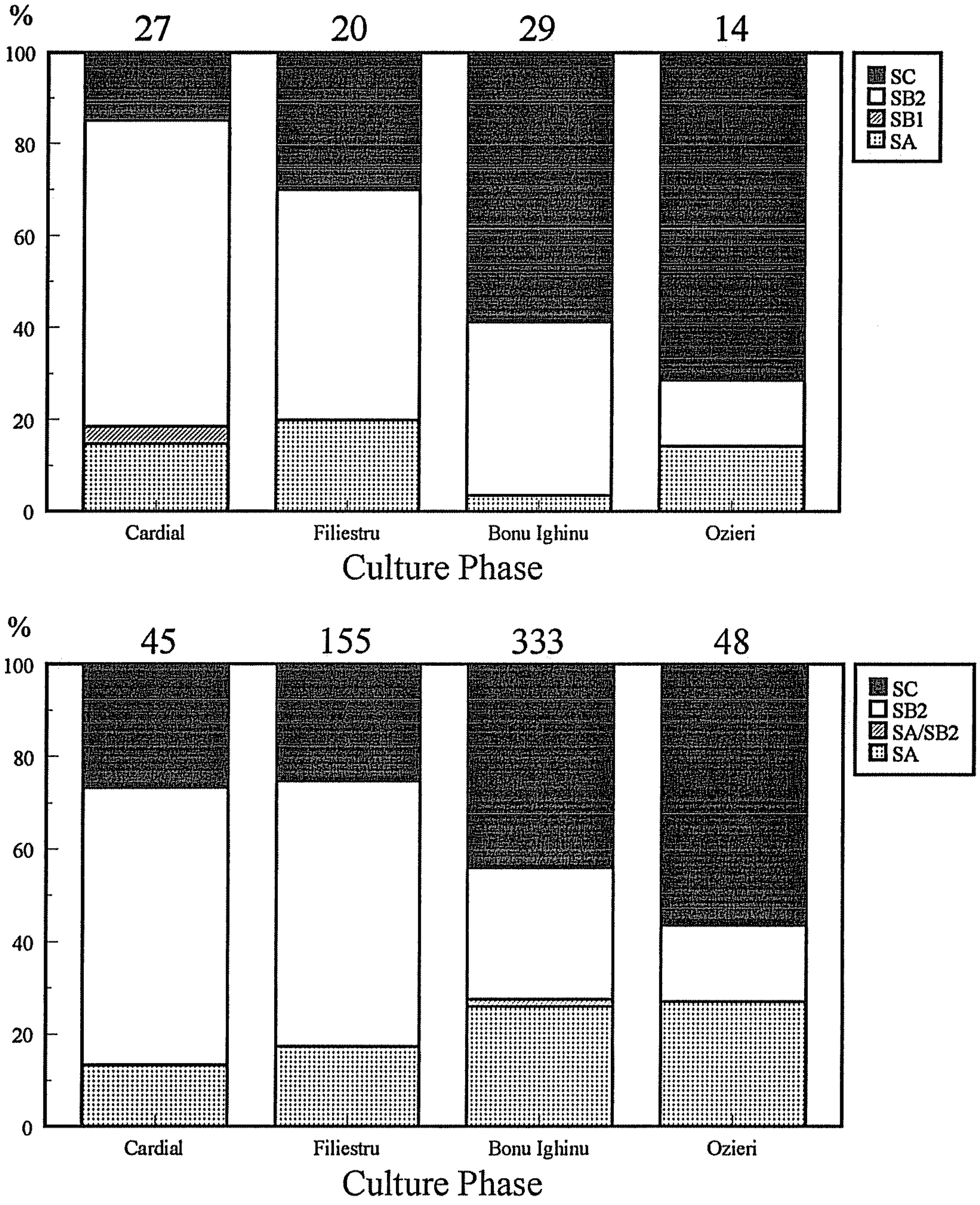




Sardinia (Figure 21, top), it is in fact not represented at all at three of the six sites there with 10 or more analyses. The chronology of the sites appears to be at least part of the explanation. Molia and Liscia Pilastru are Late Neolithic (Ozieri) sites, and Monte d'Accoddi is Final Neolithic/Chalcolithic, whereas most of the artifacts from Grotta Filiestru are Early and Middle Neolithic, as are those from Monte Maiore - both sites where type SB represents more than 45% of the obsidian assemblage. Sa 'Ucca de su Tintirriolu, 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 artifacts examined (in addition to the 20 chemically analyzed), and only 14 of 189 (7%) type SB artifacts at Li Muri (also Late Neolithic). 11% of 114 Middle Neolithic obsidian artifacts from Cala Villamarina 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 artifacts were chemically analyzed, and an additional 581 were visually provenanced (Figure 22). 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 analyzed are of type SB2 obsidian. It is also worth noting the difference in the frequency of type SA indicated by the chemical

Figure 22. Obsidian source frequency at Grotta Filiestru. Top: samples analyzed by electron microprobe, plus 4 Ozieri artifacts analyzed by NAA (Mackey & Warren 1983). Bottom: samples attributed by visual assessment. Numbers of artifacts represented are at the top of each bar.



and visual determinations. Only 1 of the 29 Bonu Ighinu artifacts analyzed by microprobe is type SA (3.5%), while visual assessment of more than 10 times as many artifacts (333) indicates it probably comprises about 25% of the assemblage. The problem, then, of even significant numbers of incorrect visual attributions appears equal to that of the sampling error associated with small numbers of analyzed artifacts. Interpreting the results from modest numbers of analyses is certainly a major problem in the western Mediterranean, since only two previously published sites - Acconia and Grotta dell'Uzzo - even have as many analyses from a single cultural period as the Bonu Ighinu level at Grotta Filiestru.

Corsica and the Tuscan Archipelago

The problem of sample size is also 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 analyzed artifacts were from that source. In contrast, chemical analyses now of 428 artifacts from 17 sites (*supra*, Figure 19) 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 23). I wrote several years ago 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 (Tykot 1992a:65). 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?

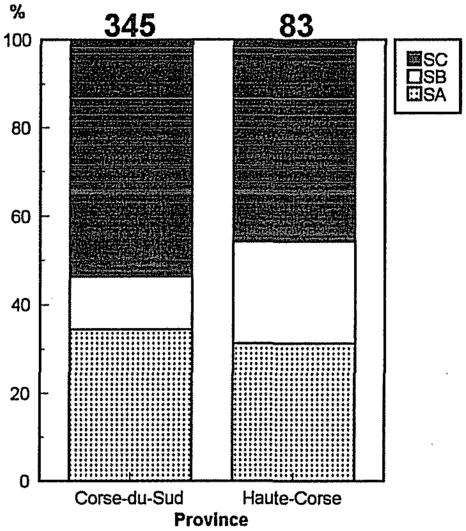
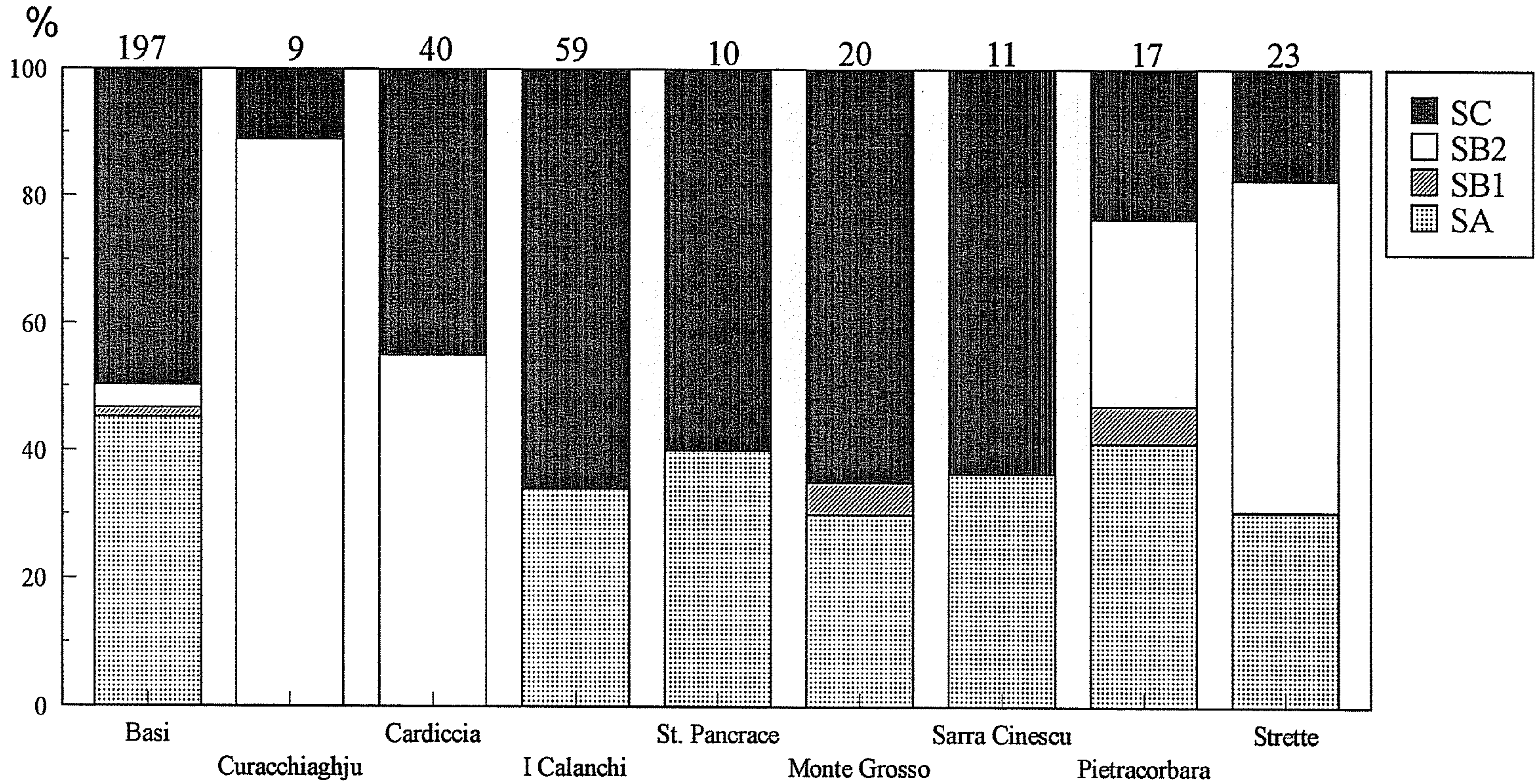


Figure 23. Obsidian source frequency in Corsica, by province. All data based on chemical analyses (Hallam et al. 1976; Crisci et al. 1994; Tykot, this work). Numbers of artifacts represented are at the top of each bar.

If we look at the data for individual sites (Figure 24), chronology again appears to provide some of the answer. Curacchiaghju, Pietracorbara and Strette are Early Neolithic or have Early Neolithic components, making the low frequency of SB obsidian at Basi (levels 7-6) 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 (22 of 40 are SB2) 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 artifacts 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

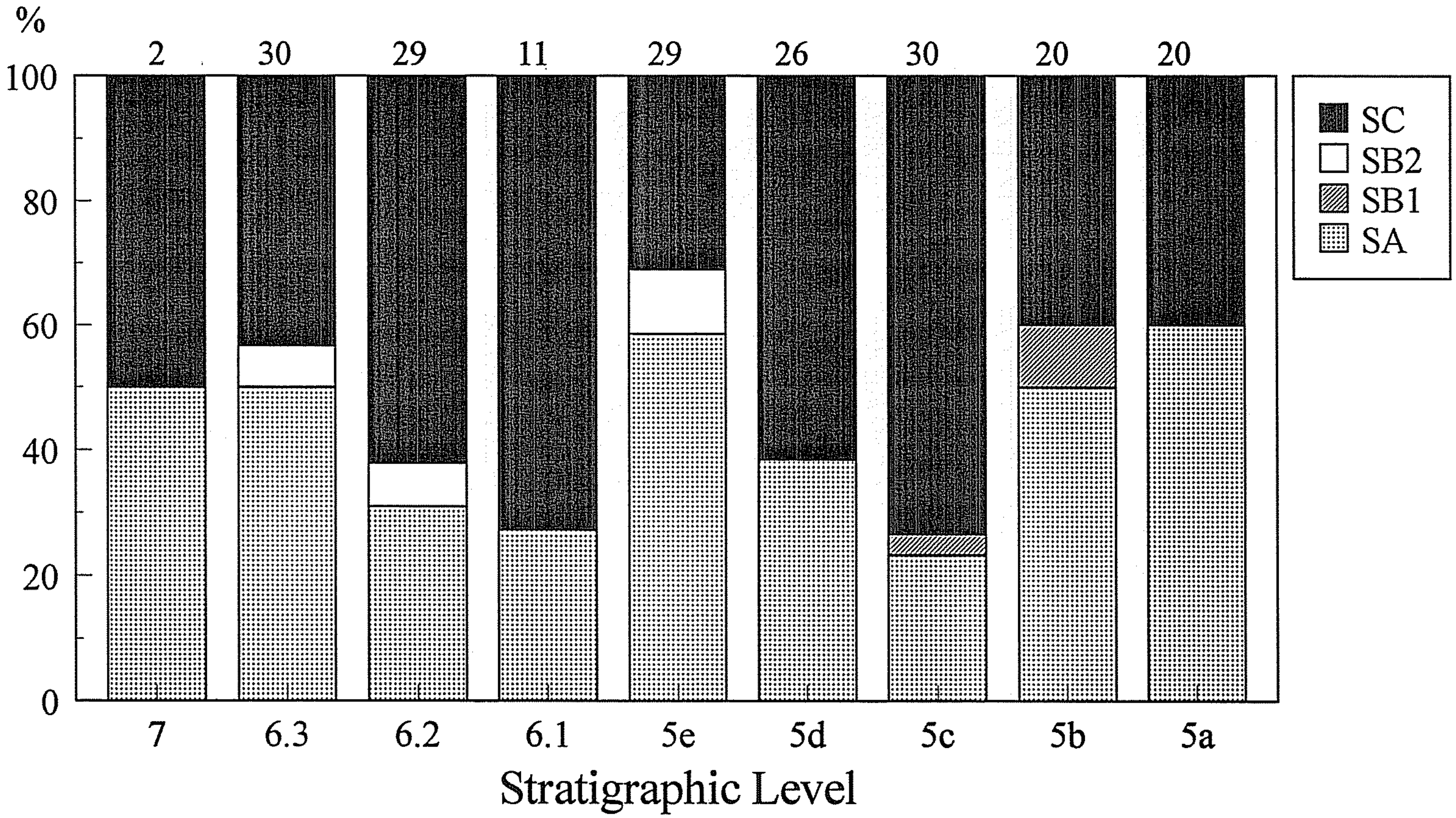
Figure 24. Obsidian source frequency at individual sites in Corsica. All analyses by microprobe (Tykot, this work) except for 9 each from Curacchiaghju and Basi plus 1 from Strette (Hallam et al. 1986; Crisci et al. 1994). Numbers of artifacts represented are at the top of each bar.



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

214 obsidian artifacts from Basi have been analyzed, 197 of them from specific stratigraphic contexts (Figure 25), the most analyses from any site in the western Mediterranean. Although a chi-square test of source frequency for each of 9 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 (Bailloud 1969a; 1969b; cf. 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 5 of the 8 levels with more than 2 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).

Figure 25. Obsidian Source Frequency at Basi. Levels 7 and 6 are Early Neolithic, Level 5 is later Neolithic (Basien). All analyses represented by microprobe (Tykot, this work). Numbers of artifacts represented are at the top of each bar.



It has been taken for granted that Sardinian obsidian made its way to the mainland via Corsica and the Tuscan archipelago, minimizing the open-water distances traveled (e.g. Phillips 1975; Hallam et al. 1976:99; Bagolini 1980:42; Williams-Thorpe, Warren & Courtin 1984:141). In fact, obsidian has been found on the islands of Elba, Capraia, Pianosa and Giglio. All 14 artifacts that I analyzed from the Cardial Impressed Ware site of La Scola on Isola Pianosa are from Sardinia and include 5 of the SB2 type, emphasizing again the importance of this source in the Early Neolithic. Two artifacts 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 analyzed, although the excavator attributes them to Lipari (Brandaglia 1985:59-60). As we will see below, however, Lipari obsidian was not extensively distributed so far north in the Early Neolithic, 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.

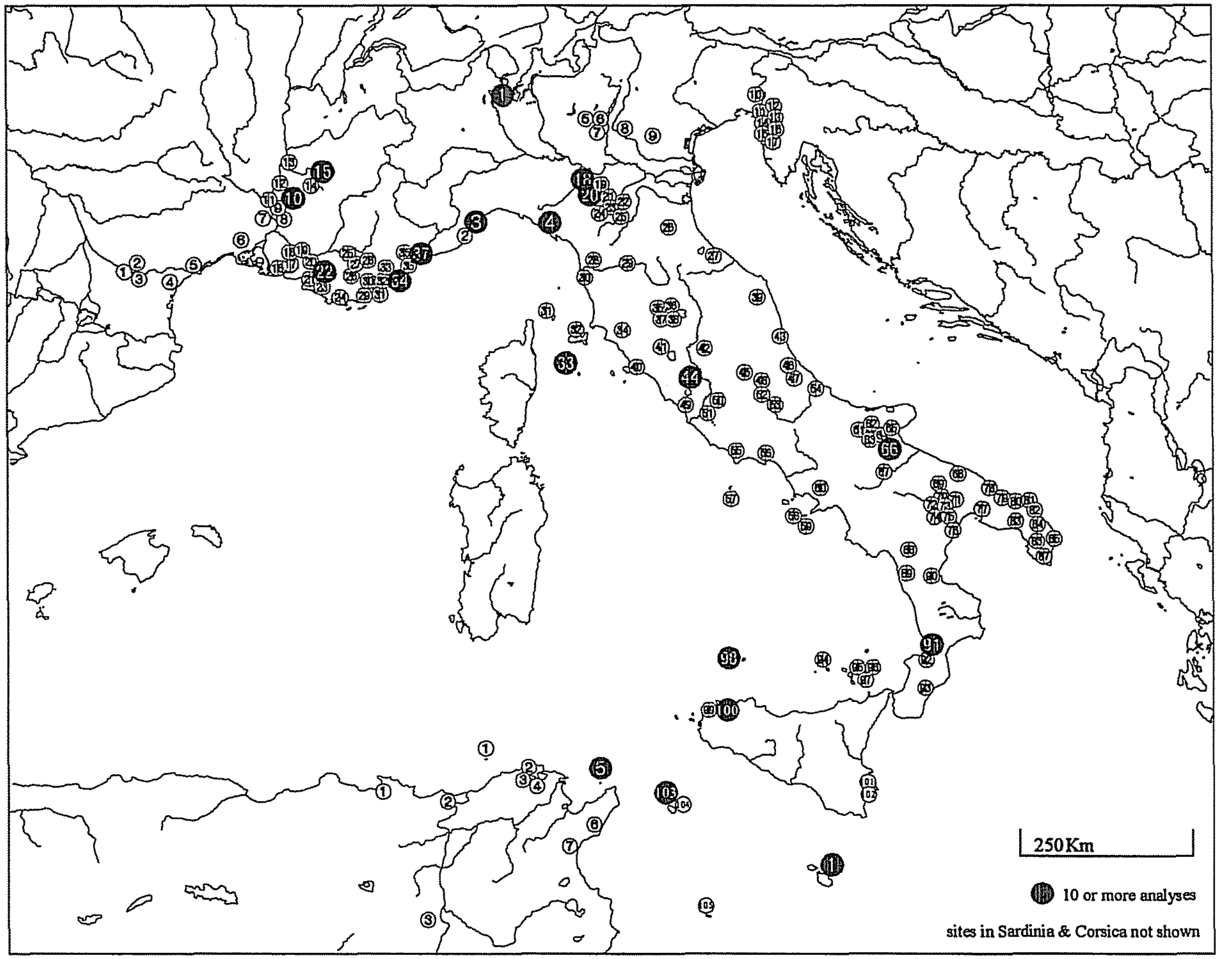
Southern France, Northern and Central Italy

In Europe and the Mediterranean regions, obsidian appears to have been distributed as part of a few mutually exclusive systems: Anatolia and the Levant; the Aegean and Greece; central Europe; and the central/western Mediterranean. The only sure examples of Melos obsidian west of the Balkans are three pieces from Grotta del Leone-Agnano from an insecure context (Bigazzi et al. 1992b;

1986; Bigazzi & 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 (Polglase 1989; Antoniazzi et al. 1990:55). Five analyzed 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 & 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 analyzed (13 SA, 1 Li: Hallam et al. 1976; Williams-Thorpe et al. 1979). The number of sites now with analyzed obsidian in the western Mediterranean is actually quite considerable, including 37 in France and over 100 in Italy and Sicily, and the list of those sites with 10 or more analyses is growing (Figure 26). Nevertheless, only 5 excavated sites outside Sardinia and Corsica have more than 20 chemical analyses.

Figure 26. Western Mediterranean sites with analyzed obsidian. Obsidian analyzed by chemical, physical, or visual methods. For Sardinia and Corsica, see Figure 19. Results and references in Appendix H, Tables H1 and H2.



FRANCE

1. Station de Chabert (Sainte-Eulalie)
2. Sta. des Plos (Ventenac-Cabardès)
3. Auriac (Carcassonne)
4. Sainte-André-de-Roquelongue
5. Peiro Signado (Portiragnes)
6. Puech de la Fontaine (Congénies)
7. Station de Saint-Loup (Tresques)
8. La Bertaude (Orange)
9. Oppidum des Roches (Piolenc)
10. Station des Combes (Piolenc)
11. Le Crestair (Mornas)
12. La Roberte (Chateauneuf-du-Rhône)
13. Beauvallon (Valence)
14. Grotte d'Antonnaire (Montmaur-en-Diois)
15. Les Terres Blanches (Menglon)
16. L'Étang de l'Olivier (Istres)
17. Beaumajour (Grans)
18. Les Ribassières (Vernègues-Cazan)
19. Camplan (Lambesc)
20. La Citadelle (Vauvenargues)
21. La Galinière (Mimet)
22. Sainte Catherine (Trets)
23. La Grande Baume (Gémenos)
24. La Maravenna (La Londe-les-Maures)
25. Grotte de l'Église Supérieure (Baudinard-sur-Verdon)
26. Tusèle (Cabasse)
27. Font Marthe (Villecroze)
28. Saint-Pierre (Tourtour)
29. Les Marres (Ramatuelle)
30. San Sebastien (Plan-de-la-Tour et Sainte-Maxime)
31. Salinettes (Saint-Tropez)
32. Vigne de Montrouge (Saint-Raphaël, Agay)
33. Les Veyssieres (Saint-Raphaël, Agay)
34. La Cabre/Le Grenouiller (Saint-Raphaël, Agay)
35. La Rouret (Carros)
36. Caucade (Nice)
37. Giribaldi (Nice)

ITALY

1. Isolino di Varese
2. Grotta Pollera (Savona)
3. Arene Candide (Finale Liguria)
4. Pianaccia di Suvero
5. Monte Covolo (Brescia)
6. Rocca di Manerba
7. Riparo Valtenesi (Manerba)
8. Bellori (Grezzana-Verona)
9. Grotta G. Perrin (Sengia Bassa di San Cassiano)
10. Sammardenchia di Pozzuolo
11. Grotta della Tartaruga (Trieste)
12. Vlašca Jama (Trieste)
13. Riparo di Monrupino (Trieste)
14. Grotta degli Zingari (Sgonico)
15. San Quirino (Trieste)
16. Grotta Lonza (Monrupino)
17. Grotta dell'Ansa (San Pelagio)
18. Gaione (Parma)
19. Razza di Campegine
20. San Polo d'Enza
21. Chiozza (Scandiano)
22. Villa Agazzotti (Formigine)
23. Cava Nuova (Fiorano)
24. Pescale (Prignano)
25. Spilamberto (Modena)
26. Fornace Cappuccini (Faenza)
27. Misano Adriatico (Riccione)
28. Grotta del Leone (Agnano)
29. Piazza della Signoria (Firenze)
30. Podere Uliveto (Livorno)
31. Isola di Capraia
32. Isola d'Elba
33. La Scola (Isola Pianosa)
34. Grotta del Fontino (Vallerotana)
35. Pienza
36. Cava Barbieri (Pienza)
37. Grotta del Beato Benincasa (Pienza)
38. Grotta dell'Orso (Sarteano)
39. Santa Maria in Selva (Treia)
40. Argentano (Grosseto)
41. Ischia di Castro (Viterbo)
42. Grotta Bella (Montecastrilli)
43. Ripoli (Corropoli)
44. Poggio Olivastro (Vulci)
45. Valle Ottara (Cittaducale)
46. Catignano (La Stepara)
47. Villa Badessa (Rosciano)
48. Ponte Peschio (Genzano)
49. Palidoro (Roma)
50. Setteville (Tivoli)
51. Via Pontina (Roma)
52. Paterno (Avezzano)
53. Santo Stefano (Ortucchio)
54. Fossacesia (Chieti)
55. Batteria (Monte Circeo-Roma)
56. Campo Mezzomonte (Roma)
57. Isola di Ponza
58. Isola di Capri
59. Grotta delle Felci (Capri)
60. Pompeii
61. La Panettaria (Lucera)
62. Lucera
63. Casone (San Severo)
64. Monte Aquilone (Manfredonia)
65. Grotta Scaloria (Manfredonia)
66. Passo di Corvo (Foggia)
67. Masseria Leonessa (Melfi)
68. Bari
68 Pulo di Altamura (Bari)
68\. S. Candida (Bari)
69\. Gravina di Picciano (Matera)
70\. Serra d'Alto (Matera)
71\. Fonte di Vita (Matera)
72\. Grotta Funeraria (Matera)
73\. Murgecchia (Matera)
74\. Murgia Timone (Matera)
75\. Grotta dei Pipistrelli (Matera)
76\. Pizzica Pantanello (Metaponto)
77\. Torre Sabea (Taranto)
78\. Torre Canne (Fasano)
79\. Torre Bianca (Fasano)
80\. Fontanelle (Ostuni)
81\. Grotta Morelli (Ostuni)
82\. Torre Testa (Brindisi)
83\. Torre S. Sussanna (Masseria Guidone)
84\. Masseria S. Gaetano (Guagnano)
85\. Laghi Alimini (Otranto)
86\. Campi Latini (Galatone)
87\. Grotta della Trinità (Ruffano)
88\. Grotta Grande di Latronico (Potenza)
89\. Grotta del Romito (Papasidero)
90\. Grotta Sant'Angelo (Cassano Ionio)
91\. Acconia
92\. Bevilacqua (Acconia)
93\. Prestarona (Canolo)
94\. Isola di Filicudi
95\. Isola di Lipari
96\. Castellaro Vecchio (Lipari)
97\. Lipari Castello
98\. Isola di Ustica
99\. Monte Cofano (Trapani)
100\. Grotta dell'Uzzo (Trapani)
101\. Santa Panegia (Siracusa)
102\. Arenella (Siracusa)
103\. Mursia (Pantelleria)
104\. Isola di Pantelleria
105\. Cala Pisana (Lampedusa)

MALTA

1. Skorba

TUNISIA

1. La Galite
2. Remel (Bizerte)
3. Environs de Bizerte
4. Djebel ed Dib (Béchateur)
5. Ile de Zembra
6. Korba
7. Sebkhet Halk el Mennzel (Hergla)

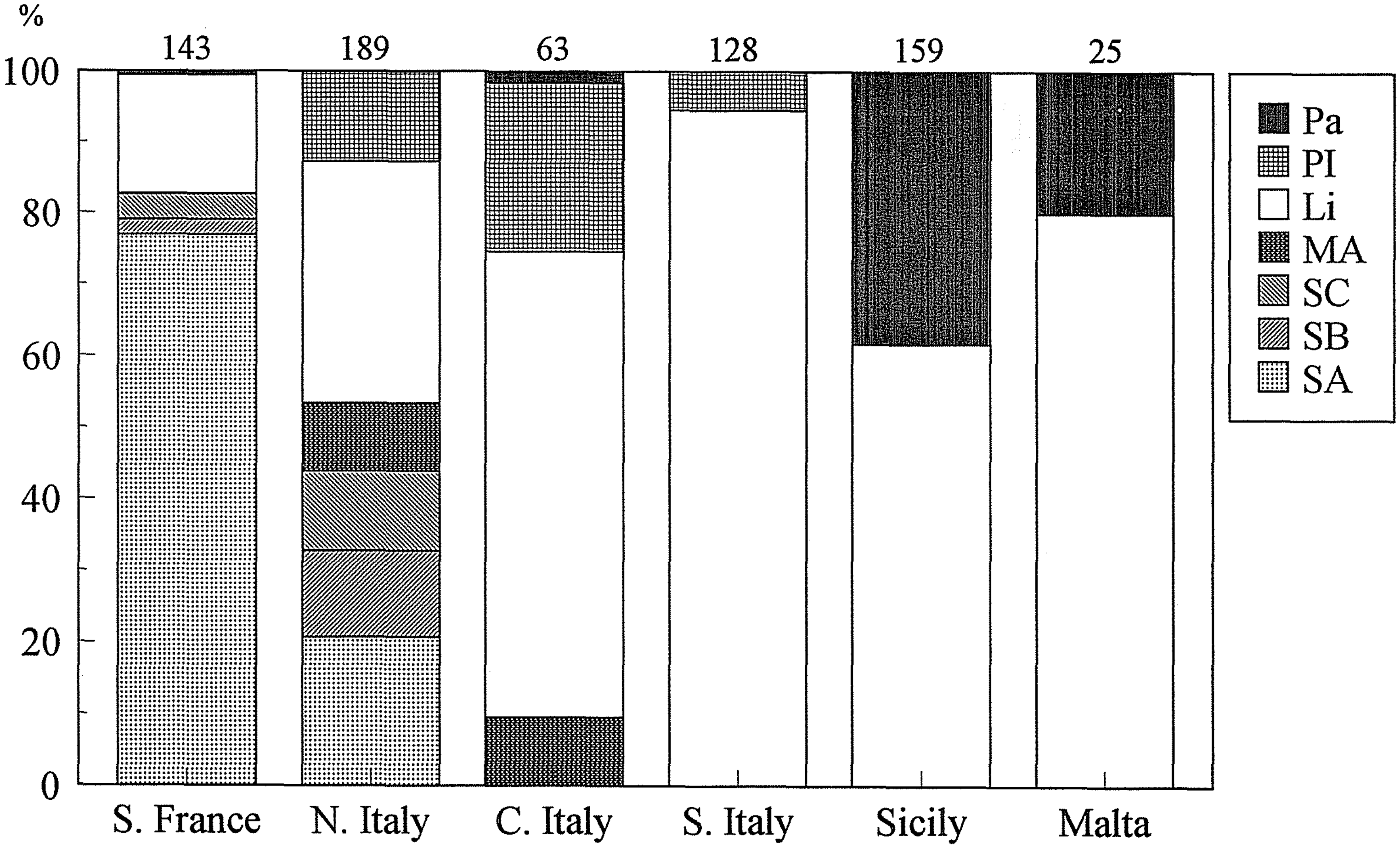
ALGERIA

1. La Marsa (Skikda)
2. Aïn Khiar (Annaba)
3. Tebessa

In southern France, obsidian from Early Neolithic sites is extremely rare, and the one piece analyzed from Peiro Signado-Portiragnes comes from Lipari (Crisci et al. 1994). Obsidian is found more regularly - but still in very small quantities - at Middle Neolithic (Chasséen) sites in the form of blades, flakes and cores. At Giribaldi-Nice, the 58 obsidian artifacts 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 & Courtin 1994). Provenance determinations of 143 obsidian artifacts from French sites show them to be predominantly of Sardinian origin (Figure 27). Only 24 analyzed artifacts are from Lipari, and most of them appear in earlier rather than later Neolithic contexts (1 Early Neolithic, 13 Early Chasséen, 7 Chasséen; 3 ?), providing a contrast to the increasing quantities of Sardinian obsidian. At the Chasséen site of La Cabre/Le Grenouiller-Agay, 37 of 41 analyzed obsidian artifacts are Sardinian, as are all 22 pieces analyzed from the Late Chasséen 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 artifacts 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 in the western Mediterranean 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

Figure 27. Obsidian source frequency in the western Mediterranean, by region. All analyses by chemical or physical methods; attribution to unspecified Sardinian sources (MA) is based on fission-track dating. Numbers of artifacts represented are at the top of each bar.



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 & 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 & 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 Provençe was the last in a network series from Sardinia to Corsica to Tuscany to Liguria, and perhaps over the Alps into Provençe from the Po Valley (Hallam et al. 1976:99; cf. also Williams Thorpe, Warren, & Courtin 1984:141). The small quantities reaching Provençe 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).

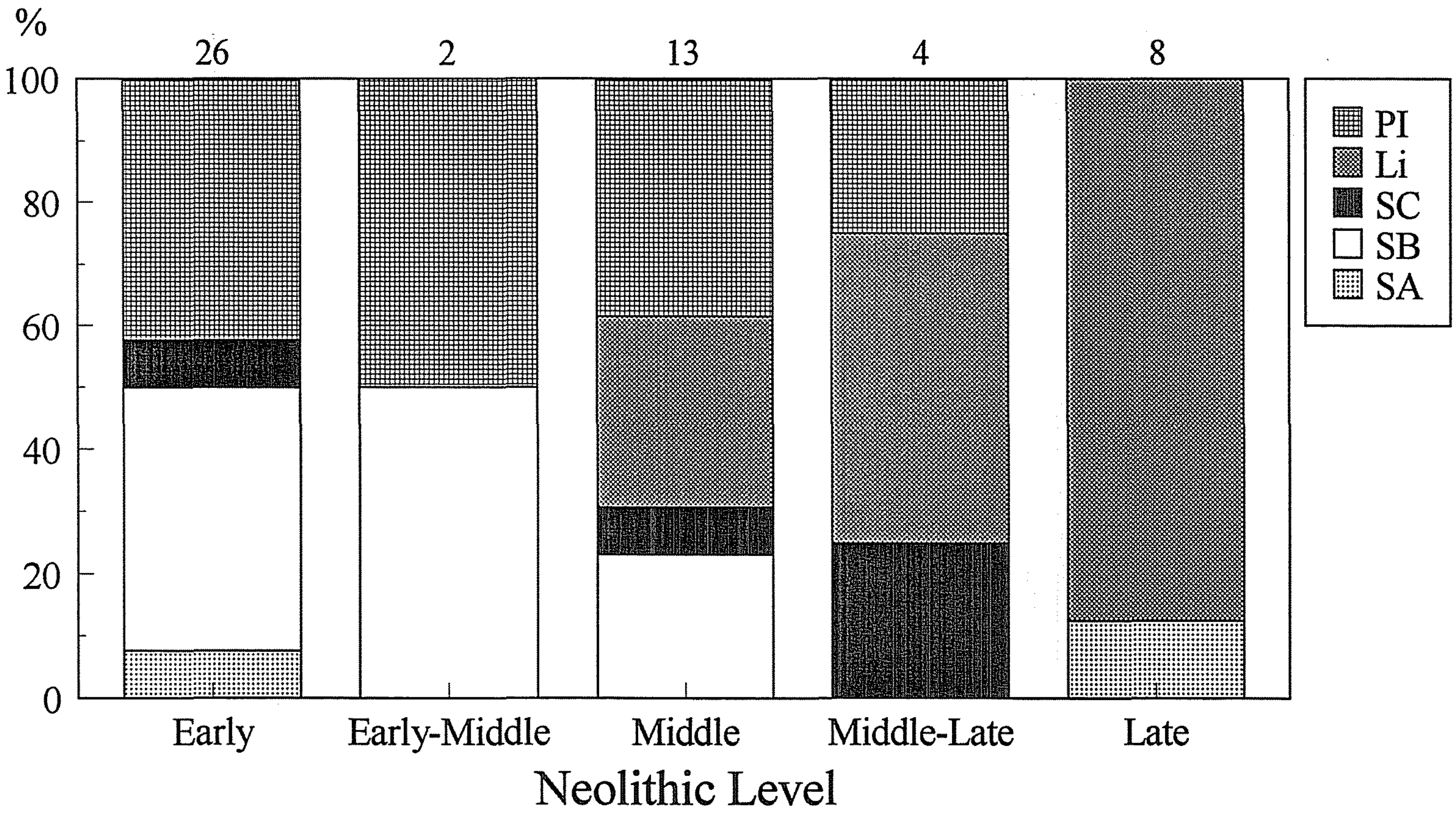
Since obsidian from at least two if not three Monte Arci sources are commonly found at sites in northern Italy (*infra*), Corsica, and even in the Oristano area, the concentration on type SA obsidian in southern France can only be explained by (1) conscious selection of that type (1a) during acquisition from their neighbors' "supply" (in a down-the-line sense) and/or (1b) by procurers in the supply zone; or by (2) the obsidian finds at so many sites deriving 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 French "merchants" (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 & 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 French sailors 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 & Courtin 1984), nearly 850 linear Km from their source. The absence of Palmarola obsidian among the many artifacts that have now been analyzed 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 & 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 (*supra*, Figure 27). 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 artifacts have been analyzed. At the Middle Neolithic 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 artifacts from several Neolithic stratigraphic contexts have been analyzed (Ammerman & Polglase 1993; 1995). In the Early Neolithic, obsidian comprises about 5% of the lithic assemblage at Arene Candide, and comes equally from Sardinia and Palmarola (Figure 28). 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 obsidian - PI + SC - remains constant), and by the Late Neolithic, nearly all obsidian artifacts are finished blades of Lipari obsidian. Ammerman & Polglase (1993; 1995) 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 analyzed only 8 Late Neolithic artifacts from Arene Candide, and Sardinian obsidian is actually better represented than Lipari among Late Neolithic artifacts from other sites (combined analyses of Williams-Thorpe et al. 1979). Furthermore, visual examination of 99 obsidian artifacts from Gaione (Polglase 1990) suggest equal use of Lipari and other sources during the Middle Neolithic, while visual examination of 334 obsidian artifacts from Fornace Cappuccini-Faenza (Polglase 1989) may indicate that non-Lipari obsidian was more common

Figure 28. Obsidian source frequency at Arene Candide. All attributions by neutron activation analysis (Ammerman & Polglase 1993; 1995). Numbers of artifacts represented are at the top of each bar.



there from the Early Neolithic through the Chalcolithic. Finally, my visual provenancing of 213 artifacts 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 Bradford researchers show only Palmarola obsidian from that site (Crummett & 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. 1963) but this attribution should not be taken for granted (e.g. Crummett & 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 1 of 25 analyzed 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 at a conference that some artifacts 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 & 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 analyzed 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 & Polglase 1993). Strong 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 (Perlès 1992:145-146), but in fact the ESR analyses performed by Mello

(1983) could not distinguish between Melos, Monte Arci, and Palmarola - the most likely possibility. To date, not a single piece of western Mediterranean obsidian has been identified east of Italy's heel.

All the obsidian found in Malta comes from Lipari and Pantelleria, not Melos (Cann & Renfrew 1964 and Hallam et al. 1976, *contra* Cornaggia Castiglione et al. 1963). Visual identification of 300 artifacts from Skorba indicate that more than 85% comes from Lipari (Cann & Renfrew 1964), indicating that Malta's socioeconomic 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 analyzed. Nearly 40% of 152 obsidian artifacts from Grotta dell'Uzzo, however, come from Pantelleria (Francaviglia & 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 & Piperno 1987), and on the island of Ustica to the north (Tykot 1995c). 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. Not a single analysis of obsidian found at North African sites has been published, however, although several samples were analyzed in 1976 (unpublished data; cf. Williams-Thorpe 1995:229). These analyses have been cited by Crummett & 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. One should note also that the few red obsidian flakes reported by Vuillemot (1954) at Pic de la Vierge (Îles Habibas, Oran) in western Algeria are andesitic and of local origin (Camps 1964:297).

Several reports identify the source of particular artifacts as from Pantelleria if they are green, and as Lipari if they are more transparent, reasonable attributions if done by experienced individuals. Gobert (1962) has thus identified a specimen from Korba as from Pantelleria, as has Camps for examples from Tebessa

(1964:296) and Hergla (1974:269). Only one obsidian artifact was found at Tebessa, and it is unclear whether this was the artifact analyzed by Williams-Thorpe. Pantelleria is also indicated in a map (Gras 1985:27; also Camps 1988:86) as the source of an unknown number of artifacts from the small island of La Galite, although no further information is given. Obsidian from Lipari has been identified by J. Morel (cited in Camps 1964:295) at Aïn Khiar and La Marsa in Algeria, and by Camps (1974:269) at Djebel ed Dib and in the Bizerte area [presumably the specimens noted by Fobis (1916) and Pallary (1905)]. The Djebel ed Dib material, however, is more likely from Pantelleria, since the 32 pieces recovered there have been described by Gruet (1947; quoted in Camps 1964:294) as "...noire mate sauf lustrage par le vent de sable, vert olive par transparence en faible épaisseur."

I personally examined 34 pieces of obsidian collected during surface surveys and excavation directed by J.-D. Vigne on the small island of Zembra. 19 of the flakes examined come from the Abri du Scorpion site which has been dated to the Neolithic based on ceramic and lithic typologies. Obsidian is found at numerous sites on the island, but never in association with Classical, Arabic, or Modern material, suggesting that it may all be dated to the Neolithic period. All 34 samples are clearly green in transmitted light and thus derive from Pantelleria. Clearly, much more analytical work will be necessary to demonstrate conclusively the relative distributions of both Pantellerian and Liparian obsidian in North Africa. Obsidian is being identified at more and more sites, although rarely in significant quantity (see 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).

CHAPTER EIGHT: DISCUSSION AND CONCLUSIONS

> La voie de l'obsidienne ainsi repérée sera celle des produits divers, mais également des idées, des hommes (Lanfranchi 1987a:441).
>
> Obsidian provenancing studies comprise one of the most productive and successful research programmes of archaeological science (Williams-Thorpe 1995:217).

In the western Mediterranean, obsidian sources exist on four islands: Lipari, Palmarola, Pantelleria, and Sardinia. Sardinia was the only source island inhabited when obsidian exploitation began in the Early Neolithic, as settlements first appeared on Lipari during the Middle Neolithic and on Palmarola and Pantelleria only in the Bronze Age; Sardinia is also unique in that obsidian does not occur right on the coastline, which facilitated its initial discovery on and procurement from the other islands. Since Sardinia is a large land mass with its own cultural history and characteristics, the distribution of obsidian from several discrete source locations was an important local economic development as well as an indicator of intercultural relationships with neighboring Corsica and the French and Italian mainland.

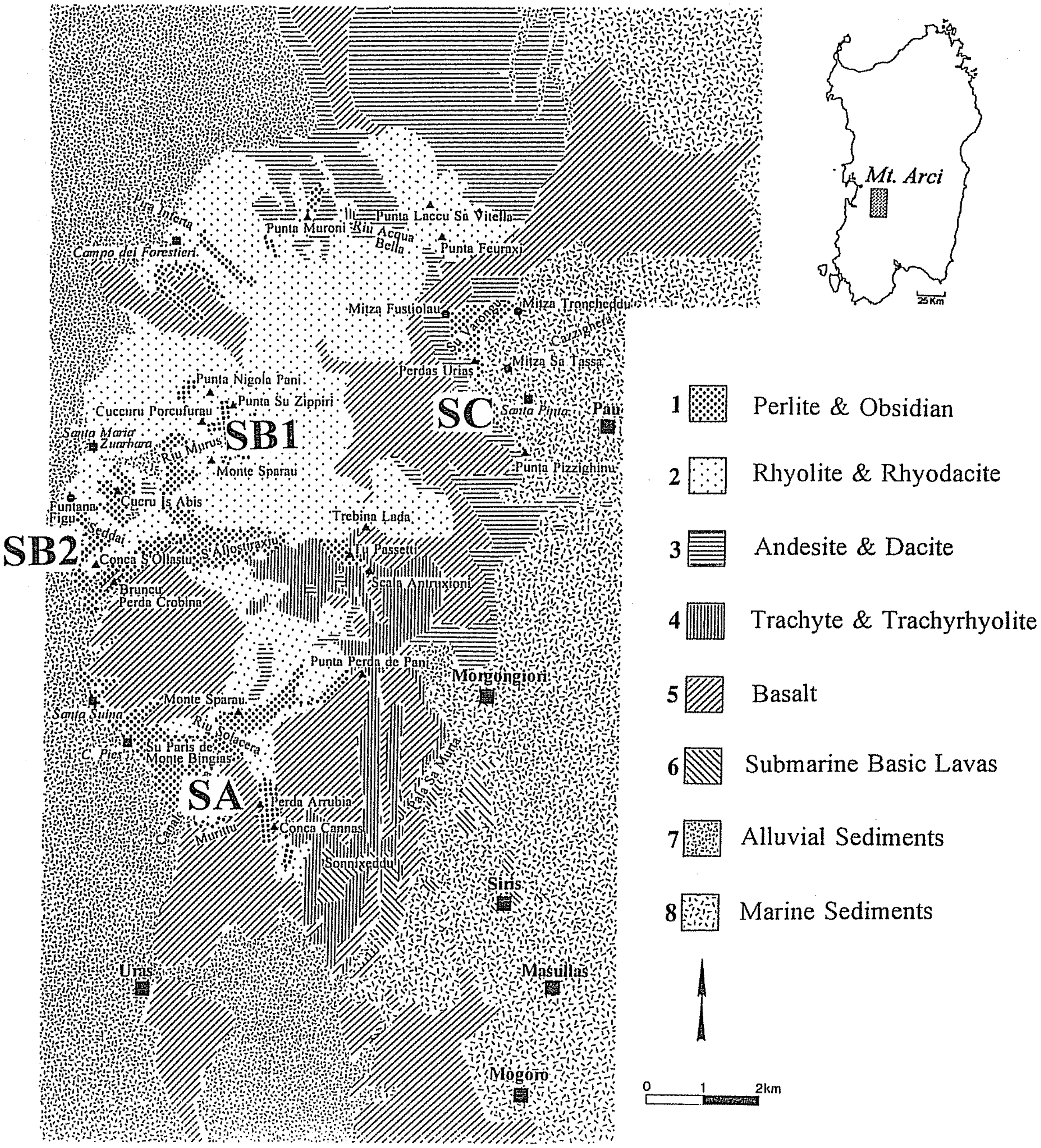
Natural blocks of workable obsidian are found abundantly in the Monte Arci area of Sardinia, and analyses of geological specimens from various localities there has demonstrated the existence of nine chemically differentiable source groups, including five (SA, SB1, SB2, SC1, SC2) which were used in prehistory for making stone tools. Trace element characterization is necessary to distinguish among these five source groups, but the minor chemical distinction between the geographically-intermingled SC1 and SC2 types is not of archaeological significance. Major element analyses are therefore sufficient for provenancing artifacts from all Mediterranean obsidian sources.

The exploited Sardinian obsidian sources are located in different areas of the Monte Arci volcanic complex (Figure 29), and vary in their accessibility, as well as in the quantity and quality of the obsidian available at each locality. Type SA obsidian is abundantly found in large nodules within a soft perlitic matrix, in a very concentrated location (Conca Cannas) easily accessible at the southwestern foot of Monte Arci. In contrast, large blocks of type SB2 occur in smaller quantities, but at multiple source localities (Bruncu Perda Crobina, Conca s'Ollastu, Seddai, Cucru Is Abis), also easily accessible on the western flanks of Monte Arci. Type SB1, usually found in localized deposits as small nodules within a much harder volcanic matrix, is also less accessible as it occurs at higher elevations towards the interior of Monte Arci. Large nodules of type SC obsidian, also originating from soft perlitic matrices, are quite abundant judging from material found in secondary contexts, although only a single *in situ* exposure has been identified. The SC source zone is located at very high elevations on the eastern side of Monte Arci, with easy access only from the south or further east.

Procurement

During the Early Neolithic, 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

Figure 29. Monte Arci obsidian source zones. Workable obsidian has been found *in situ* near Conca Cannas (SA); Monte Sparau (north), Cuccuru Porcufurau, Punta Su Zippiri and Punta Nigola Pani (SB1); Bruncu Perda Crobina, Conca s'Ollastu, Cucru Is Abis and Seddai (SB2); and Punta Pizzighinu (SC).



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, 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 & Perlès 1992). Nevertheless, both agriculturalists in California and hunter-gatherers in Australia were able, however, 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 groundstone 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.

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 & Phillips 1995), while use-functions of individual tools were also more specific in the later period (Hurcombe 1986; 1992a; 1992b). This is consistent with a general impression of progressive typological standardization and maximization of core material by the Late Neolithic (Garibaldi 1993).

In the Aegean, Torrence (1981a; 1984; 1986) has observed that exploitation of the Melos quarries was short-lived and not systematic; macrocores and debitage were not standardized in shape or size (Torrence 1979a); and the volume of obsidian extracted from Melos and distributed to Aegean sites (Torrence 1979b) does not support a hypothesis of full-time craft specialization within Neolithic villages (Torrence 1982). Rather, obsidian procurement was an inefficient, short-lived process of direct access, sporadically undertaken during the Upper Paleolithic, Mesolithic, and Neolithic in the course of multi-purpose trips made by mainland residents (Torrence 1981a; 1984; 1986; Cherry & Torrence 1982; Cherry 1985), probably using small reed-bundle boats (Johnstone 1980; Tzalas 1989; 1993). It was subsequently distributed on the mainland through simple reciprocal exchange mechanisms (Renfrew 1972; Renfrew et al. 1965; Torrence 1981a).

Binder & Perlès (1990; Binder 1987; Perlès 1992; cf. also Demoule & Perlès 1993) indicate, however, that obsidian tools were knapped by highly-skilled workers during the Neolithic in Greece and elsewhere, and that even though the open-water distances involved in travel to Melos were substantially less than for the western Mediterranean obsidian sources, maritime travel also involved considerable technical skill. Perlès (1990b; 1992) argues convincingly that itinerant knappers pre-formed cores while on Melos, and subsequently produced blades from a single core at several mainland villages.

Back in the western Mediterranean, labor specialization must have existed there also 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.

Michels et al. (1984), considering that Sardinian communities obtained their obsidian through direct procurement, suggested that access to the sources may have become restricted by the Middle Bronze Age, based on the presence of only one type of obsidian at some of the sites they tested. 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 artifacts 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 artifacts 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.

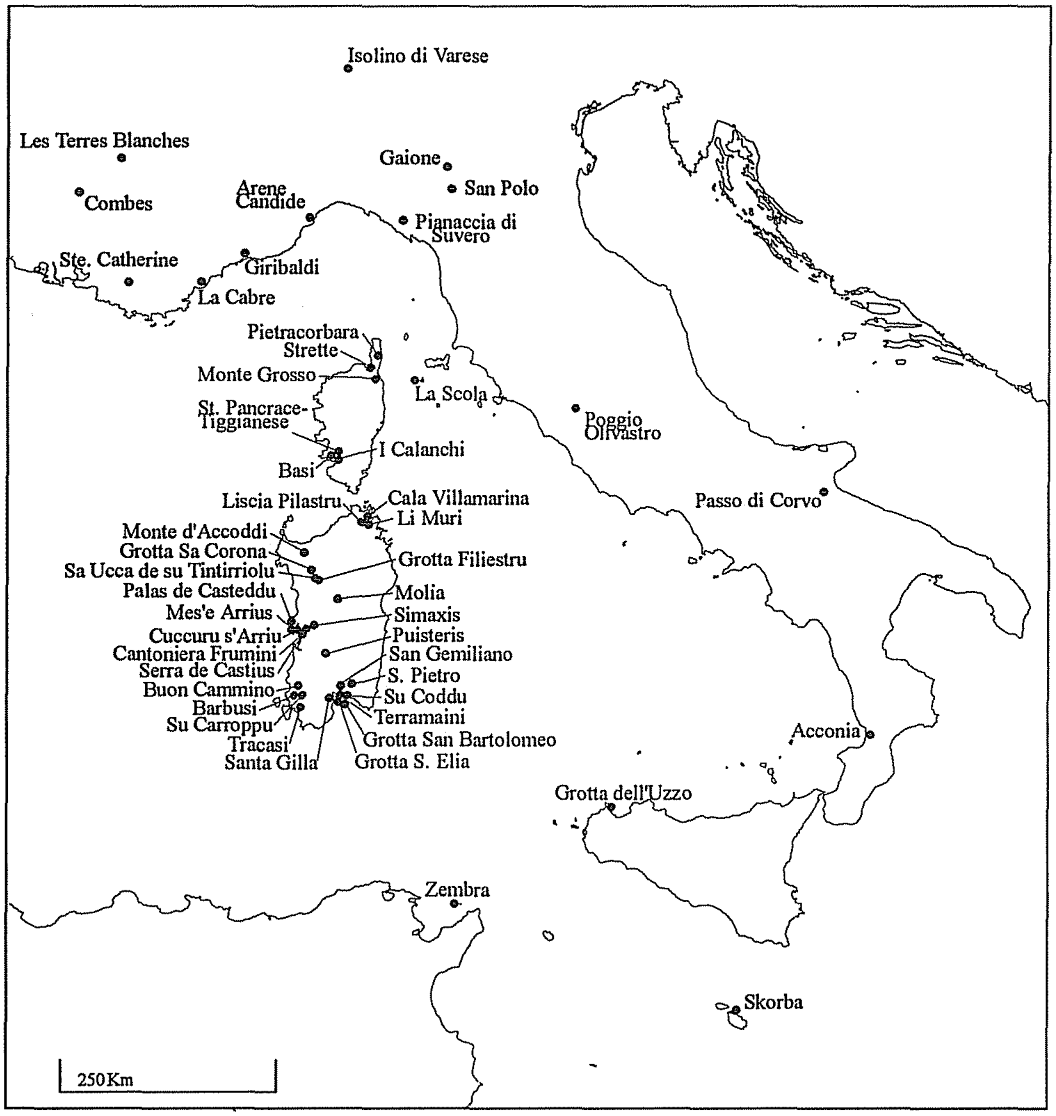
Most of the chemical-analytical data I have produced comes from Prenuragic sites, and not one of them has exclusively one type of obsidian; visual inspection, however, did reveal a few sites with lopsided frequencies (e.g. Corte Auda-Senorbì: 9 SC; San Bartolomeo-Cagliari level A: 22/23 SA) not explainable by their proximity to a single source locality (i.e. Nuraghe Domu Beccia and Nuraghe Su Para, both near the SA source). Since type SC is well represented in other contexts at San Bartolomeo, and since I have not seen the entire Corte Auda assemblage, I suggest that this minimal evidence for specific source consumption is more likely the result of single-core (or at least single-batch) production than of single-source access. For the Chalcolithic, the dozen obsidian samples analyzed from a Monte Claro context in Serra Cannigas Tomb B (Atzeni 1985) have extremely close hydration dates (Michels et al. 1984), suggesting fresh acquisition (but not necessarily by direct procurement), and two sources are represented (3 SA; 9 SC). The hypothesis of Middle Bronze Age obsidian control is supported only by Nuraghe Antigori (13 SA) and Nuraghe Loddu (9 SC), while multiple obsidian types are present at Nuraghe Ortu Còmidu and Nuraghe Tiria.

Distribution

A now substantial number of analyses continues to support the notion of mostly self-contained non-overlapping exchange regions in the western Old World. 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 artifacts each from an increasing number of neolithic sites in the western Mediterranean has contributed greatly to our understanding of obsidian distribution from each island source, although the number of analyzed specimens from the mainland, especially peninsular Italy, remains inadequate (Figure 30). 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 Neolithic. 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

Figure 30. Neolithic sites with 10 or more obsidian analyses. Results and references in Appendix H, Tables H1 and H2.



obsidian probably passed along the west Corsican coast and then across the open sea to Provençe, 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.

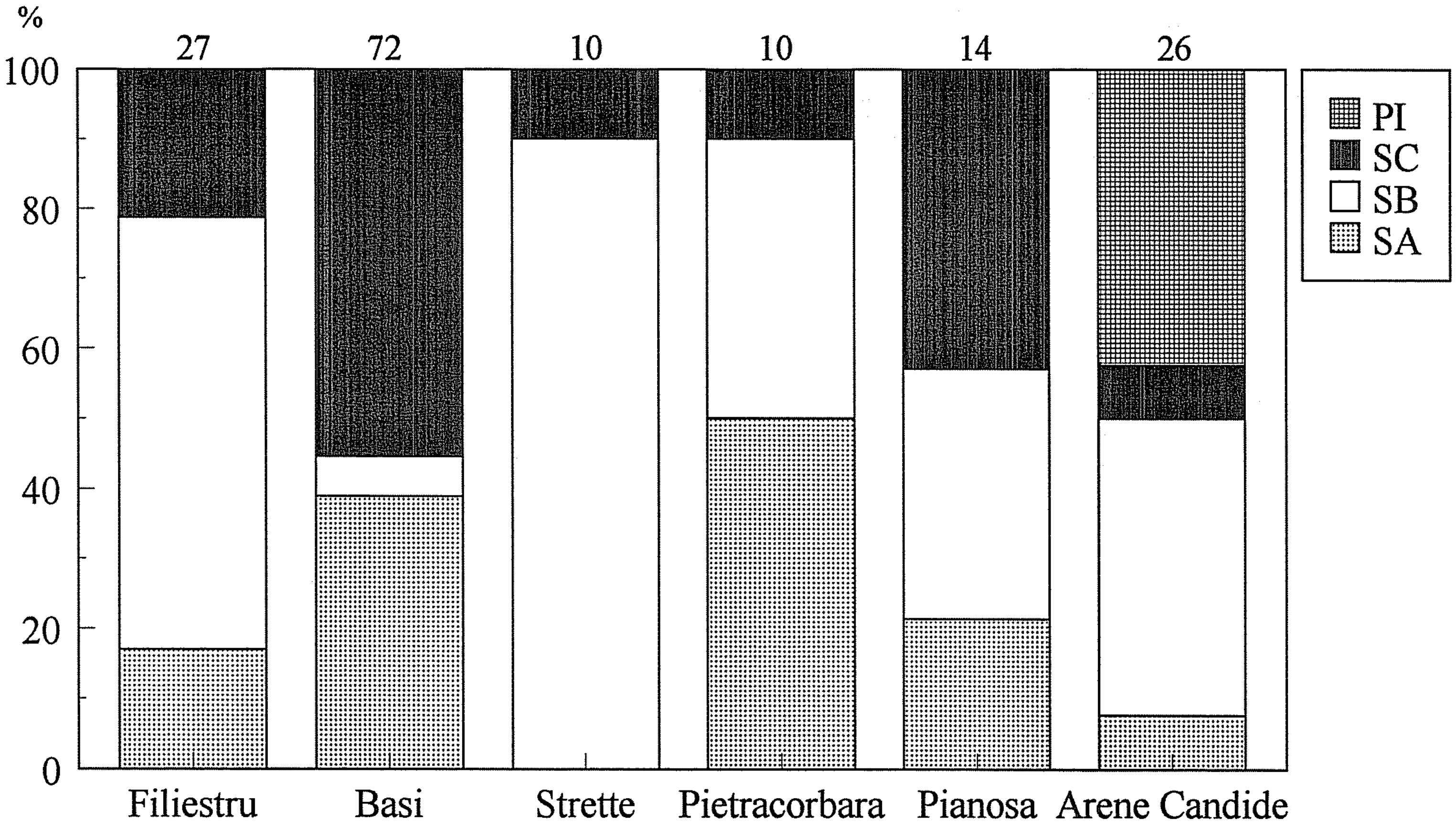
Regional differences in form and frequency of the multiple obsidian sources present at individual sites are apparent even when the obvious factors of relative source distance, quality and abundance are taken into account. High quality translucent obsidian from Lipari predominates throughout southern 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 & Phillips (1995; nd) 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 6 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 & Polglase 1993). At Arene Candide, blades of Sardinian or Palmarolan obsidian are also noticeably larger than those from more distant Lipari (Ammerman & Polglase 1995).

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 which are actually green in transmitted light). 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 31). 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

Figure 31. Obsidian source frequency at several Early Neolithic sites. All determinations by chemical analysis (Tykot, this work; Ammerman & Polglase 1993; 1995 for Arene Candide). Numbers of artifacts represented are at the top of each bar.



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 evolutive 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 peoples, whereas in Liguria there seem to have been no Late Mesolithic antecedents (Binder 1987; 1989; Vaquer 1990; Biagi et al. 1990).

Obsidian continued to be used in Sardinia throughout the Bronze Age. There is also growing evidence of its continued use (at diminished levels) at contemporary mainland sites, and though this may represent recycling of locally available material, there is other evidence that contacts between Sardinia and Tuscany were maintained (Vigliardi 1980). In the Aegean, exploitation of the Melos sources was quite extensive during the Bronze Age.

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). In Greece, for example, (1) food items were mostly procured and consumed locally, although they may have been exchanged for utilitarian items; (2) ground and flaked stone assemblages, including obsidian, had a wide circulation, primarily a utilitarian use, and were probably produced by itinerant craft specialists; (3) ceramics with high stylistic visibility were less widely distributed, served non-utilitarian as well as utilitarian functions, and were produced by local specialist potters; and (4) stone and shell ornaments, stone vessels, etc. had symbolic or ritual functions, were produced only in small quantities, but were diffused over very long distances (Perlès 1992; Vitelli 1993).

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 belongs to probably depends upon local custom and the availability of the material, and these are likely to change over time. In the western Mediterranean, obsidian was not used during the Upper Paleolithic or Mesolithic, despite the likelihood that its sources were known to the Preneolithic residents of Corsica, Sardinia, and Sicily, and its use falls off sharply in the Chalcolithic. 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 & Shennan 1991).

In the eastern Mediterranean, preneolithic trade has been considered an incentive for the adoption of agriculture and the production of surplus wealth to acquire non-local goods (Runnels & van Andel 1988; cf. also Tangri 1989 and Runnels 1989). But in the 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 social 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 (cf. Renfrew 1986; Champion 1989). Likewise, the circulation of Sardinian obsidian, flint, nephrite, steatite, and salt cannot be considered within a single exchange category (cf. 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 & Baugh 1994), although often difficult to apply given the considerable variation in reported excavation data in the last century (cf. Guidi 1987). Such systematic data is necessary for diachronic and spatial analysis of obsidian use, and an admirable effort has been made recently for the western Mediterranean by Pollmann (1993) who confirms the empirical hypothesis that obsidian use was greatest during the Middle Neolithic and the early part of the Late Neolithic, 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 artifacts 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 & Sammartino 1983; Sammartino 1986), and extrapolation of the surface finds from Gaione suggest 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 & 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 - 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).

I suggest that in the western Mediterranean the presence of obsidian should be interpreted as primarily utilitarian in function, but resulting from social and multi-level economic interactions, 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 (cf. 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 symbolic 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 (cf. Lewthwaite 1981b). Again, specifically linking extrainsular exchange of Sardinian obsidian with incoming domesticates is tidy, but impossible to demonstrate archaeologically. Nevertheless, a specific proposal has been posited for the exchange of cattle and obsidian at Catal Huyuk (Sherratt 1982).

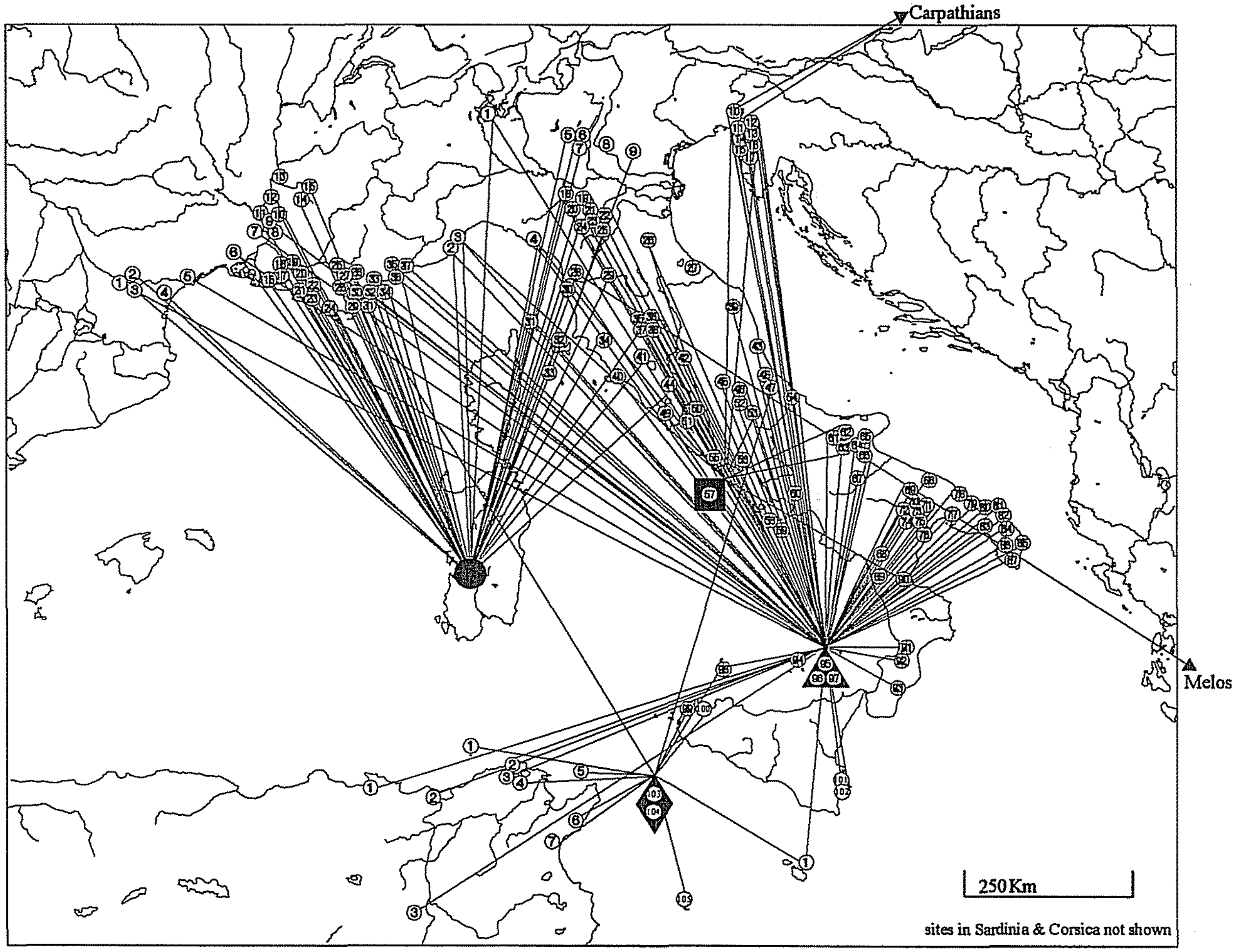
Simultaneously, ethnicity and the maintenance of kin connections are likely to have been significant factors in the creation of preferential social exchange partners, and the importance of alliances and ceremonial behavior in the functioning of exchange networks cannot be underestimated. Fine ceramics, 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).

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 32), 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.

I agree entirely with Renfrew (1993a), who has noted that archaeological artifacts may have a symbolic meaning more significant than their economic value. As a pertinent example, obsidian may have also served an ornamental and even magico-religious function in addition to being used for stone tools. Even in the last century, amulets (*pinnadellu*) that offered protection from the evil eye (*s'ogu*) were commonly worn in Sardinia, some with obsidian incorporated in their design known as *sa perda de tronu* - rock of thunder (Cabiddu 1965:248; Demartis 1986:216-217; Tavera 1987:170-171; Contu 1990-91:248; Liori 1992:246-247). It is, of course, impossible to project such a use backward several thousand years in time, but it is not unreasonable to suppose that obsidian was used for ornamental purposes, including jewellery that might have been worn only on special occasions.

We must therefore be cautious in our extraction of economic and social information from lithic distribution patterns, but it is certainly a worthwhile endeavor. Characterization alone is not enough; the derivation of structured models that integrate social and utilitarian function within specific exchange systems are necessary to fully interpret "trade" in ancient societies. The extent and significance of obsidian distribution from the western Mediterranean sources is 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

Figure 32. Obsidian distribution in the western Mediterranean. Source determinations by chemical or physical analysis, or visual assessment. Sites numbered as in Figure 26.



artifacts. Analyses of large numbers of artifacts permits chronological control at least at the site level, and therefore insight into dynamic changes in obsidian source selection. Provenance studies continue, therefore, to make significant contributions to our understanding of Neolithic social and economic systems.

Williams-Thorpe (1995) notes, however, that although obsidian provenancing has been one of the most productive and successful research programs of archaeological science, there has been a decrease in the number of papers published in recent years. While some of the decline is due to the now routine technical nature of these studies, it is clear that obsidian provenance determination is not a routine part of current excavation projects, perhaps because of financial limitations. Many important Mediterranean obsidian studies have been made by British, American or German scholars as thesis projects (Williams 1975; 1978; Hallam 1976; McDougall 1978; Mosheim 1979; 1984; Stein 1979; Torrence 1981a; Friz 1982; Mackey & Warren 1983; Herold 1986; Hurcombe 1986; Tykot, this work) which in many cases were not pursued further. Only the Pisa group (led by Radi and Bigazzi), Ammerman, Francaviglia, and their respective colleagues have sustained long-term archaeological research projects focusing on western Mediterranean obsidian exchange (cf., most recently, Ammerman & Polglase 1995; Bigazzi et al. 1992a; 1992b; Francaviglia 1993), although one hopes that additional recent efforts (e.g. Crisci et al. 1994; Randle et al. 1993) will be expanded.

I have demonstrated here that inexpensive, minimally-destructive analytical techniques can successfully be used in obsidian provenance studies in the

Mediterranean, while the non-destructive XRF technique (Giauque et al. 1993; Crisci et al. 1994), available now also in field-portable versions (Potts et al. 1995), should likewise increase the number of artifacts potentially analyzable and facilitate more large-scale research efforts. Typological/technological studies continue to identify the various stages and locations of obsidian reduction (e.g. Polglase 1989; 1990; Ammerman et al. 1990; Ammerman & Polglase 1993; 1995), and microscopic use-wear analysis narrows down the functions tools served (e.g. Hurcombe 1992a; 1992b; Vaughan 1985; 1990; Voytek 1990; Hayden 1979). The integration of source data, form, function, and reduction sequence for whole assemblages of obsidian artifacts from well-dated archaeological contexts will ultimately provide a more complete understanding of human behavior in the Neolithic western Mediterranean.

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APPENDIX A. ELEMENTAL ANALYSES OF WESTERN MEDITERRANEAN OBSIDIAN

This appendix reproduces in a series of tables all of the elemental analyses of western Mediterranean obsidian artifacts and nearly all of the instrumental analyses of geological specimens published from 1964 to 1995. Additional geological specimen data may have been presented by Acquafredda et al. (1993) and Francaviglia (1993) but are not yet in print.

Geological studies often have produced data for individual obsidian samples, frequently from unspecified localities or unworkable sources; a total of 29 such analyses are not reproduced here (cf. Chayes & Zies 1962; 1964; Noble & Haffty 1969; Baldanza et al. 1973; Klerkx et al. 1974; Pichler 1980; Dostal et al. 1982; Cioni et al. 1982; Biró et al. 1986; Mahood & Hildreth 1986; MacDonald et al. 1992; Montanini et al. 1994). An unpublished German undergraduate thesis (Mosheim 1979) does contain individual sample data for geological obsidian samples from Lipari, but was unavailable to me.

Individual sample data were not given in Mackey & Warren (1983), Biró & Pozsgai (1984), Biró et al. (1986), Francaviglia (1988), Heyworth et al. (1988), Meloni & Oddone (1992), de Romanis et al. (1995), Acquafredda et al. (1995), and Crisci et al. (1994), and are only partially given in Michels et al. (1984), Francaviglia (1984), and Francaviglia & Piperno (1987).

Trace element concentrations are in parts per million (ppm) unless otherwise noted; major and minor elements are usually reported as oxide weight percent. Geological samples are denoted by asterisks in tables containing both geological and archaeological sample data. Data from different geological sources are separated within each table by dashed lines, and presented in the same sequence as in the summary chart at the beginning of each table.

In Tables A1, A2 and A7, I have combined data from multiple publications but produced in the same laboratories. In Table A3, I have combined all of the NAA data from Bradford, with each geological source in a separate Part. In this case, the data from different publications are separated by dashed lines within each Part, and presented in the same sequence as in the summary chart at the beginning of each Part. Table A8, in which I combined all of the Milan analyses, follows the same format.

When sufficient numbers of samples have been analyzed, I have computed means and standard deviations for each geological source, occasionally rejecting outliers in the published data (in some cases probably due to typographic error rather than chemical deviation from the mean). Mean values are compared in Tables XVI-XXI in Chapter 6. Finally, I assigned artifacts in the Bradford SB group (Table A3, Part ii) to SB1 and SB2 subgroups; I also created the sample groupings in Table A6 using Herold's (1986) data, and in Table A7 using Bigazzi et al.'s (1986; 1992b) data.

APPENDIX A: List of Tables

* Elemental data were not included in this publication, but the authors have generously made them available.

Table A1: Cambridge Analyses (Cann & Renfrew 1964; Hallam et al. 1976)

Method: Optical emission spectroscopy

Source	Geological samples(*)	Archaeological samples
2a (Sardinia)		3
4a (Lipari)	9	18
4a (Palmarola)	2	6
4b (Pantelleria)	2	5
6a (Sardinia)		2
Total	13	34

Lab No.	Ba	Sr	Zr	Y	Nb	La	Rb	Li	Ga	V	Pb	Sn	% Ca	% Fe	Mg	Mo
91	180	35	44	22	60	80	125	32	12	<5	38	<10	0.46	0.93	0.0300	<3
93	150	35	32	18	46	<50	160	32	17	<5	38	<10	0.41	0.79	0.0240	<3
227	200	32	50	24	40	<50	125	16	25	<5	36		0.42	0.83	0.0300	<3
1*	38	20	130	25	30	100	160	100	17	6	44	<10	0.46	0.93	0.0170	5
2*	18	16	100	31	46	100	200	42	17	5	38	<10	0.46	0.93	0.0110	4
3*	6	<10	76	22	46	63	320	100	12	<5	33	<10	0.41	0.55	0.0048	3
4*	6	8	130	22	30	100	200	56	7	<5	38	<10	0.46	0.79	0.0110	5
5*	10	16	130	22	46	150	160	42	12	<5	25	<10	0.46	0.65	0.0072	4
6*	26	<10	220	22	37	100	200	42	17	5	38	<10	0.54	0.93	0.0300	5
8*	6	8	130	22	46	100	250	56	17	<5	33	<10	0.46	0.65	0.0072	4
9*	6	<10	130	22	46	100	200	56	17	<5	33	<10	0.41	0.65	0.0110	5
10*	26	35	130	25	46	100	200	42	8	7	44	<10	0.62	0.79	0.0240	5
11	18	<10	100	25	46	100	160	42	17	7	38	<10	0.46	0.79	0.0300	3
12	10	<10	100	22	46	100	130	32	17	<5	33	<10	0.41	0.79	0.0110	3
13	6	8	130	22	46	100	200	56	17	<5	33	<10	0.46	0.55	0.0072	4

Table A1 (continued)

Lab No.	Ba	Sr	Zr	Y	Nb	La	Rb	Li	Ga	V	Pb	Sn	Ca	Fe	Mg	Mo
52	18	<10	76	25	46	100	250	100	17	5	33	<10	0.46	0.79	0.0072	5
106	26	20	100	22	30	120	200	56	17	<5	38	<10	0.54	1.20	0.0170	3
107	22	20	100	25	30	150	200	75	22	<5	38	<10	0.62	1.20	0.0130	4
110	22	20	100	25	30	120	200	56	17	5	38	<10	0.46	1.20	0.0130	6
111	22	16	130	31	37	120	200	56	17	5	38	<10	0.54	0.93	0.0130	5
112	22	16	56	25	30	11	200	56	12	<5	38	<10	0.46	0.93	0.0110	3
113	32	24	100	31	60	150	200	42	17	<5	52	<10	0.54	1.40	0.0170	4
114	22	24	100	22	37	120	250	75	17	5	44	<10	0.54	0.93	0.0170	3
115	26	20	100	25	37	150	160	42	8	<5	38	<10	0.54	0.93	0.0130	5
220	10	32	65	32	30	190	160	47	17	<5	36		0.48	0.83	0.0160	4
221	14	25	120	24	50	130	160	27	17	<5	22		0.55	0.83	0.0130	5
224	10	15	120	32	30	100	125	27	17	<5	67		0.55	1.00	0.0130	4
226	14	25	120	32	40	100	160	27	17	<5	67		0.55	0.83	0.0130	4
229	14	15	120	32	30	130	125	22	7	<5	36		0.48	0.83	0.0130	4
230	22	40	120	40	30	130	200	47	25	<5	67		0.55	1.00	0.0130	5
17*	5	<10	220	25	60	100	200	24	17	<5	44	<10	0.31	0.65	0.0072	<3
56*	22	<10	270	25	46	150	500	180	22	<5	74	<10	0.46	2.00	0.0850	4
18	5	<10	220	25	60	100	400	32	17	<5	38	<10	0.65	0.79	0.0085	3
57	18	<10	100	22	37	150	400	75	17	<5	44	<10	0.41	0.93	0.0210	<3
222	14	32	90	24	30	70	320	80	17	<5	22		0.48	0.70	0.0090	3
223	14	20	200	40	65	250	320	35	17	<5	67		0.20	0.70	0.0160	4
225	14	10	200	50	110	190	320	16	11	<5	67		0.42	1.00	0.0160	5
228	14	25	90	24	30	100	320	63	17	<5	36		0.48	0.83	0.0160	4
14*	38	<10	1300	76	290	220	80	8	22	<5	<20	<10	0.31	0.44	0.0460	10
15*	38	<10	1000	76	460	320	130	10	29	<5	<20	<10	0.31	0.37	0.0460	15
16	18	<10	1300	190	370	260	160	32	22	<5	<20	<10	0.21	0.37	0.0072	10
104	38	<10	1300	140	460	320	200	75	47	<5	29	<10	0.41	0.63	0.0085	10
105	38	<10	1300	100	370	320	125	42	22	7	29	<10	0.31	0.63	0.0085	7

Table A1 (continued)

Lab No.	Ba	Sr	Zr	Y	Nb	La	Rb	Li	Ga	V	Pb	Sn	Ca	Fe	Mg	Mo
108	46	<10	1300	140	370	380	160	56	47	10	38	<10	0.31	0.63	0.0110	8
109	38	<10	1300	140	460	470	160	42	38	15	33	<10	0.27	0.63	0.0110	10
90	2200	170	170	15	37	150	160	18	22	20	44	<10	0.72	1.40	0.1300	<3
92	2200	210	220	15	60	120	200	18	17	15	38	<10	0.78	2.00	0.1700	<3

Table A2: Rome (Belluomini & Taddeucci 1970; 1971)

Method: 1970: Isotope dilution/mass spectrometry (U, Th)
1971: X-ray fluorescence; optical emission spectroscopy (B, F)

Source	Geological samples(*)
SA	20
Pa	20
PI	20
Li - Punta Castagna	5
Li - Acquacalda	6
Li - Forgia Vecchia	14
Vulcano	3
Total	88

		%					%	%		
No.	B	F	Rb	Y	Zr	Nb	K	Ca	U	Th
S1*	22	0.32	270	100	90	<20	4.0	0.8		
S2*	15	0.29	260	100	80	<20	5.1	1.0		
S3*	19	0.32	260	100	90	<20	5.0	1.4		
S4*	20	0.22	270	85	80	<20	5.1	0.6	6	16
S5*	16	0.36	280	75	90	<20	4.7	0.8		
S6*	21	0.28	260	80	80	<20	5.0	1.0		
S7*	16	0.25	260	85	80	<20	4.4	0.6		
S8*	16	0.22	220	80	80	<20	4.3	0.6		
S9*	19	0.31	260	75	50	<20	4.1	0.4		
S10*	21	0.20	250	80	80	<20	4.7	0.6		
S11*	17	0.24	250	100	80	<20	4.1	0.6		
S12*	14	0.22	250	80	80	<20	4.2	0.5		
S13*	19	0.46	260	85	90	<20	4.8	0.7		
S14*	17	0.32	240	80	80	<20	4.7	0.7		
S15*	18	0.29	225	80	80	<20	5.1	0.5	6	17
S16*	21	0.29	210	90	70	<20	3.7	0.4		
S17*	9	0.25	240	100	90	<20	4.1	0.5		
S18*	13	0.41	250	120	120	<20	5.3	0.5	6	18
S19*	9	0.30	240	110	120	<20	3.8	0.4		
S20*	16	0.25	240	100	90	<20	4.4	0.5		
MEAN	17	0.29	250	90	86	<20	4.5	0.7	6	17
S.D.	± 4	0.05	18	13	13		0.6	0.3	0	1

Table A2 (continued)

No.	B	% F	Rb	Y	Zr	Nb	% K	% Ca	U	Th
P1*	30	0.63	150	200	1880	310	2.8	0.4		
P2*	12	0.56	125	160	1620	260	3.9	0.4		
P3*	10	0.70	160	170	1940	300	3.1	0.4		
P4*	19	0.48	155	200	1900	300	3.2	0.4		
P5*	7	0.49	140	170	1780	260	3.6	0.3	11	34
P6*	20	0.70	145	170	1750	280	3.6	0.3		
P7*	22	0.62	140	150	1600	240	3.5	0.3		
P8*	12	0.60	145	150	1580	250	3.3	0.2		
P9*	10	0.93	160	200	1980	310	3.1	0.3		
P10*	28	0.62	150	180	1820	300	3.5	0.4		
P11*	12	0.56	160	180	1930	310	3.2	0.2		
P12*	26	0.60	130	160	1660	260	3.2	0.4		
P13*	24	0.53	145	170	1790	280	3.2	0.3	10	37
P14*	8	0.68	155	200	1930	260	3.2	0.3		
P15*	19	0.43	145	180	1860	300	3.0	0.2		
P16*	12	0.70	145	170	1810	280	3.2	0.2		
P17*	14	0.50	145	170	1930	310	3.5	0.4		
P18*	25	0.75	155	170	1970	320	3.5	0.3		
P19*	25	0.80	145	180	1930	300	3.0	0.2	11	37
P20*	18	0.62	145	180	1800	290	3.6	0.2		
MEAN	18	0.62	148	175	1823	286	3.3	0.3	11	36
S.D.	± 7	0.11	10	15	126	24	0.3	0.1	0	1
Pal1*	135	0.07	420	150	300	<20	2.5	0.3		
Pal2*	102	0.03	420	160	330	<20	2.2	0.3		
Pal3*	85	0.03	480	160	360	<20	2.2	0.3	21	69
Pal4*	85	0.03	440	150	300	<20	2.2	0.3		
Pal5*	95	0.03	420	150	330	<20	2.0	0.2		
Pal6*	95	0.03	470	170	340	<20	2.3	0.3		
Pal7*	80	0.03	470	170	260	<20	2.2	0.3		
Pal8*	85	0.03	430	170	340	<20	2.4	0.3		
Pal9*	95	0.03	460	160	340	<20	2.2	0.3		
Pal10*	85	0.10	440	150	320	<20	2.8	0.4		
Pal11*	85	0.07	405	120	270	<20	2.2	0.3		
Pal12*	102	0.12	380	120	270	<20	3.0	0.4		
Pal13*	85	0.06	315	100	210	<20	3.0	0.5	21	71
Pal14*	80	0.03	470	150	320	<20	2.5	0.3		
Pal15*	103	0.07	450	150	300	<20	2.5	0.4		
Pal16*	100	0.10	470	160	320	<20	2.5	0.2		
Pal17*	110	0.16	460	150	330	<20	2.5	0.4		

Table A2 (continued)

No.	B	% F	Rb	Y	Zr	Nb	% K	% Ca	U	Th
Pal18*	105	0.12	315	160	350	<20	2.6	0.2		
Pal19*	90	0.14	480	110	220	<20	2.6	0.4	20	71
Pal20*	95	0.07	450	170	330	<20	2.6	0.4		
MEAN	95	0.07	432	149	307	<20	2.5	0.3	21	70
S.D.	± 13	0.04	48	21	41		0.3	0.1	0	1

No.	B	% F	Rb	Y	Zr	Nb	% K	% Ca	U	Th
LPC1*	250	0.06	225	110	180	<20	3.0	0.4		
LPC2*	170	0.10	250	110	210	<20	3.2	0.5		
LPC3*	275	0.07	250	100	210	<20	2.8	0.5		
LPC4*	210	0.08	225	100	180	<20	3.1	0.5	17	56
LPC5*	210	0.09	240	110	200	<20	3.2	0.8		
LAC1*	255	0.10	200	100	180	<20	3.3	0.6		
LAC2*	320	0.08	200	100	180	<20	2.9	0.5		
LAC3*	255	0.08	240	100	210	<20	3.5	0.6		
LAC4*	145	0.07	225	110	200	<20	3.0	0.5		
LAC5*	270	0.08	225	110	180	<20	2.6	0.4		
LAC6*	260	0.09	250	130	220	<20	3.0	0.5	16	53
LFV1*	250	0.06	240	90	180	<20	3.2	0.4		
LFV2*	230	0.07	225	90	160	<20	3.3	0.5		
LFV3*	220	0.13	240	90	170	<20	3.5	0.9		
LFV4*	275	0.11	225	90	160	<20	3.0	0.5		
LFV5*	400	0.09	240	100	180	<20	3.6	0.6		
LFV6*	350	0.14	215	90	270	<20	3.5	0.7		
LFV7*	360	0.12	215	100	160	<20	3.2	0.7		
LFV8*	250	0.13	200	80	160	<20	3.3	0.6		
LFV9*	330	0.10	240	110	220	<20	3.0	0.5		
LFV10*	275	0.10	215	90	180	<20	2.7	0.5	16	56
LFV11*	330	0.13	225	110	200	<20	2.9	0.6		
LFV12*	360	0.14	215	110	180	<20	3.0	0.5		
LFV13*	280	0.23	180	90	160	<20	3.1	0.3		
LFV14*	360	0.10	215	100	170	<20	3.0	0.5		
V1*	250	0.04	225	100	240	<20	2.8	0.6		
V2*	330	0.06	225	90	220	<20	3.0	0.6		
V3*	280	0.08	225	110	250	<20	3.2	0.6		
MEAN	277	0.09	225	101	193	<20	3.1	0.5	16	55
S.D.	± 61	0.04	17	11	29		0.2	0.1	0	1

Table A3: Bradford Analyses (Hallam et al. 1976; Williams Thorpe et al. 1979; 1984; Crummett & Warren 1985)
Part i: Sardinia A

Method: Neutron activation analysis

Reference	Geological samples(*)	Archaeological samples
Hallam et al. (1976)	8	21
Williams Thorpe et al. (1979)		25
Williams Thorpe et al. (1984)		7
Total	8	53

Lab No.	% Na	La	Sm	Sc	% Fe	Co	Cs	Eu	Hf	Ce	Th	Ta	U
185/7	2.58	22.3	5.30	4.20	0.87	1.50	4.60	0.3	3.7	50	23		5.9
186/3	2.56	22.5	5.30	4.30	0.99	3.20	4.20	0.3	3.9	55	20		7.7
186/4	2.67	22.9	5.40	4.30	1.06	0.40	4.40	0.4	4.5	47	23		8.4
186/7	2.60	22.6	5.60	4.20	0.98	0.50	4.10	0.4	4.0	48	21		7.3
188/1	2.71	22.7	5.30	4.60	1.09	0.40	4.50	0.4	4.2	42	19		7.9
188/2	2.63	22.2	5.30	4.40	0.99	1.70	5.30	0.4	3.4	45	16		9.0
188/3	2.71	22.5	5.10	4.20	0.97	0.70	4.40	0.4	4.3	38	20		5.6
188/5	2.70	22.6	5.10	4.60	1.09	0.40	5.30	0.4	3.7	46	19		9.3
188/6	2.68	22.8	5.30	4.40	1.04	0.50	4.70	0.4	3.5	49	18		7.6
188/7	2.70	22.6	5.30	4.70	1.08	0.40	5.00	0.4	3.2	46	16		7.5
200/2*	2.73	23.8	5.70	4.60	1.15	0.60	5.70	0.4	3.5	47	18		7.0
201/2	2.67	22.9	5.70	4.60	1.14	0.50	4.60	0.4	3.4	46	19		6.9
202/2	2.76	23.7	5.80	4.70	1.17	0.50	4.60	0.7	3.6	46	21		5.0
211/8	2.65	23.0	5.40	4.30	1.03	0.40	4.20	0.4	4.1	46	17		7.1
212/8	2.75	22.2	5.60	4.70	1.12	0.50	4.40	0.4	4.5	53	19		7.0
215/2	2.58	22.2	5.20	4.40	1.02	0.30	3.70	0.4	4.7	55	17		9.5

Table A3, Part i (continued)

Lab No.	% Na	La	Sm	Sc	% Fe	Co	Cs	Eu	Hf	Ce	Th	Ta	U
225/1	2.46	21.5	5.20	4.30	1.02	0.50	4.40	0.3	2.8	40	16		8.3
224/7	2.61	21.5	5.60	4.20	1.15	0.30	5.60	0.5	3.6	35	14		6.6
230/3	2.81	24.0	6.10	5.00	1.17	0.50	4.80	0.4	3.4	53	18		8.6
230/4	2.80	24.0	5.60	4.80	1.32	0.30	3.90	0.5	3.1	55	19		8.3
232/1*	2.67	22.2	5.50	4.30	1.00	1.60	3.70	0.4	3.8	56	20		9.4
232/2*	2.71	23.0	5.70	4.40	1.09	1.20	4.30	0.6	4.0	49	19		8.1
232/3*	2.78	22.9	5.70	4.70	1.07	0.80	4.20	0.3	4.1	46	19		11.2
232/4*	2.64	22.8	5.60	4.60	1.07	0.80	4.30	0.4	3.3	45	16		9.0
232/5*	2.70	23.4	5.50	4.30	1.04	0.50	4.50	0.3	4.0	56	20		9.6
232/6*	2.91	24.3	6.10	4.40	1.03	0.30	4.60	0.3	4.0	64	21		10.0
232/7*	2.86	24.5	5.30	4.20	0.87	0.30	4.40	0.2	3.1	54	16		9.7
235/1	2.48	21.5	5.60	4.10	0.96	0.30	3.70	0.3	3.7	45	17		6.5
235/4	2.47	21.4	5.20	4.30	1.00	0.40	4.10	0.4	2.5	42	17		7.2
364/1	2.73	25.9		4.71	1.18	0.29	5.69			70			
364/2	2.82	26.4		4.85	1.23	0.53	5.31			59			
364/3	2.57	23.8		5.71	1.42	0.46	5.71			62			
365/1	2.59	20.5		5.34	1.28	0.53	6.00			60			
365/2	3.33	31.1		5.68	1.41	0.53	6.38			80			
365/3	2.89	27.7		5.02	1.26	0.49	5.64			68			
366/1	1.91	21.9		4.82	1.17	0.58	5.68			53			
366/2	1.82	20.9		4.65	1.12	0.42	5.38			52			
366/3	2.15	24.7		5.59	1.31	0.50	6.84			72			
382/6	2.19	25.2		5.50	1.34	0.54	5.96			60			
388/3	2.26	25.9		5.84	1.44	0.73	6.28			75			
388/4	2.19	24.9		5.47	1.41	0.83	5.92			72			
373/8	2.54	22.9		5.45	1.35	0.45	6.20			75			
374/2	3.27	29.4		5.63	1.37	0.44	5.51			76			
374/3	2.99	26.5		5.34	1.33	0.47	5.31			76			

Table A3, Part i (continued)

Lab No.	% Na	La	Sm	Sc	% Fe	Co	Cs	Eu	Hf	Ce	Th	Ta	U
374/4	3.05	27.1		5.49	1.36	0.64	5.73			73			
374/5	3.12	28.3		5.82	1.45	0.73	6.27			80			
374/6	2.62	22.7		5.29	1.34	0.74	5.80			73			
374/7	3.09	27.9		5.57	1.38	0.54	6.10			77			
374/8	3.64	31.4		5.50	1.37	0.71	5.39			84			
401/2	2.32	21.8		4.56	1.09	0.48	5.05			50			
401/3	2.35	21.3		4.29	1.11	0.55	4.89			49			
505/8	2.39	22.6		4.49	1.18	0.56	4.93			51			
505/9	2.71	24.4		4.76	1.19	0.47	5.14			63			
505/10	2.10	23.5		5.27	1.37	0.58	5.95			76			
82/2	2.14	24.4	7.42	5.45	1.31	0.51	5.75			58			
382/3	2.14	25.1	8.53	5.48	1.31	0.49	6.55			63			
382/4	2.08	22.6	7.60	5.05	1.19	0.56	5.47			53			
631/9	1.99	24.5	6.90	4.89									
631/10	1.73	24.7	6.85	4.99									
631/11	1.85	23.6	5.99	6.25									
505/4	3.11	24.8	4.67	4.84	1.19	0.49	5.58	0.5	4.2	49	17	4.02	
MEAN	2.59	23.9	5.75	4.86	1.17	0.62	5.11	0.4	3.7	57	19	4.02	8.0
S.D. ±	0.37	2.3	0.79	0.54	0.15	0.45	0.80	0.1	0.5	12	2	-	1.4

Table A3, Part ii: Sardinia B

Reference	Archaeological samples	SB1(*)	SB2
Hallam et al. (1976)	16	3	13
Williams Thorpe et al. (1979)	2	1	1
Total	18	4	14

Lab No.	% Na	La	Sm	Sc	% Fe	Co	Cs	Eu	Hf	Ce	Th	U
185/1	2.62	29.4	4.8	3.45	0.98	3.8	7.8	0.4	4.7	69	23	5.8
185/2	2.71	30.4	5.2	3.35	0.90	1.5	7.3	0.4	4.0	77	25	6.8
185/3	2.67	29.8	4.9	3.39	0.91	1.4	7.6	0.4	3.4	77	34	7.9
185/4	2.67	29.3	5.3	3.55	1.00	2.9	7.9	0.4	4.6	68	24	7.6
185/5	2.58	33.3	4.8	3.40	1.00	1.8	6.9	0.5	4.2	62	26	5.9
186/1	2.50	28.7	4.8	3.92	1.19	4.0	8.2	0.6	5.2	74	27	6.7
201/3	2.67	29.8	4.9	3.74	1.14	0.7	8.8	0.5	3.5	62	20	7.5
201/4	2.68	28.2	4.9	3.70	1.16	0.4	9.1	0.6	4.3	55	21	7.6
201/5*	2.70	35.9	5.4	3.84	1.23	0.9	8.8	0.8	3.7	77	24	6.1
201/6	2.82	32.2	5.3	3.66	1.09	0.6	9.3	0.5	4.3	64	19	6.1
201/7	2.66	28.9	5.2	3.62	1.11	0.6	7.8	0.5	3.3	64	19	5.9
202/1*	2.60	35.8	5.1	3.62	1.07	0.7	7.6	0.6	4.2	77	25	6.0
202/4*	2.65	37.6	5.0	3.74	1.17	0.8	7.2	0 7	4.7	80	25	3.8
202/5	2.69	29.8	4.6	3.75	1.17	0.9	8.7	0.5	3.4	60	21	5.9
202/6	2.60	27.3	4.4	3.60	1.06	0.5	7.9	0.4	4.4	62	18	5.7
225/3	2.41	26.7	4.4	3.55	1.03	0.7	7.3	0.4	3.6	61	20	7.1
505/7*	2.97	34.0		3.65	1.23	0.8	8.5			80		
670/17	2.50	33.5		3.42	1.11	0.8	8.2			55		
MEAN	2.65	31.1	4.9	3.61	1.09	1.3	8.0	0.5	4.1	68	23	6.4
S.D. ±	0.12	3.2	0.3	0.16	0.10	1.1	0.7	0.1	0.6	9	4	1.0

Table A3, Part iii: Sardinia C

Reference	Geological samples(*)	Archaeological samples
Hallam et al. (1976)		18
Williams Thorpe et al. (1979)		3
Total		21

Lab No.	% Na	La	Sm	Sc	% Fe	Co	Cs	Eu	Hf	Ce	Th	U
185/6	2.55	62.6	6.5	3.46	1.32	1.2	2.0	1.4	7.5	150	31	2.2
186/2	2.43	60.4	6.7	3.81	1.39	2.9	2.3	1.2	7.1	170	37	2.5
186/5	2.50	62.5	7.4	3.80	1.45	1.6	2.5	1.3	8.0	140	31	2.5
186/6	2.43	61.4	7.3	3.53	1.36	1.4	2.5	1.2	7.9	140	34	2.1
189/1	2.56	64.5	7.8	3.78	1.36	1.3	2.2	1.3	8.2	140	32	3.2
200/3	2.52	64.4	7.6	3.71	1.41	1.1	2.3	1.2	6.2	130	30	2.4
200/4	2.49	64.5	7.4	3.76	1.36	1.3	2.1	1.3	6.0	140	27	1.9
200/6	2.52	65.8	7.8	3.98	1.46	1.7	2.8	1.4	6.2	150	30	1.0
200/7	2.48	64.0	7.3	3.91	1.43	1.4	2.5	1.4	6.1	140	29	1.5
201/1	2.66	66.8	8.0	4.05	1.44	1.6	2.7	1.4	7.4	150	30	1.0
202/3	2.59	64.4	7.8	3.85	1.36	1.4	2.5	1.3	6.5	140	30	1.8
211/9	2.50	62.8	7.5	3.44	1.29	1.3	2.0	1.3	7.0	120	24	1.6
215/1	2.55	66.8	7.7	3.82	1.45	1.3	2.1	1.4	7.9	150	31	1.4
225/2	2.41	59.8	6.4	3.83	1.43	1.6	2.1	1.3	5.5	130	28	1.7
229/6	2.30	57.8	7.2	4.21	1.65	2.2	2.8	1.4	8.3	160	31	1.1
233/1	2.39	59.8	7.1	3.77	1.38	1.3	2.0	1.3	7.8	130	27	1.1
233/2	2.26	56.9	6.7	3.24	1.28	1.2	1.7	1.2	5.7	120	23	1.4
233/3	2.32	64.9	6.8	3.48	1.30	1.3	2.2	1.2	5.3	130	26	1.4
670/16	2.44	62.6		3.62	1.44	1.5	2.4			102		
670/13	2.58	66.5		3.90	1.56	1.5	2.6			109		
670/18	2.27	61.1		3.00	1.38	2.2				91		
MEAN	2.46	62.9	7.3	3.71	1.40	1.5	2.3	1.3	6.9	135	30	1.8
S.D. ±	0.11	2.8	0.5	0.28	0.09	0.4	0.3	0.1	1.0	19	3	0.6

Table A3, Part iv: Lipari

Reference	Geological samples(*)	Archaeological samples
Hallam et al. (1976)	21	40
Williams Thorpe (1978)		3
Williams Thorpe et al. (1979)		19
Williams Thorpe et al. (1984)		1
Crummett & Warren 1985		46
Total	21	109

Lab No.	% Na	La	Sm	Sc	% Fe	Co	Cs	Eu	Hf	Ce	Th	U
193/7	3.06	51	10.3	1.13	1.31	0.4	20.0	0.1	7.8	130	62	22
188/4	3.11	56	7.0	0.91	1.06	1.2	16.0	0.1	5.4	110	40	31
194/1*	2.51	55	7.2	1.38	1.47	0.3	20.0	0.2	8.9	150	69	23
194/2	2.92	52	8.8	1.19	1.34	0.3	20.1	0.2	9.7	120	59	29
194/3	2.91	53	6.5	1.15	1.40	0.4	19.8	0.2	9.3	120	61	27
194/4	2.84	51	6.8	1.20	1.44	0.4	20.6	0.2	8.2	130	64	25
194/5	2.93	54	7.2	1.18	1.33	0.4	18.4	0.1	7.9	130	60	25
194/6	2.86	50	8.4	1.13	1.39	0.3	18.8	0.1	7.9	130	59	30
197/1	3.14	58	7.5	0.98	1.28	0.5	17.2	0.3	5.2	110	57	26
197/2	3.21	59	7.9	1.06	1.29	0.4	17.9	0.2	6.1	120	52	23
197/3	3.07	57	6.5	1.03	1.26	0.4	17.0	0.1	5.4	110	50	20
197/4*	3.25	71	7.2	1.23	1.36	0.6	17.7	0.2	5.7	130	61	25
197/5*	3.34	73	8.3	1.26	1.41	0.4	19.8	0.2	6.9	140	56	29
197/6*	3.12	57	6.8	1.02	1.24	0.5	17.3	0.1	5.6	120	57	21
197/7	3.11	57	6.4	1.00	1.24	0.3	16.4	0.1	5.5	110	53	23
200/1*	3.19	58	7.2	1.12	1.39	0.4	18.8	0.2	5.9	120	60	24
208/7*	3.02	66	7.3	1.21	1.44	0.5	17.7	0.2	7.5	120	45	24

Table A3, Part iv (continued)

Lab No.	% Na	La	Sm	Sc	% Fe	Co	Cs	Eu	Hf	Ce	Th	U
208/9*	2.84	57	7.7	1.18	1.37	0.5	16.5	0.2	7.5	110	42	23
211/1	3.18	57	7.6	0.99	1.20	0.5	16.6	0.3	7.2	100	56	23
211/4	3.13	56	7.2	1.20	1.44	0.3	19.4	0.1	8.5	130	63	17
211/5	3.22	67	7.0	1.28	1.39	0.5	18.1	0.1	8.0	150	66	19
211/7	2.98	53	6.7	1.23	1.46	0.4	18.6	0.1	8.2	140	60	16
212/1	3.10	55	7.6	1.02	1.20	0.4	15.6	0.1	7.1	110	53	21
212/2	3.05	54	6.9	1.11	1.35	0.4	17.9	0.1	8.7	130	64	19
212/3	3.04	55	7.1	1.04	1.22	0.4	15.8	0.1	7.3	110	57	21
212/4	2.73	54	6.7	1.20	1.42	0.5	18.9	0.1	8.6	140	67	20
212/6	2.89	52	6.6	1.05	1.25	0.5	16.8	0.1	7.6	110	60	21
212/7	3.01	53	6.8	1.11	1.34	0.4	17.6	0.1	7.7	130	60	20
215/3	2.97	55	6.9	1.06	1.25	0.4	16.0	0.1	7.3	120	54	22
215/4	3.03	55	7.2	1.08	1.26	0.4	15.6	0.1	6.9	120	57	21
215/5	2.99	55	6.7	1.03	1.24	0.4	17.5	0.2	7.5	120	60	20
215/7	3.08	56	7.0	0.92	1.16	0.5	15.6	0.1	7.1	120	56	26
215/8	2.89	56	7.0	1.02	1.18	0.3	15.2	0.1	6.4	110	48	23
218/2	3.24	59	7.5	1.06	1.26	0.4	17.5	0.2	6.9	130	59	22
218/3	3.14	58	7.4	1.26	1.41	0.3	21.2	0.2	8.9	150	75	23
218/4	3.15	57	7.0	1.12	1.31	0.4	17.4	0.1	6.5	120	54	21
218/5	3.06	56	7.6	1.10	1.30	0.6	18.5	0.2	8.0	130	63	21
224/5	3.05	55	7.3	0.97	1.21	0.3	16.4	0.1	5.0	110	55	20
224/6	2.96	53	6.9	0.94	1.16	0.3	15.0	0.2	6.7	100	45	18
224/8	2.89	53	6.8	0.93	1.13	0.3	14.2	0.1	5.2	90	43	17
229/3	2.99	53	6.5	1.21	1.32	0.4	20.5	0.1	7.5	150	72	17
229/4	2.88	52	6.1	1.09	1.29	0.4	16.5	0.1	7.0	120	53	14
229/5	3.01	56	6.4	1.27	1.42	0.5	18.0	0.2	7.6	140	66	13
229/7	3.02	54	6.5	0.99	1.12	0.4	17.4	0.1	5.7	140	59	17
230/1	3.16	54	8.1	1.12	1.36	0.4	17.9	0.1	4.9	120	52	23
230/2	3.41	62	7.5	1.24	1.41	0.7	18.6	0.2	5.6	120	61	18

Table A3, Part iv (continued)

	%				%												
Lab No.	Na	La	Sm	Sc	Fe	Co	Cs	Eu	Hf	Ce	Th	U	Tb	Yb	Rb	Ba	Ta
230/5*	3.20	68	8.3	1.38	1.43	0.5	18.4	0.2	6.0	140	54	20					
233/6*	2.92	64	6.9	1.24	1.36	0.4	17.3	0.1	8.3	130	62	17					
233/7*	3.12	64	6.8	1.40	1.57	0.5	20.2	0.1	9.3	160	68	17					
233/8*	2.83	62	7.2	1.26	1.37	0.4	18.0	0.1	7.5	140	60	14					
235/3	2.95	53	6.7	1.02	1.25	0.4	16.5	0.1	7.1	110	57	16					
235/7*	3.09	67	6.6	1.48	1.58	0.4	21.0	0.2	8.3	160	75	17					
236/1*	3.35	72	8.2	1.30	1.43	0.4	19.0	0.1	7.9	150	63	15					
236/2*	3.41	73	8.7	1.43	1.53	0.5	19.6	0.1	9.4	170	74	15					
236/3*	3.41	67	8.0	1.15	1.23	0.4	19.4	0.1	7.3	120	57	18					
236/4*	3.18	56	6.1	1.14	1.27	1.1	16.8	0.1	7.3	100	52	16					
238/2*	3.22	70	7.3	1.20	1.33	0.4	18.0	0.1	7.5	120	59	19					
238/3*	3.02	65	6.8	1.17	1.27	0.4	17.4	0.1	7.8	130	57	17					
238/4*	2.83	57	7.2	1.06	1.27	0.6	17.7	0.1	7.3	110	59	16					
238/5*	3.25	70	7.6	1.29	0.42	0.6	18.5	0.1	9.0	150	63	17					
238/6*	3.14	69	6.5	1.17	1.29	0.5	17.3	0.1	7.7	130	57	17					
500/1	2.23	61.9	5.19	1.14	1.57	0.39	21.42	0.14	7.85	169	56.9	16.59			341	161	2.45
497/1	2.78	53.7	8.03	1.10	1.32	0.28	23.80	0.20	6.70	137	54.0	12.81			353	171	2.34
547/1	2.76	51.3	5.19	0.86	1.15	0.35	16.32	0.12	6.69	130	44.9	9.53	0.68	3.46	278	93	1.92
670/12	2.88	54.4		0.98	1.20	0.32	17.6			83							
373/1	2.30	52.3		1.31	2.57	0.49	23.79			172							
373/2	2.35	52.3		1.13	1.36	0.31	20.23			137							
373/3	2.98	66.4		1.04	1.16	0.32	16.56			141							
373/4	3.39	64.9		1.31	1.61	0.48	22.27			179							
373/5	2.85	55.8		1.31	1.55	0.46	22.81			179							
373/6	3.31	63.4		1.35	1.62	0.48	23.47			180							
373/7	2.70	51.3		1.14	1.42	0.43	21.17			150							
505/5	4.38	57.1		1.19	1.45	0.35	21.67			135							

Table A3, Part iv (continued)

	%				%							
Lab No.	Na	La	Sm	Sc	Fe	Co	Cs	Eu	Hf	Ce	Th	U
374/1	3.46	62.4		1.45	1.78	0.50	25.70			183		
374/9	2.80	50.9		1.01	1.24	0.92	17.47			125		
505/6	4.00	66.2		0.83	1.01	0.35	15.77			99		
547/2	3.13	57.7		1.02	1.32	0.33	18.67			188		
547/4	3.18	56.4		1.10	1.36	0.39	21.10			187		
547/5	2.59	49.4		0.90	1.18	0.29	16.59			145		
548/1	3.64	67.0		1.25	1.55	0.46	21.25			141		
548/2	3.42	64.1		1.15	1.41	0.36	19.39			132		
548/3	3.32	62.2		1.09	1.43	0.44	18.84			128		
382/5	2.56	63.8		1.28	1.52	0.47	23.20			159		
382/1	2.23	55.6	7.4	1.07	1.30	0.42	19.5			107		
046	3.00	56		1.1	1.40		20		7.4	130	58	23
054	3.10	56		1.1	1.40		20		7.5	130	58	23
057-13	3.00	55		1.2	1.60		21		7.7	150	69	21
075-02	3.00	55		1.1	1.50		21		7.8	140	67	18
031-02	2.80	54		1.1	1.50		20		7.5	140	63	21
065-01a	3.00	55		1.1	1.40		21		8.6	140	65	24
047-01	2.90	56		1.1	1.40		20		7.5	130	62	23
081-01	3.00	53		1.1	1.40		20		7.8	130	68	23
055-03	2.70	50		1.3	1.40		17		7.6	120	58	18
083-18	2.70	53		1.1	1.40		19		8.1	130	60	17
065-01	3.00	58		1.1	1.40		20		8.3	140	65	24
0125-03	3.20	63		1.2	1.50		21		9.1	140	68	29
151	2.90	57		1.1	1.40		19		8.8	130	64	21
048-03	2.80	53		1.4	1.50		18		7.9	130	57	17
057-09	2.80	451**		1.1	1.50		20		9.3	130	74	23

** not used in calculation of mean

Table A3, Part iv (continued)

	%				%												
Lab No.	Na	La	Sm	Sc	Fe	Co	Cs	Eu	Hf	Ce	Th	U	Tb	Yb	Rb	Ba	Ta
055-01	2.90	52		1.0	1.30		18		7.5	120	56	21					
031-03	3.10	56		1.1	1.40		19		8.3	130	62	23					
075-01	3.20	58		1.1	1.40		20		9.0	130	67	24					
057-09	2.80	52		1.2	1.50		20		9.2	140	72	23					
076	2.90	55		1.1	1.50		21		7.7	130	71	21					
085-04	3.00	57		1.2	1.60		22		7.9	140	74	17					
039-03	2.90	58		1.1	1.40		20		7.3	130	70	23					
057-13	3.00	54		1.1	1.50		19		8.2	130	71	21					
080-06	3.10	61		1.2	1.60		21		8.1	150	73	17					
065-03		60		1#													
039-01		58		1#													
031-08		54		1#													
085-05		52		1#													
032-01		57		1#													
030-01		55		1#													
125-01		55		1#													
020-09		58		1#													
031-01		54		1#													
061-03		51		1#													
084-01		58		1#													
039-02		54		1#													
082-03		56		1#													
057-09		50		1#													
080-03		65		1#													
039-04		55		1#													
047-03		51		1#													
046(Z)		58		1#													
020-03A		59		1#													
020-03B		58		1#													

= first count estimate (within about 20%)

Table A3, Part iv (continued)

Lab No.	% Na	La	Sm	Sc	% Fe	Co	Cs	Eu	Hf	Ce	Th	U	Tb	Yb	Rb	Ba	Ta
047-02		59		1#													
065-01B		56		1#													
MEAN	3.02	58	7.2	1.1	1.37	.4	19	0.14	7.4	132	60	21	0.68	3.46	324	142	2.24
S.D. ±	.29	6	.8	.1	.20	.1	2	.06	1.3	20	8	4			33	35	0.23

= first count estimate (within about 20%)

Table A3, Part v: Palmarola

Reference	Geological samples(*)	Archaeological samples
Hallam et al. (1976)	4	10
Williams Thorpe et al. (1979)		2
Total	4	12

Lab No.	% Na	La	Sm	Sc	% Fe	Co	Cs	Eu	Hf	Ce	Th	U
189/2*	3.65	92	10.1	1.43	1.23	1.2	52.0	0.3	9.4	200	69	27
189/3*	3.81	92	9.9	1.45	1.17	1.3	49.0	0.1	8.8	180	66	29
189/4	3.68	92	9.7	1.55	1.35	0.1	54.8	0.2	12.5	180	88	28
189/5*	3.93	95	10.2	1.67	1.42	0.2	57.9	0.1	12.8	190	95	29
189/6*	3.78	91	10.0	1.42	1.20	5.1	53.4	0.4	9.6	130		31
211/2	3.58	84	9.1	1.61	1.40	0.2	51.6	0.1	11.8	200	94	35
211/3	3.72	87	7.6	1.69	1.45	0.3	55.2	0.1	12.3	200	89	23
211/6	3.64	89	8.4	1.58	1.35	0.2	51.9	0.1	10.3	190	86	24
224/4	3.58	86	9.7	1.52	1.32	4.1	48.2	0.1	8.4	180	74	27
224/2	3.62	88	8.4	1.47	1.32	0.3	48.9	0.1	7.9	170	72	25
224/3	3.67	90	9.6	1.61	1.31	0.4	48.8	0.1	8.6	180	81	29
229/1	3.56	88	8.3	1.62	1.38	0.4	51.0	0.2	11.6	190	87	22
229/2	3.48	86	8.2	1.62	1.33	0.3	50.7	0.1	10.0	190	82	19
235/2	3.27	81	8.5	1.46	1.19	0.2	47.4	0.1	10.1	170	75	19
670/14	3.48	85		1.44	1.25	0.3	54.0			120		
670/15	3.85	95		1.72	1.46	0.3	62.2			134		
MEAN	3.64	89	9.1	1.55	1.32	0.9	52.3	0.2	10.3	175	81	26
S.D. ±	.16	4	.9	.10	.09	1.5	3.9	.1	1.6	25	9	5

Table A3, Part vi: Pantelleria

Reference	Geological samples(*)	Archaeological samples
Hallam et al. (1976)	1	9
Williams Thorpe et al. (1984)		2
Total	1	11

	%				%							
Lab No.	Na	La	Sm	Sc	Fe	Co	Cs	Eu	Hf	Ce	Th	U
193/1	3.63	161	22	0.49	6.34	0.24	2.60	4.92	43.6	412	34.3	36
193/2	3.64	155	22	0.46	5.85	0.11	2.66	4.73	42.8	389	32.3	34
193/3	5.24	242	26	0.50	6.58	0.12	2.76	2.94	47.3	430	35.7	38
193/4	4.08	181	23	0.52	6.46	0.09	2.85	5.02	48.3	426	36.7	37
193/5	5.05	228	23	0.46	6.68	0.19	2.70	5.21	50.3	440	36.6	37
193/6	4.75	220	25	0.49	6.34	0.10	2.28	4.96	47.1	389	38.7	43
212/5	5.42	246	26	0.39	7.31	0.17	3.15	5.62	55.5	482	43.2	36
218/6	4.39	248	28	0.38	6.65	0.17	1.69	4.78	52.8	468	41.2	27
218/7	5.38	247	26	0.51	6.72	0.22	1.56	5.04	49.9	481	40.2	36
235/6*	5.07	232	24	0.51	6.98	0.21	2.41	5.37	53.5	484	41.4	12
388/2	3.27	204	29.2	0.64	8.51	0.75	3.38			646		
389/1	10.63	266	14.5	0.41	5.66	0.14	2.67			326		
MEAN	5.04	219	24	0.48	6.67	0.21	2.56	4.86	49.1	448	38.0	34
S.D. ±	1.91	36	4	0.07	0.73	0.18	0.53	0.73	4.14	78	3.5	9

Table A4: Michels et al. 1984

Method: Atomic absorption spectroscopy

Source	Archaeological samples
SA	40
SB	4
SC	60
Total	104

Note: Analytical data were published for only 12 of the 104 analyzed samples.

Lab No.	% SiO_2	% Al_2O_3	% Na_2O	% K_2O	% Fe_2O_3	% CaO	% MgO	% TiO_2
13906	76.3	12.96	3.34	5.14	1.27	0.63	0.14	0.18
13942	75.4	13.95	3.28	5.16	1.31	0.64	0.11	0.18
13975	75.4	14.06	3.24	5.14	1.22	0.63	0.11	0.19
13919	75.6	13.63	3.35	5.21	1.27	0.67	0.11	0.18
13948	75.3	13.82	3.38	5.25	1.34	0.65	0.12	0.17
13922	73.7	13.40	3.30	5.49	2.16	1.09	0.38	0.46
13929	73.0	13.28	3.30	5.45	2.57	1.45	0.47	0.49
13933	73.9	13.82	3.09	5.70	1.80	1.02	0.30	0.36
13957	73.5	14.48	3.06	5.68	1.71	0.93	0.27	0.36
13913	73.6	14.16	3.12	5.87	1.71	0.95	0.27	0.37
13988	73.4	14.48	3.07	5.75	1.69	0.99	0.28	0.39
13961	73.4	14.10	3.21	5.81	1.79	0.97	0.32	0.40

Table A5: Francaviglia 1984

Method: X-ray fluorescence spectroscopy

Source	Geological samples(*)	Archaeological samples
SA	77	1
SB	30	
SC1	27	1
SC2	18	2
Ceca 1	14	
Ceca 2	6	
PI	36	1
Li	71	
Pa	30	
Total	309	5

Note: Analytical data were published for only the 5 archaeological samples.

No.	% SiO_2	% Al_2O_3	% Fe_2O_3	% MnO	% MgO	% CaO	% Na_2O	% K_2O	% TiO_2	% P_2O_5
4	74.19	13.95	1.87	0.06	0.17	0.59	3.56	4.81	0.11	0.05
5	71.95	13.34	2.26	0.04	0.39	1.11	3.36	5.58	0.37	0.08
3	71.94	14.62	2.36	0.04	0.35	0.91	3.42	5.31	0.34	0.08
7	72.10	14.23	2.33	0.04	0.29	0.95	3.29	5.56	0.35	0.08
8	73.55	13.34	2.26	0.08	0.12	0.51	4.71	4.65	0.12	0.02

No.	S	Cl	Nb	Zr	Y	Sr	Rb	Zn	Co	Cr	V	Ba
4	10	919	56	84	27	31	252	64	3.1	0.0	19	306
5	19	588	22	207	19	254	164	65	2.8	0.0	47	920
3	13	595	30	256	20.3	150	178	59	2.5	0.6	38	295
7	11	565	34	269	19	158	181	60	2.6	0.9	45	919
8	18	1474	81	330	49	0.0	500	55	2.8	0.0	19	319

TABLE A6: Herold 1986

Method: Atomic absorption spectroscopy

Source	Geological samples
Conca Cannas	8
Perdas Urias	8
Total	16

Sample		% MgO	% Na2O	% K2O
CC1		0.10	3.55	5.18
CC2		0.10	3.56	5.24
CC3		0.11	3.62	5.25
CC4		0.10	3.63	5.21
CC5		0.10	3.51	5.27
CC6		0.11	3.57	5.20
CC7		0.10	3.58	5.19
CC8		0.10	3.63	5.19
Mean		0.10	3.58	5.22
S.D.	±	0.00	0.04	0.03
PU160		0.32	3.28	5.78
PU161		0.33	3.36	5.75
PU162		0.33	3.38	5.82
PU163		0.35	3.32	5.76
PU164		0.32	3.34	5.77
PU165		0.33	3.38	5.74
PU166		0.33	3.32	5.79
PU167		0.35	3.36	5.80
MEAN		0.33	3.34	5.78
S.D.	±	0.01	0.03	0.02

TABLE A6 (continued)

Method: Neutron activation analysis

Source	Geological samples
Conca Cannas	3
Cucru Is Abis	3
Maria Zuarbara/Riu Ceddus/Riu Nieddu	7
Conca s'Ollastu	3
Perdas Urias	3
Monte Sparau (south)	3
Scala Larga/Acqua Marzana	3
Capudaquas	2
Palmarola	3
Total	30

No.	La	Ce	Nd	Sm	Eu	Tb	Yb	Cs	Sc	U	Th	Hf	Ta	Co	Sb
CC5	18	54	31	6.7	0.31	1.2	3.2	4.4	4.0	7.5	17	3.4	4.4	0.2	0.4
CC23	17	55	34	6.6	0.34	1.1	3.2	4.6	4.0	7.0	19	5.7	4.5	0.2	0.4
CC25	16	58	30	6.7	0.37	1.2	3.4	5.4	4.2	5.6	18	3.7	4.5	0.4	0.6
MEAN	17	56	32	6.7	0.34	1.2	3.3	4.8	4.1	6.7	18	4.3	4.5	0.3	0.5
S.D. ±	1	2	2	0.1	0.02	0.1	0.1	0.4	0.1	0.8	1	1.0	0.1	0.1	0.1
CA125	23	79	42	7.7	0.68	1.2	3.5	4.6	4.1	5.1	20	4.6	4.0	1.1	0.6
CA128	22	73	33	7.1	0.62	1.1	2.9	4.2	3.8	5.1	19	4.3	3.7	1.2	0.4
CA131	22	70	41	7.4	0.61	1.1	3.0	4.1	4.0	6.4	19	4.2	4.0	0.9	0.4
MEAN	22	74	39	7.4	0.64	1.1	3.1	4.3	4.0	5.5	19	4.4	3.9	1.1	0.5
S.D. ±	0	4	4	0.2	0.03	0.0	0.3	0.2	0.1	0.6	0	0.2	0.1	0.1	0.1

TABLE 6 (continued)

No.	La	Ce	Nd	Sm	Eu	Tb	Yb	Cs	Sc	U	Th	Hf	Ta	Co	Sb
MZ139	25	88	42	7.4	0.80	1.0	2.5	4.3	3.2	5.8	21	4.5	3.0	0.9	0.4
MZ140	31	92	48	7.0	0.91	0.9	2.3	7.2	3.5	5.9	23	5.3	2.6	1.3	0.8
RC147	30	94	42	8.1	0.84	1.2	2.5	4.5	3.4	5.8	25	5.2	3.3	1.0	0.5
RC149	30	94	52	8.3	0.86	1.1	2.6	4.4	3.5	5.7	25	6.5	3.1	1.0	0.3
RC151	28	91	44	8.3	0.85	1.1	2.5	4.3	3.5	5.9	25	4.7	3.3	0.9	0.4
RN154	27	85	47	7.8	0.74	0.9	2.5	4.3	3.5	5.9	23	4.6	5.9	0.9	0.3
RN156	30	84	44	7.9	0.75	1.0	2.5	4.3	3.5	5.6	22	4.5	3.2	0.9	0.4
MEAN	29	90	46	7.8	0.82	1.0	2.5	4.8	3.4	5.8	23	5.0	3.5	1.0	0.4
S.D. ±	2	4	3	0.5	0.06	0.1	0.1	1.0	0.1	0.1	2	0.7	1.0	0.1	0.2
CO78	25	74	32	6.1	0.60	0.6	2.1	7.3	3.2	7.0	20	3.8	2.7	0.6	0.8
CO81	24	79	34	6.4	0.62	0.8	2.4	7.3	3.2	7.2	21	4.1	2.9	0.4	0.7
CO87	23	71	33	5.9	0.54	0.8	2.2	7.4	3.2	6.4	21	3.9	2.9	0.6	0.7
MEAN	24	75	33	6.1	0.59	0.7	2.2	7.3	3.2	6.9	21	3.9	2.8	0.5	0.7
S.D. ±	1	3	1	0.2	0.03	0.1	0.1	0.1	0.0	0.3	0	0.1	0.1	0.1	0.1
PU164	42	130	60	9.9	1.26	1.0	2.6	2.4	3.4	3.1	28	6.4	2.3	1.1	0.1
PU169	51	136	68	10.3	1.27	1.0	2.6	2.4	3.5	3.5	29	6.4	2.4	0.9	0.2
PU173	46	142	65	10.7	1.32	1.1	2.9	2.4	3.5	3.8	28	6.8	2.6	1.3	0.1
MEAN	46	136	64	10.3	1.28	1.0	2.7	2.4	3.5	3.5	28	6.5	2.4	1.1	0.1
S.D. ±	4	5	3	0.3	0.03	0.1	0.1	0.0	0.1	0.3	0	0.2	0.1	0.2	0.1

TABLE 6 (continued)

No.	La	Ce	Nd	Sm	Eu	Tb	Yb	Cs	Sc	U	Th	Hf	Ta	Co	Sb
MS57	48	151	68	11.5	1.08	1.3	3.4	2.6	4.6	3.7	29	5.4	3.6	0.4	0.4
MS58	52	153	77	12.0	1.08	1.3	4.0	2.9	4.6	3.2	28	5.8	3.7	0.3	0.3
MS61	50	153	72	11.7	1.09	1.5	3.5	2.1	4.6	3.8	28	5.7	4.0	0.5	0.4
MEAN	50	152	72	11.7	1.08	1.4	3.6	2.5	4.6	3.6	28	5.6	3.8	0.4	0.4
S.D. ±	2	1	4	0.2	0.00	0.1	0.3	0.3	0.0	0.3	0	0.2	0.2	0.1	0.1
SL69	60	158	80	12.6	0.20	1.7	5.0	8.9	2.7	8.5	31	7.7	6.5	0.1	1.0
SL71	58	158	81	12.6	0.25	1.8	4.7	9.4	2.7	8.2	32	7.7	6.6	0.3	1.0
AM120	53	143	77	13.0	0.24	1.8	4.6	9.4	3.6	8.2	33	7.6	5.9	0.1	1.0
MEAN	57	153	79	12.7	0.23	1.8	4.8	9.2	3.0	8.3	32	7.7	6.3	0.2	1.0
S.D. ±	3	7	2	0.2	0.02	0.1	0.2	0.2	0.4	0.1	1	0.1	0.3	0.1	0.0
CP110	35	101	41	7.8	1.16	1.1	2.4	6.7	3.9	5.9	22	6.3	2.6	1.6	0.6
CP111	34	93	35	7.0	1.12	0.8	2.2	6.8	3.6	5.9	22	5.9	2.6	1.7	0.6
MEAN	35	97	38	7.4	1.14	1.0	2.3	6.8	3.8	5.9	22	6.1	2.6	1.7	0.6
P12	67	175	73	10.9	0.07	1.6	7.5	51.5	1.5	28	76	8.9	5.6	0.2	3.4
P18	67	178	70	11.3	0.07	1.5	7.7	51.4	1.4	27	80	9.1	5.9	0.1	3.7
P24	66	174	66	11.4	0.05	1.5	8.4	51.2	1.4	29	79	8.9	5.6	0.2	3.6
MEAN	67	176	70	11.2	0.06	1.5	7.9	51.4	1.4	28	78	9.0	5.7	0.2	3.6
S.D. ±	0	2	3	0.2	0.01	0.1	0.4	0.1	0.1	1	2	0.1	0.1	0.1	0.1

TABLE 6 (continued)

Method: X-ray fluorescence spectroscopy

Source	Geological Samples
Conca Cannas	56
Monte Sparau (south)	12
Scala Larga/Acqua Marzana/Riu Mattiabis	13
Conca s'Ollastu	28
Capudaquas	11
Cucru Is Abis	11
Maria Zuarbara/Riu Ceddus/Riu Nieddu	28
Perdas Urias	22
Palmarola	31
Total	212

	%	%	%	%	%	%	%	%	%	%	%							
No.	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	Total	Rb	Sr	Ba	Zr	Zn	Nb	Y
CC1	74.40	0.10	13.70	1.47	0.06	0.09	0.60	3.68	5.23	0.08	99.41	245	29	146	104	92	44	35
CC2	74.90	0.11	13.80	1.48	0.06	0.15	0.60	3.59	5.21	0.08	99.98	245	30	135	103	90	42	35
CC3	74.50	0.11	13.80	1.46	0.06	0.15	0.60	3.71	5.18	0.08	99.65	246	30	130	103	94	41	36
CC4	74.80	0.10	13.80	1.47	0.06	0.12	0.60	3.62	5.18	0.08	99.83	245	30	145	104	93	42	35
CC5	74.50	0.10	13.70	1.46	0.06	0.14	0.59	3.56	5.23	0.07	99.41	245	29	154	106	91	43	33
CC6	74.70	0.11	13.80	1.46	0.06	0.10	0.60	3.68	5.21	0.08	99.80	247	28	148	104	92	43	37
CC7	74.30	0.10	13.80	1.47	0.06	0.14	0.60	3.65	5.21	0.08	99.42	249	30	145	105	90	42	36
CC8	74.70	0.10	13.80	1.48	0.06	0.15	0.60	3.67	5.24	0.08	99.88	248	28	133	103	91	44	34
CC9	74.50	0.10	13.90	1.48	0.06	0.13	0.60	3.57	5.24	0.08	99.66	248	30	151	105	93	45	35

TABLE 6 (continued)

	%	%	%	%	%	%	%	%	%	%	%							
No.	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	Total	Rb	Sr	Ba	Zr	Zn	Nb	Y
CC10	74.20	0.11	13.80	1.47	0.06	0.14	0.60	3.63	5.22	0.08	99.31	247	29	139	107	92	44	38
CC11	74.40	0.11	14.00	1.47	0.06	0.15	0.60	3.70	5.22	0.08	99.80	250	31	148	107	94	44	34
CC12	74.30	0.10	13.90	1.48	0.06	0.16	0.60	3.64	5.24	0.08	99.56	245	29	145	105	90	44	35
CC13	74.60	0.11	14.00	1.48	0.06	0.14	0.60	3.52	5.22	0.08	99.81	248	30	164	103	90	43	38
CC14	74.80	0.11	13.80	1.46	0.06	0.13	0.60	3.58	5.19	0.08	99.81	250	29	156	104	92	44	36
CC15	74.30	0.11	13.80	1.47	0.06	0.12	0.61	3.78	5.17	0.08	99.50	247	32	148	104	89	42	33
CC16	74.80	0.11	13.80	1.47	0.06	0.13	0.60	3.62	5.22	0.08	99.89	246	28	132	104	90	41	38
CC17	74.70	0.10	13.80	1.48	0.06	0.12	0.60	3.58	5.21	0.08	99.73	245	30	153	105	93	44	37
CC18	74.50	0.10	13.90	1.46	0.06	0.14	0.60	3.66	5.23	0.08	99.73	248	32	142	104	92	44	36
CC19	74.10	0.11	13.90	1.48	0.06	0.13	0.61	3.75	5.24	0.08	99.45	248	29	149	107	91	42	36
CC20	74.20	0.11	14.00	1.48	0.06	0.10	0.60	3.64	5.20	0.08	99.47	249	30	141	105	93	42	36
CC21	74.70	0.10	13.80	1.47	0.06	0.14	0.61	3.59	5.22	0.08	99.77	245	30	149	107	94	42	35
CC22	74.80	0.11	13.90	1.46	0.06	0.12	0.60	3.52	5.23	0.08	99.88	246	31	148	106	90	41	37
CC23	74.50	0.11	13.80	1.47	0.06	0.13	0.60	3.70	5.19	0.08	99.64	248	29	159	104	92	43	36
CC24	74.60	0.10	13.90	1.47	0.06	0.11	0.60	3.67	5.18	0.08	99.77	249	28	162	104	91	44	34
CC25	74.30	0.10	13.90	1.47	0.06	0.12	0.59	3.68	5.22	0.08	99.52	250	29	135	106	92	42	38
CC26	74.20	0.11	13.80	1.47	0.06	0.13	0.60	3.63	5.24	0.08	99.33	246	30	146	107	93	44	35
CC27	74.60	0.10	13.80	1.48	0.06	0.16	0.60	3.61	5.18	0.08	99.67	248	30	153	105	93	41	37
CC28	75.00	0.10	13.80	1.48	0.06	0.09	0.62	3.75	5.27	0.08	100.25	248	29	139	104	92	42	34
CC29	74.70	0.10	13.70	1.46	0.06	0.15	0.60	3.65	5.17	0.08	99.67	247	31	144	104	92	44	35
CC30	74.90	0.10	13.80	1.47	0.06	0.09	0.60	3.68	5.17	0.08	99.95	247	32	135	106	93	43	39
CC31	74.40	0.11	13.90	1.47	0.06	0.09	0.60	3.72	5.24	0.08	99.67	247	29	145	104	89	41	35
CC32	74.70	0.11	13.80	1.47	0.06	0.09	0.60	3.67	5.21	0.08	99.79	246	30	139	104	92	42	36
CC33	74.50	0.11	13.80	1.46	0.06	0.14	0.60	3.67	5.18	0.07	99.59	245	29	146	103	93	42	35
CC34	74.70	0.11	13.90	1.47	0.06	0.09	0.60	3.58	5.25	0.07	99.83	246	28	151	104	92	42	35
CC35	74.30	0.10	13.90	1.46	0.06	0.15	0.60	3.59	5.21	0.07	99.44	249	29	153	106	91	44	34
CC36	74.80	0.11	13.70	1.46	0.06	0.13	0.59	3.73	5.23	0.08	99.89	248	31	134	104	92	43	36
CC37	74.60	0.11	13.80	1.47	0.06	0.13	0.60	3.67	5.21	0.08	99.73	248	32	132	105	91	43	36
CC38	74.70	0.10	13.80	1.47	0.06	0.13	0.59	3.70	5.23	0.08	99.86	246	30	142	107	94	43	36

TABLE 6 (continued)

No.	% SiO2	% TiO2	% Al2O3	% Fe2O3	% MnO	% MgO	% CaO	% Na2O	% K2O	% P2O5	% Total	Rb	Sr	Ba	Zr	Zn	Nb	Y
CC39	74.20	0.11	13.80	1.47	0.06	0.16	0.60	3.62	5.26	0.08	99.36	246	29	150	103	92	44	36
CC40	74.40	0.11	13.90	1.47	0.06	0.13	0.60	3.57	5.29	0.08	99.61	245	30	138	105	90	46	36
CC41	75.00	0.10	13.80	1.47	0.06	0.14	0.60	3.59	5.22	0.08	100.06	247	30	133	103	93	44	32
CC42	74.50	0.11	13.80	1.47	0.06	0.12	0.60	3.73	5.23	0.08	99.70	245	31	135	104	92	43	35
CC43	74.10	0.11	13.90	1.48	0.06	0.14	0.60	3.71	5.28	0.08	99.46	250	29	141	103	95	44	35
CC44	74.60	0.11	13.90	1.47	0.06	0.15	0.60	3.67	5.21	0.07	99.84	247	31	132	105	92	43	35
CC45	75.00	0.10	13.70	1.47	0.06	0.12	0.60	3.57	5.22	0.08	99.92	249	28	153	104	90	44	35
CC46	74.70	0.10	13.80	1.48	0.06	0.15	0.60	3.58	5.24	0.08	99.79	249	30	162	106	92	41	36
CC47	74.50	0.10	13.60	1.46	0.06	0.15	0.60	3.66	5.19	0.08	99.40	246	31	154	103	93	41	36
CC48	74.10	0.11	14.00	1.49	0.06	0.10	0.60	3.69	5.28	0.08	99.51	248	30	142	105	93	45	37
CC49	74.70	0.10	13.90	1.47	0.06	0.11	0.60	3.65	5.22	0.08	99.89	247	32	145	104	92	43	35
CC50	74.50	0.11	13.90	1.46	0.06	0.14	0.60	3.56	5.21	0.08	99.62	245	29	146	107	92	44	36
CC51	74.50	0.11	13.90	1.48	0.06	0.13	0.60	3.68	5.27	0.08	99.81	246	31	152	104	93	43	38
CC52	74.40	0.11	13.90	1.47	0.06	0.11	0.60	3.63	5.25	0.08	99.61	249	29	147	101	91	45	36
CC53	74.50	0.11	13.90	1.47	0.06	0.15	0.60	3.51	5.23	0.08	99.61	245	29	137	104	92	42	37
CC54	74.80	0.11	13.90	1.49	0.06	0.09	0.60	3.56	5.26	0.08	99.95	250	33	158	107	93	43	34
CC55	75.20	0.11	14.10	1.50	0.06	0.11	0.59	3.50	5.32	0.08	100.57	252	30	143	107	94	42	36
CC56	74.60	0.11	13.90	1.48	0.06	0.15	0.60	3.58	5.24	0.08	99.80	249	32	149	105	92	42	35
MEAN	74.56	0.11	13.84	1.47	0.06	0.13	0.60	3.64	5.22	0.08	99.71	247	30	145	105	92	43	36
S.D.	± 0.25	0.00	0.09	0.01	0.00	0.02	0.00	0.06	0.03	0.00	0.23	2	1	8	1	1	1	1
MS57	74.50	0.19	13.60	1.60	0.05	0.21	0.71	3.57	5.63	0.06	100.12	180	30	187	182	87	41	36
MS58	74.40	0.19	13.70	1.60	0.05	0.18	0.72	3.60	5.62	0.05	100.11	182	28	211	181	89	41	32
MS59	74.10	0.19	13.70	1.59	0.05	0.25	0.71	3.63	5.60	0.06	99.88	184	29	201	181	89	43	34
MS60	74.10	0.19	13.60	1.59	0.05	0.24	0.71	3.51	5.63	0.06	99.68	182	30	221	180	87	44	33
MS61	73.90	0.19	13.60	1.59	0.05	0.24	0.71	3.53	5.59	0.06	99.46	181	28	193	180	86	41	32
MS62	74.00	0.19	13.60	1.59	0.05	0.26	0.71	3.64	5.59	0.06	99.69	181	30	187	180	88	43	35

TABLE 6 (continued)

No.	% SiO2	% TiO2	% Al2O3	% Fe2O3	% MnO	% MgO	% CaO	% Na2O	% K2O	% P2O5	% Total	Rb	Sr	Ba	Zr	Zn	Nb	Y
MS63	74.30	0.20	13.70	1.60	0.05	0.21	0.72	3.50	5.63	0.05	99.96	183	29	218	182	85	40	36
MS64	74.10	0.19	13.70	1.59	0.05	0.27	0.71	3.58	5.61	0.05	99.85	182	30	216	183	89	42	38
MS65	74.30	0.19	13.70	1.60	0.05	0.23	0.71	3.61	5.60	0.06	100.10	182	29	205	182	87	44	34
MS66	74.20	0.19	13.60	1.62	0.05	0.20	0.72	3.60	5.63	0.05	99.85	183	32	215	180	87	40	37
MS67	74.20	0.19	13.50	1.63	0.05	0.26	0.73	3.61	5.65	0.06	99.88	175	31	181	181	84	39	37
MS68	74.20	0.19	13.60	1.65	0.05	0.25	0.72	3.51	5.60	0.05	99.82	176	32	197	187	83	39	36
MEAN	74.19	0.19	13.63	1.60	0.05	0.23	0.72	3.57	5.62	0.06	99.87	181	30	203	182	87	41	35
S.D.	± 0.16	0.00	0.06	0.02	0.00	0.03	0.01	0.05	0.02	0.00	0.19	3	1	13	2	2	2	2
SL69	75.20	0.11	12.60	1.53	0.06	0.19	0.44	4.47	4.82	0.00	99.42	272	9	17	211	98	68	53
SL70	75.10	0.11	12.60	1.54	0.06	0.20	0.45	4.32	4.80	0.01	99.19	276	8	9	212	100	69	53
SL71	75.20	0.12	12.60	1.54	0.05	0.16	0.46	4.33	4.86	0.01	99.33	270	9	37	206	100	70	52
SL72	75.10	0.11	12.70	1.55	0.06	0.18	0.45	4.42	4.84	0.00	99.41	277	7	27	211	100	69	54
SL73	75.20	0.10	12.70	1.51	0.06	0.23	0.49	4.29	4.87	0.01	99.46	288	7	48	187	101	65	52
SL74	75.10	0.10	12.80	1.49	0.06	0.16	0.49	4.14	4.74	0.01	99.09	289	8	25	187	103	71	54
CP115	74.90	0.11	12.50	1.51	0.05	0.12	0.43	4.33	4.84	0.01	98.80	271	8	10	203	96	64	51
AM119	74.90	0.11	12.80	1.51	0.06	0.15	0.50	4.31	4.89	0.01	99.24	284	10	63	187	97	66	53
AM120	74.90	0.11	12.80	1.50	0.06	0.18	0.51	4.24	4.89	0.01	99.20	280	9	43	190	95	65	54
AM121	75.00	0.11	12.70	1.52	0.05	0.18	0.43	4.38	4.82	0.01	99.20	274	8	39	207	99	73	53
AM122	74.70	0.11	12.70	1.49	0.06	0.15	0.43	4.29	4.76	0.00	98.69	278	8	23	201	100	68	53
RM182	74.90	0.09	12.70	1.49	0.06	0.13	0.48	4.35	4.80	0.00	99.00	288	9	9	175	97	66	55
RM183	75.10	0.10	12.70	1.52	0.06	0.16	0.49	4.37	4.85	0.01	99.36	285	6	20	170	95	68	57
MEAN	75.02	0.11	12.68	1.52	0.06	0.17	0.47	4.33	4.83	0.01	99.18	279	8	28	196	99	68	53
S.D.	± 0.15	0.01	0.09	0.02	0.00	0.03	0.03	0.08	0.04	0.00	0.23	7	1	16	14	2	3	1

TABLE 6 (continued)

No.	% SiO2	% TiO2	% Al2O3	% Fe2O3	% MnO	% MgO	% CaO	% Na2O	% K2O	% P2O5	% Total	Rb	Sr	Ba	Zr	Zn	Nb	Y
CA131	73.30	0.20	14.10	1.86	0.05	0.27	0.80	3.48	5.32	0.10	99.48	234	68	311	141	89	39	28
CA132	73.50	0.20	14.20	1.83	0.05	0.29	0.80	3.58	5.35	0.10	99.90	235	69	328	140	87	40	30
CA133	73.40	0.21	14.00	1.86	0.05	0.25	0.81	3.51	5.35	0.10	99.54	235	71	306	139	88	34	30
CA134	73.70	0.21	14.10	1.86	0.05	0.31	0.81	3.53	5.38	0.10	100.05	239	70	337	143	91	39	29
Ave	73.45	0.21	14.10	1.86	0.05	0.28	0.81	3.55	5.37	0.10	99.80	235	70	331	144	89	37	29
S.D. ±	0.18	0.01	0.06	0.02	0.00	0.02	0.01	0.05	0.03	0.00	0.25	2	1	14	3	2	2	1
CO93	73.10	0.25	14.10	1.82	0.03	0.30	0.78	3.55	5.69	0.10	99.72	220	90	606	199	66	26	21
CO94	73.00	0.26	14.30	1.86	0.03	0.36	0.81	3.47	5.74	0.11	99.94	218	99	617	209	67	21	23
CP112	72.70	0.23	13.90	1.74	0.03	0.33	0.75	3.58	5.67	0.09	99.02	214	92	520	187	59	21	22
CP113	72.60	0.25	14.10	1.83	0.03	0.37	0.79	3.51	5.68	0.10	99.26	212	98	548	200	61	21	24
CP114	73.20	0.24	14.00	1.77	0.03	0.32	0.76	3.40	5.78	0.10	99.60	214	87	531	193	59	20	23
G123	73.10	0.24	13.90	1.79	0.03	0.33	0.76	3.61	5.65	0.10	99.51	219	95	515	193	57	22	22
MZ135	73.50	0.20	14.10	1.75	0.04	0.25	0.75	3.48	5.74	0.11	99.92	227	82	453	168	69	26	23
MZ136	73.20	0.20	14.10	1.74	0.04	0.31	0.75	3.40	5.71	0.11	99.56	226	81	462	169	67	26	24
MZ137	73.50	0.21	14.20	1.78	0.04	0.23	0.77	3.49	5.74	0.12	100.08	226	83	465	172	76	27	23
MZ138	72.90	0.20	14.20	1.77	0.03	0.26	0.77	3.43	5.67	0.11	99.34	227	81	480	169	78	28	24
MZ139	72.90	0.23	14.00	1.74	0.03	0.25	0.74	3.45	5.61	0.09	99.04	221	85	478	170	68	24	22
MZ142	72.80	0.26	14.10	1.87	0.03	0.36	0.82	3.51	5.68	0.10	99.53	215	102	551	206	58	23	20
MZ143	72.90	0.25	14.30	1.84	0.03	0.27	0.80	3.46	5.76	0.11	99.72	218	99	596	201	67	22	24
MZ144	73.20	0.25	14.20	1.83	0.03	0.31	0.80	3.49	5.78	0.10	99.99	228	99	576	200	70	25	22
MZ145	73.20	0.21	14.10	1.83	0.05	0.30	0.81	3.55	5.42	0.10	99.57	232	77	302	146	81	33	29
RC147	73.10	0.21	14.00	1.80	0.04	0.29	0.75	3.53	5.74	0.11	99.57	227	81	426	169	68	29	24
RC148	73.20	0.21	14.10	1.80	0.04	0.31	0.75	3.48	5.74	0.11	99.74	226	82	451	170	69	28	24
RC149	72.90	0.21	14.10	1.80	0.04	0.30	0.77	3.42	5.72	0.12	99.38	229	84	444	169	73	27	28
RC150	73.30	0.21	14.00	1.80	0.04	0.30	0.77	3.51	5.73	0.12	99.78	220	81	433	168	71	25	26

TABLE 6 (continued)

	%	%	%	%	%	%	%	%	%	%	%							
No.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Total	Rb	Sr	Ba	Zr	Zn	Nb	Y
CO75	74.60	0.18	13.60	1.58	0.03	0.24	0.64	3.48	5.61	0.08	100.04	234	53	339	145	63	24	20
CO76	74.80	0.13	13.40	1.44	0.03	0.25	0.56	3.44	5.50	0.07	99.62	249	33	165	119	63	24	18
CO77	74.50	0.16	13.60	1.50	0.03	0.18	0.59	3.44	5.63	0.07	99.70	247	47	296	137	64	25	23
CO78	74.80	0.16	13.60	1.52	0.03	0.25	0.60	3.49	5.56	0.08	100.09	239	47	307	140	66	24	22
CO79	74.70	0.15	13.50	1.47	0.03	0.21	0.57	3.52	5.46	0.07	99.68	245	37	220	128	63	27	23
CO80	74.40	0.21	13.60	1.54	0.03	0.24	0.70	3.58	5.51	0.09	99.90	234	59	366	150	62	27	19
CO81	74.60	0.17	13.50	1.52	0.03	0.25	0.61	3.63	5.50	0.08	99.89	237	46	319	142	63	25	22
CO82	74.90	0.15	13.40	1.44	0.03	0.13	0.56	3.58	5.43	0.07	99.69	247	33	214	123	66	27	24
CO83	74.60	0.13	13.30	1.45	0.03	0.14	0.55	3.52	5.48	0.07	99.27	252	31	159	123	66	27	22
CO84	75.00	0.13	13.40	1.45	0.03	0.14	0.55	3.60	5.39	0.07	99.76	252	30	123	123	62	26	21
CO85	74.60	0.13	13.40	1.43	0.03	0.12	0.55	3.63	5.38	0.07	99.34	251	32	147	120	61	28	20
CO86	74.80	0.13	13.20	1.43	0.03	0.13	0.55	3.51	5.39	0.07	99.24	249	32	152	116	61	28	21
CO87	74.30	0.16	13.40	1.48	0.03	0.20	0.58	3.52	5.46	0.07	99.19	244	45	264	133	60	23	19
CO88	74.20	0.17	13.50	1.56	0.03	0.22	0.60	3.50	5.61	0.08	99.47	245	52	277	138	66	27	21
CO89	74.40	0.16	13.60	1.52	0.03	0.19	0.60	3.57	5.52	0.08	99.67	232	48	283	136	62	24	22
CO90	74.70	0.16	13.60	1.53	0.03	0.22	0.61	3.59	5.50	0.08	100.02	231	51	275	138	66	24	23
CO91	74.10	0.15	13.40	1.48	0.03	0.24	0.59	3.50	5.36	0.07	98.92	240	41	195	127	66	25	21
CO92	74.60	0.15	13.50	1.52	0.03	0.20	0.60	3.52	5.49	0.07	99.68	241	39	215	128	63	24	21
CO97	74.80	0.16	13.60	1.54	0.03	0.26	0.61	3.50	5.58	0.07	100.15	232	57	265	141	59	21	22
CO98	74.60	0.16	13.50	1.53	0.03	0.23	0.60	3.53	5.54	0.07	99.79	228	62	252	137	57	21	23
CO99	74.60	0.13	13.30	1.46	0.04	0.21	0.55	3.54	5.49	0.06	99.38	237	37	140	120	56	23	21
CO100	74.60	0.13	13.30	1.46	0.04	0.21	0.56	3.69	5.40	0.07	99.46	239	36	133	120	61	21	23
CO101	74.70	0.13	13.40	1.46	0.04	0.22	0.56	3.67	5.39	0.07	99.64	240	36	125	122	58	22	22
CO102	74.80	0.16	13.40	1.55	0.03	0.21	0.61	3.49	5.53	0.07	99.85	233	56	218	138	59	22	24
CO103	74.10	0.17	13.40	1.55	0.03	0.27	0.61	3.54	5.52	0.07	99.26	225	57	279	142	59	22	24
CO104	74.40	0.17	13.40	1.56	0.04	0.28	0.63	3.52	5.49	0.08	99.57	229	62	252	138	58	22	23
CO105	74.60	0.16	13.50	1.55	0.04	0.27	0.61	3.51	5.58	0.07	99.89	229	56	247	135	56	21	24
MZ146	74.40	0.17	13.70	1.53	0.30	0.20	0.62	3.51	5.55	0.07	100.05	230	59	328	145	65	24	22

TABLE 6 (continued)

	%	%	%	%	%	%	%	%	%	%	%							
No.	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	Total	Rb	Sr	Ba	Zr	Zn	Nb	Y
MEAN	74.58	0.15	13.46	1.50	0.03	0.21	0.59	3.54	5.49	0.07	99.65	239	46	234	132	62	24	22
S.D. ±	0.22	0.02	0.12	0.05	0.00	0.04	0.03	0.06	0.07	0.01	0.30	8	10	69	9	3	2	2
CO95	72.10	0.31	14.50	2.06	0.03	0.31	0.93	3.49	5.66	0.13	99.52	211	15	760	237	66	24	21
MZ140	72.20	0.32	14.50	2.10	0.03	0.38	0.95	3.51	5.78	0.13	99.90	211	122	706	244	62	21	24
MZ141	72.30	0.30	14.50	2.01	0.03	0.35	0.90	3.46	5.65	0.12	99.62	216	116	717	232	69	20	23
CP106	71.90	0.31	14.40	2.05	0.03	0.39	0.93	3.46	5.68	0.12	99.27	205	122	695	236	60	18	22
CP107	72.20	0.31	14.40	2.04	0.03	0.41	0.92	3.43	5.74	0.12	99.60	207	120	671	236	59	22	25
CP108	72.20	0.30	14.30	2.05	0.03	0.39	0.91	3.49	5.76	0.11	99.54	209	119	681	233	63	22	20
CP109	72.20	0.31	14.40	2.10	0.03	0.40	0.93	3.52	5.68	0.12	99.69	205	121	691	237	60	21	26
CP110	72.00	0.31	14.40	2.05	0.03	0.43	0.93	3.50	5.60	0.12	99.37	206	121	709	240	60	21	23
CP111	72.20	0.30	14.40	2.01	0.03	0.42	0.91	3.43	5.69	0.11	99.50	209	118	667	231	59	22	24
CP116	72.30	0.27	14.10	1.89	0.03	0.36	0.82	3.53	5.72	0.10	99.12	209	108	623	213	58	23	22
CP117	71.90	0.35	14.60	2.00	0.03	0.45	1.00	3.43	5.86	0.13	99.75	161	130	911	251	67	22	25
MEAN	72.14	0.31	14.41	2.03	0.03	0.39	0.92	3.48	5.71	0.12	99.53	204	119	712	235	62	21	23
S.D. ±	0.14	0.02	0.12	0.05	0.00	0.04	0.04	0.04	0.07	0.01	0.21	14	5	71	9	4	2	2
CA124	73.60	0.22	14.10	1.87	0.05	0.29	0.83	3.62	5.41	0.11	100.10	234	70	345	147	85	37	27
CA125	73.50	0.21	14.00	1.84	0.05	0.30	0.81	3.51	5.36	0.11	99.69	232	70	345	145	86	35	30
CA126	73.80	0.21	14.20	1.89	0.05	0.25	0.83	3.53	5.43	0.10	100.29	237	71	345	146	90	35	28
CA127	73.40	0.21	14.10	1.89	0.05	0.25	0.82	3.57	5.38	0.11	99.78	235	69	344	149	89	36	30
CA128	73.30	0.21	14.10	1.84	0.05	0.29	0.82	3.63	5.37	0.11	99.72	235	72	339	145	89	36	28
CA129	73.20	0.21	14.10	1.85	0.05	0.27	0.80	3.51	5.37	0.10	99.46	233	69	325	141	89	37	29
CA130	73.30	0.22	14.10	1.87	0.05	0.30	0.82	3.60	5.40	0.11	99.77	232	69	313	143	92	37	32

TABLE 6 (continued)

	%	%	%	%	%	%	%	%	%	%	%							
No.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Total	Rb	Sr	Ba	Zr	Zn	Nb	Y
RC151	73.70	0.19	14.10	1.71	0.04	0.29	0.73	3.45	5.69	0.11	100.01	226	79	401	159	72	27	24
RC152	73.20	0.21	14.10	1.79	0.04	0.27	0.75	3.42	5.72	0.11	99.61	225	80	410	161	72	28	25
RN153	73.20	0.20	14.00	1.77	0.05	0.30	0.78	3.60	5.49	0.10	99.49	234	77	337	154	78	34	29
RN154	73.70	0.21	14.00	1.78	0.04	0.32	0.76	3.63	5.67	0.11	100.22	229	79	393	162	71	29	24
RN155	73.60	0.21	14.10	1.79	0.04	0.30	0.78	3.57	5.65	0.11	100.15	228	82	395	162	70	28	26
RN156	73.50	0.21	14.10	1.77	0.04	0.29	0.77	3.52	5.62	0.11	99.93	232	81	406	162	78	28	24
RN157	73.60	0.20	14.00	1.76	0.04	0.31	0.76	3.57	5.64	0.11	99.99	227	79	374	159	73	28	25
RN158	73.40	0.21	14.00	1.79	0.04	0.34	0.79	3.68	5.55	0.10	99.90	231	82	381	157	75	31	31
RN159	73.60	0.20	14.10	1.78	0.04	0.33	0.78	3.56	5.56	0.10	100.05	231	79	350	156	75	31	27
MEAN	73.21	0.22	14.08	1.79	0.04	0.30	0.77	3.51	5.67	0.11	99.70	224	86	461	175	70	26	24
S.D. ±	0.30	0.02	0.10	0.04	0.01	0.03	0.02	0.07	0.08	0.01	0.31	6	8	83	18	6	4	3
PU160	72.10	0.31	14.30	1.91	0.03	0.39	0.91	3.33	5.82	0.13	99.23	175	128	966	241	72	27	24
PU161	72.70	0.31	14.40	1.89	0.03	0.34	0.92	3.42	5.80	0.13	99.94	176	128	955	240	74	28	27
PU162	72.40	0.31	14.40	1.91	0.03	0.36	0.91	3.50	5.85	0.13	99.80	176	127	935	240	72	27	25
PU163	72.00	0.31	14.40	1.91	0.03	0.37	0.92	3.47	5.84	0.13	99.38	175	129	978	242	70	27	25
PU164	72.70	0.30	14.40	1.89	0.03	0.35	0.92	3.57	5.80	0.13	100.09	176	127	946	241	73	25	25
PU165	72.40	0.31	14.40	1.93	0.03	0.40	0.92	3.58	5.81	0.13	99.91	177	129	992	244	74	26	24
PU166	72.30	0.31	14.40	1.93	0.03	0.40	0.94	3.52	5.85	0.13	99.81	169	129	975	242	76	25	26
PU167	71.90	0.30	14.40	1.89	0.03	0.35	0.94	3.53	5.82	0.13	99.29	173	129	980	240	74	26	26
PU168	72.10	0.30	14.40	1.89	0.03	0.35	0.92	3.50	5.80	0.13	99.42	176	127	962	241	73	28	24
PU169	72.00	0.30	14.40	1.89	0.03	0.38	0.92	3.44	5.79	0.13	99.28	178	127	964	241	72	25	27
PU170	72.30	0.31	14.40	1.92	0.03	0.41	0.93	3.41	5.87	0.13	99.71	176	127	988	241	73	28	22
PU171	71.80	0.31	14.50	1.91	0.03	0.40	0.93	3.47	5.83	0.13	99.31	178	126	988	241	76	28	24
PU172	72.40	0.31	14.50	1.92	0.03	0.34	0.93	3.38	5.83	0.13	99.77	176	127	971	242	75	28	25
PU173	72.50	0.31	14.40	1.93	0.03	0.34	0.94	3.47	5.83	0.13	99.88	170	129	978	240	75	25	25

TABLE 6 (continued)

No.	% SiO2	% TiO2	% Al2O3	% Fe2O3	% MnO	% MgO	% CaO	% Na2O	% K2O	% P2O5	% Total	Rb	Sr	Ba	Zr	Zn	Nb	Y
PU174	71.90	0.31	14.50	1.94	0.03	0.39	0.94	3.45	5.87	0.13	99.46	166	129	969	242	73	23	27
PU175	72.30	0.31	14.40	1.92	0.03	0.38	0.93	3.51	5.84	0.13	99.75	172	129	968	243	76	26	28
PU176	71.80	0.31	14.50	1.91	0.03	0.35	0.94	3.53	5.81	0.13	99.31	169	131	951	240	77	24	28
PU177	72.50	0.30	14.40	1.91	0.03	0.40	0.92	3.58	5.87	0.13	100.04	168	131	874	241	68	23	25
PU178	72.60	0.31	14.50	1.92	0.03	0.40	0.94	3.57	5.90	0.13	100.30	172	132	900	242	69	26	23
PU179	72.50	0.31	14.30	1.92	0.03	0.39	0.93	3.48	5.85	0.13	99.85	167	127	896	241	66	23	28
PU180	72.40	0.32	14.50	1.96	0.03	0.38	0.96	3.49	5.84	0.13	100.01	168	132	935	245	69	24	22
PU181	72.40	0.32	14.30	1.95	0.03	0.40	0.95	3.50	5.88	0.13	99.86	167	133	935	244	66	21	24
MEAN	72.27	0.31	14.41	1.92	0.03	0.38	0.93	3.49	5.84	0.13	99.70	173	129	955	242	72	26	25
S.D. ±	0.27	0.01	0.06	0.02	0.00	0.02	0.01	0.06	0.03	0.00	0.30	4	2	31	1	3	2	2
P1	73.60	0.10	13.40	1.80	0.08	0.06	0.47	4.74	4.97	0.01	99.23	449	5	32	296	62	60	59
P2	74.00	0.10	13.50	1.80	0.08	0.09	0.47	4.78	4.97	0.02	99.81	454	6	23	293	67	60	57
P3	73.50	0.10	13.50	1.80	0.08	0.05	0.47	4.80	4.94	0.02	99.26	458	3	31	294	67	58	58
P4	73.60	0.10	13.50	1.80	0.08	0.11	0.47	4.79	4.96	0.01	99.42	453	5	32	292	65	58	56
P5	73.80	0.10	13.60	1.80	0.08	0.07	0.47	4.77	4.96	0.01	99.66	456	2	33	294	63	59	60
P6	73.70	0.10	13.40	1.80	0.08	0.10	0.47	4.83	4.94	0.01	99.43	452	3	52	290	66	59	58
P7	73.30	0.10	13.40	1.79	0.08	0.11	0.47	4.81	4.91	0.01	98.98	454	6	45	292	66	60	60
P8	73.30	0.10	13.60	1.80	0.08	0.10	0.47	4.84	4.94	0.01	99.23	460	2	42	298	67	59	58
P9	73.80	0.10	13.50	1.81	0.08	0.09	0.47	4.77	4.96	0.01	99.59	455	5	28	294	63	59	60
P10	73.80	0.10	13.50	1.80	0.08	0.11	0.47	4.80	4.95	0.01	99.62	456	4	49	294	64	56	59
P11	73.80	0.10	13.60	1.80	0.08	0.08	0.47	4.87	4.95	0.01	99.76	454	5	30	293	64	57	60
P12	74.10	0.10	13.50	1.80	0.08	0.10	0.47	4.83	4.96	0.01	99.95	451	4	53	294	65	59	58
P13	73.50	0.10	13.50	1.80	0.08	0.12	0.47	4.83	4.94	0.01	99.35	450	6	28	293	62	59	59
P14	73.70	0.10	13.50	1.80	0.08	0.07	0.47	4.88	4.92	0.01	99.53	452	2	51	297	65	58	58
P15	73.30	0.10	13.60	1.79	0.08	0.06	0.47	4.87	4.92	0.01	99.20	453	5	45	294	62	60	57
P16	73.50	0.10	13.40	1.79	0.08	0.09	0.47	4.82	4.93	0.01	99.19	452	6	30	293	66	58	56

TABLE 6 (continued)

	%	%	%	%	%	%	%	%	%	%	%							
No.	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	Total	Rb	Sr	Ba	Zr	Zn	Nb	Y
P17	73.50	0.10	13.40	1.79	0.08	0.07	0.47	4.88	4.92	0.01	99.24	452	5	31	291	65	57	59
P18	74.10	0.10	13.50	1.81	0.08	0.07	0.47	4.73	4.95	0.01	99.82	454	3	46	293	65	57	58
P19	73.80	0.10	13.50	1.80	0.08	0.08	0.47	4.87	4.95	0.01	99.66	455	4	21	290	66	57	58
P20	74.00	0.10	13.50	1.80	0.08	0.06	0.47	4.88	4.94	0.01	99.84	453	6	41	294	63	58	61
P21	73.40	0.10	13.50	1.80	0.08	0.10	0.47	4.86	4.95	0.01	99.27	456	6	30	293	63	59	56
P22	73.90	0.10	13.50	1.80	0.08	0.08	0.46	4.85	4.95	0.01	99.73	456	3	45	292	68	61	55
P23	73.50	0.10	13.50	1.81	0.08	0.09	0.46	4.86	4.97	0.01	99.38	462	5	48	294	63	64	56
P24	73.80	0.10	13.50	1.80	0.08	0.10	0.46	4.84	4.93	0.01	99.62	454	3	13	293	64	59	59
P25	73.80	0.10	13.50	1.80	0.08	0.09	0.46	4.79	4.98	0.01	99.61	455	5	26	291	63	60	60
P26	73.60	0.10	13.60	1.80	0.08	0.11	0.47	4.85	4.96	0.01	99.58	455	5	33	293	67	60	59
P27	73.70	0.10	13.40	1.80	0.08	0.08	0.47	4.79	4.97	0.01	99.40	452	5	51	294	65	56	58
P28	73.90	0.10	13.50	1.80	0.08	0.09	0.47	4.81	4.95	0.01	99.71	455	5	40	293	64	59	59
P29	70.10	0.10	13.20	1.67	0.08	0.10	0.39	3.92	5.07	0.01	94.64	442	11	32	263	69	59	55
P30	72.00	0.10	13.70	1.79	0.09	0.14	0.43	4.71	5.14	0.01	98.12	434	7	53	266	72	66	55
P31	70.10	0.10	13.20	1.60	0.08	0.06	0.38	3.87	5.01	0.01	94.41	505	42	69	266	68	60	54
MEAN	73.63	0.10	13.48	1.79	0.08	0.09	0.46	4.82	4.96	0.01	99.45	455	5	38	291	65	59	58
S.D.	± 0.38	0.00	0.10	0.04	0.00	0.02	0.02	0.05	0.04	0.00	0.35	10	2	12	9	2	2	2

Table A7: Pavia Analyses (Bigazzi et al. 1986; Bigazzi et al. 1992b)

Method: Neutron activation analysis

Source	Geological samples*	Archaeological samples
SA?		1
SB?	1	3
Li	3	16
Pa	2	4
PI	1	3
Melos	2	3
Total	7 W. Med.	27 W. Med

No.	La	Ce	Nd	Sm	Eu	Gd	Tb	Dy	Ho
GdL7	20	43	37	17.0	0.50	4.4	1.65	17.0	1.75
MA*	42	63	33	11.3	0.38	4.7	1.21	11.7	0.88
GdB2	40	61	37	11.9	0.37	5.0	0.98	11.5	1.11
GdL3	41	63	36	10.9	0.39	5.0	1.01	10.6	1.02
Capr3	43	64	34	11.6	0.40	4.3	1.26	11.0	0.89
MEAN	42	63	35	11.4	0.39	4.8	1.12	11.2	0.98
S.D. ±	1	1	2	0.4	0.01	0.3	0.12	0.4	0.10
Li-RR*	131	65	40	15.8	0.37	13.8	1.40	5.2	0.73
Li-FV*	113	86	37	12.8	0.41	12.1	0.90	5.5	0.87
Li-Gab*	89	114	48	16.2	0.46	8.9	1.93	5.5	0.94
Lip23B	73	57	60	19.4	3.94	8.3	3.55	4.3	0.87
Lip27#	94	95	43	16.9	0.39	9.5	1.74	4.7	0.95
GdL1	65	66	36	14.6	1.14	11.9	1.70	5.6	0.73
Capr1	118	85	38	12.2	0.43	11.9	0.87	5.2	0.83
Capr2	113	85	39	13.3	0.45	12.3	0.86	5.2	0.89
SabP11	117	89	39	12.7	0.45	11.9	0.95	5.9	0.83
CL1	117	85	36	13.1	0.42	12.7	0.83	5.7	0.84
CL2	118	89	41	14.9	0.43	14.1	0.96	5.3	0.81
Font1	155	89	36	12.9	0.42	12.1	0.81	6.0	0.88
Font3	113	86	35	15.2	0.45	14.4	0.91	5.4	0.85
FDV5	119	85	37	12.5	0.44	12.0	0.93	4.8	0.87
VB2	118	86	41	14.3	0.45	13.9	0.88	5.3	0.84
VB11	113	85	39	12.8	0.43	12.8	0.89	5.5	0.86
VB12	116	88	40	12.3	0.44	11.9	0.87	5.5	0.89

Table A7 (continued)

No.	La	Ce	Nd	Sm	Eu	Gd	Tb	Dy	Ho	
Tart8S	119	81	34	12.6	0.43	12.0	0.92	5.7	0.87	
Tart7	113	86	41	12.1	0.48	11.7	0.94	5.3	0.85	
MEAN	111	84	40	14.0	0.47	12.0	1.20	5.3	0.85	
S.D. ±	19	12	6	1.9	0.16	1.6	0.65	0.4	0.05	
Pa-BdT*	152	79	40	24.6	3.3	14.1	1.95	20.1	1.53	
Pa-FdP*	127	88	47	23.2	4.8	18.9	1.45	24.8	1.26	
McV3	62	78	53	22.4	7.95	26.4	1.70	27.9	2.99	
McV7	141	81	59	19.7	4.91	20.8	3.14	20.7	2.26	
McG1-2	131	83	61	21.4	5.12	21.8	3.01	21.6	3.72	
VB1	158	79	41	24.4	3.50	14.3	1.94	20.1	1.52	
MEAN	129	81	50	22.6	4.93	19.4	2.20	22.5	2.23	
S.D. ±	32	3	8	1.7	1.52	4.3	0.64	2.9	0.89	
PI*	104	171	51	21.3	0.29	5.9	1.41	4.4	0.94	
SV1	106	161	41	22.4	0.31	6.1	1.69	5.2	1.09	
SV2	117	171	39	26.4	0.36	5.9	1.71	4.2	0.95	
SV3	78	67	48	12.4	0.30	12.4	1.15	5.9	0.80	
MEAN	101	143	45	20.6	0.32	7.6	1.49	4.9	0.95	
S.D. ±	14	44	5	5.1	0.03	2.8	0.23	0.7	0.10	
Melos1*	53	67	32	14.6	0.81	3.4	1.20	9.3	0.88	
Melos2*	250	61	21	13.4	0.70	3.9	1.00	17.7	0.94	
GdL2	57	81	39	19.3	0.87	3.9	1.09	17.1	0.88	
GdL4	58	69	32	13.4	0.71	3.6	1.31	12.3	1.48	
GdL5	53	76	32	21.6	0.86	3.7	1.21	19.1	1.53	
MEAN	94	71	31	16.5	0.79	3.7	1.16	15.1	1.14	
S.D. ±	78	7	6	3.4	0.07	0.2	0.11	3.7	0.30	
GdL7	0.19	10.5	0.10	3.21	1.12	266	3.45	2.36	16.7	5.2

Table A7 (continued)

No.	Tm	Yb	Lu	Sc	% Fe	Rb	Cs	Ta	Th	U
MA*	0.20	8.7	0.13	2.18	0.99	281	2.19	2.53	17.5	5.7
GdB2	0.21	9.6	0.16	2.31	1.16	281	2.71	2.91	17.4	5.7
GdL3	0.23	9.4	0.15	2.41	1.17	284	2.81	2.91	18.2	5.8
Capr3	0.21	8.6	0.15	2.17	0.99	282	2.2	2.5	17.5	5.9
MEAN	0.21	9.1	0.15	2.27	1.08	282	2.5	2.7	17.7	5.8
S.D. ±	0.01	0.4	0.01	0.10	0.09	1	0.3	0.2	0.3	0.1
RR*	0.27	11.0	0.16	0.67	1.00	197	8.90	1.07	51.4	11.2
FV*	0.27	7.6	0.13	0.55	0.73	159	6.5	0.88	48.9	15.6
Gab*	0.36	3.9	0.07	0.92	1.07	215	9.6	1.83	42.8	17.0
23B	0.36	11.4	0.29	0.31	0.53	110	4.80	0.77	19.3	4.9
27#	0.33	9.1	0.09	0.77	1.22	210	9.44	1.06	59.2	17.1
GdL1	0.26	12.3	0.21	0.57	0.88	246	8.18	1.08	37.2	11.9
Capr1	0.29	7.6	0.12	0.59	0.73	157	6.5	0.9	49.9	15.4
Capr2	0.31	7.5	0.14	0.55	0.77	154	6.5	0.9	48.9	14.3
Sab11	0.27	7.8	0.16	0.56	0.72	154	6.6	0.9	47.3	16.1
CL1	0.28	7.7	0.13	0.57	0.71	158	6.4	0.9	47.6	14.2
CL2	0.29	7.6	0.19	0.56	0.71	155	6.2	0.9	44.4	15.6
Font1	0.31	7.7	0.12	0.57	0.72	159	6.7	0.8	47.1	14.7
Font3	0.29	7.5	0.15	0.58	0.76	161	6.8	0.8	44.7	15.3
FDV5	0.27	7.9	0.13	0.53	0.74	155	6.6	0.9	48.8	15.3
VB2	0.28	7.7	0.12	0.57	0.77	161	7.4	0.9	47.6	15.4
VB11	0.28	7.5	0.15	0.55	0.71	156	6.6	0.9	48.1	14.6
VB12	0.26	7.2	0.15	0.56	0.76	154	6.1	0.8	43.8	14.2
Tart8S	0.29	7.3	0.13	0.57	0.83	152	6.5	0.9	47.9	14.5
Tart7	0.30	7.4	0.19	0.53	0.79	155	7.6	0.9	47.1	15.1
MEAN	0.29	8.1	0.15	0.58	0.80	167	7.0	1.0	45.9	14.3
S.D. ±	0.03	1.8	0.05	0.11	0.15	29	1.2	0.2	7.5	2.6
BdT*	0.53	15.9	0.17	0.96	2.11	49	2.40	3.51	28.4	6.9
FdP*	0.61	14.4	0.19	1.61	2.03	48	2.91	3.87	20.6	5.8
McV3	0.68	13.9	0.12	1.41	3.18	42	2.72	3.33	26.3	8.1
McV7	0.71	15.9	0.32	1.04	2.71	49	2.74	3.91	29.6	6.9
McG1	0.61	16.7	0.31	1.02	2.91	51	2.71	4.11	29.1	7.1
VB1	0.53	15.9	0.17	0.97	2.11	49	2.5	3.6	28.5	6.9
MEAN	0.61	15.5	0.21	1.17	2.51	48	2.7	3.7	27.1	7.0
S.D. ±	0.07	1.0	0.07	0.25	0.45	3	0.2	0.3	3.1	0.7

Table A7 (continued)

No.	Tm	Yb	Lu	Sc	% Fe	Rb	Cs	Ta	Th	U
PI*	0.38	1.61	0.21	0.91	1.06	273	31.4	1.7	46.1	16.7
SV1	0.36	1.71	0.26	0.81	0.81	291	21.6	1.61	41.6	15.1
SV2	0.41	2.11	0.15	1.03	0.91	310	27.4	2.01	39.6	16.3
SV3	0.27	1.24	0.13	0.67	0.74	247	18.9	1.41	41.6	12.9
MEAN	0.36	1.67	0.19	0.86	0.88	280	24.8	1.68	42.2	15.3
S.D. ±	0.05	0.31	0.05	0.13	0.12	23	4.9	0.22	2.4	1.5
Me1*	0.13	12.9	0.18	3.32	2.91	227	5.37	0.75	13.2	6.3
Me2*	0.11	11.8	0.17	2.08	1.73	206	4.69	0.62	19.4	5.5
GdL2	0.19	15.1	0.17	3.61	2.91	229	5.37	0.69	19.4	6.3
GdL4	0.15	10.4	0.17	3.12	3.71	237	5.21	0.89	13.6	6.2
GdL5	0.11	16.9	0.18	3.71	2.89	231	5.41	0.71	14.2	6.1
MEAN	0.14	13.4	0.17	3.17	2.83	226	5.21	0.73	16.0	6.1
S.D. ±	0.03	2.3	0.00	0.58	0.63	11	0.27	0.09	2.8	0.3

Average of 7 analyses

Table A8: Francaviglia & Piperno 1987

Method: X-ray fluorescence spectroscopy

Source	Archaeological samples
Li	6
Pa-Balate dei Turchi	3
Pa-Gelkhamar	1
Total	10

Note: Analytical data were published for only 10 of the 90 analyzed archaeological samples.

No.	% SiO_2	% Al_2O_3	% Fe_2O_3	% MnO	% MgO	% CaO	% Na_2O	% K_2O	% TiO_2	% P_2O_5
U3	73.53	12.56	1.97	0.07	0.08	0.82	4.52	4.90	0.09	0.02
U4	70.71	12.19	1.85	0.06	0.07	1.47	4.40	4.65	0.09	0.03
U5	71.45	12.38	1.96	0.06	0.08	0.72	4.46	4.66	0.08	0.02
MC2	74.01	12.89	2.07	0.07	0.10	0.79	4.37	5.08	0.10	0.02
MC3	73.32	12.32	3.05	0.08	0.11	0.85	4.06	5.56	0.10	0.03
MC5	59.78	19.34	11.75	0.12	1.06	1.16	1.96	3.19	1.04	0.09
U2	70.45	7.73	8.52	0.27	0.08	0.36	7.09	4.14	0.23	0.03
MC1	69.52	7.78	9.31	0.29	0.26	0.53	6.90	4.09	0.29	0.04
MC4	69.40	7.49	10.61	0.33	0.11	0.37	6.39	4.51	0.26	0.03
U1	66.34	10.49	8.94	0.30	0.18	0.70	7.40	4.50	0.62	0.04

Table A8 (continued)

No.	S	Cl	Nb	Zr	Y	Sr	Rb	Zn	Ni	Cr	V	Ba	Th	Pb	Cu	Ce	Nd	La
U3	14.4	965.3	44.1	171.5	58.0	15.1	249.4	41.8	59.8	479.6	-	16.5	44.6	28.2	-	97.7	46.2	71.6
U4	14.1	952.3	43.8	173.6	56.6	16.2	237.8	49.5	62.5	375.1	-	7.5	41.9	28.7	3.0	100.5	46.5	68.4
U5	15.8	953.8	38.8	151.5	52.9	14.8	240.9	38.4	60.4	729.3	-	21.2	42.9	30.1	6.8	85.8	38.4	67.7
MC2	22.8	1337.9	44.0	166.3	58.8	18.3	259.9	40.5	14.9	447.4	-	28.4	46.9	28.1	3.6	98.2	35.5	66.9
MC3	18.9	1257.6	25.3	106.3	33.0	13.8	196.2	37.4	33.9	1325.0	12.5	20.3	37.2	31.0	9.5	99.3	40.9	68.3
MC5	129.6	605.5	20.3	144.7	23.2	85.6	75.8	190.6	74.9	2084.1	208.4	567.4	7.2	95.7	33.3	99.3	45.6	63.8
U2	20.9	1584.6	457.8	1605.1	354.0	4.6	161.4	375.9	50.5	329.6	-	25.9	31.6	13.8	-	422.6	203.3	304.3
MC1	30.8	2301.4	475.3	1665.6	371.8	25.6	161.4	403.9	16.3	307.2	-	76.1	31.6	12.3	-	427.9	205.7	312.3
MC4	25.0	1975.8	405.8	1466.8	326.8	5.8	157.9	396.4	14.9	698.1	-	26.1	31.2	16.9	-	394.3	194.7	290.6
U1	25.7	920.2	276.0	936.5	199.0	1.6	100.7	243.2	50.1	416.0	-	29.6	16.6	8.3	-	247.7	123.1	176.6

Table A9: Milan Analyses (Ammerman et al. 1990; Ammerman & Polglase 1995)

Method: Neutron activation analysis

Source	Geological Samples(*)	Archaeological samples
SA		3
SB		15
SC		7
PI	1	20
Li	1	32
Total	2	77

No.	% Na	% K	% Fe	La	Ce	Hf	Sm	Sc	As	Th	U	Rb	Cs
G-61	3.79	5.08	1.12	24.86	45.6	3.56	4.01	4.17		18.9	3.42	345.9	5.54
G-101	3.26	3.43	1.16	22.86	48.6	2.60	3.66	4.30		16.1	5.31	229.3	4.59
G-104	2.85	4.01	1.01	23.06	47.5	2.70	3.72	4.16		17.5	5.39	313.5	4.11
MEAN	3.3	4.17	1.10	23.59	47.2	2.95	3.80	4.21		17.5	4.71	296.2	4.75
S.D.	±0.3	0.68	0.06	0.10	1.2	0.43	0.15	0.06		1.1	0.91	49.1	0.59

G-45	3.04	3.76	1.06	30.13	59.0	3.52	3.32	3.19		18.77	5.52	326.5	4.35
G-52	2.89	4.19	1.05	34.05	50.2	4.41	3.29	3.07		19.34	4.74	239.9	6.73
G-53	2.88	4.98	0.98	29.29	42.4	4.89	3.30	3.08		18.15	5.10	223.6	6.26
G-54	2.59	4.51	0.93	26.73	38.97	3.43	2.96	2.89		16.18	4.79	235.3	5.70
G-56	2.92	4.57	1.06	34.85	60.5	3.94	3.25	2.99		19.9	5.17	326.7	7.26
G-88	3.25	5.52	1.07	27.98	54.01	3.79	3.04	2.96		18.36	5.57	24.17	5.43

Table A9 (continued)

	%	%	%										
No.	Na	K	Fe	La	Ce	Hf	Sm	Sc	As	Th	U	Rb	Cs
G-89	2.87	3.33	0.93	31.91	48.4	4.02	3.08	3.16		17.6	5.62	463.0	8.47
G-92	2.75	4.73	1.02	29.96	55.1	3.52	2.94	2.97		13.50	4.60	247.1	6.77
G-94	2.93	4.32	1.02	33.47	62.02	3.96	3.21	3.17		19.8	4.58	265.5	6.23
G-98	3.04	4.72	1.19	35.04	65.1	3.92	3.23	3.32		19.4	4.53	254.2	6.54
G-99	3.03	4.11	1.13	38.08	66.0	2.90	4.13	2.88		20.7	6.90	309.0	7.19
G-102	3.65	4.92	1.07	31.03	57.5	3.62	3.29	3.16		19.92	5.72	311.5	7.56
G-105	2.72	4.57	1.03	32.74	59.6	2.80	3.34	3.14		13.9	4.27	279.8	6.19
G-108	3.16	5.34	1.03	35.53	69.3	3.99	3.37	3.22		20.9	4.80	338.8	7.46
G-110	3.06	5.23	1.17	34.21	66.5	3.28	3.25	3.47		19.4	4.76	299.1	7.02
MEAN	2.91	4.51	1.05	32.33	57.0	3.73	3.27	3.11		18.3	5.11	276.3	6.61
S.D.	±0.24	0.57	0.07	3.02	8.6	0.52	0.27	0.16		2.2	0.65	88.5	0.96

G-4	2.52	4.93	1.28	65.49	110.48	5.97	5.68	3.30	1.64	25.48	2.87	226.9	2.03
G-5	2.62	5.16	1.39	69.77	117.27	6.26	5.95	3.55	2.30	26.82	2.85	215.4	2.16
G-6	2.53	5.42	1.31	65.63	113.15	5.54	5.26	3.35	1.32	24.70	2.31	186.6	1.67
G-42	2.81	5.14	1.34	66.13	116.3	6.04	5.54	3.32		25.98	3.38	215.2	1.87
G-49	3.07	5.25	1.29	69.12	112.9	6.42	5.83	3.42		26.04	3.05	203.1	3.47
G-86	3.26	5.96	1.62	64.79	115.6	5.53	5.25	3.39		27.6	3.01	155.3	4.56
G-91	3.53	5.39	1.59	69.11	123.2	7.37	5.72	3.35		29.9	3.41	173.6	2.95
MEAN	2.91	5.32	1.40	67.15	115.6	6.16	5.60	3.38	1.75	26.6	2.98	196.6	2.67
S.D.	±0.36	0.30	0.13	1.94	3.8	0.58	0.25	0.08	0.41	1.6	0.34	23.9	0.97

Table A9 (continued)

No.	% Na	% K	% Fe	La	Ce	Hf	Sm	Sc	As	Th	U	Rb	Cs
G-2	3.58	4.33	1.27	91.28	154.11	7.71	6.69	1.40	22.11	72.66	16.22	582.6	48.89
G-15*	3.70	3.07	1.25	91.69	149.90	8.78	6.83	1.68	22.80	70.81	16.14	560.3	47.79
G-19	3.83	4.57	1.35	97.37	163.70	9.65	6.96	1.91	23.98	79.50	18.11	625.8	51.83
G-44	3.98	4.02	1.22	89.98	147.2	8.91	5.93	1.34		68.93	15.85	507.2	47.69
G-48	4.08	4.37	1.29	92.92	166.4	9.25	6.07	1.39		73.42	16.32	629.3	45.81
G-50	3.89	4.68	1.23	90.28	155.7	14.42	6.17	1.34		71.69	16.56	555.7	43.00
G-51	3.45	3.25	1.29	88.96	155.5	9.28	6.25	1.40		71.15	16.25	562.7	44.54
G-55	3.88	4.18	1.19	87.32	125.2	8.08	6.02	1.31		66.45	17.42	478.3	39.65
G-57	3.77	4.80	1.31	83.51	150.8	9.6	5.69	1.33		76.2	15.43	688.6	48.39
G-59	4.78	4.84	1.42	92.08	169.4	10.10	6.27	1.57		81.5	15.31	658.1	48.26
G-76	4.16	4.16	1.35	87.79	161.4	10.1	6.34	1.53		77.9	14.14	621.8	49.1
G-87	4.10	4.25	1.39	88.97	156.6	9.24	5.80	1.45		73.4	13.93	587.0	43.55
G-90	4.09	4.77	1.32	85.71	153.3	9.12	5.59	1.67		71.5	15.50	541.3	47.53
G-93	4.36	3.69	1.32	90.76	153.9	7.72	5.80	1.76		72.6	17.77	559.4	44.59
G-95	4.00	3.18	1.25	87.58	142.9	9.96	5.75	1.56		65.8	15.62	514.1	42.29
G-96	4.24	5.22	1.38	91.21	160.6	11.7	6.28	1.79		78.8	15.76	580.6	45.54
G-97	4.50	5.68	1.37	97.69	169.4	8.57	6.52	1.42		77.3	18.15	573.3	49.91
G-100	3.61	3.98	1.35	92.31	149.7	9.17	5.93	1.67		73.5	14.69	534.7	43.56
G-103	3.71	3.53	1.30	88.36	152.4	10.2	6.02	1.42		72.9	15.11	555.3	47.26
G-106	4.03	4.26	1.32	91.34	153.6	9.04	5.66	1.28		74.4	16.23	569.2	50.0
G-107	3.87	4.22	1.22	91.04	159.8	9.01	6.29	1.47		76.3	17.15	539.9	46.86
MEAN	3.98	4.24	1.30	90.39	154.8	9.5	6.14	1.51	22.96	73.6	16.08	572.6	46.5
S.D.	±0.31	0.64	0.06	3.25	9.5	1.4	0.37	0.17	0.77	4.0	1.15	49.1	2.9

Table A9 (continued)

No.	% Na	% K	% Fe	La	Ce	Hf	Sm	Sc	As	Th	U	Rb	Cs
G-1	2.68	4.90	1.16	56.31	99.95	5.41	5.04	1.14	19.29	49.51	12.45	378.6	15.48
G-3	2.78	4.66	1.23	57.38	99.39	5.37	5.17	1.12	19.59	50.25	12.21	380.6	15.59
G-7	3.06	4.31	1.19	55.93	99.90	5.44	4.51	1.03	17.02	44.98	10.72	335.2	13.59
G-8	3.02	4.23	1.19	55.94	99.99	7.53	4.59	1.04	17.14	44.89	10.98	344.7	13.93
G-9	3.00	3.94	1.20	56.47	97.09	5.25	4.61	1.06	16.49	45.02	10.58	314.2	14.09
G-10	3.22	4.28	1.20	58.20	99.04	5.59	4.77	1.21	17.79	45.73	10.98	329.9	14.39
G-11	3.03	4.29	1.39	55.91	98.72	5.33	5.12	1.25	18.76	48.57	12.92	359.5	13.95
G-12	3.04	4.15	1.17	55.88	99.19	5.64	5.03	1.14	18.53	47.67	12.42	387.3	15.56
G-13	3.05	4.74	1.14	55.79	95.67	5.64	5.01	1.15	18.40	47.00	12.53	332.4	15.51
G-14*	3.04	4.18	1.12	57.03	96.38	5.81	5.08	1.12	18.63	46.99	12.08	319.1	15.61
G-16	3.38	5.10	1.23	62.63	106.70	5.95	5.78	1.27	21.28	56.98	14.99	405.3	17.66
G-17	3.26	4.18	1.27	63.02	102.50	5.79	5.44	1.20	20.26	53.46	14.38	385.4	17.85
G-18	3.27	4.66	1.28	61.65	102.20	6.43	5.53	1.30	19.59	54.56	15.45	420.3	17.86
G-20	3.32	4.51	1.29	61.62	104.20	6.11	5.18	1.20	19.87	53.15	12.98	389.9	17.59
G-21	3.13	4.28	1.25	58.76	99.42	6.02	4.82	1.16	19.38	49.94	12.69	356.2	16.33
G-22	3.28	4.23	1.29	61.63	101.51	6.74	5.09	1.21	20.44	53.10	12.43	372.7	17.09
G-23	3.29	4.59	1.25	62.75	107.90	6.16	4.82	1.17	19.23	51.23	12.04	357.9	17.30
G-24	3.24	4.55	1.25	59.94	100.70	6.41	4.87	1.16	19.01	50.70	12.67	359.8	16.57
G-25	3.22	4.17	1.20	59.01	102.60	6.13	4.88	1.14	18.99	49.46	11.87	351.5	15.97
G-43	4.29	4.23	1.19	58.38	90.0	4.55	4.66	0.91		48.3	13.17	516.5	17.10
G-47	3.66	3.39	1.24	60.27	102.2	6.52	4.86	0.96		50.00	13.36	377.9	17.35
G-58	3.74	4.48	1.23	56.26	100.3	6.46	4.47	1.02		51.2	11.69	376.3	18.03
G-60	4.12	4.88	1.20	58.07	97.8	6.56	4.63	1.00		49.8	12.08	339.1	18.14
G-62	3.47	4.46	1.25	57.33	103.4	6.69	4.66	0.87		50.5	12.67	337.0	16.91
G-63	3.26	4.67	1.16	55.78	98.6	5.93	4.52	1.07		48.9	11.51	341.1	16.03
G-64	3.26	4.24	1.27	56.00	104.1	6.74	4.40	0.97		49.3	11.80	364.5	16.91
G-65	3.84	5.00	1.37	60.11	109.8	6.41	5.14	1.07		54.1	12.06	390.7	18.21
G-71	3.27	3.72	1.17	57.03	95.8	6.78	4.88	0.98		50.2	12.75	374.3	17.02
G-72	3.53	4.54	1.22	56.90	97.4	6.52	4.98	1.11		53.6	13.88	365.3	17.09

Table A9 (continued)

	%	%	%										
No.	Na	K	Fe	La	Ce	Hf	Sm	Sc	As	Th	U	Rb	Cs
G-73	3.25	4.48	1.18	56.84	105.8	6.06	4.85	0.96		50.0	12.42	379.3	16.33
G-74	3.68	4.62	1.15	60.31	106.7	6.60	5.15	0.95		52.9	13.14	396.9	15.08
G-75	4.09	5.21	1.42	55.90	103.1	6.28	4.89	1.03		52.8	11.12	361.4	17.78
G-109	4.48	3.98	1.40	56.16	107.0	6.46	4.65	1.09		49.4	11.05	380.8	16.06
MEAN	3.37	4.42	1.23	58.22	101.1	6.10	4.91	1.09	18.93	50.1	12.43	369.1	16.36
S.D.	±0.41	0.38	0.07	2.34	4.1	0.58	0.31	0.11	1.18	2.9	1.12	35.8	1.32

Table A10: Dyson et al. 1990*

Method: X-ray fluorescence spectrometry

Source	Archaeological samples
SA	10
SC	17
Total	27

	%	%	%	%	%	%	%	%								
No.	Na_2O	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	MnO	Fe_2O_3	Zn	Rb	Sr	Y	Zr	Nb	Pb	Ba
90-46	4.93	13.18	74.28	5.20	0.67	0.12	0.04	1.42	46	214	38	9	84	36		278
90-49	4.78	13.52	74.20	5.33	0.64	0.12	0.03	1.38	44	214	28	23	84	26		245
90-51	4.25	13.36	73.30	5.13	0.67	0.09	0.06	1.42	71	219	24	28	46	56	6	221
90-52	4.73	14.10	73.28	5.41	0.70	0.09	0.06	1.45	86	224	28		65	40	18	197
90-61	4.80	13.12	74.61	5.33	0.66	0.11	0.04	1.37	49	232	49	11	91	40		274
90-65	4.38	12.95	74.22	5.22	0.63	0.11	0.04	1.36	43	202	24	65	65	22	6	240
90-69	4.80	14.50	73.30	5.49	0.66	0.11	0.04	1.39	52	219	32	19	87	31	16	143
90-71	4.74	14.14	74.06	5.30	0.70	0.09	0.06	1.41	83	205	32	37	74	47	50	160
90-72	3.71	13.37	73.72	5.14	0.61	0.09	0.06	1.40	80	205	14		65	64	36	202
90-74	4.73	14.36	72.73	5.45	0.61	0.12	0.04	1.40	45	200	40	10	92	32		191
MEAN	4.59	13.66	73.77	5.30	0.66	0.11	0.05	1.40	60	213	31	25	75	39	22	215
S.D. ±	0.35	0.53	0.57	0.12	0.03	0.01	0.01	0.03	17	10	9	18	14	12	16	43

Table A10 (continued)

No.	% Na_2O	% Al_2O_3	% SiO_2	% K_2O	% CaO	% TiO_2	% MnO	% Fe_2O_3	Zn	Rb	Sr	Y	Zr	Nb	Pb	Ba
90-44	3.51	14.23	73.55	5.81	1.00	0.30	0.04	1.89	57	152	106	21	208	28	36	1240
90-45	4.45	14.10	72.13	5.72	1.02	0.30	0.04	1.84	42	165	113	24	204	26	10	1400
90-48	4.02	14.45	72.22	5.62	1.05	0.32	0.03	1.98	59	160	135	33	221	26		1250
90-50	4.91	14.08	72.05	5.87	0.99	0.30	0.04	1.86	57	159	109	16	202	33	43	1180
90-54	4.00	13.18	72.96	5.55	0.91	0.30	0.04	1.86	57	181	121	21	215	51		1210
90-56	3.86	13.16	73.03	5.67	0.97	0.30	0.03	1.85	56	162	111	30	216	26		1270
90-57	4.24	13.72	72.89	5.70	0.99	0.31	0.04	1.87	56	165	116	29	169	26		1300
90-58	5.02	13.67	72.59	5.66	1.03	0.29	0.04	1.81	60	140	102	94	190	22	6	1070
90-59	4.46	13.64	73.17	5.66	1.01	0.31	0.04	1.84	57	156	114	10	201	25		1250
90-60	4.43	14.59	73.72	5.86	0.99	0.29	0.04	1.85	58	143	103	34	207	33	22	1230
90-62	3.88	13.83	72.31	5.85	0.96	0.28	0.04	1.86	57	166	108	16	221	42	60	1260
90-63	3.99	13.69	73.21	5.77	1.05	0.31	0.04	1.85	58	161	117	17	218	36	43	1290
90-67	4.43	14.30	72.62	5.83	0.98	0.31	0.04	1.93	63	155	111	15	215	32	33	1260
90-68	3.12	13.63	73.20	5.72	0.98	0.29	0.04	1.88	57	138	93	20	202	27	29	1260
90-70	4.99	14.34	72.33	5.71	1.01	0.30	0.04	1.95	59	150	106	12	214	26	25	1240
90-73	3.11	12.72	72.58	4.77	2.13	0.56	0.06	3.42	72	151	208	71	220	25		910
90-75	4.05	14.50	73.32	5.85	0.99	0.29	0.04	1.85	56	143	97	96	200	43		1320
MEAN	4.18	13.79	72.86	5.68	1.07	0.32	0.04	1.98	59	155	115	34	206	32	33	1218
S.D. ±	0.58	0.52	0.45	0.27	0.30	0.07	0.01	0.40	4	11	27	29	14	8	15	104

Table A10 (continued)

No.	% MgO	% P_2O_5	Cu
90-65			22
90-48	0.46		11
90-50		0.28	
90-57			12
90-58			14
90-59	0.33		31
90-68		0.33	
MEAN	0.40	0.31	17
S.D. ±			8

* The elemental data supplied here were not published in this article, but were generously made available by the authors

Table A11: Randle et al. 1993

Method: Neutron activation analysis

Source	Archaeological samples
SA	1
SC	3
Li	5
Total	9

No.	La	Sm	Ce	Nd	Eu	Tb	Yb	Lu	Rb	Cs	Ba	Th	U	Zr	Hf	Ta	Sb	Sc	Co
MRV3	28	8.0	51	-	0.41	<1	2.6	0.39	278	4.7	238	18.3	4	<250	3.9	5.5	-	5.9	0.35
MRV1	61	13.1	134	55	1.6	1.30	1.86	0.29	205	2.4	980	31.0	2.4	240	7.2	3.1	-	5.2	1.46
MRV2	63	10.4	128	50	1.4	1.27	1.7	0.26	189	2.1	960	30.1	2.3	230	7.0	2.9	-	5.0	1.37
MRV4	66	11.3	135	54	1.8	1.30	2.00	0.29	202	2.7	990	31.5	2.3	250	7.5	3.2	-	5.4	1.68
SP1	66	9.1	116	43	0.19	1.47	4.4	0.17	338	18.5	127	59	11	250	6.9	3.7	1.0	1.5	0.46
SP2	58	11.4	105	-	0.14	1.34	4.9	0.8	307	16.4	<100	54	13	220	6.4	3.4	-	1.4	0.42
SP3	70	90.4	98	33	0.19	1.36	4.4	0.7	295	21	320	52	11	220	6.3	3.4	0.9	1.3	0.45
SAM2	68	9.7	87	31.0	0.20	1.23	3.8	0.59	264	21	310	46	10	200	5.6	3.0	0.8	1.2	0.45
SAM3	74	9.9	93	37	0.15	1.29	4.2	0.7	288	16.6	290	50	11	220	6.0	3.3	0.9	1.3	0.36

APPENDIX B. K-AR AND FISSION-TRACK DATES OF WEST MEDITERRANEAN OBSIDIAN

This appendix reproduces in a series of tables potassium-argon and fission-track dates of western Mediterranean obsidians published from 1970 to 1994. The reference given for each analytical result is that of the first publication; many of the data have also been re-published elsewhere (see Table IX in Chapter 4).

Initially, the purpose of these dating efforts was geologically-based, i.e. to reconstruct the formation history of the island volcanic complexes, and many K-Ar dates have been published; only those on obsidian have been included here (Table B1). The realization that there were significant age differences between the four islands' obsidian sources subsequently led to the successful application of fission-track dating to the sourcing of archaeological artifacts (Tables B2-B3).

It is important to note that fission-track dating cannot distinguish any of the island sub-sources, since they are too close in age; in the case of Sardinia, where four major sub-sources were commonly used, this presents a significant limitation to the interpretation of source data.

Notes:

* When given, the induced track density has been standardized to a neutron dose of 10^{15} n/cm^2.

** Bigazzi et al. (1976) argued convincingly that both fission-track and K-Ar ages for older samples (i.e. Monte Arci and Palmarola obsidians) needed correction due to argon loss or fading, probably caused by continuous environmental annealing. ^{40}Ar/^{39}Ar dating and stratigraphic considerations, however, seem to support the uncorrected dates (Beccaluva et al. 1985; Montanini & Villa 1993).

*** Source has been identified by the age determination and/or by the induced track density.

TABLE B1: Potassium-Argon Dates of Italian Obsidians

	Age (my)	Reference
Sardinia (Monte Arci)		
Uras quarry (SA)	2.8 ± 0.2	Belluomini et al. 1970
"	2.9 ± 0.1	"
"	2.9 ± 0.1	"
"	2.9 ± 0.1	"
"	3.0 ± 0.2	"
"	3.0 ± 0.1	"
"	3.1 ± 0.1	"
"	3.2 ± 0.1	"
"	2.9 ± 0.2	Bigazzi et al. 1976
Riu Murus (SB1)	3.3 ± 0.2	di Paola et al. 1975
Conca S'Ollastu (SB2)	3.25 ± 0.2	"
Palmarola		
Monte Tramontana	1.7 ± 0.05	Barberi et al. 1967
"	1.6 ± 0.2	Belluomini et al. 1970
Lipari		
Forgia Vecchia	< 0.3 (2 samples)	Belluomini et al. 1970
Punta Castagna	< 0.3 (2 samples)	"
Acquacalda	< 0.3	"
Vulcano	< 0.3	"
Rocche Rosse	0.0026 ± .0012 (1σ)	Gillot & Cornette 1986
"	0.0022 ± .0011	"
"	0.0019 ± .0012	"
"	0.0018 ± .0015	"
"	0.0012 ± .0010	"
"	0.0009 ± .0012	"
"	0.0000 ± .0009	"
Pantelleria		
Balata dei Turchi	< 0.3	Belluomini et al. 1970
Cuddia di Scauri center	0.303 ± .071	Mahood & Hildreth 1986
Salto La Vecchia	0.239 ± .010	"
"	0.239 ± .011	"
Cala dell'Altura center	0.159 ± .008	"

TABLE B2: Fission-Track Dates for Geological Samples of Italian Obsidian

Geological Source		Induced Track Density*	App. Age** (ma)	Age (ma)	Reference
Sardinia - Monte Arci					
Uras quarry (SA)	S 15	55000	2.9 ± 0.3		Bigazzi et al. 1971
"	S 4	64000	3.1 ± 0.3		"
"	S 18	62000	3.2 ± 0.3		"
"	4A	85000	2.93 ± 0.17	5.14 ± 0.51	Bigazzi et al. 1976
"	4A	92000	2.88 ± 0.13	5.05 ± 0.50	"
"	5B	82000	3.19 ± 0.16	5.15 ± 0.52	"
"	5B	86000	3.11 ± 0.14	4.94 ± 0.38	"
"	8B	70000	3.61 ± 0.15	5.92 ± 0.53	"
Pira Inferta (SB?)	13A	73000	3.51 ± 0.22	5.57 ± 0.53	"
"	14A	64000	3.16 ± 0.21	5.18 ± 0.88	"
Perdas Urias (SC)	16A	81000	3.38 ± 0.22	5.37 ± 0.59	"
"	16B	96000	3.22 ± 0.20	5.15 ± 0.40	"
(unspecified)		121000	2.65	4.63 ± 0.35	Arias et al. 1984
"		60000	-	4.73 ± 0.28	"
Lipari					
Gabellotto			0.0064 ± .001	0.0086 ± .0015	Wagner et al. 1976
"		145000		0.0114 ± .0018	Arias-Radi et al. 1972
"	2	243000		0.0086 ± .0016	Bigazzi & Radi 1981
Acquacalda	AC 6	158000		0.0210 ± .004	Bigazzi et al. 1971
Rocche Rosse		142000		0.0014 ± .0005	Bigazzi & Bonadonna 1973
Forgia Vecchia		162000		0.0016 ± .0004	"

TABLE B2 (continued)

Geological Source		Induced Track Density*	App. Age** (ma)	Age (ma)	Reference
Lipari (continued)					
Praia di Vinci	81-5 $P_3$1	273000		0.031 ± .003	Arias et al. 1986
"	81-5 $P_3$2	166000		0.028 ± .003	"
"	81-5 $P_3$3	269000		0.031 ± .002	"
Palmarola					
Monte Tramontana	13	176000		1.7 ± 0.3	Bigazzi et al. 1971
"	2	213000	0.84	1.58 ± 0.23	Bigazzi & Radi 1981
Pantelleria					
Balata dei Turchi	P-5	131000		0.141 ± 0.017	Bigazzi et al. 1971
"	P-16	101000		0.127 ± 0.015	"
"	P-19	157000		0.137 ± 0.016	"
"	5	199000		0.141 ± .009	Arias et al. 1984
Fossa della Pernice	5	181000	0.048	0.071 ± .008	"
"	6	154000	0.064	0.073 ± .009	"

TABLE B3: Fission Track Dates for Archaeological Obsidian

Archaeological Site		Induced Track Density*	App. Age** (ma)	Age (ma)	Reference	Geological Source***
Catignano	CH-1-1	190000		0.0100 ± .0030	Arias-Radi et al. 1972	Li
	CH-1-2	194000	-	-	"	Li
Filicudi	1	189000		0.0101 ± .0025	"	Li
	3	176000		0.0112 ± .0030	"	Li
Fossa Cesia	F-1-2	172000		0.0110 ± .0027	"	Li
	FR-2	154000		0.0097 ± .0030	"	Li
	F-261	156000		0.0119 ± .0024	"	Li
	F-2-2	187000		0.0118 ± .0034	"	Li
Lampedusa	L-1	163000		0.1220 ± .0240	"	Pa
	L-1-2	62000		0.1370 ± .0320	"	Pa
	L-2	137000		0.2035 ± .0300	"	Pa
	L-3	144000		0.1930 ± .0290	"	Pa
	L-3-2	151000		0.1370 ± .0270	"	Pa
	L-3-3	142000	-	-	"	Pa?
	L-3-4	58000	-	-	"	Pa?
	L-3-5	136000	-	-	"	Pa?
Lipari scavo	S-1	157000		0.0105 ± .0028	"	Li
Monte Aquilone	1	207000		0.0110 ± .0029	"	Li
	3	210000		0.0080 ± .0035	"	Li
	4	147000		0.0125 ± .0050	"	Li
Mursia	MB-1-V CC-1	145000		0.1530 ± .0300	"	Pa
	S-1	158000		0.1380 ± .0270	"	Pa
	S-2	135000		0.1285 ± .0250	"	Pa
	S-4	169000		0.0041 ± .0008	"	Pa

Table B3 (continued)

Archaeological Site		Induced Track Density*	App. Age** (ma)	Age (ma)	Reference	Geological Source***
Catignano	1	225000		0.0109 ± .00045	Bigazzi & Radi 1981	Li
	2	205000		0.0048 ± .00035	"	Li
Capraia	5	49000	0.31 ± .10	0.82 ± .27	"	Melos?
Fontino		86000	1.17 ± .10	4.98 ±.50	"	MA
Grotta del Beato	1	83000	3.68 ± .36	4.81 ± .55	"	MA
	2	81000	3.44 ± .35	4.92 ± .59	"	MA
	3	96000	3.12 ± .37	4.87 ± .70	"	MA
Grotta del Leone	1	206000		0.0100 ± .0025	"	Li
	2	35000		1.62 ± .18	"	Melos?
	3	88000	3.46 ± .21	4.84 ± .51	"	MA
	4	35000		1.27 ± .18	"	Melos?
	5	37000	-	-	"	Melos?
Grotta del Leone	6	97000		0.0042 ± .0031	"	MA
	7	102000	3.04 ± .27	4.87 ± .57	"	MA
Grotta della Trinità	1	208000		0.0080 ± .00022	"	Li
	2	216000		0.0094 ± .00021	"	Li
Latronico	1	227000		0.0091 ± .00025	"	Li
	2	183000		0.0080 ± .00020	"	Li
Masseria Guidone	1	231000		0.0072 ± .00032	"	Li
	2	231000		0.0071 ± .00024	"	Li
Masseria Leonessa	1	201000		0.0093 ± .00035	"	Li
	2	276000		0.0102 ± .00012	"	Li
Masseria S. Gaetano		221000	-	-	"	Li

Table B3 (continued)

Archaeological Site		Induced Track Density*	App. Age** (ma)	Age (ma)	Reference	Geological Source***
Paterno	1	235000		0.0103 ± .00029	Bigazzi & Radi 1981	Li
	2	212000		0.0111 ± .00028	"	Li
Podere Uliveto	1	108000	3.19 ± .19	4.33 ± .36	"	MA
	2	101000	-	-	"	MA
Prestarona	1	212000		0.0099 ± .00019	"	Li
	2	215000		0.0095 ± .00030	"	Li
	3	242000		0.0104 ± .00017	"	Li
Ripoli		236000		0.0080 ± .00027	"	Li
Villa Badessa	1	224000		0.0095 ± .00028	"	Li
	2	204000		0.0168 ± .00120	"	Li
Grotta Funeraria	1142-2	265000		0.0097 ± 0.0031	Bigazzi et al. 1982	
Pizzica		290000	-	-	"	Li
Serra d'Alto	1	200000		0.0105 ± .0031	"	Li
Campi Latini	1	308000		0.0037 ± .0011	Arias et al. 1984	Li
	2	281000		0.0080 ± .006	"	Li
Capraia	1	74000	2.21	4.51 ± .46	"	MA
	2	56000		1.98 ± .22	"	Melos?
	3	113000	-	-	"	MA
	4	98000	0.056	0.128 ± .029	"	MA
Filicudi	Lip 27A	280000		0.0084 ± .0013	"	Li
	Lip 27B	296000	-	-	"	Li
Fontana di Vite		253000		0.0086 ± .0009	"	Li
		110000		0.0086 ± .0012	"	Li

Table B3 (continued)

Archaeological Site		Induced Track Density*	App. Age** (ma)	Age (ma)	Reference	Geological Source***
Gravina di Picciano	1	213000		0.0012 ± .0037	Arias et al. 1984	Li
	2	196000	-	-	"	Li
Grotta dei Pipistrelli		248000		0.0088 ± .0018	"	Li
Grotta Funeraria	1143-1	233000	-	-	"	Li
	1143-2	291000		0.0089 ± .0028	"	Li
	3	235000	-	-	"	Li
Grotta Morelli	Tgl. 7-8/1	297000		0.0094 ± .0023	"	Li
	1	286000		0.0107 ± .0030	"	Li
	Tgl. 7-8/2	266000		0.0036 ± .0018	"	Li
Grotta Tartaruga	TE-8 Sup.	137000	1.13	1.55 ± .17	"	PI?
	Tgl 7	318000		0.0085 ± .0023	"	Li
Ischia di Castro		101000	-	-	"	MA
Isolino	II-115	105000	2.21	4.65 ± .66	"	MA
	.90-V	117000	2.66	4.29 ± .43	"	MA
	.90-V-445	112000	1.42	4.07 ± .41	"	MA
	II-135	111000	0.081	0.295 ± .054	"	MA
Laghi Alimini	1	293000		0.0096 ± .0024	"	Li
	2	270000	-	-	"	Li
Murgecchia	1	233000		0.0093 ± .0025	"	Li
	2	240000		0.0082 ± .0022	"	Li
	3	236000		0.0076 ± .0023	"	Li
Murgia Timone	1	241000		0.0032 ± .0023	"	Li
	2	232000		0.0072 ± .0022	"	Li

Table B3 (continued)

Archaeological Site		Induced Track Density*	App. Age** (ma)	Age (ma)	Reference	Geological Source***
Murgia Timone	3	257000		0.0076 ± .0017	Arias et al. 1984	Li
	4	207000	-	-	"	Li
Pantelleria	Mc V 7-441	180000	-	-	"	Pa
	Mc V 3	192000		0.142 ± .011	"	Pa-BdT
Podere Uliveto	A	241000	-	-	"	PI
	B	110000	1.13	5.66 ± .60	"	MA
	C	118000	2.70	4.73 ± .40	"	MA
Ponte Peschio	1	61000	1.10	1.34 ± .37	"	Melos?
	2	231000		0.0091 ± .0030	"	Li
Serra d'Alto	1	219000		0.0096 ± .0028	"	Li
	Tatarrani 1	240000	-	-	"	Li
	Tataranni 2	233000		0.0075 ± .0022	"	Li
	Gravela 2177	220000	-	-	"	Li
Setteville	1	220000	-	-	"	PI
	2	192000	-	-	"	PI
	3	327000		0.0085 ± .0027	"	Li
	4	319000		0.0090 ± .0030	"	Li
Torre Testa	1	298000		0.0065 ± .0017	"	Li
	2	290000	-	-	"	Li
	3	270000	-	-	"	Li
Villa Badessa	Rim. 1	132000	1.37	1.58 ± .15	"	PI?
	Strutt. 1-2	106000		1.81 ± .18	"	PI?
Cava Barbieri		239000		0.0096 ± .0024	Arias et al. 1986	Li
	Ins. A	242000		0.0089 ± .0028	"	Li

Table B3 (continued)

Archaeological Site		Induced Track Density*	App. Age** (ma)	Age (ma)	Reference	Geological Source***
Grotta Morelli	Ins. B/1	192000		0.0095 ± .0024	Arias et al. 1986	Li
	Ins. B/2	219000		0.0103 ± .0033	"	Li
Rialbo	1	189000		0.0099 ± .0028	"	Li
	2	198000		0.0111 ± .0027	"	Li
Torre Canne	128	202000		0.0085 ± .0029	"	Li
Fontanelle	1	245000		0.0060 ± .0018	"	Li
	2	241000		0.0060 ± .0018	"	Li
Torre Sabea		300000		0.0076 ± .0019	"	Li

APPENDIX C. CATALOGUE OF OBSIDIAN SAMPLES

Table C1	Catalogue of Geological Source-Area Specimens
Table C2	Catalogue of Archaeological Samples

Additional samples, not listed here but referred to in the text, were briefly examined on-site while visiting various museums.

TABLE C1: Catalogue of Geological Source-Area Specimens

Cat. No.	Location	Collection Type	By/From
185-194	Conca Cannas (Masullas-CA)	*in situ* geological	R. Tykot (1987)
195-204	Perdas Urias (Pau-CA)	surface archaeological?	"
205-211	Perdas Urias (Pau-CA)	surface archaeological	"
212-216	Perdas Urias (Pau-CA)	surface archaeological	"
217-226	Conca Cannas (Masullas-CA)	*in situ* geological	"
227-231	Pala Sa Murta (Morgongiori-CA)	*in situ* geological	"
232-234	Perdas Urias (Pau-CA)	surface archaeological?	"
235-239	Perdas Urias (Pau-CA)	surface archaeological?	"
240-254	Conca Cannas (Masullas-CA)	surface archaeological	"
255-264	Sonnixeddu (Masullas-CA)	surface archaeological	"
279-283	Uras Quarry	*in situ* geological	from J.W. Michels
284-291	Monte Arci	geological	from C. Puxeddu
306-309	Lipari	geological	Geology Museum, Harvard U.
310-314	Santa Maria Zuarbara	Surface collection	R. Tykot (1987)
315	Conca Cannas	*in situ* geological	"
517-524	Conca Cannas (Masullas-CA), Q1	*in situ* geological	R. Tykot (1990)
525-604	Conca Cannas (Masullas-CA), Q2	*in situ* geological	"
605-643	Conca Cannas (Masullas-CA), Q3	*in situ* geological	"
644-648	Conca Cannas (Masullas-CA), Peak	*in situ* geological	"
649-653	Perda Arrubia (Morgongiori-CA)	surface archaeological?	"
654-660	Su Paris de Monte Bingias	surface geological	"
661-672	Su Paris de Monte Bingias	surface geological	"
673-682	Monte Sparau (Morgongiori-CA)	surface geological	"
683-692	Monte Sparau (Marrubiu-CA)	surface geological	"
693-716	Porcufurau (Marrubiu-CA)	*in situ* geological	"
717-728	Punta Nigola Pani (Marrubiu-CA)	*in situ* geological	"
729-741	Punta Su Zippiri (Marrubiu-CA)	*in situ* geological	"

TABLE C1 (continued)

Cat. No.	Location	Collection Type	By/From
749-769	Seddai (Marrubiu-CA)	*in situ* geological	R. Tykot (1990)
770-780	Campo dei Forestieri (Santa Giusta-CA)	surface archaeological?	"
781-790	Punta Muroni (Palmas Arborea-OR)	surface archaeological?	"
791-857	Bruncu Perda Crobina (Morgongiori-CA)	*in situ* geological	"
858-869	Cazzighera (Pau-CA)	surface geological	"
870-890	Quarry at Perdas Urias (Pau-CA)	surface geological	"
891-900	Mitza Fustiolau (Pau-CA)	surface archaeological	"
901-910	Bar-Campeggio at Perdas Urias (Pau-CA)	surface geological	"
911-921	Riu Canali (Ales-CA)	surface archaeological?	"
922-935	Tanca Sa Tellura (Pau-CA)	surface geological	"
936-963	Punta Pizzighinu (Pau-CA)	*in situ* geological	"
964-985	Santa Pinta (Pau-CA)	surface geological	"
986-1022	Perdas Urias (Pau-CA)	surface geological	"
1023-1036	Su Varongu (Pau-CA)	surface geological	"
1037-1051	Truncheddu (Pau-CA)	surface geological	"
1727	Mt. Traessu (Romana-SS)	surface geological	R. Tykot (1994)
1728	Perdas Urias (Pau-CA)	surface archaeological?	R. Tykot (1987)

TABLE C2: Catalogue of Archaeological Samples

Cat. No.	Site	Area/Level	From
001-010	Basi (Serra di Ferro), Corsica		E. Atzeni, U. Cagliari
011-016	Filitosa (Sollacaro), Corsica		"
017-026	Puisteris (Mogoro-CA), Sardinia		"
027-041	Santa Gilla (Capoterra-CA), Sardinia		"
042-051	San Gemiliano (Sestu-CA), Sardinia		"
052-054	Ruinacchesos (Sorgono-NU), Sardinia		"
054-058	Su Carroppu (Carbonia-Sirri-CA), Sardinia		"
059-060	Tomba di Masone Perdu (Laconi-NU), Sardinia		"
061-062	Grotta Lioru (Laconi-NU), Sardinia		"
063	Villa S. Antonio (Carabassa), Sardinia		"
064	Villaperuccio (Monte Narcao-CA), Sardinia		"
065-074	Loc. Pirrotta (Simala-OR), Sardinia	raccolta	Cagliari, Museo Nazionale
075-083	Corte Auda (Senorbi-CA), Sardinia	R.S. 20	"
084-093	Su Coddu (Selargius-CA), Sardinia	sacca 27	"
094-102	"	sacca 2A lotto Sulis	"
104-113	Loc. S. Pietro (Settimo S. Pietro), Sardinia		"
114-123	San Gemiliano (Sestu-CA), Sardinia		"
124-133	Li Muri (Arzachena-SS), Sardinia	tomba 4	"
134-143	Via delle Cicale (Pirri-CA), Sardinia	S. 3 Lato W	"
144-149	Cuccuru de Is Arrius (Cabras-OR), Sardinia	sacca 382	"
150-159	"	E3 III 15	"
160-167	Nuraghe Losa (Abbasanta-NU)	surface	"
168-177	Cuccuru de Is Arrius (Cabras-OR), Sardinia	striscie III C3-4, sacca 47	"
178-184	Cuccuru de Is Arrius (Cabras-OR), Sardinia	tomba 387	"
265-278	Nuraghe Su Para (Masullas-CA)	surface	"
292-295	La Scola (Isola Pianosa), Tuscany	BC 11-12 I/3	P. Perazzi, Soprintendenza della Toscana
296-298	"	A12 tg3 (I3)	

TABLE C2 (continued)

Cat. No.	Site	Area/Level	From
299-305	La Scola (Isola Pianosa), Tuscany	A8-9-10 B12	P. Perazzi, Sopr. della Toscana
316-325	Grotta San Bartolomeo (Cagliari-CA), Sardinia	I strato	Rome, Museo Preistorico ed Etnografico "L. Pigorini"
326-335	"	II strato	
336-345	"	III strato	"
346-355	"	IV/V strato	"
356-365	Grotta S. Elia (Cagliari-CA), Sardinia	II strato	"
366-369	Palmas Arborea (Oristano-OR), Sardinia		"
370-373	Poggio Olivastro (Canino-VT), Tuscany		"
374-383	Nuraghe Tiria (Villaurbana-OR), Sardinia		"
384-393	Nuraghe Loddu (Fordongianus-OR), Sardinia		"
394-403	Nuraghe Nieddu (Oristano-OR), Sardinia		"
404-413	Serra de Castius (Sili-OR), Sardinia		"
414-423	Su Casteddu Becciu (Fordongianus-OR), Sardinia		"
424-433	Simaxis (OR), Sardinia		"
434-444	Palas de Casteddu (Cabras-OR), Sardinia		"
445-454	Domus de Janas Triarzu (Paulilatino-OR), Sardinia		"
455-465	Lacumarense (Santa Giusta-CA), Sardinia		"
466-475	Cantoniera Frumini (Sili-OR), Sardinia		"
476-495	Su Cuccuru de Is Arrius (Cabras-OR), Sardinia		"
496-505	Mes'e Arrius (Cabras-OR), Sardinia		"
506-511	Lipari (Aeolian Islands), Sicily		"
512-516	Mursia (Pantelleria), Sicily		"
1052-1061	Sa Ucca de su Tintirriolu (Mara-SS), Sardinia	C1-2	Sassari, Museo Nazionale "G.A. Sanna"
1062-1063	"	L2 186	
1064	"	L2 203	"
1065-1068	Sa Ucca de su Tintirriolu (Mara-SS), Sardinia	L2 252	"
1069-1073	Molia (Illorai-SS), Sardinia	VI A' - 13B'	"

TABLE C2 (continued)

Cat. No.	Site	Area/Level	From
1074-1089	Molia (Illorai-SS), Sardinia	VI B 2-3-4C	Sassari, Museo Nazionale "G.A. Sanna"
1090-1100	Monte Maiore (Thiesi-SS), Sardinia	II 40-60	
1101-1113	"	III 80-105 S B	"
1114-1116	"	III 80-110	"
1117-1126	"	III 145-160	"
1127-1129	Monte d'Accoddi (Sassari-SS), Sardinia	X8-S e varii 145-148	"
1130-1131	"	X8-N 109-110 2-9-53	"
1132-1134	"	X8-N 90-91 3-9-53	"
1135-1137	"	X8-N 116-117 4-9-53	"
1138-1145	"	XII-2-S 170 1959	"
1146	Monte d'Accoddi (Sassari-SS), Sardinia	XII-2-N 1959	"
1147-1148	"	XII-2-N V 6 1959	"
1149	"	XII-2-N 6 1959	"
1150-1159	Grotta Filiestru (Mara-SS), Sardinia	B8 t.4	"
1160-1169	Grotta Filiestru (Mara-SS), Sardinia	B9	"
1170-1176	"	B10	"
1177-1183	"	B11 t.2	"
1184-1186	"	B11 t.3	"
1187-1196	"	D4 t.2	"
1197-1206	"	D5 strat. col.	"
1207-1216	"	D5 t.5	"
1217-1226	"	D6 t.2	"
1227-1236	"	D7 strat. col.	"
1237-1246	Loc. Liscia Pilastru (Arzachena-SS), Sardinia		"
1247-1257	Zembra Island, Tunisia	Maison du poere	J.-D. Vigne, CNRS-Paris
1258-1261	"	transect "Eric"	"
1262-1272	"	Z27 -0/-40	"

TABLE C2 (continued)

Cat. No.	Site	Area/Level	From
1273-1280	Zembra Island, Tunisia	Z27 -40/-80	J.-D. Vigne, CNRS-Paris
1281-1290	Monte Grosso (Biguglia), Corsica	surface	J. Magdeleine, Departement de la Haute Corse
1291-1300	"	Couche V	
1301-1307	Pietracorbara (Cap Corse), Corsica	Couche V	"
1308-1317	"	Couche VI	"
1318-1329	Strette (Barbaghju), Corsica	Couche XII	"
1330-1339	"	Couche XIV	"
1340-1350	Sarra Cinescu (Castello di Rostino), Corsica	surface	"
1351-1355	Campu Ventosu (Bastia), Corsica	surface	"
1356-1362	Castellari (Rapale), Corsica	surface	"
1363-1402	Dolmen de Cardiccia (Sartene), Corsica	Chambre 1, couche 2	J. Cesari, Departement de la Corse du Sud
1403-1412	Saint Pancrace-Tiggianese (Pila-Canale), Corsica		
1413-1452	I Calanchi Taffonu 2 (Sollacaro), Corsica	Chambre 4, Couche B	"
1453-1472	I Calanchi Taffonu 6 (Sollacaro), Corsica	Couche C	"
1473-1492	Basi (Serra di Ferro), Corsica	Couche 5a	Musée de Préhistoire Corse
1493-1512	"	Couche 5b	"
1513-1542	"	Couche 5c	"
1543-1569	"	Couche 5d	"
1570-1599	"	Couche 5e	"
1600-1611	"	Couche 6.1	"
1612-1641	"	Couche 6.2	"
1642-1671	"	Couche 6.3	"
1672-1673	"	Couche 7	"
1674-1714	Ortu Comidu (Sardara-CA), Sardinia		M.S. Balmuth, Tufts U.
1715-1726	Ustica, Sicily	surface	R. Ross Holloway, Brown U.

APPENDIX D. ICP-MS DATA

Table D1 presents the data for those obsidian samples analyzed by inductively coupled plasma - mass spectrometry (ICP-MS). As noted in Chapter 5, the instrument was only calibrated for a few elements, and no attempt was made to standardize the results against reference materials of known values, since the purpose of the analyses was to establish the number of differentiable source groups rather than their quantitative chemical characterization. These data, therefore, are not necessarily indicative of the actual composition of the samples although in many cases they are reasonably accurate. All values are in parts per million (ppm) and represent the total concentration for that element as calculated from the response of a particular isotope and its known natural abundance.

As reported here, some sources tend to have negative values for certain elements; this results when the raw sample value was less than the value of the blank solution which was subtracted from all samples. Normally, one would report these cases as "not detected," but they are included here since this differentiates them from other obsidian sources which have positive values, and because none of the data should be considered truly quantitative. The data for a dozen elements which were never present in positive concentrations are not included.

TABLE D1

Cat.	Source	Sc45	Mn55	As75	Rb85	Sr88	Y89	Ba137	Ba138	La139	Ce140	Pr141
001a	SA	18.5	398	4.7	253	23.2	6.4	123.4	114.6	2.6	19.4	0.7
001b	SA	16.3	393	6.9	237	21.1	7.0	117.9	116.0	1.2	20.5	0.5
003a	SC	16.2	264	3.9	187	97.1	0.9	39.0	35.3	0.7	6.3	0.3
003b	SC	14.5	244	2.5	160	89.2	0.7	35.3	32.5	0.7	5.7	0.3
004a	SC	18.0	202	1.7	167	88.6	1.0	30.7	27.5	0.7	15.0	0.3
004b	SC	13.1	264	3.4	159	88.7	0.7	32.0	29.2	0.8	19.1	0.4
005a	SC	18.7	252	4.1	176	93.4	0.5	34.8	32.0	1.1	21.8	0.3
005b	SC	15.1	246	0.7	173	92.8	0.8	33.2	32.6	0.8	21.3	0.3
006a	SA	19.1	362	4.6	253	24.1	6.8	118.7	106.0	1.2	20.9	0.4
006b	SA	17.0	307	5.8	241	22.0	6.1	118.4	108.2	0.8	20.5	0.4
008a	SC	23.4	266	3.4	194	103.9	1.0	45.1	42.7	0.8	23.0	0.6
008b	SC	18.5	264	3.1	168	103.3	0.8	46.5	41.3	0.9	21.8	0.4
009a	SA	30.9	470	6.1	307	23.5	3.6	49.8	48.3	0.2	9.5	0.0
009b	SA	24.3	433	4.0	266	23.1	4.2	52.5	47.7	0.1	9.9	0.0
010a	SC	23.8	278	4.3	193	89.8	0.6	48.3	45.8	0.9	10.3	0.2
010b	SC	17.8	201	0.7	185	94.8	0.6	50.8	46.5	2.2	10.2	0.4
011a	SA	20.4	332	6.1	237	21.4	5.2	124.1	119.2	2.8	26.0	0.8
011b	SA	18.0	369	4.3	203	19.8	4.9	128.4	117.5	1.6	23.6	0.8
012a	SA	19.7	406	5.4	248	21.7	5.2	120.0	110.1	0.5	25.4	0.5
012b	SA	15.3	379	5.5	233	22.3	6.3	127.9	112.5	0.8	26.8	0.4
013a	SC	22.2	263	4.9	204	100.5	1.4	88.2	75.9	3.2	31.2	1.0
013b	SC	15.5	257	4.3	164	96.1	1.6	82.8	78.2	3.9	34.3	1.3
014a	SA	15.4	402	8.3	227	23.1	6.2	132.2	125.7	2.1	28.1	0.8
014b	SA	9.2	326	3.8	211	21.8	7.1	134.9	122.3	1.8	28.5	0.7
015a	SA	13.3	356	5.2	213	20.5	3.2	91.3	83.6	0.7	19.2	0.5
015b	SA	11.8	348	4.7	209	20.7	3.2	93.6	83.8	0.8	19.6	0.5
188a	SA	8.2	357	0.9	216	17.6	4.0	4.4	48.4	0.0	2.5	0.4
188b	SA	7.1	355	3.3	219	17.6	3.9	5.0	46.8	-0.0	2.6	0.1
189a	SA	5.4	337	3.1	205	16.2	3.0	4.1	38.4	-0.0	3.1	0.1
189b	SA	3.2	332	3.4	211	17.0	4.1	4.2	40.2	-0.1	2.9	0.1
191a	SA	3.9	330	2.7	199	14.7	3.3	3.8	40.5	-0.0	5.5	0.1
191b	SA	4.1	323	3.3	207	14.7	3.4	3.9	38.8	-0.0	4.9	0.1
192a	SA	3.1	330	1.9	216	14.1	3.0	3.8	39.6	-0.1	3.3	0.1
192b	SA	4.1	334	1.9	205	12.1	3.2	4.3	39.2	-0.0	3.4	0.2
193a	SA	3.0	331	0.3	208	14.9	3.5	4.2	45.2	0.2	2.8	0.1
193b	SA	4.7	330	2.3	214	14.9	3.5	5.2	49.8	0.0	3.1	0.1
194a	SA	3.9	335	0.5	214	15.0	3.2	3.7	34.3	-0.0	2.7	0.0
194b	SA	4.9	337	2.1	216	14.8	3.1	3.7	36.2	-0.1	2.7	0.1
195	SC	2.7	219	2.4	161	100.8	-0.1	54.6	47.8	0.3	2.7	0.2
205	SC	3.1	229	1.4	165	102.3	-0.7	38.4	33.5	0.1	2.5	0.2
206	SC	1.4	238	2.0	170	105.1	-0.6	18.7	12.7	0.2	1.9	0.1
217a	SA	-6.9	132	-1.1	128	5.6	2.2	0.7	11.2	-0.0	1.0	0.0
217b	SA	-8.2	128	0.5	115	5.3	2.1	0.6	7.7	-0.1	0.6	0.1
221a	SA	-3.0	351	3.9	238	14.4	2.6	3.6	33.1	0.9	9.5	0.3
221b	SA	-2.5	340	0.7	238	15.2	2.0	3.4	37.9	-0.1	9.7	0.1
222a	SA	-2.9	340	1.1	234	15.4	1.6	4.1	39.6	0.1	7.5	-0.0
222b	SA	-3.1	336	1.0	236	14.7	1.8	4.5	42.8	-0.1	7.9	0.1
223a	SA	-3.2	341	1.1	233	14.8	2.7	4.2	37.4	-0.1	7.9	0.0
223b	SA	0.6	358	3.5	246	14.9	3.0	4.3	41.2	-0.1	8.5	0.1
224a	SA	-2.6	342	1.9	233	14.2	2.0	3.9	36.7	-0.1	8.4	0.1
224b	SA	-1.3	335	2.6	229	15.3	1.9	4.1	42.5	-0.0	8.5	0.1

TABLE D1 (continued)

Cat.	Source	Sc45	Mn55	As75	Rb85	Sr88	Y89	Ba137	Ba138	La139	Ce140	Pr141
225a	SA	2.6	345	1.4	226	16.0	2.0	5.1	51.9	-0.0	5.5	0.1
225b	SA	1.2	341	2.6	232	16.6	2.1	6.0	55.5	0.1	5.5	0.1
226a	SA	-0.1	327	1.9	231	14.2	3.0	3.2	37.5	0.1	6.7	0.1
226b	SA	0.7	336	1.3	249	15.7	3.2	5.1	41.7	0.2	6.4	0.2
244a	SA	3.0	206	0.6	158	89.4	0.7	2.9	29.2	2.6	6.4	0.6
244b	SA	0.9	212	1.8	159	84.6	0.5	3.0	27.7	2.7	6.8	0.7
255a	SA	0.8	204	0.9	147	79.9	-0.4	0.5	2.1	0.2	2.1	0.1
255b	SA	2.6	204	1.3	153	83.2	-0.3	0.5	3.9	0.1	1.2	0.1
259a	SA	-6.2	344	2.1	220	16.0	0.9	3.2	33.9	-0.1	7.9	0.0
259b	SA	-5.3	342	2.2	225	13.9	0.9	3.0	34.8	-0.2	7.5	0.0
269a	SA	13.9	389	4.0	242	24.5	4.4	126.7	119.5	0.5	12.1	0.2
269b	SA	12.5	390	4.6	243	23.9	3.9	130.2	119.0	0.4	12.4	0.3
270a	SA	15.8	414	4.1	257	24.7	5.0	132.8	120.3	0.3	20.5	0.4
270b	SA	14.7	402	5.3	264	25.2	4.8	125.8	120.2	0.8	19.6	0.3
271a	SA	18.5	419	5.6	275	27.5	3.6	136.9	129.9	0.7	21.3	0.5
271b	SA	15.0	418	5.5	252	25.7	3.7	131.7	124.3	1.0	21.2	0.5
272a	SA	17.3	407	4.3	248	23.3	3.9	135.1	123.8	0.2	24.0	0.3
272b	SA	15.6	378	4.5	240	22.0	4.0	123.0	117.1	0.3	21.7	0.3
273a	SA	16.1	374	3.8	245	21.4	3.0	66.6	59.6	0.2	8.3	0.3
273b	SA	15.9	387	3.3	229	20.8	2.8	61.4	58.0	0.3	8.7	0.2
292a	SA	17.5	376	5.1	228	20.8	3.0	94.2	89.9	0.3	16.3	0.3
292b	SA	12.2	362	3.9	220	19.9	2.8	103.1	91.8	0.3	17.4	0.4
293a	SC	17.1	187	3.4	174	89.8	1.4	67.3	63.3	2.0	31.8	0.9
293b	SC	11.7	164	1.5	142	83.1	0.6	64.2	57.3	1.7	29.1	0.8
294a	SC	38.9	279	5.8	187	91.0	0.1	268.8	252.2	0.2	3.6	0.0
294b	SC	14.5	290	7.0	179	90.6	-0.1	247.2	248.0	-0.0	3.3	0.6
295a	SA	24.7	407	2.7	197	21.0	1.8	90.6	59.8	0.3	4.2	0.2
295b	SA	2.8	400	1.9	156	21.0	1.1	87.3	80.6	1.7	3.3	0.1
296a	SB2	9.7	238	7.0	203	34.8	1.8	104.1	96.9	0.8	28.2	0.4
296b	SB2	9.0	226	5.7	186	32.4	1.6	101.0	93.1	1.0	28.4	0.4
297a	SB2	12.9	195	4.2	197	11.0	1.1	46.2	39.0	0.2	5.2	0.2
297b	SB2	10.1	184	4.6	171	10.0	1.2	39.2	38.4	0.2	4.9	0.1
298a	SC	13.6	91	4.1	84	7.3	0.7	51.7	47.5	0.3	1.1	0.2
298b	SC	8.4	55	1.9	68	6.5	0.6	49.7	48.5	0.2	1.2	0.2
299a	SC	13.8	90	1.9	152	0.9	1.9	10.1	10.3	0.3	1.2	0.2
299b	SC	9.1	85	3.4	135	0.7	2.0	9.8	9.7	0.4	1.3	0.3
300a	SC	14.0	66	5.6	165	1.8	2.1	18.0	16.2	0.5	1.2	0.3
300b	SC	8.9	61	4.3	132	1.5	2.0	17.8	15.8	0.4	1.0	0.3
301a	SC	12.2	58	5.2	132	1.1	1.0	15.0	13.3	0.1	0.9	0.1
301b	SC	10.2	58	4.7	125	0.8	1.4	16.6	14.2	0.1	0.9	0.1
302a	SB2	12.6	217	4.4	193	3.3	4.6	23.6	22.3	0.2	3.4	0.3
302b	SB2	11.9	204	3.2	175	2.9	5.2	21.5	21.8	0.2	3.5	0.3
303a	SB2	17.7	175	21.5	333	0.8	1.4	3.8	3.7	0.4	3.7	0.1
303b	SB2	10.8	232	22.2	331	0.7	1.1	4.3	3.9	0.2	6.1	0.2
304a	SB2	18.8	235	6.8	234	11.5	3.5	29.9	29.1	0.6	34.0	0.4
304b	SB2	11.6	218	3.9	194	10.2	3.1	31.9	27.6	0.9	33.0	0.3
305a	SA	40.6	569	24.2	461	6.7	1.9	8.3	9.7	1.9	19.9	0.1
305b	SA	13.9	575	23.9	410	5.2	2.4	11.9	6.9	0.0	18.1	-0.0
517a	SA	-5.5	319	2.5	209	14.1	1.9	3.5	36.0	0.1	2.8	0.0
517b	SA	-2.6	316	1.1	217	14.6	2.7	3.9	39.6	-0.1	2.5	0.0
518a	SA	-1.8	327	-0.0	225	14.8	1.5	4.6	41.4	-0.0	2.8	0.1

TABLE D1 (continued)

Cat.	Source	Sc45	Mn55	As75	Rb85	Sr88	Y89	Ba137	Ba138	La139	Ce140	Pr141
518b	SA	-0.6	318	1.7	229	14.9	1.5	4.0	40.8	0.1	2.5	0.1
519a	SA	-1.7	323	1.5	228	13.3	1.8	3.5	33.3	-0.1	2.4	0.1
519b	SA	-1.3	312	1.4	232	13.3	1.7	3.3	35.2	0.1	2.5	0.0
520a	SA	-1.7	320	1.8	234	13.7	1.4	3.7	36.6	-0.1	2.2	0.1
520b	SA	0.1	311	3.0	235	13.5	1.5	3.8	36.9	-0.0	2.3	0.0
521a	SA	1.1	330	1.7	249	13.5	2.2	3.2	30.3	-0.1	4.4	0.1
521b	SA	0.9	322	2.3	239	13.9	2.0	3.2	32.7	-0.1	4.3	0.1
525a	SA	-0.5	336	2.7	246	14.7	1.8	3.9	39.1	-0.1	4.7	0.2
525b	SA	0.9	332	2.7	250	15.9	2.5	4.0	41.8	0.5	3.9	0.1
526a	SA	0.1	332	2.5	255	14.1	2.4	3.5	37.5	-0.1	9.2	0.1
526b	SA	2.7	342	2.6	270	14.8	3.1	4.1	43.0	-0.1	9.3	0.0
527a	SA	0.7	343	3.6	264	14.8	1.5	3.7	38.0	-0.1	6.5	0.0
527b	SA	2.2	342	4.0	273	14.7	1.4	3.3	37.9	-0.1	6.7	0.1
544a	SA	2.9	344	2.0	245	15.6	2.2	3.9	35.5	-0.1	8.4	0.1
544b	SA	3.2	334	2.7	243	14.3	2.3	3.6	35.0	0.0	8.6	0.1
545a	SA	3.2	341	1.9	246	14.3	2.5	3.3	30.7	-0.1	10.2	0.1
545b	SA	0.6	334	2.1	248	13.6	2.2	2.9	29.2	-0.0	9.6	0.1
546a	SA	-1.8	323	1.5	252	14.4	2.1	4.1	39.8	0.6	15.6	0.3
546b	SA	-0.1	327	4.4	251	15.5	2.3	4.3	39.8	0.3	14.3	0.2
547a	SA	3.7	347	3.0	268	14.7	2.6	4.1	41.9	0.0	10.0	0.1
547b	SA	2.4	340	1.7	263	14.8	2.3	3.9	39.0	-0.0	10.0	0.1
548a	SA	3.7	328	0.6	219	21.4	4.4	4.7	49.2	0.1	3.9	0.2
548b	SA	2.6	311	1.2	219	21.6	4.6	4.8	45.5	-0.0	4.0	0.2
549a	SA	2.2	315	1.0	205	17.8	3.3	3.5	34.3	-0.1	4.8	0.1
549b	SA	2.7	317	1.5	204	17.2	3.3	3.7	37.8	0.1	5.2	0.2
550a	SA	0.7	336	1.5	203	16.7	2.8	3.5	34.6	-0.0	5.6	0.1
550b	SA	1.0	323	0.1	200	16.9	3.0	3.4	34.2	-0.0	5.5	0.1
551a	SA	-1.8	308	2.0	191	16.5	3.4	4.3	39.6	-0.1	5.9	0.2
551b	SA	0.8	317	1.2	203	18.0	3.8	4.0	42.8	0.0	6.1	0.2
552a	SA	0.2	313	1.6	191	18.8	3.9	4.0	43.0	0.0	8.8	0.2
552b	SA	-1.4	254	1.3	195	17.2	9.2	4.1	40.1	0.0	5.2	0.1
553a	SA	1.0	309	0.4	197	19.1	4.0	4.5	40.4	0.6	6.1	0.6
553b	SA	-0.3	314	1.6	200	19.5	4.5	4.3	39.9	1.8	4.5	0.5
605a	SA	0.7	314	1.4	201	17.8	3.1	3.6	37.1	-0.0	3.7	0.2
605b	SA	0.0	321	0.9	211	20.3	3.6	4.2	45.8	-0.0	4.1	0.1
606a	SA	-0.6	261	1.1	194	15.6	2.3	3.0	27.7	-0.0	3.5	0.1
606b	SA	-0.1	299	-0.7	201	16.9	2.8	2.8	27.2	-0.1	3.4	0.1
607a	SA	-1.0	326	1.2	204	18.5	3.1	3.0	29.5	-0.0	3.2	0.1
607b	SA	-0.4	325	1.3	198	18.1	2.8	3.2	32.3	-0.0	3.3	0.1
612a	SA	0.5	341	1.5	201	23.7	5.5	4.4	46.9	0.1	5.3	0.3
612b	SA	0.7	342	1.5	208	23.7	12.6	5.4	49.6	0.2	5.2	0.3
613a	SA	4.6	349	1.7	229	20.2	4.2	5.1	48.4	1.2	7.9	0.3
613b	SA	2.7	337	3.3	220	18.7	3.8	4.9	47.7	0.3	5.7	0.4
614a	SA	-0.5	309	1.3	203	17.1	3.0	4.2	39.3	-0.0	4.0	0.1
614b	SA	1.5	336	0.8	211	17.7	3.4	4.2	41.5	-0.0	3.9	0.1
617a	SA	-1.3	335	1.7	205	17.6	3.4	4.0	41.8	0.0	3.6	0.1
617b	SA	2.8	352	1.5	225	18.8	3.7	4.3	41.8	0.0	3.6	0.2
618a	SA	2.3	330	1.7	211	16.8	3.1	3.8	36.2	-0.0	4.2	0.2
618b	SA	3.2	330	2.4	214	17.3	3.6	3.7	39.8	0.0	4.1	0.1
619a	SA	1.0	349	2.3	211	16.7	3.6	3.9	40.0	-0.0	5.4	0.1
619b	SA	2.9	340	1.2	213	17.6	3.6	4.1	42.1	-0.1	5.0	0.1

TABLE D1 (continued)

Cat.	Source	Sc45	Mn55	As75	Rb85	Sr88	Y89	Ba137	Ba138	La139	Ce140	Pr141
624a	SA	1.8	336	1.7	206	17.8	4.5	4.7	47.0	0.3	7.5	0.7
624b	SA	2.4	313	1.2	208	17.6	4.7	4.2	44.4	0.5	6.9	0.4
625a	SA	1.1	315	1.0	210	16.9	3.7	3.7	41.2	0.1	5.2	0.2
625b	SA	-0.2	312	1.0	207	17.9	3.7	4.1	41.9	0.2	5.0	0.1
626a	SA	3.3	334	0.9	217	19.7	4.7	4.1	39.5	0.2	4.5	0.2
626b	SA	2.4	330	1.6	209	19.8	3.8	4.4	45.1	0.0	4.6	0.5
627a	SA	1.1	327	1.5	197	18.7	3.6	4.0	39.3	-0.0	4.2	0.1
627b	SA	1.0	336	0.4	208	18.4	3.6	4.3	43.1	-0.0	4.2	0.1
628a	SA	2.6	332	1.2	206	19.8	4.6	4.3	42.6	0.3	6.1	0.2
628b	SA	3.5	337	2.5	220	21.2	5.2	4.4	45.4	0.3	5.5	0.4
629a	SA	4.3	351	3.3	226	16.8	3.4	3.3	33.5	0.1	4.1	0.1
629b	SA	4.0	348	2.0	216	16.7	3.0	3.7	35.6	-0.1	4.5	0.1
663a	SA	20.7	339	3.8	252	19.4	3.6	4.2	36.9	0.0	9.6	0.1
663b	SA	19.0	350	4.0	259	18.7	3.6	3.8	40.0	-0.0	9.4	0.1
664a	SA	16.8	358	2.7	258	17.7	3.6	3.9	37.9	-0.0	11.2	0.1
664b	SA	19.2	358	3.7	253	17.3	3.7	3.9	37.5	-0.0	11.0	0.1
665a	SA	17.7	355	3.7	265	18.2	4.3	4.2	38.1	0.0	9.9	0.1
665b	SA	17.5	306	3.2	264	17.6	4.5	4.2	37.4	0.0	10.6	0.1
666a	SA	19.9	308	3.1	270	16.7	3.5	3.7	29.4	-0.0	8.0	0.1
666b	SA	19.9	358	2.6	250	15.9	3.4	2.9	32.0	0.0	8.2	0.1
667a	SA	18.8	357	4.0	258	16.4	3.7	3.7	37.8	-0.0	10.0	0.1
667b	SA	17.2	360	2.6	264	15.8	4.0	4.1	39.1	0.0	9.7	0.1
673a	SA	18.9	352	2.5	254	17.7	3.6	4.2	36.9	0.3	9.7	0.1
673b	SA	17.5	310	3.5	262	18.1	3.9	3.9	39.2	-0.0	8.6	0.1
674a	SA	18.5	356	4.4	258	20.5	4.0	4.2	39.8	-0.0	8.4	0.1
674b	SA	18.2	347	3.7	251	19.1	4.1	4.1	40.0	-0.0	8.2	0.1
685a	SB1	-10.3	300	-10.0	188	46.2	0.7	17.1	161.1	0.1	6.4	0.2
685b	SB1	-11.8	285	-10.0	191	46.0	0.7	17.0	165.9	-0.0	6.1	0.1
686a	SB1	-7.7	243	-9.2	187	40.0	0.8	15.5	151.3	-0.0	4.6	0.0
686b	SB1	-8.8	284	-8.5	191	41.2	0.6	15.3	149.1	-0.0	4.6	0.1
687a	SB1	4.2	316	-8.2	228	44.2	1.4	13.5	136.6	0.2	7.0	0.0
687b	SB1	3.0	306	-7.7	242	45.5	1.4	13.1	130.3	-0.0	6.9	0.1
705a	SB1	7.3	326	-8.8	242	51.3	1.4	16.4	162.6	-0.0	5.3	0.1
705b	SB1	5.0	318	-8.0	232	47.6	1.1	16.4	161.7	-0.0	5.3	0.1
706a	SB1	4.6	208	-7.9	241	60.1	-0.4	8.2	85.0	0.1	4.5	0.1
706b	SB1	7.1	243	-8.8	237	58.0	-0.5	7.9	79.7	-0.0	4.6	0.1
707a	SB1	11.0	325	-6.6	243	52.3	1.7	17.6	166.9	0.0	8.5	0.1
707b	SB1	11.5	268	-6.3	244	53.4	1.8	18.1	173.6	0.1	8.0	0.2
708a	SB1	11.0	236	-7.3	223	54.4	-0.2	7.1	67.9	-0.1	1.9	0.1
708b	SB1	12.6	258	-7.2	232	56.4	-0.3	7.2	73.9	0.1	2.0	0.1
709a	SB1	8.0	189	-8.6	228	53.9	-0.3	2.7	21.8	0.0	2.1	0.1
709b	SB1	9.7	177	-7.2	217	55.4	-0.4	2.3	22.3	0.0	2.0	0.0
710a	SB1	17.5	244	-6.0	233	57.4	-0.2	15.3	151.3	0.1	3.7	0.1
710b	SB1	16.6	248	-7.0	230	56.6	-0.0	15.7	148.0	0.0	3.8	0.1
711a	SB1	14.9	231	-8.1	237	55.2	0.0	3.0	27.9	0.1	6.0	0.1
711b	SB1	15.5	241	-6.6	223	53.5	0.1	3.2	29.5	0.1	6.1	0.1
712a	SB1	16.5	250	-6.9	230	56.7	-0.1	1.1	10.7	0.0	3.1	0.2
712b	SB1	18.0	197	-6.5	224	53.5	-0.1	1.2	11.9	0.1	3.2	0.1
719a	SB1	14.6	307	-6.6	224	50.9	1.7	18.0	175.8	0.1	8.9	0.1
719b	SB1	16.2	314	-6.6	230	50.8	1.8	18.7	181.1	-0.0	9.8	0.1
720a	SB1	14.8	314	-5.2	235	49.5	1.6	18.6	180.6	-0.0	8.6	0.0

TABLE D1 (continued)

Cat.	Source	Sc45	Mn55	As75	Rb85	Sr88	Y89	Ba137	Ba138	La139	Ce140	Pr141
720b	SB1	18.3	309	-7.3	231	48.9	1.9	17.6	172.2	0.1	8.4	0.1
721a	SB1	15.8	303	-7.2	221	49.5	1.6	17.8	174.1	0.0	7.2	0.0
721b	SB1	16.7	312	-6.4	239	51.0	1.5	18.0	177.2	-0.1	7.4	0.1
730a	SB1	16.1	312	-7.2	216	58.0	1.3	16.3	163.4	-0.0	4.4	0.1
730b	SB1	14.0	256	-3.6	221	56.9	1.4	16.6	161.2	-0.0	4.8	0.2
731a	SB1	25.1	311	-8.5	211	55.2	3.0	17.9	174.3	0.1	12.4	0.1
731b	SB1	28.4	326	-8.0	223	55.8	3.7	18.9	178.6	0.2	13.0	0.2
732a	SB1	24.7	247	-7.0	201	55.4	2.9	19.8	196.4	-0.0	7.1	0.2
732b	SB1	21.4	294	-8.8	204	56.5	2.7	20.3	197.1	0.1	7.9	0.2
733a	SB1	21.0	291	-7.9	202	52.5	2.5	6.8	68.5	0.1	5.5	0.2
733b	SB1	25.2	261	-8.8	206	52.9	2.1	7.5	74.4	-0.0	5.1	0.1
743a	SB2	23.5	166	-8.0	199	20.4	1.9	2.9	31.9	0.1	6.6	0.1
743b	SB2	24.4	211	-7.6	215	19.8	2.0	3.8	36.2	-0.1	7.5	0.2
744a	SB2	22.9	178	-7.9	188	70.9	1.3	7.4	59.5	1.4	6.6	0.7
744b	SB2	21.8	195	-8.3	175	66.5	0.5	6.5	61.9	1.3	7.5	5.3
745a	SB2	25.4	156	-5.8	202	27.8	1.0	11.1	101.3	0.4	6.1	0.2
745b	SB2	21.1	160	-4.0	216	27.1	1.3	11.3	109.0	0.2	7.1	0.2
746a	SB2	26.1	317	-8.2	202	31.8	3.6	12.1	113.5	-0.1	9.8	0.2
746b	SB2	25.9	282	-6.9	216	35.1	3.1	12.1	118.0	0.1	11.1	0.2
750a	SB2	24.5	199	-6.4	222	28.2	0.6	7.4	73.9	0.0	2.9	0.1
750b	SB2	22.5	189	-7.4	218	29.7	0.8	7.4	71.1	0.2	2.7	0.1
751a	SB2	18.1	193	-8.4	214	26.7	5.6	8.4	80.8	5.0	15.0	4.8
751b	SB2	20.5	163	-7.3	228	29.2	2.4	8.2	83.6	21.6	7.6	2.0
752a	SB2	21.1	209	-4.8	227	23.9	1.3	6.8	71.2	0.1	6.9	0.4
752b	SB2	17.7	204	-6.4	218	22.7	0.9	7.4	69.8	0.3	7.2	0.1
753a	SB2	23.4	209	-6.8	225	21.6	1.5	6.9	65.4	-0.0	6.7	0.2
753b	SB2	20.3	158	-6.2	213	22.0	0.7	6.0	63.9	0.4	6.1	0.1
754a	SB2	21.2	199	-7.6	215	35.2	1.9	16.8	157.6	2.6	14.8	1.1
754b	SB2	21.8	206	-7.4	205	34.4	2.0	16.4	160.5	5.3	15.7	0.7
755a	SB2	21.5	212	-7.7	216	26.9	1.8	12.0	113.3	1.7	6.1	0.4
755b	SB2	22.0	206	-5.6	223	27.6	1.4	12.4	116.2	0.9	5.1	0.5
756a	SB2	19.3	201	-7.6	213	22.7	2.4	8.4	78.8	3.0	9.9	0.5
756b	SB2	20.4	152	-7.2	224	23.1	2.2	8.1	84.0	2.6	16.3	1.7
757a	SB2	20.0	188	-6.1	212	32.1	5.1	13.6	140.9	9.3	22.9	4.8
757b	SB2	19.3	191	-7.4	200	32.7	3.7	13.5	129.9	11.5	17.7	2.1
758a	SB2	24.0	194	-6.7	249	29.7	9.1	14.1	139.1	13.9	56.5	4.5
758b	SB2	25.1	161	-5.4	259	31.2	12.7	13.8	139.9	14.1	36.1	4.1
758c	SB2	23.5	191	-6.0	255	29.9	4.5	11.4	123.1	3.8	22.5	1.3
758d	SB2	26.1	202	-7.3	263	33.8	6.2	13.1	126.3	5.8	21.6	1.9
823a	SB2	22.6	212	-4.1	231	22.5	3.2	5.8	61.6	0.5	6.7	0.2
823b	SB2	22.4	210	-6.9	238	23.2	1.2	5.9	60.2	0.5	5.5	0.2
824a	SB2	-0.2	204	-7.6	235	19.0	1.1	4.6	46.7	0.8	18.0	0.2
824b	SB2	2.4	176	-4.6	230	19.7	1.0	4.1	48.1	0.5	19.7	0.2
825a	SB2	21.1	202	-5.4	255	18.7	0.6	4.6	45.9	-0.0	6.4	0.1
825b	SB2	23.1	171	-4.5	231	18.1	1.0	4.7	45.1	0.1	6.6	0.0
826a	SB2	20.8	164	-6.6	236	32.4	0.5	13.4	133.0	-0.1	6.7	0.1
826b	SB2	19.3	160	-7.8	233	33.9	0.9	13.5	131.8	-0.1	5.8	0.0
827a	SB2	23.0	223	-4.1	240	22.1	1.1	4.8	50.9	-0.0	6.9	-0.0
827b	SB2	20.8	177	-7.1	236	22.1	1.2	5.6	55.3	-0.1	7.7	-0.0
828a	SB2	19.8	220	-5.7	235	21.0	1.0	4.5	45.7	0.2	4.9	0.1
828b	SB2	21.8	218	-7.7	235	21.4	1.0	5.2	50.8	0.0	4.7	0.0

TABLE D1 (continued)

Cat.	Source	Sc45	Mn55	As75	Rb85	Sr88	Y89	Ba137	Ba138	La139	Ce140	Pr141
829a	SB2	17.5	162	-4.6	225	21.9	0.9	4.8	53.1	0.0	2.9	0.1
829b	SB2	24.7	179	-5.4	242	23.0	0.7	5.7	59.0	0.1	2.9	0.1
830a	SB2	21.0	210	-8.2	232	21.7	1.6	6.1	56.6	0.2	6.4	0.2
830b	SB2	18.8	168	-8.0	225	18.5	1.5	5.0	53.7	0.5	4.7	0.4
870	SC	0.9	210	1.6	171	106.8	-0.6	25.5	22.8	0.0	2.7	0.1
872	SC	9.0	264	2.3	215	61.6	1.4	315.4	246.1	0.7	6.5	0.2
873	SC	0.5	379	4.6	318	-1.4	3.6	-69.1	-64.1	1.2	5.2	0.4
874	SC	1.2	345	5.2	280	-1.0	0.3	-66.6	-60.1	-0.1	1.7	0.0
901a	SC	3.7	238	0.8	162	107.4	-0.7	108.4	97.0	0.2	2.7	0.1
901b	SC	4.1	236	0.3	173	113.0	-0.7	116.5	103.4	0.2	1.8	0.2
902a	SC	4.3	241	0.8	184	110.5	-0.6	27.3	31.0	0.2	3.3	0.1
902b	SC	4.4	246	-0.4	173	107.3	-0.7	29.0	28.9	0.1	2.7	0.0
911a	SC	-0.1	229	1.4	167	95.1	-0.5	19.4	16.5	0.1	2.1	0.1
911b	SC	2.6	182	-0.1	180	101.2	-0.7	28.0	23.6	0.2	3.8	0.1
912a	SC	4.6	229	0.3	173	101.1	-0.5	42.9	37.3	0.1	3.5	0.1
912b	SC	3.3	217	-0.2	173	98.9	-0.6	39.5	36.1	0.1	3.3	0.2
922a	SC	4.8	230	0.3	174	105.9	-0.6	29.2	27.1	0.1	3.6	0.1
922b	SC	5.3	227	1.1	169	104.2	-0.6	27.3	23.2	0.1	3.5	0.1
923a	SC	1.5	230	0.8	179	103.4	-0.6	37.6	32.0	0.3	2.9	0.2
923b	SC	3.1	239	0.9	163	107.3	-0.6	42.1	39.9	0.1	2.3	0.1
924a	SC	4.0	230	0.4	167	106.5	-0.7	62.8	58.8	0.2	2.0	0.1
924b	SC	2.9	175	1.3	172	105.8	-0.6	60.9	60.3	0.2	1.8	0.1
939a	SC	8.9	228	0.9	180	101.8	0.6	656.5	356.9	0.2	4.8	0.1
939b	SC	4.0	221	1.1	177	93.5	0.7	652.7	376.2	0.4	4.1	0.2
940a	SC	4.1	227	-0.9	176	117.0	0.6	848.4	441.3	0.3	4.5	0.3
940b	SC	5.5	226	1.3	164	109.8	0.4	828.1	453.4	0.3	4.2	0.3
941a	SC	3.8	225	0.1	170	119.9	0.6	810.3	457.6	0.2	5.2	0.2
941b	SC	7.6	243	0.8	184	128.5	1.0	915.4	462.9	0.3	5.7	0.3
942a	SC	4.3	233	0.9	173	113.1	0.7	865.3	437.0	0.2	5.2	0.2
942b	SC	9.6	239	0.9	171	113.7	0.7	867.1	456.2	0.5	5.4	0.2
943a	SC	8.6	252	0.6	202	131.7	1.2	1015.9	519.4	0.5	5.8	0.5
943b	SC	6.7	241	1.4	187	122.1	1.0	978.9	501.6	1.2	5.5	0.3
944a	SC	4.3	236	-0.3	178	114.9	1.0	924.9	469.0	0.4	5.0	0.4
944b	SC	2.7	236	-0.4	175	118.0	0.8	948.0	495.7	0.6	4.6	0.4
945a	SC	4.5	176	1.2	187	114.5	1.4	712.9	404.1	1.0	10.9	0.9
945b	SC	5.3	235	0.3	178	103.4	1.5	729.7	386.3	2.7	11.7	0.6
964a	SC	4.7	245	0.5	202	133.5	0.8	1003.8	524.4	0.4	5.3	0.3
964b	SC	5.5	249	0.7	199	129.5	1.1	1042.0	531.3	0.4	5.8	0.4
965a	SC	3.8	246	0.5	199	79.9	1.2	618.1	326.2	1.5	6.9	0.9
965b	SC	0.3	181	1.3	177	97.7	2.0	593.1	329.9	1.5	87.3	0.9
966a	SC	4.0	250	0.5	174	116.2	1.2	910.6	454.7	0.9	6.2	0.5
966b	SC	0.8	240	1.7	180	113.4	0.9	870.0	453.0	0.7	6.1	0.4
974a	SC	2.6	233	0.2	176	99.2	0.8	706.9	378.7	1.1	5.9	0.3
974b	SC	1.4	215	0.5	180	106.2	0.9	675.2	365.1	0.5	5.3	0.4
975a	SC	11.2	115	1.7	97	8.4	1.2	49.2	44.1	0.0	1.9	0.1
975b	SC	10.3	111	1.8	95	8.3	0.8	47.4	44.0	0.1	2.4	0.1
986a	SC	11.9	61	2.5	97	11.1	1.0	51.7	49.4	0.1	1.7	0.1
986b	SC	11.7	94	2.1	86	10.6	0.9	50.5	47.6	0.0	1.5	0.1
987a	SC	12.5	57	2.6	102	9.5	1.6	51.0	48.4	0.2	6.0	0.2
987b	SC	12.0	57	2.9	92	10.4	1.5	54.2	46.4	0.2	5.9	0.2
988a	SC	13.3	58	2.8	100	17.0	1.7	43.8	40.3	0.1	5.8	0.1

TABLE D1 (continued)

Cat.	Source	Sc45	Mn55	As75	Rb85	Sr88	Y89	Ba137	Ba138	La139	Ce140	Pr141
988b	SC	11.4	90	2.5	94	16.9	1.7	46.5	40.8	0.1	6.4	0.1
989a	SC	14.5	134	2.9	113	7.8	1.2	50.4	47.0	0.7	2.3	0.2
989b	SC	11.5	91	2.3	103	7.0	1.1	46.5	44.8	0.2	1.8	0.4
990a	SC	6.8	88	2.3	80	13.9	1.0	54.7	50.1	0.1	0.9	0.1
990b	SC	17.0	168	4.6	156	24.7	1.8	96.5	89.9	0.2	1.6	0.1
996a	SC	6.5	96	2.2	88	9.2	0.5	47.4	42.7	0.2	1.8	0.1
996b	SC	6.8	99	1.8	94	8.6	0.6	47.3	45.0	0.2	1.5	0.2
997a	SC	10.3	88	0.8	102	14.0	0.2	51.6	48.5	0.1	0.6	0.0
997b	SC	9.9	82	2.5	88	13.3	0.2	50.3	47.8	0.0	0.5	0.1
998a	SC	8.5	88	2.1	92	10.4	0.9	38.4	35.1	0.0	1.6	0.1
998b	SC	10.3	52	1.8	89	11.2	0.9	38.7	36.4	0.0	1.1	0.1
999a	SC	9.6	88	3.0	94	12.9	0.8	48.6	46.6	0.0	1.5	0.1
999b	SC	10.5	87	1.8	92	12.9	0.9	50.0	46.3	0.1	1.6	0.1
1000a	SC	11.4	86	2.2	95	11.8	1.8	53.2	48.1	0.1	3.8	0.1
1000b	SC	8.8	85	3.3	92	11.8	1.7	51.3	45.8	0.0	4.0	0.2
1023	SC	28.2	289	4.4	201	125.0	1.1	626.9	468.1	0.9	7.4	0.3
1024	SC	28.1	321	4.6	226	129.9	0.8	402.2	342.4	0.6	4.9	0.4
1025	SC	22.7	297	7.0	241	122.7	-0.1	43.6	36.1	0.1	3.4	0.1
1026	SC	12.5	267	2.5	215	110.8	-0.8	-31.2	-29.4	0.7	3.3	0.1
1027	SC	13.5	301	3.8	216	108.1	-0.8	-29.2	-29.1	-0.1	8.8	0.1
1037	SC	11.6	276	4.3	228	98.9	-1.0	-51.7	-44.8	-0.2	9.2	-0.0
1038	SC	8.8	273	3.2	203	94.2	-0.8	-29.0	-24.8	0.1	6.6	0.2
1039	SC	7.4	274	2.4	200	97.7	-1.1	-51.7	-47.8	-0.1	9.2	-0.0
1040	SC	3.7	259	1.8	177	95.8	-0.9	-32.6	-31.4	0.3	7.3	0.2
1041	SC	3.9	261	0.5	185	103.7	-0.6	-33.1	-33.1	1.1	6.0	0.4

TABLE D1 (continued)

Cat.	Nd145	Nd146	Sm147	Eu151	Gd157	Tb159	Dy162	Ho165	Er166	Tm169	Yb174	Th232	U238
001a	3.2	2.7	1.1	0.1	1.7	0.5	3.3	0.8	1.7	0.2	1.5	4.6	7.5
001b	2.3	1.9	1.3	0.1	1.7	0.5	2.9	0.9	1.5	0.2	1.7	4.0	7.4
003a	1.4	1.4	0.3	0.0	0.5	0.1	0.6	0.1	0.2	0.0	0.3	0.8	4.8
003b	1.3	1.3	0.5	0.1	0.4	0.1	0.5	0.1	0.1	0.0	0.3	0.8	4.7
004a	1.0	1.4	0.5	0.0	0.4	0.1	0.5	0.1	0.3	0.0	0.3	0.8	5.2
004b	1.3	1.0	0.5	0.1	0.2	0.1	0.5	0.1	0.2	0.0	0.2	1.0	5.6
005a	1.2	1.1	0.2	0.0	0.3	0.1	0.7	0.2	0.3	0.0	0.3	0.8	5.0
005b	1.0	1.2	0.7	0.0	0.6	0.0	0.7	0.1	0.2	0.0	0.3	1.1	4.9
006a	2.3	1.4	0.5	0.1	1.3	0.4	2.8	0.8	1.3	0.2	1.5	4.5	8.4
006b	1.6	1.5	1.3	0.0	1.4	0.4	3.5	0.8	1.2	0.2	1.6	4.1	8.5
008a	1.8	2.0	0.5	0.1	0.6	0.1	0.7	0.1	0.3	0.0	0.3	1.1	4.7
008b	2.5	1.9	0.4	0.1	0.7	0.1	0.7	0.1	0.2	0.0	0.2	1.3	4.5
009a	0.8	0.3	0.5	0.1	1.2	0.3	2.1	0.6	1.3	0.1	1.7	1.8	8.2
009b	0.3	0.1	0.7	0.0	1.4	0.3	2.0	0.6	1.3	0.2	1.6	1.7	8.2
010a	1.7	1.2	0.6	0.1	0.3	0.1	0.5	0.1	0.2	0.0	0.1	0.8	4.5
010b	1.9	2.0	0.3	0.0	0.3	0.1	0.6	0.1	0.1	0.0	0.3	0.8	4.6
011a	1.5	4.2	1.6	0.1	1.4	0.3	2.4	0.5	1.3	0.1	1.1	4.6	8.0
011b	3.5	2.8	1.3	0.1	2.1	0.4	2.3	0.6	1.1	0.2	1.5	6.0	8.2
012a	1.6	2.3	1.3	0.1	1.4	0.4	2.6	0.7	1.0	0.2	1.5	4.0	7.7
012b	2.3	2.1	1.3	0.0	1.6	0.3	3.1	0.8	1.3	0.2	1.3	3.8	7.7
013a	3.1	4.0	0.8	0.2	0.7	0.1	0.6	0.3	0.3	0.0	0.2	1.6	4.5
013b	3.5	2.7	0.7	0.1	0.9	0.1	0.7	0.2	0.2	0.0	0.2	1.7	4.5
014a	3.1	5.1	1.3	0.0	1.9	0.4	3.7	1.0	1.3	0.2	2.0	5.7	7.8
014b	2.6	4.8	1.8	0.1	2.1	0.5	3.2	0.7	1.5	0.2	1.9	5.8	8.8
015a	1.5	1.9	1.0	0.0	1.1	0.3	1.9	0.5	0.8	0.1	1.0	3.9	8.7
015b	2.5	2.2	1.1	0.0	1.2	0.3	1.8	0.5	1.0	0.1	1.0	3.6	8.0
188a	0.9	0.6	1.1	0.0	1.3	0.4	2.7	0.4	1.3	0.2	1.3	1.1	7.0
188b	1.6	1.1	0.7	0.1	1.3	0.4	2.9	0.5	1.3	0.2	1.4	1.0	7.4
189a	0.6	0.5	0.4	0.1	0.8	0.3	2.2	0.4	1.0	0.2	1.3	0.9	7.4
189b	0.6	0.5	0.5	0.0	0.9	0.3	2.3	0.4	0.9	0.2	1.3	0.8	7.8
191a	1.2	0.8	0.6	0.1	1.1	0.3	2.3	0.4	1.3	0.2	1.3	1.2	7.4
191b	0.9	0.8	0.7	0.1	1.0	0.3	2.2	0.4	1.2	0.2	1.3	1.1	7.6
192a	0.7	0.4	0.7	0.0	0.8	0.3	2.5	0.4	1.0	0.2	1.1	1.1	7.8
192b	0.7	0.5	0.7	0.0	1.1	0.3	2.1	0.4	1.1	0.2	1.2	1.1	7.9
193a	0.9	0.8	0.5	0.0	1.0	0.3	2.5	0.4	1.2	0.2	1.2	0.9	7.7
193b	0.9	0.9	0.5	0.0	1.0	0.3	2.3	0.5	1.2	0.1	1.3	1.0	8.2
194a	0.8	0.7	0.4	0.0	1.1	0.2	2.4	0.4	1.2	0.2	1.0	0.9	7.7
194b	0.3	0.6	0.6	0.1	1.2	0.3	2.1	0.4	1.1	0.2	1.2	0.9	7.9
195	0.9	0.9	0.3	0.0	0.4	0.1	0.4	0.1	0.2	0.0	0.3	0.3	3.8
205	0.7	0.7	0.1	0.0	0.3	0.1	0.1	0.1	0.1	0.0	0.2	0.3	4.4
206	0.7	1.0	0.3	0.1	0.5	0.0	0.4	0.0	0.1	0.0	0.1	0.2	4.3
217a	0.5	0.6	0.2	0.0	0.7	0.2	2.2	0.3	0.8	0.2	1.1	0.7	3.8
217b	0.5	0.4	0.5	0.0	0.8	0.2	1.9	0.3	0.9	0.1	1.0	0.6	3.5
221a	0.9	0.5	0.7	0.0	0.7	0.2	2.3	0.3	1.0	0.1	1.1	2.2	6.7
221b	0.8	1.1	0.7	0.0	0.8	0.2	2.2	0.4	1.0	0.2	1.1	1.8	6.8
222a	0.6	0.5	0.3	0.0	0.6	0.2	1.6	0.3	0.9	0.1	0.9	1.0	6.9
222b	0.4	0.4	0.4	0.0	0.8	0.2	1.9	0.3	0.7	0.1	1.1	1.5	7.2
223a	0.9	0.3	0.5	0.0	0.8	0.2	2.1	0.4	1.1	0.2	1.1	1.8	7.1
223b	0.2	0.4	0.5	0.0	0.9	0.3	2.1	0.4	1.2	0.2	1.1	1.7	7.4
224a	0.2	0.3	0.4	0.0	0.9	0.2	1.9	0.3	0.9	0.2	1.0	1.8	6.9
224b	0.4	0.4	0.5	0.0	0.9	0.2	1.7	0.4	1.2	0.1	1.2	1.5	7.3
225a	0.3	0.4	0.3	0.0	0.7	0.2	1.8	0.3	0.9	0.1	1.0	1.0	7.0
225b	0.6	0.6	0.4	0.0	0.8	0.2	1.9	0.4	0.8	0.1	1.1	1.1	7.3
226a	0.7	0.5	0.5	0.0	1.0	0.3	2.0	0.4	1.3	0.2	1.2	2.1	7.0

TABLE D1 (continued)

Cat.	Nd145	Nd146	Sm147	Eu151	Gd157	Tb159	Dy162	Ho165	Er166	Tm169	Yb174	Th232	U238
226b	0.4	0.6	0.5	0.1	0.9	0.3	2.2	0.4	1.0	0.1	1.2	1.9	7.3
244a	5.1	3.8	0.4	0.1	0.7	0.1	0.6	0.1	0.1	0.0	0.3	1.7	4.3
244b	2.8	4.9	0.8	0.1	0.1	0.1	0.5	0.1	0.2	0.0	0.3	2.4	4.4
255a	0.6	0.5	0.2	0.0	0.2	0.0	0.2	0.1	0.1	0.0	0.1	0.2	4.2
255b	0.1	0.5	0.2	0.0	0.3	0.1	0.3	0.1	0.1	0.0	0.2	0.2	4.6
259a	0.3	0.1	0.3	0.1	0.4	0.2	1.4	0.2	0.6	0.1	1.0	1.1	7.3
259b	0.2	0.1	0.2	0.0	0.5	0.2	1.5	0.3	0.5	0.1	0.8	1.1	7.4
269a	1.2	1.0	0.8	0.1	1.3	0.3	2.4	0.7	0.9	0.2	1.3	2.4	7.7
269b	0.6	1.1	0.6	0.0	1.2	0.3	2.5	0.7	1.1	0.2	1.5	2.6	7.6
270a	1.2	1.1	1.1	0.1	1.2	0.4	2.4	0.7	1.2	0.2	1.4	3.3	8.0
270b	0.6	1.6	0.9	0.0	1.4	0.3	2.4	0.7	1.2	0.2	1.3	3.3	8.0
271a	1.8	2.0	1.0	0.0	1.5	0.3	2.3	0.6	1.2	0.2	1.2	3.8	8.7
271b	1.5	2.0	1.2	0.0	1.5	0.3	2.6	0.6	1.2	0.2	1.2	4.0	8.9
272a	1.4	1.6	1.0	0.0	1.2	0.3	2.3	0.7	1.4	0.2	1.4	3.6	8.7
272b	1.2	1.3	0.8	0.1	1.0	0.3	2.5	0.7	1.3	0.2	1.3	3.3	8.4
273a	1.3	0.7	0.4	0.0	1.0	0.2	1.9	0.4	0.9	0.1	1.0	2.4	8.2
273b	1.2	0.9	0.5	0.1	0.8	0.3	1.9	0.4	0.7	0.1	0.9	2.3	8.0
292a	1.5	1.5	0.6	0.1	1.2	0.3	2.2	0.6	0.9	0.1	1.0	3.2	8.8
292b	1.3	1.4	0.8	0.0	1.3	0.3	2.1	0.5	0.8	0.2	1.2	3.0	8.8
293a	1.8	2.7	0.9	0.1	0.6	0.1	1.0	0.2	0.3	0.0	0.3	1.8	5.4
293b	0.8	2.6	0.7	0.1	0.5	0.0	0.7	0.1	0.3	0.0	0.2	1.3	5.0
294a	2.0	-0.0	0.3	0.0	0.1	0.0	0.5	0.2	0.2	0.0	0.2	0.5	5.4
294b	-0.8	-0.2	-0.0	-0.0	0.2	0.1	0.4	0.1	-0.0	-0.0	0.2	0.1	5.2
295a	0.3	0.2	0.3	-0.0	0.3	0.1	0.9	0.3	0.5	0.1	0.4	1.3	8.0
295b	0.4	0.4	0.8	0.1	0.5	0.1	1.1	0.2	0.4	-0.0	0.2	1.8	8.1
296a	2.0	2.2	1.0	0.1	1.1	0.2	1.1	0.3	0.5	0.1	0.6	3.1	8.3
296b	2.1	2.2	0.9	0.0	1.1	0.2	1.5	0.4	0.5	0.1	0.6	3.0	8.5
297a	0.7	0.8	0.4	0.1	0.5	0.1	1.1	0.2	0.4	0.1	0.5	1.8	7.6
297b	1.0	1.0	0.6	0.0	0.3	0.2	0.9	0.2	0.3	0.0	0.6	2.0	8.1
298a	0.5	0.9	0.3	0.0	0.3	0.1	0.4	0.2	0.2	0.0	0.2	0.9	1.9
298b	0.8	0.7	0.1	0.1	0.1	0.1	0.4	0.1	0.3	0.0	0.3	0.8	1.8
299a	0.7	0.9	0.3	0.0	0.5	0.1	0.8	0.1	0.3	0.1	0.4	3.0	4.2
299b	0.9	0.8	0.3	0.0	0.2	0.1	0.6	0.2	0.4	0.0	0.4	3.4	4.4
300a	0.7	0.7	0.3	0.0	0.8	0.1	0.8	0.2	0.5	0.1	0.5	2.6	3.0
300b	0.9	1.5	0.5	0.0	0.7	0.1	0.6	0.2	0.3	0.1	0.5	2.7	2.7
301a	0.5	0.4	0.2	0.0	0.3	0.0	0.4	0.2	0.2	0.0	0.3	1.9	2.0
301b	0.9	0.6	0.3	-0.0	0.1	0.0	0.4	0.0	0.2	0.0	0.3	2.0	2.0
302a	1.2	1.4	1.0	0.0	1.1	0.3	2.5	0.5	1.1	0.2	1.1	4.6	7.1
302b	1.8	1.3	1.2	0.1	1.6	0.3	2.3	0.8	0.9	0.2	1.4	5.0	7.2
303a	0.1	0.1	0.2	-0.0	0.3	0.1	1.0	0.3	0.5	0.1	1.0	0.7	25.6
303b	0.5	0.2	0.3	-0.0	0.1	0.1	0.7	0.2	0.6	0.1	0.8	0.7	26.5
304a	1.3	1.9	1.1	0.0	1.3	0.3	1.8	0.5	0.8	0.1	1.2	5.1	8.0
304b	4.2	1.6	1.3	0.1	0.8	0.2	1.8	0.6	0.8	0.1	1.0	5.0	7.8
305a	0.3	0.8	0.3	-0.0	0.4	0.1	1.0	0.3	0.6	0.1	2.0	0.6	28.6
305b	1.1	-0.0	-0.1	-0.0	0.3	0.1	1.1	0.3	0.7	0.1	1.5	0.1	30.4
517a	0.6	0.4	0.3	0.0	0.6	0.2	2.0	0.3	0.9	0.2	1.0	1.4	8.0
517b	1.1	0.6	0.3	0.0	0.8	0.2	1.9	0.3	0.9	0.2	1.0	1.4	8.4
518a	0.2	0.5	0.5	0.0	0.7	0.2	1.8	0.3	0.9	0.1	1.1	1.2	7.9
518b	0.6	0.7	0.2	0.0	0.8	0.2	1.9	0.3	1.0	0.2	1.1	1.3	8.3
519a	0.6	0.3	0.4	0.0	0.7	0.2	1.9	0.3	0.9	0.1	1.1	1.3	8.2
519b	0.5	0.4	0.4	0.0	0.8	0.2	1.8	0.3	0.9	0.1	1.0	1.4	8.2
520a	0.3	0.3	0.4	0.0	0.6	0.2	1.7	0.3	0.8	0.1	0.9	1.1	8.3
520b	0.6	0.4	0.4	0.0	0.8	0.2	1.6	0.3	0.9	0.1	1.0	1.1	8.3
521a	0.3	0.5	0.4	0.1	0.8	0.3	1.8	0.4	0.9	0.2	1.2	1.6	7.8

TABLE D1 (continued)

Cat.	Nd145	Nd146	Sm147	Eu151	Gd157	Tb159	Dy162	Ho165	Er166	Tm169	Yb174	Th232	U238
521b	0.8	0.5	0.5	0.0	0.7	0.3	1.8	0.4	0.9	0.1	1.0	1.6	8.2
525a	0.2	0.7	0.4	0.1	0.6	0.3	2.0	0.3	0.9	0.1	1.1	1.6	8.1
525b	0.7	0.5	0.5	0.0	1.5	0.2	1.8	0.3	1.1	0.1	1.2	2.2	8.1
526a	0.3	0.5	0.5	0.0	0.6	0.3	2.3	0.4	0.9	0.1	1.1	1.8	7.7
526b	0.5	0.4	0.4	0.0	0.9	0.3	2.2	0.4	0.9	0.1	1.3	1.7	8.3
527a	0.3	0.3	0.6	0.0	0.7	0.2	1.7	0.3	0.8	0.1	0.9	1.0	7.9
527b	0.3	0.3	0.6	0.0	0.7	0.2	1.5	0.3	0.8	0.1	1.2	1.2	7.8
544a	0.6	0.2	0.4	0.1	1.1	0.2	1.8	0.4	1.0	0.1	1.1	1.7	7.1
544b	0.6	0.4	0.4	0.0	1.1	0.2	1.9	0.4	1.0	0.2	1.2	1.7	7.6
545a	0.5	0.4	0.5	0.0	0.8	0.2	1.8	0.3	1.0	0.2	1.2	1.7	7.6
545b	0.1	0.4	0.4	0.0	0.8	0.2	1.6	0.4	1.1	0.1	1.2	1.7	7.5
546a	1.6	1.4	0.9	0.0	1.5	0.3	2.0	0.3	1.0	0.1	1.0	2.8	7.6
546b	1.6	1.5	0.5	0.2	0.8	0.2	2.4	0.3	0.9	0.1	0.9	4.6	7.8
547a	0.6	0.5	0.2	0.1	0.4	0.3	2.2	0.4	1.1	0.2	1.2	1.9	7.5
547b	0.4	0.5	0.5	0.1	0.7	0.3	2.2	0.4	1.2	0.2	1.2	1.9	7.5
548a	1.3	1.3	0.8	0.1	1.9	0.4	3.3	0.6	1.7	0.2	1.8	0.8	8.3
548b	0.8	1.1	0.9	0.1	1.4	0.4	3.7	0.6	1.6	0.3	1.8	0.9	7.9
549a	0.2	0.9	0.8	0.0	1.0	0.3	2.6	0.5	1.3	0.2	1.5	0.9	7.8
549b	0.2	0.7	0.6	0.1	1.4	0.3	2.7	0.4	1.3	0.2	1.3	0.7	7.9
550a	1.0	0.6	0.6	0.1	1.1	0.3	2.4	0.3	1.2	0.2	1.0	0.7	7.8
550b	0.6	0.6	0.8	0.0	1.0	0.3	2.6	0.4	1.3	0.2	1.3	0.7	8.0
551a	0.3	1.0	0.7	0.1	1.3	0.4	2.8	0.5	1.5	0.2	1.6	0.9	8.1
551b	1.2	1.0	0.8	0.1	1.3	0.3	2.9	0.5	1.4	0.2	1.5	1.0	7.7
552a	1.3	1.4	0.7	0.1	1.3	0.4	2.9	0.5	1.5	0.2	1.5	0.8	8.1
552b	1.3	1.4	0.8	0.1	1.2	0.3	3.0	1.1	1.5	0.2	1.5	0.9	7.9
553a	2.1	2.0	0.9	0.1	1.9	0.4	2.9	0.5	1.3	0.3	1.5	2.2	8.0
553b	2.6	2.0	0.9	0.0	1.3	0.4	2.9	0.5	1.4	0.2	1.5	3.4	8.2
605a	0.7	0.6	0.6	0.1	1.2	0.4	2.5	0.5	1.2	0.3	1.5	0.6	8.0
605b	1.0	1.1	0.7	0.1	1.4	0.3	3.1	0.5	1.3	0.2	1.6	0.6	8.5
606a	0.8	0.7	0.5	0.0	1.2	0.3	2.2	0.4	1.0	0.2	1.1	0.5	7.9
606b	0.7	0.5	0.5	0.0	0.8	0.2	1.9	0.4	1.0	0.1	1.2	0.4	8.3
607a	0.8	0.8	0.7	0.1	1.0	0.3	2.3	0.4	1.3	0.1	1.2	0.6	8.0
607b	0.8	0.7	0.7	0.1	0.9	0.3	2.5	0.5	1.1	0.2	1.4	0.6	8.2
612a	1.6	1.5	1.3	0.1	1.6	0.5	3.5	0.6	1.8	0.3	1.8	0.8	8.4
612b	1.5	1.5	1.1	0.1	1.7	0.5	3.6	0.7	1.8	0.3	1.8	0.9	9.1
613a	1.3	1.5	0.6	0.0	1.3	0.3	3.0	0.6	1.4	0.2	1.6	0.9	8.0
613b	0.9	1.6	0.7	0.0	1.1	0.3	3.1	0.6	1.5	0.2	1.5	1.5	7.6
614a	0.5	0.7	0.6	0.0	1.1	0.4	2.6	0.5	1.2	0.2	1.6	0.6	7.4
614b	0.6	0.7	0.5	0.1	1.1	0.3	2.6	0.5	1.3	0.2	1.4	0.6	7.7
617a	5.7	0.9	0.8	0.0	1.1	0.3	2.7	0.4	1.3	0.2	1.5	0.8	7.3
617b	0.6	0.6	0.6	0.1	1.2	0.4	2.6	0.5	1.2	0.2	1.4	0.8	7.8
618a	0.9	0.5	0.6	0.1	0.9	0.3	2.3	0.3	1.1	0.2	1.2	0.8	7.5
618b	0.9	0.6	0.6	0.0	1.0	0.3	2.2	0.4	1.1	0.1	1.1	0.8	7.7
619a	0.9	0.9	0.6	0.1	1.2	0.3	2.8	0.5	1.2	0.2	1.5	0.8	7.7
619b	0.3	0.7	0.8	0.1	1.1	0.3	2.6	0.5	1.4	0.2	1.5	0.8	7.9
624a	1.0	1.8	0.9	0.0	1.6	0.4	3.2	0.5	1.5	0.2	1.6	2.1	7.7
624b	1.0	1.2	0.7	0.1	1.5	0.3	2.9	0.5	1.5	0.2	1.6	1.9	7.8
625a	1.1	1.2	1.0	0.0	1.1	0.4	2.6	0.5	1.2	0.2	1.4	0.8	7.7
625b	2.1	0.9	1.8	0.0	1.3	0.3	3.0	0.5	1.5	0.2	1.5	1.1	7.9
626a	0.8	0.9	0.7	0.1	1.3	0.4	3.1	0.5	1.3	0.2	1.6	0.7	7.9
626b	0.8	0.9	0.8	0.1	1.4	0.4	3.2	0.5	1.7	0.2	1.7	0.8	8.1
627a	0.6	0.7	1.0	0.1	1.1	0.4	2.9	0.5	1.5	0.2	1.5	0.6	7.6
627b	0.9	0.8	0.8	0.1	1.3	0.4	3.1	0.5	1.4	0.2	1.5	0.7	8.0
628a	1.6	2.0	1.0	0.1	1.8	0.4	3.2	0.5	1.6	0.2	1.7	1.2	7.7

TABLE D1 (continued)

Cat.	Nd145	Nd146	Sm147	Eu151	Gd157	Tb159	Dy162	Ho165	Er166	Tm169	Yb174	Th232	U238
628b	1.7	2.3	1.0	0.1	1.7	0.4	3.1	0.6	1.7	0.3	1.6	1.4	8.3
629a	0.8	1.1	0.3	0.1	1.0	0.3	2.1	0.4	1.0	0.2	1.1	0.6	6.7
629b	0.6	0.6	0.8	0.0	1.2	0.3	2.2	0.4	1.1	0.1	1.1	0.6	7.3
663a	1.0	0.6	0.8	0.1	1.1	0.2	2.1	0.4	0.9	0.1	1.1	0.9	5.4
663b	0.8	0.5	0.6	0.0	0.8	0.3	2.1	0.3	0.9	0.2	1.1	0.9	5.6
664a	0.5	0.5	0.6	0.0	0.9	0.3	2.3	0.4	1.0	0.2	1.1	1.2	5.6
664b	0.5	0.5	0.5	0.0	1.1	0.3	2.3	0.4	1.1	0.1	1.2	1.1	5.7
665a	0.9	0.6	0.6	0.1	0.9	0.2	2.3	0.4	1.0	0.2	1.1	1.1	5.2
665b	0.5	0.7	0.7	0.1	1.0	0.3	2.2	0.4	1.1	0.1	1.1	1.2	5.4
666a	0.9	0.7	0.5	0.0	0.7	0.2	1.9	0.3	0.9	0.1	0.9	0.9	5.2
666b	0.3	0.5	0.5	0.1	0.7	0.2	1.7	0.3	1.1	0.2	0.9	0.9	5.6
667a	0.4	0.7	0.5	0.0	0.9	0.3	2.3	0.3	1.0	0.2	1.1	1.0	5.3
667b	0.8	0.4	0.5	0.1	0.8	0.3	2.2	0.3	0.9	0.1	1.0	1.1	5.2
673a	0.9	0.4	0.5	0.0	1.0	0.3	2.0	0.4	0.9	0.2	1.1	0.9	5.3
673b	0.8	0.8	0.5	0.1	0.9	0.3	2.2	0.3	1.2	0.1	1.2	0.9	5.7
674a	0.6	0.6	0.6	0.0	1.0	0.3	2.3	0.3	1.0	0.1	1.1	0.9	5.4
674b	0.5	0.5	0.5	0.1	1.2	0.3	2.2	0.4	1.0	0.1	1.1	0.9	5.5
685a	0.6	0.5	0.4	0.1	0.4	0.2	1.3	0.2	0.8	0.1	0.8	0.6	6.8
685b	0.1	0.9	0.3	0.1	0.5	0.2	1.3	0.2	0.5	0.1	0.6	0.6	7.0
686a	0.3	0.6	0.5	0.0	0.7	0.2	1.6	0.3	0.8	0.1	0.8	0.5	7.6
686b	0.6	0.4	0.3	0.0	0.7	0.2	1.5	0.3	0.7	0.1	0.8	0.4	7.6
687a	0.4	0.4	0.3	0.0	0.5	0.2	1.2	0.2	0.7	0.1	0.6	0.2	4.8
687b	0.3	0.5	0.3	0.0	0.5	0.1	1.3	0.2	0.5	0.1	0.6	0.3	4.6
705a	0.1	0.5	0.4	0.0	0.5	0.2	1.2	0.2	0.5	0.1	0.7	0.3	4.6
705b	0.6	0.5	0.2	0.1	0.6	0.2	1.1	0.2	0.5	0.1	0.6	0.3	4.6
706a	0.1	0.3	0.1	0.0	0.3	0.0	0.5	0.0	0.2	0.0	0.2	0.1	4.1
706b	0.2	0.4	0.1	0.0	0.3	0.0	0.5	0.1	0.2	0.0	0.2	0.2	4.3
707a	0.9	0.5	0.2	0.1	1.0	0.2	1.6	0.3	0.6	0.1	0.7	0.4	5.2
707b	1.0	0.7	0.6	0.0	0.9	0.2	1.5	0.3	0.7	0.1	0.7	0.7	5.0
708a	0.7	0.5	0.1	0.0	0.1	0.1	0.5	0.1	0.2	0.0	0.2	0.4	4.3
708b	0.1	0.5	0.2	0.0	0.2	0.0	0.6	0.1	0.1	0.0	0.3	0.2	4.6
709a	0.3	0.7	0.0	-0.0	0.2	0.0	0.6	0.1	0.2	0.0	0.2	0.2	4.7
709b	0.5	0.5	0.1	0.0	0.2	0.1	0.4	0.0	0.1	0.0	0.2	0.2	4.6
710a	0.9	0.6	0.2	0.0	0.3	0.1	0.7	0.1	0.2	0.0	0.3	0.2	4.8
710b	0.5	0.6	0.1	0.0	0.4	0.1	0.6	0.1	0.3	0.0	0.2	0.3	4.8
711a	-0.1	0.5	0.3	0.0	0.3	0.1	0.4	0.1	0.1	0.0	0.2	0.2	4.9
711b	1.3	0.5	0.2	0.0	0.2	0.1	0.6	0.1	0.2	0.0	0.2	0.2	5.0
712a	0.6	0.1	0.3	0.0	0.4	0.0	0.4	0.1	0.2	0.0	0.3	0.2	4.9
712b	0.2	0.7	0.3	0.0	0.3	0.1	0.6	0.1	0.2	0.0	0.2	0.2	4.8
719a	0.3	0.2	0.5	0.1	0.9	0.2	1.2	0.2	0.7	0.1	0.8	0.3	4.7
719b	0.6	0.2	0.4	0.0	0.7	0.2	1.5	0.2	0.8	0.1	0.7	0.3	5.0
720a	0.5	0.7	0.3	0.1	0.5	0.2	1.3	0.2	0.7	0.1	0.7	0.4	5.3
720b	0.3	0.5	0.4	0.1	0.5	0.2	1.4	0.3	0.8	0.1	0.7	0.3	5.2
721a	0.3	0.2	0.3	0.0	0.5	0.2	1.4	0.2	0.6	0.1	0.7	0.2	4.9
721b	0.4	0.6	0.3	0.1	0.6	0.2	1.3	0.2	0.6	0.1	0.7	0.2	5.4
730a	1.0	0.7	0.3	0.1	1.2	0.2	1.5	0.3	0.5	0.1	0.7	0.4	5.3
730b	1.3	0.4	0.4	0.0	0.7	0.2	1.4	0.2	0.7	0.1	0.6	0.4	5.1
731a	0.9	1.4	0.8	0.0	1.3	0.2	2.0	0.4	0.9	0.1	0.9	0.5	6.3
731b	0.7	1.3	0.5	0.0	1.0	0.3	2.2	0.3	0.9	0.1	1.0	0.4	6.4
732a	1.5	1.1	0.8	0.1	1.1	0.2	2.0	0.3	0.7	0.1	0.9	0.5	6.5
732b	0.4	0.8	0.6	0.0	1.2	0.3	2.3	0.3	0.9	0.2	1.1	3.1	6.6
733a	0.5	0.5	0.4	0.0	0.8	0.2	1.4	0.3	0.9	0.2	0.7	0.2	6.4
733b	0.1	0.8	0.4	0.1	0.8	0.2	2.3	0.3	0.9	0.1	0.8	0.2	6.2
743a	0.1	0.5	0.5	0.0	0.7	0.1	1.6	0.3	0.7	0.1	0.7	0.4	7.3

TABLE D1 (continued)

Cat.	Nd145	Nd146	Sm147	Eu151	Gd157	Tb159	Dy162	Ho165	Er166	Tm169	Yb174	Th232	U238
743b	0.7	1.0	0.4	0.0	0.9	0.2	1.5	0.3	0.7	0.1	0.8	1.3	7.2
744a	2.0	1.5	0.6	0.1	0.4	0.1	0.5	0.1	0.2	0.0	0.2	0.7	5.8
744b	2.4	4.5	0.3	0.1	0.6	0.1	0.5	0.1	0.3	0.0	0.3	1.5	5.6
745a	1.9	0.6	0.5	0.1	0.4	0.2	1.1	0.2	0.5	0.1	0.5	0.6	6.6
745b	0.7	0.4	0.2	0.1	0.5	0.2	1.2	0.2	0.5	0.1	0.7	0.8	7.0
746a	0.8	0.6	0.4	0.1	1.1	0.2	2.3	0.4	1.2	0.1	1.2	0.7	6.4
746b	1.0	0.7	0.4	0.1	0.9	0.3	2.8	0.4	1.1	0.1	1.2	0.7	6.9
750a	0.1	0.2	0.1	0.1	0.4	0.1	0.9	0.2	0.4	0.1	0.4	0.4	6.8
750b	0.8	0.7	0.0	0.0	0.4	0.1	0.8	0.2	0.4	0.0	0.5	0.3	6.7
751a	4.1	5.6	3.9	0.1	3.9	0.2	1.5	0.7	1.3	0.1	0.6	2.6	6.0
751b	15.8	3.2	0.9	0.4	0.9	0.2	1.6	0.2	0.9	0.2	1.7	19.6	6.4
752a	0.9	1.5	0.4	0.1	0.5	0.1	1.0	0.2	0.5	0.1	0.3	0.5	6.6
752b	0.5	0.3	0.3	0.0	0.2	0.1	1.1	0.2	0.5	0.1	0.5	0.5	6.2
753a	0.5	0.5	0.2	0.0	0.2	0.1	1.0	0.2	0.3	0.1	0.4	0.4	6.5
753b	0.4	0.3	0.1	0.0	0.6	0.0	0.8	0.1	0.4	0.1	0.5	0.4	6.6
754a	2.6	4.0	1.0	0.1	1.3	0.2	1.7	0.2	0.7	0.1	0.5	4.7	6.5
754b	4.3	3.7	0.6	0.1	1.1	0.2	1.7	0.2	0.5	0.1	0.5	2.8	6.4
755a	1.6	2.2	0.5	0.1	0.6	0.1	1.2	0.1	0.5	0.1	0.5	1.4	6.7
755b	0.7	0.6	0.4	0.2	0.2	0.1	0.9	0.2	0.5	0.1	0.5	1.1	6.5
756a	2.6	1.8	0.6	0.0	1.0	0.1	1.6	0.3	0.5	0.1	0.7	3.8	6.1
756b	2.8	3.2	1.1	0.1	1.0	0.2	1.3	0.2	0.5	0.1	0.7	2.7	6.6
757a	10.5	6.9	1.3	0.1	1.7	0.7	1.7	0.4	1.0	0.1	0.7	6.6	5.9
757b	8.1	5.5	2.0	0.2	1.9	0.2	1.4	0.2	0.9	0.2	1.0	10.2	6.4
758a	10.3	23.0	3.8	0.3	3.3	0.4	2.2	0.7	1.0	0.2	1.4	24.3	6.4
758b	10.3	12.3	2.8	0.3	3.1	0.4	6.1	0.7	1.0	0.2	0.9	15.4	6.4
758c	4.5	4.6	1.3	0.1	1.1	0.2	1.7	0.3	0.7	0.1	1.0	5.8	6.2
758d	10.8	6.7	2.0	0.2	1.3	0.2	1.9	0.3	0.5	0.1	0.8	5.3	6.7
823a	0.0	4.9	0.2	-0.0	0.6	0.2	0.8	0.2	0.6	0.1	0.5	0.7	6.0
823b	0.5	0.6	0.1	0.0	0.6	0.1	1.1	0.3	0.5	0.2	0.5	1.3	5.9
824a	1.6	0.7	0.2	0.1	0.6	0.1	1.0	0.2	0.6	0.1	0.5	1.5	6.6
824b	0.6	0.8	0.3	0.1	0.6	0.3	1.2	0.2	0.7	0.1	0.7	2.1	7.8
825a	0.3	0.2	0.1	0.1	0.5	0.1	1.2	0.2	0.5	0.1	0.6	0.9	6.7
825b	0.1	0.1	0.2	0.0	0.5	0.1	1.3	0.1	0.4	0.1	0.5	0.8	6.5
826a	0.4	0.3	0.1	0.0	0.3	0.1	0.7	0.1	0.5	0.0	0.3	0.2	6.2
826b	0.3	0.5	0.3	0.0	0.6	0.1	1.1	0.1	0.5	0.0	0.5	0.2	6.0
827a	0.2	0.1	0.0	0.0	0.5	0.2	1.0	0.2	0.5	0.1	0.6	0.2	6.2
827b	0.2	0.3	0.2	0.0	0.6	0.1	1.2	0.2	0.4	0.1	0.6	0.3	6.2
828a	0.2	0.6	0.1	0.0	0.5	0.1	1.2	0.2	0.5	0.1	0.6	0.3	5.8
828b	0.3	0.5	0.1	0.0	0.6	0.2	1.2	0.2	0.5	0.1	0.5	0.3	5.9
829a	0.1	0.4	0.1	0.0	0.3	0.1	0.9	0.2	0.4	0.1	0.4	1.6	6.2
829b	0.3	0.5	0.2	0.0	0.5	0.1	1.1	0.2	0.5	0.1	0.6	0.2	7.1
830a	0.3	2.6	0.2	0.1	0.2	0.1	1.0	0.2	0.4	0.1	0.5	1.3	6.5
830b	0.4	0.6	0.3	0.0	0.8	0.1	1.1	0.2	0.6	0.1	0.5	0.9	6.4
870	0.9	0.7	0.1	0.1	0.3	0.0	0.4	0.1	0.2	0.0	0.2	0.2	4.3
872	1.2	0.9	0.7	0.1	0.8	0.2	1.4	0.3	0.6	0.1	0.6	0.5	5.4
873	2.0	1.5	0.6	0.0	1.3	0.3	2.6	0.8	1.3	0.2	1.4	1.4	10.2
874	0.6	0.2	0.1	0.0	0.4	0.1	0.9	0.2	0.6	0.1	0.7	0.2	9.2
901a	0.4	0.8	14.1	0.0	0.4	0.0	0.4	0.1	0.1	0.0	0.2	0.2	3.7
901b	0.7	0.6	0.1	0.0	0.3	0.1	0.3	0.1	0.2	0.0	0.2	0.1	4.0
902a	0.4	0.1	0.1	0.0	0.4	0.1	0.3	0.1	0.1	0.0	0.2	0.2	3.8
902b	0.4	0.8	0.2	0.1	0.5	0.0	0.2	0.1	0.1	0.0	0.2	0.1	3.8
911a	1.0	0.4	0.1	0.0	0.2	0.0	0.2	0.0	0.1	0.0	0.2	0.2	3.5
911b	0.5	0.6	0.3	0.0	0.4	0.0	0.4	0.0	0.1	0.0	0.1	0.2	4.0
912a	0.9	0.6	0.3	0.1	0.2	0.0	0.3	0.1	0.1	0.0	0.2	0.1	4.1

TABLE D1 (continued)

Cat.	Nd145	Nd146	Sm147	Eu151	Gd157	Tb159	Dy162	Ho165	Er166	Tm169	Yb174	Th232	U238
912b	0.5	0.9	0.1	0.1	0.5	0.1	0.4	0.1	0.1	0.0	0.1	0.1	4.2
922a	0.7	0.6	0.5	0.0	0.5	0.1	0.3	0.1	0.2	0.0	0.2	0.2	4.2
922b	0.8	0.6	0.2	0.0	0.4	0.0	0.5	0.1	0.1	0.0	0.2	0.3	4.1
923a	0.8	0.8	0.4	0.1	0.3	0.0	0.3	0.1	0.2	0.0	0.2	0.2	4.0
923b	1.4	0.7	0.3	0.1	0.5	0.0	0.4	0.0	0.2	0.0	0.2	0.2	4.1
924a	0.6	0.5	0.3	0.0	0.2	0.1	0.4	0.1	0.2	0.0	0.2	0.1	4.0
924b	0.6	0.7	0.2	0.1	0.2	0.0	0.3	0.1	0.1	0.0	0.1	0.2	4.0
939a	1.0	0.8	0.4	0.1	1.4	0.1	1.0	0.3	0.4	0.1	0.5	0.1	4.3
939b	1.5	1.2	0.4	0.1	1.0	0.1	1.2	0.2	0.4	0.1	0.5	0.1	3.8
940a	1.6	1.7	0.7	0.1	1.9	0.2	1.1	0.3	0.5	0.1	0.6	0.1	4.2
940b	1.0	1.1	0.6	0.1	1.4	0.2	1.0	0.3	0.5	0.1	0.4	0.1	4.1
941a	1.3	0.9	0.4	0.1	1.6	0.1	0.9	0.2	0.5	0.0	0.4	0.1	3.9
941b	1.2	1.1	0.5	0.1	1.5	0.2	0.9	0.2	0.5	0.0	0.5	0.1	4.5
942a	1.0	0.9	0.5	0.1	1.7	0.2	1.1	0.3	0.5	0.1	0.5	0.1	4.3
942b	1.2	1.3	0.6	0.1	1.6	0.2	1.0	0.3	0.5	0.1	0.6	0.1	4.5
943a	1.5	1.6	0.7	0.2	1.9	0.2	1.6	0.4	0.7	0.1	0.6	0.1	5.0
943b	2.3	1.3	0.5	0.1	2.3	0.1	1.3	0.3	0.6	0.0	0.6	0.2	4.7
944a	2.1	1.5	0.9	0.1	1.7	0.2	1.3	0.3	0.5	0.1	0.6	0.2	4.4
944b	1.5	1.9	0.6	0.1	1.6	0.2	1.0	0.2	0.5	0.1	0.5	0.2	4.3
945a	1.6	2.4	1.3	0.1	1.9	0.2	1.5	0.4	0.6	0.1	0.6	1.1	4.9
945b	2.9	2.5	1.2	0.2	1.7	0.2	1.4	0.4	0.7	0.1	0.7	1.3	4.5
964a	2.4	1.8	0.7	0.1	1.9	0.2	1.5	0.4	0.6	0.1	0.6	0.1	5.2
964b	1.9	2.0	0.8	0.2	2.2	0.2	1.4	0.3	0.7	0.1	0.7	0.1	5.0
965a	3.8	3.3	0.8	0.2	1.7	0.2	1.4	0.4	0.6	0.1	0.6	1.7	4.5
965b	4.6	3.1	1.2	0.1	1.5	0.2	1.3	0.4	0.6	0.1	0.5	0.8	4.7
966a	2.2	2.3	0.7	0.1	2.1	0.2	1.4	0.3	0.6	0.1	0.7	0.2	4.7
966b	2.4	2.2	0.9	0.1	2.0	0.2	1.5	0.4	0.6	0.1	0.6	0.2	4.4
974a	1.6	1.4	0.7	0.1	1.5	0.2	1.3	0.4	0.6	0.1	0.5	0.1	4.7
974b	2.4	1.3	0.7	0.2	1.3	0.2	1.4	0.3	0.6	0.1	0.6	0.2	5.0
975a	0.7	0.5	0.4	0.0	0.5	0.1	0.5	0.1	0.3	0.0	0.3	0.9	1.9
975b	0.2	0.5	0.2	0.1	0.4	0.1	0.5	0.1	0.2	0.0	0.3	1.2	1.8
986a	0.8	0.5	0.2	0.0	0.3	0.1	0.5	0.2	0.3	0.0	0.3	1.0	1.2
986b	0.3	0.4	0.3	0.0	0.3	0.0	0.5	0.1	0.1	0.0	0.3	0.9	1.0
987a	0.5	0.9	0.5	0.1	0.3	0.1	0.6	0.1	0.3	0.0	0.3	1.6	1.3
987b	0.9	1.2	0.3	0.1	0.4	0.1	0.6	0.2	0.3	0.0	0.3	1.5	1.3
988a	0.1	0.8	0.3	0.0	0.4	0.1	0.7	0.2	0.3	0.1	0.4	3.0	0.8
988b	0.8	0.7	0.3	0.0	0.3	0.1	0.6	0.1	0.3	0.0	0.3	2.9	0.7
989a	0.8	1.8	0.3	0.1	0.6	0.1	0.6	0.2	0.3	0.0	0.3	1.0	2.3
989b	1.1	0.6	0.3	0.1	0.3	0.1	0.6	0.2	0.3	0.0	0.3	1.0	2.2
990a	0.3	0.2	0.1	0.0	0.0	0.1	0.5	0.1	0.1	0.0	0.3	1.2	0.9
990b	0.3	0.3	0.3	0.0	0.6	0.1	0.9	0.2	0.5	0.1	0.7	2.2	1.6
996a	0.6	0.7	0.9	0.0	0.3	0.1	0.3	0.1	0.2	0.0	0.2	1.0	1.6
996b	0.7	0.6	0.2	0.0	0.3	0.0	0.3	0.1	0.2	0.0	0.2	1.2	1.7
997a	0.0	0.4	0.1	-0.0	0.0	0.0	0.2	0.1	0.1	0.0	0.1	0.7	0.9
997b	0.2	0.3	0.0	0.0	0.1	0.0	0.2	0.1	0.0	0.0	0.1	0.7	0.9
998a	0.5	0.5	0.2	0.0	0.3	0.1	0.3	0.1	0.2	0.0	0.3	1.0	1.1
998b	0.2	0.3	0.2	0.0	0.2	0.1	0.3	0.1	0.2	0.0	0.3	1.0	1.0
999a	0.1	0.4	0.1	0.0	0.4	0.1	0.5	0.1	0.3	0.0	0.3	1.1	1.0
999b	-0.1	0.2	0.2	0.0	0.4	0.1	0.5	0.1	0.2	0.0	0.3	1.0	0.9
1000a	0.3	0.7	0.3	0.0	0.5	0.1	0.5	0.2	0.3	0.0	0.5	2.5	0.9
1000b	0.2	0.4	0.3	0.0	0.4	0.1	0.5	0.2	0.3	0.0	0.4	2.3	0.9
1023	1.5	0.7	0.3	0.0	1.8	0.1	0.5	0.2	0.1	0.0	0.2	0.2	2.7
1024	2.0	0.5	0.2	0.1	1.5	0.1	0.4	0.0	0.0	0.0	0.2	0.2	3.0
1025	0.8	0.3	0.1	0.1	0.4	0.0	0.3	0.0	0.1	0.0	0.1	0.1	3.1

TABLE D1 (continued)

Cat.	Nd145	Nd146	Sm147	Eu151	Gd157	Tb159	Dy162	Ho165	Er166	Tm169	Yb174	Th232	U238
1026	0.6	0.3	0.2	0.0	0.2	0.1	0.2	0.0	0.0	0.0	0.2	0.2	3.1
1027	-0.0	0.4	0.4	0.1	0.1	0.0	0.4	0.0	0.0	0.0	0.0	0.1	3.2
1037	0.1	-0.1	0.1	0.0	0.3	0.0	0.2	-0.0	0.1	0.0	0.0	0.0	3.0
1038	0.6	0.7	0.1	0.0	0.0	0.0	0.4	0.0	0.2	0.0	0.2	0.5	3.0
1039	0.7	0.2	0.1	0.0	0.0	0.0	0.3	0.0	0.1	0.0	0.2	0.1	3.3
1040	1.3	0.9	0.4	0.1	0.3	0.0	0.5	0.1	0.1	0.0	0.2	0.2	3.4
1041	1.5	1.4	0.4	0.0	0.2	0.1	0.2	0.1	0.2	0.0	0.1	1.0	3.0

APPENDIX E. X-RAY FLUORESCENCE DATA

Cat.	Rb	Sr	Y	Zr	Nb	Fe2O3
						%
228	292	0	53	231	82	1.40
308	301	1	46	204	43	1.76
506	275	15	39	166	32	1.65
512	131	0	128	1559	233	8.01
546	263	32	50	90	64	1.26
551	240	25	38	96	55	1.33
602	242	26	33	96	57	1.34
603	225	17	35	79	56	1.31
604	258	26	35	93	64	1.43
654	265	27	31	93	64	1.46
668	259	30	37	93	62	1.37
669	242	25	38	88	62	1.38
685	225	81	32	139	40	1.71
688	236	75	20	168	41	1.56
709	237	95	23	177	43	1.74
710	234	95	27	171	39	1.68
712	222	92	21	173	44	1.69
722	207	112	27	214	44	1.76
723	247	104	37	165	50	1.78
729	219	109	20	229	42	1.77
734	252	97	38	155	56	1.60
742	252	32	23	113	39	1.36
743	247	28	19	105	43	1.31
744	217	141	23	253	34	1.93
758	259	49	19	148	43	1.39
759	239	59	24	142	41	1.39
769	207	124	19	231	38	1.79
830	259	42	22	118	43	1.44
831	235	35	11	109	42	1.34
832	237	51	21	134	43	1.42
946	166	147	31	262	34	1.84
947	156	143	28	263	34	1.80
948	157	145	27	274	38	1.81
976	146	135	20	236	30	1.79
977	168	151	27	270	41	1.78
978	170	148	23	260	38	1.85

APPENDIX F. ELECTRON MICROPROBE DATA FOR GEOLOGICAL OBSIDIAN SAMPLES

This appendix presents the analytical data from electron probe microanalysis for geological obsidian samples. All analyses were internally calibrated against international standards. A laboratory reference material, hornblende, was also repeatedly measured to insure consistency between analytical sessions, with the average and standard deviation for each session shown below (Table F1). The standard deviation for the 43 analyses of this standard may be considered as the analytical precision for all measurements.

Table F2 contains the raw data for each point analyzed, for each geological specimen. A series of individual samples were analyzed ten times each, to illustrate the homogeneity of obsidian glass; otherwise, at least three points per sample were analyzed. Phosphorus, manganese, and barium were not analyzed for all samples. Table F3 gives the average, normalized values for each specimen.

Date	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MgO	CaO	Na_2O	K_2O	P_2O_5	MnO	BaO
10/93 ave	40.58	14.64	4.77	11.48	13.17	10.19	2.76	2.10	0.17	0.09	0.04
10/93 sd	0.01	0.08	0.06	0.17	0.06	0.06	0.03	0.01	0.01	0.01	0.02
2/94 ave	40.62	14.53	4.80	11.49	13.20	10.15	2.77	2.12	0.16	0.09	0.05
2/94 sd	0.23	0.09	0.04	0.10	0.08	0.06	0.05	0.03	0.02	0.02	0.03
4/94 ave	40.69	14.53	4.77	11.61	13.16	10.08	2.75	2.09			0.07
4/94 sd	0.08	0.04	0.04	0.08	0.09	0.06	0.03	0.04			0.02
11/94 ave	40.60	14.50	4.86	11.57	13.14	10.10	2.77	2.14			0.07
11/94 sd	0.20	0.11	0.03	0.09	0.04	0.11	0.04	0.02			0.03
3/95 ave	40.70	14.42	4.81	11.59	13.29	10.04	2.77	2.10			0.03
3/95 sd	0.06	0.02	0.02	0.07	0.06	0.05	0.06	0.02			0.01
Ave	40.63	14.54	4.80	11.54	13.18	10.13	2.76	2.11	0.16	0.09	0.06
SD	0.17	0.10	0.05	0.12	0.08	0.08	0.04	0.03	0.02	0.02	0.03
n	43	43	43	43	43	43	43	42	24	24	43

Table F1. Microprobe analyses of a hornblende standard reference material.

TABLE F1

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
185	2.9a	74.73	13.39	0.07	1.11	0.10	0.56	3.38	5.06			0.03	98.43
185	2.9b	74.99	13.70	0.07	1.21	0.12	0.60	3.30	5.08			0.10	99.16
185	2.9c	75.12	13.36	0.06	1.13	0.10	0.57	3.45	5.16			0.02	98.97
185	2.9d	74.89	13.56	0.08	1.31	0.11	0.60	3.43	5.06			0.05	99.10
185	2.9e	73.98	13.54	0.07	1.18	0.12	0.59	3.42	4.94			0.03	97.87
186	2.10a	74.39	13.42	0.08	1.26	0.09	0.55	3.36	5.07			0.00	98.21
186	2.10b	74.34	13.35	0.07	1.21	0.08	0.58	3.39	5.06			0.00	98.06
186	2.10c	74.88	13.28	0.06	1.21	0.08	0.55	3.16	5.19			0.03	98.42
186	2.10d	75.10	13.11	0.06	1.26	0.08	0.54	3.37	5.07			0.05	98.64
186	2.10e	74.55	13.21	0.05	1.26	0.07	0.53	3.11	5.01			0.00	97.79
187	7.1a	74.83	13.35	0.10	1.23	0.10	0.60	3.49	5.17	0.07	0.05	0.00	98.99
187	7.1b	74.37	13.43	0.11	1.23	0.09	0.57	3.48	5.22	0.09	0.05	0.01	98.65
187	7.1c	74.31	13.53	0.10	1.24	0.09	0.59	3.47	5.29	0.07	0.04	0.01	98.75
188	7.2a	74.29	13.33	0.11	1.12	0.08	0.57	3.41	5.31	0.08	0.06	0.02	98.36
188	7.2b	73.77	13.99	0.09	1.11	0.06	0.72	4.01	4.74	0.08	0.03	0.03	98.62
188	7.2c	74.26	13.45	0.09	1.12	0.07	0.59	3.44	5.25	0.07	0.05	0.01	98.39
189	7.3a	74.14	13.32	0.10	1.28	0.08	0.59	3.41	5.30	0.07	0.05	0.01	98.35
189	7.3b	74.24	13.44	0.10	1.23	0.08	0.58	3.41	5.26	0.07	0.03	0.02	98.47
189	7.3c	74.56	13.44	0.11	1.17	0.08	0.60	3.43	5.28	0.09	0.05	0.05	98.85
190	7.4a	74.06	13.41	0.09	1.28	0.09	0.61	3.41	5.30	0.09	0.05	0.03	98.41
190	7.4b	73.98	13.56	0.11	1.26	0.09	0.60	3.42	5.26	0.09	0.04	0.00	98.42
190	7.4c	74.19	13.44	0.10	1.27	0.08	0.59	3.36	5.24	0.07	0.05	0.01	98.42
190	7.4d	74.27	13.52	0.10	1.23	0.09	0.60	3.45	5.22	0.07	0.05	0.00	98.59
191	7.5a	74.10	13.20	0.10	1.34	0.07	0.57	3.23	5.22	0.09	0.06	0.00	97.98
191	7.5b	73.70	13.46	0.09	1.17	0.05	0.62	3.59	5.12	0.08	0.06	0.03	97.96
191	7.5c	73.65	13.53	0.09	1.25	0.07	0.64	3.56	5.14	0.09	0.06	0.04	98.11

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
192	7.6a	74.13	13.30	0.08	1.18	0.05	0.60	3.37	5.24	0.09	0.07	0.04	98.15
192	7.6b	73.96	13.24	0.09	1.27	0.08	0.58	3.27	5.34	0.09	0.06	0.04	98.01
192	7.6c	73.48	13.28	0.10	1.24	0.07	0.57	3.35	5.25	0.10	0.05	0.03	97.52
192	7.6d	75.17	13.14	0.09	1.22	0.07	0.55	3.26	5.35	0.08	0.08	0.00	99.00
192	7.6e	74.29	13.43	0.10	1.24	0.07	0.59	3.36	5.30	0.07	0.05	0.02	98.55
192	7.6f	74.59	13.39	0.09	1.20	0.08	0.61	3.42	5.20	0.08	0.06	0.07	98.78
193	7.7a	73.13	13.15	0.11	1.29	0.08	0.58	3.37	5.25	0.07	0.05	0.04	97.12
193	7.7b	74.52	13.47	0.09	1.40	0.09	0.62	3.42	5.29	0.08	0.05	0.02	99.05
193	7.7c	73.83	13.79	0.08	1.11	0.08	0.81	3.70	5.03	0.08	0.06	0.05	98.62
193	7.7d	75.07	13.39	0.09	1.12	0.07	0.56	3.35	5.33	0.06	0.06	0.04	99.16
194	7.8a	74.35	13.56	0.10	1.31	0.09	0.59	3.46	5.26	0.07	0.05	0.03	98.87
194	7.8b	74.78	13.34	0.08	1.29	0.08	0.58	3.40	5.26	0.08	0.04	0.01	98.95
194	7.8c	74.71	13.33	0.08	1.26	0.07	0.60	3.45	5.23	0.08	0.05	0.02	98.89
195	1.10a	70.56	13.66	0.26	6.19	1.30	0.84	3.15	5.23	0.12	0.09		101.40
195	1.10b	71.40	13.62	0.25	3.42	0.71	0.79	3.13	5.54	0.12	0.07		99.04
195	1.10c	73.63	14.14	0.32	0.72	0.05	0.83	3.34	6.06	0.10	0.05		99.23
205	1.11a	74.02	13.98	0.27	0.81	0.04	0.78	3.28	5.95	0.11	0.02		99.26
205	1.11b	74.03	14.07	0.23	0.78	0.04	0.81	3.37	5.81	0.10	0.04		99.28
205	1.11c	71.96	13.57	0.24	2.17	0.04	0.78	3.36	5.88	0.12	0.03		98.16
206	1.12a	73.26	14.05	0.30	1.77	0.30	0.89	3.22	5.72	0.13	0.06		99.70
206	1.12b	72.55	14.09	0.27	1.75	0.30	0.87	3.25	5.76	0.13	0.06		99.02
206	1.12c	72.20	14.03	0.28	1.89	0.32	0.86	3.21	5.87	0.13	0.06		98.84
206	1.12d	73.28	14.09	0.30	1.84	0.27	0.86	2.05	5.13	0.11	0.05	0.11	98.09
212	1.13a	73.92	14.24	0.29	0.77	0.04	0.81	3.31	5.90	0.11	0.05	0.12	99.55
212	1.13b	74.51	14.15	0.27	0.79	0.04	0.80	3.36	5.81	0.11	0.05	0.12	100.02
212	1.13c	74.01	14.15	0.28	0.76	0.04	0.82	3.39	5.87	0.11	0.05	0.11	99.58

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
217	2.11a	74.26	13.45	0.06	1.24	0.12	0.59	3.20	5.12			0.04	98.08
217	2.11b	73.59	13.37	0.06	1.24	0.11	0.60	3.30	4.96			0.03	97.25
217	2.11c	74.12	13.46	0.08	1.34	0.12	0.61	3.35	5.03			0.00	98.10
217	2.11d	73.84	13.52	0.07	1.19	0.11	0.59	3.38	4.99			0.05	97.73
217	2.11e	74.40	13.52	0.07	1.26	0.10	0.59	3.46	4.87			0.00	98.27
227	2.12a	74.42	12.40	0.06	1.43	0.06	0.47	4.17	4.71			0.03	97.76
227	2.12b	74.05	12.18	0.07	1.39	0.07	0.46	4.06	4.49			0.02	96.79
227	2.12c	75.84	12.55	0.08	1.46	0.08	0.47	4.17	4.53			0.02	99.20
227	2.12d	74.87	12.43	0.06	1.44	0.08	0.45	4.14	4.66			0.00	98.12
227	2.12e	75.09	12.40	0.07	1.43	0.06	0.47	4.07	4.65			0.00	98.23
231.1	8.1a	73.29	12.15	0.11	1.34	0.06	0.47		4.82	0.02	0.06	0.00	92.32
231.1	8.1b	74.04	12.37	0.10	1.29	0.05	0.46	4.19	4.76	0.02	0.06	0.00	97.35
231.1	8.1c	74.16	12.28	0.10	1.35	0.05	0.44	4.17	4.76	0.01	0.08	0.01	97.41
231.2	8.2a	74.46	12.19	0.09	1.28	0.05	0.45	4.20	4.79	0.02	0.05	0.01	97.60
231.2	8.2b	74.03	12.21	0.10	1.54	0.04	0.44	4.15	4.86	0.03	0.05	0.00	97.46
231.2	8.2c	74.37	12.28	0.10	1.30	0.06	0.49	4.17	4.82	0.02	0.03	0.00	97.65
279	B1a	74.83	13.59	0.10	1.20	0.07	0.57	3.14	5.43				98.93
279	B1b	75.18	13.64	0.11	1.19	0.07	0.57	3.33	5.45				99.54
279	B1c	75.02	13.64	0.11	1.17	0.06	0.61	3.52	5.15				99.28
279	B1d	74.90	13.43	0.11	1.15	0.07	0.57	3.40	5.53				99.16
279	B1e	75.05	13.43	0.11	1.15	0.06	0.59	3.30	5.40				99.09
279	B1f	74.19	13.47	0.11	1.25	0.06	0.56	3.24	5.38				98.26
279	B1g	75.10	13.50	0.11	1.18	0.08	0.57	3.27	5.55				99.36
279	B1h	75.32	13.35	0.11	1.23	0.06	0.58	3.32	5.20				99.17
279	B1i	74.58	13.54	0.12	1.21	0.06	0.59	3.34	5.51				98.95
279	B1j	74.66	13.40	0.12	1.25	0.06	0.57	3.37	5.42				98.85

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
280	B2a	75.14	13.68	0.10	1.26	0.07	0.55	3.17	5.48				99.45
280	B2b	75.25	13.58	0.11	1.24	0.08	0.60	3.34	5.39				99.59
280	B2c	75.37	13.58	0.10	1.25	0.08	0.59	3.36	5.44				99.77
280	B2d	75.50	13.62	0.10	1.14	0.08	0.53	3.28	5.50				99.75
280	B2e	64.44	13.90	0.68	8.22	2.56	0.43	2.75	6.46				99.44
280	B2f	75.03	13.53	0.09	1.26	0.07	0.57	3.32	5.46				99.33
280	B2g	74.77	13.42	0.11	1.23	0.07	0.57	3.33	5.47				98.97
280	B2h	75.00	13.44	0.10	1.13	0.07	0.58	3.38	5.47				99.17
280	B2i	75.06	13.58	0.08	1.20	0.08	0.56	3.39	5.23				99.18
280	B2j	74.94	13.52	0.11	1.18	0.08	0.55	3.31	5.44				99.13
280	B2k	74.49	13.45	0.10	1.31	0.08	0.58	3.27	5.44				98.72
281	B3a	75.41	13.56	0.10	1.27	0.09	0.60	3.33	5.44				99.80
281	B3b	75.18	13.37	0.09	1.26	0.07	0.58	3.34	5.37				99.26
281	B3c	74.95	13.52	0.10	1.35	0.08	0.58	3.38	5.25				99.21
281	B3d	74.58	13.41	0.10	1.27	0.08	0.56	3.32	5.28				98.60
281	B3e	74.72	13.18	0.09	1.31	0.08	0.58	3.41	5.35				98.72
281	B3f	74.92	13.52	0.12	1.24	0.09	0.61	3.36	5.36				99.22
281	B3g	74.79	13.56	0.09	1.44	0.09	0.59	3.32	5.33				99.21
281	B3h	75.05	13.50	0.12	1.27	0.08	0.59	3.41	5.39				99.41
281	B3i	75.19	13.47	0.12	1.29	0.08	0.57	3.35	5.29				99.36
281	B3j	75.06	13.31	0.10	1.26	0.08	0.60	3.38	5.38				99.17
282	B4a	74.93	13.60	0.09	1.31	0.08	0.62	3.22	5.42				99.27
282	B4b	74.72	13.40	0.10	1.26	0.07	0.57	3.32	5.42				98.86
282	B4c	74.73	13.36	0.09	1.26	0.06	0.61	3.32	5.47				98.90
282	B4d	75.23	13.59	0.08	1.26	0.07	0.57	3.35	5.50				99.65
282	B4e	74.41	13.59	0.10	1.28	0.07	0.61	3.31	5.49				98.86

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
282	B4f	73.45	14.11	0.07	1.01	0.06	0.68	4.04	5.19				98.61
282	B4g	74.42	13.31	0.10	1.36	0.08	0.62	3.43	5.46				98.78
282	B4h	74.84	13.31	0.09	1.21	0.07	0.61	3.29	5.51				98.93
282	B4i	75.48	13.54	0.07	1.35	0.08	0.58	3.32	5.46				99.88
282	B4j	75.09	13.60	0.08	1.29	0.08	0.58	3.27	5.44				99.43
284	1.1a	86.39	0.52	0.00	0.04	0.01	0.12	0.14	0.15			0.00	87.39
284	1.1b	86.88	0.52	0.01	0.03	0.01	0.15	0.14	0.12			0.00	87.86
285	1.2a	48.90	11.98	2.05	8.42	2.96	5.34	4.51	1.44			0.05	85.65
285	1.2b	49.46	11.87	2.02	8.15	2.85	5.32	4.50	1.42			0.02	85.62
286	1.3a	80.71	1.05	0.04	0.29	0.16	0.14	0.22	0.41			0.01	83.03
286	1.3b	78.44	1.25	0.02	0.25	0.13	0.17	0.26	0.41			0.00	80.93
287	1.4a	79.65	1.00	0.02	0.13	0.09	1.63	0.19	0.22			0.01	82.95
287	1.4b	80.85	0.94	0.00	0.08	0.09	0.22	0.19	0.17			0.00	82.55
288	1.5a	84.74	0.89	0.02	1.53	0.66	0.14	0.15	1.02			0.00	89.15
288	1.5b	85.44	1.05	0.07	1.56	0.67	0.15	0.19	1.08			0.00	90.21
289	1.6a	80.91	0.64	0.01	0.12	0.04	0.12	0.19	0.19			0.01	82.24
289	1.6b	81.27	0.53	0.01	0.15	0.06	0.14	0.15	0.19			0.00	82.50
290	1.7a	78.40	0.51	0.01	1.24	0.54	0.06	0.12	0.85			0.03	81.76
290	1.7b	79.75	0.87	0.00	1.47	0.67	0.12	0.17	1.02			0.00	84.07
291	1.8a	83.34	0.68	0.01	0.17	0.03	0.09	0.21	0.11			0.06	84.70
291	1.8b	84.44	0.09	0.00	0.00	0.00	0.05	0.06	0.02			0.05	84.72
306	1.14a	74.77	13.16	0.08	1.60	0.04	0.74	3.99	5.08	0.09	0.05	0.00	99.61
306	1.14b	74.19	13.13	0.09	1.75	0.04	0.75	3.96	5.02	0.12	0.09	0.00	99.15
306	1.14c	74.57	13.11	0.09	1.81	0.06	0.70	3.98	5.04	0.12	0.07	0.00	99.55
307	1.15a	74.51	13.21	0.09	1.65	0.05	0.67	4.02	4.95	0.10	0.05	0.00	99.30
307	1.15b	74.54	13.14	0.07	1.69	0.04	0.70	4.07	5.03	0.11	0.02	0.00	99.42

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
307	1.15c	74.31	13.13	0.08	1.80	0.04	0.75	3.95	5.03	0.10	0.04	0.00	99.24
308	1.16a	74.18	12.99	0.08	1.55	0.04	0.67	3.72	5.44	0.12	0.03	0.02	98.83
308	1.16b	74.55	13.15	0.10	1.73	0.05	0.72	3.75	5.46	0.13	0.06	0.00	99.69
308	1.16c	74.47	12.85	0.07	1.70	0.04	0.72	3.71	5.26	0.13	0.06	0.00	98.99
310	3.4a	76.00	12.96	0.12	1.16	0.09	0.55	3.22	5.22	0.09	0.05	0.02	99.47
310	3.4b	76.11	13.19	0.11	1.09	0.11	0.52	3.30	5.31	0.12	0.09	0.03	99.97
310	3.4c	73.93	12.91	0.11	2.79	0.11	0.56	3.38	5.24	0.12	0.07	0.04	99.25
311	3.5a	76.12	13.23	0.11	1.13	0.10	0.54	3.36	5.28	0.10	0.05	0.00	100.03
311	3.5b	75.83	13.17	0.11	1.18	0.11	0.56	3.31	5.26	0.11	0.02	0.03	99.68
311	3.5c	75.91	13.11	0.10	1.01	0.10	0.54	3.40	5.40	0.10	0.04	0.02	99.72
312	3.6a	75.86	13.09	0.12	1.11	0.11	0.52	3.18	5.26	0.12	0.03	0.03	99.44
312	3.6b	75.92	13.10	0.12	1.03	0.11	0.55	3.30	5.24	0.13	0.06	0.02	99.57
312	3.6c	75.61	13.14	0.10	1.09	0.10	0.53	3.38	5.23	0.13	0.06	0.03	99.38
313	3.7a	75.97	13.07	0.13	1.07	0.11	0.55	3.26	5.35	0.13	0.06	0.00	99.71
313	3.7b	75.94	13.07	0.12	1.04	0.10	0.55	3.24	5.35	0.11	0.05	0.02	99.60
313	3.7c	75.85	13.05	0.13	1.07	0.11	0.58	3.24	5.26	0.11	0.05	0.03	99.48
314	3.8a	75.48	13.10	0.11	1.17	0.13	0.59	3.48	5.16			0.06	99.27
314	3.8b	75.50	13.12	0.11	1.15	0.12	0.60	3.26	5.24			0.00	99.09
314	3.8c	75.51	12.99	0.14	1.04	0.13	0.62	3.30	5.36			0.04	99.12
314	3.8d	75.09	13.13	0.12	1.04	0.16	0.57	3.40	5.24			0.04	98.80
314	3.8e	75.01	13.11	0.12	1.07	0.14	0.59	3.45	5.28			0.03	98.78
315	2.8a	73.22	12.98	0.05	1.30	0.07	0.54	3.42	4.76			0.00	96.33
315	2.8b	76.24	6.51	0.03	0.51	0.03	0.26	1.77	2.55			0.00	87.90
315	2.8c	73.38	12.78	0.05	1.27	0.08	0.55	3.22	4.81			0.00	96.14
315	2.8d	72.41	13.05	0.05	1.25	0.09	0.53	3.33	4.84			0.03	95.56
315	2.8e	73.67	12.68	0.07	1.20	0.09	0.54	3.09	4.86			0.02	96.21

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
315	B6a	74.83	13.65	0.09	1.31	0.09	0.60	3.22	5.32				99.11
315	B6b	74.54	13.36	0.10	1.34	0.09	0.59	3.37	5.30				98.69
315	B6c	74.55	13.46	0.08	1.29	0.09	0.57	3.33	5.45				98.82
315	B6d	74.90	13.67	0.10	1.31	0.08	0.58	3.41	5.31				99.36
315	B6e	74.68	13.56	0.11	1.31	0.09	0.59	3.36	5.38				99.08
315	B6f	75.56	13.49	0.09	1.16	0.05	0.61	3.60	5.17				99.73
315	B6g	74.47	13.59	0.11	1.28	0.09	0.60	3.40	5.51				99.05
315	B6h	74.67	13.30	0.08	1.34	0.10	0.61	3.35	5.33				98.78
315	B6i	74.75	13.48	0.09	1.26	0.08	0.59	3.34	5.27				98.86
315	B6j	74.28	13.59	0.09	1.37	0.08	0.59	3.39	5.36				98.75
544	7.9a	74.67	13.60	0.09	1.13	0.06	0.58	3.46	5.21	0.08	0.06	0.00	98.95
544	7.9b	74.85	13.28	0.11	1.15	0.05	0.55	3.31	5.31	0.09	0.05	0.01	98.76
544	7.9c	71.38	16.07	0.06	0.75	0.02	1.06	5.51	4.09	0.10	0.02	0.10	99.17
545	7.10a	74.82	13.07	0.09	1.14	0.06	0.52	3.29	5.16	0.08	0.06	0.00	98.29
545	7.10b	74.78	13.30	0.09	1.17	0.06	0.57	3.43	5.23	0.08	0.06	0.00	98.75
545	7.10c	75.09	13.29	0.10	1.17	0.06	0.54	3.34	5.19	0.09	0.03	0.01	98.92
546	7.11a	74.70	13.52	0.10	1.26	0.08	0.59	3.45	5.26	0.08	0.04	0.02	99.09
546	7.11b	70.44	13.05	0.16	6.26	0.11	0.55	3.48	4.92	0.09	0.07	0.04	99.17
546	7.11c	74.44	13.37	0.08	1.22	0.08	0.60	3.43	5.22	0.09	0.05	0.04	98.63
547	7.12a	75.34	13.19	0.08	1.03	0.04	0.53	3.46	4.99	0.10	0.07	0.04	98.86
547	7.12b	74.48	13.36	0.08	1.22	0.07	0.54	3.36	5.31	0.08	0.04	0.07	98.63
547	7.12c	74.29	13.53	0.09	1.08	0.05	0.62	3.59	5.10	0.09	0.04	0.00	98.48
548	7.13a	75.02	13.11	0.09	1.00	0.05	0.52	3.25	5.14	0.10	0.05	0.04	98.38
548	7.13b	74.33	13.18	0.10	1.13	0.06	0.55	3.34	5.12	0.09	0.05	0.02	97.96
548	7.13c	74.59	13.56	0.09	1.00	0.04	0.58	3.52	5.03	0.08	0.04	0.01	98.55
624	7.14a	74.49	13.41	0.09	1.15	0.06	0.52	3.34	5.17	0.08	0.05	0.02	98.39

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
624	7.14b	75.13	13.18	0.07	0.96	0.05	0.52	3.41	4.92	0.09	0.06	0.05	98.44
624	7.14c	74.16	13.35	0.09	1.23	0.09	0.55	3.37	5.15	0.10	0.07	0.08	98.23
625	7.15a	74.12	13.44	0.10	1.22	0.07	0.58	3.39	5.27	0.08	0.05	0.03	98.33
625	7.15b	74.05	13.40	0.10	1.33	0.09	0.57	3.38	5.28	0.08	0.03	0.01	98.32
625	7.15c	74.33	13.56	0.10	1.19	0.07	0.56	3.40	5.16	0.08	0.06	0.02	98.54
626	7.16a	74.33	13.46	0.09	1.19	0.08	0.57	3.40	5.16	0.10	0.07	0.00	98.46
626	7.16b	74.38	13.47	0.09	1.21	0.09	0.57	3.46	5.19	0.09	0.03	0.00	98.58
626	7.16c	74.60	13.42	0.09	1.11	0.10	0.56	3.39	5.10	0.08	0.03	0.01	98.49
628	7.17a	73.90	13.84	0.09	1.14	0.08	0.73	3.77	4.75	0.07	0.05	0.00	98.42
628	7.17b	74.09	13.62	0.08	1.11	0.08	0.61	3.53	5.01	0.09	0.06	0.00	98.28
628	7.17c	74.11	13.62	0.08	1.11	0.07	0.60	3.58	4.94	0.08	0.02	0.03	98.24
629	7.18a	74.24	13.33	0.11	1.27	0.09	0.58	3.37	5.18	0.07	0.04	0.02	98.29
629	7.18b	74.22	13.55	0.09	1.28	0.09	0.59	3.35	5.24	0.08	0.05	0.00	98.54
629	7.18c	74.73	13.41	0.10	1.24	0.08	0.57	3.40	5.14	0.09	0.05	0.02	98.83
654	8.5a	73.77	13.39	0.09	1.18	0.04	0.59	3.56	5.15	0.08	0.06	0.00	97.90
654	8.5b	74.55	13.18	0.09	1.29	0.06	0.56	3.37	5.39	0.06	0.05	0.00	98.60
654	8.5c	74.14	13.51	0.09	1.19	0.06	0.63	3.47	5.12	0.08	0.07	0.03	98.39
655	8.6a	73.90	13.51	0.08	1.14	0.05	0.62	3.61	5.14	0.06	0.08	0.05	98.24
655	8.6b	74.03	13.40	0.10	1.21	0.06	0.58	3.41	5.32	0.09	0.05	0.01	98.27
655	8.6c	74.00	13.23	0.10	1.20	0.06	0.57	3.35	5.37	0.09	0.05	0.00	98.02
656	8.7a	73.78	13.37	0.08	1.25	0.07	0.58	3.37	5.36	0.07	0.06	0.03	98.03
656	8.7b	73.79	13.39	0.10	1.28	0.08	0.59	3.41	5.31	0.07	0.03	0.03	98.08
656	8.7c	75.14	12.97	0.09	1.13	0.06	0.60	3.27	5.03	0.07	0.07	0.02	98.44
668	8.3a	74.04	13.45	0.09	1.24	0.08	0.53	3.46	5.27	0.09	0.07	0.00	98.32
668	8.3b	73.75	13.41	0.10	1.25	0.09	0.57	3.40	5.28	0.09	0.06	0.00	98.01
668	8.3c	74.11	13.59	0.09	1.24	0.09	0.58	3.45	5.37	0.08	0.04	0.00	98.64

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
669	8.4a	73.71	13.09	0.10	1.34	0.05	0.57		5.30	0.06	0.06	0.01	94.29
669	8.4b	74.28	13.15	0.09	1.25	0.05	0.57	3.29	5.32	0.09	0.05	0.00	98.14
669	8.4c	73.98	13.27	0.09	1.18	0.05	0.61	3.40	5.29	0.07	0.06	0.02	98.04
683	4.11a	73.36	13.70	0.19	1.51	0.16	0.87	3.49	5.22	0.11	0.02	0.04	98.66
683	4.11b	73.06	13.77	0.20	1.65	0.21	0.99	3.48	5.08	0.13	0.04	0.07	98.68
683	4.11c	72.49	13.69	0.21	1.92	0.26	0.98	3.39	4.99	0.14	0.06	0.05	98.18
683	4.11d	72.96	14.10	0.20	1.48	0.20	1.07	3.61	5.10			0.02	98.73
683	4.11e	73.11	13.66	0.20	1.79	0.20	0.99	3.48	5.11			0.08	98.60
684	4.12a	73.68	13.67	0.16	1.27	0.13	0.78	3.44	5.27	0.10	0.05	0.08	98.63
684	4.12b	73.54	13.65	0.17	1.28	0.13	0.75	3.44	5.38	0.10	0.04	0.04	98.53
684	4.12c	72.65	13.53	0.16	1.33	0.13	0.82	3.53	5.25	0.09	0.06	0.02	97.57
685	4.13a	72.89	13.50	0.16	1.55	0.16	0.77	3.37	5.32	0.10	0.07	0.00	97.89
685	4.13b	72.17	13.34	0.17	1.80	0.17	0.76	3.49	5.28	0.12	0.04	0.06	97.40
685	4.13c	72.93	13.58	0.16	1.46	0.16	0.79	3.41	5.41	0.12	0.04	0.07	98.13
688	4.14a	73.82	13.48	0.15	1.21	0.09	0.73	3.36	5.51	0.11	0.05	0.06	98.57
688	4.14b	73.85	13.44	0.13	1.12	0.07	0.73	3.31	5.47	0.09	0.04	0.06	98.31
688	4.14c	72.38	13.43	0.15	2.91	0.28	0.69	3.32	5.33	0.08	0.11	0.05	98.74
689	4.15a	73.52	13.40	0.15	1.50	0.15	0.74	3.51	5.37	0.09	0.05	0.04	98.52
689	4.15b	73.14	13.50	0.16	1.46	0.13	0.76	3.41	5.19	0.11	0.06	0.07	97.98
689	4.15c	73.11	13.40	0.16	1.58	0.14	0.77	3.41	5.29	0.10	0.05	0.09	98.09
708	5.1a	73.50	13.63	0.19	1.36	0.14	0.72	3.31	5.72	0.12	0.03	0.10	98.83
708	5.1b	73.36	13.64	0.19	1.62	0.16	0.71	3.32	5.60	0.12	0.03	0.09	98.83
708	5.1c	73.06	13.56	0.19	1.71	0.18	0.72	3.26	5.67	0.11	0.04	0.06	98.56
710	5.2a	73.51	13.65	0.18	0.85	0.06	0.73	3.40	5.75	0.12	0.02	0.07	98.32
710	5.2b	72.62	13.61	0.18	2.44	0.26	0.73	3.25	5.54	0.12	0.05	0.05	98.87
710	5.2c	73.47	13.78	0.18	0.75	0.06	0.74	3.29	5.71	0.11	0.04	0.08	98.22

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
711	5.3a	72.74	13.57	0.18	1.36	0.15	0.73	3.25	5.72	0.11	0.03	0.03	97.87
711	5.3b	72.67	13.48	0.17	1.35	0.15	0.73	3.22	5.61	0.12	0.04	0.03	97.56
711	5.3c	72.40	13.44	0.18	1.41	0.15	0.73	3.19	5.65	0.10	0.05	0.01	97.31
713	5.4a	72.82	13.36	0.15	1.35	0.13	0.76	3.39	5.28	0.06	0.07	0.00	97.37
713	5.4b	72.92	13.42	0.14	1.38	0.13	0.76	3.46	5.39	0.08	0.05	0.04	97.77
713	5.4c	72.58	13.41	0.14	1.17	0.12	0.74	3.38	5.25	0.08	0.05	0.04	96.97
714	5.5a	72.34	13.43	0.18	1.46	0.18	0.76	3.25	5.51	0.14	0.05	0.07	97.38
714	5.5b	72.38	13.58	0.18	1.20	0.10	0.75	3.27	5.62	0.12	0.05	0.08	97.33
714	5.5c	72.19	13.36	0.19	1.69	0.18	0.73	3.21	5.46	0.10	0.02	0.09	97.23
722	5.6a	72.41	13.42	0.14	1.37	0.13	0.74	3.35	5.47	0.08	0.05	0.01	97.17
722	5.6b	72.69	13.53	0.16	1.16	0.11	0.64	3.38	5.54	0.09	0.02	0.03	97.35
722	5.6c	73.00	13.44	0.14	1.76	0.23	1.32	3.90	3.81	0.11	0.02	0.04	97.77
723	5.7a	72.81	13.43	0.14	1.25	0.13	0.75	3.33	5.37	0.09	0.03	0.00	97.33
723	5.7b	72.53	13.39	0.14	1.25	0.12	0.74	3.35	5.35	0.09	0.03	0.01	97.00
723	5.7c	72.54	13.44	0.14	2.27	0.13	0.74	3.44	5.32	0.10	0.05	0.01	98.18
724	5.8a	72.75	13.32	0.12	1.18	0.09	0.76	3.36	5.31	0.12	0.05	0.02	97.08
724	5.8b	72.71	13.17	0.13	1.52	0.10	0.70	3.27	5.38	0.09	0.05	0.01	97.12
724	5.8c	72.44	13.38	0.13	1.64	0.11	0.70	3.32	5.42	0.09	0.06	0.00	97.28
724	5.8d	64.44	19.15	0.16	1.29	0.27	4.26	4.90	2.97	0.12	0.04	0.04	97.65
724	5.8e	72.14	13.25	0.13	1.88	0.10	0.69	3.22	5.34	0.08	0.06	0.04	96.93
725	5.9a	69.73	13.49	0.57	3.86	0.72	0.75	3.28	5.51	0.10	0.06	0.05	98.12
725	5.9b	74.05	13.59	0.14	1.26	0.09	0.79	3.34	5.44			0.05	98.74
725	5.9c	73.81	13.44	0.15	1.27	0.11	0.70	3.44	5.42			0.05	98.38
726	5.10a	72.55	13.47	0.14	1.20	0.09	0.77	3.34	5.44	0.09	0.06	0.00	97.14
726	5.10b	73.07	13.31	0.14	1.28	0.10	0.74	3.35	5.31	0.10	0.07	0.04	97.51
726	5.10c	72.70	13.44	0.15	1.30	0.10	0.74	3.26	5.35	0.07	0.05	0.07	97.23

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
729	5.11a	72.70	13.74	0.25	1.20	0.12	0.81	3.57	5.54	0.10	0.01	0.10	98.15
729	5.11b	71.31	13.66	0.25	1.32	0.12	0.82	3.53	5.53	0.12	0.04	0.10	96.81
729	5.11c	71.00	13.30	0.26	1.38	0.18	0.86		5.50	0.12	0.05	0.04	92.69
729	5.11d	72.99	13.83	0.25	1.72	0.40	0.82	3.50	5.55			0.05	99.11
729	5.11e	73.19	13.80	0.24	1.28	0.21	0.79	3.56	5.70			0.09	98.86
734	5.12a	73.77	13.40	0.13	1.22	0.07	0.70	3.29	5.52	0.08	0.07	0.03	98.28
734	5.12b	72.67	13.32	0.13	2.60	0.08	0.67	3.23	5.52	0.09	0.05	0.03	98.39
734	5.12c	73.42	13.38	0.13	1.12	0.08	0.72	3.24	5.51	0.10	0.04	0.03	97.78
735	5.13a	71.37	15.09	0.10	0.74	0.03	0.91	4.56	4.86	0.07	0.03	0.25	98.00
735	5.13b	72.89	13.01	0.15	1.39	0.18	0.76		5.54	0.11	0.04	0.04	94.11
735	5.13c	72.37	13.22	0.14	1.19	0.08	0.70	3.23	5.42	0.08	0.06	0.01	96.50
736	5.14a	73.59	13.19	0.13	0.96	0.04	0.73	3.50	5.14	0.10	0.04	0.04	97.46
736	5.14b	72.65	13.05	0.13	1.10	0.08	0.56	3.30	5.44	0.09	0.04	0.06	96.51
736	5.14c	72.93	13.32	0.15	1.02	0.06	0.73	3.48	5.07	0.08	0.02	0.07	96.92
737	5.15a	72.78	13.11	0.13	1.56	0.08	0.65	3.36	5.43	0.07	0.03	0.02	97.22
737	5.15b	73.79	13.36	0.13	0.99	0.06	0.73	3.44	5.10	0.07	0.04	0.05	97.74
737	5.15c	73.33	13.48	0.14	1.03	0.07	0.74	3.49	5.21	0.07	0.05	0.06	97.67
742	6.1a	74.57	13.02	0.13	1.30	0.09	0.55	3.39	5.41	0.08	0.04	0.04	98.62
742	6.1b	74.72	13.03	0.13	1.23	0.10	0.55	3.37	5.34	0.09	0.04	0.00	98.60
742	6.1c	74.59	12.84	0.13	1.20	0.10	0.58	3.37	5.43	0.07	0.05	0.03	98.39
743	6.2a	73.71	12.70	0.12	2.06	0.09	0.58	3.32	5.32	0.09	0.03	0.02	98.05
743	6.2b	74.81	12.99	0.11	0.96	0.09	0.54	3.29	5.35	0.08	0.04	0.00	98.25
743	6.2c	74.35	12.87	0.11	1.02	0.09	0.57	3.30	5.42	0.09	0.05	0.00	97.87
743	6.2d	74.64	12.86	0.11	1.07	0.09	0.56	3.34	5.35	0.07	0.02	0.01	98.11
745	6.4a	73.78	13.01	0.15	2.53	0.13	0.58	3.32	5.40	0.07	0.04	0.04	99.06
745	6.4b	74.27	13.18	0.15	1.25	0.14	0.62	3.44	5.50	0.08	0.04	0.00	98.66

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
745	6.4c	74.55	13.18	0.14	1.16	0.13	0.60	3.40	5.51	0.08	0.05	0.04	98.83
747	6.5a	73.46	13.46	0.14	1.15	0.11	0.64	3.30	5.54	0.09	0.06	0.04	97.99
747	6.5b	73.50	13.39	0.13	1.32	0.11	0.69	3.42	5.44	0.08	0.06	0.05	98.18
747	6.5c	73.43	13.49	0.13	1.46	0.16	0.66	3.31	5.50	0.09	0.05	0.06	98.35
756	6.6a	74.35	12.94	0.13	1.01	0.11	0.58	3.30	5.36	0.07	0.02	0.03	97.89
756	6.6b	74.40	12.99	0.15	1.05	0.11	0.58	3.29	5.47	0.07	0.01	0.03	98.15
756	6.6c	74.37	12.84	0.13	1.10	0.13	0.58	3.30	5.43	0.07	0.05	0.00	98.00
757	6.7a	73.65	13.06	0.15	1.15	0.13	0.65	3.24	5.53	0.08	0.02	0.04	97.71
757	6.7b	73.71	13.06	0.16	0.99	0.10	0.65	3.25	5.78	0.08	0.03	0.03	97.85
757	6.7c	73.60	13.13	0.16	1.57	0.19	0.62	3.23	5.69	0.09	0.03	0.02	98.34
759	6.8a	74.94	13.17	0.16	0.76	0.06	0.59	3.37	5.67	0.09	0.03	0.02	98.84
759	6.8b	74.06	13.25	0.15	1.48	0.18	0.59	3.35	5.67	0.09	0.06	0.05	98.91
759	6.8c	74.63	13.19	0.15	0.82	0.06	0.62	3.42	5.67	0.09	0.03	0.06	98.74
760	6.9a	74.92	13.31	0.15	1.17	0.13	0.62	3.24	5.59	0.07	0.03	0.04	99.27
760	6.9b	74.40	13.16	0.16	1.11	0.13	0.63	3.27	5.59	0.09	0.05	0.03	98.61
760	6.9c	74.16	13.17	0.15	1.14	0.13	0.61	3.37	5.67	0.07	0.04	0.05	98.56
761	6.10a	73.77	13.14	0.15	1.46	0.17	0.59	3.21	5.81	0.07	0.05	0.00	98.44
761	6.10b	73.98	13.18	0.15	1.17	0.14	0.60	3.13	5.74	0.08	0.05	0.08	98.30
761	6.10c	74.09	13.08	0.15	1.06	0.10	0.59	3.18	5.90	0.07	0.04	0.00	98.26
821	6.11a	73.96	12.81	0.12	1.01	0.10	0.60	3.33	5.44	0.08	0.02	0.01	97.50
821	6.11b	74.00	12.76	0.13	1.36	0.15	0.56	3.23	5.49	0.07	0.03	0.03	97.83
821	6.11c	74.01	12.89	0.12	1.10	0.10	0.60	3.27	5.40	0.08	0.03	0.05	97.66
822	6.12a	74.46	12.93	0.12	1.11	0.11	0.60	3.28	5.42	0.07	0.02	0.05	98.17
822	6.12b	73.54	12.92	0.16	1.71	0.31	0.57	3.27	5.46	0.07	0.03	0.06	98.11
822	6.12c	74.46	12.97	0.13	1.20	0.11	0.60	3.28	5.35	0.07	0.04	0.00	98.20
823	6.13a	74.50	13.00	0.14	1.22	0.12	0.59	3.33	5.49	0.09	0.04	0.05	98.58

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
823	6.13b	74.36	12.97	0.13	1.28	0.11	0.59	3.37	5.51	0.07	0.04	0.06	98.49
823	6.13c	74.04	13.08	0.15	1.20	0.14	0.60	3.46	5.44	0.08	0.03	0.02	98.25
824	6.14a	74.15	13.02	0.12	1.45	0.10	0.59	3.28	5.45	0.07	0.02	0.01	98.28
824	6.14b	74.76	13.01	0.13	1.13	0.11	0.58	3.29	5.45	0.07	0.03	0.02	98.58
824	6.14c	74.34	12.94	0.13	1.07	0.11	0.58	3.25	5.52	0.07	0.03	0.00	98.04
825	6.15a	73.99	12.92	0.13	1.16	0.10	0.59	3.27	5.47	0.07	0.04	0.00	97.74
825	6.15b	74.10	12.87	0.12	1.31	0.11	0.59	3.30	5.44	0.08	0.05	0.02	98.00
825	6.15c	73.83	12.78	0.12	1.17	0.11	0.59	3.24	5.33	0.08	0.05	0.00	97.28
901	45.1a	71.72	13.75	0.28	1.63	0.26	0.86	3.25	5.90			0.11	97.78
901	45.1b	71.97	13.66	0.29	1.75	0.25	0.83	3.17	5.85			0.16	97.95
902	45.2a	72.25	13.65	0.26	1.30	0.13	0.87	3.21	6.11			0.07	97.85
902	45.2b	72.26	13.64	0.25	1.46	0.18	0.81	3.21	6.00			0.10	97.91
936	8.8a	72.27	13.13	0.23	1.32	0.18	0.72		6.07	0.12	0.03	0.09	94.16
936	8.8b	72.56	13.81	0.29	1.50	0.20	0.90	3.26	5.93	0.17	0.03	0.12	98.76
936	8.8c	72.00	13.84	0.29	1.73	0.26	0.89	3.32	5.77	0.14	0.04	0.16	98.43
946	8.9a	71.96	14.02	0.28	1.48	0.25	0.89	3.32	5.91	0.11	0.03	0.09	98.34
946	8.9b	71.79	13.66	0.28	2.13	0.28	0.79	3.23	6.01	0.15	0.03	0.11	98.45
946	8.9c	71.77	14.23	0.26	1.50	0.21	1.08	3.38	5.70	0.15	0.02	0.09	98.40
947	8.10a	72.14	13.98	0.28	1.58	0.26	0.86	3.26	5.92	0.13	0.03	0.11	98.54
947	8.10b	71.88	13.95	0.28	1.64	0.25	0.91	3.21	5.95	0.13	0.02	0.10	98.32
947	8.10c	71.67	14.10	0.31	1.77	0.35	0.90	3.32	5.92	0.12	0.01	0.11	98.58
948	8.11a	71.51	13.96	0.28	1.67	0.28	0.87	3.25	5.96	0.13	0.02	0.11	98.03
948	8.11b	71.76	13.83	0.28	1.62	0.28	0.85	3.25	5.93	0.12	0.04	0.11	98.08
948	8.11c	71.83	13.91	0.29	1.60	0.29	0.84	3.26	6.05	0.15	0.03	0.08	98.33
949	8.12a	71.54	13.71	0.29	1.53	0.23	0.96	3.25	5.86	0.19	0.03	0.14	97.73
949	8.12b	71.82	13.92	0.28	1.65	0.27	0.91	3.24	5.98	0.13	0.03	0.07	98.30

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
949	8.12c	72.06	14.24	0.27	1.49	0.21	0.97	3.31	5.90	0.14	0.02	0.12	98.73
950	8.13a	71.80	13.90	0.23	1.48	0.20	0.84	3.23	5.95	0.12	0.03	0.10	97.88
950	8.13b	72.85	13.72	0.22	1.41	0.21	0.73	3.17	5.97	0.12	0.04	0.09	98.53
950	8.13c	72.39	13.87	0.26	1.56	0.21	0.85	3.24	5.95	0.14	0.02	0.06	98.56
967	9.11a	72.54	14.05	0.30	1.41	0.24	1.25	3.61	5.17	0.17	0.01	0.12	98.86
967	9.11b	72.26	14.08	0.29	1.41	0.19	0.88	3.22	6.12	0.16	0.02	0.16	98.79
967	9.11c	72.77	13.93	0.29	1.36	0.11	0.85	3.23	6.04	0.13	0.02	0.15	98.87
968	9.12a	72.12	13.93	0.29	1.38	0.18	0.92	3.39	5.78	0.13	0.03	0.10	98.25
968	9.12b	71.89	13.89	0.30	1.68	0.21	0.80	3.28	6.04	0.14	0.04	0.09	98.35
968	9.12c	72.17	13.90	0.28	1.48	0.26	1.19	3.66	5.02	0.15	0.03	0.05	98.20
969	9.13a	71.70	13.81	0.28	1.68	0.28	0.89		5.56	0.12	0.03	0.08	94.43
969	9.13b	72.23	14.19	0.30	1.63	0.27	0.89	3.27	5.73	0.13	0.02	0.09	98.75
969	9.13c	71.65	14.02	0.29	1.82	0.27	0.87	3.33	5.77	0.13	0.03	0.09	98.28
970	9.14a	72.26	13.93	0.28	1.79	0.26	0.88	3.20	5.79	0.16	0.02	0.10	98.66
970	9.14b	72.18	13.88	0.27	1.74	0.25	0.89	3.20	5.85	0.13	0.06	0.12	98.56
970	9.14c	71.82	13.88	0.35	2.07	0.40	0.80	3.28	5.95	0.14	0.05	0.06	98.80
971	9.15a	70.98	14.13	0.29	1.97	0.30	0.93	3.22	5.78	0.13	0.05	0.10	97.89
971	9.15b	71.65	13.96	0.31	1.59	0.21	0.93	3.19	5.91	0.13	0.01	0.13	98.00
971	9.15c	71.13	14.08	0.31	1.79	0.28	0.92	3.27	5.85	0.14	0.02	0.05	97.82
974	9.1a	70.52	15.10	0.15	1.02	0.10	1.57	3.76	5.28	0.24	0.01	0.15	97.92
974	9.1b	71.81	13.91	0.20	1.31	0.13	0.89	3.33	5.79	0.11	0.04	0.09	97.63
974	9.1c	69.21	16.46	0.17	0.97	0.11	2.18	4.23	4.57	0.14	0.03	0.16	98.22
976	9.2a	72.04	14.11	0.28	1.21	0.09	0.91	3.28	6.04	0.14	0.03	0.07	98.20
976	9.2b	68.71	13.86	0.79	3.56	1.23	0.83	3.02	6.34	0.18	0.03	0.19	98.72
976	9.2c	71.15	13.90	0.29	1.74	0.37	0.95	3.16	5.89	0.20	0.06	0.15	97.86
977	9.3a	72.60	13.82	0.22	0.99	0.05	0.77	3.27	6.01	0.11	0.04	0.14	98.02

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
977	9.3b	72.46	13.86	0.18	0.82	0.04	0.98	3.37	5.66	0.15	0.03	0.11	97.66
977	9.3c	72.54	14.01	0.26	0.93	0.05	0.79	3.28	6.08	0.14	0.03	0.13	98.23
977	9.3d	72.84	13.50	0.23	1.56	0.16	0.74	3.14	5.99			0.05	98.20
977	9.3e	72.97	13.65	0.23	1.19	0.10	0.76	3.16	5.98			0.04	98.08
978	9.4a	72.39	14.11	0.22	1.24	0.15	0.99	3.34	5.88	0.11	0.01	0.11	98.56
978	9.4b	72.93	13.85	0.26	1.38	0.11	0.77	3.20	6.21	0.14	0.01	0.07	98.93
978	9.4c	72.19	13.89	0.27	2.08	0.37	1.20	3.54	4.98	0.16	0.02	0.08	98.76
979	9.5a	69.92	13.05	1.13	6.91	0.18	0.72	3.15	5.65	0.15	0.05	0.13	101.04
979	9.5b	71.52	13.61	0.24	1.94	0.45	1.47	3.26	5.61	0.63	0.07	0.09	98.89
979	9.5c	73.67	13.77	0.23	1.26	0.10	0.77	3.08	6.02	0.12	0.04	0.08	99.14
979	9.5d	67.59	18.32	0.11	0.76	0.06	3.08	5.29	3.56			0.08	98.87
979	9.5e	73.10	13.62	0.24	1.43	0.14	0.76	3.20	5.90			0.10	98.48
979	9.5f	72.25	13.74	0.26	1.72	0.17	0.75	3.15	6.22			0.15	98.42
986	9.6a	72.51	13.69	0.27	1.72	0.21	0.79	3.12	6.10	0.12	0.04	0.07	98.63
986	9.6b	72.19	13.86	0.32	1.48	0.30	1.01	3.17	6.12	0.24	0.03	0.07	98.80
986	9.6c	72.55	13.86	0.26	1.29	0.17	0.82	3.20	6.16	0.14	0.03	0.11	98.59
986	45.3a	72.95	13.73	0.28	1.52	0.25	1.02	3.79	5.01			0.12	98.67
986	45.3b	72.00	13.92	0.25	1.50	0.23	0.80	3.27	6.14			0.13	98.25
991	9.7a	70.97	14.90	0.24	1.44	0.22	1.47	3.65	5.35	0.15	0.02	0.12	98.53
991	9.7b	72.19	13.84	0.28	1.70	0.27	0.86	3.12	6.10	0.14	0.03	0.11	98.65
991	9.7c	72.49	13.91	0.28	1.48	0.23	0.92	3.28	5.97	0.13	0.02	0.13	98.84
992	9.8a	71.45	14.06	0.28	1.53	0.26	0.86	3.20	5.99	0.14	0.05	0.14	97.97
992	9.8b	71.46	14.07	0.32	1.56	0.24	0.83	3.22	6.06	0.16	0.03	0.09	98.04
992	9.8c	71.59	13.98	0.29	1.24	0.17	0.91	3.25	5.94	0.15	0.04	0.04	97.60
993	9.9a	72.50	14.58	0.28	0.75	0.09	1.21	3.57	5.64	0.14	0.02	0.17	98.97
993	9.9b	72.29	14.08	0.30	1.51	0.37	0.87	3.23	6.05	0.16	0.02	0.15	99.03

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
993	9.9c	71.81	13.89	0.29	1.98	0.38	0.85	3.11	5.98	0.14	0.02	0.16	98.62
994	9.10a	72.14	14.28	0.28	1.01	0.13	1.06	3.45	5.74	0.14	0.00	0.14	98.38
994	9.10b	72.70	14.00	0.31	1.52	0.04	0.84	3.23	6.29	0.13	0.03	0.10	99.19
994	9.10c	71.43	14.23	0.27	2.10	0.37	1.04	3.33	5.67	0.14	0.06	0.16	98.80
995	45.4a	71.50	14.37	0.26	1.42	0.20	1.15	3.64	5.54			0.10	98.20
995	45.4b	71.62	13.65	0.29	2.28	0.45	1.20	3.65	4.83			0.10	98.06
996	45.5a	72.46	13.77	0.28	1.62	0.21	0.87	3.26	6.01			0.07	98.55
996	45.5b	71.95	13.53	0.29	1.67	0.21	0.86	3.27	5.96			0.09	97.83
997	45.6a	72.68	13.90	0.28	1.57	0.22	1.12	4.36	4.21			0.10	98.44
997	45.6b	71.75	14.38	0.25	1.61	0.34	1.49	4.60	3.85			0.13	98.41
1001	45.7a	71.65	13.77	0.30	1.79	0.28	0.88	3.30	5.93			0.08	97.98
1001	45.7b	71.66	14.11	0.30	1.59	0.24	1.05	3.38	5.80			0.04	98.18
1002	45.8a	71.81	13.75	0.29	1.56	0.19	0.86	3.32	5.97			0.13	97.89
1002	45.8b	72.37	13.78	0.28	1.40	0.20	0.93	3.38	5.87			0.14	98.35
1003	45.9a	71.80	13.78	0.56	1.52	0.12	0.96	3.30	6.04			0.06	98.13
1003	45.9b	71.40	13.94	0.28	1.67	0.22	0.97	3.33	5.90			0.09	97.79
1004	45.10a	72.26	14.16	0.28	0.92	0.05	1.11	3.34	5.90			0.10	98.11
1004	45.10b	71.97	13.71	0.28	1.86	0.29	0.84	3.22	6.12			0.05	98.35
1005	45.11a	72.19	13.77	0.28	1.92	0.13	0.92	3.35	5.85			0.10	98.51
1005	45.11b	72.74	13.87	0.30	0.91	0.05	0.84	3.27	6.13			0.09	98.19
1006	45.12a	72.23	13.66	0.29	1.79	0.18	0.83	3.30	6.03			0.13	98.45
1006	45.12b	71.42	13.56	0.28	1.64	0.30	0.88	3.19	5.93			0.11	97.31
1026	45.13a	73.39	13.25	0.22	1.38	0.11	0.74	3.21	6.07			0.11	98.47
1026	45.13b	71.87	14.62	0.16	1.24	0.10	1.41	3.76	5.33			0.11	98.60
1027	45.14a	72.76	13.72	0.28	1.42	0.16	0.88	3.39	5.89			0.11	98.61
1027	45.14b	72.19	13.69	0.28	1.99	0.42	0.90	3.29	5.86			0.11	98.73

TABLE F1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1027	45.14c	72.74	13.98	0.29	1.65	0.20	0.89	3.31	5.94			0.13	99.13
1715	1.9a	73.42	14.01	0.24	1.04	0.16	1.05	3.54	5.12	0.10	0.03		98.73
1715	1.9b	74.83	14.18	0.27	1.40	0.25	0.88	2.87	5.42	0.10	0.05		100.25
1715	1.9c	73.25	13.82	0.24	1.46	0.22	0.85	2.62	5.43	0.08	0.06		98.04
1715	B7a	72.61	13.92	0.31	1.63	0.22	0.87	3.28	6.01				98.85
1715	B7b	73.36	13.90	0.28	1.37	0.15	0.91	3.11	6.01				99.09
1715	B7c	72.97	14.22	0.31	1.35	0.17	0.87	3.26	6.06				99.21
1715	B7d	72.80	14.03	0.30	2.23	0.26	0.85	3.28	6.04				99.79
1715	B7e	72.59	13.95	0.28	1.56	0.20	0.87	3.20	5.89				98.54
1715	B7f	72.93	13.95	0.31	1.86	0.21	0.85	3.33	6.07				99.51
1715	B7g	72.42	13.92	0.31	1.95	0.21	0.91	3.27	5.96				98.95
1715	B7h	73.08	14.16	0.31	1.21	0.13	0.91	3.35	6.13				99.28
1715	B7i	73.51	14.03	0.30	1.50	0.14	0.88	2.94	6.08				99.38
1715	B7j	71.92	13.91	0.26	2.31	0.38	0.84	3.25	5.97				98.84
1715	B7k	64.68	16.75	0.16	0.79	0.10	2.79	4.84	3.43				93.54
1727	44.7a	73.35	11.73	0.05	1.00	0.05	0.62	3.27	5.04			0.01	95.12
1727	44.7b	64.65	18.46	0.03	0.12	0.00	0.21	3.13	11.83			1.21	99.65

TABLE F2

Cat.	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
185	74.85	13.53	0.07	1.19	0.11	0.59	3.40	5.07			0.03	98.85
186	75.12	13.36	0.06	1.25	0.08	0.56	3.30	5.11			0.02	98.85
187	74.66	13.46	0.10	1.24	0.09	0.59	3.49	5.24	0.08	0.05	0.01	99.00
188	74.75	13.47	0.10	1.12	0.07	0.58	3.45	5.31	0.08	0.05	0.02	99.00
189	74.65	13.46	0.10	1.23	0.08	0.59	3.43	5.30	0.08	0.04	0.03	99.00
190	74.53	13.56	0.10	1.27	0.09	0.60	3.43	5.28	0.08	0.05	0.01	99.00
191	74.55	13.53	0.09	1.27	0.06	0.62	3.49	5.21	0.09	0.06	0.02	99.00
192	74.78	13.39	0.09	1.23	0.07	0.59	3.36	5.32	0.09	0.06	0.03	99.00
193	74.69	13.42	0.09	1.24	0.08	0.59	3.40	5.32	0.07	0.06	0.04	99.00
194	74.69	13.42	0.09	1.29	0.08	0.59	3.44	5.26	0.08	0.05	0.02	99.00
195	72.65	13.89	0.28			0.81	3.19	6.07	0.11	0.07		98.90
205	72.73	13.90	0.25			0.79	3.35	5.90	0.11	0.03		98.90
206	72.41	14.06	0.29	1.81	0.30	0.87	3.21	5.76	0.12	0.06	0.11	99.00
212		14.10	0.28			0.80	3.34	5.82	0.11	0.05	0.12	99.00
217	74.77	13.60	0.07	1.27	0.11	0.60	3.37	5.04			0.02	98.85
227	75.49	12.50	0.07	1.45	0.07	0.46	4.16	4.65			0.01	98.85
231	75.33	12.47	0.11	1.35	0.05	0.46	4.25	4.86	0.02	0.07	0.00	99.00
231	75.38	12.41	0.10	1.39	0.05	0.47	4.23	4.89	0.02	0.04	0.00	99.00
279	74.73	13.47	0.11	1.20	0.06	0.58	3.32	5.39				98.85
280	74.71	13.48	0.10	1.21	0.08	0.57	3.30	5.41				98.85
281	74.72	13.39	0.10	1.29	0.08	0.58	3.35	5.33				98.85
282	74.63	13.43	0.09	1.28	0.07	0.59	3.30	5.45				98.85
284	97.73	0.59	0.01	0.04	0.01	0.15	0.16	0.15			0.00	98.85
285	56.77	13.77	2.35	9.56	3.35	6.15	5.20	1.65			0.04	98.85
286	95.95	1.39	0.04	0.33	0.17	0.19	0.29	0.49			0.01	98.85
287	95.87	1.16	0.01	0.13	0.11	1.10	0.23	0.23			0.01	98.85

TABLE F2 (continued)

Cat.	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
288	93.79	1.07	0.05	1.70	0.73	0.16	0.19	1.16			0.00	98.85
289	97.31	0.70	0.01	0.16	0.06	0.16	0.20	0.23			0.01	98.85
290	94.28	0.82	0.01	1.61	0.72	0.11	0.17	1.11			0.02	98.85
291	97.89	0.45	0.01	0.10	0.02	0.08	0.16	0.08			0.06	98.85
306	74.19	13.08	0.09	1.71	0.05	0.73	3.96	5.03	0.11	0.07	0.00	99.00
307	74.21	13.12	0.08	1.70	0.04	0.70	4.00	4.99	0.11	0.04	0.00	99.00
308	74.27	12.97	0.08	1.66	0.04	0.70	3.72	5.38	0.12	0.05	0.01	99.00
310	75.48	12.94	0.11	1.12	0.10	0.54	3.28	5.23	0.11	0.07	0.03	99.00
311	75.34	13.06	0.11	1.10	0.10	0.54	3.33	5.27	0.10	0.04	0.02	99.00
312	75.47	12.99	0.12	1.06	0.10	0.56	3.22	5.29	0.12	0.06	0.02	99.00
313	75.47	12.99	0.12	1.06	0.10	0.56	3.22	5.29	0.12	0.06	0.02	99.00
314	75.19	13.07	0.12	1.09	0.14	0.59	3.37	5.25			0.03	98.85
315	74.59	13.49	0.09	1.30	0.09	0.59	3.35	5.35				98.85
315	75.29	13.25	0.06	1.29	0.08	0.56	3.36	4.95			0.02	98.85
544	74.87	13.46	0.10	1.14	0.06	0.57	3.39	5.27	0.09	0.06	0.01	99.00
545	75.16	13.27	0.09	1.16	0.06	0.55	3.36	5.21	0.08	0.05	0.00	99.00
546	74.68	13.46	0.09	1.24	0.08	0.60	3.44	5.25	0.09	0.05	0.03	99.00
547	74.91	13.44	0.08	1.12	0.05	0.57	3.49	5.16	0.09	0.05	0.04	99.00
548	75.18	13.38	0.09	1.05	0.05	0.55	3.39	5.13	0.09	0.05	0.02	99.00
624	75.04	13.43	0.08	1.13	0.07	0.53	3.40	5.13	0.09	0.06	0.04	99.00
625	74.62	13.55	0.10	1.25	0.08	0.57	3.41	5.27	0.08	0.05	0.02	99.00
626	74.81	13.52	0.09	1.18	0.09	0.57	3.43	5.18	0.09	0.04	0.00	99.00
628	74.65	13.72	0.08	1.13	0.08	0.61	3.58	5.01	0.08	0.04	0.01	99.00
629	74.73	13.49	0.10	1.27	0.09	0.58	3.39	5.21	0.08	0.05	0.01	99.00
654	74.68	13.46	0.09	1.23	0.05	0.60	3.49	5.26	0.07	0.06	0.01	99.00
655	74.60	13.49	0.09	1.19	0.06	0.59	3.49	5.32	0.08	0.06	0.02	99.00

TABLE F2 (continued)

Cat.	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
656	74.85	13.35	0.09	1.23	0.07	0.59	3.38	5.28	0.07	0.05	0.03	99.00
668	74.48	13.58	0.09	1.25	0.09	0.56	3.46	5.34	0.09	0.06	0.00	99.00
669	74.88	13.26	0.09	1.27	0.05	0.59	3.38	5.34	0.07	0.06	0.01	99.00
683	73.26	13.84	0.20	1.68	0.21	0.98	3.50	5.12	0.13	0.04	0.05	99.00
684	73.86	13.72	0.16	1.30	0.13	0.79	3.50	5.34	0.10	0.05	0.05	99.00
685	73.55	13.64	0.17	1.62	0.17	0.78	3.47	5.40	0.11	0.05	0.04	99.00
688	74.34	13.53	0.14	1.17	0.08	0.72	3.35	5.47	0.09	0.05	0.06	99.00
689	73.85	13.54	0.16	1.53	0.14	0.76	3.47	5.33	0.10	0.05	0.07	99.00
708	73.49	13.65	0.19	1.57	0.16	0.72	3.31	5.68	0.12	0.03	0.08	99.00
710	74.16	13.77	0.18	0.81	0.06	0.74	3.34	5.71	0.12	0.04	0.07	99.00
711	73.67	13.69	0.18	1.39	0.15	0.74	3.27	5.74	0.11	0.04	0.02	99.00
713	73.98	13.62	0.15	1.32	0.13	0.77	3.47	5.40	0.07	0.06	0.03	99.00
714	73.55	13.69	0.19	1.48	0.16	0.76	3.30	5.63	0.12	0.04	0.08	99.00
722	73.88	13.68	0.15	1.29	0.12	0.70	3.43	5.60	0.09	0.03	0.03	99.00
723	74.08	13.64	0.14	1.27	0.13	0.75	3.42	5.43	0.09	0.04	0.01	99.00
724	73.95	13.54	0.14	1.53	0.10	0.73	3.36	5.47	0.10	0.05	0.02	99.00
725	74.11	13.56	0.15	1.27	0.10	0.75	3.37	5.48	0.10	0.06	0.05	99.00
726	74.05	13.64	0.15	1.28	0.10	0.76	3.37	5.46	0.09	0.06	0.04	99.00
729	73.22	13.80	0.25	1.31	0.16	0.83	3.58	5.62	0.11	0.03	0.08	99.00
734	74.40	13.49	0.13	1.18	0.08	0.70	3.28	5.57	0.09	0.05	0.03	99.00
735	74.13	13.54	0.14	1.30	0.13	0.74	3.30	5.54	0.09	0.05	0.02	99.00
736	74.59	13.46	0.14	1.05	0.06	0.69	3.50	5.33	0.09	0.03	0.06	99.00
737	74.38	13.52	0.14	1.21	0.07	0.72	3.48	5.33	0.07	0.04	0.04	99.00
742	74.99	13.02	0.13	1.25	0.10	0.56	3.39	5.42	0.08	0.04	0.02	99.00
743	75.08	12.98	0.11	1.29	0.09	0.57	3.34	5.41	0.08	0.04	0.01	99.00
745	74.71	13.16	0.15	1.21	0.13	0.60	3.40	5.49	0.08	0.04	0.03	99.00

TABLE F2 (continued)

Cat.	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
747	74.08	13.56	0.13	1.32	0.13	0.67	3.37	5.54	0.09	0.06	0.05	99.00
756	75.12	13.05	0.14	1.06	0.12	0.59	3.33	5.47	0.07	0.03	0.02	99.00
757	74.44	13.22	0.16	1.25	0.14	0.65	3.27	5.73	0.08	0.03	0.03	99.00
759	74.66	13.23	0.15	1.02	0.10	0.60	3.39	5.68	0.09	0.04	0.04	99.00
760	74.63	13.24	0.15	1.14	0.13	0.62	3.30	5.63	0.08	0.04	0.04	99.00
761	74.45	13.22	0.15	1.24	0.14	0.60	3.19	5.86	0.07	0.05	0.03	99.00
821	75.01	13.00	0.13	1.17	0.12	0.59	3.32	5.52	0.08	0.03	0.03	99.00
822	74.84	13.06	0.14	1.35	0.11	0.60	3.30	5.46	0.07	0.03	0.04	99.00
823	74.73	13.09	0.14	1.24	0.12	0.60	3.41	5.51	0.08	0.04	0.04	99.00
824	74.94	13.08	0.13	1.23	0.11	0.59	3.30	5.51	0.07	0.03	0.01	99.00
825	74.96	13.03	0.13	1.23	0.11	0.60	3.31	5.49	0.08	0.05	0.01	99.00
901	72.57	13.84	0.29	1.71	0.26	0.85	3.24	5.93			0.14	98.85
902	72.97	13.78	0.26	1.39	0.16	0.85	3.24	6.12			0.09	98.85
936	72.65	13.91	0.29	1.52	0.21	0.84	3.31	5.95	0.14	0.03	0.12	99.00
946	72.44	14.09	0.28	1.50	0.25	0.93	3.34	5.92	0.14	0.03	0.10	99.00
947	72.27	14.08	0.29	1.67	0.29	0.89	3.28	5.96	0.13	0.02	0.11	99.00
948	72.32	14.02	0.29	1.64	0.29	0.86	3.28	6.03	0.13	0.03	0.10	99.00
949	72.36	14.06	0.28	1.57	0.24	0.95	3.29	5.96	0.15	0.03	0.11	99.00
950	72.80	13.95	0.24	1.50	0.21	0.81	3.24	6.01	0.13	0.03	0.08	99.00
967	72.58	14.03	0.29	1.39	0.22	0.87	3.23	6.09	0.15	0.02	0.14	99.00
968	72.54	14.00	0.29	1.52	0.22	0.87	3.36	5.95	0.14	0.03	0.08	99.00
969	72.40	14.08	0.29	1.72	0.27	0.89	3.32	5.79	0.13	0.03	0.09	99.00
970	72.45	13.97	0.28	1.78	0.26	0.86	3.24	5.89	0.14	0.04	0.09	99.00
971	72.04	14.21	0.31	1.80	0.27	0.94	3.26	5.91	0.13	0.03	0.09	99.00
974	73.00	14.14	0.18	1.12	0.11	0.90	3.60	5.62	0.17	0.03	0.14	99.00
976	72.45	14.09	0.29	1.49	0.09	0.91	3.18	6.15	0.18	0.04	0.14	99.00

TABLE F2 (continued)

Cat.	**SiO2**	**Al2O3**	**TiO2**	**Fe2O3**	**MgO**	**CaO**	**Na2O**	**K2O**	**P2O5**	**MnO**	**BaO**	**Total**
977	73.34	13.89	0.23	1.11	0.08	0.82	3.27	6.00	0.13	0.03	0.09	99.00
978	72.75	14.00	0.25	1.31	0.13	0.88	3.37	6.07	0.14	0.01	0.09	99.00
979	73.28	13.81	0.22	1.43	0.13	0.75	3.18	5.91	0.13	0.05	0.11	99.00
986	72.71	13.86	0.28	1.51	0.23	0.89	3.32	5.93	0.13	0.03	0.10	99.00
991	72.57	13.92	0.28	1.55	0.24	0.89	3.21	6.05	0.14	0.02	0.12	99.00
992	72.33	14.20	0.30	1.46	0.23	0.88	3.26	6.07	0.15	0.04	0.09	99.00
993	72.30	14.20	0.29	1.42	0.28	0.98	3.31	5.90	0.15	0.02	0.16	99.00
994	72.29	14.14	0.29	1.54	0.25	0.98	3.33	5.89	0.14	0.03	0.13	99.00
995	72.09	14.11	0.28	1.86	0.33	1.18	3.67	5.22			0.10	98.85
996	72.69	13.74	0.29	1.66	0.21	0.87	3.29	6.03			0.08	98.85
997	72.53	14.20	0.27	1.60	0.28	1.31	4.50	4.05			0.12	98.85
1001	72.22	14.05	0.30	1.70	0.26	0.97	3.37	5.91			0.06	98.85
1002	72.63	13.87	0.29	1.49	0.20	0.90	3.37	5.96			0.14	98.85
1003	72.25	13.99	0.42	1.61	0.17	0.97	3.35	6.02			0.08	98.85
1004	72.57	14.02	0.28	1.40	0.17	0.98	3.30	6.05			0.08	98.85
1005	72.83	13.89	0.29	1.42	0.09	0.88	3.33	6.02			0.10	98.85
1006	72.54	13.75	0.29	1.73	0.24	0.86	3.28	6.04			0.12	98.85
1026	72.86	13.98	0.19	1.31	0.11	1.08	3.50	5.72			0.11	98.85
1027	72.58	13.80	0.28	1.69	0.26	0.89	3.33	5.90			0.12	98.85
1727	76.23	12.19	0.05	1.04	0.05	0.64	3.40	5.24			0.01	98.85
1728	72.70	13.97	0.28	1.49	0.21	0.87	3.25	6.00	0.09	0.05	0.00	98.90

APPENDIX G. ELECTRON MICROPROBE DATA FOR ARCHAEOLOGICAL OBSIDIAN

This appendix presents the analytical data from electron probe microanalysis for archaeological obsidian artifacts in two tables.

Table Gl contains the raw data for each point analyzed, for each artifact. Phosphorus and manganese were not analyzed for all samples. Table G2 gives the average, normalized values for each artifact, along with visually-based and analytical-statistically based provenience attributions.

All analyses were internally calibrated against international standards. A laboratory reference material, hornblende, was also repeatedly measured to insure consistency between analytical sessions. The standard deviation for the 43 analyses of this standard may be considered as the analytical precision for all measurements (see Appendix F, Table F1).

TABLE G1

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
178	2.1a	75.49	12.83	0.09	1.01	0.12	0.54	3.52	5.02			0.04	98.66
178	2.1b	75.09	12.86	0.09	1.13	0.11	0.58	3.40	5.02			0.05	98.34
178	2.1c	74.90	12.93	0.09	1.08	0.11	0.56	3.49	5.12			0.00	98.29
178	2.1d	74.26	12.53	0.07	1.07	0.08	0.55	3.19	5.13			0.00	96.89
178	2.1e	75.41	12.73	0.10	1.04	0.12	0.55	3.43	5.18			0.00	98.56
179	2.2a	74.94	12.80	0.10	0.92	0.13	0.57	3.08	5.03			0.00	97.56
179	2.2b	75.00	12.93	0.10	1.01	0.12	0.57	3.19	5.20			0.02	98.14
179	2.2c	75.03	12.93	0.08	1.03	0.12	0.54	3.18	5.08			0.00	97.99
179	2.2d	75.78	13.21	0.10	1.04	0.12	0.57	3.33	5.18			0.06	99.38
179	2.2e	74.46	12.78	0.07	1.04	0.14	0.55	3.34	5.16			0.00	97.54
180	2.3a	74.99	12.96	0.08	1.00	0.12	0.55	3.36	5.22			0.02	98.29
180	2.3b	75.18	12.93	0.09	1.11	0.12	0.62	3.31	5.03			0.02	98.40
180	2.3c	74.96	12.99	0.10	1.05	0.12	0.56	3.26	5.28			0.00	98.32
180	2.3d	75.44	12.94	0.07	1.09	0.14	0.57	3.34	5.20			0.04	98.82
180	2.3e	75.06	12.92	0.10	0.98	0.12	0.57	3.34	5.12			0.07	98.28
181	2.4a	74.66	12.99	0.09	0.99	0.12	0.55	3.24	5.23			0.02	97.90
181	2.4b	74.10	12.83	0.11	1.46	0.11	0.59	3.22	5.07			0.04	97.52
181	2.4c	74.96	12.96	0.10	1.08	0.12	0.56	3.36	4.95			0.02	98.09
181	2.4d	74.76	12.74	0.13	1.00	0.13	0.54	3.37	4.93			0.05	97.65
181	2.4e	75.03	12.88	0.10	1.06	0.12	0.57	3.34	5.16			0.00	98.26
182	2.5a	73.38	12.64	0.10	3.68	0.15	0.50	3.22	5.02			0.00	98.67
182	2.5b	75.21	12.80	0.10	1.05	0.10	0.57	3.14	5.00			0.04	98.01
182	2.5c	75.24	12.85	0.10	1.10	0.14	0.55	3.22	5.19			0.00	98.40
182	2.5d	75.41	13.00	0.11	0.99	0.12	0.59	3.27	5.11			0.02	98.62
182	2.5e	75.25	12.95	0.10	1.14	0.12	0.57	3.21	5.17			0.04	98.55
184	2.7a	74.71	13.05	0.08	1.05	0.11	0.58	3.31	5.12			0.02	98.01

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
184	2.7b	74.32	12.77	0.10	1.70	0.12	0.58	3.34	5.18			0.03	98.14
184	2.7c	75.66	12.80	0.09	1.10	0.11	0.54	3.38	5.30			0.03	98.99
184	2.7d	75.01	12.85	0.10	1.04	0.12	0.53	3.41	5.10			0.05	98.21
184	2.7e	74.59	12.78	0.09	1.20	0.10	0.54	3.20	5.23			0.03	97.76
292	2.13a	74.14	13.57	0.05	1.23	0.10	0.58	3.43	5.06			0.02	98.17
292	2.13b	74.61	13.54	0.08	1.14	0.08	0.59	3.30	5.05			0.03	98.40
292	2.13c	74.95	13.51	0.07	1.20	0.09	0.57	3.32	5.08			0.06	98.84
292	2.13d	74.80	13.61	0.06	1.22	0.11	0.57	3.33	5.19			0.03	98.93
292	2.13e	74.12	13.39	0.09	1.13	0.10	0.58	3.29	5.06			0.02	97.76
293	2.14a	72.61	13.94	0.27	1.69	0.28	0.85	3.14	5.58			0.20	98.56
293	2.14b	72.28	13.95	0.25	1.56	0.28	0.85	3.22	5.78			0.15	98.31
293	2.14c	72.36	13.80	0.24	1.48	0.24	0.84	3.16	5.77			0.10	97.99
293	2.14d	72.59	14.10	0.27	1.53	0.28	0.89	3.34	5.78			0.17	98.95
293	2.14e	71.88	13.62	0.26	1.40	0.24	1.20	2.97	5.57			0.13	97.27
294	2.15a	69.96	13.40	0.24	0.94	0.08	0.85	3.07	5.69			0.11	94.32
294	2.15b	73.83	14.20	0.29	0.88	0.05	0.88	3.16	5.83			0.15	99.28
294	2.15c	71.47	13.67	0.26	0.94	0.05	0.81	3.04	5.68			0.15	96.07
294	2.15d	72.09	13.93	0.23	1.32	0.17	0.88	3.24	5.87			0.16	97.88
294	2.15e	72.64	13.96	0.27	1.33	0.06	0.77	3.17	5.78			0.14	98.11
295	2.16a	74.47	13.45	0.07	1.27	0.10	0.56	3.41	5.20			0.02	98.55
295	2.16b	73.46	13.14	0.04	1.19	0.08	0.57	3.23	5.03			0.03	96.77
295	2.16c	73.73	13.19	0.06	1.19	0.09	0.57	3.23	5.14			0.00	97.19
295	2.16d	71.12	12.75	0.05	2.18	0.08	0.54	3.22	4.96			0.00	94.91
295	2.16e	75.40	13.33	0.08	0.96	0.05	0.76	3.48	4.50			0.03	98.58
296	3.1a	75.63	13.23	0.14	1.11	0.10	0.54	3.19	5.29	0.09	0.05	0.03	99.40
296	3.1b	76.43	13.23	0.11	1.08	0.10	0.55	3.22	5.33	0.12	0.09	0.03	100.28

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
296	3.1c	76.09	13.29	0.12	1.17	0.10	0.56	3.33	5.30	0.12	0.07	0.04	100.18
296	3.1d	75.50	13.17	0.10	1.24	0.12	0.62	1.97	5.25			0.00	97.97
296	3.1e	76.02	13.08	0.13	1.33	0.13	0.59	1.67	5.04			0.04	98.03
296	3.1f	74.95	12.93	0.11	1.12	0.12	0.59	3.41	5.32			0.00	98.53
296	3.1g	75.24	13.12	0.14	1.09	0.13	0.66	3.29	5.28			0.02	98.96
296	3.1h	75.02	13.29	0.12	1.24	0.13	0.59	3.19	5.28			0.02	98.88
297	3.2a	75.33	13.30	0.11	0.90	0.08	0.62	3.33	5.26			0.07	99.02
297	3.2b	75.49	13.25	0.11	0.98	0.09	0.63	3.36	5.29			0.02	99.22
297	3.2c	75.52	13.20	0.10	0.93	0.09	0.59	3.47	5.27			0.04	99.22
297	3.2d	75.04	13.14	0.13	0.89	0.10	0.54	3.27	5.34			0.03	98.47
297	3.2e	74.42	13.16	0.12	0.91	0.10	0.59	3.36	5.26			0.07	97.99
298	3.3a	72.81	13.89	0.33	1.29	0.13	0.96	3.29	5.85			0.21	98.76
298	3.3b	70.77	13.44	0.30	3.71	1.10	0.90	3.03	5.14			0.15	98.53
298	3.3c	70.19	13.37	0.31	3.53	1.29	0.90	3.21	5.20			0.15	98.16
298	3.3d	71.17	13.75	0.31	3.74	1.18	1.03	3.21	5.25			0.18	99.81
298	3.3e	72.72	13.99	0.35	1.20	0.09	0.92	3.24	5.73			0.18	98.40
506	4.1a	73.49	12.40	0.07	1.77	0.02	0.72	3.90	5.06	0.03	0.04	0.00	97.49
506	4.1b	73.32	12.42	0.06	1.85	0.02	0.72	3.98	5.03	0.01	0.07	0.00	97.51
506	4.1c	73.86	12.40	0.07	1.68	0.03	0.72	3.94	5.06	0.01	0.07	0.01	97.85
507	4.2a	73.81	12.57	0.06	1.60	0.03	0.73	3.93	5.03	0.02	0.08	0.03	97.88
507	4.2b	73.67	12.37	0.07	1.61	0.02	0.71	3.96	4.97	0.03	0.06	0.00	97.45
507	4.2c	73.60	12.50	0.08	1.61	0.03	0.72	3.99	5.02	0.03	0.07	0.01	97.66
508	4.3a	73.65	12.63	0.07	1.56	0.04	0.71	4.93	3.64	0.03	0.07	0.00	97.34
508	4.3b	73.03	12.45	0.07	1.53	0.03	0.67	2.84	6.64	0.02	0.06	0.04	97.39
508	4.3c	72.94	12.59	0.07	1.62	0.04	0.71	3.55	5.62	0.01	0.06	0.03	97.23
509	4.4a	73.86	12.47	0.08	1.56	0.03	0.69	3.96	4.89	0.01	0.07	0.02	97.63

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
509	4.4b	73.90	12.66	0.08	1.42	0.02	0.68	4.01	5.09	0.00	0.06	0.02	97.93
509	4.4c	74.33	12.59	0.07	1.24	0.02	0.68	3.99	5.00	0.02	0.04	0.01	97.99
510	4.5a	74.25	12.61	0.08	1.58	0.03	0.73	3.99	4.98	0.03	0.07	0.02	98.36
510	4.5b	74.43	12.58	0.07	1.64	0.03	0.70	3.99	4.99	0.02	0.04	0.00	98.49
510	4.5c	73.53	12.54	0.07	1.62	0.02	0.71	4.00	5.00	0.02	0.04	0.00	97.56
511	4.6a	74.43	12.64	0.07	1.49	0.01	0.67	3.96	5.01	0.01	0.06	0.02	98.38
511	4.6b	74.34	12.61	0.08	1.67	0.01	0.72	4.04	4.96	0.00	0.07	0.01	98.52
511	4.6c	73.55	12.74	0.08	1.65	0.02	0.68	3.99	5.08	0.01	0.05	0.00	97.84
513	4.7a	70.95	7.49	0.23	8.47	0.01	0.26	7.02	4.19	0.04	0.31	0.03	99.00
513	4.7b	70.59	7.31	0.23	8.46	0.02	0.26	7.08	4.15	0.04	0.29	0.04	98.47
513	4.7c	70.13	7.47	0.22	8.41	0.02	0.26	7.01	4.13	0.02	0.32	0.00	97.99
514	4.8a	70.04	7.42	0.24	8.53	0.02	0.25	6.95	4.19	0.03	0.29	0.04	98.00
514	4.8b	69.66	7.37	0.22	8.42	0.00	0.27	6.97	4.18	0.02	0.33	0.05	97.49
514	4.8c	69.70	7.46	0.21	8.42	0.00	0.27	7.10	4.23	0.02	0.29	0.04	97.74
515	4.9a	65.55	9.39	0.61	9.30	0.13	0.50	7.58	4.40	0.05	0.34	0.00	97.86
515	4.9b	65.48	9.37	0.60	9.49	0.13	0.48	7.57	4.33	0.05	0.35	0.00	97.84
515	4.9c	66.14	9.37	0.59	9.34	0.13	0.48	7.58	4.33	0.06	0.35	0.01	98.37
516	4.10a	70.31	7.44	0.21	8.43	0.01	0.26	7.30	4.07	0.02	0.29	0.00	98.36
516	4.10b	70.16	7.36	0.20	8.30	0.01	0.25	7.31	4.21	0.03	0.29	0.03	98.14
516	4.10c	69.68	7.34	0.20	8.39	0.01	0.25	7.15	4.38	0.02	0.29	0.00	97.72
1052	10.1a	73.36	13.90	0.09	1.17	0.07	0.75	3.88	4.98	0.10	0.06	0.00	98.37
1052	10.1b	73.54	13.82	0.09	1.21	0.07	0.73	3.66	5.05	0.08	0.05	0.00	98.31
1052	10.1c	73.81	13.37	0.08	1.22	0.07	0.56	3.37	5.28	0.07	0.04	0.00	97.88
1053	10.2a	71.44	13.89	0.29	1.58	0.20	0.92	3.30	5.89	0.14	0.02	0.10	97.77
1053	10.2b	72.13	14.09	0.29	1.04	0.08	0.90	3.33	5.97	0.13	0.01	0.08	98.06
1053	10.2c	71.26	13.74	0.30	1.60	0.21	0.91	3.26	5.92	0.13	0.02	0.08	97.43

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1054	10.3a	71.62	14.00	0.27	1.32	0.19	0.89	3.21	5.90	0.13	0.03	0.05	97.62
1054	10.3b	71.08	13.89	0.28	1.23	0.18	0.90	3.23	5.87	0.14	0.02	0.09	96.92
1054	10.3c	70.07	13.72	0.28	2.21	0.27	0.88	3.19	5.87	0.12	0.04	0.03	96.68
1055	10.4a	71.56	14.08	0.26	1.38	0.21	0.91	3.29	5.80	0.13	0.00	0.08	97.70
1055	10.4b	70.61	14.89	0.25	1.32	0.21	1.56	3.75	5.12	0.11	0.05	0.06	97.94
1055	10.4c	71.76	14.06	0.28	1.67	0.29	0.91	3.28	5.71	0.12	0.04	0.07	98.19
1056	10.5a	71.59	13.95	0.28	1.77	0.25	0.90	3.32	5.90	0.13	0.03	0.07	98.20
1056	10.5b	72.26	13.94	0.28	1.77	0.29	0.89	3.29	5.79	0.11	0.04	0.04	98.70
1056	10.5c	71.76	14.04	0.29	1.31	0.16	0.90	3.31	5.86	0.14	0.04	0.05	97.87
1057	10.6a	71.44	13.82	0.27	1.55	0.16	0.86	3.23	6.00	0.13	0.03	0.07	97.58
1057	10.6b	71.85	14.05	0.27	1.29	0.18	0.88	3.28	5.98	0.13	0.01	0.08	98.00
1057	10.6c	71.75	13.92	0.28	1.66	0.26	0.88	3.18	5.92	0.15	0.03	0.07	98.09
1058	10.7a	71.84	14.04	0.28	1.28	0.18	0.95	3.21	5.84	0.13	0.01	0.10	97.86
1058	10.7b	71.44	13.79	0.27	1.80	0.24	0.95	3.22	5.70	0.13	0.01	0.08	97.64
1058	10.7c	70.68	13.94	0.30	1.61	0.26	0.88	3.29	5.90	0.12	0.04	0.11	97.12
1059	10.8a	72.40	14.07	0.29	1.31	0.13	0.92	3.40	5.59	0.14	0.02	0.11	98.39
1059	10.8b	71.37	13.83	0.29	1.63	0.19	0.91	3.28	5.80	0.12	0.03	0.07	97.52
1059	10.8c	72.10	13.87	0.29	1.33	0.18	0.89	3.37	5.86	0.14	0.05	0.10	98.19
1059	10.9a	72.24	13.32	0.11	1.37	0.14	0.68	3.50	5.23	0.08	0.07	0.00	96.72
1060	10.9b	73.58	13.15	0.09	1.17	0.08	0.57	3.33	5.30	0.08	0.05	0.00	97.40
1060	10.9c	73.12	13.31	0.08	1.48	0.07	0.59	3.43	5.22	0.08	0.06	0.00	97.44
1061	10.10a	73.78	13.18	0.15	1.20	0.12	0.63	3.31	5.62	0.09	0.03	0.04	98.15
1061	10.10b	74.27	13.24	0.15	1.37	0.13	0.62	3.32	5.55	0.09	0.05	0.04	98.84
1061	10.10c	73.38	13.20	0.15	1.25	0.13	0.62	3.41	5.58	0.08	0.05	0.04	97.91
1062	10.11a	71.60	13.62	0.21	1.62	0.28	0.71	3.25	5.90	0.10	0.05	0.07	97.43
1062	10.11b	71.72	14.20	0.22	1.41	0.16	1.25	4.06	4.80	0.12	0.01	0.06	98.02

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1062	10.11c	72.82	13.92	0.25	1.20	0.10	0.82	3.45	5.58	0.12	0.01	0.06	98.31
1063	10.12a	71.84	13.78	0.25	1.51	0.21	0.78	3.10	5.93	0.12	0.02	0.06	97.60
1063	10.12b	71.36	14.05	0.24	1.28	0.18	0.98	3.29	5.88	0.14	0.03	0.08	97.51
1063	10.12c	72.10	13.70	0.20	1.30	0.16	0.81	3.12	5.85	0.13	0.04	0.08	97.50
1064	10.13a	73.91	13.10	0.09	1.22	0.08	0.55	3.25	5.33	0.08	0.07	0.01	97.70
1064	10.13b	73.89	13.30	0.09	1.23	0.07	0.55	3.33	5.22	0.09	0.03	0.05	97.85
1064	10.13c	74.21	13.34	0.10	2.02	0.08	0.56	3.29	5.22	0.10	0.05	0.06	99.03
1065	10.14a	71.58	13.93	0.30	1.27	0.21	0.88	3.30	5.95	0.14	0.05	0.10	97.70
1065	10.14b	71.38	13.84	0.29	1.40	0.21	0.90	3.25	5.91	0.13	0.02	0.10	97.42
1065	10.14c	70.62	13.91	0.31	2.23	0.36	0.90	3.24	5.85	0.12	0.03	0.13	97.70
1066	10.15a	74.49	13.02	0.13	1.02	0.09	0.57	3.25	5.47	0.09	0.05	0.00	98.19
1066	10.15b	74.33	12.98	0.12	1.07	0.08	0.56	3.23	5.47	0.07	0.05	0.02	97.98
1066	10.15c	74.66	13.03	0.12	1.12	0.10	0.57	3.29	5.45	0.07	0.04	0.04	98.50
1067	10.16a	74.49	13.17	0.16	1.30	0.14	0.60	3.29	5.64	0.08	0.04	0.03	98.95
1067	10.16b	73.95	13.08	0.15	1.11	0.14	0.61	3.30	5.65	0.08	0.00	0.03	98.11
1067	10.16c	73.67	13.14	0.15	1.64	0.16	0.62	3.25	5.57	0.09	0.03	0.04	98.37
1068	10.17a	72.26	13.97	0.28	1.27	0.16	0.86	3.12	6.18	0.16	0.04	0.13	98.43
1068	10.17b	72.52	13.94	0.27	1.62	0.24	0.96	3.38	5.77	0.13	0.05	0.12	99.00
1068	10.17c	72.41	13.87	0.26	1.27	0.12	0.83	3.19	6.17	0.14	0.00	0.08	98.35
1069	11.1a	73.50	14.19	0.24	1.17	0.12	0.79	3.22	6.12	0.15	0.00	0.09	99.59
1069	11.1b	73.02	13.83	0.28	2.04	0.31	0.78	3.22	6.06	0.12	0.04	0.09	99.80
1069	11.1c	73.80	13.87	0.20	1.20	0.14	0.74	3.21	5.96	0.07	0.01	0.10	99.30
1069	11.1d	72.26	15.15	0.15	0.91	0.12	1.59	4.03	5.16	0.12	0.02	0.10	99.61
1069	11.1e	73.82	13.87	0.26	1.30	0.16	0.79	3.22	6.06	0.13	0.03	0.12	99.76
1071	11.3a	74.01	13.76	0.22	1.23	0.09	0.59	3.15	6.18	0.12	0.04	0.09	99.48
1071	11.3b	74.36	13.79	0.21	1.07	0.06	0.82	3.46	5.65	0.12	0.05	0.11	99.70

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1071	11.3c	71.72	15.26	0.18	0.92	0.04	1.41	4.06	5.16	0.10	0.03	0.13	99.01
1072	11.4a	72.25	13.93	0.28	2.03	0.35	0.93	3.28	5.91	0.27	0.04	0.05	99.32
1072	11.4b	73.02	13.95	0.29	1.54	0.13	0.82	3.34	6.06	0.15	0.02	0.15	99.47
1072	11.4c	72.27	14.55	0.25	1.25	0.14	1.19	3.68	5.37	0.12	0.03	0.11	98.96
1073	11.5a	74.77	13.59	0.08	1.21	0.09	0.59	3.62	5.20	0.08	0.07	0.03	99.33
1073	11.5b	74.67	13.47	0.09	1.30	0.08	0.57	3.54	5.29	0.10	0.06	0.03	99.20
1073	11.5c	74.89	13.48	0.10	1.21	0.09	0.58	3.53	5.23	0.10	0.05	0.07	99.33
1074	11.6a	72.40	14.17	0.30	1.55	0.25	0.91	3.43	5.90	0.13	0.02	0.13	99.19
1074	11.6b	72.33	14.00	0.29	1.67	0.27	0.89	3.47	5.94	0.12	0.05	0.13	99.16
1074	11.6c	71.53	14.89	0.25	1.48	0.28	1.38	4.02	4.91	0.16	0.03	0.15	99.08
1075	11.7a	72.32	14.02	0.29	1.44	0.17	0.91	3.36	5.92	0.16	0.03	0.10	98.72
1075	11.7b	71.15	15.03	0.31	2.17	0.16	1.61	3.98	4.98	0.19	0.01	0.10	99.69
1075	11.7c	72.73	14.20	0.29	1.68	0.21	0.88	3.35	5.93	0.12	0.02	0.10	99.51
1076	11.8a	73.12	14.52	0.30	1.69	0.34	1.17	1.66	4.89	0.16	0.04	0.10	97.99
1076	11.8b	68.72	13.90	0.90	3.58	1.69	0.72	3.08	6.18	0.14	0.05	0.26	99.22
1076	11.8c	72.76	13.96	0.31	1.36	0.23	0.87	3.43	5.83	0.17	0.05	0.15	99.12
1077	11.9a	71.99	13.93	0.31	1.61	0.23	0.92	3.41	5.89	0.13	0.02	0.13	98.57
1077	11.9b	72.12	14.20	0.30	1.61	0.27	0.92	3.37	5.90	0.13	0.02	0.13	98.97
1077	11.9c	71.43	14.08	0.30	1.98	0.34	0.91	3.36	5.86	0.14	0.05	0.09	98.54
1078	11.10a	74.83	13.47	0.09	1.26	0.09	0.58	3.49	5.27	0.08	0.08	0.05	99.29
1078	11.10b	73.88	13.54	0.09	1.74	0.10	0.59	3.57	5.30	0.08	0.06	0.01	98.96
1078	11.10c	74.91	13.28	0.09	1.26	0.09	0.59	3.50	5.32	0.07	0.06	0.01	99.18
1079	11.11a	72.02	13.83	0.28	1.71	0.26	0.90	3.39	5.84	0.12	0.05	0.11	98.51
1079	11.11b	71.71	13.93	0.29	1.74	0.29	0.89	3.35	5.92	0.15	0.05	0.13	98.45
1079	11.11c	72.39	13.98	0.29	1.66	0.25	1.01	3.38	5.74	0.21	0.04	0.11	99.06
1080	11.12a	73.94	13.32	0.09	1.37	0.08	0.58	3.55	5.24	0.08	0.08	0.01	98.34

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1080	11.12b	74.57	13.49	0.09	1.35	0.08	0.58	3.40	5.24	0.08	0.07	0.00	98.95
1080	11.12c	74.22	13.59	0.09	1.21	0.08	0.61	3.58	5.32	0.07	0.04	0.04	98.85
1081	11.13a	72.49	13.94	0.31	1.38	0.21	0.89	3.30	5.92	0.13	0.03	0.13	98.73
1081	11.13b	72.52	14.13	0.30	1.23	0.18	1.00	3.47	5.78	0.13	0.02	0.12	98.88
1081	11.13c	72.78	14.06	0.30	1.40	0.22	0.92	3.24	5.96	0.14	0.02	0.16	99.20
1082	11.14a	72.25	14.09	0.30	1.37	0.18	0.89	3.41	5.94	0.13	0.02	0.13	98.71
1082	11.14b	71.34	13.95	0.30	1.73	0.21	0.90	3.31	5.87	0.15	0.05	0.15	97.96
1082	11.14c	71.52	13.91	0.28	1.41	0.16	0.93	3.47	5.91	0.14	0.03	0.07	97.83
1083	44.8a	72.79	13.75	0.28	1.57	0.20	0.84	3.27	6.00			0.08	98.78
1083	44.8b	72.37	13.76	0.28	1.65	0.25	0.90	3.17	5.87			0.09	98.33
1084	11.16a	72.36	14.00	0.28	0.86	0.06	0.87	3.36	5.97	0.15	0.00	0.09	98.00
1084	11.16b	70.67	15.24	0.27	1.71	0.14	1.64	3.98	4.97	0.11	0.02	0.09	98.84
1084	11.16c	71.90	14.09	0.29	1.52	0.18	0.88	3.36	5.94	0.13	0.01	0.14	98.44
1085	11.17a	73.01	14.07	0.08	1.03	0.05	0.64	3.46	5.84	0.06	0.03	0.01	98.28
1085	11.17b	74.31	13.33	0.10	1.27	0.08	0.58	3.23	5.53	0.09	0.07	0.03	98.62
1085	11.17c	74.34	13.37	0.08	1.32	0.06	0.57	3.20	5.57	0.10	0.06	0.00	98.67
1086	11.18a	73.40	13.48	0.09	1.20	0.08	0.60	3.57	5.26	0.07	0.05	0.04	97.84
1086	11.18b	74.06	13.49	0.10	1.23	0.09	0.57	3.39	5.37	0.09	0.06	0.01	98.46
1086	11.18c	73.57	13.44	0.09	1.30	0.09	0.62	3.58	5.31	0.08	0.07	0.01	98.16
1087	12.1a	72.65	13.65	0.26	1.47	0.18	0.77	3.24	5.96	0.13	0.06	0.12	98.49
1087	12.1b	72.77	13.73	0.24	1.31	0.14	0.80	3.33	5.88	0.14	0.03	0.12	98.49
1087	12.1c	73.00	13.70	0.24	1.25	0.16	0.78	3.26	5.96	0.14	0.01	0.11	98.61
1088	12.2a	72.61	13.96	0.29	1.44	0.20	0.90	3.34	5.88	0.14	0.01	0.11	98.88
1088	12.2b	72.56	13.78	0.29	1.32	0.19	0.89	3.25	5.87	0.13	0.03	0.06	98.37
1088	12.2c	71.10	13.72	0.31	2.94	0.37	0.87	3.24	5.73	0.14	0.04	0.07	98.53
1089	12.3a	73.07	13.69	0.26	1.59	0.15	0.74	3.22	6.01	0.13	0.03	0.11	99.00

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1089	12.3b	73.04	13.86	0.26	1.41	0.17	0.98	3.48	5.40	0.12	0.05	0.08	98.85
1089	12.3c	72.93	13.70	0.25	1.31	0.16	0.73	3.23	6.02	0.12	0.02	0.11	98.58
1090	12.4a	74.41	13.65	0.10	1.14	0.08	0.69	3.63	5.06	0.07	0.07	0.03	98.93
1090	12.4b	74.32	13.30	0.10	1.31	0.07	0.60	3.39	5.16	0.08	0.09	0.05	98.47
1090	12.4c	74.77	13.32	0.10	1.24	0.08	0.58	3.42	5.26	0.08	0.07	0.02	98.94
1091	12.5a	72.27	13.90	0.30	1.68	0.13	0.76	3.08	6.24	0.13	0.05	0.13	98.67
1091	12.5b	72.11	13.83	0.30	1.39	0.08	0.82	3.26	6.14	0.13	0.02	0.11	98.19
1091	12.5c	72.62	13.93	0.28	1.09	0.11	0.78	3.27	6.16	0.13	0.04	0.12	98.53
1092	12.6a	72.12	13.85	0.31	1.61	0.23	0.90	3.35	5.91	0.14	0.05	0.10	98.57
1092	12.6b	72.09	13.72	0.27	2.11	0.41	0.87	3.30	5.69	0.13	0.01	0.10	98.70
1092	12.6c	72.26	13.86	0.28	1.67	0.21	0.87	3.26	5.85	0.15	0.04	0.12	98.57
1093	12.7a	74.57	12.98	0.14	0.89	0.08	0.60	2.46	5.50	0.07	0.04	0.05	97.38
1093	12.7b	74.81	13.13	0.16	0.93	0.09	0.62	3.44	5.54	0.08	0.05	0.04	98.89
1093	12.7c	74.47	13.07	0.16	1.09	0.08	0.60	3.37	5.48	0.09	0.03	0.05	98.49
1094	12.8a	72.24	13.80	0.30	1.35	0.13	0.93	3.29	5.96	0.17	0.03	0.14	98.34
1094	12.8b	71.63	13.86	0.40	2.21	0.32	0.92	3.31	5.88	0.17	0.05	0.03	98.78
1094	12.8c	72.10	13.76	0.31	1.80	0.27	0.89	3.28	5.88	0.15	0.04	0.09	98.57
1095	12.9a	75.67	12.98	0.13	1.36	0.09	0.53	3.41	5.43	0.07	0.04	0.03	99.74
1095	12.9b	75.32	12.97	0.12	1.08	0.14	0.54	3.42	5.30	0.07	0.03	0.02	99.01
1095	12.9c	75.06	13.03	0.12	1.60	0.16	0.59	3.53	5.21	0.07	0.03	0.03	99.43
1096	12.10a	74.52	13.23	0.05	1.23	0.07	0.57	3.36	5.29	0.06	0.05	0.00	98.43
1096	12.10b	74.15	13.28	0.06	1.22	0.09	0.56	3.38	5.32	0.06	0.04	0.00	98.16
1096	12.10c	74.30	13.12	0.09	1.28	0.08	0.60	3.35	5.33	0.09	0.06	0.03	98.33
1097	12.11a	74.75	12.73	0.12	1.27	0.11	0.56	3.25	5.38	0.07	0.03	0.00	98.27
1097	12.11b	74.86	12.89	0.13	0.97	0.10	0.57	3.21	5.38	0.06	0.04	0.00	98.21
1097	12.11c	75.01	12.71	0.13	0.99	0.10	0.56	3.19	5.36	0.07	0.04	0.01	98.17

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1098	12.12a	74.64	12.74	0.11	1.56	0.08	0.54	3.22	5.51	0.06	0.04	0.04	98.54
1098	12.12b	75.01	12.77	0.12	0.97	0.09	0.53	3.33	5.52	0.06	0.03	0.02	98.45
1098	12.12c	75.29	12.91	0.12	0.93	0.09	0.55	3.22	5.48	0.07	0.04	0.03	98.73
1099	12.13a	73.18	13.74	0.26	1.40	0.19	1.02	3.30	5.54	0.15	0.02	0.07	98.87
1099	12.13b	72.22	13.63	0.27	1.74	0.13	0.71	2.98	6.18	0.13	0.03	0.12	98.14
1099	12.13c	72.47	13.55	0.28	1.83	0.23	0.79	3.12	6.04	0.14	0.06	0.12	98.63
1100	12.14a	72.81	13.95	0.27	0.71	0.24	0.90	3.30	6.01	0.15	0.04	0.11	98.49
1100	12.14b	71.88	13.72	0.29	2.21	0.24	0.90	3.24	5.75	0.12	0.03	0.08	98.46
1100	12.14c	73.16	14.04	0.28	0.51	0.22	0.92	3.33	6.06	0.14	0.05	0.07	98.78
1101	12.15a	72.27	13.87	0.25	1.72	0.28	0.84	3.28	5.68	0.10	0.00	0.04	98.33
1101	12.15b	71.97	13.93	0.24	1.73	0.28	0.87	3.26	5.73	0.12	0.00	0.08	98.21
1101	12.15c	72.11	13.72	0.29	1.79	0.25	0.90	3.32	5.68	0.14	0.03	0.09	98.32
1102	12.16a	72.51	13.75	0.29	1.56	0.20	0.88	3.23	5.76	0.14	0.01	0.10	98.43
1102	12.16b	72.06	13.79	0.29	1.81	0.30	0.88	3.42	5.71	0.15	0.03	0.13	98.57
1102	12.16c	71.98	13.88	0.30	1.78	0.32	0.90	3.30	5.72	0.12	0.02	0.14	98.46
1103	12.17a	72.38	13.88	0.30	1.55	0.21	0.84	3.25	5.92	0.15	0.03	0.10	98.61
1103	12.17b	71.76	13.82	0.30	1.56	0.18	0.87	3.26	5.86	0.14	0.03	0.06	97.84
1103	12.17c	71.86	13.60	0.29	1.82	0.32	0.94	3.25	5.68	0.13	0.03	0.05	97.97
1104	12.18a	72.53	13.83	0.30	1.56	0.25	0.86	3.20	6.01	0.16	0.03	0.09	98.82
1104	12.18b	72.49	13.88	0.28	1.54	0.26	0.84	3.23	5.99	0.14	0.05	0.12	98.82
1104	12.18c	72.48	13.73	0.29	1.58	0.26	0.83	3.19	5.93	0.13	0.04	0.18	98.64
1105	13.1a	72.94	13.89	0.30	1.25	0.15	0.99	3.43	5.77	0.16	0.05	0.12	99.05
1105	13.1b	72.92	13.77	0.29	1.35	0.07	0.87	3.39	5.91	0.14	0.02	0.14	98.87
1105	13.1c	72.51	13.97	0.28	1.40	0.17	1.02	3.47	5.51	0.14	0.04	0.13	98.64
1106	13.2a	75.30	12.78	0.10	1.03	0.08	0.53	3.38	5.33	0.08	0.03	0.01	98.65
1106	13.2b	75.25	12.72	0.11	1.03	0.09	0.57	3.32	5.44	0.08	0.01	0.03	98.65

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1106	13.2c	75.14	12.53	0.12	1.67	0.08	0.53	3.25	5.38	0.10	0.04	0.03	98.87
1107	13.3a	74.74	13.24	0.14	0.92	0.07	0.63	3.39	5.57	0.07	0.00	0.00	98.77
1107	13.3b	74.46	13.12	0.16	1.08	0.12	0.60	3.35	5.50	0.08	0.02	0.04	98.53
1107	13.3c	74.77	13.09	0.16	1.03	0.09	0.62	3.45	5.56	0.09	0.04	0.00	98.90
1108	13.4a	74.83	12.93	0.14	1.10	0.12	0.57	3.36	5.40	0.10	0.03	0.02	98.60
1108	13.4b	74.60	12.90	0.14	1.08	0.12	0.58	3.35	5.34	0.08	0.03	0.00	98.22
1108	13.4c	74.67	12.86	0.14	1.13	0.13	0.58	3.37	5.37	0.08	0.02	0.03	98.38
1109	13.5a	75.77	12.82	0.13	1.02	0.11	0.56	3.38	5.27	0.06	0.04	0.00	99.16
1109	13.5b	75.06	12.70	0.13	0.96	0.10	0.56	3.41	5.31	0.07	0.01	0.02	98.33
1109	13.5c	75.09	12.93	0.12	1.13	0.11	0.57	3.32	5.34	0.07	0.03	0.05	98.76
1110	13.6a	73.74	12.73	0.13	3.02	0.11	0.54	3.42	5.16	0.08	0.01	0.00	98.94
1110	13.6b	74.74	12.81	0.12	1.07	0.09	0.58	3.36	5.31	0.09	0.04	0.01	98.22
1110	13.6c	74.24	12.43	0.12	1.16	0.08	0.58		5.27	0.08	0.03	0.03	94.02
1111	13.7a	74.80	12.88	0.11	1.18	0.09	0.56	3.40	5.26	0.07	0.02	0.05	98.42
1111	13.7b	75.11	12.67	0.12	1.13	0.08	0.56	3.34	5.23	0.07	0.04	0.08	98.43
1111	13.7c	74.87	12.85	0.12	1.13	0.10	0.57	3.39	5.24	0.07	0.05	0.00	98.39
1112	13.8a	75.20	12.59	0.11	1.07	0.09	0.54	3.38	5.25	0.08	0.05	0.05	98.41
1112	13.8b	74.84	12.80	0.12	1.36	0.11	0.57	3.32	5.20	0.07	0.02	0.00	98.41
1112	13.8c	74.94	12.80	0.12	1.05	0.09	0.56	3.31	5.28	0.09	0.03	0.00	98.27
1113	13.9a	75.01	12.88	0.12	0.98	0.09	0.55	3.35	5.36	0.08	0.03	0.01	98.46
1113	13.9b	74.39	12.83	0.13	0.97	0.09	0.55	3.34	5.45	0.08	0.03	0.00	97.86
1113	13.9c	74.47	12.88	0.12	1.00	0.07	0.57	3.28	5.34	0.07	0.04	0.05	97.89
1114	13.10a	74.69	12.82	0.12	1.15	0.10	0.57	3.32	5.32	0.08	0.03	0.08	98.28
1114	13.10b	74.33	12.81	0.12	1.20	0.12	0.58	3.30	5.26	0.08	0.02	0.00	97.82
1114	13.10c	75.17	12.93	0.13	1.12	0.11	0.55	3.35	5.20	0.08	0.02	0.06	98.72
1115	13.11a	74.27	12.44	0.14	1.18	0.10	0.54		5.25	0.06	0.03	0.06	94.07

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1115	13.11b	74.66	12.76	0.12	1.25	0.10	0.58	3.42	5.19	0.07	0.03	0.01	98.19
1115	13.11c	74.64	12.87	0.13	1.26	0.10	0.57	3.31	5.25	0.09	0.06	0.04	98.32
1116	13.12a	74.33	12.65	0.13	2.14	0.10	0.56	3.31	5.28	0.07	0.03	0.00	98.60
1116	13.12b	75.01	12.79	0.12	1.01	0.09	0.55	3.34	5.33	0.08	0.02	0.00	98.34
1116	13.12c	75.12	12.61	0.12	1.30	0.10	0.55	3.33	5.31	0.07	0.04	0.01	98.56
1117	13.13a	71.81	13.05	0.50	3.35	0.30	0.77	3.17	5.51	0.14	0.05	0.09	98.74
1117	13.13b	70.68	16.18	0.20	0.81	0.08	2.06	4.35	4.41	0.12	0.01	0.18	99.08
1117	13.13c	73.51	13.65	0.27	1.27	0.20	0.97	3.60	5.08	0.15	0.02	0.10	98.82
1118	13.14a	71.63	13.84	0.29	1.85	0.35	0.91	3.30	5.69	0.13	0.05	0.16	98.20
1118	13.14b	72.53	13.95	0.29	1.23	0.18	0.89	3.30	5.89	0.13	0.02	0.13	98.54
1118	13.14c	71.02	13.84	0.28	3.48	0.07	0.85	3.37	5.68	0.13	0.00	0.16	98.88
1119	13.15a	72.80	13.71	0.30	1.41	0.15	0.90	3.34	5.81	0.12	0.03	0.13	98.70
1119	13.15b	72.63	13.92	0.30	1.25	0.16	0.90	3.29	5.83	0.13	0.03	0.11	98.55
1119	13.15c	72.07	13.80	0.28	1.56	0.20	0.89	3.40	5.85	0.15	0.03	0.16	98.39
1120	13.16a	73.20	13.57	0.22	1.20	0.13	0.75	3.26	5.78	0.12	0.03	0.12	98.38
1120	13.16b	72.62	13.31	0.30	1.90	0.28	0.73	3.10	5.97	0.17	0.03	0.08	98.49
1120	13.16c	73.52	13.44	0.21	1.20	0.13	0.69	3.19	5.88	0.12	0.03	0.09	98.50
1121	13.17a	74.86	12.81	0.13	1.05	0.10	0.57	3.37	5.29	0.07	0.02	0.02	98.29
1121	13.17b	75.17	12.59	0.09	0.95	0.08	0.53	3.37	5.20	0.06	0.04	0.01	98.09
1121	13.17c	75.63	12.63	0.11	0.91	0.08	0.53	3.35	5.27	0.06	0.07	0.00	98.64
1122	13.18a	72.15	13.92	0.28	1.68	0.28	0.86	3.27	5.65	0.15	0.06	0.10	98.40
1122	13.18b	71.85	13.81	0.28	1.68	0.27	0.85	3.27	5.71	0.13	0.03	0.07	97.95
1122	13.18c	69.54	16.28	0.22	1.29	0.19	2.21	4.21	4.59	0.14	0.02	0.12	98.81
1123	14.1a	74.76	12.93	0.10	1.12	0.12	0.55	3.40	5.35	0.05	0.03	0.00	98.41
1123	14.1b	74.86	12.83	0.09	1.08	0.11	0.53	3.41	5.48	0.05	0.00	0.00	98.44
1123	14.1c	74.57	12.91	0.13	1.32	0.10	0.55	3.44	5.36	0.07	0.04	0.06	98.55

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1124	14.2a	75.01	13.14	0.12	1.00	0.08	0.54	3.42	5.44	0.05	0.05	0.04	98.89
1124	14.2b	74.42	12.77	0.13	1.47	0.09	0.56	3.30	5.31	0.07	0.03	0.04	98.19
1124	14.2c	74.56	12.55	0.11	0.97	0.08	0.54		5.42	0.06	0.03	0.05	94.37
1125	14.3a	73.89	13.28	0.09	1.33	0.07	0.56	3.42	5.35	0.07	0.07	0.00	98.13
1125	14.3b	73.89	13.55	0.10	1.03	0.06	0.67	3.67	5.06	0.08	0.06	0.00	98.17
1125	14.3c	74.11	13.24	0.08	1.14	0.07	0.47	3.44	5.39	0.09	0.03	0.04	98.10
1126	14.4a	76.09	12.12	0.08	0.89	0.07	0.59	3.55	4.63	0.06	0.04	0.04	98.16
1126	14.4b	74.96	12.97	0.11	1.01	0.08	0.55	3.38	5.36	0.06	0.04	0.02	98.54
1126	14.4c	74.50	13.01	0.12	1.11	0.09	0.55	3.37	5.31	0.08	0.04	0.02	98.20
1127	14.5a	74.21	13.28	0.09	1.18	0.08	0.59	3.46	5.30	0.09	0.06	0.06	98.40
1127	14.5b	74.12	13.33	0.10	1.26	0.09	0.59	3.49	5.21	0.08	0.05	0.03	98.35
1127	14.5c	74.03	13.26	0.10	1.22	0.08	0.60	3.54	5.25	0.10	0.04	0.02	98.24
1128	14.6a	73.87	13.34	0.11	1.35	0.08	0.58	3.45	5.25	0.10	0.04	0.00	98.17
1128	14.6b	74.30	13.37	0.10	1.27	0.09	0.59	3.36	5.28	0.07	0.05	0.02	98.50
1128	14.6c	73.90	13.30	0.09	1.22	0.10	0.59	3.45	5.29	0.06	0.03	0.02	98.05
1129	14.7a	72.13	13.95	0.30	1.63	0.26	0.89	3.30	5.87	0.12	0.05	0.12	98.62
1129	14.7b	72.09	13.78	0.28	1.93	0.27	0.88	3.38	5.84	0.13	0.05	0.12	98.75
1129	14.7c	72.06	13.85	0.29	1.39	0.17	0.89	3.34	5.92	0.14	0.04	0.12	98.21
1130	14.8a	72.21	14.00	0.29	1.62	0.20	0.86	3.36	5.96	0.15	0.04	0.13	98.82
1130	14.8b	71.88	13.73	0.28	1.87	0.26	0.88	3.22	5.80	0.15	0.03	0.12	98.22
1130	14.8c	72.13	14.03	0.30	1.57	0.26	0.90	3.29	5.84	0.15	0.05	0.12	98.64
1131	14.9a	73.18	13.93	0.29	1.32	0.17	0.84	3.36	5.90	0.14	0.03	0.14	99.30
1131	14.9b	72.33	13.57	0.29	1.75	0.28	0.91	3.28	5.69	0.21	0.04	0.10	98.45
1131	14.9c	73.02	13.56	0.31	2.09	0.30	0.85	3.32	5.63	0.13	0.01	0.17	99.39
1132	14.10a	72.71	14.00	0.30	1.07	0.10	0.88	3.28	5.98	0.12	0.01	0.11	98.56
1132	14.10b	70.01	15.33	0.26	1.72	0.26	1.91	3.81	4.87	0.15	0.02	0.11	98.45

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1132	14.10c	71.93	13.87	0.30	1.74	0.23	0.91	3.20	5.97	0.12	0.04	0.11	98.42
1133	14.11a	71.87	13.90	0.29	1.96	0.34	0.91	3.27	5.78	0.13	0.04	0.08	98.57
1133	14.11b	72.34	14.01	0.32	0.87	0.05	0.90	3.34	5.97	0.13	0.01	0.13	98.07
1133	14.11c	71.99	13.80	0.29	1.40	0.21	0.88	3.33	5.88	0.15	0.02	0.16	98.11
1134	14.12a	74.29	13.39	0.08	0.87	0.04	0.58	3.94	4.76	0.08	0.05	0.00	98.08
1134	14.12b	73.71	13.22	0.11	1.30	0.08	0.57	3.40	5.29	0.08	0.06	0.00	97.82
1134	14.12c	73.80	13.02	0.09	1.43	0.08	0.54	3.34	5.28	0.08	0.08	0.02	97.76
1135	14.13a	73.92	13.48	0.09	1.27	0.08	0.63	3.49	5.18	0.09	0.04	0.03	98.30
1135	14.13b	73.83	13.29	0.10	1.24	0.07	0.59	3.48	5.17	0.08	0.06	0.00	97.91
1135	14.13c	73.97	13.28	0.10	1.21	0.08	0.61	3.49	5.17	0.09	0.07	0.00	98.07
1136	14.14a	72.56	13.89	0.29	1.84	0.24	0.90	3.36	5.73	0.12	0.02	0.12	99.07
1136	14.14b	72.54	13.94	0.29	2.31	0.43	0.93	3.36	5.60	0.13	0.06	0.08	99.67
1136	14.14c	72.44	14.00	0.29	2.06	0.25	0.85	3.29	5.87	0.15	0.02	0.09	99.31
1137	14.15a	71.65	13.95	0.29	1.81	0.29	0.93	3.30	5.83	0.14	0.04	0.15	98.38
1137	14.15b	71.94	13.74	0.29	1.59	0.27	0.86	3.29	5.86	0.14	0.03	0.14	98.15
1137	14.15c	72.15	13.96	0.27	1.45	0.19	0.87	3.26	5.95	0.13	0.03	0.09	98.35
1138	14.16a	74.38	13.46	0.09	1.16	0.09	0.59	3.50	5.17	0.07	0.04	0.04	98.59
1138	14.16b	74.17	13.11	0.09	1.28	0.08	0.55	3.40	5.22	0.08	0.08	0.00	98.06
1138	14.16c	74.11	13.13	0.09	1.30	0.08	0.59	3.36	5.29	0.09	0.05	0.01	98.10
1139	14.17a	74.15	13.19	0.10	1.52	0.08	0.57	3.41	5.31	0.08	0.04	0.00	98.45
1139	14.17b	74.04	13.41	0.09	1.36	0.08	0.58	3.49	5.14	0.07	0.04	0.00	98.30
1139	14.17c	73.66	13.34	0.08	1.46	0.08	0.59	3.53	5.14	0.09	0.06	0.07	98.10
1140	14.18a	70.89	13.39	0.22	4.17	0.74	0.50	3.18	5.65	0.09	0.06	0.04	98.93
1140	14.18b	72.34	13.21	0.14	3.48	0.20	0.56	3.41	5.23	0.08	0.06	0.01	98.72
1140	14.18c	73.70	13.91	0.08	1.13	0.07	0.69	3.88	4.92	0.07	0.05	0.03	98.53
1140	14.18d	74.26	13.34	0.10	1.21	0.08	0.64	3.52	5.03	0.08	0.05	0.00	98.31

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1140	14.18e	74.19	13.38	0.10	1.44	0.12	0.59	3.42	5.21	0.09	0.05	0.01	98.60
1140	14.18f	74.34	13.20	0.10	1.65	0.08	0.56	3.46	5.18	0.09	0.05	0.01	98.72
1141	15.1a	74.40	13.38	0.09	1.23	0.08	0.57	3.55	5.23	0.07	0.04	0.00	98.64
1141	15.1b	74.00	13.36	0.09	1.23	0.08	0.58	3.36	5.27	0.08	0.04	0.01	98.10
1141	15.1c	74.30	13.25	0.09	1.16	0.06	0.58	3.46	5.14	0.09	0.06	0.04	98.23
1142	15.2a	73.84	13.40	0.10	1.24	0.09	0.59	3.43	5.31	0.09	0.05	0.02	98.16
1142	15.2b	74.26	13.18	0.09	1.19	0.08	0.56	3.47	5.19	0.10	0.07	0.05	98.24
1142	15.2c	74.40	13.38	0.10	1.25	0.09	0.57	3.42	5.20	0.06	0.03	0.07	98.57
1143	15.3a	72.80	13.90	0.28	1.30	0.15	0.87	3.36	5.93	0.14	0.03	0.15	98.91
1143	15.3b	72.81	13.94	0.27	1.36	0.18	0.90	3.32	5.86	0.16	0.01	0.11	98.92
1143	15.3c	72.20	13.76	0.29	1.38	0.16	0.89	3.31	5.83	0.15	0.01	0.09	98.07
1144	15.4a	74.58	13.12	0.10	1.26	0.08	0.54	3.38	5.21	0.09	0.07	0.00	98.43
1144	15.4b	74.59	13.34	0.10	1.33	0.08	0.55	3.47	5.13	0.09	0.07	0.00	98.75
1144	15.4c	74.35	13.40	0.09	1.31	0.08	0.59	3.49	5.15	0.08	0.05	0.00	98.59
1145	15.5a	74.00	13.45	0.10	1.18	0.09	0.57	3.47	5.21	0.08	0.06	0.00	98.21
1145	15.5b	73.66	13.36	0.09	1.26	0.09	0.60	3.48	5.23	0.07	0.04	0.00	97.88
1145	15.5c	73.68	13.35	0.09	1.28	0.08	0.59	3.54	5.15	0.10	0.06	0.03	97.95
1146	15.6a	72.06	13.86	0.29	1.86	0.25	0.89	3.29	5.73	0.12	0.02	0.10	98.47
1146	15.6b	71.69	13.98	0.30	1.57	0.25	0.91	3.37	5.75	0.12	0.02	0.11	98.07
1146	15.6c	71.85	14.10	0.29	1.79	0.28	0.90	3.42	5.69	0.12	0.02	0.10	98.56
1147	15.7a	73.83	13.42	0.08	1.22	0.08	0.58	3.46	5.21	0.08	0.06	0.00	98.02
1147	15.7b	73.87	13.28	0.10	1.30	0.08	0.57	3.38	5.18	0.09	0.04	0.00	97.89
1147	15.7c	74.22	13.40	0.09	1.15	0.08	0.59	3.44	5.15	0.08	0.05	0.00	98.25
1148	15.8a	72.06	13.95	0.30	1.29	0.20	0.90	3.38	5.80	0.14	0.02	0.10	98.14
1148	15.8b	72.41	14.01	0.30	1.26	0.18	0.88	3.36	5.82	0.15	0.02	0.11	98.50
1148	15.8c	71.96	13.84	0.30	2.06	0.20	0.89	3.34	5.84	0.14	0.02	0.13	98.72

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1148	15.8d	72.45	13.96	0.30	1.14	0.19	0.90	3.34	5.79	0.14	0.02	0.10	98.33
1148	15.8e	72.77	13.92	0.29	1.35	0.18	0.91	3.33	5.88	0.12	0.04	0.14	98.93
1149	15.9a	74.42	13.24	0.09	1.30	0.09	0.58	3.43	5.06	0.08	0.05	0.02	98.36
1149	15.9b	73.87	13.28	0.09	1.30	0.09	0.62	3.55	5.19	0.08	0.02	0.02	98.11
1149	15.9c	74.69	13.02	0.09	1.19	0.07	0.53	3.49	5.14	0.07	0.05	0.05	98.39
1150	15.10a	74.72	12.70	0.12	1.27	0.10	0.59	3.32	5.22	0.05	0.05	0.03	98.17
1150	15.10b	74.96	12.78	0.13	1.17	0.09	0.54	3.33	5.26	0.09	0.02	0.02	98.39
1150	15.10c	74.92	12.96	0.12	1.07	0.09	0.54	3.29	5.26	0.09	0.04	0.06	98.44
1151	15.11a	74.78	12.84	0.12	1.11	0.08	0.53	3.34	5.43	0.06	0.04	0.03	98.36
1151	15.11b	74.87	12.84	0.13	1.10	0.10	0.55	3.35	5.45	0.05	0.02	0.05	98.51
1151	15.11c	74.82	12.91	0.13	1.24	0.09	0.54	3.29	5.43	0.08	0.01	0.00	98.54
1152	15.12a	70.38	13.64	0.36	4.72	0.48	0.88	3.26	5.49	0.14	0.04	0.12	99.51
1152	15.12b	72.33	13.98	0.30	1.50	0.22	0.90	3.29	5.84	0.12	0.02	0.08	98.58
1152	15.12c	72.67	14.00	0.29	1.42	0.18	0.90	3.31	5.77	0.12	0.02	0.11	98.79
1153	15.13a	75.22	12.70	0.11	1.23	0.08	0.55	3.32	5.23	0.06	0.02	0.00	98.52
1153	15.13b	73.84	12.74	0.13	2.94	0.09	0.56	3.39	5.21	0.06	0.03	0.05	99.04
1153	15.13c	75.05	12.93	0.11	1.01	0.08	0.54	3.35	5.27	0.07	0.04	0.03	98.48
1154	15.14a	72.65	13.42	0.23	1.64	0.23	0.92	3.15	5.79	0.23	0.05	0.11	98.42
1154	15.14b	72.51	13.85	0.26	2.09	0.35	0.83	3.22	5.80	0.14	0.05	0.09	99.19
1154	15.14c	71.92	13.98	0.29	1.61	0.24	0.93	3.26	5.75	0.12	0.03	0.11	98.24
1155	15.15a	71.94	13.88	0.30	1.38	0.10	0.90	3.30	5.89	0.13	0.02	0.07	97.91
1155	15.15b	72.63	13.89	0.29	1.53	0.19	0.92	3.30	5.82	0.16	0.02	0.09	98.84
1155	15.15c	71.42	13.83	0.30	2.38	0.40	0.87	3.20	5.68	0.13	0.04	0.08	98.33
1156	15.16a	71.45	13.98	0.35	1.96	0.32	0.95	3.33	5.80	0.15	0.03	0.10	98.42
1156	15.16b	71.47	14.08	0.37	1.99	0.27	0.97	3.34	5.80	0.15	0.06	0.13	98.63
1156	15.16c	72.20	13.93	0.31	2.06	0.24	0.96	3.31	5.78	0.13	0.03	0.10	99.05

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1157	16.1a	72.49	14.03	0.34	1.87	0.38	1.22	3.70	4.99	0.14	0.03	0.11	99.30
1157	16.1b	72.17	14.21	0.33	1.96	0.37	1.17	3.75	5.07	0.14	0.03	0.10	99.30
1157	16.1c	72.20	14.35	0.35	1.97	0.32	0.86	3.38	5.93	0.13	0.05	0.13	99.67
1158	16.2a	74.97	12.91	0.10	1.10	0.10	0.57	3.35	5.45	0.06	0.06	0.04	98.71
1158	16.2b	74.77	12.90	0.11	1.21	0.10	0.54	3.30	5.43	0.07	0.02	0.02	98.47
1158	16.2c	74.56	12.80	0.11	1.10	0.10	0.55	3.32	5.41	0.06	0.06	0.02	98.09
1160	16.4a	74.96	12.73	0.11	0.96	0.06	0.53	3.35	5.41	0.09	0.05	0.02	98.27
1160	16.4b	74.72	12.88	0.12	1.09	0.09	0.55	3.34	5.41	0.08	0.02	0.04	98.34
1160	16.4c	74.46	12.89	0.13	1.18	0.10	0.56	3.37	5.35	0.07	0.01	0.01	98.13
1161	16.5a	74.96	13.34	0.09	1.30	0.07	0.59	3.39	5.29	0.08	0.06	0.01	99.18
1161	16.5b	74.00	13.35	0.09	1.70	0.07	0.62	3.55	5.21	0.11	0.06	0.00	98.76
1161	16.5c	74.56	13.36	0.09	1.29	0.08	0.59	3.45	5.25	0.08	0.07	0.00	98.82
1162	16.6a	72.56	14.11	0.30	1.60	0.24	0.85	3.29	5.98	0.13	0.04	0.11	99.21
1162	16.6b	72.60	13.41	0.23	1.81	0.32	0.85	3.20	5.71	0.16	0.04	0.08	98.41
1162	16.6c	73.03	13.67	0.26	1.59	0.18	0.80	3.22	5.99	0.13	0.04	0.10	99.01
1163	16.7a	72.31	13.74	0.24	1.55	0.20	0.78	2.53	7.01	0.13	0.03	0.07	98.59
1163	16.7b	72.00	13.69	0.27	2.02	0.17	0.89	2.87	6.53	0.21	0.02	0.05	98.72
1163	16.7c	72.84	13.89	0.23	1.44	0.16	0.75	3.23	6.01	0.11	0.03	0.07	98.76
1164	16.8a	74.14	13.06	0.09	1.21	0.05	0.55	3.26	5.33	0.08	0.07	0.00	97.84
1164	16.8b	74.33	13.38	0.08	1.23	0.05	0.56	3.38	5.39	0.08	0.06	0.00	98.54
1164	16.8c	73.68	13.28	0.10	1.26	0.05	0.57	3.38	5.38	0.08	0.08	0.01	97.87
1165	16.9a	72.41	14.63	0.06	0.89	0.05	0.94	4.50	4.69	0.08	0.06	0.03	98.34
1165	16.9b	74.01	13.47	0.09	1.26	0.07	0.58	3.38	5.38	0.08	0.07	0.02	98.41
1165	16.9c	73.33	13.25	0.08	2.83	0.06	0.59	3.46	5.09	0.08	0.06	0.00	98.83
1166	16.10a	72.81	13.59	0.22	1.19	0.09	0.72	3.18	6.06	0.10	0.05	0.08	98.09
1166	16.10b	72.60	13.72	0.24	1.48	0.13	0.74	3.17	6.10	0.12	0.02	0.08	98.40

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1166	16.10c	72.53	13.98	0.23	1.17	0.11	0.88	3.26	5.83	0.13	0.03	0.02	98.17
1167	16.11a	74.36	13.32	0.09	1.31	0.06	0.57	3.30	5.35	0.09	0.05	0.00	98.50
1167	16.11b	73.29	13.38	0.09	1.18	0.09	0.59	3.30	5.40	0.11	0.05	0.03	97.51
1167	16.11c	73.58	13.17	0.10	1.15	0.08	0.58	3.35	5.34	0.09	0.07	0.00	97.51
1168	16.12a	71.50	13.94	0.29	1.82	0.23	0.91	3.33	5.87	0.12	0.02	0.06	98.09
1168	16.12b	71.48	13.90	0.29	1.31	0.15	0.92	3.27	5.92	0.16	0.02	0.14	97.56
1168	16.12c	71.14	13.91	0.30	1.85	0.17	0.94	3.34	5.90	0.15	0.03	0.17	97.90
1169	16.13a	71.81	13.87	0.29	1.64	0.23	0.92	3.29	5.90	0.16	0.03	0.12	98.26
1169	16.13b	70.75	13.96	0.29	1.58	0.21	0.93	3.14	6.01	0.14	0.02	0.10	97.13
1169	16.13c	70.12	13.84	0.33	2.78	0.23	0.85	3.32	5.99	0.12	0.04	0.16	97.78
1170	16.14a	73.94	12.82	0.11	1.69	0.10	0.53	3.33	5.36	0.08	0.06	0.00	98.02
1170	16.14b	74.65	12.87	0.12	1.04	0.10	0.54	3.34	5.46	0.06	0.02	0.00	98.20
1170	16.14c	74.95	12.85	0.11	1.10	0.10	0.56	3.30	5.46	0.08	0.03	0.03	98.57
1171	16.15a	73.19	13.30	0.09	1.25	0.07	0.58	3.40	5.31	0.07	0.06	0.00	97.32
1171	16.15b	72.90	13.28	0.10	1.31	0.08	0.59	3.39	5.30	0.08	0.08	0.03	97.14
1171	16.15c	72.89	13.39	0.09	1.35	0.09	0.57	3.39	5.38	0.09	0.07	0.02	97.33
1172	16.16a	73.20	12.95	0.12	1.48	0.20	0.57	3.39	5.39	0.07	0.03	0.01	97.41
1172	16.16b	73.57	13.00	0.13	1.20	0.14	0.57	3.35	5.37	0.06	0.05	0.00	97.44
1172	16.16c	73.51	13.09	0.14	1.02	0.11	0.58	3.35	5.49	0.06	0.03	0.03	97.41
1173	16.17a	73.16	12.89	0.14	1.17	0.13	0.60	3.34	5.54	0.07	0.02	0.01	97.07
1173	16.17b	73.14	13.09	0.13	1.18	0.13	0.58	3.36	5.56	0.08	0.02	0.02	97.29
1173	16.17c	73.00	13.17	0.15	1.27	0.14	0.59	3.38	5.60	0.05	0.03	0.00	97.38
1174	16.18a	72.83	13.39	0.09	1.16	0.07	0.57	3.42	5.47	0.08	0.06	0.00	97.14
1174	16.18b	71.70	13.85	0.07	1.11	0.06	0.66	3.76	5.15	0.08	0.05	0.07	96.56
1174	16.18c	73.35	13.32	0.09	1.20	0.07	0.59	3.40	5.42	0.08	0.09	0.01	97.62
1174	16.18d	73.81	13.58	0.08	1.25	0.08	0.64	3.11	5.25	0.08	0.07	0.03	97.98

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1174	16.18e	73.41	13.41	0.09	1.15	0.07	0.57	3.36	5.34	0.08	0.06	0.07	97.61
1175	17.1a	74.93	13.01	0.13	1.22	0.09	0.56	3.41	5.43	0.07	0.02	0.04	98.91
1175	17.1b	74.75	12.93	0.13	1.05	0.10	0.54	3.35	5.45	0.08	0.03	0.00	98.41
1175	17.1c	74.52	13.02	0.13	1.09	0.10	0.55	3.38	5.47	0.06	0.03	0.03	98.38
1176	17.2a	73.30	13.85	0.17	1.00	0.08	0.73	3.46	5.74	0.12	0.03	0.06	98.54
1176	17.2b	73.74	13.63	0.16	1.07	0.06	0.73	3.42	5.72	0.12	0.02	0.06	98.73
1176	17.2c	73.96	13.72	0.17	1.04	0.08	0.70	3.35	5.76	0.10	0.03	0.08	98.99
1177	17.3a	74.77	13.02	0.12	1.12	0.11	0.56	3.38	5.39	0.07	0.04	0.01	98.59
1177	17.3b	74.46	12.94	0.12	1.09	0.11	0.56	3.39	5.45	0.08	0.04	0.00	98.24
1177	17.3c	73.74	12.87	0.12	2.54	0.11	0.55	3.43	5.38	0.08	0.04	0.00	98.86
1178	17.4a	75.47	13.08	0.13	1.02	0.11	0.57	3.43	5.55	0.05	0.03	0.00	99.44
1178	17.4b	74.78	12.94	0.13	1.08	0.10	0.57	3.43	5.49	0.05	0.04	0.01	98.62
1179	17.4c	75.02	13.02	0.11	1.10	0.09	0.57	3.42	5.40	0.07	0.05	0.01	98.86
1179	17.5a	74.29	12.80	0.12	1.09	0.09	0.57	3.35	5.54	0.06	0.04	0.01	97.96
1179	17.5b	74.88	12.95	0.12	1.15	0.09	0.56	3.30	5.49	0.08	0.05	0.00	98.67
1179	17.5c	74.25	13.11	0.11	1.14	0.10	0.56	3.35	5.51	0.09	0.02	0.00	98.24
1180	17.6a	74.72	13.11	0.12	1.13	0.10	0.57	3.36	5.44	0.09	0.03	0.06	98.73
1180	17.6b	74.99	12.96	0.11	1.14	0.11	0.56	3.44	5.51	0.06	0.04	0.05	98.97
1180	17.6c	73.49	12.79	0.13	3.30	0.18	0.54	3.38	5.35	0.08	0.02	0.01	99.27
1181	17.7a	74.50	12.99	0.11	1.03	0.11	0.56	3.39	5.44	0.07	0.02	0.03	98.25
1181	17.7b	74.68	12.93	0.11	1.09	0.11	0.60	3.48	5.47	0.10	0.03	0.02	98.62
1181	17.7c	74.46	12.91	0.13	1.38	0.11	0.56	3.42	5.42	0.06	0.03	0.02	98.50
1182	17.8a	72.17	13.67	0.25	1.43	0.19	0.80	3.25	5.91	0.12	0.02	0.13	97.94
1182	17.8b	72.25	13.82	0.26	1.70	0.25	0.80	3.23	6.02	0.11	0.04	0.11	98.59
1182	17.8c	72.12	13.85	0.25	1.48	0.18	0.83	3.33	6.03	0.14	0.04	0.07	98.32
1183	17.9a	74.33	13.01	0.13	1.05	0.11	0.55	3.40	5.53	0.08	0.04	0.05	98.28

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1183	17.9b	73.98	12.98	0.13	1.18	0.10	0.55	3.40	5.36	0.08	0.04	0.04	97.84
1183	17.9c	74.95	13.01	0.12	1.19	0.11	0.58	3.43	5.46	0.07	0.05	0.00	98.97
1184	17.10a	71.28	13.79	0.30	3.02	0.35	1.01	3.36	5.56	0.17	0.03	0.09	98.96
1184	17.10b	72.43	13.95	0.29	1.57	0.21	0.87	3.30	6.13	0.15	0.03	0.17	99.10
1184	17.10c	72.26	14.01	0.28	1.59	0.22	0.95	3.26	5.86	0.18	0.03	0.18	98.82
1185	17.11a	73.66	13.26	0.16	1.13	0.13	0.62	3.41	5.54	0.09	0.06	0.00	98.06
1185	17.11b	73.80	12.98	0.15	1.34	0.15	0.61	3.32	5.53	0.07	0.04	0.00	97.99
1185	17.11c	73.18	13.16	0.15	1.44	0.15	0.60	3.39	5.56	0.08	0.04	0.00	97.75
1186	17.12a	75.00	13.03	0.12	1.03	0.12	0.57	3.50	5.40	0.06	0.02	0.03	98.88
1186	17.12b	74.45	12.95	0.12	0.93	0.12	0.56	3.49	5.48	0.09	0.04	0.02	98.25
1186	17.12c	74.71	13.31	0.13	0.99	0.12	0.56	3.40	5.49	0.08	0.05	0.04	98.88
1187	17.13a	69.58	15.25	0.26	1.49	0.21	1.62	3.94	5.11	0.14	0.02	0.14	97.76
1187	17.13b	71.59	14.17	0.36	1.70	0.36	0.90	3.32	6.08	0.11	0.04	0.15	98.78
1187	17.13c	71.90	13.97	0.28	1.51	0.19	0.90	3.39	5.93	0.13	0.05	0.08	98.33
1188	17.14a	70.73	13.92	0.28	1.60	0.22	0.90	3.30	5.82	0.13	0.04	0.09	97.03
1188	17.14b	70.93	14.03	0.30	1.60	0.24	0.89	3.13	5.83	0.14	0.06	0.09	97.24
1188	17.14c	70.60	13.94	0.30	1.76	0.26	0.90	3.38	5.95	0.13	0.02	0.14	97.38
1189	17.15a	72.20	14.09	0.28	1.63	0.25	0.93	3.35	5.75	0.11	0.04	0.12	98.75
1189	17.15b	71.92	13.92	0.29	1.70	0.23	0.94	3.29	5.96	0.16	0.02	0.13	98.56
1189	17.15c	72.28	14.07	0.27	1.49	0.18	0.88	3.30	5.84	0.15	0.02	0.12	98.60
1190	17.16a	74.95	12.97	0.12	1.15	0.11	0.58	3.38	5.45	0.09	0.04	0.04	98.88
1190	17.16b	74.49	12.96	0.12	1.10	0.11	0.55	3.38	5.50	0.08	0.04	0.00	98.33
1190	17.16c	74.67	12.92	0.10	1.07	0.11	0.55	3.41	5.47	0.07	0.03	0.00	98.40
1191	18.1a	70.99	14.56	0.38	1.84	0.44	1.26	2.65	6.89	0.15	0.06	0.15	99.37
1191	18.1b	71.33	14.08	0.41	2.32	0.42	1.05	3.39	5.78	0.15	0.05	0.11	99.09
1191	18.1c	71.51	14.14	0.41	2.33	0.40	1.05	3.35	5.73	0.15	0.04	0.03	99.14

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1192	18.2a	73.02	13.98	0.27	1.52	0.19	0.86	3.20	6.00	0.12	0.05	0.13	99.34
1192	18.2b	72.75	14.02	0.27	1.51	0.20	0.90	3.22	5.93	0.12	0.04	0.11	99.07
1192	18.2c	73.00	13.75	0.28	1.60	0.25	0.88	3.24	5.91	0.14	0.05	0.09	99.19
1193	44.9a	71.77	13.89	0.31	1.80	0.30	0.90	3.22	5.84			0.13	98.15
1193	44.9b	72.56	13.82	0.30	1.82	0.30	0.90	3.43	5.85			0.10	99.06
1194	18.4a	72.67	13.79	0.29	1.59	0.29	0.95	3.29	5.85	0.20	0.03	0.15	99.10
1194	18.4b	72.73	14.01	0.29	1.56	0.27	0.89	3.31	5.78	0.14	0.02	0.10	99.10
1194	18.4c	72.92	13.91	0.31	1.52	0.26	0.87	3.29	5.94	0.14	0.04	0.15	99.35
1195	18.5a	61.69	12.79	1.07	4.54	2.17	0.85	2.61	6.02	0.33	0.04	0.18	92.29
1195	18.5b	65.01	12.50	0.24	1.82	0.31	0.93	2.80	5.31	0.11	0.03	0.09	89.15
1195	18.5c	67.93	14.02	0.84	3.72	1.93	0.79	2.93	6.35	0.12	0.04	0.22	98.89
1195	18.5d	72.85	14.06	0.29	1.61	0.27	0.86	3.29	5.91	0.13	0.02	0.13	99.42
1195	18.5e	73.04	13.84	0.24	1.52	0.23	0.83	3.28	5.96	0.11	0.02	0.11	99.18
1195	18.5f	72.85	14.09	0.28	1.47	0.21	0.88	3.34	5.98	0.13	0.03	0.14	99.40
1196	18.6a	71.58	13.77	0.26	1.66	0.26	0.92	0.54	10.05	0.18	0.04	0.10	99.36
1196	18.6b	72.11	13.76	0.27	1.69	0.26	0.83	0.40	10.21	0.11	0.04	0.16	99.84
1196	18.6c	71.94	13.86	0.26	1.66	0.23	0.83	1.03	9.20	0.12	0.05	0.13	99.31
1196	18.6d	72.14	13.78	0.25	1.70	0.25	0.81	1.90	7.76			0.08	98.67
1196	18.6e	71.45	13.88	0.27	1.81	0.27	0.84	0.88	9.45			0.09	98.93
1197	18.7a	71.30	15.54	0.27	1.31	0.20	1.58	3.96	5.21	0.16	0.02	0.14	99.69
1197	18.7b	72.91	14.06	0.29	1.73	0.23	0.87	3.28	5.99	0.15	0.02	0.13	99.66
1197	18.7c	72.35	13.99	0.29	1.67	0.24	0.88	3.27	6.01	0.14	0.05	0.10	98.99
1198	18.8a	72.93	13.79	0.34	1.72	0.31	1.09	3.99	4.82	0.15	0.02	0.11	99.27
1198	18.8b	73.14	14.20	0.32	1.36	0.17	0.96	3.65	5.58	0.19	0.02	0.10	99.69
1198	18.8c	72.66	13.95	0.33	1.84	0.20	1.03	3.92	5.02	0.16	0.02	0.07	99.20
1199	18.9a	73.82	13.43	0.16	1.98	0.23	0.56	3.40	5.43	0.07	0.08	0.00	99.16

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1199	18.9b	74.59	13.61	0.08	1.19	0.07	0.61	3.71	5.24	0.09	0.06	0.05	99.30
1199	18.9c	74.89	13.42	0.09	1.32	0.07	0.53	3.37	5.36	0.08	0.07	0.00	99.20
1200	18.10a	74.83	13.26	0.15	1.25	0.13	0.60	3.39	5.57	0.07	0.04	0.01	99.30
1200	18.10b	75.00	13.24	0.14	1.15	0.13	0.59	3.46	5.53	0.09	0.01	0.00	99.34
1200	18.10c	74.73	13.23	0.14	1.15	0.14	0.60	3.46	5.47	0.09	0.01	0.01	99.03
1201	18.11a	72.95	14.08	0.30	1.41	0.24	0.92	3.45	5.89	0.14	0.04	0.16	99.58
1201	18.11b	72.91	14.22	0.31	0.96	0.09	0.91	3.44	6.03	0.14	0.00	0.12	99.13
1201	18.11c	72.35	14.24	0.36	1.43	0.24	0.97	3.43	5.97	0.13	0.03	0.07	99.22
1202	18.12a	71.52	14.62	0.28	1.58	0.25	1.28	3.62	5.48	0.13	0.03	0.13	98.92
1202	18.12b	72.39	13.84	0.27	1.57	0.23	0.85	3.31	5.90	0.11	0.02	0.17	98.66
1202	18.12c	73.12	13.99	0.27	1.15	0.15	0.83	3.31	6.07	0.12	0.02	0.12	99.15
1203	44.10a	75.24	12.93	0.13	1.13	0.10	0.55	3.39	5.40			0.00	98.88
1203	44.10b	74.83	12.89	0.13	1.23	0.11	0.58	3.51	5.39			0.02	98.69
1204	18.14a	71.39	14.34	0.38	2.02	0.40	1.06	3.33	5.84	0.14	0.05	0.07	99.02
1204	18.14b	71.92	14.34	0.35	1.52	0.28	1.05	3.40	5.79	0.13	0.02	0.10	98.90
1204	18.14c	72.13	14.41	0.38	1.44	0.21	1.09	3.47	5.93	0.18	0.00	0.15	99.39
1205	18.15a	72.60	13.80	0.28	1.61	0.19	0.85	3.30	6.00	0.14	0.00	0.12	98.89
1205	18.15b	72.25	14.04	0.50	2.17	0.25	0.86	3.36	5.87	0.15	0.05	0.10	99.60
1205	18.15c	72.46	14.00	0.27	2.01	0.31	0.86	3.27	5.87	0.13	0.06	0.06	99.30
1206	18.16a	64.19	21.36	0.08	0.35	0.02	4.48	6.25	2.43	0.10	0.00	0.21	99.47
1206	18.16b	72.55	14.23	0.27	1.65	0.27	0.88	3.37	5.83	0.14	0.05	0.10	99.34
1206	18.16c	72.14	14.01	0.29	1.62	0.24	0.90	3.32	5.91	0.14	0.03	0.11	98.71
1207	19.1a	73.11	13.90	0.25	1.48	0.17	0.76	3.15	6.05	0.12	0.03	0.10	99.12
1207	19.1b	72.96	13.76	0.26	1.55	0.17	0.76	3.24	6.04	0.13	0.03	0.08	98.98
1207	19.1c	72.68	13.75	0.22	1.81	0.14	0.80	3.25	5.90	0.10	0.03	0.11	98.79
1208	19.2a	75.25	12.98	0.11	1.18	0.10	0.60	3.30	5.40	0.08	0.03	0.08	99.11

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1208	19.2b	74.44	13.24	0.11	1.08	0.09	0.64	3.64	5.22	0.09	0.02	0.03	98.60
1208	19.2c	73.47	13.02	0.18	1.67	0.23	0.56	3.38	5.50	0.07	0.04	0.04	98.16
1209	19.3a	74.58	12.96	0.12	1.23	0.10	0.57	3.36	5.43	0.07	0.03	0.00	98.45
1209	19.3b	74.33	12.83	0.15	1.23	0.10	0.57	3.37	5.48	0.07	0.05	0.00	98.18
1209	19.3c	74.68	13.03	0.12	1.18	0.11	0.55	3.28	5.42	0.07	0.02	0.00	98.46
1210	19.4a	74.71	13.01	0.11	1.13	0.11	0.58	3.38	5.43	0.07	0.02	0.01	98.56
1210	19.4b	74.72	12.99	0.12	1.15	0.12	0.62	3.37	5.40	0.08	0.03	0.04	98.64
1210	19.4c	74.79	12.99	0.11	1.11	0.11	0.59	3.46	5.47	0.07	0.05	0.03	98.78
1211	19.5a	72.16	14.01	0.30	1.70	0.23	0.98	3.41	5.84	0.13	0.04	0.12	98.92
1211	19.5b	72.47	14.18	0.33	1.22	0.19	1.03	3.42	5.96	0.15	0.02	0.10	99.07
1211	19.5c	70.86	14.22	0.38	1.87	0.34	1.06	3.38	5.77	0.14	0.03	0.13	98.18
1212	19.6a	73.65	12.92	0.14	1.21	0.14	0.58	1.17	8.86	0.06	0.01	0.02	98.76
1212	19.6b	74.04	12.86	0.14	1.32	0.13	0.60	1.33	8.70	0.07	0.03	0.00	99.22
1212	19.6c	73.76	12.94	0.13	1.15	0.13	0.59	1.44	8.49	0.08	0.01	0.00	98.72
1212	19.6d	73.96	12.93	0.14	1.16	0.12	0.58	1.54	8.21			0.02	98.66
1212	19.6e	73.82	12.75	0.15	1.18	0.12	0.58	1.39	8.31			0.01	98.32
1213	19.7a	73.20	13.62	0.23	1.49	0.13	0.75	3.17	6.03	0.11	0.02	0.12	98.87
1213	19.7b	69.63	17.17	0.16	0.90	0.10	2.55	4.84	4.01	0.13	0.01	0.12	99.62
1213	19.7c	73.06	13.80	0.23	0.97	0.06	0.79	3.25	6.14	0.15	0.01	0.12	98.58
1214	19.8a	74.64	13.01	0.13	1.06	0.10	0.57	3.30	5.64	0.08	0.02	0.05	98.60
1214	19.8b	74.29	13.09	0.13	1.10	0.09	0.57	3.24	5.60	0.08	0.03	0.01	98.23
1214	19.8c	75.25	12.97	0.12	1.08	0.09	0.58	3.29	5.62	0.08	0.03	0.02	99.13
1215	19.9a	75.18	13.22	0.14	1.18	0.15	0.58	3.45	5.56	0.08	0.03	0.02	99.59
1215	19.9b	75.16	13.17	0.14	1.15	0.12	0.59	3.40	5.65	0.08	0.04	0.05	99.55
1215	19.9c	74.92	13.14	0.15	1.12	0.13	0.60	3.40	5.49	0.08	0.05	0.03	99.11
1216	19.10a	72.51	13.81	0.24	1.47	0.18	0.86	3.23	5.90	0.13	0.07	0.07	98.47

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1216	19.10b	72.49	13.96	0.24	1.43	0.20	0.93	3.34	5.79	0.13	0.04	0.06	98.61
1216	19.10c	69.47	16.38	0.18	0.80	0.06	2.41	4.42	4.25	0.15	0.04	0.13	98.29
1217	19.11a	75.08	12.97	0.11	1.51	0.09	0.57	3.38	5.47	0.06	0.04	0.03	99.31
1217	19.11b	74.26	12.94	0.11	1.04	0.08	0.54	3.32	5.48	0.06	0.02	0.02	97.87
1217	19.11c	75.30	12.99	0.12	0.97	0.09	0.54	3.36	5.48	0.07	0.00	0.03	98.95
1218	19.12a	73.39	13.76	0.11	1.17	0.09	0.74	4.00	5.12	0.07	0.06	0.02	98.53
1218	19.12b	75.09	12.90	0.13	1.18	0.10	0.58	3.42	5.38	0.08	0.06	0.00	98.92
1218	19.12c	74.23	13.01	0.14	1.16	0.10	0.54	3.37	5.47	0.08	0.03	0.02	98.15
1219	19.13a	75.21	13.04	0.13	0.76	0.02	0.55	3.32	5.57	0.08	0.02	0.02	98.72
1219	19.13b	74.17	12.89	0.12	1.77	0.15	0.55	3.35	5.45	0.08	0.03	0.00	98.56
1219	19.13c	75.55	13.22	0.11	0.70	0.02	0.55	3.36	5.50	0.09	0.03	0.03	99.16
1220	19.14a	75.46	13.13	0.14	1.09	0.11	0.56	3.44	5.46	0.08	0.03	0.05	99.55
1220	19.14b	75.69	13.11	0.13	1.11	0.11	0.54	3.32	5.40	0.05	0.02	0.00	99.48
1220	19.14c	74.96	13.09	0.13	1.20	0.11	0.58	3.32	5.36	0.05	0.03	0.00	98.83
1221	19.15a	74.65	12.91	0.13	1.00	0.08	0.57	3.44	5.49	0.07	0.05	0.01	98.40
1221	19.15b	74.75	12.99	0.14	1.77	0.08	0.55	3.41	5.42	0.08	0.05	0.02	99.26
1221	19.15c	75.05	13.04	0.12	0.74	0.03	0.58	3.31	5.63	0.07	0.02	0.00	98.59
1222	19.16a	75.01	13.09	0.12	1.21	0.10	0.56	3.38	5.41	0.08	0.04	0.01	99.01
1222	19.16b	75.57	12.98	0.12	1.12	0.11	0.56	3.36	5.37	0.08	0.03	0.01	99.31
1222	19.16c	75.24	12.98	0.12	1.05	0.10	0.57	3.38	5.57	0.08	0.03	0.01	99.13
1223	19.17a	74.77	12.94	0.12	1.33	0.09	0.56	3.38	5.47	0.07	0.04	0.02	98.79
1223	19.17b	75.08	12.90	0.12	1.04	0.10	0.57	3.34	5.52	0.07	0.04	0.00	98.78
1223	19.17c	74.50	12.92	0.12	1.06	0.09	0.59	3.33	5.49	0.09	0.03	0.04	98.26
1224	19.18a	74.82	12.91	0.12	0.98	0.09	0.57	3.29	5.56	0.09	0.05	0.02	98.50
1224	19.18b	75.35	12.99	0.11	1.02	0.09	0.58	3.32	5.40	0.07	0.02	0.04	98.99
1225	20.1a	71.81	13.86	0.31	2.07	0.38	0.89	3.26	5.77	0.15	0.03	0.12	98.65

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1225	20.1b	71.92	13.81	0.30	1.66	0.26	0.90	3.20	5.85	0.15	0.02	0.06	98.13
1225	20.1c	72.26	13.79	0.31	1.75	0.19	0.91	3.21	5.89	0.13	0.04	0.10	98.58
1226	20.2a	74.54	13.14	0.16	1.17	0.13	0.57	3.32	5.49	0.07	0.03	0.04	98.66
1226	20.2b	74.41	12.99	0.15	1.19	0.12	0.59	3.31	5.44	0.06	0.04	0.00	98.30
1226	20.2c	74.41	12.93	0.14	1.27	0.13	0.61	3.35	5.52	0.08	0.04	0.00	98.48
1227	20.3a	75.03	12.76	0.12	1.23	0.11	0.57	3.25	5.32	0.07	0.05	0.01	98.52
1227	20.3b	74.78	12.79	0.13	1.16	0.11	0.57	3.30	5.34	0.08	0.04	0.01	98.31
1227	20.3c	74.56	12.93	0.13	1.12	0.09	0.54	3.28	5.32	0.07	0.06	0.01	98.11
1228	20.4a	74.51	13.31	0.09	1.26	0.06	0.57	3.36	5.25	0.08	0.08	0.00	98.57
1228	20.4b	74.11	13.36	0.10	1.26	0.09	0.58	3.34	5.35	0.07	0.06	0.02	98.34
1228	20.4c	74.11	13.08	0.10	1.17	0.06	0.59	3.38	5.23	0.08	0.05	0.00	97.85
1229	20.5a	74.21	13.09	0.16	1.26	0.15	0.60	3.23	5.55	0.07	0.02	0.05	98.39
1229	20.5b	74.25	13.03	0.15	1.05	0.15	0.60	3.34	5.60	0.09	0.03	0.03	98.32
1229	20.5c	74.18	13.02	0.16	1.08	0.13	0.58	3.37	5.66	0.08	0.04	0.02	98.32
1230	20.6a	75.15	12.70	0.11	1.06	0.08	0.54	3.25	5.55	0.07	0.04	0.02	98.57
1230	20.6b	75.42	12.70	0.10	1.05	0.05	0.54	3.24	5.49	0.07	0.03	0.01	98.70
1230	20.6c	74.79	12.83	0.11	1.14	0.07	0.56	3.32	5.45	0.08	0.02	0.04	98.41
1231	20.7a	72.48	14.10	0.30	1.52	0.13	0.91	3.32	5.90	0.12	0.03	0.10	98.91
1231	20.7b	72.45	13.76	0.29	1.49	0.15	0.92	3.28	5.91	0.19	0.01	0.08	98.53
1231	20.7c	70.23	15.89	0.24	1.78	0.16	2.26	4.32	4.08	0.15	0.03	0.16	99.30
1232	20.8a	74.59	12.96	0.12	1.10	0.11	0.57	3.30	5.28	0.09	0.04	0.00	98.16
1232	20.8b	74.53	12.89	0.12	1.13	0.10	0.56	3.35	5.31	0.08	0.03	0.00	98.10
1232	20.8c	75.08	12.82	0.12	1.08	0.10	0.55	3.32	5.41	0.07	0.03	0.00	98.58
1233	20.9a	73.19	13.30	0.10	1.24	0.09	0.60	3.32	5.20	0.06	0.05	0.00	97.15
1233	20.9b	73.35	13.09	0.10	1.31	0.09	0.60	3.35	5.30	0.05	0.03	0.00	97.27
1233	20.9c	73.43	13.21	0.08	1.32	0.09	0.60	3.35	5.27	0.07	0.03	0.00	97.45

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1234	20.10a	74.04	13.06	0.16	1.75	0.12	0.59	3.30	5.61	0.08	0.04	0.00	98.75
1234	20.10b	74.77	13.02	0.14	1.07	0.11	0.58	3.16	5.69	0.06	0.05	0.01	98.66
1234	20.10c	74.68	12.96	0.15	1.01	0.12	0.60	3.28	5.60	0.07	0.04	0.01	98.52
1235	20.11a	72.85	13.49	0.32	1.46	0.15	0.80	3.14	5.92	0.16	0.03	0.05	98.37
1235	20.11b	71.93	14.53	0.21	1.38	0.12	1.29	3.70	5.30	0.13	0.01	0.05	98.65
1235	20.11c	71.75	13.81	0.28	2.37	0.26	0.90	3.35	5.66	0.14	0.04	0.13	98.69
1236	20.12a	73.35	13.98	0.10	0.91	0.07	0.60	4.10	5.31	0.07	0.01	0.06	98.56
1236	20.12b	74.85	12.76	0.11	1.19	0.09	0.55	3.33	5.36	0.05	0.02	0.00	98.31
1236	20.12c	74.86	12.87	0.12	1.12	0.10	0.54	3.27	5.38	0.08	0.05	0.01	98.40
1237	20.13a	72.08	13.72	0.29	1.75	0.25	0.88	3.25	5.83	0.16	0.04	0.10	98.35
1237	20.13b	71.95	13.76	0.28	1.60	0.25	0.85	3.22	5.88	0.12	0.02	0.09	98.02
1237	20.13c	71.19	13.67	0.30	2.34	0.45	0.88	3.23	5.81	0.14	0.03	0.08	98.12
1238	20.14a	71.38	13.83	0.29	1.65	0.28	0.84	3.17	5.93	0.12	0.02	0.05	97.56
1238	20.14b	71.23	13.69	0.40	1.88	0.26	0.87	3.19	5.83	0.14	0.05	0.08	97.62
1238	20.14c	70.91	13.75	0.30	2.01	0.38	0.96	3.23	5.67	0.18	0.03	0.06	97.48
1239	20.15a	74.67	13.32	0.10	1.26	0.07	0.59	3.34	5.25	0.10	0.07	0.00	98.77
1239	20.15b	74.25	13.12	0.10	1.30	0.07	0.57	3.35	5.32	0.08	0.06	0.00	98.22
1239	20.15c	74.40	13.29	0.08	1.14	0.07	0.58	3.37	5.31	0.08	0.05	0.00	98.37
1240	20.16a	72.29	13.76	0.27	1.79	0.25	0.94	3.28	5.74	0.18	0.04	0.07	98.61
1240	20.16b	71.75	13.91	0.30	2.08	0.30	0.92	3.43	5.61	0.12	0.02	0.08	98.52
1240	20.16c	72.09	13.84	0.28	1.26	0.14	0.83	3.26	6.12	0.12	0.00	0.13	98.07
1241	20.17a	73.90	13.16	0.10	1.31	0.07	0.62	3.39	5.20	0.09	0.04	0.00	97.88
1241	20.17b	74.13	13.31	0.09	1.32	0.09	0.59	3.33	5.31	0.09	0.05	0.02	98.33
1241	20.17c	74.21	13.36	0.10	1.35	0.09	0.59	3.30	5.29	0.07	0.06	0.02	98.44
1242	20.18a	72.04	13.85	0.30	1.12	0.13	0.91	3.17	6.07	0.13	0.01	0.09	97.82
1242	20.18b	71.46	13.72	0.29	1.66	0.24	0.90	3.13	5.97	0.11	0.03	0.12	97.63

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1242	20.18c	71.96	13.81	0.29	1.17	0.15	0.87	3.17	6.02	0.14	0.01	0.12	97.71
1243	21.1a	72.79	13.99	0.31	1.42	0.15	0.93	3.01	6.26	0.16	0.04	0.16	99.22
1243	21.1b	72.31	13.96	0.30	1.80	0.29	0.95	3.10	5.96	0.12	0.01	0.02	98.82
1243	21.1c	68.59	17.14	0.21	1.03	0.15	3.07	4.50	3.82	0.12	0.00	0.07	98.70
1244	21.2a	72.99	13.90	0.29	1.56	0.23	0.90	3.31	5.92	0.11	0.03	0.14	99.38
1244	21.2b	72.51	13.96	0.29	1.58	0.32	0.88	3.33	5.82	0.13	0.06	0.13	99.01
1244	21.2c	71.56	13.85	0.29	1.47	0.25	1.62	3.31	5.76	0.89	0.03	0.11	99.14
1245	21.3a	72.80	13.85	0.28	1.53	0.22	0.84	3.17	6.04	0.15	0.04	0.07	98.99
1245	21.3b	72.87	13.90	0.26	1.55	0.25	0.81	3.20	6.00	0.12	0.02	0.05	99.03
1245	21.3c	72.17	14.79	0.24	1.18	0.16	1.39	3.76	5.31	0.12	0.02	0.08	99.22
1246	21.4a	71.98	13.98	0.28	2.31	0.47	0.90	3.28	5.65	0.13	0.06	0.11	99.15
1246	21.4b	72.81	14.07	0.28	1.24	0.17	0.88	3.29	5.83	0.14	0.05	0.09	98.85
1246	21.4c	72.73	13.90	0.30	1.93	0.26	0.90	3.29	5.77	0.13	0.06	0.09	99.36
1281	21.5a	73.87	13.40	0.09	1.33	0.08	0.58	3.39	5.19	0.06	0.05	0.04	98.08
1281	21.5b	73.44	13.53	0.09	1.16	0.07	0.64	3.51	4.96	0.00	0.05	0.07	97.52
1281	21.5c	73.65	12.98	0.10	1.37	0.08	0.53	3.19	5.06	0.00	0.07	0.05	97.08
1282	21.6a	73.88	13.40	0.06	1.23	0.08	0.60	3.45	5.28			0.00	97.98
1282	21.6b	73.93	13.18	0.06	1.21	0.07	0.55	3.44	5.31			0.00	97.75
1283	21.7a	71.98	13.76	0.30	1.61	0.21	0.80	3.26	6.17			0.11	98.21
1283	21.7b	71.91	13.91	0.27	1.27	0.11	0.73	3.24	6.22			0.10	97.77
1284	21.8a	74.22	13.36	0.10	1.26	0.07	0.59	3.29	5.19			0.04	98.12
1284	21.8b	73.82	13.40	0.10	1.23	0.06	0.60	3.48	5.12			0.03	97.84
1285	21.9a	73.17	14.08	0.34	1.57	0.14	0.77	3.28	5.99	0.16	0.01	0.08	99.59
1285	21.9b	73.44	14.00	0.27	1.38	0.14	0.82	3.27	6.03	0.13	0.02	0.09	99.59
1285	21.9c	73.49	13.93	0.25	1.83	0.22	0.78	3.27	5.95	0.12	0.02	0.12	99.98
1286	21.10a	72.44	13.80	0.23	1.27	0.10	0.78	3.18	6.02			0.09	97.93

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1286	21.10b	72.70	13.72	0.27	1.45	0.16	0.82	3.18	6.03			0.11	98.44
1287	21.11a	69.87	16.05	0.21	1.42	0.22	2.22	4.29	4.41			0.11	98.80
1287	21.11b	72.44	13.87	0.29	1.38	0.20	0.84	3.32	5.99			0.10	98.43
1288	21.12a	71.94	13.69	0.24	1.59	0.17	0.79	3.16	6.01			0.07	97.66
1288	21.12b	72.30	13.79	0.33	1.37	0.23	1.04	3.43	5.64			0.15	98.26
1289	21.13a	72.27	13.84	0.30	1.18	0.10	0.83	3.21	5.99			0.10	97.82
1289	21.13b	72.37	13.55	0.22	1.40	0.15	0.76	3.16	5.79			0.12	97.52
1290	21.14a	73.49	13.90	0.26	1.48	0.20	0.83	3.19	6.02	0.14	0.03	0.10	99.64
1290	21.14b	73.60	14.03	0.26	1.71	0.22	0.81	3.20	6.08	0.13	0.04	0.12	100.20
1290	21.14c	73.06	13.97	0.27	1.45	0.19	0.82	3.23	6.06	0.11	0.05	0.10	99.31
1291	21.15a	72.31	13.93	0.28	1.65	0.23	1.22	3.83	4.63			0.06	98.14
1291	21.15a	71.62	14.64	0.21	1.20	0.14	1.27	3.62	5.65			0.13	98.47
1291	21.15b	70.43	15.33	0.23	1.09	0.10	1.54	3.96	5.40			0.16	98.25
1291	21.15b	70.86	15.24	0.24	0.95	0.07	1.76	4.31	4.32			0.14	97.88
1291	21.15c	71.90	13.64	0.26	1.53	0.22	0.82	3.22	5.84			0.06	97.49
1292	21.16a	69.81	15.99	0.17	0.95	0.12	2.08	4.38	4.56			0.14	98.21
1292	21.16b	71.35	14.50	0.22	1.27	0.14	1.28	3.65	5.57			0.10	98.07
1293	21.17a	72.70	13.67	0.19	1.36	0.13	0.74	3.28	6.02			0.01	98.11
1293	21.17b	72.67	13.31	0.21	1.27	0.15	0.69	3.16	6.07			0.02	97.56
1293	21.17c	73.63	13.43	0.22	1.22	0.15	0.77	3.17	6.08			0.04	98.70
1294	21.18a	75.56	13.46	0.08	1.10	0.08	0.58	3.46	5.20	0.09	0.06	0.00	99.67
1294	21.18b	75.40	13.49	0.10	1.18	0.09	0.56	3.46	5.24	0.08	0.06	0.05	99.71
1294	21.18c	73.97	13.44	0.08	1.23	0.08	0.71		5.14	0.09	0.05	0.02	94.81
1295	22.1a	74.24	13.46	0.09	1.21	0.07	0.60	3.44	5.09			0.03	98.24
1295	22.1b	74.32	13.37	0.10	1.31	0.07	0.56	3.44	5.15			0.00	98.32
1296	22.2a	73.07	13.74	0.21	1.66	0.14	0.72	3.19	5.86			0.11	98.69

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1296	22.2b	72.63	13.68	0.28	2.38	0.13	0.77	3.20	5.84			0.09	99.01
1297	22.3a	74.03	13.39	0.10	1.10	0.06	0.56	3.54	5.11			0.02	97.89
1297	22.3b	73.85	13.54	0.10	1.55	0.06	0.61	3.67	5.05			0.05	98.47
1298	22.4a	72.47	13.91	0.30	1.28	0.10	0.83	3.27	5.94			0.12	98.21
1298	22.4b	72.67	13.75	0.23	1.51	0.19	0.80	3.20	5.81			0.11	98.27
1299	22.5a	72.22	13.50	0.25	1.74	0.26	0.96	3.08	6.00			0.08	98.08
1299	22.5b	73.03	13.69	0.26	1.16	0.12	0.81	3.25	6.15			0.09	98.58
1300	22.6a	73.14	14.05	0.24	1.50	0.20	0.83	3.32	5.83			0.07	99.18
1300	22.6b	73.06	14.07	0.24	1.23	0.14	0.83	3.25	5.96			0.10	98.87
1301	34.1a	74.25	13.26	0.10	1.19	0.09	0.59	3.50	5.29			0.03	98.30
1301	34.1b	74.34	13.18	0.09	1.26	0.08	0.59	3.49	5.36			0.00	98.38
1301	34.1c	74.30	13.22	0.10	1.23	0.09	0.59	3.50	5.33			0.02	98.34
1302	34.2a	74.14	13.20	0.09	1.27	0.09	0.58	3.43	5.31			0.00	98.10
1302	34.2b	74.01	13.24	0.09	1.26	0.08	0.60	3.50	5.35			0.00	98.14
1302	34.2c	74.08	13.22	0.09	1.27	0.09	0.59	3.47	5.33			0.00	98.12
1303	34.3a	74.17	13.02	0.15	1.19	0.12	0.62	3.40	5.57			0.07	98.30
1303	34.3b	74.06	13.02	0.15	1.15	0.13	0.60	3.37	5.69			0.05	98.22
1304	34.4a	71.76	14.03	0.28	1.59	0.26	0.89	3.33	5.83			0.05	98.02
1304	34.4b	71.86	13.76	0.26	1.78	0.25	0.88	3.41	5.86			0.11	98.18
1305	34.5a	71.78	13.72	0.28	1.76	0.27	0.90	3.22	6.03			0.12	98.09
1305	34.5b	71.83	13.86	0.30	1.87	0.31	0.89	3.34	5.89			0.09	98.39
1306	34.6a	72.30	13.83	0.30	0.95	0.08	0.92	3.42	6.00			0.10	97.91
1306	34.6b	72.70	14.00	0.31	1.26	0.13	0.91	3.42	6.02			0.17	98.92
1307	34.7a	73.78	12.78	0.13	1.05	0.11	0.54	1.70	8.00			0.00	98.09
1307	34.7b	74.47	12.77	0.12	0.95	0.10	0.56	2.24	7.17			0.00	98.38
1308	34.8a	73.90	13.10	0.09	1.30	0.09	0.57	3.40	5.30			0.00	97.75

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1308	34.8b	73.97	13.38	0.09	1.24	0.08	0.62	3.59	5.20			0.01	98.17
1309	34.9a	74.62	13.42	0.08	1.36	0.08	0.59	3.40	5.25			0.00	98.81
1309	34.9b	73.77	13.26	0.09	1.23	0.08	0.58	3.42	5.31			0.00	97.73
1310	34.10a	74.29	12.74	0.11	1.13	0.11	0.54	3.32	5.43			0.00	97.67
1310	34.10b	74.85	12.75	0.11	1.08	0.09	0.56	3.38	5.48			0.00	98.30
1311	34.11a	74.22	13.37	0.10	1.24	0.07	0.59	3.47	5.32			0.02	98.42
1311	34.11b	73.54	13.63	0.10	1.13	0.06	0.66	3.73	5.12			0.02	98.00
1312	34.12a	73.41	13.81	0.08	1.38	0.06	0.72	3.94	5.04			0.01	98.46
1312	34.12b	74.15	13.29	0.09	1.31	0.08	0.57	3.44	5.32			0.04	98.29
1313	34.13a	73.99	12.94	0.13	1.09	0.12	0.58	3.37	5.48			0.05	97.74
1313	34.13b	74.37	12.97	0.14	1.19	0.12	0.59	3.35	5.53			0.03	98.29
1314	34.14a	71.93	13.87	0.30	1.30	0.19	0.91	3.36	5.98			0.08	97.92
1314	34.14b	68.69	16.99	0.21	0.86	0.10	2.57	4.71	4.11			0.07	98.31
1315	34.15a	73.66	13.36	0.08	1.15	0.06	0.65	3.72	5.09			0.04	97.80
1315	34.15b	73.95	13.20	0.07	1.21	0.07	0.58	3.34	5.33			0.07	97.82
1316	34.16a	72.44	13.35	0.17	1.71	0.18	0.72	3.39	5.62			0.04	97.61
1316	34.16b	72.91	13.46	0.18	1.45	0.18	0.74	3.39	5.70			0.02	98.03
1317	34.17a	74.15	12.91	0.14	1.17	0.14	0.59	3.42	5.55			0.07	98.13
1317	34.17b	74.38	13.06	0.14	1.25	0.14	0.55	3.46	5.54			0.05	98.57
1318	35.1a	74.03	13.20	0.08	1.22	0.08	0.57	3.41	5.36			0.00	97.95
1318	35.1b	74.43	13.11	0.09	1.25	0.07	0.54	3.35	5.32			0.00	98.18
1319	35.2a	74.84	12.88	0.13	1.08	0.11	0.56	3.40	5.44			0.00	98.43
1319	35.2b	73.92	12.80	0.13	1.12	0.11	0.57	3.40	5.39			0.00	97.43
1320	35.3a	73.68	13.26	0.09	1.18	0.08	0.58	3.59	5.35			0.02	97.83
1320	35.3b	74.01	13.20	0.09	1.19	0.08	0.55	3.42	5.33			0.05	97.90
1321	35.4a	74.40	12.83	0.11	1.07	0.10	0.57	3.30	5.54			0.01	97.93

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1321	35.4b	74.61	12.78	0.11	1.16	0.11	0.56	3.31	5.57			0.00	98.20
1322	45.15a	75.03	13.21	0.10	1.25	0.08	0.54	3.36	5.38			0.03	98.98
1322	45.15b	74.78	13.20	0.10	1.22	0.08	0.57	3.31	5.38			0.03	98.67
1322	45.15c	74.76	13.22	0.10	1.29	0.08	0.55	3.37	5.35			0.02	98.74
1323	35.6a	74.29	13.19	0.09	1.23	0.07	0.56	3.37	5.30			0.00	98.10
1323	35.6b	73.17	13.51	0.09	1.64	0.07	0.68	3.72	5.07			0.00	97.94
1324	35.7a	74.02	13.45	0.09	1.26	0.08	0.66	3.63	5.14			0.02	98.34
1324	35.7b	73.94	13.35	0.09	1.33	0.08	0.56	3.30	5.34			0.00	98.00
1325	35.8a	72.07	13.83	0.28	1.68	0.21	0.85	3.29	5.95			0.12	98.28
1325	35.8b	71.87	13.61	0.29	2.32	0.50	0.97	3.30	5.83			0.07	98.77
1326	35.9a	74.85	12.78	0.10	1.14	0.10	0.60	3.35	5.47			0.04	98.44
1326	35.9b	74.48	12.82	0.12	1.15	0.10	0.58	3.24	5.51			0.02	98.02
1327	35.10a	68.62	13.94	0.79	3.68	1.28	0.83	3.33	6.04			0.25	98.78
1327	35.10b	72.52	13.78	0.25	1.53	0.22	0.71	3.26	6.03			0.12	98.44
1328	35.11a	72.63	14.00	0.27	0.91	0.08	0.83	3.30	6.11			0.11	98.24
1328	35.11b	73.02	13.87	0.28	1.38	0.16	0.85	3.23	6.03			0.14	98.96
1329	35.12a	73.77	13.64	0.09	1.24	0.09	0.64	3.58	5.27			0.03	98.35
1329	35.12b	75.22	13.01	0.09	1.24	0.06	0.54	3.32	5.36			0.03	98.88
1330	35.13a	74.74	12.89	0.11	1.16	0.11	0.54	3.37	5.45			0.02	98.38
1330	35.13b	74.36	12.74	0.12	1.11	0.11	0.56	3.41	5.45			0.05	97.91
1331	35.14a	74.51	12.75	0.14	1.15	0.12	0.59	3.31	5.58			0.05	98.20
1331	35.14b	74.36	12.81	0.14	1.07	0.11	0.56	3.41	5.45			0.09	98.00
1332	35.15a	74.80	12.78	0.11	1.06	0.11	0.54	3.44	5.35			0.05	98.23
1332	35.15b	74.33	12.90	0.12	1.12	0.10	0.54	3.34	5.42			0.01	97.87
1333	35.16a	74.62	12.76	0.12	1.16	0.09	0.55	3.41	5.48			0.02	98.22
1333	35.16b	75.08	12.89	0.13	1.09	0.09	0.57	3.39	5.44			0.03	98.70

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1334	35.17a	74.87	12.90	0.14	1.06	0.11	0.55	3.36	5.45			0.01	98.45
1334	35.17b	74.76	12.86	0.14	1.09	0.11	0.58	3.34	5.51			0.00	98.39
1335	36.1a	73.78	12.63	0.13	2.34	0.09	0.56	3.38	5.34			0.02	98.27
1335	36.1b	74.90	12.64	0.12	1.12	0.09	0.55	3.35	5.45			0.01	98.25
1336	36.2a	74.69	12.95	0.11	1.16	0.09	0.56	3.34	5.46			0.00	98.37
1336	36.2b	75.04	12.81	0.12	1.13	0.09	0.55	3.36	5.43			0.00	98.52
1337	36.3a	74.69	12.80	0.12	1.12	0.09	0.56	3.31	5.47			0.05	98.21
1337	36.3b	74.52	12.83	0.11	1.04	0.10	0.56	3.44	5.56			0.05	98.22
1338	36.4a	72.86	13.71	0.27	1.30	0.14	0.78	3.37	6.04			0.07	98.54
1338	36.4b	72.79	13.71	0.23	1.77	0.25	0.92	3.33	5.90			0.08	98.98
1339	36.5a	75.56	12.88	0.10	1.04	0.10	0.56	3.41	5.38			0.00	99.03
1339	36.5b	75.08	12.80	0.12	1.14	0.11	0.55	3.39	5.50			0.00	98.68
1340	36.6a	72.37	13.15	0.83	2.91	0.14	0.89	3.22	5.70			0.02	99.23
1340	36.6b	74.12	13.28	0.19	1.39	0.13	0.69	3.16	5.96			0.04	98.95
1341	36.7a	71.27	14.81	0.21	1.19	0.17	1.41	3.78	5.30			0.17	98.30
1341	36.7b	71.85	14.77	0.21	1.23	0.17	1.19	3.74	5.56			0.17	98.89
1342	36.8a	72.29	13.87	0.32	1.59	0.28	0.87	3.31	5.95			0.06	98.55
1342	36.8b	72.66	13.60	0.28	1.38	0.19	0.84	3.27	6.19			0.03	98.44
1343	36.9a	74.69	13.23	0.08	1.26	0.07	0.57	3.38	5.29			0.04	98.62
1343	36.9b	74.59	13.01	0.10	1.17	0.06	0.57	3.39	5.32			0.06	98.27
1344	36.10a	74.58	13.41	0.09	1.26	0.08	0.56	3.33	5.42			0.00	98.73
1344	36.10b	74.71	13.36	0.09	1.27	0.08	0.57	3.39	5.38			0.00	98.84
1345	36.11a	71.62	15.21	0.19	0.93	0.09	1.57	4.00	5.11			0.08	98.81
1345	36.11b	73.10	13.64	0.23	1.43	0.18	0.74	3.19	6.14			0.08	98.72
1346	36.12a	72.25	13.85	0.29	1.44	0.10	0.82	3.28	6.17			0.16	98.36
1346	36.12b	72.30	13.68	0.27	1.69	0.19	0.78	3.23	6.09			0.16	98.40

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1347	36.13a	74.24	13.63	0.09	1.21	0.08	0.66	3.74	5.10			0.00	98.74
1347	36.13b	74.11	14.04	0.09	0.96	0.06	0.76	4.23	4.79			0.04	99.09
1348	36.14a	72.55	13.81	0.28	1.58	0.15	0.82	3.28	6.05			0.11	98.63
1348	36.14b	72.87	13.64	0.25	1.40	0.17	0.79	3.23	6.11			0.14	98.59
1349	36.15a	72.11	13.82	0.28	1.71	0.27	0.88	3.33	5.84			0.10	98.34
1349	36.15b	71.45	13.67	0.29	1.73	0.28	0.88	3.25	5.86			0.08	97.47
1350	36.16a	74.45	13.34	0.09	1.52	0.07	0.57	3.43	5.27			0.07	98.81
1350	36.16b	74.16	13.08	0.08	1.13	0.07	0.55	3.42	5.32			0.04	97.86
1351	36.17a	71.84	13.81	0.31	1.78	0.25	0.86	3.24	5.96			0.10	98.16
1351	36.17b	71.63	13.62	0.29	2.04	0.22	0.89	3.28	5.97			0.06	97.99
1352	37.1a	74.35	13.17	0.08	1.15	0.08	0.59	3.51	5.26			0.05	98.24
1352	37.1b	74.40	13.27	0.09	1.46	0.08	0.60	3.46	5.25			0.02	98.64
1353	37.2a	71.86	13.64	0.29	1.88	0.28	0.85	3.26	5.97			0.09	98.11
1353	37.2b	72.73	13.80	0.32	1.04	0.13	0.88	3.34	5.93			0.09	98.27
1355	37.3a	72.16	13.63	0.29	1.72	0.29	0.82	3.25	5.96			0.13	98.25
1355	37.3b	71.85	13.59	0.29	1.97	0.41	0.98	3.40	5.55			0.11	98.13
1356	37.4a	72.30	13.50	0.28	1.71	0.25	0.82	3.30	5.93			0.11	98.20
1356	37.4b	70.43	13.15	0.52	4.61	0.10	0.90	3.09	5.97			0.20	98.97
1357	37.5a	72.89	13.64	0.26	1.18	0.08	0.90	3.40	5.80			0.12	98.26
1357	37.5b	73.61	13.61	0.25	1.01	0.07	0.75	3.24	6.12			0.13	98.79
1358	37.6a	72.40	13.65	0.22	1.29	0.13	1.00	3.27	5.94			0.13	98.04
1358	37.6b	72.29	13.72	0.27	1.29	0.12	0.88	3.26	6.02			0.10	97.96
1359	37.7a	72.61	13.38	0.24	1.58	0.20	0.74	3.12	6.18			0.08	98.13
1359	37.7b	72.61	13.57	0.23	1.48	0.15	0.85	3.27	5.95			0.06	98.17
1360	37.8a	73.02	13.57	0.24	1.43	0.18	0.74	3.26	5.94			0.13	98.51
1360	37.8b	72.51	13.24	0.39	1.97	0.16	0.74	3.21	5.86			0.15	98.21

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1361	37.9a	71.70	14.11	0.30	1.70	0.20	1.11	3.54	5.52			0.07	98.25
1361	37.9b	72.20	13.85	0.28	1.61	0.17	0.86	3.29	5.92			0.08	98.25
1362	37.10a	69.65	15.60	0.23	1.24	0.19	1.93	4.22	4.65			0.07	97.78
1362	37.10b	72.73	13.63	0.28	1.64	0.17	1.01	3.47	5.49			0.10	98.50
1363	37.11a	75.18	12.70	0.12	1.10	0.11	0.53	3.38	5.40			0.03	98.55
1363	37.11b	75.21	12.83	0.09	1.03	0.10	0.53	2.81	5.46			0.00	98.05
1364	37.12a	74.78	12.91	0.15	1.22	0.11	0.55	3.37	5.44			0.02	98.54
1364	37.12b	75.17	12.89	0.09	1.09	0.10	0.52	3.42	5.54			0.00	98.82
1365	37.13a	74.99	12.85	0.15	1.25	0.10	0.54	3.40	5.38			0.00	98.66
1365	37.13b	75.27	12.76	0.12	1.19	0.11	0.57	3.48	5.32			0.03	98.85
1366	37.14a	74.95	12.75	0.11	1.37	0.11	0.55	3.46	5.38			0.06	98.74
1366	37.14b	74.88	12.91	0.12	1.35	0.11	0.57	3.35	5.48			0.01	98.78
1367	37.15a	74.05	12.70	0.20	1.95	0.32	0.54	3.29	5.49			0.01	98.56
1367	37.15b	74.87	12.76	0.12	1.17	0.10	0.56	3.37	5.42			0.01	98.40
1368	37.16a	74.85	12.75	0.11	1.08	0.10	0.56	3.28	5.41			0.01	98.14
1368	37.16b	75.08	12.64	0.12	1.42	0.11	0.54	3.41	5.38			0.01	98.72
1369	37.17a	74.94	12.84	0.11	1.16	0.11	0.55	3.38	5.34			0.04	98.47
1369	37.17b	74.96	12.80	0.13	1.02	0.11	0.56	3.35	5.34			0.03	98.29
1370	37.18a	74.74	12.69	0.14	1.21	0.13	0.56	3.30	5.49			0.02	98.28
1370	37.18b	74.98	12.81	0.13	1.17	0.11	0.56	3.40	5.49			0.04	98.69
1371	38.1a	75.07	12.80	0.12	1.62	0.09	0.56	3.43	5.52			0.04	99.24
1371	38.1b	74.95	12.96	0.13	1.16	0.10	0.56	3.39	5.48			0.04	98.76
1372	38.2a	74.93	12.84	0.12	1.16	0.11	0.55	3.34	5.44			0.00	98.49
1372	38.2b	75.35	12.79	0.13	1.17	0.12	0.56	3.51	5.43			0.00	99.06
1373	38.3a	74.97	12.96	0.16	1.10	0.13	0.61	3.37	5.51			0.01	98.80
1373	38.3b	74.48	12.91	0.15	1.18	0.14	0.59	3.40	5.55			0.02	98.42

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1374	38.4a	74.90	12.93	0.13	1.16	0.11	0.54	3.36	5.45			0.00	98.58
1374	38.4b	75.74	12.77	0.13	1.07	0.11	0.54	3.40	5.45			0.00	99.21
1375	38.5a	75.47	12.82	0.11	1.10	0.09	0.57	3.46	5.43			0.01	99.06
1375	38.5b	75.03	12.58	0.10	1.07	0.08	0.55	3.43	5.45			0.01	98.29
1376	38.6a	75.30	12.70	0.12	1.06	0.07	0.58	3.38	5.43			0.00	98.65
1376	38.6b	75.19	12.81	0.14	1.14	0.11	0.60	3.40	5.47			0.01	98.88
1377	38.7a	73.16	13.65	0.25	1.29	0.14	0.78	3.18	6.09			0.09	98.62
1377	38.7b	73.27	13.72	0.25	1.10	0.10	0.77	3.29	6.09			0.06	98.65
1378	38.8a	72.66	13.80	0.29	1.61	0.25	0.90	3.26	5.91			0.11	98.80
1378	38.8b	72.71	13.78	0.29	1.43	0.18	0.91	3.34	6.06			0.10	98.80
1379	38.9a	72.52	13.62	0.25	1.14	0.16	0.80	3.23	6.05			0.09	97.85
1379	38.9b	72.77	13.84	0.31	1.28	0.20	0.93	3.33	5.82			0.08	98.55
1380	38.10a	72.83	13.81	0.28	1.41	0.22	0.88	3.26	5.91			0.08	98.67
1380	38.10b	72.72	13.92	0.29	1.85	0.23	0.85	3.30	5.90			0.09	99.15
1381	38.11a	72.37	13.96	0.26	1.41	0.24	0.94	3.46	5.77			0.13	98.55
1381	38.11b	72.55	13.72	0.27	1.56	0.16	0.82	3.35	6.01			0.10	98.54
1382	38.12a	72.59	13.87	0.34	1.66	0.24	1.02	3.49	5.58			0.10	98.89
1382	38.12b	68.23	17.74	0.17	0.70	0.08	3.21	5.15	3.41			0.17	98.86
1383	38.13a	72.99	13.84	0.30	1.32	0.13	0.87	3.36	6.08			0.15	99.02
1383	38.13b	72.39	13.67	0.29	1.64	0.18	0.86	3.32	6.09			0.09	98.53
1384	38.14a	72.62	13.99	0.30	1.62	0.19	0.86	3.36	6.04			0.09	99.07
1384	38.14b	71.79	14.79	0.26	1.19	0.07	1.43	3.84	5.22			0.10	98.70
1385	38.15a	73.17	13.76	0.26	1.22	0.17	0.83	3.27	6.03			0.08	98.79
1385	38.15b	71.91	13.67	0.29	2.50	0.27	0.85	3.23	5.98			0.09	98.78
1386	38.16a	71.26	15.35	0.22	1.13	0.16	1.58	4.02	5.06			0.12	98.90
1386	38.16b	73.40	13.62	0.24	1.40	0.16	0.76	3.20	5.96			0.11	98.87

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1387	38.17a	72.76	13.88	0.29	1.25	0.13	1.02	3.47	5.55			0.06	98.41
1387	38.17b	72.15	13.77	0.29	1.69	0.24	1.12	3.22	5.95			0.09	98.53
1388	38.18a	72.69	13.70	0.25	1.32	0.17	0.72	3.19	6.31			0.04	98.40
1388	38.18b	72.53	13.65	0.26	2.13	0.46	0.73	3.07	6.06			0.09	98.98
1388	38.18c	73.32	13.81	0.27	1.09	0.07	0.75	3.04	6.36			0.04	98.76
1389	39.1a	75.27	12.58	0.12	1.08	0.10	0.56	3.28	5.36			0.00	98.34
1389	39.1b	75.16	12.82	0.12	1.10	0.10	0.54	3.26	5.42			0.01	98.53
1390	39.2a	74.87	12.77	0.13	1.15	0.10	0.56	3.36	5.42			0.00	98.36
1390	39.2b	74.98	12.86	0.13	1.08	0.11	0.54	3.36	5.51			0.01	98.58
1391	39.3a	74.71	12.84	0.14	1.00	0.10	0.56	3.37	5.47			0.01	98.19
1391	39.3b	75.04	12.72	0.12	1.10	0.12	0.57	3.24	5.51			0.01	98.42
1392	39.4a	73.48	12.92	0.20	2.56	0.14	0.59	3.40	5.56			0.02	98.86
1392	39.4b	71.24	12.76	0.31	6.13	0.17	0.57	3.36	5.27			0.06	99.86
1393	39.5a	72.89	13.70	0.23	1.47	0.21	0.76	3.61	5.65			0.08	98.60
1393	39.5b	72.75	13.74	0.24	1.37	0.18	0.75	3.66	5.71			0.08	98.48
1394	39.6a	72.55	13.61	0.27	1.45	0.12	0.83	3.32	5.95			0.18	98.27
1394	39.6b	72.63	13.72	0.27	1.49	0.23	0.83	3.31	5.94			0.13	98.54
1395	39.7a	74.56	12.72	0.13	1.30	0.12	0.56	3.38	5.44			0.05	98.26
1395	39.7b	74.86	12.69	0.13	0.85	0.07	0.56	3.34	5.54			0.04	98.08
1396	39.8a	73.80	12.29	0.14	1.64	0.11	0.52	2.22	7.13			0.02	97.87
1396	39.8b	74.40	12.62	0.13	1.14	0.10	0.54	3.21	5.49			0.00	97.63
1397	39.9a	72.04	13.56	0.29	2.39	0.37	0.85	3.28	5.84			0.11	98.72
1397	39.9b	71.68	14.23	0.28	1.46	0.20	1.21	3.57	5.51			0.10	98.23
1398	39.10a	72.48	13.81	0.27	1.17	0.11	0.80	3.29	6.03			0.13	98.09
1398	39.10b	72.81	13.70	0.25	1.07	0.08	0.79	3.29	6.06			0.14	98.18
1399	39.11a	74.60	12.61	0.12	1.41	0.13	0.53	3.40	5.44			0.00	98.23

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1399	39.11b	74.94	12.82	0.13	0.87	0.08	0.56	3.40	5.37			0.00	98.17
1400	39.12a	74.35	12.73	0.15	1.18	0.17	0.55	3.34	5.35			0.02	97.84
1400	39.12b	74.69	12.96	0.11	0.88	0.06	0.54	3.37	5.44			0.00	98.04
1401	39.13a	72.10	13.77	0.28	1.73	0.31	0.84	3.40	5.91			0.06	98.41
1401	39.13b	71.67	13.87	0.29	1.87	0.39	0.95	3.44	5.61			0.11	98.21
1402	39.14a	72.79	13.81	0.25	1.18	0.17	0.87	3.25	5.96			0.09	98.37
1402	39.14b	72.46	13.86	0.30	1.39	0.23	0.86	3.32	6.09			0.10	98.61
1403	39.15a	73.41	13.61	0.09	1.19	0.07	0.66	3.74	5.18			0.05	98.00
1403	39.15b	73.47	13.71	0.07	1.15	0.07	0.68	3.81	4.99			0.00	97.95
1404	39.16a	74.02	13.17	0.10	1.25	0.08	0.58	3.41	5.32			0.01	97.94
1404	39.16b	74.19	13.19	0.11	1.38	0.07	0.55	3.40	5.29			0.04	98.22
1405	39.17a	72.16	13.93	0.39	1.73	0.36	1.11	3.63	5.29			0.09	98.70
1405	39.17b	72.82	13.84	0.26	1.41	0.17	0.78	3.26	6.09			0.11	98.75
1406	39.18a	72.34	13.48	0.23	1.44	0.18	0.76	0.89	9.53			0.06	98.91
1406	39.18b	72.71	13.54	0.23	1.23	0.19	0.72	2.75	6.56			0.06	98.01
1407	40.1a	72.44	13.74	0.29	1.31	0.17	0.89	3.26	5.98			0.05	98.12
1407	40.1b	72.51	13.77	0.30	1.30	0.13	0.83	3.31	6.13			0.08	98.35
1408	40.2a	69.28	16.81	0.13	0.61	0.03	2.51	5.14	3.87			0.11	98.48
1408	40.2b	72.58	13.48	0.22	1.91	0.17	0.67	3.06	6.13			0.10	98.32
1409	40.3a	72.41	13.80	0.26	1.50	0.18	0.76	3.23	5.99			0.12	98.26
1409	40.3b	72.46	13.94	0.24	1.45	0.16	0.92	3.33	5.79			0.09	98.39
1410	40.4a	72.63	13.95	0.28	1.50	0.21	0.88	3.41	5.90			0.11	98.85
1410	40.4b	72.50	13.76	0.32	1.70	0.37	0.82	3.28	5.98			0.13	98.86
1411	40.5a	73.27	13.16	0.08	1.30	0.09	0.58	1.14	8.72			0.06	98.40
1411	40.5b	74.07	12.99	0.08	1.28	0.09	0.58	2.70	6.42			0.00	98.20
1411	40.5c	73.80	13.45	0.10	1.28	0.08	0.64	3.01	6.15			0.00	98.51

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1411	40.5d	73.56	13.30	0.09	1.28	0.09	0.61	1.66	8.15			0.01	98.76
1412	40.6a	74.72	12.98	0.09	1.33	0.07	0.58	3.32	5.27			0.01	98.36
1412	40.6b	74.34	13.06	0.12	1.50	0.09	0.55	3.39	5.28			0.00	98.33
1412	40.6c	74.55	13.33	0.10	1.10	0.06	0.54	3.34	5.24			0.00	98.26
1412	40.6d	74.27	13.22	0.09	1.19	0.07	0.58	3.35	5.28			0.00	98.05
1413	40.7a	74.09	13.37	0.10	1.06	0.08	0.61	3.59	5.22			0.02	98.13
1413	40.7b	74.45	13.18	0.10	1.19	0.08	0.54	3.36	5.33			0.02	98.25
1414	40.8a	74.34	13.11	0.10	1.43	0.08	0.55	3.36	5.36			0.01	98.34
1414	40.8b	74.27	13.29	0.09	1.13	0.08	0.55	3.56	5.29			0.02	98.27
1415	40.9a	75.47	13.16	0.08	1.15	0.04	0.54	3.36	5.31			0.00	99.11
1415	40.9b	75.13	13.07	0.08	1.22	0.06	0.54	3.33	5.29			0.00	98.73
1416	40.10a	74.68	13.28	0.10	1.15	0.06	0.56	3.44	5.23			0.02	98.51
1416	40.10b	74.97	13.34	0.10	1.10	0.08	0.61	3.58	5.18			0.07	99.02
1417	40.11a	74.24	13.83	0.09	1.26	0.07	0.66	3.78	5.17			0.04	99.14
1417	40.11b	74.11	13.14	0.11	1.31	0.11	0.55	3.32	5.32			0.01	97.98
1418	40.12a	74.18	13.41	0.09	1.57	0.08	0.61	3.56	5.24			0.03	98.78
1418	40.12b	75.04	13.25	0.09	1.35	0.09	0.58	3.52	5.36			0.03	99.30
1419	40.13a	74.13	13.36	0.10	1.16	0.08	0.59	3.48	5.32			0.01	98.24
1419	40.13b	74.22	13.59	0.09	1.06	0.08	0.64	3.60	5.24			0.03	98.54
1420	40.14a	74.03	13.10	0.09	1.24	0.07	0.55	3.45	5.28			0.00	97.81
1420	40.14b	74.22	13.38	0.09	1.27	0.08	0.61	3.46	5.17			0.00	98.29
1421	40.15a	71.84	13.48	0.28	1.69	0.24	0.85	3.24	5.91			0.10	97.64
1421	40.15b	71.96	13.72	0.29	1.65	0.24	0.84	3.28	5.92			0.14	98.04
1422	40.16a	74.61	13.27	0.09	1.23	0.07	0.56	3.10	5.84			0.02	98.79
1422	40.16b	74.91	13.34	0.09	1.21	0.07	0.55	3.07	6.02			0.02	99.29
1423	40.17a	74.42	13.12	0.10	1.27	0.06	0.56	3.28	5.23			0.06	98.09

TABLE G1 (continued)

Cat.	**Disk**	**SiO2**	**Al2O3**	**TiO2**	**Fe2O3**	**MgO**	**CaO**	**Na2O**	**K2O**	**P2O5**	**MnO**	**BaO**	**Total**
1423	40.17b	74.02	13.32	0.10	1.19	0.05	0.62	3.44	5.28			0.01	98.03
1424	41.1a	74.89	13.41	0.09	1.21	0.09	0.55	3.44	5.27			0.00	98.94
1424	41.1b	74.93	13.25	0.08	1.29	0.08	0.57	3.50	5.32			0.00	99.01
1425	41.2a	74.58	13.16	0.09	1.14	0.08	0.56	3.33	5.37			0.02	98.33
1425	41.2b	74.22	13.27	0.11	1.22	0.08	0.59	3.35	5.34			0.02	98.21
1426	41.3a	72.53	13.82	0.29	1.69	0.26	0.86	3.34	5.99			0.15	98.92
1426	41.3b	71.83	13.65	0.29	1.76	0.24	0.86	3.30	5.97			0.13	98.03
1427	41.4a	73.43	13.81	0.09	1.13	0.08	0.79	3.95	4.96			0.00	98.24
1427	41.4b	73.69	13.22	0.09	1.29	0.09	0.61	3.44	5.27			0.00	97.70
1428	41.5a	72.71	13.75	0.25	1.43	0.17	0.79	3.24	5.92			0.07	98.33
1428	41.5b	73.13	13.58	0.25	1.49	0.20	0.88	3.46	5.52			0.04	98.56
1429	41.6a	72.31	13.71	0.28	1.76	0.19	0.83	3.27	5.92			0.13	98.40
1429	41.6b	72.98	13.45	0.25	1.42	0.18	0.78	3.25	6.02			0.09	98.42
1430	41.7a	70.74	13.78	0.40	2.31	0.80	0.83	3.21	6.16			0.13	98.35
1430	41.7b	72.56	13.83	0.31	1.31	0.07	0.89	3.28	6.02			0.02	98.28
1431	41.8a	73.11	13.91	0.24	1.30	0.15	1.31	3.51	5.23			0.08	98.83
1431	41.8b	72.79	13.69	0.24	1.18	0.11	0.78	2.27	7.68			0.10	98.84
1432	41.9a	72.72	13.75	0.27	1.22	0.12	0.84	3.25	6.13			0.10	98.41
1432	41.9b	70.26	16.05	0.20	0.96	0.11	1.67	4.31	5.29			0.23	99.07
1433	41.10a	72.53	13.78	0.25	1.53	0.17	0.82	3.16	6.11			0.11	98.47
1433	41.10b	70.84	14.90	0.19	1.38	0.24	1.33	3.51	6.09			0.24	98.72
1434	41.11a	73.31	13.64	0.27	1.04	0.10	0.80	3.27	5.98			0.08	98.49
1434	41.11b	72.56	14.29	0.20	0.99	0.11	1.13	3.61	5.60			0.10	98.59
1435	41.12a	72.11	13.71	0.26	1.34	0.19	0.85	3.29	5.91			0.10	97.76
1435	41.12b	73.06	13.46	0.21	1.49	0.18	0.80	3.23	5.88			0.11	98.43
1436	41.13a	72.63	13.96	0.28	1.28	0.16	0.94	3.36	5.75			0.12	98.46

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1436	41.13b	72.75	13.59	0.25	1.55	0.17	0.82	3.23	5.96			0.07	98.41
1437	41.14a	72.36	13.77	0.32	1.73	0.17	0.79	3.24	6.11			0.12	98.61
1437	41.14b	72.44	13.89	0.28	1.37	0.09	0.78	3.18	6.13			0.14	98.31
1438	41.15a	72.13	13.91	0.30	1.65	0.20	0.88	3.28	5.91			0.15	98.42
1438	41.15b	71.85	13.95	0.31	1.40	0.15	0.91	3.38	5.90			0.12	97.96
1439	41.16a	69.82	13.87	0.57	3.05	1.07	0.70	3.06	6.33			0.15	98.62
1439	41.16b	72.22	13.62	0.24	1.67	0.20	0.83	3.24	6.01			0.09	98.12
1440	41.17a	72.44	13.91	0.29	1.49	0.20	0.85	3.31	5.98			0.11	98.58
1440	41.17b	72.07	13.78	0.28	1.80	0.35	0.90	3.34	5.87			0.10	98.48
1441	41.18a	72.19	13.60	0.27	1.77	0.34	0.80	3.20	5.98			0.15	98.31
1441	41.18b	72.08	13.71	0.26	1.64	0.23	0.80	3.17	5.98			0.11	97.97
1442	42.1a	72.40	13.65	0.23	1.59	0.22	0.76	2.90	6.37			0.08	98.20
1442	42.1b	72.10	13.57	0.25	1.60	0.20	0.77	2.96	6.32			0.11	97.88
1443	42.2a	73.10	13.56	0.24	1.47	0.16	0.78	3.27	5.95			0.12	98.64
1443	42.2b	72.13	13.87	0.30	1.70	0.21	0.88	3.30	5.91			0.09	98.40
1444	42.3a	72.01	13.89	0.28	1.60	0.15	0.86	3.36	5.88			0.11	98.14
1444	42.3b	72.15	13.75	0.27	1.44	0.13	0.82	3.31	5.92			0.11	97.91
1445	42.4a	71.89	13.80	0.29	1.63	0.26	0.88	3.29	5.91			0.08	98.03
1445	42.4b	72.66	13.99	0.29	1.20	0.14	0.94	3.37	5.84			0.13	98.56
1446	42.5a	72.65	13.58	0.24	1.35	0.15	0.75	3.23	6.11			0.06	98.12
1446	42.5b	71.17	13.61	0.26	2.73	0.21	0.91	2.46	7.05			0.04	98.43
1447	42.6a	71.93	13.91	0.27	1.40	0.18	0.97	3.20	5.98			0.11	97.96
1447	42.6b	71.50	13.95	0.30	2.06	0.22	0.92	2.64	6.81			0.12	98.51
1448	42.7a	73.06	13.72	0.19	1.29	0.15	0.71	3.30	6.04			0.11	98.58
1448	42.7b	72.69	13.51	0.26	1.56	0.21	0.78	3.24	5.94			0.10	98.29
1449	42.8a	66.65	17.68	0.26	1.16	0.37	2.86	5.14	3.70			0.12	97.93

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1449	42.8b	72.89	13.70	0.25	1.59	0.22	0.83	3.35	5.69			0.07	98.59
1450	42.9a	71.71	13.93	0.27	1.47	0.17	0.92	3.21	5.97			0.10	97.74
1450	42.9b	71.48	13.77	0.29	2.52	0.59	0.87	3.16	5.77			0.05	98.50
1451	42.10a	72.12	13.65	0.29	1.59	0.32	0.83	3.23	5.96			0.04	98.02
1451	42.10b	71.65	13.83	0.28	1.77	0.30	0.84	3.32	5.95			0.09	98.02
1452	42.11a	73.89	13.53	0.10	1.23	0.08	0.60	3.57	5.12			0.00	98.12
1452	42.11b	74.20	13.20	0.09	1.31	0.08	0.58	3.39	5.39			0.00	98.24
1453	42.12a	74.23	13.25	0.09	1.15	0.07	0.54	3.39	5.20			0.00	97.92
1453	42.12b	73.75	13.23	0.10	1.17	0.07	0.58	3.38	5.28			0.01	97.56
1454	42.13a	74.24	13.38	0.10	1.18	0.06	0.55	3.33	5.21			0.07	98.13
1454	42.13b	74.40	13.20	0.08	1.10	0.07	0.56	3.42	5.20			0.05	98.08
1455	42.14a	71.27	13.80	0.27	2.21	0.56	1.00	3.28	5.70			0.14	98.23
1455	42.14b	72.14	13.90	0.29	1.63	0.28	0.85	3.24	5.75			0.13	98.21
1455	42.14c	71.91	13.84	0.30	1.69	0.27	0.87	3.30	5.74			0.11	98.02
1456	42.15a	73.90	13.27	0.08	1.24	0.08	0.58	3.42	5.21			0.00	97.78
1456	42.15b	73.37	13.35	0.10	1.22	0.07	0.60	3.45	5.19			0.00	97.36
1457	42.16a	74.08	13.16	0.09	1.17	0.08	0.55	3.44	5.21			0.01	97.79
1457	42.16b	74.07	13.29	0.08	1.34	0.09	0.57	3.34	5.23			0.05	98.05
1458	42.17a	71.68	14.43	0.18	1.60	0.10	1.27	3.86	5.11			0.07	98.30
1458	42.17b	72.38	13.50	0.23	2.06	0.13	0.73	3.31	5.88			0.07	98.29
1459	42.18a	71.91	13.85	0.29	1.79	0.26	0.88	3.31	5.93			0.11	98.33
1459	42.18b	72.14	13.78	0.30	1.69	0.27	0.92	1.84	5.81			0.08	96.83
1460	43.1a	72.30	13.80	0.29	1.57	0.22	0.87	3.31	5.89			0.09	98.35
1460	43.1b	72.14	13.97	0.25	1.43	0.22	0.83	3.34	6.02			0.18	98.37
1461	43.2a	72.61	13.56	0.27	1.52	0.17	0.77	3.19	5.96			0.12	98.18
1461	43.2b	72.82	13.51	0.22	1.46	0.17	0.76	3.21	5.96			0.11	98.23

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1462	43.3a	72.69	13.79	0.29	1.27	0.12	0.87	3.47	5.93			0.07	98.50
1462	43.3b	71.77	13.96	0.28	1.45	0.21	1.19	3.87	5.08			0.11	97.93
1463	43.4a	71.61	14.39	0.21	1.38	0.12	1.26	3.63	5.41			0.12	98.13
1463	43.4b	71.84	13.58	0.29	1.99	0.33	0.83	3.26	5.89			0.10	98.10
1464	43.5a	72.16	13.76	0.24	1.98	0.25	0.78	3.15	5.93			0.10	98.36
1464	43.5b	72.09	13.72	0.30	1.46	0.21	0.84	3.18	6.04			0.11	97.97
1465	43.6a	73.78	13.32	0.17	1.22	0.13	0.70	3.20	5.74			0.10	98.38
1465	43.6b	73.14	13.58	0.24	1.50	0.19	0.76	3.28	6.00			0.14	98.82
1466	43.7a	72.79	13.98	0.28	1.27	0.17	0.87	3.30	6.08			0.10	98.84
1466	43.7b	72.74	13.67	0.27	1.36	0.19	0.82	3.23	5.92			0.12	98.33
1467	43.8a	72.93	13.92	0.30	1.40	0.21	0.85	3.39	5.86			0.12	98.98
1467	43.8b	72.21	13.79	0.30	1.53	0.22	0.86	3.27	5.86			0.10	98.13
1468	43.9a	74.68	13.22	0.10	1.18	0.08	0.58	3.37	5.26			0.03	98.49
1468	43.9b	74.09	13.16	0.10	1.77	0.09	0.55	3.41	5.35			0.01	98.53
1470	43.10a	71.79	13.75	0.31	1.73	0.29	0.94	3.04	5.87			0.16	97.85
1470	43.10b	71.79	13.93	0.32	1.73	0.29	0.98	3.28	5.83			0.16	98.29
1471	43.11a	72.13	13.81	0.29	1.69	0.25	0.90	3.34	5.84			0.11	98.36
1471	43.11b	72.92	13.90	0.29	1.74	0.26	0.87	3.29	5.84			0.11	99.23
1472	43.12a	73.41	14.35	0.07	0.94	0.05	0.97	4.40	4.50			0.04	98.73
1472	43.12b	74.45	13.18	0.10	1.21	0.08	0.57	3.39	5.33			0.02	98.34
1473	22.7a	71.83	13.70	0.46	2.82	0.15	0.91	3.35	5.71			0.11	99.04
1473	22.7b	72.92	13.87	0.25	1.32	0.20	0.81	3.21	5.98			0.10	98.66
1474	44.11a	72.93	13.70	0.26	1.47	0.19	0.84	3.28	5.94			0.12	98.73
1474	44.11b	72.68	13.62	0.24	1.50	0.16	0.84	3.23	6.03			0.06	98.36
1475	22.9a	73.36	13.72	0.24	1.58	0.18	0.83	3.20	5.85			0.08	99.03
1475	22.9b	71.30	15.11	0.23	1.21	0.18	1.54	4.05	4.98			0.11	98.72

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1475	22.9c	72.71	13.89	0.30	1.46	0.21	0.91	3.32	5.91			0.12	98.82
1476	22.10a	72.69	14.00	0.28	1.43	0.20	0.95	2.85	6.42			0.13	98.94
1476	22.10b	72.00	14.13	0.31	2.23	0.38	0.90	2.78	6.39			0.16	99.29
1477	22.11a	72.62	14.11	0.29	1.90	0.28	0.85	3.33	5.79			0.10	99.26
1477	22.11b	73.50	14.13	0.29	1.17	0.09	0.83	3.26	5.83			0.12	99.22
1478	22.12a	72.37	14.12	0.27	1.38	0.17	0.93	3.33	5.83			0.17	98.56
1478	22.12b	72.80	14.17	0.29	1.31	0.15	0.84	3.26	6.00			0.12	98.94
1479	22.13a	72.24	13.97	0.26	1.93	0.27	0.97	3.38	5.58			0.13	98.74
1479	22.13b	72.28	14.09	0.30	1.71	0.24	0.86	3.35	5.82			0.13	98.78
1480	22.14a	74.83	13.43	0.11	1.18	0.08	0.57	3.45	5.17			0.05	98.86
1480	22.14b	74.43	13.58	0.12	1.23	0.09	0.58	3.40	5.12			0.02	98.57
1481	22.15a	74.66	13.51	0.10	1.31	0.08	0.51	3.37	5.23			0.00	98.77
1481	22.15b	74.75	13.42	0.09	1.32	0.09	0.57	3.43	5.16			0.02	98.85
1482	22.16a	74.68	13.46	0.09	1.19	0.05	0.60	3.44	5.05			0.00	98.57
1482	22.16b	74.78	13.44	0.08	1.24	0.08	0.56	3.39	5.20			0.01	98.80
1483	22.17a	74.56	13.34	0.09	1.19	0.08	0.59	3.44	5.18			0.00	98.47
1483	22.17b	74.38	13.45	0.10	1.66	0.09	0.56	3.40	5.14			0.01	98.78
1484	22.18a	74.44	13.30	0.09	1.30	0.08	0.55	2.85	5.96			0.00	98.58
1484	22.18b	74.05	13.42	0.10	1.20	0.08	0.56	3.25	5.58			0.02	98.26
1485	23.1a	74.47	13.38	0.09	1.24	0.07	0.63	3.50	5.15			0.03	98.56
1485	23.1b	74.58	13.36	0.09	1.31	0.07	0.54	3.38	5.28			0.02	98.63
1486	23.2a	74.58	13.21	0.10	1.22	0.09	0.58	3.29	5.31			0.04	98.42
1486	23.2b	75.48	13.27	0.09	1.20	0.08	0.55	3.30	5.27			0.02	99.26
1487	23.3a	74.38	13.68	0.10	1.06	0.08	0.62	3.86	4.84			0.04	98.65
1487	23.3b	74.34	13.37	0.07	1.30	0.09	0.55	3.28	5.30			0.02	98.32
1488	23.4a	74.16	13.23	0.09	1.19	0.09	0.57	3.38	5.16			0.00	97.87

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1488	23.4b	73.86	13.23	0.10	1.59	0.08	0.57	3.38	5.23			0.00	98.05
1489	23.5a	73.69	12.99	0.10	1.19	0.06	0.58	2.99	5.34			0.00	96.93
1489	23.5b	74.49	13.35	0.08	1.12	0.06	0.63	3.49	4.99			0.01	98.22
1490	23.6a	73.78	13.16	0.09	1.24	0.10	0.55	2.23	6.86			0.02	98.01
1490	23.6b	73.78	13.29	0.09	1.22	0.08	0.61	2.42	6.63			0.03	98.15
1491	23.7a	74.37	13.27	0.09	1.25	0.09	0.56	3.45	5.11			0.02	98.20
1491	23.7b	73.97	13.27	0.09	1.28	0.08	0.57	3.27	5.13			0.03	97.69
1492	23.8a	72.92	14.05	0.28	1.01	0.08	0.86	3.22	6.05			0.15	98.63
1492	23.8b	73.35	14.31	0.28	1.01	0.07	0.91	3.31	5.86			0.17	99.28
1493	23.9a	72.90	13.91	0.48	1.38	0.10	0.79	3.26	6.08			0.14	99.04
1493	23.9b	72.72	13.80	0.29	1.46	0.26	0.82	3.22	6.06			0.17	98.80
1494	23.10a	73.10	13.60	0.23	1.39	0.17	0.75	3.16	5.88			0.07	98.35
1494	23.10b	72.14	14.17	0.20	1.14	0.14	0.73	3.30	6.09			0.26	98.18
1495	23.11a	72.56	14.03	0.23	1.33	0.08	0.91	3.32	5.96			0.03	98.45
1495	23.11b	72.52	13.94	0.23	1.32	0.14	1.02	3.45	5.58			0.06	98.27
1496	23.12a	73.02	13.85	0.23	1.65	0.20	0.78	3.18	5.64			0.10	98.66
1496	23.12b	72.14	13.85	0.55	2.21	0.15	0.84	3.21	5.85			0.10	98.91
1497	23.13a	72.39	13.91	0.28	1.71	0.32	0.91	3.32	5.57			0.07	98.48
1497	23.13b	72.75	14.31	0.20	1.14	0.10	0.66	3.14	6.47			0.33	99.11
1498	23.14a	73.65	13.73	0.25	1.43	0.17	0.79	3.25	5.91			0.09	99.27
1498	23.14b	72.24	13.77	0.22	1.85	0.34	1.03	3.34	5.67			0.12	98.58
1498	23.14c	73.69	13.35	0.20	1.33	0.15	0.75	3.10	5.92			0.10	98.60
1499	23.15a	73.82	13.54	0.19	1.17	0.09	0.73	3.21	5.75			0.04	98.55
1499	23.15b	73.86	13.72	0.23	1.19	0.11	0.77	3.22	5.68			0.05	98.84
1500	23.16a	73.35	13.28	0.09	3.05	0.08	0.57	3.43	5.13			0.01	98.98
1500	23.16b	73.44	13.77	0.09	1.43	0.08	0.71	3.65	4.92			0.00	98.08

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1501	23.17a	72.39	14.01	0.29	1.73	0.26	0.92	3.34	5.60			0.10	98.64
1501	23.17b	72.50	13.97	0.30	1.71	0.31	0.90	3.23	5.81			0.07	98.83
1502	23.18a	74.99	13.60	0.10	1.34	0.09	0.57	3.42	5.23			0.02	99.37
1502	23.18b	74.25	13.28	0.10	1.38	0.10	0.57	3.38	5.16			0.00	98.21
1503	24.1a	73.48	13.46	0.19	1.21	0.11	0.74	3.24	5.78			0.08	98.30
1503	24.1b	73.01	13.69	0.23	1.15	0.16	0.69	3.16	5.77			0.15	98.00
1504	24.2a	74.54	13.33	0.08	1.19	0.08	0.60	3.39	5.15			0.00	98.36
1504	24.2b	74.79	13.45	0.10	1.20	0.08	0.59	3.41	5.15			0.01	98.78
1505	24.3a	74.18	13.66	0.09	1.20	0.06	0.75	3.70	4.83			0.02	98.50
1505	24.3b	74.58	13.22	0.10	1.16	0.07	0.56	3.44	4.98			0.01	98.12
1506	24.4a	74.87	13.35	0.10	1.33	0.09	0.58	3.33	5.09			0.00	98.73
1506	24.4b	74.66	13.32	0.10	1.18	0.07	0.62	3.36	5.16			0.00	98.46
1507	24.5a	74.27	13.48	0.10	1.27	0.08	0.61	3.42	5.19			0.05	98.47
1507	24.5b	74.58	13.44	0.10	1.27	0.09	0.60	3.37	5.21			0.02	98.69
1508	24.6a	74.27	13.46	0.09	1.21	0.09	0.60	3.36	5.22			0.09	98.38
1508	24.6b	74.32	13.30	0.07	1.42	0.08	0.57	3.47	4.99			0.03	98.26
1509	24.7a	74.94	13.22	0.09	1.41	0.07	0.55	3.37	5.03			0.00	98.69
1509	24.7b	75.06	13.57	0.09	1.24	0.07	0.58	3.38	5.22			0.00	99.22
1510	44.12a	74.28	13.17	0.10	1.27	0.15	0.53	3.37	5.32			0.00	98.21
1510	44.12b	74.20	13.79	0.08	1.04	0.07	0.72	3.84	5.05			0.02	98.80
1511	24.9a	73.92	13.38	0.10	1.36	0.09	0.56	3.40	5.14			0.00	97.94
1511	24.9b	74.05	13.33	0.11	1.27	0.08	0.56	3.46	5.14			0.01	98.00
1512	24.10a	73.09	14.13	0.28	1.74	0.27	0.87	3.34	5.83			0.13	99.68
1512	24.10b	72.30	13.97	0.29	1.76	0.29	0.91	3.31	5.68			0.07	98.57
1513	24.11a	73.39	13.82	0.23	1.46	0.12	0.79	3.25	5.91			0.14	99.10
1513	24.11b	73.60	14.01	0.21	0.94	0.08	0.83	3.30	5.91			0.13	99.02

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1514	24.12a	73.16	14.12	0.28	1.37	0.16	0.88	3.32	5.84			0.12	99.25
1514	24.12b	72.81	14.03	0.28	1.37	0.17	0.84	3.18	6.00			0.15	98.84
1514	24.12c	72.53	13.90	0.28	1.58	0.24	0.84	2.90	6.40			0.13	98.80
1515	24.13a	72.50	13.83	0.26	2.06	0.24	0.74	3.22	5.96			0.08	98.88
1515	24.13b	72.58	13.83	0.28	1.50	0.08	0.83	3.39	5.80			0.08	98.37
1516	24.14a	73.28	13.80	0.22	1.49	0.15	0.72	3.24	5.80			0.08	98.78
1516	24.14b	69.27	17.41	0.15	0.84	0.08	2.85	5.10	3.40			0.09	99.18
1516	24.14c	72.42	14.02	0.22	1.12	0.11	1.14	3.49	5.65			0.11	98.27
1517	24.15a	71.92	14.10	0.30	2.51	0.24	0.89	3.40	5.73			0.11	99.21
1517	24.15b	72.77	14.16	0.28	1.58	0.22	0.87	3.31	5.75			0.10	99.04
1518	24.16a	72.85	13.94	0.25	1.46	0.13	0.78	3.16	5.92			0.15	98.65
1518	24.16b	72.36	13.68	0.24	1.54	0.18	0.80	3.19	5.90			0.12	98.01
1519	24.17a	72.18	13.88	0.28	1.33	0.13	0.82	3.16	5.80			0.11	97.70
1519	24.17b	72.27	13.99	0.26	1.47	0.17	0.83	3.25	5.90			0.10	98.23
1520	24.18a	72.09	13.81	0.39	1.44	0.14	0.85	3.20	5.75			0.12	97.79
1520	24.18b	72.58	13.94	0.26	1.42	0.19	0.80	3.27	5.77			0.12	98.37
1521	25.1a	72.69	13.84	0.25	1.42	0.19	0.86	3.27	5.77			0.10	98.40
1521	25.1b	72.78	13.87	0.27	1.40	0.21	0.81	3.27	5.96			0.09	98.66
1522	25.2a	73.28	13.85	0.26	1.56	0.16	0.81	3.24	6.09			0.07	99.32
1522	25.2b	73.06	13.78	0.23	1.43	0.18	0.78	3.18	5.91			0.06	98.61
1523	25.3a	73.02	13.77	0.26	1.24	0.08	0.78	3.20	5.92			0.08	98.34
1523	25.3b	72.49	14.86	0.20	0.92	0.05	1.48	3.94	5.09			0.13	99.15
1524	25.4a	73.14	13.89	0.25	1.26	0.09	0.81	3.31	5.77			0.11	98.62
1524	25.4b	73.28	13.82	0.28	1.48	0.25	0.72	3.21	6.05			0.12	99.20
1525	25.5a	73.04	13.83	0.26	1.40	0.17	0.77	3.19	5.92			0.10	98.67
1525	25.5b	73.39	13.90	0.27	1.40	0.17	0.85	3.40	5.73			0.11	99.23

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1526	25.6a	74.80	13.75	0.09	1.10	0.07	0.71	3.61	5.00			0.01	99.14
1526	25.6b	75.19	13.26	0.09	1.26	0.08	0.56	3.41	5.13			0.00	98.99
1527	25.7a	74.49	13.30	0.10	1.44	0.07	0.56	3.43	5.22			0.00	98.62
1527	25.7b	73.77	13.21	0.13	1.43	0.14	0.60		5.05			0.02	94.37
1527	25.7c	74.35	14.01	0.08	1.07	0.06	0.82	4.06	4.86			0.03	99.35
1528	25.8a	75.41	13.66	0.10	1.26	0.08	0.54	3.45	4.99			0.04	99.53
1528	25.8b	74.53	13.38	0.11	1.25	0.07	0.57	3.45	5.22			0.01	98.58
1529	25.9a	74.08	13.34	0.10	1.73	0.11	0.64	3.73	5.00			0.06	98.79
1529	25.9b	74.96	13.15	0.09	1.32	0.11	0.56	3.49	5.30			0.05	99.02
1530	25.10a	75.04	13.59	0.10	1.16	0.09	0.68	3.74	5.01			0.07	99.48
1530	25.10b	74.56	13.47	0.09	1.34	0.08	0.56	3.45	5.20			0.07	98.83
1531	25.11a	72.98	14.10	0.28	1.72	0.27	0.90	3.31	5.71			0.14	99.42
1531	25.11b	72.40	14.14	0.26	1.88	0.28	0.88	3.32	5.72			0.13	99.01
1532	25.12a	72.37	14.12	0.29	1.98	0.32	0.91	3.36	5.59			0.15	99.09
1532	25.12b	72.46	14.04	0.28	1.76	0.27	0.92	2.84	5.54			0.10	98.22
1533	25.13a	75.88	13.66	0.09	1.18	0.07	0.56	3.50	5.21			0.00	100.16
1533	25.13b	75.53	13.58	0.10	1.23	0.07	0.56	3.52	5.11			0.02	99.72
1534	25.14a	74.67	13.33	0.10	1.14	0.08	0.57	3.39	5.33			0.00	98.61
1534	25.14b	74.68	13.44	0.09	1.20	0.08	0.57	3.46	5.31			0.00	98.84
1535	44.13a	73.01	13.53	0.24	1.44	0.17	0.78	3.27	6.01			0.11	98.57
1535	44.13b	72.83	13.41	0.29	1.45	0.29	0.76	3.16	6.08			0.09	98.37
1536	25.16a	72.47	13.70	0.28	1.58	0.23	0.80	3.28	5.90			0.10	98.35
1536	25.16b	72.25	13.90	0.71	2.04	0.17	0.80	3.20	5.76			0.11	98.95
1537	25.17a	73.85	13.99	0.24	1.70	0.26	0.84	3.50	5.49			0.06	99.93
1537	25.17b	73.40	13.81	0.22	1.56	0.18	0.73	3.30	5.72			0.05	98.96
1538	25.18a	72.43	15.08	0.15	1.23	0.09	1.46	3.90	5.03			0.09	99.46

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1538	25.18b	74.48	13.83	0.21	1.46	0.19	0.70	3.30	5.71			0.06	99.93
1539	26.1a	72.98	13.86	0.25	1.29	0.11	0.82	3.27	5.84			0.13	98.55
1539	26.1b	72.96	13.97	0.29	1.24	0.09	0.80	3.26	6.01			0.12	98.74
1540	26.2a	72.96	14.29	0.18	1.22	0.10	1.08	3.58	5.46			0.05	98.93
1540	26.2b	73.38	13.52	0.19	1.80	0.11	0.64	3.11	6.02			0.12	98.90
1541	26.3a	72.80	14.44	0.19	1.23	0.13	1.01	3.50	5.49			0.09	98.89
1541	26.3b	73.86	13.73	0.22	1.08	0.06	0.69	3.17	5.96			0.10	98.87
1542	26.4a	72.79	13.89	0.31	1.33	0.13	0.85	3.25	5.95			0.13	98.63
1542	26.4b	72.13	14.12	0.29	1.64	0.26	0.94	3.41	5.73			0.15	98.68
1544	26.5a	72.37	13.82	0.28	1.55	0.21	0.83	3.28	5.76			0.11	98.21
1544	26.5b	72.92	13.89	0.26	1.33	0.16	0.87	3.26	5.77			0.11	98.57
1545	26.6a	73.06	13.81	0.27	1.53	0.20	0.77	3.21	5.80			0.11	98.76
1545	26.6b	73.43	13.80	0.24	1.53	0.20	0.76	3.14	5.78			0.10	98.98
1546	26.7a	72.83	13.90	0.26	1.56	0.19	0.75	3.15	6.08			0.11	98.84
1546	26.7b	73.63	13.72	0.26	1.49	0.16	0.76	3.18	5.93			0.13	99.26
1547	26.8a	72.89	13.56	0.23	1.54	0.18	0.76	3.15	5.70			0.10	98.12
1547	26.8b	72.86	13.82	0.27	1.63	0.18	0.79	3.24	5.94			0.10	98.83
1548	26.9a	72.81	13.90	0.27	1.52	0.14	0.77	3.22	5.90			0.12	98.64
1548	26.9b	73.12	13.79	0.24	1.16	0.12	0.73	3.14	6.07			0.11	98.48
1549	26.10a	71.06	14.90	0.21	1.33	0.15	1.44	3.81	5.10			0.13	98.13
1549	26.10b	72.95	13.83	0.23	1.33	0.17	0.85	3.14	5.93			0.09	98.51
1550	26.11a	73.39	14.07	0.27	1.59	0.24	0.76	3.31	5.72			0.08	99.43
1550	26.11b	73.37	13.60	0.24	1.64	0.18	0.73	3.26	5.56			0.11	98.69
1551	26.12a	74.21	13.45	0.08	1.15	0.08	0.60	3.49	5.06			0.06	98.17
1551	26.12b	74.90	13.54	0.09	1.21	0.07	0.58	3.40	5.23			0.08	99.11
1552	26.13a	74.44	13.37	0.08	1.25	0.07	0.57	3.42	5.28			0.00	98.49

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1552	26.13b	75.07	13.38	0.08	1.23	0.08	0.58	3.49	5.20			0.00	99.11
1553	26.14a	74.57	13.52	0.08	1.38	0.07	0.56	3.48	5.18			0.05	98.90
1553	26.14b	73.85	13.85	0.09	1.53	0.08	0.65	3.79	4.84			0.01	98.67
1554	26.15a	74.42	13.34	0.09	1.36	0.08	0.58	3.39	5.13			0.00	98.39
1554	26.15b	74.60	13.32	0.10	1.26	0.07	0.56	3.40	5.21			0.01	98.53
1555	26.16a	71.89	14.32	0.28	1.77	0.27	1.08	3.42	5.51			0.08	98.63
1555	26.16a	72.42	14.07	0.30	1.77	0.28	0.94	3.27	5.70			0.09	98.84
1556	26.17a	74.46	13.44	0.10	1.29	0.11	0.57	3.40	5.13			0.00	98.51
1556	26.17b	74.62	13.46	0.10	1.27	0.09	0.60	3.44	5.21			0.00	98.78
1557	26.18a	75.06	13.33	0.10	1.48	0.08	0.54	3.38	5.12			0.00	99.10
1557	26.18b	74.57	13.30	0.10	1.34	0.09	0.57	3.39	5.17			0.02	98.56
1558	27.1a	74.21	13.48	0.08	1.12	0.06	0.61	3.60	5.07			0.00	98.22
1558	27.1b	73.95	13.57	0.09	1.21	0.08	0.64	3.58	5.10			0.00	98.22
1559	27.2a	74.26	13.18	0.09	1.25	0.06	0.56	3.34	5.25			0.00	97.98
1559	27.2b	74.00	13.21	0.09	1.24	0.07	0.53	3.34	5.36			0.00	97.83
1560	27.3a	73.10	13.20	0.04	1.05	0.07	0.60	3.62	4.85			0.00	96.53
1560	27.3b	73.18	12.72	0.05	1.38	0.06	0.48	3.48	5.00			0.00	96.36
1561	27.4a	72.64	13.63	0.24	1.62	0.26	0.77	3.22	6.02			0.13	98.54
1561	27.4b	72.26	14.08	0.21	1.19	0.15	0.87	3.43	6.18			0.19	98.55
1562	27.5a	73.68	13.44	0.10	1.23	0.07	0.65	3.57	5.08			0.03	97.86
1562	27.5b	74.46	13.38	0.10	1.30	0.07	0.59	3.42	5.17			0.02	98.50
1563	27.6a	71.96	14.01	0.29	1.30	0.07	0.87	3.24	5.83			0.12	97.71
1563	27.6b	72.38	13.93	0.31	1.32	0.07	0.86	3.25	5.97			0.08	98.16
1564	27.7a	72.53	13.71	0.29	1.62	0.27	0.85	3.24	5.96			0.11	98.59
1564	27.7b	72.66	13.82	0.31	1.49	0.10	0.85	3.26	6.04			0.17	98.70
1565	27.8a	71.89	13.67	0.28	1.76	0.28	0.85	3.36	5.95			0.11	98.15

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1565	27.8b	72.17	13.58	0.29	1.64	0.26	0.85	3.31	6.02			0.07	98.17
1566	27.9a	72.07	13.43	0.25	1.65	0.14	0.81	3.19	5.99			0.07	97.60
1566	27.9b	72.46	13.58	0.26	1.57	0.23	0.81	3.16	6.01			0.09	98.17
1567	27.10a	72.54	13.89	0.30	1.34	0.16	0.78	3.20	5.96			0.11	98.27
1567	27.10b	71.71	13.85	0.30	2.29	0.48	1.24	3.62	4.71			0.02	98.23
1568	27.11a	72.79	13.80	0.25	1.37	0.16	0.76	3.21	5.92			0.08	98.35
1568	27.11b	72.92	13.83	0.25	1.42	0.13	0.75	3.25	5.92			0.13	98.60
1569	27.12a	71.50	14.46	0.25	1.18	0.16	1.26	3.69	5.40			0.12	98.02
1569	27.12b	73.10	13.43	0.25	1.51	0.15	0.78	3.26	6.01			0.08	98.56
1570	27.13a	72.18	13.58	0.27	2.05	0.33	0.88	3.28	5.79			0.11	98.46
1570	27.13b	72.49	13.73	0.28	1.19	0.14	0.89	3.34	5.92			0.11	98.10
1571	27.14a	71.52	13.50	0.28	1.96	0.31	0.85	3.24	5.93			0.12	97.70
1571	27.14b	72.04	13.93	0.26	1.60	0.21	1.05	3.45	5.62			0.10	98.27
1572	27.15a	72.87	13.62	0.24	1.50	0.17	0.77	3.17	5.86			0.12	98.32
1572	27.15b	72.63	13.83	0.23	1.71	0.17	0.80	3.23	5.75			0.12	98.46
1573	27.16a	72.52	13.91	0.24	1.53	0.19	0.81	3.12	5.89			0.15	98.37
1573	27.16b	72.23	13.91	0.25	1.44	0.16	0.88	3.18	5.92			0.13	98.11
1574	27.17a	71.36	13.30	0.26	1.52	0.24	0.77	3.19	5.86			0.12	96.61
1574	27.17b	72.56	13.39	0.25	1.63	0.20	0.75	3.25	5.89			0.11	98.03
1576	28.1a	71.84	13.95	0.29	1.96	0.28	0.89	3.22	5.63			0.11	98.17
1576	28.1b	71.89	13.89	0.28	1.88	0.32	0.84	3.26	5.57			0.08	98.02
1577	28.2a	74.26	13.40	0.09	1.37	0.12	0.58	3.42	5.31			0.03	98.57
1577	28.2b	73.34	13.12	0.09	1.27	0.07	0.57		4.95			0.00	93.41
1577	28.2c	74.05	13.31	0.11	1.19	0.08	0.59	3.42	5.07			0.00	97.82
1577	28.2d	74.16	13.08	0.08	1.49	0.06	0.57	3.52	5.22			0.02	98.20
1578	28.3a	72.71	13.59	0.27	1.35	0.20	0.86	3.29	5.88			0.14	98.28

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1578	28.3b	72.74	13.67	0.28	1.56	0.21	0.88	3.34	5.84			0.11	98.63
1579	28.4a	74.08	12.92	0.09	1.24	0.07	0.64	3.55	5.11			0.02	97.72
1579	28.4b	73.98	13.05	0.09	1.20	0.09	0.59	3.38	5.30			0.02	97.70
1579	28.4c	73.87	13.01	0.09	1.57	0.06	0.54	3.34	5.26			0.00	97.74
1579	28.4d	74.35	13.29	0.09	1.28	0.09	0.58	3.36	5.34			0.07	98.44
1579	28.4	73.76	13.19	0.09	1.26	0.09	0.57	3.37	5.30			0.04	97.66
1580	28.5a	72.44	13.93	0.26	1.47	0.25	0.82	3.22	5.92			0.11	98.42
1580	28.5b	72.56	13.93	0.24	1.56	0.21	0.80	3.24	5.88			0.07	98.50
1581	28.6a	72.34	14.01	0.28	1.68	0.25	0.83	3.21	5.71			0.08	98.38
1581	28.6b	72.31	13.85	0.30	1.74	0.27	0.88	3.24	5.63			0.07	98.28
1582	28.7a	73.80	13.70	0.09	1.12	0.07	0.76	3.76	4.97			0.05	98.30
1582	28.7b	74.13	13.39	0.09	1.32	0.08	0.59	3.39	5.12			0.00	98.13
1583	28.8a	74.14	12.91	0.09	1.21	0.08	0.57	3.40	5.17			0.01	97.57
1583	28.8b	74.11	12.99	0.10	1.19	0.07	0.57	3.35	5.27			0.00	97.64
1584	28.9a	74.14	12.91	0.09	1.74	0.06	0.56	3.31	5.23			0.05	98.09
1584	28.9b	74.27	12.94	0.09	1.42	0.07	0.56	3.35	5.29			0.05	98.04
1585	28.10a	74.58	13.52	0.09	1.15	0.07	0.60	3.74	5.08			0.04	98.89
1585	28.10b	73.64	13.54	0.11	1.52	0.17	0.61	3.50	5.10			0.00	98.18
1586	28.11a	74.46	13.34	0.08	1.21	0.06	0.60	3.47	5.11			0.05	98.38
1586	28.11b	74.58	13.12	0.10	1.27	0.08	0.54	3.36	5.14			0.00	98.18
1587	28.12a	74.88	13.08	0.10	1.22	0.06	0.55	3.42	5.12			0.00	98.44
1587	28.12b	74.51	13.52	0.09	1.26	0.08	0.58	3.40	5.13			0.00	98.58
1588	28.13a	74.06	13.17	0.08	1.15	0.07	0.64	3.60	4.99			0.00	97.77
1588	28.13b	74.58	12.96	0.09	1.17	0.07	0.54	3.39	5.22			0.01	98.04
1589	28.14a	74.40	12.76	0.10	1.22	0.04	0.56	3.34	5.17			0.01	97.60
1589	28.14b	74.30	12.94	0.09	1.32	0.07	0.56	3.39	5.29			0.05	98.03

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1590	28.15a	74.65	12.76	0.15	1.07	0.12	0.60	3.36	5.40			0.02	98.12
1590	28.15b	74.60	12.80	0.16	1.14	0.13	0.59	3.40	5.47			0.05	98.34
1591	28.16a	74.47	12.94	0.09	1.22	0.09	0.59	3.40	5.25			0.02	98.07
1591	28.16b	74.53	13.26	0.10	1.31	0.08	0.57	3.42	5.26			0.02	98.57
1592	28.17a	74.16	13.01	0.11	1.44	0.10	0.55	3.36	5.23			0.01	97.98
1592	28.17b	74.27	13.02	0.10	1.22	0.09	0.56	3.37	5.44			0.00	98.08
1593	28.18a	73.97	12.97	0.10	1.25	0.08	0.58	3.35	5.21			0.01	97.52
1593	28.18b	74.07	13.13	0.10	1.30	0.08	0.55	3.29	5.21			0.02	97.77
1594	29.1a	74.56	13.69	0.10	1.29	0.07	0.59	3.63	5.17			0.03	99.14
1594	29.1b	74.58	13.72	0.10	1.13	0.06	0.68	3.73	4.86			0.01	98.87
1595	29.2a	74.57	13.49	0.09	1.24	0.07	0.58	3.48	5.05			0.05	98.62
1595	29.2b	75.42	13.37	0.10	1.21	0.06	0.57	3.48	5.25			0.01	99.48
1596	29.3a	75.14	13.71	0.08	1.24	0.08	0.65	3.57	5.16			0.00	99.62
1596	29.3b	74.81	13.53	0.09	1.08	0.06	0.63	3.49	5.01			0.00	98.70
1597	29.4a	75.04	13.47	0.09	1.38	0.09	0.55	3.47	5.11			0.01	99.21
1597	29.4b	75.38	13.44	0.10	1.14	0.05	0.56	3.56	4.94			0.05	99.23
1598	29.5a	75.06	13.62	0.11	1.08	0.05	0.65	3.68	5.01			0.00	99.27
1598	29.5b	74.09	13.74	0.10	1.39	0.05	0.66	3.83	4.92			0.01	98.79
1599	29.6a	75.56	13.45	0.09	1.28	0.07	0.57	3.47	5.17			0.04	99.70
1599	29.6b	74.44	13.63	0.09	1.89	0.07	0.62	3.63	4.99			0.02	99.39
1600	29.7a	73.22	14.11	0.29	1.48	0.25	0.87	3.35	5.85			0.10	99.52
1600	29.7b	73.20	14.16	0.29	1.49	0.21	0.88	3.36	5.75			0.13	99.47
1601	29.8a	73.69	13.96	0.22	1.53	0.18	0.74	3.18	5.73			0.10	99.35
1601	29.8b	70.92	13.70	0.50	4.64	0.24	0.97	3.31	5.64			0.14	100.06
1601	29.8c	73.59	13.92	0.21	1.20	0.10	0.79	3.33	5.70			0.15	98.99
1602	29.9a	73.49	13.31	0.07	1.22	0.08	0.65	3.59	5.20			0.07	97.68

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1602	29.9b	73.79	13.15	0.10	1.25	0.07	0.61	3.42	5.24			0.04	97.68
1602	44.15a	72.82	15.20	0.08	0.93	0.06	1.31	4.72	4.09			0.01	99.23
1602	44.15b	74.83	13.33	0.09	1.18	0.07	0.57	3.54	5.29			0.02	98.93
1603	29.10a	72.07	15.25	0.24	1.25	0.18	1.47	3.94	4.90			0.08	99.38
1603	29.10b	73.06	13.96	0.26	1.89	0.30	1.08	3.71	4.81			0.04	99.11
1604	29.11a	73.31	14.02	0.25	1.42	0.17	0.77	3.32	5.82			0.17	99.24
1604	29.11b	70.81	13.49	0.29	1.52	0.29	0.75	3.18	5.65			0.17	96.14
1604	29.11c	70.45	16.34	0.18	1.24	0.13	2.11	4.31	4.41			0.15	99.33
1604	29.11d	70.18	15.77	0.31	2.18	0.10	1.50	4.38	5.32			0.15	99.89
1605	29.12a	72.80	14.14	0.28	1.31	0.16	0.88	3.32	5.81			0.11	98.81
1605	29.12b	72.90	14.09	0.29	1.51	0.15	0.86	3.30	5.93			0.10	99.13
1606	29.13a	73.20	13.90	0.23	1.42	0.20	0.78	3.27	5.67			0.11	98.77
1606	29.13b	73.11	13.89	0.25	1.58	0.19	0.84	3.33	5.71			0.13	99.03
1607	29.14a	72.70	14.23	0.28	1.47	0.16	0.88	3.33	5.89			0.14	99.07
1607	29.14b	72.88	14.16	0.28	1.33	0.16	0.99	3.38	5.81			0.10	99.08
1608	29.15a	72.01	13.81	0.28	1.58	0.23	0.83	3.20	5.80			0.09	97.81
1608	29.15b	71.69	13.75	0.26	1.82	0.25	0.83	3.15	5.79			0.09	97.64
1609	29.16a	72.31	13.68	0.28	1.76	0.20	0.84	3.33	5.70			0.13	98.24
1609	29.16b	71.71	13.79	0.36	2.38	0.18	0.85	3.20	5.88			0.15	98.50
1610	29.17a	74.70	12.96	0.08	1.18	0.06	0.50	3.22	5.14			0.03	97.88
1610	29.17b	73.91	13.38	0.09	1.34	0.08	0.53	3.21	5.33			0.03	97.91
1611	29.18a	73.87	13.12	0.10	1.21	0.07	0.57	3.35	5.11			0.00	97.40
1611	29.18b	73.66	13.25	0.10	1.29	0.06	0.57	3.35	5.26			0.00	97.55
1612	30.1a	72.82	13.83	0.27	1.35	0.14	0.83	3.23	5.79			0.10	98.37
1612	30.1b	72.23	13.82	0.28	1.78	0.28	0.86	3.26	5.80			0.09	98.39
1613	30.2a	74.97	13.00	0.13	1.11	0.08	0.55	3.33	5.39			0.03	98.57

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1613	30.2b	74.67	13.12	0.12	1.62	0.12	0.57	3.41	5.31			0.05	98.99
1614	30.3a	72.50	13.88	0.28	1.66	0.20	0.81	3.29	5.83			0.08	98.55
1614	30.3b	72.64	13.92	0.29	1.45	0.17	0.82	3.29	5.94			0.10	98.62
1615	30.4a	73.38	13.89	0.21	1.38	0.16	0.73	3.23	5.85			0.11	98.93
1615	30.4b	72.93	14.17	0.21	1.30	0.14	0.85	3.37	5.82			0.10	98.89
1616	30.5a	73.19	13.82	0.22	1.51	0.17	0.74	3.25	5.79			0.11	98.81
1616	30.5b	72.96	13.82	0.22	1.37	0.16	0.77	3.27	5.89			0.09	98.56
1618	30.7a	72.48	14.36	0.24	1.15	0.16	1.08	3.65	5.41			0.11	98.65
1618	30.7b	72.93	13.93	0.28	1.37	0.21	0.81	3.26	5.91			0.12	98.82
1619	30.8a	72.71	14.12	0.29	1.69	0.25	0.86	3.35	5.74			0.12	99.13
1619	30.8b	72.47	13.97	0.29	1.68	0.31	0.89	3.38	5.78			0.06	98.83
1619	30.8c	72.43	13.99	0.30	1.90	0.32	1.04	3.32	5.75			0.09	99.13
1620	30.9a	72.79	13.78	0.24	1.62	0.19	0.82	3.16	5.81			0.14	98.54
1620	30.9b	72.36	13.50	0.32	1.52	0.19	0.77	3.19	5.88			0.05	97.78
1621	30.10a	73.94	13.29	0.10	1.24	0.08	0.57	3.40	5.16			0.03	97.82
1621	30.10b	74.41	13.28	0.10	1.23	0.08	0.58	3.43	5.19			0.03	98.34
1622	30.11a	74.01	13.23	0.10	1.26	0.09	0.59	3.39	5.32			0.00	97.97
1622	30.11b	74.91	12.94	0.10	1.26	0.07	0.53	3.36	5.32			0.00	98.50
1622	30.11c	74.54	13.42	0.08	1.23	0.08	0.60	3.45	5.34			0.00	98.75
1622	30.11d	73.65	13.30	0.09	1.23	0.08	0.60	3.87	5.35			0.00	98.17
1623	30.12a	74.28	13.33	0.09	1.14	0.09	0.62	3.51	5.22			0.03	98.29
1623	30.12b	74.45	13.13	0.09	1.33	0.08	0.57	3.39	5.21			0.01	98.26
1624	30.13a	73.69	13.76	0.10	1.08	0.07	0.80	3.77	4.91			0.07	98.24
1624	30.13b	73.24	13.75	0.08	1.19	0.08	0.77	3.81	4.93			0.00	97.85
1625	30.14a	74.13	13.24	0.08	1.24	0.10	0.54	3.42	5.25			0.01	98.03
1625	30.14b	74.09	13.26	0.09	1.27	0.08	0.57	3.44	5.22			0.02	98.04

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1626	30.15a	74.51	13.15	0.08	1.17	0.09	0.57	3.39	5.28			0.00	98.24
1626	30.15b	74.45	13.19	0.09	1.24	0.07	0.57	3.38	5.35			0.00	98.35
1627	30.16a	73.83	13.49	0.09	1.16	0.06	0.67	3.72	5.07			0.01	98.11
1627	30.16b	73.99	13.07	0.10	1.19	0.06	0.55	3.35	5.23			0.03	97.58
1628	30.17a	73.62	13.03	0.11	1.16	0.08	0.57	3.01	5.80			0.00	97.38
1628	30.17b	73.77	12.97	0.08	1.23	0.08	0.58	2.42	6.70			0.00	97.84
1629	30.18a	74.12	13.10	0.09	1.26	0.07	0.56	3.36	5.21			0.00	97.76
1629	30.18b	74.35	12.88	0.09	1.20	0.08	0.56	3.40	5.12			0.02	97.71
1630	31.1a	72.00	13.70	0.30	1.45	0.20	0.90	3.29	5.84			0.12	97.80
1630	31.1b	72.43	13.80	0.29	1.46	0.24	0.87	3.28	5.76			0.14	98.27
1631	31.2a	72.68	13.63	0.24	1.41	0.19	0.83	3.23	5.88			0.14	98.23
1631	31.2b	71.85	13.65	0.32	2.00	0.29	0.83	3.23	5.79			0.17	98.13
1632	31.3a	72.16	13.73	0.28	1.41	0.20	0.89	3.26	5.84			0.11	97.87
1632	31.3b	72.32	13.67	0.29	1.50	0.24	0.90	3.24	5.74			0.11	98.03
1633	31.4a	73.42	13.29	0.19	1.34	0.12	0.64	3.16	5.96			0.06	98.20
1633	31.4b	71.65	14.56	0.15	1.10	0.10	1.39	3.77	5.14			0.04	97.90
1634	31.5a	71.05	13.45	0.28	1.72	0.32	0.88	3.12	5.92			0.10	96.83
1634	31.5b	71.63	13.80	0.28	1.50	0.19	0.86	3.26	5.91			0.09	97.53
1635	31.6a	74.61	12.65	0.11	1.19	0.10	0.56	3.21	5.38			0.00	97.82
1635	31.6b	74.55	12.76	0.13	1.67	0.10	0.53	3.37	5.39			0.00	98.48
1636	31.7a	71.77	13.86	0.29	1.55	0.21	1.04	3.40	5.44			0.07	97.62
1636	31.7b	72.11	13.85	0.29	1.55	0.17	0.94	3.37	5.71			0.09	98.09
1637	31.8a	72.47	13.92	0.29	1.38	0.17	0.87	3.32	5.92			0.13	98.48
1637	31.8b	72.61	13.86	0.27	1.11	0.14	0.85	3.34	5.81			0.12	98.12
1638	31.9a	71.72	13.62	0.29	1.68	0.24	0.97	3.73	5.00			0.12	97.37
1638	31.9b	72.50	13.66	0.29	1.61	0.28	1.24	4.01	4.37			0.16	98.13

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1639	31.10a	72.55	13.57	0.24	1.62	0.24	0.88	3.29	5.60			0.13	98.13
1639	31.10b	71.82	13.85	0.29	1.64	0.12	0.84	3.21	6.02			0.10	97.89
1640	31.11a	72.46	13.70	0.26	1.76	0.18	0.86	3.30	5.90			0.12	98.54
1640	31.11b	72.78	13.71	0.27	1.55	0.16	0.83	3.27	5.85			0.10	98.52
1641	31.12a	71.42	14.27	0.20	1.31	0.19	1.21	3.60	5.38			0.04	97.62
1641	31.12b	70.10	13.13	0.66	4.24	0.25	0.90		5.67			0.06	95.00
1642	31.13a	72.65	13.87	0.27	1.26	0.11	0.88	3.29	5.92			0.13	98.38
1642	31.13b	72.52	13.67	0.28	1.21	0.09	0.89	3.29	5.93			0.12	98.00
1643	31.14a	72.55	13.53	0.24	1.31	0.17	0.83	3.11	5.96			0.07	97.76
1643	31.14b	73.04	13.49	0.28	1.48	0.13	1.12	3.68	4.92			0.12	98.26
1644	31.15a	73.78	12.76	0.12	1.60	0.12	0.55	3.40	5.31			0.03	97.68
1644	31.15b	74.58	12.63	0.13	0.93	0.09	0.54	3.27	5.33			0.03	97.53
1645	31.16a	74.11	13.13	0.09	1.23	0.07	0.57	3.31	5.18			0.00	97.68
1645	31.16b	73.82	13.02	0.09	1.20	0.08	0.59	3.39	5.21			0.00	97.39
1646	31.17a	73.61	13.27	0.08	1.12	0.07	0.67	3.58	4.97			0.02	97.39
1646	31.17b	73.86	12.99	0.09	1.20	0.09	0.61	3.43	5.32			0.02	97.61
1647	31.18a	74.17	13.09	0.10	1.17	0.07	0.59	3.44	5.27			0.03	97.93
1647	31.18b	74.17	13.23	0.09	1.23	0.08	0.58	3.37	5.29			0.01	98.05
1648	32.1a	74.03	13.15	0.09	1.26	0.08	0.60	3.48	5.14			0.00	97.84
1648	32.1b	74.43	13.24	0.09	1.27	0.09	0.57	3.47	5.23			0.00	98.39
1649	32.2a	74.03	13.22	0.10	1.18	0.09	0.59	3.37	5.22			0.00	97.80
1649	32.2b	74.01	13.54	0.08	1.12	0.10	0.65	3.61	5.04			0.00	98.16
1650	32.3a	74.51	13.15	0.10	1.18	0.08	0.56	3.40	5.30			0.00	98.28
1650	32.3b	74.43	13.18	0.10	1.21	0.08	0.56	3.40	5.29			0.02	98.28
1651	32.4a	74.69	13.46	0.09	1.19	0.07	0.60	3.53	5.03			0.00	98.66
1651	32.4b	73.80	14.03	0.09	1.04	0.06	0.64	4.06	5.04			0.00	98.75

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1652	32.5a	74.56	13.22	0.11	1.31	0.07	0.59	3.45	5.11			0.01	98.42
1652	32.5b	74.68	13.18	0.09	1.19	0.06	0.60	3.50	5.05			0.01	98.35
1653	32.6a	74.61	13.17	0.09	1.23	0.08	0.57	3.44	5.19			0.01	98.40
1653	32.6b	74.59	13.08	0.08	1.12	0.07	0.55	3.45	5.22			0.00	98.16
1654	32.7a	74.27	13.64	0.09	1.11	0.08	0.71	3.72	4.99			0.04	98.65
1654	32.7b	72.89	14.47	0.09	1.00	0.07	1.22	4.24	4.47			0.01	98.46
1655	32.8a	74.78	13.42	0.09	1.17	0.06	0.67	3.60	5.10			0.02	98.91
1655	32.8b	74.88	13.08	0.10	1.18	0.07	0.55	3.40	5.24			0.00	98.51
1656	32.9a	74.47	13.25	0.09	1.26	0.09	0.59	3.42	5.17			0.00	98.34
1656	32.9b	74.11	13.25	0.11	1.27	0.08	0.58	3.41	5.27			0.05	98.14
1657	32.10a	74.59	13.25	0.09	1.26	0.08	0.59	3.38	5.19			0.00	98.43
1657	32.10b	74.62	13.18	0.09	1.28	0.08	0.57	3.42	5.21			0.00	98.44
1658	32.11a	75.11	12.87	0.14	1.02	0.09	0.58	3.36	5.34			0.06	98.56
1658	32.11b	75.24	12.90	0.13	1.07	0.10	0.57	3.42	5.22			0.05	98.69
1659	32.12a	74.59	13.34	0.08	1.10	0.08	0.60	3.05	5.92			0.08	98.85
1659	32.12b	74.07	13.17	0.09	1.25	0.09	0.58	2.49	6.57			0.07	98.37
1660	32.13a	75.01	13.35	0.11	1.22	0.09	0.57	3.43	5.21			0.00	98.98
1660	32.13b	74.61	13.36	0.10	1.22	0.09	0.59	3.50	5.16			0.00	98.62
1661	32.14a	72.71	13.67	0.28	1.73	0.24	0.86	3.29	5.68			0.16	98.61
1661	32.14b	72.69	13.75	0.29	1.66	0.27	0.89	3.33	5.76			0.11	98.77
1662	32.15a	73.18	13.41	0.24	1.40	0.19	0.79	3.22	5.94			0.05	98.40
1662	32.15b	72.50	13.65	0.30	1.45	0.23	0.85	3.30	5.85			0.09	98.22
1663	32.16a	72.75	13.93	0.28	1.50	0.18	0.90	3.38	5.78			0.12	98.82
1663	32.16b	72.89	13.69	0.28	1.25	0.14	0.91	3.27	5.90			0.11	98.43
1664	32.17a	73.03	13.67	0.28	1.45	0.22	0.88	3.44	5.81			0.06	98.83
1664	32.17b	72.41	13.71	0.28	2.11	0.34	0.91	3.35	5.73			0.11	98.95

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1665	33.1a	72.14	13.73	0.28	1.36	0.14	0.86	3.28	6.08			0.09	97.97
1665	33.1b	72.60	13.62	0.27	1.94	0.28	0.89	3.41	5.65			0.10	98.77
1665	33.1c	71.93	13.46	0.27	1.11	0.08	0.88	3.41	5.88			0.13	97.15
1665	33.1d	72.49	14.00	0.29	1.30	0.14	0.85	3.26	6.07			0.08	98.48
1666	33.2a	72.43	13.63	0.24	1.32	0.18	0.76	3.24	5.90			0.12	97.82
1666	33.2b	72.74	13.55	0.25	1.36	0.16	0.78	3.25	5.92			0.10	98.10
1667	33.3a	72.66	13.75	0.29	1.40	0.18	0.93	3.21	5.83			0.11	98.36
1667	33.3b	72.09	13.76	0.27	1.65	0.23	0.90	3.23	5.85			0.11	98.09
1668	33.4a	70.38	15.25	0.25	1.53	0.24	1.79	4.02	4.89			0.14	98.50
1668	33.4b	72.39	13.71	0.31	1.60	0.14	0.85	3.24	6.07			0.20	98.51
1668	33.4c	72.11	13.59	0.28	2.28	0.57	0.81	3.19	5.73			0.04	98.59
1669	33.5a	71.32	13.88	0.30	1.75	0.26	0.84	3.25	6.11			0.12	97.83
1669	33.5b	73.07	13.49	0.24	1.41	0.19	0.80	3.24	5.95			0.12	98.50
1670	33.6a	72.91	13.64	0.25	1.40	0.18	0.77	3.21	6.12			0.12	98.61
1670	33.6b	72.92	13.63	0.25	1.21	0.14	0.80	3.28	6.15			0.13	98.51
1671	33.7a	72.30	13.77	0.28	1.41	0.12	0.93	3.25	6.16			0.06	98.28
1671	33.7b	72.45	13.60	0.25	1.56	0.29	0.85	3.19	6.08			0.07	98.34
1672	33.8a	71.74	13.68	0.28	1.93	0.33	0.90	3.26	5.91			0.11	98.14
1672	33.8b	72.16	13.88	0.30	1.38	0.12	0.91	3.35	6.02			0.13	98.25
1673	33.9a	73.77	13.30	0.10	1.27	0.09	0.58	3.32	5.36			0.01	97.80
1673	33.9b	74.18	13.12	0.10	1.26	0.08	0.57	3.38	5.42			0.01	98.13
1715	43.13a	73.15	12.50	0.07	1.56	0.03	0.71	4.00	5.02			0.00	97.04
1715	43.13b	73.41	12.61	0.08	1.60	0.03	0.68	4.06	5.13			0.00	97.59
1716	43.14a	74.09	12.62	0.08	1.67	0.03	0.73	4.04	5.19			0.04	98.49
1716	43.14b	74.64	12.66	0.06	1.61	0.02	0.71	4.10	5.09			0.00	98.89
1716	43.14c	74.00	12.63	0.06	1.58	0.02	0.69	4.13	5.12			0.00	98.24

TABLE G1 (continued)

Cat.	Disk	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	P2O5	MnO	BaO	Total
1717	43.15	54.93	9.35	0.06	1.18	0.04	0.64	3.18	3.86			0.00	73.24
1718	43.16a	73.41	12.59	0.10	1.57	0.05	0.73	4.08	5.13			0.02	97.68
1718	43.16b	73.15	12.65	0.08	1.52	0.04	0.71	4.05	5.12			0.02	97.35
1719	43.17a	73.90	12.58	0.07	1.53	0.02	0.70	3.84	5.16			0.00	97.81
1719	43.17b	74.02	12.66	0.09	1.45	0.03	0.66	4.00	5.26			0.04	98.20
1720	43.18a	73.56	12.68	0.09	1.90	0.04	0.93	3.92	5.07			0.00	98.18
1720	43.18b	73.90	12.60	0.08	1.66	0.03	0.68	4.03	5.11			0.02	98.11
1721	44.1a	74.46	12.69	0.08	1.56	0.03	0.70	3.95	5.10			0.00	98.58
1721	44.1b	73.61	12.56	0.07	1.55	0.03	0.68	4.06	5.12			0.00	97.68
1722	44.2a	73.86	12.49	0.07	1.63	0.03	0.68	3.96	5.19			0.00	97.91
1722	44.2b	73.89	12.46	0.08	1.70	0.03	0.68	4.01	5.05			0.00	97.90
1723	44.3a	73.90	12.76	0.06	1.52	0.03	0.69	3.96	5.21			0.00	98.13
1723	44.3b	74.51	12.64	0.07	1.62	0.03	0.71	4.10	5.05			0.00	98.73
1724	44.4a	73.64	12.59	0.07	1.59	0.02	0.69	4.04	5.08			0.00	97.72
1724	44.4b	73.32	12.44	0.06	1.59	0.01	0.68	4.01	5.10			0.00	97.21
1725	44.5a	73.74	12.41	0.08	1.70	0.02	0.67	3.97	5.03			0.02	97.64
1725	44.5b	73.62	12.45	0.08	1.56	0.02	0.69	3.99	5.05			0.00	97.45
1726	44.6a	66.02	11.01	0.60	8.30	0.17	0.58	7.45	4.70			0.03	98.86
1726	44.6b	65.77	10.68	0.62	8.32	0.17	0.55	7.46	4.72			0.03	98.31

TABLE G2

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
178	SB2	SA	75.57	12.86	0.09	1.08	0.11	0.56	3.43	5.13			0.02	98.85
179	SA	SA	75.60	13.03	0.09	1.01	0.13	0.57	3.25	5.17			0.02	98.85
180	SA	SA	75.46	13.00	0.09	1.05	0.12	0.58	3.33	5.19			0.03	98.85
181	SA	SA	75.44	13.01	0.11	1.13	0.12	0.57	3.34	5.12			0.02	98.85
182	SA	SA	75.63	12.96	0.10	1.07	0.13	0.56	3.23	5.12			0.02	98.85
184	SA	SA	75.45	12.93	0.09	1.11	0.11	0.56	3.35	5.22			0.03	98.85
292	SA/SB2	SA	74.85	13.58	0.07	1.19	0.09	0.58	3.35	5.11			0.03	98.85
293	SC	SC	72.82	13.97	0.26	1.55	0.26	0.86	3.19	5.73			0.15	98.85
294	SC	SC	73.27	14.08	0.26	1.10	0.06	0.85	3.19	5.87			0.14	98.85
295	SA	SA	74.88	13.39	0.06	1.17	0.08	0.58	3.37	5.18			0.01	98.85
296	SB2	SB2	75.22	13.15	0.12	1.17	0.12	0.59	3.26	5.28	0.11	0.07	0.02	99.00
297	SB2	SB2	75.21	13.22	0.11	0.92	0.09	0.60	3.36	5.29			0.05	98.85
298	SC	SC	72.96	13.98	0.32	1.25	0.11	0.94	3.20	5.81			0.17	98.85
506	Li	Li	74.60	12.58	0.07	1.79	0.02	0.73	4.00	5.12	0.02	0.06	0.00	99.00
507	Li	Li	74.70	12.65	0.07	1.63	0.03	0.73	4.01	5.08	0.03	0.07	0.01	99.00
508	Li	Li	74.91	12.77	0.07	1.60	0.04	0.71			0.02	0.06	0.02	99.00
509	Li	Li	74.90	12.72	0.08	1.42	0.02	0.69	4.03	5.05	0.01	0.06	0.02	99.00
510	Li	Li	74.72	12.69	0.07	1.63	0.03	0.72	4.03	5.03	0.02	0.05	0.01	99.00
511	Li	Li	74.67	12.76	0.08	1.62	0.01	0.70	4.03	5.06	0.01	0.06	0.01	99.00
513	Pa	Pal	70.92	7.46	0.23	8.49	0.02	0.26	7.07	4.18	0.03	0.31	0.02	99.00
514	Pa	Pal	70.70	7.51	0.23	8.57	0.01	0.27	7.10	4.25	0.02	0.31	0.04	99.00
515	Pa	Pa2	66.38	9.47	0.61	9.47	0.13	0.49	7.65	4.40	0.05	0.35	0.00	99.00
516	Pa	Pal	70.71	7.45	0.21	8.45	0.01	0.26	7.32	4.26	0.02	0.29	0.01	99.00
1052	SA	SA	74.18	13.81	0.09	1.21	0.07	0.69	3.67	5.15	0.09	0.05	0.00	99.00
1053	SB	SC	72.37	14.09	0.30	1.61	0.20	0.92	3.34	6.00	0.14	0.02	0.09	99.00
1054	SC	SC	72.62	14.15	0.29	1.30	0.21	0.91	3.28	6.00	0.14	0.03	0.06	99.00
1055	SC	SC	72.43	14.22	0.27	1.47	0.24	0.92	3.32	5.82	0.12	0.03	0.07	99.00

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1056	SC	SC	72.42	14.08	0.29	1.63	0.24	0.90	3.33	5.89	0.13	0.04	0.05	99.00
1057	SC	SC	72.49	14.09	0.28	1.52	0.20	0.88	3.27	6.03	0.14	0.03	0.08	99.00
1058	SC	SC	72.38	14.13	0.29	1.59	0.23	0.94	3.29	5.90	0.13	0.02	0.10	99.00
1059	SC	SC	72.67	14.06	0.30	1.44	0.17	0.91	3.38	5.81	0.14	0.04	0.09	99.00
1060	SA	SA	74.34	13.51	0.10	1.37	0.10	0.62	3.48	5.35	0.08	0.06	0.00	99.00
1061	SB2	SB2	74.33	13.30	0.15	1.28	0.13	0.63	3.37	5.62	0.09	0.05	0.04	99.00
1062	SC	SC	73.04	13.93	0.23	1.42	0.18	0.77	3.39	5.81	0.12	0.03	0.07	99.00
1063	SC	SC	72.84	14.05	0.24	1.39	0.18	0.87	3.21	5.98	0.13	0.03	0.08	99.00
1064	SA	SA	74.61	13.36	0.10	1.50	0.08	0.56	3.32	5.30	0.09	0.05	0.04	99.00
1065	SC	SC	72.54	14.09	0.30	1.35	0.26	0.91	3.31	5.99	0.13	0.03	0.11	99.00
1066	SB2	SB2	75.08	13.11	0.13	1.08	0.09	0.57	3.28	5.51	0.08	0.05	0.02	99.00
1067	SB2	SB2	74.43	13.20	0.16	1.36	0.15	0.62	3.30	5.65	0.09	0.02	0.04	99.00
1068	SC	SC	72.69	13.98	0.27	1.39	0.18	0.88	3.24	6.07	0.15	0.03	0.11	99.00
1069	SC	SC	73.30	13.85	0.23	1.14	0.14	0.77	3.20	6.01	0.12	0.02	0.10	99.00
1071	SC	SC	73.75	13.69	0.20	1.07	0.06	0.70	3.29	5.88	0.11	0.04	0.11	99.00
1072	SA	SC	72.33	13.88	0.27	1.39	0.13	0.87	3.30	5.96	0.13	0.03	0.13	99.00
1073	SA	SA	74.56	13.47	0.09	1.24	0.09	0.58	3.55	5.22	0.09	0.06	0.04	99.00
1074	SC	SC	72.24	14.06	0.28	1.56	0.27	0.90	3.44	5.91	0.14	0.03	0.14	99.00
1075	SC	SC	72.44	14.09	0.30	1.56	0.18	0.89	3.35	5.92	0.16	0.02	0.10	99.00
1076	SC	SC	72.67	13.91	0.31	1.53	0.29	0.87	3.43	5.99	0.16	0.05	0.13	99.00
1077	SC	SC	72.22	14.11	0.30	1.61	0.28	0.92	3.39	5.90	0.13	0.03	0.12	99.00
1078	SA	SA	74.69	13.41	0.09	1.26	0.09	0.59	3.51	5.29	0.08	0.07	0.02	99.00
1079	SA	SC	72.28	13.96	0.29	1.71	0.27	0.94	3.38	5.85	0.16	0.05	0.12	99.00
1080	SA	SA	74.46	13.51	0.09	1.31	0.08	0.59	3.52	5.28	0.08	0.06	0.02	99.00
1081	SC	SC	72.64	14.05	0.30	1.34	0.20	0.94	3.34	5.89	0.13	0.02	0.14	99.00
1082	SC	SC	72.31	14.10	0.30	1.52	0.18	0.91	3.43	5.96	0.14	0.03	0.12	99.00
1083	SC	SC	72.80	13.80	0.28	1.61	0.23	0.87	3.23	5.95			0.09	98.85

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1084	SC	SC	72.31	14.16	0.28	1.62	0.16	0.88	3.39	6.00	0.13	0.01	0.11	99.00
1085	SA	SA	74.59	13.40	0.09	1.21	0.06	0.60	3.31	5.57	0.08	0.05	0.01	99.00
1086	SA	SA	74.31	13.59	0.09	1.25	0.09	0.60	3.54	5.36	0.08	0.06	0.02	99.00
1087	SC	SC	73.15	13.76	0.25	1.35	0.16	0.79	3.29	5.96	0.14	0.03	0.12	99.00
1088	SC	SC	72.86	13.88	0.30	1.39	0.20	0.89	3.29	5.85	0.14	0.03	0.08	99.00
1089	SC	SC	73.15	13.78	0.26	1.44	0.16	0.74	3.23	6.03	0.12	0.03	0.10	99.00
1090	SA	SA	74.67	13.45	0.10	1.23	0.08	0.62	3.49	5.17	0.08	0.08	0.03	99.00
1091	SC	SC	72.73	13.96	0.29	1.39	0.11	0.79	3.22	6.21	0.13	0.04	0.12	99.00
1092	SC	SC	72.44	13.92	0.29	1.65	0.22	0.88	3.32	5.84	0.14	0.03	0.11	99.00
1093	SB2	SB2	74.87	13.16	0.15	0.98	0.08	0.61	3.42	5.55	0.08	0.04	0.05	99.00
1094	SC	SC	72.57	13.87	0.31	1.58	0.30	0.92	3.31	5.93	0.16	0.04	0.09	99.00
1095	SB2	SB2	75.05	12.94	0.12	1.34	0.13	0.55	3.44	5.29	0.07	0.03	0.03	99.00
1096	SA	SA	74.85	13.30	0.07	1.25	0.08	0.58	3.39	5.35	0.07	0.05	0.01	99.00
1097	SB2	SB2	75.47	12.88	0.13	1.09	0.10	0.57	3.24	5.42	0.07	0.04	0.00	99.00
1098	SB2	SB2	75.30	12.86	0.12	1.16	0.09	0.54	3.27	5.53	0.06	0.04	0.03	99.00
1099	SC	SC	72.96	13.70	0.27	1.67	0.18	0.75	3.15	6.15	0.14	0.04	0.10	99.00
1100	SC	SC	73.25	13.96	0.28	0.61	0.23	0.91	3.30	5.96	0.14	0.04	0.09	99.00
1101	SC	SC	72.64	13.94	0.26	1.76	0.27	0.88	3.31	5.74	0.12	0.01	0.07	99.00
1102	SC	SC	72.56	13.88	0.29	1.73	0.27	0.89	3.33	5.76	0.14	0.02	0.12	99.00
1103	SC	SC	72.63	13.89	0.30	1.66	0.24	0.89	3.28	5.87	0.14	0.03	0.07	99.00
1104	SC	SC	72.68	13.85	0.29	1.56	0.26	0.85	3.21	5.99	0.14	0.04	0.13	99.00
1105	SC	SC	72.90	13.90	0.29	1.34	0.13	0.96	3.44	5.74	0.15	0.04	0.13	99.00
1106	SB	SB2	75.44	12.71	0.11	1.25	0.08	0.54	3.33	5.40	0.09	0.03	0.02	99.00
1107	SB	SB2	74.86	13.19	0.15	1.01	0.09	0.62	3.41	5.56	0.08	0.02	0.01	99.00
1108	SB2/SA	SB2	75.16	12.98	0.14	1.11	0.12	0.58	3.38	5.40	0.09	0.03	0.02	99.00
1109	SB2	SB2	75.50	12.85	0.13	1.04	0.11	0.56	3.38	5.32	0.07	0.03	0.02	99.00
1110	SB2/SA	SB2	75.09	12.73	0.12	1.12	0.09	0.57	3.40	5.28	0.08	0.03	0.01	99.00

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1111	SA/SB2	SB2	75.37	12.88	0.12	1.15	0.09	0.57	3.40	5.27	0.07	0.04	0.04	99.00
1112	SA/SB2	SB2	75.48	12.81	0.12	1.17	0.10	0.56	3.36	5.28	0.08	0.03	0.02	99.00
1113	SB2	SB2	75.33	12.99	0.12	0.99	0.08	0.56	3.35	5.43	0.08	0.03	0.02	99.00
1114	SB2	SB2	75.28	12.95	0.12	1.17	0.11	0.57	3.35	5.30	0.08	0.02	0.05	99.00
1115	SB2	SB2	75.10	12.79	0.13	1.24	0.10	0.57	3.39	5.27	0.07	0.04	0.04	99.00
1116	SB2	SB2	75.48	12.75	0.12	1.16	0.10	0.56	3.34	5.33	0.07	0.03	0.00	99.00
1117	SC	SC	73.64	13.38	0.24	1.27	0.25	0.87	3.39	5.09	0.14	0.03	0.12	99.00
1118	SC	SC	72.54	13.94	0.29	1.55	0.27	0.89	3.34	5.78	0.13	0.02	0.15	99.00
1119	SC	SC	72.83	13.87	0.29	1.41	0.17	0.90	3.36	5.86	0.13	0.03	0.13	99.00
1120	SC	SC	73.52	13.51	0.24	1.44	0.18	0.73	3.20	5.91	0.14	0.03	0.10	99.00
1121	SA	SB2	75.72	12.76	0.11	0.98	0.09	0.55	3.39	5.29	0.06	0.04	0.01	99.00
1122	SC	SC	72.61	13.98	0.28	1.69	0.28	0.86	3.30	5.73	0.14	0.04	0.10	99.00
1123	SB2	SB2	75.13	12.96	0.11	1.18	0.11	0.55	3.44	5.43	0.06	0.02	0.02	99.00
1124	SB2	SB2	74.92	12.87	0.12	1.15	0.08	0.55	3.38	5.41	0.06	0.04	0.04	99.00
1125	SB2	SA	74.62	13.47	0.09	1.18	0.07	0.57	3.54	5.31	0.08	0.05	0.01	99.00
1126	SA	SB2	75.21	13.07	0.10	1.01	0.08	0.57	3.46	5.37	0.07	0.04	0.03	99.00
1127	SA	SA	74.63	13.38	0.10	1.23	0.08	0.60	3.52	5.29	0.09	0.05	0.04	99.00
1128	SA	SA	74.60	13.44	0.10	1.29	0.09	0.59	3.45	5.31	0.08	0.04	0.01	99.00
1129	SC	SC	72.44	13.93	0.29	1.66	0.23	0.89	3.36	5.91	0.13	0.05	0.12	99.00
1130	SC	SC	72.40	13.98	0.29	1.69	0.24	0.88	3.30	5.89	0.15	0.04	0.12	99.00
1131	SC	SC	72.81	13.68	0.30	1.76	0.29	0.87	3.32	5.74	0.13	0.03	0.14	99.00
1132	SC	SC	72.69	14.01	0.30	1.41	0.17	0.90	3.26	6.01	0.13	0.02	0.11	99.00
1133	SC	SC	72.41	14.01	0.30	1.69	0.28	0.90	3.34	5.92	0.14	0.02	0.12	99.00
1134	SA	SA	74.77	13.36	0.09	1.21	0.07	0.57	3.41	5.35	0.08	0.06	0.01	99.00
1135	SA	SA	74.59	13.47	0.10	1.25	0.08	0.62	3.52	5.22	0.09	0.06	0.01	99.00
1136	SC	SC	72.26	13.89	0.29	2.06	0.31	0.89	3.32	5.71	0.13	0.03	0.10	99.00
1137	SC	SC	72.43	13.98	0.29	1.63	0.25	0.89	3.31	5.92	0.14	0.03	0.13	99.00

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1138	SA	SA	74.79	13.33	0.09	1.26	0.08	0.58	3.45	5.27	0.08	0.06	0.02	99.00
1139	SA	SA	74.49	13.41	0.09	1.46	0.08	0.58	3.50	5.23	0.08	0.05	0.02	99.00
1140	SA	SA	74.61	13.46	0.12	1.36	0.09	0.59	3.41	5.22	0.08	0.05	0.02	99.00
1141	SA	SA	74.74	13.42	0.09	1.21	0.07	0.58	3.48	5.25	0.08	0.05	0.02	99.00
1142	SA	SA	74.68	13.41	0.10	1.24	0.09	0.58	3.46	5.27	0.08	0.05	0.05	99.00
1143	SC	SC	72.87	13.92	0.28	1.35	0.16	0.89	3.34	5.90	0.15	0.02	0.12	99.00
1144	SA	SA	74.82	13.34	0.10	1.31	0.08	0.56	3.46	5.18	0.09	0.06	0.00	99.00
1145	SA	SA	74.52	13.52	0.09	1.25	0.09	0.59	3.53	5.25	0.08	0.05	0.01	99.00
1146	SC	SC	72.33	14.07	0.30	1.75	0.26	0.91	3.38	5.76	0.12	0.02	0.10	99.00
1147	SA	SA	74.69	13.50	0.09	1.24	0.08	0.59	3.46	5.23	0.08	0.05	0.00	99.00
1148	SC	SC	72.81	14.00	0.30	1.27	0.19	0.90	3.37	5.85	0.14	0.02	0.12	99.00
1149	SA	SA	74.87	13.28	0.09	1.27	0.08	0.58	3.52	5.17	0.08	0.04	0.03	99.00
1150	SA	SB2	75.37	12.90	0.12	1.18	0.09	0.56	3.34	5.28	0.08	0.04	0.04	99.00
1151	SA	SB2	75.23	12.93	0.13	1.16	0.09	0.54	3.34	5.47	0.06	0.02	0.03	99.00
1152	SC	SC	72.73	14.03	0.30	1.46	0.20	0.89	3.29	5.82	0.13	0.03	0.10	99.00
1153	SB2	SB2	75.52	12.83	0.12	1.13	0.08	0.55	3.36	5.25	0.06	0.03	0.03	99.00
1154	SC	SC	72.42	13.96	0.26	1.64	0.24	0.90	3.22	5.80	0.16	0.04	0.10	99.00
1155	SC	SC	72.74	13.96	0.30	1.46	0.15	0.90	3.29	5.83	0.14	0.03	0.08	99.00
1156	SC	SC	71.92	14.04	0.34	2.01	0.28	0.96	3.34	5.81	0.14	0.04	0.11	99.00
1157	SC	SC	71.98	14.14	0.34	1.93	0.36	1.08	3.59	5.31	0.14	0.04	0.11	99.00
1158	SC	SB2	75.20	12.95	0.11	1.14	0.10	0.56	3.34	5.46	0.06	0.05	0.03	99.00
1160	SA	SB2	75.29	12.93	0.12	1.08	0.08	0.55	3.38	5.43	0.08	0.03	0.02	99.00
1161	SA	SA	74.57	13.36	0.09	1.43	0.07	0.60	3.47	5.25	0.09	0.06	0.00	99.00
1162	SC	SC	72.82	13.75	0.26	1.67	0.25	0.83	3.24	5.90	0.14	0.04	0.10	99.00
1163	SC	SC	72.81	13.82	0.25	1.50	0.18	0.81	3.24	6.02	0.15	0.03	0.06	99.00
1164	SA	SA	74.74	13.36	0.09	1.24	0.05	0.57	3.37	5.42	0.08	0.07	0.00	99.00
1165	SA	SA	74.45	13.41	0.08	1.27	0.06	0.59	3.43	5.26	0.08	0.06	0.02	99.00

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1166	SC	SC	73.22	13.87	0.23	1.29	0.11	0.79	3.23	6.04	0.12	0.03	0.06	99.00
1167	SA	SA	74.62	13.45	0.09	1.23	0.08	0.59	3.36	5.43	0.10	0.06	0.01	99.00
1168	SC	SC	72.21	14.08	0.30	1.68	0.19	0.93	3.35	5.97	0.15	0.02	0.12	99.00
1169	SC	SC	72.23	14.07	0.31	1.63	0.23	0.91	3.29	6.04	0.14	0.03	0.13	99.00
1170	SA	SB2	75.27	12.94	0.11	1.08	0.10	0.55	3.35	5.47	0.07	0.04	0.01	99.00
1171	SA	SA	74.30	13.56	0.10	1.33	0.08	0.59	3.45	5.43	0.08	0.07	0.02	99.00
1172	SB2	SB2	74.62	13.22	0.13	1.25	0.15	0.58	3.42	5.50	0.06	0.04	0.01	99.00
1173	SA/SB2	SB2	74.42	13.29	0.14	1.23	0.14	0.60	3.42	5.67	0.07	0.02	0.01	99.00
1174	SA	SA	74.41	13.62	0.09	1.19	0.07	0.62	3.37	5.41	0.08	0.07	0.04	99.00
1175	SA	SB2	75.06	13.04	0.13	1.12	0.10	0.55	3.39	5.47	0.07	0.03	0.02	99.00
1176	SC	SB1	73.85	13.77	0.17	1.04	0.07	0.72	3.42	5.75	0.11	0.03	0.07	99.00
1177	SA	SB2	75.06	13.00	0.12	1.11	0.11	0.56	3.42	5.43	0.08	0.04	0.00	99.00
1178	SA	SB2	75.11	13.02	0.12	1.07	0.10	0.57	3.43	5.48	0.06	0.04	0.01	99.00
1179	SA	SB2	75.01	13.05	0.12	1.13	0.09	0.57	3.36	5.55	0.08	0.04	0.00	99.00
1180	SA	SB2	74.97	12.96	0.12	1.14	0.13	0.56	3.39	5.43	0.08	0.03	0.04	99.00
1181	SA	SB2	74.96	13.01	0.12	1.17	0.11	0.58	3.45	5.47	0.08	0.03	0.02	99.00
1182	SC	SC	72.71	13.88	0.26	1.55	0.21	0.82	3.29	6.03	0.12	0.03	0.10	99.00
1183	SA	SB2	74.90	13.08	0.13	1.15	0.11	0.56	3.43	5.49	0.08	0.04	0.03	99.00
1184	SC	SC	72.37	13.92	0.29	1.58	0.22	0.94	3.31	5.85	0.17	0.03	0.15	99.00
1185	SB2/SA	SB2	74.35	13.28	0.15	1.32	0.14	0.62	3.41	5.60	0.08	0.05	0.00	99.00
1186	SA	SB2	74.97	13.14	0.12	0.99	0.12	0.57	3.48	5.48	0.08	0.04	0.03	99.00
1187	SC	SC	72.39	14.13	0.30	1.58	0.25	0.90	3.37	6.03	0.13	0.04	0.12	99.00
1188	SC	SC	72.05	14.22	0.30	1.68	0.24	0.91	3.33	5.97	0.14	0.04	0.11	99.00
1189	SC	SC	72.40	14.08	0.28	1.61	0.22	0.92	3.33	5.87	0.14	0.03	0.12	99.00
1190	SA	SB2	75.05	13.01	0.11	1.11	0.11	0.56	3.41	5.50	0.08	0.04	0.01	99.00
1191	SC	SC	71.13	14.23	0.40	2.16	0.42	1.12	3.37	5.75	0.15	0.05	0.10	99.00
1192	SC	SC	72.78	13.89	0.27	1.54	0.21	0.88	3.21	5.93	0.13	0.05	0.11	99.00

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1193	SC	SC	72.34	13.89	0.31	1.81	0.30	0.90	3.33	5.86			0.12	98.85
1194	SA	SC	72.64	13.88	0.30	1.55	0.27	0.90	3.29	5.85	0.16	0.03	0.13	99.00
1195	SA/SB2	SC	72.55	13.91	0.27	1.65	0.26	0.88	3.25	5.92	0.12	0.03	0.15	99.00
1196	SC	SC	71.51	13.78	0.26	1.70	0.25	0.84	0.71	9.69	0.14	0.04	0.11	99.00
1197	SC	SC	72.39	13.98	0.28	1.56	0.22	0.87	3.26	5.71	0.15	0.03	0.12	99.00
1198	SC	SC	72.63	13.93	0.33	1.63	0.23	1.02	3.84	5.12	0.17	0.02	0.09	99.00
1199	SA	SA	74.55	13.46	0.08	1.25	0.07	0.57	3.49	5.33	0.08	0.07	0.02	99.00
1200	SA	SB2	74.68	13.21	0.14	1.18	0.13	0.60	3.43	5.51	0.08	0.02	0.01	99.00
1201	SC	SC	72.51	14.14	0.32	1.41	0.24	0.93	3.43	5.94	0.14	0.02	0.12	99.00
1202	SC	SC	72.41	14.16	0.27	1.58	0.24	0.84	3.42	5.99	0.12	0.02	0.14	99.00
1203	SA	SB2	75.08	12.92	0.13	1.18	0.11	0.57	3.45	5.40			0.01	98.85
1204	SC	SC	71.74	14.35	0.37	1.48	0.24	1.07	3.40	5.85	0.15	0.02	0.11	99.00
1205	SC	SC	72.46	13.91	0.27	1.81	0.25	0.85	3.30	5.90	0.14	0.04	0.09	99.00
1206	SC	SC	72.33	14.12	0.28	1.63	0.25	0.89	3.34	5.87	0.14	0.04	0.10	99.00
1207	SC	SC	72.94	13.81	0.24	1.61	0.16	0.77	3.21	6.00	0.12	0.03	0.10	99.00
1208	SA	SB2	74.95	13.13	0.11	1.13	0.10	0.60	3.45	5.39	0.08	0.03	0.05	99.00
1209	SA	SB2	75.01	13.02	0.13	1.22	0.10	0.57	3.36	5.48	0.07	0.03	0.00	99.00
1210	SA	SB2	75.00	13.04	0.11	1.13	0.11	0.60	3.42	5.45	0.07	0.03	0.03	99.00
1211	SC	SC	72.03	14.18	0.34	1.60	0.25	1.03	3.41	5.87	0.14	0.03	0.12	99.00
1212	SA/SB2	SB2	74.04	12.91	0.14	1.21	0.13	0.59	1.38	8.54	0.07	0.02	0.01	99.00
1213	SC	SC	73.33	13.75	0.23	1.12	0.10	0.77	3.22	6.10	0.13	0.01	0.12	99.00
1214	SA	SB2	74.99	13.07	0.13	1.08	0.09	0.58	3.29	5.64	0.08	0.03	0.03	99.00
1215	SA	SB2	74.77	13.12	0.14	1.15	0.13	0.59	3.40	5.54	0.08	0.04	0.03	99.00
1216	SC	SC	72.84	13.95	0.24	1.46	0.19	0.90	3.30	5.87	0.14	0.05	0.09	99.00
1217	SA	SB2	75.10	13.01	0.11	1.18	0.09	0.55	3.36	5.49	0.06	0.02	0.03	99.00
1218	SA	SB2	75.01	13.02	0.13	1.18	0.10	0.56	3.41	5.45	0.08	0.05	0.01	99.00
1219	SA	SB2	75.12	13.07	0.12	1.08	0.06	0.55	3.35	5.52	0.08	0.03	0.02	99.00

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1220	SA	SB2	75.15	13.07	0.13	1.13	0.11	0.56	3.35	5.39	0.06	0.03	0.02	99.00
1221	SA	SB2	75.01	13.01	0.13	1.17	0.06	0.57	3.40	5.53	0.07	0.04	0.01	99.00
1222	SA	SB2	75.16	13.00	0.12	1.13	0.10	0.56	3.37	5.44	0.08	0.03	0.01	99.00
1223	SA	SB2	75.08	12.97	0.12	1.15	0.09	0.58	3.36	5.52	0.08	0.04	0.02	99.00
1224	SB2	SB2	75.28	12.98	0.12	1.00	0.09	0.58	3.31	5.49	0.08	0.04	0.03	99.00
1225	?	SC	72.56	13.90	0.31	1.72	0.23	0.91	3.24	5.87	0.14	0.03	0.09	99.00
1226	SA	SB2	74.85	13.09	0.15	1.22	0.13	0.59	3.34	5.51	0.07	0.04	0.01	99.00
1227	SA	SB2	75.31	12.92	0.13	1.18	0.10	0.56	3.30	5.36	0.07	0.05	0.01	99.00
1228	SA	SA	74.81	13.35	0.10	1.24	0.07	0.58	3.39	5.32	0.08	0.06	0.01	99.00
1229	SB2	SB2	74.71	13.13	0.16	1.14	0.14	0.60	3.34	5.64	0.08	0.03	0.03	99.00
1230	SA	SB2	75.46	12.80	0.11	1.09	0.07	0.55	3.28	5.52	0.07	0.03	0.02	99.00
1231	SC	SC	72.67	13.97	0.28	1.60	0.15	0.92	3.31	5.92	0.15	0.02	0.11	99.00
1232	SA	SB2	75.28	12.98	0.12	1.11	0.10	0.56	3.35	5.37	0.08	0.03	0.00	99.00
1233	SA	SA	74.61	13.43	0.09	1.31	0.09	0.61	3.40	5.35	0.06	0.04	0.00	99.00
1234	SB2	SB2	75.04	13.06	0.15	1.04	0.12	0.59	3.26	5.65	0.07	0.04	0.01	99.00
1235	SC	SC	72.49	14.00	0.27	1.43	0.18	0.85	3.26	5.82	0.14	0.03	0.08	99.00
1236	SA	SB2	75.35	12.90	0.11	1.16	0.09	0.57	3.32	5.38	0.07	0.03	0.02	99.00
1237	SB/SC	SC	72.61	13.83	0.29	1.69	0.25	0.88	3.26	5.89	0.14	0.03	0.09	99.00
1238	SB/SC	SC	72.23	13.96	0.30	1.67	0.27	0.90	3.24	5.90	0.15	0.03	0.06	99.00
1239	SA	SA	74.85	13.32	0.09	1.24	0.07	0.58	3.37	5.32	0.09	0.06	0.00	99.00
1240	SC	SC	72.48	13.92	0.29	1.53	0.23	0.90	3.34	5.86	0.14	0.02	0.09	99.00
1241	SA	SA	74.67	13.38	0.10	1.34	0.08	0.60	3.37	5.31	0.08	0.05	0.01	99.00
1242	SC	SC	72.91	13.97	0.30	1.16	0.14	0.91	3.20	6.10	0.13	0.02	0.11	99.00
1243	SB	SC	72.54	13.97	0.30	1.61	0.22	0.94	3.05	6.11	0.13	0.02	0.08	99.00
1244	SB	SC	72.61	13.88	0.29	1.53	0.27	0.89	3.31	5.82	0.12	0.04	0.13	99.00
1245	SC	SC	72.83	13.87	0.26	1.54	0.23	0.82	3.18	6.02	0.13	0.03	0.07	99.00
1246	SB	SC	72.42	13.97	0.29	1.58	0.21	0.89	3.28	5.74	0.13	0.06	0.10	99.00

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1281	SA	SA	74.74	13.50	0.09	1.31	0.08	0.59	3.41	5.14	0.02	0.06	0.05	99.00
1282	SA	SA	74.65	13.42	0.06	1.23	0.08	0.58	3.48	5.35			0.00	98.85
1283	SC	SC	72.58	13.96	0.29	1.45	0.16	0.77	3.28	6.25			0.11	98.85
1284	SA	SA	74.68	13.50	0.10	1.26	0.07	0.60	3.42	5.20			0.04	98.85
1285	SC	SC	72.84	13.90	0.28	1.58	0.17	0.78	3.25	5.95	0.14	0.02	0.10	99.00
1286	SC	SC	73.06	13.85	0.25	1.37	0.13	0.81	3.20	6.07			0.10	98.85
1287	SC	SC	72.75	13.93	0.29	1.39	0.20	0.84	3.33	6.02			0.10	98.85
1288	SC	SC	72.78	13.86	0.29	1.49	0.20	0.92	3.32	5.88			0.11	98.85
1289	SC	SC	73.19	13.86	0.26	1.31	0.13	0.80	3.22	5.96			0.11	98.85
1290	?	SC	72.86	13.87	0.26	1.54	0.20	0.81	3.18	6.01	0.13	0.04	0.11	99.00
1291	SC	SC	71.90	14.70	0.22	1.15	0.12	1.41	3.63	5.55			0.15	98.85
1291	SC	SC	72.87	13.93	0.26	1.61	0.23	0.83	3.26	5.92			0.09	98.85
1292	SC	SC	71.92	14.62	0.20	1.12	0.13	1.69	3.68	5.61			0.12	98.85
1293	SB/SC	SB1	73.54	13.57	0.21	1.29	0.14	0.74	3.23	6.10			0.02	98.85
1294	SB2	SA	74.96	13.37	0.09	1.16	0.08	0.57	3.44	5.16	0.09	0.06	0.02	99.00
1295	SA	SA	74.71	13.49	0.10	1.27	0.07	0.58	3.46	5.15			0.02	98.85
1296	SC	SC	72.85	13.71	0.24	1.66	0.14	0.74	3.20	5.85			0.10	98.85
1297	SA	SA	74.45	13.56	0.10	1.33	0.06	0.59	3.63	5.11			0.04	98.85
1298	SC	SC	73.02	13.92	0.27	1.40	0.15	0.82	3.26	5.91			0.12	98.85
1299	SC?	SC	73.01	13.67	0.26	1.46	0.19	0.89	3.18	6.11			0.09	98.85
1300	SC	SC	72.97	14.04	0.24	1.36	0.17	0.83	3.28	5.88			0.08	98.85
1301	SA	SA	74.68	13.29	0.10	1.23	0.09	0.59	3.51	5.35			0.02	98.85
1302	SA	SA	74.63	13.32	0.09	1.27	0.09	0.59	3.49	5.37			0.00	98.85
1303	SA	SB2	74.56	13.10	0.15	1.18	0.13	0.61	3.41	5.66			0.06	98.85
1304	SC	SC	72.36	14.00	0.27	1.70	0.26	0.89	3.40	5.89			0.08	98.85
1305	SC	SC	72.25	13.88	0.29	1.83	0.29	0.90	3.30	6.00			0.11	98.85
1306	SC	SC	72.82	13.98	0.31	1.11	0.11	0.92	3.44	6.04			0.14	98.85

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1307	SB2/SA	SB2	74.59	12.86	0.13	1.01	0.11	0.55	1.98	7.63			0.00	98.85
1308	SA	SA	74.61	13.36	0.09	1.28	0.09	0.60	3.53	5.30			0.01	98.85
1309	SA	SA	74.63	13.42	0.09	1.30	0.08	0.59	3.43	5.31			0.00	98.85
1310	SB2	SB2	75.23	12.86	0.11	1.11	0.10	0.55	3.38	5.50			0.00	98.85
1311	SA	SA	74.36	13.59	0.10	1.19	0.07	0.63	3.62	5.25			0.02	98.85
1312	SB2	SA	74.14	13.62	0.09	1.35	0.07	0.65	3.71	5.21			0.03	98.85
1313	SA?	SB2	74.81	13.07	0.14	1.15	0.12	0.59	3.39	5.55			0.04	98.85
1314	SC	SC	72.61	14.00	0.30	1.31	0.19	0.92	3.39	6.04			0.08	98.85
1315	SA	SA	74.59	13.42	0.08	1.19	0.07	0.62	3.57	5.27			0.06	98.85
1316	SC	SB1	73.44	13.55	0.18	1.60	0.18	0.74	3.43	5.72			0.03	98.85
1317	SA?	SB2	74.64	13.05	0.14	1.22	0.14	0.57	3.46	5.57			0.06	98.85
1318	SA	SA	74.83	13.26	0.09	1.24	0.08	0.56	3.41	5.38			0.00	98.85
1319	SB2	SB2	75.08	12.96	0.13	1.11	0.11	0.57	3.43	5.47			0.00	98.85
1320	SA	SA	74.59	13.36	0.09	1.20	0.08	0.57	3.54	5.39			0.04	98.85
1321	SA/SB2	SB2	75.10	12.91	0.11	1.12	0.11	0.57	3.33	5.60			0.01	98.85
1322	SA	SA	74.90	13.22	0.10	1.26	0.08	0.55	3.34	5.37			0.03	98.85
1323	SA	SA	74.36	13.46	0.09	1.45	0.07	0.63	3.58	5.23			0.00	98.85
1324	SA	SA	74.49	13.49	0.09	1.30	0.08	0.61	3.49	5.28			0.01	98.85
1325	SC?	SC	72.21	13.77	0.29	2.01	0.36	0.91	3.31	5.91			0.10	98.85
1326	SB2	SB2	75.14	12.88	0.11	1.15	0.10	0.59	3.32	5.52			0.03	98.85
1327	SC	SC	72.82	13.84	0.25	1.54	0.22	0.71	3.27	6.06			0.12	98.85
1328	SC	SC	73.01	13.97	0.28	1.15	0.12	0.84	3.27	6.09			0.13	98.85
1329	SA	SA	74.67	13.36	0.09	1.24	0.08	0.59	3.46	5.33			0.03	98.85
1330	SB2?	SB2	75.09	12.91	0.12	1.14	0.11	0.55	3.41	5.49			0.04	98.85
1331	SB2?	SB2	75.01	12.88	0.14	1.12	0.12	0.58	3.39	5.56			0.07	98.85
1332	SB2	SB2	75.17	12.95	0.12	1.10	0.11	0.54	3.42	5.43			0.03	98.85
1333	SB2	SB2	75.15	12.88	0.13	1.13	0.09	0.56	3.41	5.48			0.03	98.85

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1334	SB2?	SB2	75.14	12.94	0.14	1.08	0.11	0.57	3.36	5.50			0.01	98.85
1335	SB2	SB2	74.79	12.71	0.13	1.74	0.09	0.56	3.39	5.43			0.02	98.85
1336	SA	SB2	75.17	12.93	0.12	1.15	0.09	0.56	3.36	5.47			0.00	98.85
1337	SA/SB2	SB2	75.09	12.90	0.12	1.09	0.10	0.56	3.40	5.55			0.05	98.85
1338	SC	SC	72.89	13.72	0.25	1.54	0.20	0.85	3.35	5.98			0.08	98.85
1339	SC	SB2	75.32	12.84	0.11	1.09	0.11	0.55	3.40	5.44			0.00	98.85
1340	SC	SC	73.07	13.18	0.51	2.14	0.13	0.79	3.18	5.82			0.03	98.85
1341	SC	SC	71.75	14.83	0.21	1.21	0.17	1.30	3.77	5.44			0.17	98.85
1342	SC	SC	72.74	13.78	0.30	1.49	0.24	0.86	3.30	6.09			0.05	98.85
1343	SA	SA	74.95	13.17	0.09	1.22	0.07	0.57	3.40	5.33			0.05	98.85
1344	SA	SA	74.70	13.39	0.09	1.27	0.08	0.57	3.36	5.40			0.00	98.85
1345	SC	SC	72.42	14.44	0.21	1.18	0.14	1.16	3.60	5.63			0.08	98.85
1346	SC	SC	72.62	13.83	0.28	1.57	0.15	0.80	3.27	6.16			0.16	98.85
1347	SA	SA	74.13	13.83	0.09	1.08	0.07	0.71	3.98	4.94			0.02	98.85
1348	SC	SC	72.89	13.76	0.27	1.49	0.16	0.81	3.26	6.09			0.13	98.85
1349	SA	SC	72.47	13.88	0.29	1.74	0.28	0.89	3.32	5.91			0.09	98.85
1350	SA	SA	74.70	13.28	0.09	1.33	0.07	0.56	3.44	5.32			0.06	98.85
1351	SA?	SC	72.30	13.82	0.30	1.93	0.24	0.88	3.29	6.01			0.08	98.85
1352	SA	SA	74.69	13.28	0.09	1.31	0.08	0.60	3.50	5.28			0.04	98.85
1353	SC	SC	72.78	13.81	0.31	1.47	0.21	0.87	3.32	5.99			0.09	98.85
1355	SC	SC	72.49	13.70	0.29	1.86	0.35	0.91	3.35	5.79			0.12	98.85
1356	SC	SC	72.78	13.59	0.28	1.72	0.25	0.83	3.32	5.97			0.11	98.85
1357	SC	SC	73.49	13.67	0.26	1.10	0.08	0.83	3.33	5.98			0.13	98.85
1358	SC	SC	72.97	13.80	0.25	1.30	0.13	0.95	3.29	6.03			0.12	98.85
1359	SC	SC	73.13	13.57	0.24	1.54	0.18	0.80	3.22	6.11			0.07	98.85
1360	SC	SC	73.13	13.47	0.32	1.71	0.17	0.74	3.25	5.93			0.14	98.85
1361	SC?	SC	72.39	14.07	0.29	1.67	0.19	0.99	3.44	5.76			0.08	98.85

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1362	SC	SC	72.99	13.68	0.28	1.65	0.17	1.01	3.48	5.51			0.10	98.85
1363	SB2?	SB2	75.62	12.84	0.11	1.07	0.11	0.53	3.11	5.46			0.02	98.85
1364	SB2?	SB2	75.11	12.92	0.12	1.16	0.11	0.54	3.40	5.50			0.01	98.85
1365	SA/SB2	SB2	75.20	12.82	0.14	1.22	0.11	0.56	3.44	5.36			0.02	98.85
1366	SB2?	SB2	74.98	12.84	0.12	1.36	0.11	0.56	3.41	5.44			0.04	98.85
1367	SB2?	SB2	74.74	12.78	0.16	1.57	0.21	0.55	3.34	5.48			0.01	98.85
1368	SB2	SB2	75.29	12.75	0.12	1.25	0.11	0.55	3.36	5.42			0.01	98.85
1369	SA/SB2	SB2	75.31	12.88	0.12	1.10	0.11	0.56	3.38	5.37			0.04	98.85
1370	SB2	SB2	75.14	12.80	0.14	1.19	0.12	0.56	3.36	5.51			0.03	98.85
1371	SA	SB2	74.90	12.86	0.12	1.39	0.09	0.56	3.40	5.49			0.04	98.85
1372	SB2	SB2	75.20	12.83	0.13	1.17	0.12	0.56	3.43	5.44			0.00	98.85
1373	SB2	SB2	74.91	12.97	0.16	1.14	0.14	0.60	3.39	5.54			0.02	98.85
1374	SB2	SB2	75.29	12.84	0.13	1.11	0.11	0.54	3.38	5.45			0.00	98.85
1375	SA	SB2	75.38	12.72	0.11	1.09	0.09	0.56	3.45	5.45			0.01	98.85
1376	SB2?	SB2	75.31	12.77	0.13	1.10	0.09	0.59	3.39	5.45			0.00	98.85
1377	SC	SC	73.38	13.72	0.25	1.20	0.12	0.78	3.24	6.10			0.08	98.85
1378	SC	SC	72.72	13.80	0.29	1.52	0.22	0.91	3.30	5.99			0.11	98.85
1379	SC	SC	73.13	13.82	0.28	1.22	0.18	0.87	3.30	5.97			0.09	98.85
1380	SC	SC	72.73	13.86	0.28	1.63	0.22	0.86	3.28	5.90			0.08	98.85
1381	SC	SC	72.69	13.88	0.27	1.49	0.20	0.88	3.42	5.91			0.12	98.85
1382	SC	SC	72.56	13.86	0.34	1.66	0.24	1.02	3.49	5.58			0.10	98.85
1383	SC	SC	72.75	13.77	0.30	1.48	0.16	0.87	3.34	6.09			0.12	98.85
1384	SC	SC	72.18	14.39	0.28	1.40	0.13	1.15	3.60	5.63			0.09	98.85
1385	SC	SC	72.59	13.72	0.28	1.86	0.22	0.84	3.25	6.01			0.09	98.85
1386	SC	SC	72.31	14.48	0.23	1.26	0.16	1.17	3.61	5.51			0.11	98.85
1387	SC	SC	72.74	13.88	0.29	1.48	0.19	1.07	3.36	5.77			0.08	98.85
1388	SC	SC	72.95	13.74	0.26	1.51	0.23	0.73	3.10	6.25			0.06	98.85

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1389	SB2	SB2	75.53	12.75	0.12	1.09	0.10	0.55	3.28	5.41			0.01	98.85
1390	SB/SC	SB2	75.22	12.86	0.13	1.12	0.11	0.55	3.37	5.49			0.01	98.85
1391	SB2	SB2	75.29	12.85	0.13	1.06	0.11	0.57	3.32	5.52			0.01	98.85
1392	SB/SC	SB2	73.47	12.92	0.20	2.56	0.14	0.59	3.40	5.56			0.02	98.85
1393	SB2	SC	73.05	13.76	0.24	1.42	0.20	0.76	3.65	5.70			0.08	98.85
1394	SC	SC	72.92	13.73	0.27	1.48	0.18	0.83	3.33	5.97			0.16	98.85
1395	SB/SC	SB2	75.23	12.79	0.13	1.08	0.10	0.56	3.38	5.53			0.05	98.85
1396	SB/SC	SB2	74.94	12.60	0.14	1.41	0.11	0.54	2.75	6.38			0.01	98.85
1397	SC	SC	72.13	13.95	0.29	1.93	0.29	1.03	3.44	5.70			0.11	98.85
1398	SC	SC	73.18	13.86	0.26	1.13	0.10	0.80	3.31	6.09			0.14	98.85
1399	SB/SC	SB2	75.27	12.80	0.13	1.15	0.11	0.55	3.42	5.44			0.00	98.85
1400	SA/SB	SB2	75.21	12.96	0.13	1.04	0.12	0.55	3.39	5.45			0.01	98.85
1401	SC	SC	72.28	13.90	0.29	1.81	0.35	0.90	3.44	5.79			0.09	98.85
1402	SC	SC	72.89	13.89	0.28	1.29	0.20	0.87	3.30	6.05			0.10	98.85
1403	SA	SA	74.10	13.78	0.08	1.18	0.07	0.68	3.81	5.13			0.03	98.85
1404	SA	SA	74.69	13.28	0.11	1.33	0.08	0.57	3.43	5.35			0.03	98.85
1405	SC	SC	72.40	13.92	0.35	1.74	0.33	1.03	3.35	5.61			0.13	98.85
1406	SC	SC	73.17	13.31	0.20	1.67	0.17	0.92	3.80	5.54			0.08	98.85
1407	SC	SC	72.93	13.84	0.30	1.31	0.15	0.87	3.31	6.09			0.07	98.85
1408	SC	SC	72.97	13.55	0.22	1.92	0.17	0.67	3.08	6.16			0.10	98.85
1409	SC	SC	72.82	13.94	0.25	1.48	0.17	0.84	3.30	5.92			0.11	98.85
1410	SC	SC	72.56	13.85	0.30	1.60	0.29	0.85	3.34	5.94			0.12	98.85
1411	SA	SA	74.05	13.50	0.10	1.28	0.08	0.64	3.02	6.17			0.00	98.85
1412	SA	SA	74.94	13.37	0.10	1.15	0.07	0.56	3.36	5.30			0.00	98.85
1413	SA	SA	74.77	13.36	0.10	1.13	0.08	0.58	3.50	5.31			0.02	98.85
1414	SA	SA	74.72	13.27	0.10	1.29	0.08	0.55	3.48	5.35			0.02	98.85
1415	SA	SA	75.25	13.11	0.08	1.18	0.05	0.54	3.34	5.30			0.00	98.85

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1416	SA	SA	74.89	13.32	0.10	1.13	0.07	0.59	3.51	5.21			0.04	98.85
1417	SA	SA	74.40	13.52	0.10	1.29	0.09	0.61	3.56	5.26			0.02	98.85
1418	SA	SA	74.47	13.30	0.09	1.46	0.08	0.59	3.53	5.29			0.03	98.85
1419	SA	SA	74.52	13.54	0.10	1.12	0.08	0.62	3.56	5.30			0.02	98.85
1420	SA	SA	74.73	13.35	0.09	1.27	0.08	0.58	3.48	5.27			0.00	98.85
1421	SA	SC	72.64	13.74	0.29	1.69	0.24	0.85	3.29	5.98			0.12	98.85
1422	SA	SA	74.62	13.28	0.09	1.22	0.07	0.55	3.08	5.92			0.02	98.85
1423	SA	SA	74.82	13.33	0.10	1.24	0.06	0.59	3.39	5.30			0.04	98.85
1424	SA	SA	74.82	13.31	0.08	1.25	0.08	0.56	3.47	5.29			0.00	98.85
1425	SA	SA	74.84	13.29	0.10	1.19	0.08	0.58	3.36	5.39			0.02	98.85
1426	SA?	SC	72.46	13.79	0.29	1.73	0.25	0.86	3.33	6.00			0.14	98.85
1427	SA/SB2	SA	74.22	13.64	0.09	1.22	0.09	0.71	3.73	5.16			0.00	98.85
1428	SC	SC	73.22	13.72	0.25	1.47	0.19	0.84	3.36	5.74			0.06	98.85
1429	SC	SC	72.97	13.64	0.27	1.60	0.19	0.81	3.27	6.00			0.11	98.85
1430	SC	SC	72.04	13.88	0.36	1.82	0.44	0.86	3.26	6.12			0.08	98.85
1431	SC	SC	72.96	13.80	0.24	1.24	0.13	1.05	2.89	6.46			0.09	98.85
1432	SC	SC	73.05	13.81	0.27	1.23	0.12	0.84	3.26	6.16			0.10	98.85
1433	SC	SC	71.87	14.38	0.22	1.46	0.21	1.08	3.34	6.12			0.18	98.85
1434	SC	SC	73.17	14.01	0.24	1.02	0.11	0.97	3.45	5.81			0.09	98.85
1435	SC	SC	73.14	13.69	0.24	1.43	0.19	0.83	3.29	5.94			0.11	98.85
1436	SC	SC	73.00	13.83	0.27	1.42	0.17	0.88	3.31	5.88			0.10	98.85
1437	SC	SC	72.69	13.89	0.30	1.56	0.13	0.79	3.22	6.14			0.13	98.85
1438	SC	SC	72.48	14.02	0.31	1.53	0.18	0.90	3.35	5.94			0.14	98.85
1439	SC	SC	71.37	13.81	0.41	2.37	0.64	0.77	3.17	6.20			0.12	98.85
1440	SC	SC	72.49	13.89	0.29	1.65	0.28	0.88	3.34	5.94			0.11	98.85
1441	SC	SC	72.66	13.75	0.27	1.72	0.29	0.81	3.21	6.02			0.13	98.85
1442	SC	SC	72.85	13.72	0.24	1.61	0.21	0.77	2.95	6.40			0.10	98.85

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1443	SC	SC	72.86	13.76	0.27	1.59	0.19	0.83	3.30	5.95			0.11	98.85
1444	SC	SC	72.69	13.94	0.28	1.53	0.14	0.85	3.36	5.95			0.11	98.85
1445	SC	SC	72.68	13.97	0.29	1.42	0.20	0.92	3.35	5.91			0.11	98.85
1446	SC	SC	72.33	13.67	0.25	2.05	0.18	0.83	2.86	6.62			0.05	98.85
1447	SC	SC	72.17	14.02	0.29	1.74	0.20	0.95	2.94	6.43			0.12	98.85
1448	SC	SC	73.18	13.67	0.23	1.43	0.18	0.75	3.28	6.02			0.11	98.85
1449	SC	SC	73.08	13.74	0.25	1.59	0.22	0.83	3.36	5.71			0.07	98.85
1450	SC	SC	72.13	13.95	0.28	2.01	0.38	0.90	3.21	5.91			0.08	98.85
1451	SC	SC	72.49	13.86	0.29	1.69	0.31	0.84	3.30	6.01			0.07	98.85
1452	SA	SA	74.55	13.46	0.10	1.28	0.08	0.59	3.50	5.29			0.00	98.85
1453	SA	SA	74.83	13.39	0.10	1.17	0.07	0.57	3.42	5.30			0.01	98.85
1454	SA	SA	74.89	13.39	0.09	1.15	0.07	0.56	3.40	5.24			0.06	98.85
1455	SA	SC	72.28	13.95	0.29	1.86	0.37	0.91	3.30	5.77			0.13	98.85
1456	SA	SA	74.60	13.48	0.09	1.25	0.08	0.60	3.48	5.27			0.00	98.85
1457	SA/SB2	SA	74.78	13.35	0.09	1.27	0.09	0.57	3.42	5.27			0.03	98.85
1458	SC	SC	72.44	14.04	0.21	1.84	0.12	1.01	3.61	5.53			0.07	98.85
1459	SC	SC	72.97	14.00	0.30	1.76	0.27	0.91	2.60	5.95			0.10	98.85
1460	SC	SC	72.58	13.95	0.27	1.51	0.22	0.85	3.34	5.98			0.14	98.85
1461	SC	SC	73.19	13.62	0.25	1.50	0.17	0.77	3.22	6.00			0.12	98.85
1462	SC	SC	72.70	13.97	0.29	1.37	0.17	1.04	3.69	5.54			0.09	98.85
1463	SC	SC	72.26	14.09	0.25	1.70	0.23	1.05	3.47	5.69			0.11	98.85
1464	SC	SC	72.63	13.84	0.27	1.73	0.23	0.82	3.19	6.03			0.11	98.85
1465	SC	SC	73.65	13.48	0.21	1.36	0.16	0.73	3.25	5.88			0.12	98.85
1466	SC	SC	72.96	13.86	0.28	1.32	0.18	0.85	3.27	6.02			0.11	98.85
1467	SC	SC	72.79	13.90	0.30	1.47	0.22	0.86	3.34	5.88			0.11	98.85
1468	SA	SA	74.64	13.24	0.10	1.48	0.09	0.57	3.40	5.32			0.02	98.85
1470	SB/SC	SC	72.36	13.95	0.32	1.74	0.29	0.97	3.18	5.90			0.16	98.85

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1471	SB/SC	SC	72.57	13.86	0.29	1.72	0.26	0.89	3.32	5.84			0.11	98.85
1472	SA	SA	74.17	13.81	0.09	1.08	0.07	0.77	3.91	4.93			0.03	98.85
1473	SC	SC	73.06	13.79	0.25	1.32	0.18	0.86	3.28	5.85			0.10	98.85
1474	SC	SC	73.03	13.70	0.25	1.49	0.18	0.84	3.27	6.00			0.09	98.85
1475	SC	SC	72.98	13.79	0.26	1.42	0.19	0.87	3.26	5.88			0.10	98.85
1476	SC	SC	72.62	14.03	0.29	1.43	0.29	0.92	2.81	6.39			0.14	98.85
1477	SC	SC	72.77	14.06	0.29	1.53	0.18	0.84	3.28	5.79			0.11	98.85
1478	SC	SC	72.66	14.16	0.28	1.35	0.16	0.89	3.30	5.92			0.15	98.85
1479	SC	SC	72.33	14.04	0.28	1.82	0.26	0.92	3.37	5.71			0.13	98.85
1480	SA/SB2	SA	74.73	13.52	0.12	1.21	0.09	0.58	3.43	5.15			0.04	98.85
1481	SA/SB2	SA	74.74	13.47	0.10	1.32	0.09	0.54	3.40	5.20			0.01	98.85
1482	SA	SA	74.85	13.47	0.09	1.22	0.07	0.58	3.42	5.13			0.01	98.85
1483	SA	SA	74.64	13.43	0.10	1.43	0.09	0.58	3.43	5.17			0.01	98.85
1484	SB2/SA	SA	74.57	13.42	0.10	1.26	0.08	0.56	3.27	5.61			0.01	98.85
1485	SA	SA	74.72	13.40	0.09	1.28	0.07	0.59	3.45	5.23			0.03	98.85
1486	SA	SA	75.04	13.24	0.10	1.21	0.09	0.57	3.30	5.29			0.03	98.85
1487	SA	SA	74.64	13.57	0.09	1.18	0.09	0.59	3.30	5.33			0.03	98.85
1488	SA	SA	74.68	13.35	0.10	1.40	0.09	0.58	3.41	5.24			0.00	98.85
1489	SA	SA	75.06	13.34	0.09	1.17	0.06	0.61	3.28	5.23			0.01	98.85
1490	SB2/SA	SA	74.36	13.33	0.09	1.24	0.09	0.58	2.34	6.80			0.03	98.85
1491	SA	SA	74.86	13.39	0.09	1.28	0.09	0.57	3.39	5.17			0.03	98.85
1492	SC/SB	SC	73.06	14.16	0.28	1.01	0.07	0.88	3.26	5.95			0.16	98.85
1493	SC	SC	72.76	13.85	0.29	1.42	0.18	0.80	3.24	6.07			0.15	98.85
1494	SC	SC	73.05	13.97	0.22	1.27	0.16	0.74	3.25	6.02			0.17	98.85
1495	SC	SC	72.90	14.05	0.23	1.33	0.11	0.97	3.40	5.80			0.05	98.85
1496	SC	SC	72.63	13.86	0.23	1.65	0.18	0.81	3.20	5.75			0.10	98.85
1497	SC	SC	72.61	14.12	0.24	1.43	0.21	0.79	3.23	6.02			0.20	98.85

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1498	SC	SB1	73.61	13.62	0.22	1.54	0.16	0.77	3.23	5.84			0.10	98.85
1499	SC	SB1	73.96	13.65	0.21	1.18	0.10	0.75	3.22	5.72			0.05	98.85
1500	SA	SA	74.02	13.57	0.09	1.44	0.08	0.64	3.55	5.04			0.00	98.85
1501	SB2	SC	72.53	14.01	0.30	1.72	0.29	0.91	3.29	5.71			0.09	98.85
1502	SA	SA	74.67	13.45	0.10	1.36	0.10	0.57	3.40	5.20			0.01	98.85
1503	SC	SC	73.77	13.67	0.21	1.19	0.14	0.72	3.22	5.82			0.12	98.85
1504	SA	SA	74.88	13.43	0.09	1.20	0.08	0.60	3.41	5.16			0.01	98.85
1505	SA	SA	74.79	13.51	0.10	1.19	0.07	0.66	3.59	4.93			0.02	98.85
1506	SA	SA	74.96	13.37	0.10	1.26	0.08	0.60	3.35	5.14			0.00	98.85
1507	SB2/SA	SA	74.63	13.50	0.10	1.27	0.09	0.61	3.40	5.21			0.04	98.85
1508	SA/SB2	SA	74.70	13.45	0.08	1.32	0.09	0.59	3.43	5.13			0.06	98.85
1509	SA/SB2	SA	74.92	13.38	0.09	1.32	0.07	0.56	3.37	5.12			0.00	98.85
1510	SA/SB2	SA	74.50	13.53	0.09	1.16	0.11	0.63	3.62	5.20			0.01	98.85
1511	SA/SB2	SA	74.65	13.47	0.11	1.33	0.09	0.57	3.46	5.19			0.01	98.85
1512	SB	SC	72.49	14.01	0.28	1.75	0.28	0.89	3.32	5.74			0.10	98.85
1513	SC	SC	73.34	13.89	0.22	1.20	0.10	0.81	3.27	5.90			0.13	98.85
1514	SC	SC	72.75	14.00	0.28	1.44	0.19	0.85	3.13	6.07			0.13	98.85
1515	SC	SC	72.71	13.86	0.27	1.51	0.16	0.79	3.31	5.89			0.08	98.85
1516	SC	SC	73.09	13.96	0.22	1.31	0.13	0.93	3.38	5.74			0.09	98.85
1517	SC	SC	72.63	14.09	0.29	1.58	0.23	0.88	3.35	5.72			0.10	98.85
1518	SC	SC	72.99	13.88	0.25	1.51	0.16	0.79	3.19	5.94			0.14	98.85
1519	SC	SC	72.88	14.06	0.27	1.41	0.15	0.83	3.23	5.90			0.11	98.85
1520	SC	SC	72.90	13.98	0.33	1.44	0.17	0.83	3.26	5.81			0.12	98.85
1521	SC	SC	72.97	13.90	0.26	1.41	0.20	0.84	3.28	5.88			0.10	98.85
1522	SC/SB	SC	73.09	13.80	0.24	1.49	0.17	0.79	3.21	5.99			0.06	98.85
1523	SC	SC	72.83	14.33	0.23	1.08	0.07	0.78	3.22	5.95			0.11	98.85
1524	SC	SC	73.17	13.85	0.26	1.37	0.17	0.76	3.26	5.91			0.11	98.85

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1525	SC	SC	73.14	13.85	0.26	1.40	0.17	0.81	3.29	5.82			0.10	98.85
1526	SA/SB2	SA	74.83	13.48	0.09	1.18	0.07	0.63	3.50	5.05			0.00	98.85
1527	SA/SB2	SA	74.66	13.29	0.10	1.31	0.09	0.58	3.44	5.15			0.02	98.85
1528	SA/SB2	SA	74.81	13.49	0.10	1.25	0.07	0.55	3.44	5.10			0.02	98.85
1529	SA/SB2	SA	74.48	13.24	0.09	1.52	0.11	0.60	3.61	5.15			0.05	98.85
1530	SB2	SA	74.57	13.49	0.09	1.25	0.08	0.62	3.58	5.09			0.07	98.85
1531	SC	SC	72.42	14.07	0.27	1.79	0.27	0.89	3.30	5.69			0.13	98.85
1532	SC	SC	72.56	14.11	0.29	1.87	0.30	0.92	3.35	5.58			0.13	98.85
1533	SA	SA	74.88	13.47	0.09	1.19	0.07	0.55	3.47	5.10			0.01	98.85
1534	SA/SB2	SA	74.77	13.40	0.10	1.17	0.08	0.57	3.43	5.33			0.00	98.85
1535	SB2	SC	73.20	13.52	0.27	1.45	0.23	0.77	3.23	6.07			0.10	98.85
1536	SB2	SC	72.51	13.83	0.28	1.59	0.20	0.80	3.25	5.84			0.11	98.85
1537	SB2/SA	SC	73.19	13.82	0.23	1.62	0.22	0.78	3.38	5.57			0.05	98.85
1538	SB2/SB1	SB1	73.68	13.68	0.18	1.33	0.14	0.69	3.26	5.65			0.07	98.85
1539	SB2/SB1	SC	73.12	13.94	0.27	1.27	0.10	0.81	3.27	5.94			0.13	98.85
1540	SB2/SA	SC	73.12	13.90	0.18	1.51	0.10	0.86	3.34	5.74			0.08	98.85
1541	SB2/SA	SC	73.31	14.08	0.20	1.15	0.09	0.85	3.33	5.72			0.09	98.85
1542	SB1/SB2	SC	72.60	14.03	0.30	1.49	0.20	0.90	3.34	5.85			0.14	98.85
1544	SC	SC	72.98	13.92	0.27	1.45	0.19	0.85	3.29	5.79			0.11	98.85
1545	SC	SC	73.23	13.80	0.25	1.53	0.20	0.76	3.17	5.79			0.10	98.85
1546	SC	SC	73.08	13.78	0.26	1.52	0.17	0.75	3.16	5.99			0.12	98.85
1547	SC	SC	73.15	13.74	0.25	1.59	0.18	0.78	3.21	5.84			0.10	98.85
1548	SC	SC	73.18	13.89	0.26	1.34	0.13	0.75	3.19	6.00			0.12	98.85
1549	SC/SB2	SC	73.20	13.88	0.22	1.34	0.16	0.85	3.15	5.95			0.11	98.85
1550	SC	SC	73.23	13.80	0.25	1.61	0.21	0.74	3.28	5.63			0.09	98.85
1551	SA	SA	74.71	13.52	0.09	1.18	0.08	0.59	3.45	5.16			0.07	98.85
1552	SB2/SA	SA	74.79	13.38	0.08	1.24	0.08	0.58	3.46	5.24			0.00	98.85

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1553	SA/SB2	SA	74.53	13.69	0.09	1.46	0.08	0.61	3.48	5.18			0.03	98.85
1554	SA	SA	74.81	13.38	0.10	1.32	0.08	0.57	3.41	5.19			0.01	98.85
1555	SC	SC	72.24	14.21	0.29	1.77	0.28	1.01	3.35	5.61			0.09	98.85
1556	SA	SA	74.69	13.48	0.10	1.28	0.10	0.59	3.43	5.18			0.00	98.85
1557	SA/SB2	SA	74.83	13.32	0.10	1.41	0.09	0.56	3.39	5.15			0.01	98.85
1558	SA/SB2	SA	74.56	13.61	0.09	1.17	0.07	0.63	3.61	5.12			0.00	98.85
1559	SA/SB2	SA	74.85	13.32	0.09	1.26	0.07	0.55	3.37	5.36			0.00	98.85
1560	SA	SA	74.96	13.28	0.05	1.25	0.07	0.55	3.64	5.05			0.00	98.85
1561	SC	SC	72.67	13.90	0.23	1.41	0.21	0.82	3.34	6.12			0.16	98.85
1562	SA/SB2	SA	74.57	13.50	0.10	1.27	0.07	0.62	3.52	5.16			0.03	98.85
1563	SC	SC	72.84	14.10	0.30	1.32	0.07	0.87	3.28	5.95			0.10	98.85
1564	SB/SC	SC	72.75	13.79	0.30	1.56	0.19	0.85	3.26	6.01			0.14	98.85
1565	SC/SB2	SC	72.54	13.72	0.29	1.71	0.27	0.86	3.36	6.03			0.09	98.85
1566	SC	SC	72.98	13.64	0.26	1.63	0.19	0.82	3.21	6.06			0.08	98.85
1567	SB2/SC	SC	72.57	13.95	0.30	1.35	0.16	0.78	3.22	6.00			0.07	98.85
1568	SB2/SC	SC	73.13	13.87	0.25	1.40	0.15	0.76	3.24	5.94			0.11	98.85
1569	SB2	SC	72.71	14.03	0.25	1.35	0.16	0.78	3.27	6.03			0.10	98.85
1570	SC	SC	73.04	13.73	0.28	1.20	0.14	0.89	3.33	5.89			0.11	98.85
1571	SC	SC	72.41	13.84	0.27	1.80	0.26	0.96	3.37	5.83			0.11	98.85
1572	SC	SC	73.09	13.79	0.24	1.61	0.17	0.79	3.21	5.83			0.12	98.85
1573	SC	SC	72.82	14.00	0.25	1.49	0.18	0.85	3.17	5.94			0.14	98.85
1574	SC	SC	73.09	13.56	0.26	1.60	0.22	0.77	3.27	5.97			0.12	98.85
1576	SC	SC	72.42	14.03	0.29	1.93	0.30	0.87	3.26	5.64			0.10	98.85
1577	SB2	SA	74.52	13.33	0.09	1.34	0.08	0.58	3.48	5.18			0.01	98.85
1578	SB	SC	73.02	13.68	0.28	1.46	0.21	0.87	3.33	5.88			0.13	98.85
1579	SA/SB2	SA	74.68	13.28	0.09	1.38	0.08	0.57	3.38	5.35			0.04	98.85
1580	SB2	SC	72.79	13.99	0.25	1.52	0.23	0.81	3.24	5.92			0.09	98.85

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1581	SC	SC	72.71	14.00	0.29	1.72	0.26	0.86	3.24	5.70			0.08	98.85
1582	SB2/SA	SA	74.44	13.63	0.09	1.23	0.08	0.68	3.60	5.08			0.03	98.85
1583	SA/SB2	SA	75.07	13.12	0.10	1.22	0.08	0.58	3.42	5.29			0.01	98.85
1584	SB2	SA	74.80	13.03	0.09	1.59	0.07	0.56	3.36	5.30			0.05	98.85
1585	SA/SB2	SA	74.35	13.57	0.10	1.34	0.12	0.61	3.63	5.11			0.02	98.85
1586	SB2	SA	74.95	13.31	0.09	1.25	0.07	0.57	3.43	5.15			0.03	98.85
1587	SA/SB2	SA	74.95	13.35	0.10	1.24	0.07	0.57	3.42	5.14			0.00	98.85
1588	SA/SB2	SA	75.04	13.19	0.09	1.17	0.07	0.60	3.53	5.15			0.01	98.85
1589	SB2	SB2	75.14	12.99	0.10	1.28	0.06	0.57	3.40	5.29			0.03	98.85
1590	SB2	SB2	75.10	12.86	0.16	1.11	0.13	0.60	3.40	5.47			0.04	98.85
1591	SB2/SA	SA	74.90	13.17	0.10	1.27	0.09	0.58	3.43	5.28			0.02	98.85
1592	SB2	SB2	74.84	13.12	0.11	1.34	0.10	0.56	3.39	5.38			0.01	98.85
1593	SA/SB2	SA	74.93	13.21	0.10	1.29	0.08	0.57	3.36	5.27			0.02	98.85
1594	SA/SB2	SA	74.45	13.68	0.10	1.21	0.06	0.63	3.67	5.01			0.02	98.85
1595	SA/SB2	SA	74.84	13.40	0.09	1.22	0.06	0.57	3.47	5.14			0.03	98.85
1596	SA/SB2	SA	74.74	13.58	0.08	1.16	0.07	0.64	3.52	5.07			0.00	98.85
1597	SB2/SA	SA	74.93	13.40	0.09	1.26	0.07	0.55	3.50	5.01			0.03	98.85
1598	SB2	SA	74.44	13.66	0.10	1.23	0.05	0.65	3.75	4.96			0.01	98.85
1599	SA/SB2	SA	74.48	13.45	0.09	1.57	0.07	0.59	3.53	5.04			0.03	98.85
1600	SC/SB2	SC	72.74	14.04	0.29	1.48	0.23	0.87	3.33	5.76			0.11	98.85
1601	SC	SC	73.40	13.90	0.21	1.36	0.14	0.76	3.25	5.65			0.13	98.85
1602	SB2/SA	SA	74.53	13.39	0.09	1.25	0.08	0.64	3.54	5.28			0.06	98.85
1603	SC	SC	72.87	13.92	0.25	1.56	0.24	1.08	3.81	4.84			0.06	98.85
1604	SC/SB2	SC	72.91	13.92	0.26	1.40	0.17	0.77	3.29	5.80			0.16	98.85
1605	SC	SC	72.76	14.10	0.28	1.41	0.15	0.87	3.31	5.86			0.10	98.85
1607	SB2	SC	72.62	14.16	0.28	1.40	0.16	0.93	3.35	5.84			0.12	98.85
1608	SC/SA	SC	72.68	13.94	0.27	1.72	0.24	0.84	3.21	5.86			0.09	98.85

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1609	SC	SC	72.36	13.80	0.32	1.77	0.19	0.85	3.28	5.82			0.14	98.85
1610	SA/SB2	SA	75.03	13.30	0.09	1.27	0.07	0.52	3.25	5.29			0.03	98.85
1611	SB2/SA	SA	74.81	13.37	0.10	1.27	0.07	0.58	3.40	5.26			0.00	98.85
1612	SC	SC	72.87	13.89	0.28	1.57	0.21	0.85	3.26	5.82			0.10	98.85
1613	SB2	SB2	74.87	13.07	0.13	1.37	0.10	0.56	3.37	5.35			0.04	98.85
1614	SC	SC	72.77	13.94	0.29	1.56	0.19	0.82	3.30	5.90			0.09	98.85
1615	SC	SC	73.11	14.02	0.21	1.34	0.15	0.79	3.30	5.83			0.10	98.85
1616	SC	SC	73.20	13.84	0.22	1.44	0.17	0.76	3.27	5.85			0.10	98.85
1618	SC/SB2	SC	72.79	14.16	0.26	1.26	0.19	0.95	3.46	5.67			0.12	98.85
1619	SC	SC	72.40	14.00	0.29	1.75	0.29	0.93	3.34	5.75			0.09	98.85
1620	SA/SB2	SC	73.09	13.74	0.28	1.58	0.19	0.80	3.20	5.89			0.10	98.85
1621	SB2	SA	74.76	13.39	0.10	1.24	0.08	0.58	3.44	5.22			0.03	98.85
1622	SB2/SA	SA	74.39	13.41	0.09	1.24	0.08	0.60	3.67	5.36			0.00	98.85
1623	SB2	SA	74.80	13.31	0.09	1.24	0.09	0.60	3.47	5.25			0.02	98.85
1624	SB2/SA	SA	74.07	13.87	0.09	1.14	0.08	0.79	3.82	4.96			0.04	98.85
1625	SB2/SA	SA	74.73	13.36	0.09	1.27	0.09	0.56	3.46	5.28			0.02	98.85
1626	SB2/SA	SA	74.90	13.24	0.09	1.21	0.08	0.57	3.40	5.34			0.00	98.85
1627	SB2/SA	SA	74.67	13.42	0.10	1.19	0.06	0.62	3.57	5.20			0.02	98.85
1628	SB2	SA	74.63	13.17	0.10	1.21	0.08	0.58	3.06	5.89			0.00	98.85
1629	SB2/SA	SA	75.08	13.14	0.09	1.24	0.08	0.57	3.42	5.22			0.01	98.85
1630	SB2/SC	SC	72.82	13.86	0.30	1.47	0.22	0.89	3.31	5.85			0.13	98.85
1631	SC	SC	72.76	13.73	0.28	1.72	0.24	0.84	3.25	5.87			0.16	98.85
1632	SB2	SC	72.90	13.83	0.29	1.47	0.22	0.90	3.28	5.84			0.11	98.85
1633	SB2	SC	73.13	14.04	0.17	1.23	0.11	0.64	3.18	6.00			0.05	98.85
1634	SB2	SC	72.57	13.86	0.28	1.64	0.26	0.88	3.24	6.02			0.10	98.85
1635	SB2	SB2	75.11	12.80	0.12	1.44	0.10	0.55	3.31	5.42			0.00	98.85
1636	SC	SC	72.67	14.00	0.29	1.57	0.19	1.00	3.42	5.63			0.08	98.85

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1637	SB2	SC	72.95	13.97	0.28	1.25	0.16	0.86	3.35	5.90			0.13	98.85
1638	SA/SB2	SC	72.92	13.79	0.29	1.66	0.26	0.98	3.79	5.08			0.14	98.85
1639	SB2/SC	SC	72.80	13.83	0.27	1.64	0.18	0.87	3.28	5.86			0.12	98.85
1640	SC	SC	72.86	13.75	0.27	1.66	0.17	0.85	3.30	5.89			0.11	98.85
1641	SC	SC	72.32	14.45	0.20	1.33	0.22	1.07	3.65	5.59			0.05	98.85
1642	SC	SC	73.07	13.86	0.28	1.24	0.10	0.89	3.31	5.96			0.13	98.85
1643	SC	SC	73.42	13.63	0.26	1.41	0.15	0.84	3.14	6.03			0.10	98.85
1644	SB2	SB2	75.13	12.86	0.13	1.28	0.11	0.55	3.38	5.39			0.03	98.85
1645	SB2	SA	74.96	13.25	0.09	1.23	0.08	0.59	3.40	5.27			0.00	98.85
1646	SB2/SA	SA	74.76	13.31	0.09	1.18	0.08	0.65	3.55	5.22			0.02	98.85
1647	SB2/SA	SA	74.82	13.28	0.10	1.21	0.08	0.59	3.43	5.33			0.02	98.85
1648	SB2/SA	SA	74.79	13.29	0.09	1.27	0.09	0.59	3.50	5.22			0.00	98.85
1649	SB2/SA	SA	74.68	13.50	0.09	1.16	0.10	0.63	3.52	5.18			0.00	98.85
1650	SB2/SA	SA	74.90	13.24	0.10	1.20	0.08	0.56	3.42	5.33			0.01	98.85
1651	SB2/SA	SA	74.83	13.49	0.09	1.12	0.07	0.62	3.54	5.04			0.00	98.85
1652	SB2/SA	SA	74.97	13.26	0.10	1.26	0.07	0.60	3.49	5.10			0.01	98.85
1653	SB2/SA	SA	75.03	13.20	0.09	1.18	0.08	0.56	3.46	5.24			0.01	98.85
1654	SB2/SA	SA	74.42	13.67	0.09	1.06	0.08	0.71	3.73	5.00			0.03	98.85
1655	SB2/SA	SA	74.94	13.27	0.10	1.18	0.07	0.61	3.50	5.18			0.01	98.85
1656	SB2/SA	SA	74.75	13.33	0.10	1.27	0.09	0.59	3.44	5.25			0.03	98.85
1657	SB2/SA	SA	74.92	13.27	0.09	1.28	0.08	0.58	3.41	5.22			0.00	98.85
1658	SB2	SB2	75.35	12.91	0.14	1.05	0.10	0.58	3.40	5.29			0.06	98.85
1659	SB2	SA	74.51	13.29	0.09	1.18	0.09	0.59	3.05	5.92			0.08	98.85
1660	SB2	SA	74.85	13.36	0.11	1.22	0.09	0.58	3.47	5.19			0.00	98.85
1661	SB2	SC	72.82	13.73	0.29	1.70	0.26	0.88	3.32	5.73			0.14	98.85
1662	SC	SC	73.24	13.60	0.27	1.43	0.21	0.82	3.28	5.93			0.07	98.85
1663	SC	SC	72.99	13.84	0.28	1.38	0.16	0.91	3.33	5.85			0.12	98.85

TABLE G2 (continued)

Cat.	Visual	Analysis	SiO2	Al2O3	TiO2	Fe2O3	MgO	CaO	Na2O	K2O	MnO	P2O5	BaO	Total
1664	SB2/SC	SC	72.69	13.68	0.28	1.78	0.28	0.89	3.39	5.77			0.08	98.85
1665	SC	SC	72.85	13.81	0.28	1.44	0.16	0.88	3.37	5.97			0.10	98.85
1666	SB2/SC	SC	73.24	13.71	0.25	1.35	0.17	0.78	3.27	5.96			0.11	98.85
1667	SC	SC	72.84	13.84	0.28	1.53	0.21	0.92	3.24	5.88			0.11	98.85
1668	SC	SC	72.47	13.69	0.28	1.57	0.19	0.83	3.22	5.92			0.13	98.85
1669	SC	SC	72.70	13.78	0.27	1.59	0.23	0.83	3.27	6.07			0.12	98.85
1670	SC	SC	73.13	13.68	0.25	1.31	0.16	0.79	3.25	6.15			0.13	98.85
1671	SC	SC	72.77	13.76	0.27	1.49	0.21	0.89	3.24	6.15			0.07	98.85
1672	SC	SC	72.43	13.87	0.29	1.67	0.23	0.91	3.33	6.00			0.12	98.85
1673	SB2/SA	SA	74.64	13.33	0.10	1.28	0.09	0.58	3.38	5.44			0.01	98.85
1715	Li	Li	74.44	12.75	0.08	1.60	0.03	0.71	4.09	5.15			0.00	98.85
1716	Li	Li	74.48	12.68	0.07	1.63	0.02	0.71	4.10	5.15			0.01	98.85
1717	Li	Li	74.14	12.62	0.08	1.59	0.05	0.86	4.29	5.21			0.00	98.85
1718	Li	Li	74.28	12.79	0.09	1.57	0.05	0.73	4.12	5.20			0.02	98.85
1719	Li	Li	74.60	12.73	0.08	1.50	0.03	0.69	3.95	5.25			0.02	98.85
1720	Li	Li	74.26	12.73	0.09	1.79	0.04	0.81	4.00	5.13			0.01	98.85
1721	Li	Li	74.58	12.72	0.08	1.57	0.03	0.70	4.03	5.15			0.00	98.85
1722	Li	Li	74.59	12.60	0.08	1.68	0.03	0.69	4.02	5.17			0.00	98.85
1723	Li	Li	74.52	12.75	0.07	1.58	0.03	0.70	4.05	5.15			0.00	98.85
1724	Li	Li	74.52	12.69	0.07	1.61	0.02	0.69	4.08	5.16			0.00	98.85
1725	Li	Li	74.67	12.60	0.08	1.65	0.02	0.69	4.03	5.11			0.01	98.85
1726	Pa	Pa2	66.07	10.87	0.61	8.33	0.17	0.57	7.48	4.72			0.03	98.85

APPENDIX H. WESTERN MEDITERRANEAN SITES WITH OBSIDIAN ANALYSES

This Appendix summarizes the results of provenance analyses of archaeological obsidian from west Mediterranean sites. Analyses in Table H1 were done by elemental analysis, fission-track or ESR; analyses in Table H2 are based on visual assessment. The reference for each analysis is given, as is the archaeological context when known. In many cases, artifacts have no stratigraphic context; in others, the reports do not provide this important information.

Samples from North Africa (Bizerte? and Tebessa?) analyzed at Bradford remain unpublished (cf. Williams-Thorpe 1995), although source attributions are shown in a published map (Crummett & Warren 1985); Sardinian obsidian has been reported from Florence (Booth 1989); and both Lipari and Palmarola obsidian have been identified at Santo Stefano (Ortucchio) and Fornace Cappuccini (Faenza) (Bigazzi et al. 1992a); no details of these analyses have been published. Attributions by Cornaggia Castiglione et al. (1963), although included in recently published obsidian distribution maps (e.g. Crummett & Warren 1985; Bigazzi et al. 1992a) are not given here since they may not be reliable. Finally, the attributions for 5 artifacts analyzed by Acquafredda et al. (1995) are most likely accurate but the EDS analyses do not rule out a Sardinian provenance for those listed as from Lipari. The references given in the tables are as follows:

<u>Table H1</u>

1	Acquafredda et al. 1995
2	Ammerman et al. 1990
3	Ammerman & Polglase 1993; 1995
4	Arias et al. 1984
5	Arias et al. 1986
6	Arias-Radi et al. 1972
7	Bigazzi & Radi 1981
8	Bigazzi et al. 1982
9	Bigazzi et al. 1986
10	Bigazzi et al. 1992a
11	Bigazzi et al. 1992b
12	Cann & Renfrew 1964
13	Crisci et al. 1994
14	Crummett & Warren 1985
15	de Romanis et al. 1995
16	Francaviglia 1984
17	Francaviglia 1988
18	Francaviglia & Piperno 1987
19	Hallam et al. 1976
20	Mackey & Warren 1983
21	Mello 1983
22	Michels et al. 1984
23	Randle et al. 1993
24	Tykot (this work)
25	Warren et al. unpublished
26	Williams Thorpe et al. 1979
27	Williams Thorpe et al. 1984

<u>Table H2</u>

1	Camps 1964
2	Camps 1974
3	Camps 1988
4	Cann & Renfrew 1964
5	Gobert 1962
6	Polglase 1989
7	Polglase 1990
8	Tykot (this work)

<u>Abbreviations</u>

Carp	Carpathian sources
Li	Lipari
Pa	Pantelleria
Pl	Palmarola
SA	Sardinia A
SB	Sardinia B
SC	Sardinia C
MA	Monte Arci

TABLE H1: RESULTS OF PHYSICO-CHEMICAL ANALYSES OF ARCHAEOLOGICAL OBSIDIAN

SITE, PROVINCE	SOURCE GROUP(S)	CONTEXT	ANALYSIS REFERENCE
SARDINIA			
Barbusi (Carbonia), Cagliari	9 SC; 2 SA	Ozieri	22
Buon Camino (Iglesias), Cagliari	5 SA; 7 SC	Bonu Ighinu	22
Conca Illonis (Cabras), Cagliari	1 SA; 1 SB	Ozieri	19
"	3 SC	Ozieri	20
Crabi (Villaperuccio), Cagliari	1 SA	unstratified	12; 19
Cuccuru Craboni (Maracalagonis), Cagliari, Tomb A	5 SA; 8 SC	Bonnanaro	22
Cuccuru Nuraxi (Settimo San Pietro), Cagliari, Tomb A	1 SB; 2 SC	Bonnanaro	22
Nuraghe Antigori (Sarroch), Cagliari	13 SC	Nuragic	22
Nuraghe Ortu Còmidu (Sardara), Cagliari	10 SC; 3 SA	Nuragic	20
"	13 SA; 13 SC; 1 SB?	"	24
Nuraghe Su Para (Masullas), Cagliari	5 SA	Nuragic?	24
Puisteris (Mogoro), Cagliari	1 SA; 1 SC	unstratified	12; 19
"	3 SA	Ozieri	20
"	1 SA; 1 SC2	Nuragic?	16
Roja Cannas (Mogoro), Cagliari	1 SC	unstratified	12; 19
San Benedetto (Iglesias), Cagliari, Tomb A	3 SA; 2 SC	Ozieri	22
Santa Gilla (Capoterra), Cagliari	1 SB2; 2 SC	Ozieri	20
Serra Cannigas (Nuraminis-Villagreca), Cagliari, Tomb B	3 SA; 9 SC	Prenuragic	22
Su Carroppu (Sirri-Carbonia), Cagliari	8 SA; 1 SB; 6 SC	Impressed Ware	22
Tracasi (Tratalias-Carbonia), Cagliari	5 SA; 2 SB; 3 SC	Ozieri	22
Nuraghe Losa (Abbasanta), Nuoro	1 SC	unstratified	16
Ruinacchesos (Sorgono), Nuoro	1 SB2; 2 SC	Ozieri	20
Tortoli (Ogliastra), Nuoro	1 SA; 1 SC	unstratified	19
Cuccuru s'Arriu (Cabras), Oristano	1 SB2; 3 SC	Ozieri	20
" tomb 387	5 SA; 1 SB2	Bonu Ighinu	24

TABLE H1 (continued)

SITE, PROVINCE	SOURCE GROUP(S)	CONTEXT	ANALYSIS REFERENCE
Gribaia (Nurachi), Oristano	2 SA, 1 SC	Ozieri	20
Lake Omodeo, Oristano	1 SC	unstratified	16
Ludosu (Riola Sardo), Oristano	2 SA, 1 SC	Ozieri	20
Monte Arci, Oristano	5 SB	unstratified	19
Nuraghe Domu Beccia (Uras), Oristano	10 SA	Nuragic	22
Perda Lada (San Vero Milis), Oristano	1 SA; 1 SB1; 1 SC	Ozieri	20
Su Pranu (Solanas), Oristano	3 SC	Ozieri	20
Santa Vittoria (Nuraxinieddu), Oristano	1 SB1; 2 SC	Ozieri	20
S'Arriedu (Cabras), Oristano	3 SC	Ozieri	20
Grotta Filiestru (Mara), Sassari	4 SA; 1 SB1; 18 SB2; 4 SC	Impressed Ware	24
Grotta Filiestru (Mara), Sassari	4 SA; 10 SB2; 6 SC	Filiestru	24
Grotta Filiestru (Mara), Sassari	1 SA; 12 SB2; 16 SC	Bonu Ighinu	24
Grotta Filiestru (Mara), Sassari	1 SB2; 9 SC	Ozieri	24
Grotta Filiestru (Mara), Sassari	2 SA; 1 SB2; 1 SC	Ozieri	20
Ile Monica (Santa Teresa di Gallura), Sassari	1 SA; 1 SB; 1 SC	unstratified, Neolithic	19
Loc. Liscia Pilastru (Arzachena), Sassari	2 SA; 8 SC	Ozieri	24
Molia (Illorai), Sassari	5 SA; 15 SC	Ozieri	24
Monte d'Accoddi, Sassari	4 SA; 7 SC	Ozieri	24
Monte d'Accoddi, Sassari	9 SA; 3 SC	Chalcolithic	24
Monte d'Accoddi, Sassari	1 SA	unstratified, Neo. or Chalc.	19
Monte d'Accoddi, Sassari	1 SC	Ozieri/Chalcolithic	19
Monte Maiore (Thiesi), Sassari	1 SA; 15 SB2; 10 SC	Filiestru	24
Monte Maiore (Thiesi), Sassari	2 SA; 4 SB2; 5 SC	Bonu Ighinu	24
Sa Ucca de su Tintirriolu (Mara), Sassari	3 SA; 3 SB2; 11 SC	Ozieri	24

TABLE H1 (continued)

SITE, PROVINCE	SOURCE GROUP(S)	CONTEXT	ANALYSIS REFERENCE
CORSICA			
Basi (Serra di Ferro), Corse-du-Sud	28 SA; 4 SB2; 40 SC	Impressed Ware	24
Basi (Serra di Ferro), Corse-du-Sud	56 SA; 3 SB1; 3 SB2; 63 SC	Basien	24
Basi (Serra di Ferro), Corse-du-Sud	4 SC	Late Neolithic?	19
Basi (Serra di Ferro), Corse-du-Sud	3 SA; 2 SC	?	13
Basi (Serra di Ferro), Corse-du-Sud	2 SA; 6 SC	Basien?	24
Cap Pertusato (Bonifacio), Corse-du-Sud	1 SB	?	13
Curacchiaghju (Levie), Corse-du-Sud	6 SB	Early Neolithic	19
"	2 SB; 1 SC	Late Neolithic	19
Dolmen de Cardiccia (Sartène), Corse-du-Sud	22 SB2; 18 SC	Chalcolithic?	24
Filitosa (Sollacaro), Corse-du-Sud	4 SA; 1 SC	Early Neolithic	24
I Calanchi Taffonu 2 (Sollacaro), Corse-du-Sud	14 SA; 26 SC	Basien	24
I Calanchi Taffonu 6 (Sollacaro), Corse-du-Sud	6 SA; 13 SC	Basien	24
Monte Lazzo (Casaglione-Tiuccia), Corse-du-Sud	1 SA	?	13
Saint Pancrace-Tiggianese (Pila-Canale), Corse-du-Sud	4 SA; 6 SC	Basien/Late Basien	24
Tivolaggio (Sartène), Corse-du-Sud	1 SA	unstratified	19
"	2 SC	Late Neolithic	19
Vascolacciu (Figari), Corse-du-Sud	3 SC	Late Neolithic	19
Campu Ventosu (Bastia), Haute-Corse	1 SA; 3 SC	surface collection	24
Carcu-Modria (Catteri-Balagne), Haute-Corse	1 SA	?	13
Castellari (Rapale), Haute-Corse	7 SC	surface collection	24
Monte Grosso (Biguglia), Haute-Corse	3 SA; 1 SB1; 6 SC	Late Neolithic	24
Monte Grosso (Biguglia), Haute-Corse	3 SA; 7 SC	Neolithic/Chalcolithic	24
Pietracorbara, Haute-Corse	5 SA; 1 SB1; 3 SB2; 1 SC	Early Neolithic	24
"	2 SA; 2 SB2; 3 SC	Middle Neolithic	24
Sarra Cinescu (Castello di Rostino), Haute-Corse	4 SA; 7 SC	surface collection	24

TABLE H1 (continued)

SITE, PROVINCE	SOURCE GROUP(S)	CONTEXT	ANALYSIS REFERENCE
Strette (Barbaghju), Haute-Corse	9 SB2; 1 SC	Early Neolithic	24
Strette (Barbaghju), Haute-Corse	6 SA; 3 SB2; 3 SC	Late Neolithic	24
Strette (Barbaghju), Haute-Corse	1 SA	?	13
FRANCE			
Caucade (Nice), Alpes-Maritimes	1 Li	Early Chasseen	25
"	1 SA	"	13
Giribaldi (Nice), Alpes-Maritimes	11 Li	Proto-Chasseen	13
La Rouret (Carros), Alpes-Maritimes	1 Li	Chasseen	13
Auriac (Carcassonne), Aude	1 SA	Chasseen	13
Sainte-André-de-Roquelongue, Aude	2 SA	surface, Chasseen	13
Station de Chabert (Sainte-Eulalie), Aude	1 Li	?	13
Station des Plos (Ventenac-Cabardès), Aude	1 SA	Chasseen?	13
Beaumajour (Grans), Bouches-du-Rhône	5 SA	Chasseen	27
"	2 SA	"	13
Camplan (Lambesc), Bouches-du-Rhône	1 SA	unstratified, Chasseen?	27; 13
La Citadelle (Vauvenargues), Bouches-du-Rhône	1 SA	Final Neolithic	13
La Galinière (Mimet), Bouches-du-Rhône	1 SA	mixed, Chasseen?	25
La Grande Baume (Gémenos), Bouches-du-Rhône	1 SC	Chasseen	25; 13
Les Ribassières (Vernègues-Cazan), Bouches-du-Rhône	1 SA	Late Chasseen	25; 13
L'Étang de l'Olivier/Miouvin (Istres), Bouches-du-Rhône	1 SA	Late Chasseen	27
Sainte Catherine (Trets), Bouches-du-Rhône	1 SA	Late Chasseen	19
"	18 SA; 2 SB; 1 SC	"	13
Beauvallon (Valence), Drôme	4 ?	Chasseen?	13
Grotte d'Antonnaire (Montmaur-en-Diois), Drôme	2 SA	?	13
La Roberte (Chateauneuf-du-Rhône), Drôme	1 SA	Late Chasseen	13

TABLE H1 (continued)

SITE, PROVINCE	SOURCE GROUP(S)	CONTEXT	ANALYSIS REFERENCE
Les Terres Blanches (Menglon), Drôme	2 SA	Chasseen	19
"	11 SA	"	13
Puech de la Fontaine (Congénies), Gard	2 SA; 1 Li	Chasseen	13
Station de Saint-Loup (Tresques), Gard	1 Li	?	13
Peiro Signado (Portiragnes), Hérault	1 Li	Early Neolithic	13
Grotte de l'Église Supérieure (Baudinard-sur-Verdon), Var	1 Li	Early Chasseen	27
La Cabre/Le Grenouiller (Saint-Raphaël, Agay), Var	36 SA; 1 SC; 4 Li	Chasseen	13
La Maravenna (La Londe-les-Maures), Var	1 SA	Chasseen	13
Les Marres (Ramatuelle), Var	1 SA; 1 SC	Chasseen	19
Les Veyssieres (Saint-Raphaël, Agay), Var	1 SB	unstratified	13
Saint-Pierre (Tourtour), Var	1 SA	Late Chasseen	19; 13
Salinettes (Saint-Tropez), Var	2 SA	Chasseen	19
San Sebastien (Plan-de-la-Tour et Sainte-Maxime), Var	2 Pa	Final Neolithic	27; 13
Stations de Villecroze (Font Marthe), Var	1 SA; 1 Li	Chasseen	19
Tusèle (Cabasse), Var	1 SA	Late Chasseen	13
Vigne de Montrouge (Saint-Raphaël, Agay), Var	1 SA	unstratified	13
La Bertaude (Orange), Vaucluse	1 Li	unstratified, Chasseen?	19
Le Crestair (Mornas), Vaucluse	1 ?	?	13
Oppidum des Roches (Piolenc), Vaucluse	2 SA	Chasseen	13
Station des Combes (Piolenc), Vaucluse	10 SA	unstratified	13
ITALY			
Monte Covolo (Villanuova sul Clisi), Brescia	1 SA	unstratified, late VBQ/Lagozza?	19
Riparo Valtenesi (Manerba), Brescia	1 SA; 3 SC	Chalcolithic (Remedello?)	23
Rocca di Manerba, Brescia	1 SA	unstratified, Lagozza?	19

TABLE H1 (continued)

SITE, PROVINCE	SOURCE GROUP(S)	CONTEXT	ANALYSIS REFERENCE
Capraia Island, Livorno	1 PI/Melos?	surface, Neolithic/Chalcolithic?	7
"	3 MA; 1 Melos?	"	8; 4
"	1 MA, 2 Li	"	9
Isola d'Elba, Livorno	1 SA; 1 SC	Neolithic?	19
La Scola (Isola Pianosa), Livorno	3 SA; 5 SB2; 6 SC	Impressed Ware	24
Podere Uliveto, Livorno	2 MA	surface, Neolithic/Chalcolithic?	7
"	2 MA; 1 PI	"	8; 4; 5
Cava Nuova (Fiorano), Modena	3 Li	VBQ?	26
Chiozza (Scandiano), Modena	2 Li	VBQ	26
Spilamberto, Modena	1 Li	Late Neolithic (Lagozza?)	23
"	2 Li	Chalcolithic (Remedello?)	23
Villa Agazzotti (Formigine), Modena	1 SB; 1 Li	Neolithic?	26
Gaione, Parma	3 SC; 2 PI; 12 Li	VBQ	2
Grotta del Leone (La Croce di Agnano), Pisa	3 MA; 1 Li; 3 Melos	unstratified	7
"	2 MA; 1 Li; 3 Melos	"	9
Fornace Cappuccini (Faenza), Ravenna	? Li; ? PI	Impressed Ware, E. Neo.	10
Pescale (Prignano), Reggio Emilia	1 SA	unstratified, Lagozza?	19
"	5 SA	unstratified, Lagozza?	26
Razza di Campegine (Fondo Paglia), Reggio Emilia	3 Li	Middle VBQ	26
San Polo d'Enza, Reggio Emilia	1 SA; 1 SC	VBQ?	19
"	8 SA; 1 Li	"	26
Arene Candide (Finale Liguria), Savona	2 SA; 11 SB; 2 SC; 11 PI; 1 Li	Early Neolithic	3
"	1 SB; 1 SC	Early Neolithic	26
"	1 SB; 1 PI	Early-Middle Neolithic	3
"	1 SB	Lower-Middle Neolithic	19
"	3 SB; 1 SC; 5 PI; 4 Li	Middle Neolithic	3

TABLE H1 (continued)

SITE, PROVINCE	SOURCE GROUP(S)	CONTEXT	ANALYSIS REFERENCE
Arene Candide (Finale Liguria), Savona	2 PI	Middle Neolithic	26
"	1 SC; 1 PI; 2 Li	Middle-Late Neolithic	3
"	1 SA; Li	Late Neolithic	3
"	1 Li	Late Neolithic	26
Grotta Pollera, Savona	1 SC; 1 Li	Early Neolithic	26
"	1 SC	Middle Neolithic	26
Grotta Lonza (Monrupino), Trieste	1 Li	?	26
Grotta dell'Ansa (San Pelagio), Trieste	1 Li	Chalcolithic?	26
Grotta degli Zingari (Sgonico), Trieste	1 Li	?	26
Grotta della Tartaruga, Trieste	1 Li; 1 Carp	Neolithic	26
"	1 PI; 1 Li	?	8; 4; 5
"	2 Li	?	11
Riparo di Monrupino, Trieste	2 Li	Middle Neolithic	26
San Quirino, Trieste	1 Li	Neolithic?	26
Vlašca Jama, Trieste	1 PI	mixed M. Neo. to Chalcolithic	19
"	2 Li	"	26
Sammardenchia di Pozzuolo, Udine	2 Li; 1 Carp	Early Neolithic (Fiorano?)	23
Isolino di Varese, Varese	1 SA	Neolithic?	19
"	4 MA	?	8; 4
"	12 SA; 1 Li	Neolithic?	26
Bellori (Grezzana), Verona	?	surface	26
Grotta G. Perrin (Sengia Bassa di San Cassiano), Vicenza	1 SA	Lagozza or Chalcolithic	19
Fossacesia, Chieti	4 Li	Ripoli	6
Misano Adriatico, Forlì	1 ?	Middle Neolithic	26
Argentano, Grosseto	1 Li	Middle Neolithic	19
Grotta del Fontino (Vallerotana) , Grosseto	1 MA	Chalcolithic/Beaker	7

TABLE H1 (continued)

SITE, PROVINCE	SOURCE GROUP(S)	CONTEXT	ANALYSIS REFERENCE
Paterno (Avezzano), L'Aquila	2 Li	Late Ripoli	7
Ponte Peschio (Genzano), L'Aquila	1 Li; 1 Melos?	?	8; 4
Santo Stefano (Ortucchio), L'Aquila	? Li; ? PI	Impressed Ware	10
Batteria, Monte Circeo, Latina	1 PI	Neolithic	19
Campo Mezzomonte, Latina	1 PI	unstratified	19
Catignano, Pescara	2 Li	Scaloria, earlier Neolithic	6
"	2 Li	"	7
Villa Badessa (Rosciano), Pescara	2 Li	earlier Neolithic	7
"	2 PI?	earlier Neolithic	8; 4; 5
"	3 Li; 1 Pa	earlier Neolithic	11
Valle Ottara (Cittaducale), Rieti	1 Li	Early-Middle Neolithic	19
Palidoro, Rome	1 PI	Early Neolithic	19
Setteville (Tivoli), Rome	2 PI; 2 Li	?	8; 4
"	3 PI	?	9
Via Pontina (Rome), Rome	1 PI	?	16
Cava Barbieri (Pienza), Siena	2 Li	?	5
Grotta del Beato Benincasa (Pienza), Siena	3 MA	unstratified, Neolithic?	7
"	1 MA	"	9
Pienza, Siena	1 PI; 1 Li	Neolithic?	19
Grotta dell'Orso (Sarteano), Siena	1 Li	Middle Neolithic	19
Ripoli (Corropoli), Teramo	1 Li	Ripoli?	19
"	1 Li	"	7
Grotta Bella (Montecastrilli), Terni	2 Li	Early Neolithic	19
Ischia di Castro, Viterbo	1 MA	?	8; 4
Bari, Bari	1 Li	unstratified	19
Pulo di Altamura, Bari	2 Li	?	1

TABLE H1 (continued)

SITE, PROVINCE	SOURCE GROUP(S)	CONTEXT	ANALYSIS REFERENCE
S. Candida, Bari	1 Li	?	1
Fontanelle (Ostuni), Brindisi	2 Li	Impressed Ware	5
"	2 Li	Impressed Ware	11
Grotta Morelli (Ostuni), Brindisi	3 Li	Early Neolithic	8; 4; 5
"	2 Li	"	5
Masseria Guidone (Torre S. Sussanna), Brindisi	2 Li	surface, Impressed Ware	7
Torre Bianca (Fasano), Brindisi	2 Li	Early Neolithic	19
Torre Canne (Fasano), Brindisi	1 Li	Early Neolithic	19
Torre Canne (Fasano), Brindisi	1 Li	?	5
Torre Testa, Brindisi	3 Li	?	8; 4
Acconia, Catanzaro	46 Li	Stentinello	14
Bevilacqua (Acconia), Catanzaro	6 Li	Stentinello	2
Grotta del Romito (Papasidero), Cosenza	1 Li	Middle Neolithic	21
Grotta Sant'Angelo (Cassano Ionio), Cosenza	1 PI	Early-Middle Neolithic	19
"	1 Li	"	21
Casone (San Severo), Foggia	2 PI	unstratified	19
Grotta Scaloria (Manfredonia), Foggia	1 Li; 1?	Middle Neolithic	21
La Panettaria (Lucera), Foggia	1 Li	Trench III	19
Lucera Castle, Foggia	2 Li; 1 PI	unstratified	19
Monte Aquilone (Manfredonia), Foggia	3 Li	Early Neolithic	6
Passo di Corvo, Foggia	10 Li; 2 PI/MA/Melos	Middle Neolithic	21
"	1 Li; 1 PI	?	1
Campi Latini (Galatone), Lecce	2 Li	Impressed Ware	8; 4; 5
Campi Latini (Galatone), Lecce	2 Li	"	11
Grotta della Trinità (Ruffano), Lecce	2 Li	mixed, Neolithic	7
Masseria S. Gaetano (Guagnano), Lecce	1 Li	surface, later Neolithic?	7

TABLE H1 (continued)

SITE, PROVINCE	SOURCE GROUP(S)	CONTEXT	ANALYSIS REFERENCE
Santa Maria in Selva (Treia), Macerata	1 Li	Middle-Late Neolithic	19
Fonte di Vita, Matera	2 Li	?	8; 4
"	1 Li	?	11
Gravina di Picciano, Matera	2 Li	?	4
Grotta Funeraria, Matera	1 Li	?	8
"	3 Li	?	4
Grotta dei Pipistrelli, Matera	1 Li	Neolithic	19
"	1 Li	?	8; 4
Murgecchia, Matera	3 Li	?	4
Murgia Timone, Matera	2 Li	Middle Neolithic	19
"	4 Li	?	4
Pizzica Pantanello (Metaponto), Matera	1 Li	?	8
Serra d'Alto, Matera	2 Li	Early Neolithic	19
"	1 Li	?	8
"	4 Li	?	4
Isola di Capri, Naples	3 PI	Neolithic	19
Grotta delle Felci (Capri), Naples	1 PI	Middle-Late Neolithic	19
Pompeii, Naples	3?	Roman	15
Isola di Ponza, Naples	2 PI	unstratified	12; 19
Laghi Alimini, Otranto	2 Li	?	8; 4
Grotta Grande di Latronico, Potenza	2 Li	Diana?	7
Masseria Leonessa (Melfi), Potenza	2 Li	Ripoli/Scaloria	7
Prestarona (Canolo), Reggio Calabria	3 Li	surface, Stentinello	7
Torre Sabea, Taranto	1 Li	Impressed Ware	5
"	1 Li	"	11
Cala Pisana (Isola di Lampedusa), Agrigento	8 Pa	Middle Neolithic	6

TABLE H1 (continued)

SITE, PROVINCE	SOURCE GROUP(S)	CONTEXT	ANALYSIS REFERENCE
Castellaro Vecchio (Lipari), Messina	2 Li	Impressed Ware	12; 19
"	7 Li	"	19
Isola Filicudi, Messina	2 Li	?	6
"	2 Li	Bronze Age	8; 4
"	1 Li	?	9
Isola Lipari, Messina	6 Li	Late Neolithic	24
Lipari Castello, Messina	1 Li	Capo Graziano	12; 19
"	1 Li	"	6
"	1 Li	"	9
Isola di Ustica, Palermo	2 Li	unstratified	19
"	11 Li; 1 Pa2	"	24
Arenella, Siracusa	1 Li	Early-Middle Neolithic	19
Santa Panegia, Siracusa	1 Li	Early-Middle Neolithic	19
Grotta dell'Uzzo, Trapani	93 Li; 55 Pa1; 4 Pa2	Early Neolithic	18
Monte Cofano, Trapani	3 Li; 2 Pa1	surface	18
Mursia (Pantelleria), Trapani	4 Pa	Bronze Age	6
"	2 Pa	Bronze Age	19
"	2 Pa	Bronze Age	8; 4
"	3 Pa	Bronze Age	9
"	66 Pa1; 11 Pa2	surface, Bronze Age	17
"	3 Pa1; 1 Pa2; 1 Pa	Bronze Age	24
Isola di Pantelleria, Trapani	1 Pa	unstratified	12
"	6 Pa	"	19
Rialbo	2 Li	?	5

TABLE H1 (continued)

SITE, PROVINCE	SOURCE GROUP(S)	CONTEXT	ANALYSIS REFERENCE
MALTA			
Skorba	2 Li; 2 Pa	Ghar Dalam	12
"	2 Li; 2 Pa	Grey Skorba	12
"	1 Li	Grey Skorba	19
"	2 Li	Red Skorba	19
"	2 Li	Zebbug	12
"	1 Li	Zebbug	19
"	1 Li	Ggantija	19
"	1 Li	Hal Saflieni	19
"	2 Li	Tarxien	12
"	5 Li; 1 Pa	unstratified	19
unknown	1 Li	unstratified	12
TUNISIA			
Environs de Bizerte?	1? Pa	?	14; 25
Tebessa?	1? Li	?	14; 25

TABLE H2: RESULTS OF VISUAL ANALYSES OF ARCHAEOLOGICAL OBSIDIAN

SITE, PROVINCE	SOURCE GROUP(S)	CONTEXT	ANALYSIS REFERENCE
SARDINIA			
Corte Auda (Senorbi), Cagliari	9 SC	Late/Final Neolithic	8
Grotta S. Elia, Cagliari	7 SA; 14 SC	Neolithic?	8
Grotta San Bartolomeo, Cagliari (level A)	22 SA; 1 SC	Late Neolithic	8
Grotta San Bartolomeo, Cagliari (level I)	9 SA; 10 SC	Late Neolithic	8
Grotta San Bartolomeo, Cagliari (level II)	8 SA; 12 SC	Late Neolithic	8
Grotta San Bartolomeo, Cagliari (level III)	5 SA; 11 SC	Chalcolithic	8
Grotta San Bartolomeo, Cagliari (levels IV/V)	16 SA; 6 SB2; 54 SC	Chalcolithic	8
Loc. S. Pietro (Settimo San Pietro), Cagliari	19 SA; 2 SB2; 17 SA/SB2; 60 SC	Late Neolithic	8
Monte Narcao (Villaperuccio), Cagliari	1 SC	Late Neolithic?	8
Nuraghe Su Para (Masullas), Cagliari	8 SA; 1 SC	Bronze Age	8
San Gemiliano (Sestu), Cagliari	38 SA; 7 SB2; 133 SC	Late Neolithic/Chalcolithic	8
Santa Gilla (Capoterra), Cagliari	3 SA; 1 SA/SB2; 11 SC	Late Neolithic	8
Su Carroppu (Sirri-Carbonia), Cagliari	32 SA; 12 SB2; 24 SC	Early-Middle Neolithic	8
Su Coddu (Selargius), Cagliari	6 SA; 4 SC	Late Neolithic	8
Su Coddu (Selargius), Cagliari	3 SA; 1 SA/SB2; 6 SC	Late Neolithic/Chalcolithic	8
Terramaini (Pirri), Cagliari	2 SA; 8 SC	Late Neolithic/Chalcolithic	8
Villa S. Antonio (Carabassa), Cagliari	1 SC	Late Neolithic? (menhir)	8
Grotta Lioru (Laconi), Nuoro	2 SA		8
Ruinacchesos (Sorgono), Nuoro	3 SC	Late Neolithic	8
Tomba di Masone Perdu (Laconi), Nuoro	2 SC		8
Cantoniera Frumini (Sili), Oristano	4 SA; 6 SC		8
Cuccuru s'Arriu (Cabras), Oristano	60 SA; 13 SB2; 61 SC	Bonu Ighinu	8
Domus de Janas Triarzu (Paulilatino), Oristano	2 SA; 8 SC		8
Lacumarense (Santa Giusta), Oristano	4 SA; 5 SC		8

TABLE H2 (continued)

SITE, PROVINCE	SOURCE GROUP(S)	CONTEXT	ANALYSIS REFERENCE
Loc. Pirrotta (Simala), Oristano	1 SA; 8 SC	?	8
Mes'e Arrius (Cabras), Oristano	20 SA; 39 SC		8
Nuraghe Loddu (Fordongianus), Oristano	9 SC	Bronze Age	8
Nuraghe Losa (Abbasanta), Oristano	3 SC	Bronze Age?	8
Nuraghe Nieddu, Oristano	4 SA; 6 SC	Bronze Age	8
Nuraghe Tiria (Villaurbana), Oristano	5 SA; 2 SB2; 3 SC	Bronze Age	8
Palas de Casteddu (Cabras), Oristano	5 SA; 1 SA/SB2; 4 SC		8
Palmas Arborea, Oristano	3 SA; 1 SC		8
Puisteris (Mogoro), Oristano	2 SA; 1 SB/SC; 7 SC	Middle/Late Neolithic	8
Serra de Castius (Sili), Oristano	4 SA; 1 SB2; 5 SC		8
Simaxis, Oristano	4 SA; 6 SC		8
Su Casteddu Becciu (Fordongianus), Oristano	2 SA; 1 SB2; 5 SC		8
Li Muri tomb 3 (Arzachena), Sassari	19 SA; 5 SB2; 17 SC	Late Neolithic	8
Li Muri tomb 4 (Arzachena), Sassari	3 SA; 5 SC	Late Neolithic	8
Li Muri circle tombs (Arzechena), Sassari	10 SA; 9 SB2; 121 SC	Late Neolithic	8
Molia (Illorai), Sassari	18 SA; 45 SC	Ozieri	8
Grotta Filiestru (Mara), Sassari	6 SA; 27 SB2; 12 SC	Cardial	8
"	27 SA; 89 SB2; 39 SC	Filiestru	8
"	87 SA; 5 SA/B2; 95 SB2; 146SC	Bonu Ighinu	8
"	13 SA; 8 SB2; 27 SC	Ozieri	8
Cala Villamarina (Santo Stefano), Sassari	20 SA; 13 SB2; 81 SC	Middle Neolithic	8
ITALY			
Pianaccia di Suvero	4 Li; 4 SA; 1 SB; 1 SC	Early Neolithic	8
Gaione, Parma	51 Li, 42 S, 6 S/PI	VBQ	7
Fornace Cappuccini (Faenza), Ravenna	95 Li; 158 PI/MA; 81?	Early Neolithic-Chalcolithic	6
Poggio Olivastro (Canino), Viterbo	4 Li; 106 SA; 7 SB2; 89 SC	Middle-Late Neolithic	8

TABLE H2 (continued)

SITE, PROVINCE	SOURCE GROUP(S)	CONTEXT	ANALYSIS REFERENCE
MALTA			
Skorba	96 Li; 21 Pa	Ghar Dalam	4
"	29 Li; 11 Pa	Grey Skorba	4
"	63 Li; 1 Pa	Red Skorba	4
"	23 Li; 3 Pa	Zebbug	4
"	2 Li	Mgarr	4
"	33 Li; 4 Pa	Ggantija	4
"	3 Li; 1 Pa	Saflieni	4
"	8 Li	Tarxien	4
TUNISIA			
La Galite	1? Pa	?	3
Remel (Bizerte)	1 Li	Neolithic?	1
Environs de Bizerte	1 Li	Neolithic?	1
Djebel ed Dib (Béchateur)	32? Pa	Neolithic?	1
Abri du Scorpion (Ile de Zembra)	19 Pa	Late Neolithic	8
La Maison du Poète (Ile de Zembra)	10 Pa	Late Neolithic?	8
"Eric" survey transect (Ile de Zembra)	4 Pa	Late Neolithic?	8
Korba	1 Pa	Neolithic?	5
Sebkhet Halk el Mennzel (Hergla)	1 Pa	Neolithic?	2
ALGERIA			
La Marsa (Skikda)	1 Li	Neolithic?	1
Aïn Khiar (Annaba)	1 Li	Neolithic?	1
Tebessa	1 Pa?	Neolithic?	1