Lithic landscapes and taskscapes: obsidian procurement, production and use in west central Sardinia, Italy

Volume 1

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Abstract

This thesis studies lithic landscapes and taskscapes from an explicit perspective of social practice. Inspired by Bourdieu's (1990) concept of practice, Dobres's (2000) redefinition of technology as a verb and arena for human interaction, Anglo-French *chaîne opératoire* studies (Pelegrin 1990; Schlanger 1994; 1996) and Ingold's (1993) concepts of landscape and taskscapes, it explores the spatial and temporal dimensions of the three main interlocking lithic activities: procurement, production and use/discard. Five key concepts are used to explore human choice and interaction in these three fields: practice, knowledge, skill, strategy and tradition. Sardinia and the obsidian artefacts from the *Riu Mannu* Survey Project data have served as a case study.

Most studies about Sardinian obsidian fall in two categories. In west Mediterranean obsidian exchange studies, a colonial perspective and a linear or meta-*chaîne opératoire* viewpoint predominates. Sardinia and its main obsidian source, the Monte Arci, are merely regarded as a raw material provider. Local (Sardinian) modes of procurement and production are rarely taken into account. In contrast, lithic studies in Sardinia predominantly focus on lithic consumption, specifically the retouched artefacts ('tools'). My research approach was developed to bridge these gaps and gain an understanding of the spatial and temporal developments of Sardinian lithic landscape and taskscapes. It has provided much-needed information on procurement and production strategies in Sardinia.

Careful examination of the spatial and temporal interplay between source location, obsidian types, primary and secondary *chaîne opératoires* and aesthetic preferences has demonstrated that lithic practice is an inherently social day-to-day practice. Analysis has revealed a number of long-standing *habitus* in Sardinian lithic practice; procurement, production and use/discard strategies are not easily tied to specific regions or time periods. At the same time, variations also existed, and local choices are clearly visible. Production and use/discard is organised at a house-hold level and occurs primarily, but not exclusively, at permanent settlements. Part of the dataset has also shown that occasional and different activities occurred elsewhere. Moreover, this

study revealed that so-called simple or expedient assemblages, especially single-stage flake, blade and mixed flake/blade reduction and bipolar flake reduction are skilfully knapped.

This thesis offers an approach to the study of lithic landscapes and taskscapes that is useful not only for Sardinian and Mediterranean archaeology but also for those with an interest in social technology, landscape and survey archaeology.

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Introduction

The aim of this research has been refined several times since its inception in 1999, but the basic question has always stayed the same: 'what did prehistoric people do with obsidian in Sardinia?' I first seriously thought about this question at the University of Leiden in 1996, when I received a couple of bags of obsidian from the *Riu Mannu* Survey Project for my honours dissertation. I thought, with the optimism and confidence that seems to characterise undergraduates, that it was a matter of 'simply' mastering two things: learning to recognise lithic artefacts and then fitting them into the existing Sardinian framework. It is fair to say I have since learnt to appreciate the duplicity of the word 'simply', and have also learnt to accept that these 'two things' have morphed into a plethora of related research interests.

Levity and sentimentality aside, this research has changed significantly since I first started in 2001. This introduction outlines how it has changed, and briefly explains the structure of this thesis and the conventions used for terminology, tables, maps and appendices.

Changed theoretical and methodological perspectives

The most significant change has been the shift from a traditional approach to lithic technology to a social one. In the early stages of research design, the theoretical and methodological framework and accompanying variables and attributes reflected a concern with environmental constraints, adaptive human behaviour and socio-economic processes. Although vaguely uncomfortable with this distanced view to human preferences and social conditions, I was unsure how to apply a social approach to my dataset. Social approaches seemed mostly site and excavation-based, focused on monumental types of material culture, and took place in regions with well-defined chronologies. In contrast, my dataset consisted of continuous strips of survey material, and expediently flaked assemblages with mostly informal tool types for which chronological control was tenuous, and for which little comparative material was available.

Key theoretical perspectives

A few key studies in social technology studies, landscape and survey archaeology, however, have offered a way out of this dilemma. Bourdieu's concept of practice (1990), Dobres's *social approach to technology* (2000), Ingold's (1993; 2000) concepts of landscape and taskscapes and the Anglo-French *chaîne opératoire* studies (Pelegrin 1990; Schlanger 1990; 1992; 1994; 1996) have provided theoretical and methodological perspectives to examine the social and material dynamics of lithic technology. Survey archaeology is an excellent means to study the regional and spatial dimension of human activity, but lithics rarely feature in models and interpretations. Some European and British studies, however, have offered alternative approaches to the analysis and presentation of lithic survey data (Edmonds *et al.* 1999; Zvelebil *et al.* 1987; 1992; Zvelebil & Green 1990).

These realisations culminated in the development of a new, broader social approach to technology and landscape would enable me to gain an understanding of the spatial and temporal developments of the Sardinian lithic landscape and taskscapes using the *Riu Mannu* Survey Project data as a case study.

In my approach, technology is a socially embedded practice. It is not merely conditioned by environmental constraints, but people's habitual, daily routines, interactions, and cultural traditions play an important role; it is both an active verb and an arena for social action and interaction. To emphasise this, the lithic landscape and three taskscapes (procurement, production and use/discard) are the basis for analyses and interpretation. Density and chronology are treated as additional variables. Moreover, the *Riu Mannu* Survey Project material is well suited for this approach. The project's field methodology, a continuous point-by-point collection, allows for the combination of detailed technological analysis of individual artefact with a fixed position in the physical landscape.

Methodological changes

This theoretical shift is best illustrated through three methodological changes. Firstly, descriptions moved away from a focus on form to one on process. This meant that static descriptions of end products (form) were replaced by the study of the dynamics of knapping (process). The generic reduction sequence, in which artefacts are attributed to sequential stages that represent the overall transformation of raw material nodules into implements, for example, was complemented with detailed reconstructions of flaking biographies of individual artefacts. Originally, the core recording system was a static typology that emphasised the final artefact form, which is a result of all combined knapping actions. It was substituted by the core biography approach, which reconstructs the actions and decisions taken in the process of core reduction.

Secondly, the changed perspective on technology, from environmentally-constrained adaptive human behaviour to a socially embedded cultural practice, also affected the concept of use. At first, the word 'use' was equated with function and linked to secondary technology or the retouched artefacts (*i.e.* tools). Similarly, again following traditional technology studies, it was believed that social information predominantly resided in these finished artefacts. As a result of their assumed importance, one of the early aims of this study was to set up a tool typology. The realisation that such view is unnecessarily restrictive, however, diminished the 'importance' of retouched artefacts for this study. Instead, research aims shifted towards understanding secondary technology in relation to primary technology. Analysis focused on comparing the scale, location, density, degree of skill in manufacture, and the extent to which primary and secondary distribution patterns correspond and reveal information on procurement, production and use/discard strategies.

Lastly, to examine human choice and preferences specifically, extra variables were added to the recording system. Raw material characteristics (*e.g.* lustre, translucency, colour and patterning) for instance, allowed visual source characterisation and exploration of aesthetic preferences.

Influences of changes on data analyses and display

These changes did not occur rapidly or uniformly, which has to some extent affected data analyses, interpretations and presentation. Firstly, the additional variables, raw material characteristics and cortex location, have not been recorded for *Riu Mannu* transect 14, and therefore only part of the transect's core assemblage has been restudied using the core biography approach. Secondly, after careful consideration, the artefact collection of Cuccuru s' Arriu has not been included in the final data analysis and discussion. I studied part of a 19th century collection from this Neolithic site, that was made available for study by the Museum of Ethnography and Prehistory *Luigi Pigorini* in Rome, prior to the start of my PhD research. It served as a test case for some recording variables and was meant to facilitate integration of old collections and new research (*cf.* Gardiner 1987). Early in my research design, where 'use' equalled retouched artefacts and function, a high importance was placed on a comparison between my tool typology and the LaPlace tool types, common in Italian lithic studies. Disconnecting use, function and retouched pieces from each other diminished the necessity of comparing typological schemes. The shifted theoretical outlook restricted the value of the *Cuccuru* analysis for this research, while financial and logistical constraints prevented restudy of the collection (de Bruijn 2000; 2002). Following this shift, I intended to use the collection to examine whether or not, and how, a shift in this theoretical and methodological framework would have affected interpretations. As a result of time constraints, however, this is now a future project. At the start of research six *Riu Mannu* transects were studied, but after the diminished relevance of the Cuccuru s' Arriu collection, another five transects were added to broaden the chronological and geographical coverage in this thesis.

Thirdly, in the early stages of research the coordinate system used by the *Riu Mannu* Survey Project did not prove a problem for data presentation. A traditional site and chronology-based analysis did not require detailed regional presentation of find distributions, lithic variables or attributes in all transects. Thus, a mathematical conversion rate that calculates the correlation between each *Riu Mannu* coordinate and a real world coordinate, was not needed. As lithic technology became the prime focus, however, lithic data presentation on a regional level increased in importance. Unfortunately, by that time it was too late to convert the *Riu Mannu* coordinate system into real word coordinates. As a result the GIS-programme Arcview and the Access database were not linked to compile regional maps from the geographical data. A compromise has been found, with the maps in the chapters displaying summaries of the relevant information. Individual transect information is presented in maps and tables in appendices displayed. These maps are unfortunately rather abstract, as physical landscape maps based on real world coordinates, could not be linked to the find data, which was only available in *Riu Mannu* coordinates.

Thesis structure

This thesis consists of four parts. The first part, chapters one to three, introduces the wider Sardinian context and outlines the theoretical and methodological framework. The second part, chapters four to six, presents the *Riu Mannu* data analysis, which is structured to reflect the focus on the lithic landscape and taskscapes rather than chronological constructs. The third part discusses and contextualises the main conclusions of this study within wider contexts. Chapter seven focuses on the contributions this study makes to Sardinian and Mediterranean archaeology, while chapter eight places this research in the wider framework of social landscape and technology studies, survey archaeology and lithic studies. It also offers some directions for future research. The appendices are the final part of this thesis.

Chapter one introduces the wider framework of Sardinian archaeology and lithic studies to contextualise my research. Rather than presenting yet another overview of the archaeological periods, sites and finds it concentrates on two topics. To understand the different ways in which Sardinian archaeological discourse have shaped Sardinian obsidian studies, I first analyse a number of key texts on Sardinian archaeology and explore why and how certain theoretical and methodological research themes in Sardinian archaeology have gained predominance, while others have been overlooked. Secondly, it discusses past and present developments in Sardinian obsidian studies. Here too, I eschew presenting an overview of period-specific main tool types, but instead focus on research developments and themes. It is demonstrated that to date, barring some notable and very recent exceptions, there is little done or known on obsidian procurement and production *in Sardinia*. This thesis was set up specifically to begin to address this imbalance.

Chapter two consists of two parts. Firstly, it outlines the development of, and current themes in, the four main theoretical frameworks that have shaped my research: 1) social technology studies, 2) lithic studies, particularly the *chaîne opératoire* concept and procurement, production and use studies, 3) regional landscape and survey archaeology and 4) the role of lithics from survey projects in understanding human behaviour. The second part of the chapter presents and discusses the key concepts used in this thesis.

I follow social approaches to technology and landscape and regard human behaviour not just as being purely conditioned by environmental constraints. People's habitual, daily routines, interactions and cultural traditions also play an important role in choices. I use the *chaîne opératoire* concept as a useful theoretical and methodological tool. Originally a French anthropological construct, it is often used as a sequence model ('operational chain') in English-speaking academic circles. I use it in three ways:

- Following social technology studies, as a conceptual device that connects the maker and the object(s) made, and emphasises human choices and cultural traditions rather than environmental constraints
- Following most traditional and social technology studies as an analytical tool for reconstructing individual flaking biographies rather than generalised reduction sequences
- As a means to explore the Sardinian lithic landscape, where each main 'stage' of *chaîne opératoires* broadly corresponds to one of three interlocking sets of lithic 'taskscapes': procurement, production, and use/discard (*cf.* Ingold 1993). The lithic landscape, however, is *not* a direct result, a simple representation of, or in binary opposition to, lithic taskscapes. Postdepositional processes, a 'work in progress' character and particularly chronology constitute taskscapes and reflect the fundamental temporality of the landscape.

Survey projects such as the *Riu Mannu* Survey Project with their focus on continuous surveying enable exploration of the spatial component of lithic taskscapes, by tying the *chaîne opératoire* to the physical landscape. The chapter also defines the five key concepts, practice, knowledge, skill, strategy and tradition that are used to explore human choice and interaction in lithic technology.

Chapter three consists of three parts. The first part introduces the *Riu Mannu* Survey Project. It discusses the project's field methodology in relation to the four problems common lithic survey studies: finding, dating, defining and interpreting lithic scatters. The second part presents the eleven *Riu Mannu* transects that were studied and discusses how the Sardinian lithic landscape can be studied, outlining the advantages and limitations of this approach. The third part presents the lithic methodology and discusses how the three taskscapes are explored.

Traditional lithic studies usually consider the relationship between procurement, production and use/discard as straightforward and several key concepts have become almost mutually exclusive. Direct (embedded or special purpose trips) and indirect (exchange) procurement strategies for instance have been linked to specific modes of subsistence, mobility, technologies and source use. Likewise, production and use are still often correlated with unretouched and retouched artefacts, in an allegedly straightforward relationship. This connection is not maintained in my thesis and data analysis cuts across artefact classes. Retouched artefacts, for instance, contribute to analyses of primary and secondary knapping. Conversely, unretouched artefacts contribute to analyses of use and discard patterns. Most studies have largely neglected the different strategies employed within larger sequences or have overlooked systemisation and variation in simple technologies and plainly retouched artefacts. In this study, detailed reconstructions of primary and secondary flaking strategies are used to identify flaking traditions and variations. Likewise, a wide variety of variables and attributes that help explore the human dimension of lithic practices.

The next part of the thesis presents the studied *Riu Mannu* dataset. Rather than using the physical landscapes or chronology as chapter divisions, each chapter broadly represents one of three technological phases: raw material, primary technology and secondary technology. This structure is intentional and results from the emphasis on lithic technology as practice.

Chapter four is divided into three parts. The first part briefly summarises the current state of research on the availability and use of raw material obsidian sources in west central Sardinia. Past research has predominantly focused on geological evidence, concentrating on locating and chemically characterising the primary and secondary locations on the Monte Arci, the main source of raw material for obsidian. The chapter also presents new *Riu Mannu* evidence for the existence of secondary raw material sources along the river Mògoro away from the Monte Arci. The second part of this chapter explores whether or not the two types of sources (the Monte Arci and the Mògoro sources) may be distinguished and discusses the current evidence for use of both types of sources and current procurement theories. The last part of this chapter outlines why and how visual characterisation is applied and linked to the three main obsidian types (SA, SB and SC) generally recognised for Sardinian obsidian.

Chapter five presents the main results of primary technology analyses. It first presents where and in what densities artefacts associated with primary flaking (cores, rejuvenation pieces, unretouched flakes and blades, chunks and fragments) are found. Secondly, it details the individual flaking strategies recognised within the dataset and discusses the derived flaking traditions and variations. Thirdly, it presents the data needed for procurement analysis with specific attention to 1) reconstructions of raw material selection criteria (size, shape and condition of parent materials), 2) recognition of raw material source types (primary or secondary source use) and obsidian types, and 3) examination of aesthetic preferences. The last section examines knapping abilities on an assemblage level through the examination of 1) consistency and intensity of knapping, 2) standard deviation and co-efficient of variation for artefact sizes, 3) ratio core stage to previous removals, 4) nodule manipulation and core abandonment 5) technical errors and evidence for corrections and whether or not any evidence for 'novices' exists. Throughout these sections emphasis is placed on examining the relationship between the flaking traditions, raw material sources, obsidian types, knapping abilities and their spatial distribution.

Chapter six closely mirrors chapter five in structure. It presents and discusses the main results of secondary technology analyses. It first presents where and in what densities artefacts associated with secondary flaking (those pieces that show (possible) evidence of retouch) are found. The second part details the secondary flaking strategies recognised and which traditions and variations can be discerned. Specific attention is paid to 1) blank selection and whether or not blanks correspond to primary flaked material or are obtained from elsewhere, 2) location, position and types of modification including examination of whether not intentional modification can be separated from use wear or (unintentional) edge damage, 3) intensity and consistency of retouch and 4) whether or not knapping skills can be recognised. The final section presents the raw material analyses (parent material, sizes, source locations, obsidian types, aesthetic preferences) of modified pieces. Data are compared to primary flaking data to examine whether or not differences in procurement and production strategies exist.

Chapter seven, the third part of this thesis, discusses the traditions and variations of the three lithic taskscapes recognised in the *Riu Mannu* dataset, and how these tie in with current procurement, production and use studies in Sardinian and Mediterranean archaeology. Additionally, I return to three central themes in lithic studies and discuss the contribution of this research to such studies. Specifically, I discuss 1) the organisation of procurement, production and use/discard, 2) the relevance of distinguishing between direct and indirect procurement, and 3) the value of examining knapping abilities in expedient assemblages rather than looking for specialisation or curation. In the second part of the chapter the temporality of the lithic landscape is discussed. The focus is on establishing whether or not developments can securely be dated, what limitations exist, and how the *Riu Mannu* field methodology has shaped interpretation of the lithic landscape and its temporality.

Chapter eight places this research in a wider context and discusses the main contributions it has made to current debates in landscape, survey and technology studies. It also suggests some directions for future research.

Terminology, use of tables, maps and appendices

A brief note on the conventions used in this thesis. Knowledge of the basic lithic terms is expected. The terminology used here follows other lithic studies with exceptions provided in the text and appendices (see Andrefsky 1998; Inizan *et al.* 1999). All the theoretical and methodological concepts that are used are defined in the relevant chapters. Foreign terms are italicised (*chaîne opératoire, nuraghi, domus de janas, bronzetti*), as is Riu Mannu when it refers to the Survey Project (*e.g. Riu Mannu* analysis, *Riu Mannu* data) but not when referring to the river. Many different variations exist for the spelling of Sardinian place names, and they often contain many accented letters. In this thesis, I have generally chosen one spelling, and used accents sparingly. Original spellings are maintained in the bibliography, which thus includes some variation.

Tables are used extensively throughout this thesis and in two different ways. In chapters one to three, they present very detailed types of information (*e.g.* theories, terms, definitions, archaeological periods, sites, examples and bibliographical references), which are further discussed and referred to in the text. Thus, they are integral to the text. In chapters four to six, tables summarise the presented data and often correspond to extensive tables in the appendices. Maps in the text are summaries of detailed find information, where the focus is on spatial distribution. The tables on which these maps are based always include artefact densities and are made available in the appendices. Lastly, please note that the extensive use of bullet points in this thesis is deliberate. This is a 'data' thesis, and I have tried to limit the necessary data presentation/descriptions as much as possible by summarising them in bullet point form.

Appendices are provided in volume 2. Numbering consists of chapter number and order of appearance (*e.g.* Appendix 5.7. for the seventh appendix in chapter five). Transect maps are exported as JPGs from the relevant Arcview projects. The Access database, Excel analysis files and Arcview projects upon which the data chapters and appendices are based are available upon request.

Chapter One

Sardinian archaeological discourse and its impact on lithic studies

Analysis of archaeological discourse can help understand why and how certain theoretical and methodological themes have gained predominance, while others have been overlooked (Dobres 2000: 69; van Dommelen 1998: 52). This chapter examines the different ways in which Sardinian archaeological discourse has shaped Sardinian lithic studies. To do so, I analyse key texts on Sardinian archaeology, focussing primarily on prehistory, and discuss how the underlying themes in Sardinian archaeological thought have shaped Sardinian lithic studies. It should be noted that this chapter does not give an overview of the relevant archaeological periods, cultures, sites and chronology; these already exist elsewhere in English and Italian (Appendix 1.1; and Contu 1997a; 1997b; van Dommelen 1998; Lilliu 1988; Rowland 2001).

1.1. Historical overview of pre-1970s Sardinian archaeology

In the 15th century AD, interest in history, and especially in Classical antiquity, grew in Europe and the Mediterranean. In Sardinia, too, fascination with ancient remains, in particular the *nuraghi* (round stone towers), increased. For two centuries, explanations of their origins, construction techniques, function, architectural and chronological development were predominantly based on fables and etymology. From the 18th century onwards explorers and travellers began to include other cultural periods and monuments in their field expeditions. At the same time, more rational explanations were introduced, based on stylistic and architectural comparisons with the east Mediterranean (Table 1.1; van Dommelen 1998: 53; Lilliu 1981). The 19th century saw the birth of a 'scientific' archaeology, in which cultural chronologies were based on excavations and archaeological finds and no longer on classical authors. In Sardinia the accomplishments of two men, Giovanni Spano and Ettore Pais, stand out. They carried out the first stratigraphic excavations and maintained a high publication level (Table 1.1; van Dommelen 1998: 53; Lilliu 1981; 1988: 583-584). The unification of Italy in 1870 formalised and intensified contacts between mainland Italy and Sardinia. This resulted in a growing body of known sites, syntheses and interpretations. Importantly, these developments were not restricted to a particular period, and as a result both prehistoric and historical periods benefited (Table 1.1). Following this initial impetus, Sardinian researchers elaborated on old, and developed some new, ideas in relative freedom. In other Italian regions such developments stagnated because of the physical closeness of Rome, where Pigorini had started to restrict innovations (Guidi 1987; Loney 2002).

Timeline	Main interests	Basis for explanations	Main 'researchers'	References
15-17th century	*Nuraghi*	Mythological or etymological	S. Arquer, G. Francesco Fara	Balmuth 1992; van Dommelen 1998: 53-54; Guidi 1987; Koberstein 1993: 7; Lilliu 1981; 1988: 584-585; Ugas 1980; Webster 1996a: 16
18th century	*Nuraghi, domus de janas, tombe di giganti*, Classical remains	Stylistic and architectural comparisons, *ex-oriente lux* theories	V. Angius, A. Della Marmora	
19th century	All periods, monuments and monumental material culture	Stratigraphic excavations and archaeological finds	E. Pais, G. Spano	
20th century up to 1940s	All periods, monuments and monumental material culture	Field archaeology, extensive excavations, surface (site) reconnaissance	A.Taramelli	

Table 1.1. Overview of the development of Sardinian archaeology, from the 15th century AD to the 1940s.

Antonio Taramelli, in particular, in his capacity as the Director of the Museum and of the Excavations of Antiquities at the office of *Soprintendente Archeologico per la Sardegna,* shaped Sardinian, and especially prehistoric archaeology, in the first half of the 20th century (Table 1.1). His contributions still resonate today in three areas. Firstly, he set the standards for the modern Sardinian approach to fieldwork by systematically investigating the entire island (van Dommelen 1998: 54; Lilliu 1981). Secondly, as a result of these extensive fieldwork projects, he significantly increased the number of recorded sites and, more importantly, he published his findings in numerous fieldwork reports, which still are routinely cited by most archaeologists today. Thirdly, Taramelli further professionalised Sardinian archaeology by institutionalising the use of "an island-wide network of professional and lay inspectors, who carried out fieldwork for him and kept him informed of finds in particular areas" (van Dommelen 1998: 54).

Giovanni Lilliu is without doubt the 'father' of modern Sardinian archaeology. He has shaped developments in the second half of the 20th century in three main ways (van Dommelen 1998: 55; Koberstein 1993: 10). First of all, he has continued Taramelli's traditions through encouraging topographical exploration by local archaeologists and training interested amateurs and students, amongst whom Cornelio Puxeddu is particularly important for lithic studies (see Section 1.3.1). Secondly, he is particularly well known for his extensive work in, and redefinition of, Nuragic archaeology (Perra 1997; Ugas 1980; Webster 1996a: 17-18). Lastly, Lilliu reconnected with trends prevalent in mainland Italian prehistory studies, where *Kulturgeschichte* and the emotive approach to culture promoted by Croce, and transferred into chrono-typologies by Peroni, had become extremely influential (Loney 2002).

The 'Great Divide' between classical and prehistoric archaeology, common in other countries, did not exist in Sardinia before the Second World War (van Dommelen 1998: 55; Renfrew 1980). When this split developed it took on a geographical significance. Phoenician, Punic and Roman studies were mostly conducted in southern Sardinia and prehistoric research was carried out in the northern part of the island. This gap has been bridged in the last 30 years through the work of two other influential archaeologists, Enrico Atzeni and Vincenzo Santoni. Both have done much to promote prehistoric presence in southern Sardinia, in their respective functions as Chair of Sardinian Antiquities at the University of Cagliari and as Director of the *Soprintendenza* for the Cagliari and Oristano provinces (van Dommelen 1998: 55; Lilliu 1988: 586-590). By the 1970s, however, certain parts of Sardinian archaeology, especially "prehistoric and Roman archaeology ... [had] apparently lost contact with mainstream prehistoric and Roman archaeology outside the island" (van Dommelen 1998: 55). On the Italian mainland, for instance, a small but vocal group of prehistorians started questioning the dominant interpretative frameworks in the 1970-80s. They introduced Marxist models into Late Bronze Age and Iron Age archaeology by drawing on processual archaeology in the United States and Britain. Recently some postprocessual trends, particularly the uniqueness of historical contexts, have taken hold in Italian protohistoric studies, presumably because it connects well with the traditional cultural historical line of research (Bietti & Bietti Sestieri 1985; Bietti Sestieri 2000; Guidi 1987; 2000; Loney 2002; Malone 2003; Sirigu 2004).

1.2. Sardinian archaeology: discourse analysis of current research themes

This analysis of discourse in Sardinian archaeology encompasses the Palaeolithic to Roman periods, but concentrates on the Prenuragic period (Table 1.2). This focus is relevant because applied archaeological theories and practices of early prehistoric Sardinian archaeology have directly affected the way in which lithic artefacts have been studied. Discursive frameworks of early prehistory, however, are rarely critically discussed or are only briefly touched upon, mostly by overseas researchers (van Dommelen 1998: 55; 2004; Lewthwaite 1990: 97; Webster 1996a: 18).

Period		**Dates and cultures**
Palaeolithic	*Lower*	Approx. 500,000 BP
	Middle	Approx. 200,000 BP
	Upper	Approx. 30,000-12,500 BP
Preneolithic		Approx. 8,750 BP
Neolithic (Prenuragic)	*Early*	6000?-5300 BC Cardial I
		5300-4700 BC Filiestru
		4700-4000BC Bono Ighinu
	Middle	4800BC? / 3500BC? San Ciriaco
	Late	4000-3200? BC Ozieri
Chalcolithic (Prenuragic)	*Early/Middle*	3200?-2700? BC Sub-Ozieri, Filigosa, Abealzu
	Middle/Late	2700?-2200? BC Monte Claro
	Late/Final	Beaker (A/B)
Bronze Age (Prenuragic)	*Early*	2200-1900 BC Bonnanaro A (Corona Moltana)
Nuragic	*Middle Bronze Age*	1900-1600 BC Bonnanaro B (Sa Turricula)
		1600-1300 BC Nuragic I
	Late	1300-1150 BC Nuragic II
	Final	1150-850 BC Nuragic III
Iron Age	*Early*	850-730 BC Geometric / Phoenician / Nuragic IV
		730-580 BC Orientalising / Phoenician / Nuragic IV
		580-510 BC Archaic / Phoenician / Nuragic IV
	Late	510-238 BC Punic / Nuragic V
		238-1 BC Roman Republican / Nuragic V
		1AD-476 AD Roman Imperial / Nuragic V

Table 1.2. Basic periodisation in Sardinian archaeology.

In contrast, discourse in Bronze Age, Iron Age and Roman archaeologies have been critically evaluated recently by Sardinian and overseas researchers, which has led to new insights and research interests (for Bronze Age archaeology see Perra 1997; Usai, A. 1995; Webster 1996a: 13-27; for Iron Age and Roman archaeology see van Dommelen 1998). The aforementioned lack of contact with mainstream European and Italian archaeology, and the predominantly cultural historical trends in numerous studies, may explain the near-absence of a discourse analysis of Sardinian early prehistoric archaeology. As outlined in detail below, I argue that two underlying and entwined concepts, cultural evolutionism and isolationism, underlie many of the current research topics in Sardinian archaeological thought.

1.2.1. Cultural evolutionism

Cultural evolutionism has underlain Sardinian archaeological discourse to a great extent, and this influence may be divided into four aspects: inevitable cultural progression, treatment of material culture, intuitive interpretations and a Childean concept of culture (Table 1.3; van Dommelen 1999a). First of all, cultures are still believed to progress naturally and inevitably towards civilisation from extremely simple to fully developed. This natural advance occurs on different scales. On a large, inter-period scale, Prenuragic cultures gear up for the Nuragic 'civilisation'. It also occurs on an intra-period level, with early and middle period divisions leading towards the cultural (late) 'climaxes' (Table 1.3). The period names illustrate this point well. The term '***Pre***nuragic' for early prehistory (Neolithic-Early Bronze Age) for instance, pointedly places it in its evolutionary place: dependent on the later Nuragic period (*cf.* Blake 1999; van Rossenberg 1999: 130). Thus, the term, and by implication the entire period, serves to underscore the importance of the Nuragic period. Those who propose to refer just to the Chalcolithic or Early Bronze Age as 'Prenuragic' only accentuate this problem, as it creates an awkward line up with the already existing Protonuragic/ Nuragic Phase I or *Nuragico Arcaico* (as used respectively by Webster 1996a: 62 and Lilliu 1988: 273). Similarly, the use of neutral terms like Neolithic or Chalcolithic has only obscured this underlying, cultural evolutionist, theme (Lewthwaite 1984a: note 1; Trump 1984a). Research objectives have not significantly changed. This is well-illustrated by the terminology recently used by Rowland, who summarised the data as follows:

> [...] so it will thus be best to consider these 'cultures' [...] as regional or even micro-regional variations of a single post-Ozieri culture and to regard the *entire* period as transitional to the nuragic civilisation [...] utilizing the concept Prenuragic to emphasize that the period is *primarily* an intermediate phase during which the foundation for the final stage of indigenous *evolutionary* development, the Nuragic Age, was being established. (Rowland 2001: 25, my emphasis)

Secondly, irrespective of archaeological periodisation, cultural evolutionism has strongly influenced material culture studies. Constructions and meticulous refinement of chrono-typologies for standing monuments and portable material culture with a 'monumental' aspect such as decorated pottery, bronze or stone figurines, dominate in all archaeological periods under discussion. Chronology and typology are often end goals, accompanied by a constant search for stylistic similarities in a limited selection of artefact categories (Table 1.3).

Main elements	Characteristics	Examples	References
Inevitable cultural progression	Simple to complex	Palaeolithic to Nuragic	Lilliu 1987
	Cultural build-up	Prenuragic to Nuragic	Lewthwaite 1985b; Perra 1997; Webster 1996a
	Early-Middle-Late divisions	All periods	Atzeni 1980; 1981; Contu 1997a; 1998; Lilliu 1987; 1988: 46; 1989
Treatment of material culture	Chrono-typological developments, stylistic comparisons	Monuments: *nuraghi*, *domus de janas*, *tombe di giganti*, stone cists circles, menhirs, Monte d'Accoddi ('*ziggurat*') well sanctuaries, Nuragic villages, Phoenician, Punic and Roman cities and cemeteries. Portable objects: decorated pottery, stone figurines, *bronzetti*, oxhides	Anati 1999; Balmuth & Tykot 1998; Carratelli 1981; Campus, F. 2000; Campus, L. 1997; Contu 1997a; 1997b; Lilliu 1988; 1997; 1998; 1999; 2002; Rowland 2001; Serreli & Vacca 2001; Tykot and Andrews 1992; Webster 1996a
Interpretations	Somnambulistic: natural and inevitable progressions do not need to be explained	Art, religion: female stone figurines (Mother Goddess / 'beloved companion of man"), *bronzetti* (e.g. 'mother of dead warrior')	Atzeni 1978; Lantemari 1954; Lilliu 1957; 1987; 1988: 193-270; 1999; Rowland 2001 / Contu 1997a: 91
Childean concept of culture	A set of material equals a group of people	Arzachena, Abealzu-Filigosa, Beaker 'cultures', Phoenicians, Myceneans	Ferrarese Ceruti 1997

Table 1.3. The influence of four main elements of cultural evolution on Sardinian archaeological discourse and the resultant predominant themes, examples and key references.

Thirdly, intuitive interpretations are common but often implicit within Sardinian prehistoric archaeology. The *research* focus on settlement and subsistence for Early and Middle Neolithic sites and ritual or socio-political organisation for the Late Neolithic, for instance, is unquestioningly transferred into interpretative models of simple (practical) lifestyles evolving into complex (ritual) ones. Critical assessment of functional, let alone social, differences in relation to assemblage variation, are practically non-existent, as most attention is focussed on comparing stylistic similarities (Table 1.3). This attitude follows from the (often unarticulated) idea that phenomena need not be explained; the concept of cultural evolutionism already *is* the explanation (*cf.* van Dommelen 1998: 53; 2004; Lewthwaite 1990; Webster 1996a: 18). This point is underscored by the fourth and last way that cultural evolution has influenced discourse within Sardinian archaeology, the use of the Childean concept of culture, in which a recurring set of material culture is equated with a group of people (van Dommelen 2004; Webster 1996a: 18). Near-exclusive occurrences of Early and Middle Chalcolithic (Abealzu-Filigosa, Arzachena and Beaker) material in burial contexts, for example, are simply interpreted as new cultures (Table 1.3; Appendix 1.1). Some do acknowledge the limitations of such interpretations, and have pointed out that Arzachena material, for instance, is only found in stone cist circle burials in the north of Sardinia (Gallura), but the implications have not been investigated further (Balmuth 1992; Rowland 2001: 25; Webster 1996a: 52). In some cases, the terms 'culture' and 'civilisation' have been replaced with the more neutral terms such as 'phase' (*corrente*) or 'pottery styles' (for the former see Lilliu 1988: 160; for the latter Lazrus 1999; Patton 1996: 96). This has, however, not significantly changed the practice of archaeology (see for example Rowland's 2001: 25-27 presentation of the Abealzu-Filogosa data).

1.2.2. Isolationism

Two types of isolationism may be recognised in Sardinian archaeological discourse: ordained (*i.e.* imposed by others) and self-imposed. These are closely tied with, respectively, negative or positive correlations and Prenuragic or Nuragic archaeology. Ordained isolation is characteristic of Prenuragic archaeology. It holds primarily negative connotations, in which social isolation and backwardness are equated with physical isolation and distance. This view has been particularly persistent since Febvre's classification of Sardinia as an '*île conservatoire*' and fits within the wider 19th century evolutionist mode of thinking that is still prevalent in the Mediterranean and Sardinia (van Dommelen 1999; Rainbird 1999; Rowland 2001: 1). As a result, isolationism is at times seen as a true characteristic of past and present Sardinian society (Lilliu 1988: 8-15, 65).

The second type of isolationism, self-imposed, entails the common perspective that the Nuragic period is the last true indigenous Sardinian culture (Lilliu 1998: 418-419, 481; Odermatt 1996; Rowland 2001: 80-81). Thus, this period has very positive connotations that have become interwoven with the modern Sardinian identity. The current situation in Sardinia, where the Italian presence is experienced as the latest in a line of colonisation, is certainly a contributing factor to the significance ascribed to the Nuragic period (van Dommelen 1998: 33, 214-216). In that regard the names for later periods are as telling as the denomination of early prehistoric cultures. By classifying these periods after Phoenician, Punic and Roman colonisers, it is implied, and by some explicitly stated, that the indigenous Nuragic culture had been (brutally) ended (Rowland 2001: 80-81 for an overview, but see van Dommelen 1997; 1998).

A second response to the view that prehistoric Sardinia was physically and socially backward has been to disprove isolation (Lilliu 1989; Rowland 2001: 1; Trump 1984a; Tykot 1999). This reaction is increasingly predominant in Prenuragic archaeology, which at first expanded, but now constrained, research. The existence and development of indigenous cultures and the evidence and extent of their contact with the wider Mediterranean are two resultant and predominant research topics, which may be illustrated through four examples.

First of all, there is the recent search for the earliest occupation of Sardinia. Up until the 1970s, knowledge of prehistoric Sardinia was limited. Only the Late Neolithic was well known, while Chalcolithic and (Early) Bronze Age 'cultures' consisted of a confusing array of material remains. David Trump's research in the Bono Ighinu Valley demonstrated that permanent Early and Middle Neolithic habitation existed on the island (Appendix 1.1; Lorìa & Trump 1978; Trump 1983). After these first discoveries the Early and Middle Neolithic presence was well attested. Most subsequent efforts, however, have been aimed towards locating more sites and setting up and refining chrono-typologies through re-evaluation of old collections and new fieldwork projects (Appendix 1.1). Similar trends can be seen for the Preneolithic, although the Sardinian record is more contested and scarce in comparison to Corsican evidence (Appendix 1.1; for Corsica see de Lanfranchi 1998; Lewthwaite 1983; 1985a; 1986a; 1989a; Vigne 1998; Vigne & Desse-Berset 1995). Overall, research into these earlier periods is focussed on proving their overall existence, and adding sites to period-based distribution maps.

A second example of the search for the earliest occupation of Sardinia as one of the means to disprove isolation is the fierce and emotional debate over the existence of a Sardinian Palaeolithic. In essence, this consists of two sub-debates, one on the Upper, and one on the Lower/Middle Palaeolithic. The former is mostly concentrated on the reliability of faunal evidence and the possibility of human interference with this evidence. Today most researchers seem to accept the arguments and data presented, especially after the discoveries in the late 1990s (Appendix 1.1; see Cherry 1992; Tykot 1994 for earlier critiques).

The Lower/Middle Palaeolithic presence is more problematic. In the 1970s, finds from a series of locations in the Pérfugas area, in the north of Sardinia were found and published (Arca *et al.* 1982; Lilliu 1988: 23-26). Overall, these were taken for granted, until the 1990s, when Cherry re-assessed the evidence. He disputed most claims, including the Sardinian one, for the existence of a Lower/Middle Palaeolithic on the Mediterranean islands (Cherry 1990; 1992). His examination triggered a debate that has since intensified considerably (for rejections see Contu 1997a: 29-39; Martini 1992; 1999; Migaleddu 1994; Rowland 2001: 10, Sondaar 1998, but see Mussi 2001: 45, 90 who recently reiterated it). That emotions run high and feelings are strong, especially amongst the supporters, is evident (*e.g.* Martini 1999: 19-22; 22: '*arrogante intervento*'; Sondaar 1998: 45).

To date, this debate has mostly ignored lithic assemblages, only briefly touching on problematic aspects such as the uncritical use of typological classifications and the unquestioned comparisons with equally problematic assemblages in mainland Italy, France and Spain (Milliken 1999; Mussi 2001: 37-38; 44-46). Those mainland artefacts have been re-evaluated in the context of the mid-1990s 'earliest occupation of Europe' debate (Dennell & Roebroeks 1996; Mussi 2001: 44-46; Roebroeks & van Kolfschoten 1994). There, it has been argued that search for an 'African model', in which simple assemblages are equated with old or early sites, stems from a desire to reflect human evolution directly in tool types (Mussi 2001: 45-46). With the high propensity for cultural evolutionism in Sardinian archaeology, discussed above, it is credible to suggest that this aspect also underlies the Sardinian Palaeolithic debate.

The strong focus in material culture studies on stylistic comparative analyses of selective groups of artefacts found on, and outside the island, is a third consequence of the wish to demonstrate contact with the Mediterranean. Absence or presence of stylistic variation is generally interpreted in two ways: either very similar assemblages signify contact, or diverse assemblages denote isolation or indigenous development. The fourth and last example is the bipartite direction that lithic research has taken in Sardinia with 1) a focus on tool typology, and 2) a focus on obsidian provenancing and exchange studies. Below I argue in detail that this concentration has been particularly influenced by isolationism and cultural evolutionism (Sections 1.3.1, 1.3.3).

In summary, it is proposed that the predilection for producing Pre-, Early and Middle Neolithic site distribution maps, and the tenacity and ferociousness of those proponents involved in the Sardinian Lower/Middle Palaeolithic debate, stem from a wish to place Sardinia on equal footing with the rest of the Mediterranean. After all, by demonstrating not just early but earliest occupation, the valuable role of Sardinia in, and for, the Mediterranean is shown. Furthermore, showing that Neolithic and Chalcolithic Sardinia had contacts with the Mediterranean and, more importantly, that it held a *central* position, refutes its social backwardness and turns negative connotations around. Additionally, proving early occupation and Prenuragic contact with, and status in, the Mediterranean also ties in with the deep-seated cultural evolutionist themes. The earlier that contact and status can be demonstrated, the more 'logical' and 'inevitable' the progression into the Nuragic civilisation is.

1.2.3. Influential theoretical and methodological approaches

The underlying concepts of isolationism and cultural evolutionism, and the research topics that predominate in Sardinian archaeology, are the outcome of a cultural historical interpretative framework. In fact, most of Sardinian theoretical and methodological approaches, irrespective of periodisation, may be classified as cultural historical (van Dommelen 1998: 52; Lewthwaite 1990; Webster 1996a: 15-22; after Trigger 1989: 148-206). More recently, processual and postprocessual trends have also been introduced, primarily in late prehistoric and protohistoric archaeology (Table 1.4).

Prenuragic research has benefited least from these new approaches. Few studies have made an attempt to go beyond descriptive chrono-typological data presentations. Those that do cannot be considered processual or postprocessual but are best considered 'functional' (following Trigger 1989: 244-288; see Table 1.4). Multiperiod region-based settlement archaeology, for instance, has recently become more common, sometimes combined with heritage management. Most studies, however, blend traditional settlement archaeology with a physical landscape approach, whereby sites, monuments and the natural landscape are central, thus essentially continuing Taramelli's work. This approach should not be confused with current landscape archaeology (Knapp 1997: 2, see also Chapter 2.1).

Approach	Periods	Research themes	References
Functional	Prenuragic	Settlement / (topographical) survey archaeology, *Bonu Ighinu* Survey Project	Capara *et al.* 1996; Depalmas 1998; Loria & Trump 1978; Moravetti 1998; Santoni 1995; Tanda 1996; 1998; Trump 1983; 1984a; 1984b;1985; 1986; 1989; 1990 ; Usai, D. 1990
		Ceramic technology	Bertorino *et al.* 2000
Processual	Prenuragic	Island colonisation	Cherry 1981; 1984; 1990; 1992; Evans 1977; Keegan & Diamond 1987; Malone 1999; 2003; Patton 1996
		Transition to farming	Lewthwaite 1985a 1986a; 1987; 1989a
		(Prehistoric) pastoralism	Lewthwaite 1981; 1984a; 1984b
		Obsidian provenancing and exchange studies	See Section 1.3.3
	Nuragic (often including the Chalcolithic)	Emergence of social complexity, greater interest in settlement patterns, ritual practice, trade and exchange	Balmuth 1986; Balmuth & Rowland 1984; Hayden, C. 1998; Michels & Webster 1987; Lewthwaite 1984a; 1985b; 1986b; Perra 1997; Santillo Frizell 1991; Trump 1990; Ugas 1980; Usai, A. 1993; 1995; Webster 1991; 1996a; 2001
	Roman	Rural settlement / Romanisation	Dyson & Rowland 1988; 1989; 1991a; 1991b; 1992a; 1992b
Post processual	Nuragic	Social dimensions and identities of *nuraghi*, role of miniature nuraghe	Blake 1997; 1998; 1999
		Social 'irrationality' of *nuraghi*, feuding	Webster 1996b
		(Italian) Bronze Age discourse analysis	Van Rossenberg 1999 for Sardinia see: 19-28, 93-94, 129-139, 170
	Phoenician/ Punic/ Roman	Postcolonial theory	Van Dommelen 1997; 1998; 2001

Table 1.4. Brief overview of the main processual and postprocessual trends in Sardinian archaeology.

At this point, a distinction between two types of studies should be made. There are what one might call 'primary' data studies, which not only take place *in* Sardinia but also add new data and address existing research biases. 'Secondary' studies are *of* Sardinia, in that they include the island in wider Mediterranean frameworks, and/or review Sardinian research without necessarily carrying out new projects (*cf.* Horden & Purcell's 2000: 2 'in and of the Mediterranean' see also van Dommelen 2000a). Most Prenuragic research falls under primary studies, the majority of which are firmly embedded in the cultural historical framework and are carried out by Sardinian and overseas archaeologists.

Processual Prenuragic research, however, is predominantly carried out by overseas researchers and falls under secondary studies. Some examples are island colonisation, the transition to farming, the origins of social complexity and obsidian exchange studies, whereby the latter is an important exception as new studies are carried out (Table 1.4; Section 1.3.3). To date, postprocessual approaches are absent in Prenuragic archaeology. As for Italian archaeology in the 1980s, this lacking may be understood in light of the discrepancy between "refined theories and a still absolutely poorly unknown archaeological record" (Guidi 1998: 679).

Nuragic archaeology has benefited most from the diversity in theoretical and methodological approaches, with an array of cultural historical, functional, processual and postprocessual traits (Appendix 1.1; Table 1.4). The wealth of readily available datasets, long research traditions and the overall significance attributed to this period, has facilitated the expansion of this research scope. Phoenician, Punic and Roman archaeology, with their near-exclusive focus on urban settlements and traditional views on colonialism, are predominantly cultural historical (for instance Bernardini 2001; for an overview see Rowland 2001: 53-125). Recently, van Dommelen re-assessed these three 'colonial' phases, and, by applying postcolonial theory, aimed to understand each in their own unique historical and local context (1997; 1998; 2001).

Regardless of chronological and theoretical frameworks and despite the many new research projects, research has remained site and monument-based, with fieldwork methodologies left unquestioned (Appendix 1.1, Tables 1.3, 1.4). In particular, the concept of 'site' and the subsequent discussions of settlement patterns are uncritically accepted. Prenuragic pottery and lithic surface scatters, for instance, are all mapped as if representing settlement, in spite of clear differences in artefact density, research intensity, and publication level. Effectively, these are archaeological 'recovery' maps, rather than distribution maps (Needham 1993: 164). Resultant distribution maps, nonetheless, constitute the basis for theories and discussions on changing settlement patterns (*e.g.* Atzeni 1980; Lilliu 1988: 32; Rowland 2001: 17; Webster 1996a: 47, but see Koberstein 1993: 24). Likewise, for later periods, new survey and excavation programmes have continued to focus on sites with monumental architecture, while less monumental villages and farmsteads remain understudied (van Dommelen 1998: 60; van Dommelen & Sharpe 2004). Secondly, in publications the same sites keep reappearing, and local circumstances are too easily transferred to the entire island, thus creating false homogeneous views (see van Rossenberg 1999: 143 on 'totalising' views). Lastly, few studies use a fieldwork strategy specifically designed to avoid the pitfalls of a monument and site-based methodology.

1.2.4. Conclusion: strong and problematic aspects of Sardinian archaeology

Since the 19th century Sardinian archaeology has matured into a discipline with well-established practices. It has a very strong tradition of data collection, and in particular, stratigraphic excavations, surface collections, and monument recording, which when combined with the solid basis of amateur groups in many regions, has resulted in dense site distributions (or better: 'recovery') maps (Figure 1.1).

Similarly, many archaeologists have an intimate and detailed knowledge of material culture, which, when combined with the high level of catalogue-type publications, has made certain elements of Sardinian material culture readily available for study. Since the 1970s, Sardinian archaeology has gone through many changes. New secure evidence for early prehistoric, Early and Middle Neolithic, habitation came to light, and subsequent research revealed a wealth of early prehistoric data. Renewed contact with the Italian mainland, other European and US archaeologists has broadened the scope of research. In particular, Nuragic archaeology has benefited from the contributions made by regional settlement and studies of social complexity.

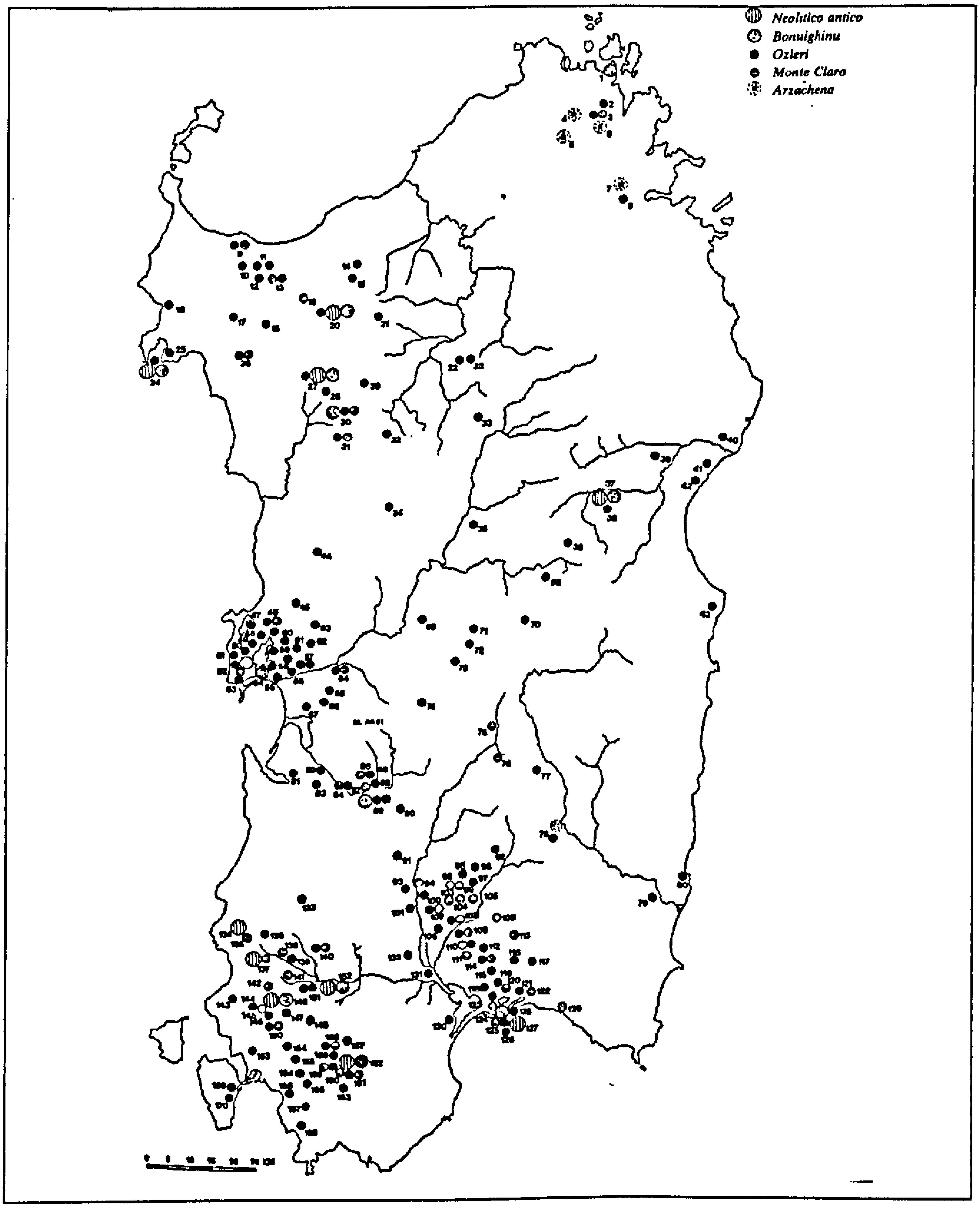

Figure 1.1. Example of a current Prenuragic site distribution map (from Lilliu 1988: Figure 3).

Discourse analysis has shown that an intricate relationship exists among dominant theoretical frameworks, periodisation and two underlying concepts: cultural evolutionism and isolationism. I have argued that much of current, and past, research may be understood in light of these two concepts. In particular, the dominant cultural historical framework, the view of the Nuragic period as the last true Sardinian civilisation, the resulting subservient role for Prenuragic cultures, and destroyer role for Phoenician, Punic and Roman colonisers, have directed and restricted research. Prenuragic archaeology, despite being a young research area, has seen most of these limitations. Theoretical frameworks are primarily cultural historical, and the production of site maps appears to have become an end goal. Despite many new survey and excavations, only a small number of studies have addressed some of the fieldwork-induced biases in the archaeological record.

1.3. Sardinian lithic studies

The phrase 'Sardinian lithic studies' is rather deceptive, because it implies that flaked stone has been systematically studied in Sardinian archaeology. Sadly, the reverse is true. The role of lithic artefacts in understanding human behaviour has mostly been undervalued. The term here is best understood in its 'catch all' capacity. Obsidian has only been seriously considered four times in the past 150 years: in the 19th century by Zanardelli (1899), in the mid to late 1950s by Puxeddu (1957), from the 1990s onwards by Tykot (1995; 1996) and most recently by the Monte Arci Project from the University of Cagliari (Luglie 2004a; Santoni 2004). Other raw materials such as flint and quartz are studied even less often. They have only been examined haphazardly, either in relation to obsidian or in the context of Palaeolithic and Preneolithic material (cf. Lugliè 2000a; Appendix 1.1; Table 1.5). With these caveats in mind, three types of lithic research can be distinguished. The first group contains the majority of studies from the 19th century up to now, and fits in the traditional cultural historical mould. Since the 1980-90s two additional directions have come to the fore. Firstly, a group of mostly Sardinian and Italian archaeologists have recently taken up the LaPlace tool typology that is common on the Italian mainland. Even more recently, some have begun to explore the ways in which obsidian was procured, knapped and used in Sardinia. Secondly, mainly, but not exclusively, overseas researchers have concentrated on west Mediterranean obsidian exchange networks, and the role of Sardinia as a raw material source.

Periods/cultures	Sites	Lithic information	References
Early Neolithic	Habitation sites in caves and open air sites.	Tool types: transversal geometric/trapezoid microliths. No distinctions between flint and obsidian industries. *In situ* production attested to by flaking waste and cores. Material obtained either directly or via travelling merchants	Atzeni 1977; 1978; 1981; 1987; 1992; Lilliu 1988: 42; Trump 1983: 60-71
Middle Neolithic	Habitation and ritual sites (*e.g.* Sa Ucca de su Tintirriolu) in caves, open air settlement sites, tombs	Obsidian and flint flakes, cores, geometric/trapezoid microliths, end- and side scrapers, retouched blades, burins. Continuation of Early Neolithic traditions. Assemblage variation corresponding with site functions/interpretation?	Atzeni 1987; Lilliu 1988; Loria & Trump 1978
Late Neolithic (Ozieri)	Open air settlement sites, obsidian distribution centre (Puisteris), *domus de janas*, ritual sites (Monte d' Accoddi)	Blades ('knives'), side and endscrapers, denticulates, awls, burins, arrowheads/lance points, flaking waste, flakes. Differential quantitative and qualitative artefact distribution on sites? The Monte Arci and surrounding river systems provide opportunity for raw material collection.	Atzeni 1959; 1962; 1978; 1987; Depalmas 1988; 1991; Cicilloni & Ragucci 2004; Cossu 1993; Lilliu 1957: 25, note 102; 1988; Manunza 2004; Tanda & Depalmas 1997; Ugas *et al.* 1985.
Chalcolithic (Monte Claro)	Settlement sites (Enna Pruna, Sa Sedda da Biriai), dolmen, *allées couvertes*	As above: strong Late Neolithic traditions, but decline in quantities. Decrease in arrowheads and increase in highly diverse scrapers. Possible (site specific) differences tool types for obsidian and flint and sporadic use of other raw materials. *In situ* production. Settlements closer to source areas?	Atzeni 1959; 1962; Atzeni M. L. 2004; Atzori 1959; Cicilloni 2004; Lilliu 1988: 142-143 ; Lilliu & Ferrarese Ceruti 1959
Chalcolithic (Beaker)	Tombs	Arrowheads, microliths in obsidian and flint	Atzeni 2001
Nuragic	*Nuraghi*, *tombe di giganti*	Arrowheads, scrapers, blades. Decrease in artefact quantities. Evidence for *in situ* production. Raw materials: obsidian, flint (calcareous areas in north and Masullas in W-C Sardinia). Interpreted as evidence for prehistoric presence before Nuragic habitation, or contemporaneous but inferior and decreased (re-)use.	Atzeni, M.L. 2004; Cicilloni & Ragucci 2004) ; Ferraresi Ceruti 1980; Lilliu 1988 ; Contu 1997b
		Wide occurrence of lithic scatters with *nuraghi* (80 of 121 in Maryland-Wesleyan University Survey). *In situ* knapping (cores, chips, debris). Interpreted as contemporaneous.	Dyson & Rowland 1992a; 1992b (list appendices)

Table 1.5. Overview of post-WWII 'traditional' views on lithic typology and technology in Sardinian lithic studies.

Below I review the main characteristics of each research angle, focussing on their strengths, limitations, and relationships with developments elsewhere. It should be noted that again the emphasis here is not on presenting and discussing the period-specific lithic tool types and industries extensively as that information is available elsewhere (see summative Tables 1.5, 1.8).

1.3.1. Traditional lithic studies: cultural evolutionism and isolationism

Interest in obsidian emerged with the 19th century professionalisation of Sardinian archaeology. The Monte Arci was recognised as a main raw material source for stone tools, and the first geological explorations there were carried out in the 1840s and 1850s by Della Marmora (Puxeddu 1957; Tykot 1992). At the turn of the century, archaeological site publications started consistently reporting obsidian artefacts from open-air settlements, cave habitations and burials across the island (*e.g.* Ardu Onnis 1899; Mannai & Loddo 1902; Mantovani 1875a; 1875b; 1876; Orsoni 1879; Pigorini 1903a; 1903b; 1908). At the same time, the role of Sardinia as an obsidian source for the west Mediterranean was recognised (Palumbo 1876; Niccolucci 1876; summaries in Tykot 1992). The first person to conduct a regional surface collection and focus on obsidian sites in Sardinia was Tito Zanardelli, who collected more than 8000 artefacts at over 40 localities in the Oristano province. He also set up a site typology, distinguishing four site categories based on a combination of their position in the landscape and proximity to other sites (Table 1.6).

The second half of the 20th century saw a revived interest in obsidian. Lilliu and several of his protégés conducted, and published, a series of explorations that expanded on earlier explorations and brought new sites to light (Atzori 1959; Atzeni 1959; 1962; Lilliu & Ferrarese Ceruti 1959; Puxeddu 1957; 1975). Particularly impressive is the work of Cornelio Puxeddu, which until very recently remained the only relatively recent regional work on obsidian site distributions *within* the island. Consequently, it continues to be referenced extensively (*e.g.* Contu 1997a; Lugliè 2000a; Lilliu 1988; Tykot 1992; 1995; 1996; 1999). Puxeddu has provided an extensive overview of the work that has been previously carried out and has presented his own surface collections from around the Monte Arci. He has listed over 250 sites, which were classified into four groups (Table 1.6; see Section 4.2.2.1.).

Classification	Description‡	Sites (n)#
Independent*	High elevation scatters, unassociated with other archaeological remains	4
Nuragic*	Scatters in proximity to *nuraghi*, but without clear associations	27
*Domus de janas**	Scatters in proximity to *domus de janas*, but without clear associations	4
Lacumarensi †	Scatters on lagoon/lake banks	6
Giacimenti orginari o presumibili cave	Original layers or possible mines/quarries with obsidian mixed with other material, rounded in form, or in pediments	6
Centri di raccolta	Collection centres where blocks of obsidian, worked or unworked are abundant	13
Stazioni	Stations where obsidian is found reasonably abundant, consisting of raw material and waste but surface material does not provide enough information for attribution to the other two site types. Generally, tools are missing at these sites	278
Officine	Workshops where surface material clearly indicates a fairly extensive flaking centre. Tools, complete and incomplete, are found frequently	95

Table 1.6. Site classifications according to Zanardelli (1899, top four rows) and Puxeddu (1957; 1975, bottom four rows).

Key to Table:
*Labels based on Zanardelli's descriptions.
†Original Zanardelli label.
#Top four figures are estimates, based on Zanardelli's site discussions; bottom four are estimates based on a combination of site lists, map A and site discussions in Puxeddu 1957; 1975.
‡Top four are summaries only, bottom four are author's translations of full original text.

Puxeddu's work is undoubtedly a seminal contribution to Sardinian obsidian studies. Given the countless new insights in lithic procurement and production studies (see Section 2.3), his site classification criteria require re-evaluation. Tykot began this reassessment in the 1990s but has primarily focussed on locating, and chemically characterising, primary and secondary raw material sources on the Monte Arci (Tykot 1992; 1995: 83-87; 1997; see below and Chapter 4.1.1). Puxeddu's other three site types, *centri di raccolta, stazioni* and *officine,* are usually only translated into English as collections centres, stations, and reduction sites or workshops, respectively (Table 1.6; Tykot 1992: 52; 1996: 48). These translations, however, are either non-descript ('stations') or imply a similarity with terms in use in current lithic studies (workshops or reduction centres) that does not exist. Some Sardinian archaeologists have recently resumed research on some of his sites and/or have begun to revise Puxeddu's work, simultaneous to, but independent of, my own re-examination

(Logliè 2000b: 13; Usai, E. 2004; for my reassessment of Puxeddu's work, see Section 4.2.2.1).

The insightfulness of these early studies should not be underestimated. Zanardelli and Puxeddu's site classification criteria, with the inclusion of landscape, tool assemblage variation, an interest in regional site distribution patterns, and the attention for raw material sources, are even more impressive when one takes into consideration the fact that they predate the concept 'lithic studies' or Bordes's influential work on lithic assemblages in France (Bordes 1961).

Despite such studies, the majority of past, and current, Sardinian lithic studies reflect the cultural historical character of Sardinian archaeology in two ways. First of all, stone tools are rarely studied in their own right. Their overall presence is often mentioned in site reports, find catalogues, or overview articles. These publications consist of general assemblage (diagnostic artefacts) descriptions and are compared with assemblages from sites on and outside the island to establish contemporaneity (Table 1.5). Effectively, they are a continuation and refinement of the 19^{th} century style of reporting. This so-called 'placing dots on a map' phenomenon, which stems from an overall focus on finding sites, is a common trait in Mediterranean archaeology (Bintliff 2000a; Section 2.1). Secondly, most Sardinian lithic studies contain three of the four cultural historical characteristics: inevitable cultural evolution, treatment of material culture, and intuitive interpretations.

Inevitable cultural progression is clear from a chrono-typological preoccupation with the evolution of tool types, the use of diffusionism as a main explanation for cultural change, and the examples used to support the idea of cultural built up. As a result there is a strong focus on continuity in lithic tool traditions whereby Late Neolithic/Late Chalcolithic cultures are seen as culminations of technological and typological prowess (Table 1.7). Interestingly, this continuation is not considered contradictory to the idea that these 'better' Late Neolithic and Chalcolithic innovations derive, directly or indirectly, from the Aegean. In fact, the opposite reasoning can be seen. The poorly known 'cultures' such as Arzachena, Sub-Ozieri, Abealzu-Filigosa, are given a transitional role in the overall evolution of Sardinian civilisation, enabling the

'Sards' to make these innovations their own (Lilliu 1988: 62; 115 but see Usai, A. 1993). Moreover, continued traditions endorse the idea of an old and uninterrupted Sardinian resistance to colonisation. The attractiveness of this view may be understood by looking at the modern situation and the wider isolationism viewpoints discussed above. The focus on continued traditions by proponents of an indigenous Sardinian development is equally understandable since recognition of continued traditions is one of their core concepts. As a result, the traditional decline of stone due to the introduction of metal argument is present, but not very strong (Ugas *et al.* 1985). A decline in quantity rather than quality is stressed more often (Ferrarese Ceruti 1980; Lilliu 1988).

Main elements	Characteristics	Examples	References
Inevitable cultural evolution	Cultural built up	Early-Middle Neolithic tool types lead up to 'better' Late Neolithic ones	Lilliu 1988; Phillips 1992
		Obsidian exchange is prime mover for nuragic civilisation and leads to metal exchange	Lilliu 1987; 1988; 1989; Rowland 2001: 11-12, 15; Tykot 1999
	Diffusionism explains progress/change	Rigid Early-Middle Neolithic traditions prevent evolution, until Late Neolithic traditions from the east come in.	Lilliu 1988: 42, 62
Treatment of material culture	Focus on continuity in tool assemblages	Early/Middle to Late Neolithic traditions, Late Neolithic to Late Chalcolithic traditions	Lilliu 1988: 109, 124, 141-142: Rowland 2001: 19, 42, 53; Webster 1996a: 74
	Chrono-typological developments, stylistic comparisons, focus on tools	Brief site notes with mention of tool types only, catalogue-like publications	See Table 1.5.
Interpretations	Somnambulistic and intuitive	Settlement assemblages are functional, burial assemblages are personal gear or afterlife amulets.	Atzeni 1959; Cicilloni 2004: 246; Lilliu 1957; 1988.
		Role of obsidian trade in site establishment and development (Puisteris as distribution centre)	Atzeni 1987; Contu 1991; Lilliu 1988: 78

Table 1.7. Influences of cultural evolutionism and isolation on Sardinian lithic studies.

Inevitable cultural progression and intuitive interpretations also underlie the idea that obsidian trade ('*commercio*'), with Sardinian merchants travelling directly to Italy and France, is an instrumental factor in the cultural evolution of the Nuragic 'civilisation'. This is echoed by other (*i.e.* functional and processual) ideas from non-Sardinian researchers who examine west

Mediterranean obsidian exchange networks (Table 1.7; for discussion see Section 1.3.3).

The cultural historical treatment of material culture is evident in the chrono-typological focus. It is also very strongly present in the near-exclusive attention paid to lithic consumption (*i.e.* tools) as procurement and production are occasionally mentioned, but rarely examined (Table 1.5 but see below).

Intuitive interpretations are widespread. This is noticeable, for instance, in the way in which function is primarily based on form, and in the predominance of functional explanations. Potential typological or technological inter and intra assemblage variation is sometimes suggested, but for the most part is left unaddressed. Likewise, assemblage variation across different raw materials (flint versus obsidian or quartz) or across different contexts (*i.e.* cave versus open air sites, burial versus settlement or ritual sites) is alluded to, but generally not discussed any further (Tables 1.5, 1.7). Furthermore, site and assemblage interpretations are intuitive and consist of broad, unsupported, statements. Puisteris, a Neolithic-Chalcolithic site in the Campidano, for instance, has been interpreted as an 'obsidian distribution centre', whereby its existence and subsequent development are attributed to the production and trade in obsidian (Table 1.7). This is not uncommon, and comparable reasoning has occurred elsewhere in the Mediterranean. Pescale, on mainland Italy, was similarly interpreted but recent survey evidence has challenged this view (Ammerman 1985c). On Melos, establishment and development of Phylakopi had been attributed to source control and elite development. There, technological assemblage analysis for Melian quarries has refuted those statements (Torrence 1986). Sardinian interpretations, as were their early Mediterranean counterparts, are primarily based on proximity to raw material sources, numerical, and typological comparisons. To date, technological analyses, fieldwork and its collection size biases remain overlooked as the means to understand Sardinian site assemblages.

Isolationism has also influenced lithic research and interpretations. It underlies not only the focus on continuity but also the interest in extra-insular obsidian trade. After all, evidence for Sardinian participation in Mediterranean-wide trade networks counters claims of social backwardness (Contu 1991; 1997a:

54-60; 71; Lilliu 1988: 29; 1989; Rowland 2001: 2, 11-15; Tykot 1999). The suggested travelling Sardinian merchants reinforce this point. Their existence not only contradicts backwardness, but also gives Sardinia an active and principal role in the Mediterranean trade. This viewpoint also provides a better understanding of why most studies do not go beyond establishing general evidence for trade, since once the role has been established, more details are not 'necessary'. At the same time, these suggestions concerning the traditional obsidian trade also fit the inevitable cultural progression theme, because they are seen as progressing into Nuragic metal exchange networks (Table 1.7). Thus, it can be suggested that at least one of the reasons overseas research into Sardinia's role in the Mediterranean obsidian exchange network is encouraged and incorporated, is because it is disproves notions of social backwardness.

1.3.2. Recent developments

In the last decade or so, Sardinian archaeologists have begun to study lithic artefacts more systematically by implementing the LaPlace classification system (Table 1.8). By doing so, they have reconnected with trends in mainland Italian prehistory, where this system has gained predominance since the 1970s. LaPlace, a Frenchman who had become dissatisfied with the Bordian cultural historical framework, had developed an analytical and morphological approach to the study of stone tools (1966; 1968). Unfortunately, instead of adopting his methodology, most researchers have just implemented his (Upper Palaeolithic) tool classification, applied his typometrical analysis to tools, and refined typological schemes (*e.g.* Bagolini 1968; 1970; 1971; Di Lernia 1995; Galiberti 1989; Martini & di Lernia 1991). Overall, the Italian, including the Sardinian, use of the LaPlace classification is uncritical and several problematic aspects are left undiscussed. First of all, in its current form it emphasises tools and does not address, or leave room for addressing raw material procurement, reduction sequences, postdepositional processes, or assessments of fieldwork bias (Mussi 2001: 167-168, 236-238). Moreover, few have explicitly acknowledged that an Upper Palaeolithic tool typology is less than well suited for the study of later prehistoric assemblages (but see Conati Barbaro & Lemorini 1996). Its popularity, however, is unsurprising. Italian prehistory has always retained a strong cultural historical influence, in which chrono-typologies play a pivotal part (Loney 2002). Thus, despite the more systematic approach, the use of this classification system still falls within the cultural historical characteristics of Sardinian lithic studies and archaeology. It should be noted that they, and Italian, lithic research differ from developments in English-speaking and French academic circles. In the former, the role of lithic technology in adaptive human behaviour has become central, and interests in stone tool production and use have replaced tool typologies. In the latter, lithic technology as a means through which to understand social and cognitive elements of human behaviour also shifted from typological to technological analyses (see Section 2.3).

Three other recent developments are of particular interest. Firstly, there is an increased interest in the Monte Arci from a heritage management perspective. There are extremely complex relationships between nationalism, archaeology, tourism and heritage management in the (re-)construction, management and (re-)presentation of the past. Extensive discussion falls outside the scope of this research but it is worthwhile to note some points briefly. With EU and UNESCO legislation and financial support several areas in Sardinia, including the Monte Arci, have recently seen the establishment of several heritage management projects (Santoni 2004). These projects serve a twofold purpose: the preservation of cultural and natural resources, and the socio-economic support of local pastoral, rural and mining communities thereby endorsing, if not constructing, local identities (*e.g.* '*il paese dell' Ossidiana*' as the official slogan for the village of Pau). Attracting, so-called 'sensible' or 'intelligent', tourism to certain geologically, historically and archaeologically significant areas is the means through which these aims are achieved. As a result, many cultural and natural parks, local museums, and *agroturismo,* a bed and breakfast-style tourist accommodation scheme that relies mostly on self-made produce, are created (Santoni 2004). Local councils are given, and have taken, significant control in these initiatives. They are instrumental in the organisation of local events and the production of tourist items such as guides, books, calendars and videos detailing local history (Marras 2004a; 2004b). The council in Pau, for instance, has initiated annual obsidian conferences *'L'ossidiana del Monte Arci nel Mediterraneo'* (*e.g.* Manias 2004), and published a number of books and videos (Cau *et al.* 2002; Lugliè *et al.* 2002; Morgana 2001). Many archaeologists participate in these events and activities.

To date, few local or overseas scholars have addressed the wider political and ethical implications of their participation (but see Odermatt and commentaries 1996). Moreover, without self-reflection on the archaeological methods and theories employed, the use of archaeological data will ensure that existing biases in the datasets are perpetuated.

Secondly, a few new studies have abandoned typology-orientated, consumption-based lithic studies, and have started examining lithic procurement and production strategies (Table 1.8). In particular the Monte Arci Project, from the university of Cagliari, stands out. This multidisciplinary and intensive survey and excavation programme on the east side of the Monte Arci started in 2001 and is aimed at understanding diachronic changes in the organisation of obsidian procurement, production and exchange at the Sennixeddu quarry (Lugliè 2004a; Santoni 2004; Tykot *et al.* 2003b). The results are eagerly awaited from this much-needed and long overdue project that follows in the footsteps of similar studies carried out at extractions sites elsewhere (Bradley & Edmonds 1993; Ericson & Purdy 1984; Torrence 1986). Moreover, Lugliè and others have also commenced exploring lithic production for settlement sites, providing much-needed reconstructions of reduction sequences for lithic assemblages. Following developments in lithic studies elsewhere (see Section 2.3.2), Linda Hurcombe has started use wear analysis in Sardinian archaeology, studying various assemblages (Table 1.8). At the moment these studies are sparse but some interesting points have appeared. Hurcombe & Phillip's (1998) technological and functional examination of lithic assemblages from Trump's excavations at Filiestru, for example, has indicated that the suggested change in site function that has been based on pottery is not accompanied by a marked change in the Early to Middle Neolithic lithic assemblages (Trump 1984a, 1984b, 1985 on changed site functions; Tables 1.5, 1.8). The indistinct link between site function and lithic assemblage raises interesting methodological questions and counters traditional evolutionist viewpoints. Their analysis has also demonstrated that unretouched or so-called 'debitage' pieces, were used. Once again this reminds archaeologists of the limitations of traditional lithic classification schemes with their 'retouch = use' assumptions.

Period	Sites	Lithic information	References
Early Neolithic	Cave habitation & open-air settlement / special purpose sites?	*In situ* tool production evidenced by raw material nodules and cores, but some primary core reduction elsewhere. Use of small pebbles, from secondary sources (Campidano). Unidirectional, direct percussion, simple blade production. Tool types: predominantly geometric microliths, scrapers, borers, burins (on truncated blades and flakes).	Alba 1990, Alba & Canino 2004; Atzeni 2000; Atzeni *et al.* 2004; Koberstein 1993: 167; Lugliè 1998; 1999; 2000b
Middle Neolithic	Bau Angius, Filiestru	Unidirectional direct percussion blade core reduction. No marked distinction between Early/Middle Neolithic assemblages. Expedient or exhaustive use of material (unretouched material with use traces). (Intentional/funerary?) deposition of indirect percussion blade core, blades, hammer stones. Similar (EN) tool types with increase in scrapers, borers, fewer geometric microliths.	Lugliè 2000b; 2004b; Hurcombe & Phillips 1998
Late Neolithic/Late Chalcolithic	Open air and cave settlement, funerary and ritual contexts, obsidian quarry Sennixeddu (Perdias Urias source zone)	Differential use/significance obsidian - flint: (specialist) prismatic flint blade production, distribution in settlement and funerary contexts. Unidirectional simple blade core (pebble-based) reduction in obsidian. Lithic quarry with various locations indicating macroblade core reduction. *In situ* knapping at (some) sites: presence of stone percursors, raw material nodules. Two types of flake production; expedient small flakes from chunks/large flakes and informal flake core production. Evidence for bipolar technique (*pieces esquilées*)? Use of locally available other stone: quartz, limestone: blade and flake production / scrapers. Technical problems evidenced by overshot blades. Appearance of obsidian bifacial tools / pressure flaked retouch, (leaf-shaped (LN?) and tanged arrowheads (LC?); with most standardised forms in LC. Obsidian tool types: burins, borers, side and end scrapers, denticulates. Flint tool types: blades, scrapers, tanged arrowheads.	Depalmas 1991; Cossu 1993; Locci 2000; Lugliè 2000a; 2000b; 2004a; Sabatini 1997
Nuragic	*Nuraghi,* tombs, Nuraghe Antigori, Nuraghe Ortu Comidu	Unretouched 'geometric' flake production (a.k.a. lunates, *geometrici a croissant*, *microliti a cresente, denti di falce*) for specialist use: plant processing. Control over sources. Differential source use as means of dating sites	Hurcombe 1992a; 1992b; 1993; Lilliu 1988; Locci 2004; Michels 1987; Michels *et al.* 1984 Trump 1984b; 1990: 12, 27-28
(post-) Roman		Continued Roman, and post Roman (based on hydration dates) use of obsidian at *nuraghi*	Dyson & Rowland 1989: note 9; 1992a ; Dyson *et al.* 1990

Table 1.8. Overview of recent views and results of technological and typological Sardinian lithic studies

A second interesting point is that, contrary to the standard opinion, differences between flint and obsidian assemblages have emerged (Tables 1.5; 1.8). Formal blade production, *i.e.* prismatic blade removal using indirect percussion from predominantly unidirectional blade cores, occurs overwhelmingly in flint, while obsidian blade production is informal. Blades are removed with direct percussion from pebble parent material, from unidirectional and multidirectional cores. For the former, specialist production is suggested, while local, household production is proposed for the latter (Table 1.8). An interesting example is the recent discovery of a Middle Neolithic vessel containing a blade core, its eight detached blades, two hammer stones and two polishing stones. The unclear find context made it difficult to interpret this assemblage but its similarity with depositional contexts in funerary contexts has been noted (Lugliè 2004b). Intentional deposition should not be ruled out.

Finally, there are the new ways in which obsidian is used as a dating mechanism. Relative cross dating of tool types has been in use since the 19th century. More recently attention has focussed on absolute hydration dating and the possibility of dating assemblages through chronologically distinct source use (Table 1.8). One outcome that has emerged from these new dating mechanisms is the evidence for the use of obsidian well into late prehistoric and historical periods. The presence of obsidian in and around *nuraghi* has been known, and reported for a long time. Two main interpretations are common: 1) the (re-)use of obsidian in Bronze Age Sardinia, albeit of inferior quality and quantity, and alternatively 2) that such finds represent traces of earlier habitation, using typological cross-referencing with other assemblages or a small amount of prehistoric pottery as proof (Table 1.5). Certainly, continued settlement is attested to but, as some recent studies have demonstrated, it cannot be assumed *a priori* or on the presence of obsidian alone. Obsidian hydration dating and unambiguous stratigraphic evidence have testified to the continued use of obsidian in later prehistoric periods. Recent technological studies have also provided an insight into the process and organisation of production, showing substantial and possibly even specialised use (Table 1.8).

In sum, the majority of Sardinian lithic studies have continued the 19th century 'cataloguing-and-reporting' tradition. The focus lies squarely on tool types and obsidian. These are mostly used to indicate (early) prehistoric presence, to compare and date sites and assemblages to facilitate (re-)constructions of period-specific site distribution maps, to (re-)construct cultural traditions and past lifestyles, and to counter claims of social backwardness. Most of these studies may be classified as 'primary' research studies, which are firmly embedded in cultural historical or functional traditions and have been carried out by Sardinian, and some foreign, archaeologists (Table 1.5). In the last decade or so, a reconnection with studies on the Italian mainland has taken place with the use of the LaPlace methodology and typology. It has been argued that these studies are, unnecessarily, restricted to lithic consumption and predominantly contain cultural historical overtones. In the late 1990s interest in lithic procurement and production grew. These new projects have drawn on theoretical and methodological insights from Anglo-French lithic studies with promising early results (Tables 1.5; 1.8). 'Secondary' research studies are virtually absent, presumably because the nature of Sardinian lithic studies has hindered their incorporation into wider theoretical discussions.

1.3.3. Mediterranean obsidian exchange studies: Sardinia as a source

One large body of research still remains to be discussed, Mediterranean obsidian provenancing and exchange studies. It is characterised by two views: a Sardinian and overseas perspective. The predominantly cultural historical Sardinian viewpoint has been discussed above and can be summarised as the view that travelling Sardinian merchants directly controlled trade routes, not only ensuring the wealth of certain individuals or sites, but also ultimately leading to more evolved Nuragic bronze trade network. I have argued that cultural evolutionism and isolationism have largely, ([sub]-consciously), shaped this line of reasoning (see Table 1.7).

The second, predominantly non-Sardinian viewpoint holds that the role of Sardinia in west Mediterranean obsidian exchange networks laid the basis for the (elitist) Bronze Age exchange networks. It is suggested that increased control over raw material sources during the Middle Neolithic and participation in exchange networks gave rise to an 'elite'. Furthermore, it is assumed that this elite group secured its position during the Late Neolithic and Chalcolithic, and set up the contacts for the metal trade in the Nuragic period (Table 1.7).

Obviously, the near-complete absence of information on the organisation of procurement and production makes it impossible to validate any of these ideas (also Luglié 2000a).

These views, and west Mediterranean obsidian exchange studies, are inextricably tied with modern provenance and exchange studies. These were developed in the 1960s when it became possible to characterise (or 'fingerprint') the chemical composition of materials. Furthermore, composition comparisons helped link individual geological sources and archaeological artefacts so that source use and source distribution patterns could be examined. Mediterranean obsidian was one of the first materials to be sourced. Methods such as neutron activation analysis (NAA), X-ray fluorescence (XRF), and optical emission spectroscopy (OES) were tested, demonstrating inter- and intra-source variability and setting up the first trade and exchange models (Cann & Renfrew 1964; Hallam *et al.* 1976; Taylor 1976; Williams Thorpe 1995 for an overview). Since then, both provenancing and exchange studies have developed into rich and diverse subdisciplines of archaeology. Today characterisation studies employ a wide variety of trace element and isotopic analysis techniques for a broad range of materials. Each method has its own requirements, strengths, and limitations, which must be balanced against archaeological research objectives (Poupeau *et al.* 2004; Tykot 2002a; 2003; 2004a; Tykot & Young 1996). As is often acknowledged however, "mere characterisation is not enough" (Renfrew 1993: 15). Provenancing artefacts/assemblages is an integral part of many procurement, subsistence, social complexity, craft specialisation, trade and exchange studies today (Bradley & Edmonds 1993; Brumfiel & Earle 1987; Cherry & Knapp 1994; Ericson & Earle 1982; Ericson & Purdy 1984; Robb & Farr 2005; also Section 2.3).

West Mediterranean obsidian characterisation studies are predominantly linked to trade and exchange studies, whereby two main research directions may be recognised. Firstly, following Hallam and colleagues (1976), studies have continued characterising archaeological artefacts from sites in non-source areas, in particular France and Italy (Ammerman *et al.* 1988; 1990; Bigazzi *et al.* 1992; Crummett & Warren 1985; Randle *et al.* 1993; Williams Thorpe *et al.* 1979; 1984). Similarly, further reconstruction and refinement of source distribution patterns has taken place using increasingly complex explanatory models to examine trade and exchange mechanisms and routes (Ammerman 1985a; 1989; Ammerman & Andrefsky 1982; Barfield 1981; de Lanfranchi 1980; Phillips 1986; 1992; Pollmann 1993; Robb & Tykot 2003; Skeates 1993; Tykot 1992; 1995, 155-188; 1996; 1999; Williams Thorpe 1995).

Secondly, and initially on a much smaller scale, research in the source areas has continued to pinpoint and characterise geological sources (Francaviglia 1988; Mackey & Warren 1983; summaries in Tykot 1992). From the 1990s onwards, Robert Tykot has carried out extensive characterisation programmes for all west Mediterranean source islands, demonstrating intra-source variability for Pantelleria, Sardinia and Palmarola (Tykot 1995: 61-97; 1997; 2002a; 2004b; Tykot *et al.* 2005b; for Sardinia see Section 4.1).

In the 1990s Pollmann (1993) and Tykot & Ammerman (1997) evaluated and critiqued west Mediterranean characterisation studies pointing out two important issues. Firstly, they noted that on the whole low numbers of artefacts from single sites were sourced, and that relatively few sites with obsidian assemblages were examined. Many more unsourced than sourced sites were, and are, known. Secondly, they suggest that fieldwork practices influenced distribution patterns. Small stratigraphic excavations, limited assemblage information, limited or unknown site functions, unacknowledged research foci on specific type sites (*i.e.* settlement versus burial), poorly or undated collections, and differing inter and intra-regional research intensities affected distribution patterns and, in turn, trade and exchange modelling. Although neither author has acknowledged this explicitly, current distribution maps are 'recovery maps' that primarily display the knowledge of the archaeological community rather than being an accurate display of past distribution patterns (Needham 1993: 164). To date, new research has primarily readdressed the second point by advocating "comprehensive sourcing" (Ammerman & Polglase 1993: 101). Thus, more assemblages from new sites are characterised and assemblages are almost entirely sourced using a combination of chemical or visual means (*e.g.* Bietti *et al.* 2004; Tykot 1997; 1999; 2002b; Tykot *et al.* 2003a; 2005a).

Notwithstanding many important improvements in provenancing techniques and an increasingly solid quantitative dataset, some important gaps and problems remain. First of all, there is still too strong a focus on sourcing and distribution mapping. While the influence of research bias on distribution maps is (sometimes) acknowledged, the consequences remain undiscussed. Additionally, most maps are cumulative. All find locations are represented as if equal. Chronological or other differences such as site function, site size or assemblage composition are rarely incorporated (*e.g.* Figure 1.2. but see Pollmann 1993: Figures 1-112).

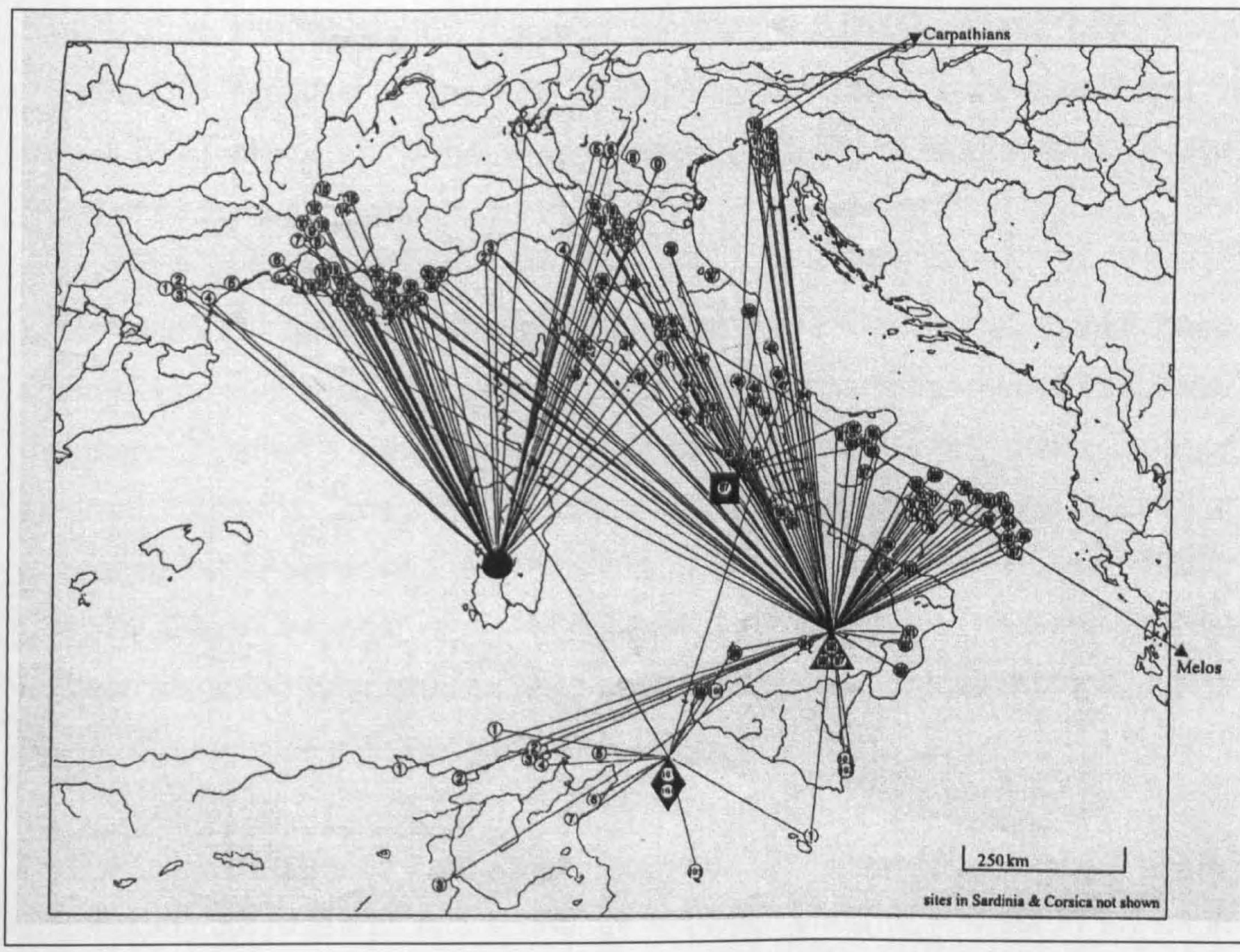

Figure 1.2. Example of a recovery map presented as an obsidian distribution map (from Tykot 1996: Figure 10).

Secondly, for most of the known find spots little additional lithic information, beyond quantities of sourced artefacts, is available. Recently, only a few site or region specific studies in mainland Italy and Sardinia have investigated chronological changes in source use combined with technological assemblage and/or use-wear analyses. Here the work of Ammerman and colleagues in north and south Italy stands out (Ammerman & Polglase 1993; 1997; Ammerman *et al.* 1988; 1990; Hurcombe & Phillips 1998; Tykot 1996). As a result of both points, data from a small number of sites are extended to larger regions to create totalising views. This is reminiscent of the way in which certain Sardinian Prenuragic sites are used to build *the* picture of *the* Prenuragic period (see above).

Thirdly, there is a widening gap, both theoretically and methodologically, between west Mediterranean obsidian exchange studies and general exchange studies. With regard to methodological disparities, the former still predominantly reconstruct their distribution patterns based on distance to source and artefact quantities per source. Early exchange studies, drawing heavily from anthropological research, particularly Sahlins (1972), used these variables to examine if, and how, exchange mechanisms were reflected in distribution patterns and if these were associated with, or represented, specific types of social organisation.

Later research, however, demonstrated that the underlying economic basis could not be sustained, that different exchange mechanisms resulted in similar distribution patterns, and vice versa. Similar mechanisms could produce different patterns and that exchange was not necessarily equal or uninterrupted (Ammerman & Andrefsky 1982; Earle 1982; Hodder 1982). Despite these findings, and in contrast to that found elsewhere, west Mediterranean obsidian studies have been slow to change their methodological basis, with the recent exceptions noted above.

Theoretical differences are also present. In the 1980s and 1990s, anthropological research into exchange showed renewed interest in the work by Mauss (1990[1950]) and Malinowski (1922), who emphasised the social nature of exchange and the contemporaneity of different exchange mechanisms and levels. In these new studies, the social rather than the economic life of objects was now examined, and it was argued that objects moved between different exchange spheres, and could accordingly, change meaning during their life spans (Appadurai 1986). Moreover, other studies examined the influence of the western ways of thinking. It was argued that idealisation of non-western cultures, the recent 19th century separation of economic and social spheres, and the search for legitimacy of western society underlay much of the anthropological theoretical frameworks (similar insights developed in social landscape and technology studies, see Sections 2.1.2; 2.4.1). As a result, economic commodity exchange had been considered a western trait, and social gift exchange, a non-western one (Bazelmans 1996: 57-107; Carrier 1995; Gregory 1982; Bloch & Parry 1989). In the 1990s archaeological exchange studies started incorporating these new anthropological insights (*e.g.* Bradley & Edmonds 1993; Hodder 1982; Renfrew 1993; Robb & Farr 2005).

West Mediterranean obsidian exchange studies, however, seem to have solidified the distinction between commodity and gift-exchange into strict binary oppositions, which are linked to specific connotations and distribution patterns. Commodity exchange is seen as a form of down-the-line exchange, represented by fall-off curves. It carries socio-economic connotations such as functional, domestic, and common, where obsidian is often considered a prime example. Gift exchange, on the other hand, is socio-political with symbolic properties. Objects are scarce and exotic, both in terms of raw material and distances to sources (*e.g.* Barfield 1981; Skeates 1993; Tykot 1996). This type of exchange is considered highly visible and communicative; the objects display cultural messages that echo similar arguments in the 'style versus function' debate (see Section 2.3.3). Moreover, the two types of exchange are given a physical dimension. Down-the-line 'ordinary' exchange is suggested for the source areas and nearby regions, while gift exchange is suggested for the further away regions (Tykot 1996; 1999). A 'bird's-eye' view is visible, where an awareness of the original source is presumed on the part of the recipients (hence the 'exotic' designation), which is in actuality archaeological knowledge. A related problematic aspect is the role of obsidian exchange in the rise of Sardinian social complexity in the Bronze Age and bronze exchange networks. As we have seen above, obsidian networks are considered a 'prototype' of the bronze ones. Increased source control in Sardinia and an alleged prestigious role of Sardinian obsidian in the non-source areas, is supposed to have given rise to a semi-elite from which the Bronze Age elite grew. This viewpoint is clearly driven by an evolutionist perspective and overlooks the lack of any evidence for such source control. After all, the existence of quarries does not suggest control over a source area, as demonstrated by Torrence for Melos (1986). Moreover, the reasoning behind the importance of obsidian exchange networks holds a curious paradox. The start and end points (*i.e.* the sources and the receiving areas) are given paramount values, yet the middle (the use/value of obsidian in the source areas) is considered in functional terms with simple down-the-line, commodity exchange. Presumably, the near-complete lack of information on procurement, production and use in these areas has exacerbated this situation. Admittedly, not every source island was inhabited when sources began to be used, but certainly in Sardinia habitation predated west Mediterranean obsidian use. The paradox is effectively a physical representation of a 'meta' or 'linear' application of a general *chaîne opératoire* (see Section 2.2). I propose that the often-assumed direct causal relationship between the organisation of procurement, production and use underlies this paradox and its physical manifestation in a general *chaîne opératoire* (following Bradley & Edmonds 1993: 11). It is clear that contextual analyses of lithic procurement, production and use/discard in both, but especially source areas, is urgently needed (see also Bradley & Edmonds 1993; Gero 1989; Hodder 1982).

1.4. Conclusion

Following recent recognition that archaeological discourse analysis offers insights into understanding the predominance of certain research themes over others, I have reviewed Sardinian archaeological discourse and its impact on lithic studies. It was demonstrated that most Sardinian archaeological discourse is carried out in a cultural historical, theoretical, and methodological framework. Four elements: inevitable cultural progression, chrono-typological treatment of selective elements of material culture, intuitive interpretations and a Childean concept of culture, underlie most research but are particularly deep-seated in Prenuragic and Roman archaeologies. In contrast, discourse in Nuragic archaeology has shown a wider variety of theoretical and methodological approaches. I have also argued that two forms of isolationism run through Sardinian discourse that can be characterised as 'ordained' and 'self imposed'. The former is predominant in early prehistoric research and centres on countering, if not turning around, Sardinia's allegedly socially backward position in the Mediterranean. As a result, studies focus on finding early occupation and searching for evidence of contact with the Mediterranean through stylistic comparison and obsidian exchange networks. Self-imposed isolation refers to the view that the Nuragic period is the last and true indigenous society. The current situation in Sardinia, with the Italian presence considered the latest in a long line of colonisation, has contributed much to the understanding of this view.

In an extensive review of 'Sardinian lithic studies' I have concluded that this phrase is too generous for the current situation. Until very recently, the 19th century cultural evolutionist 'cataloguing-and-reporting' style has dominated. A restricted number of tool types are used to date sites, to establish contemporaneity, and to create site distribution maps. In the 1990s the LaPlace methodology was implemented, but this is largely a systemisation of the older practices. 'Ordained' isolationism has strongly affected obsidian studies. The desire to disprove the islands socially backward position has resulted in a focus on the role of Sardinia as a raw material source. In line with their theoretical framework most Sardinian archaeologists simply attribute an active role to 'merchants' or 'travellers', who control the trade. Non-Sardinian researchers, despite using sophisticated provenancing equipment and theoretical models, have maintained a colonialist perspective by only considering Sardinia as a raw material source. This is clearly visible in the strict binary opposition between commodity and gift exchange, the physical manifestation of a general *chaîne opératoire,* and the view of obsidian exchange as the forerunner of Mediterranean bronze exchange networks to 'explain' the rise of social complexity in the Nuragic period, the lack of evidence notwithstanding.

Thus, to date there is little done or known on lithic procurement, production, and use *in Sardinia,* with some notable and very recent exceptions (*e.g.* Table 1.8). This thesis was set up specifically to address this imbalance using a systematically collected dataset and a conceptually strong framework. The next chapter discusses the theoretical developments in social landscape, survey and technology studies that have been used to develop my theoretical and methodological approach to the study of lithic landscapes and taskscapes.

Chapter Two

Studying lithic landscapes and taskscapes: a conceptual framework

The previous chapter indicated that Sardinian archaeology, and lithic studies in particular, has overlooked several conceptual and methodological themes and approaches common today in Europe and the United States. This chapter reviews developments in the research areas that have inspired my research and helped me to formulate a conceptual and methodological framework for this study. It is divided into six sections:

1) Review current approaches to technology, and outline the merits of a social approach.
2) Evaluate the *chaîne opératoire* concept and its theoretical and analytical value.
3) Discuss current themes and approaches in lithic studies, focussing on procurement, production and use.
4) Examine regional studies, focussing on modern survey archaeology and social approaches to landscape to understand the *Riu Mannu* dataset in its wider context.
5) Evaluate lithic analyses in recent regional survey projects.
6) Discuss and define the key concepts used in this thesis.

2.1. The study of technology

Technology has always played a fundamental role in anthropology and archaeology, forming the basis of models of human evolution and civilisation. The concept itself and underlying assumptions, however, have rarely been studied (Dobres 2000: 11; Gero 1991; Graves-Brown 1995a; 1995b; Ingold 1990; 2000: 312-322, 362-372; Pfaffenberger 1988; 1992). A standard view of technology has developed with two predominant perspectives on the relationship between technology and human behaviour: technological somnambulism and technological determinism (Pfaffenberger 1988; 1992). In the former the 'rationalist' or 'commonsense' viewpoint prevails; the relationship is straightforward and can be defined simply in terms of 'production' and 'use'. The latter takes the opposite view. Technology determines people's social and cultural lives (Pfaffenberger 1988: 238-239;

also Dobres 2000: chapters 1-3; Loney 2000). Although distinct, both notions have their origin in western concepts of technology, and both underlie much of the thinking about prehistoric and/or non-western technologies. In recent years those views have been reappraised and the social dimensions of technology are increasingly the explicit focus of research (Dobres 2000; Dobres & Hoffman 1994; 1999a; Edmonds 1995; Greene 2004; Ingold 2000: 289-419; Loney 2000; Sinclair & Schlanger 1990).

2.1.1. A critique of the standard view of technology

Three recurring ideas characterise the traditional view of technology and have been evaluated by those advocating a more social approach. The first one is the idea that "necessity is the mother of invention" (Pfaffenberger 1992: 495). Culture is a nature-driven technological evolution or in other words, nature, not culture, defines necessity. As a result, it has been argued that technology can be objectively studied and is the main tool for understanding cultural changes. In prehistoric processual archaeology, studies have aimed to understand the influence of different environmental constraints on technology (see Section 2.3 below). Technology is the means by which man has adapted himself to environmental conditions and risks (Binford 1965; 1979; Torrence 1989a; see Sinclair 1990 for a critical review of the latter). And please note that the use of 'man' and 'himself' is deliberate. In the standard anthropological and archaeological perspective, technology and especially lithic technology, are very much seen as male endeavours. This is implicitly based on the modern perception, and reality, that technology as a male-dominated domain (Brumfiel 1992; Dobres 1995; 2000: 14-16, 19-33; Gero 1991; Pfaffenberger 1992).

The second idea is a result of the first. The meaning of an artefact is often divided into two distinct components: a primary, functional element and a secondary, stylistic or social/symbolic one. As a result, human behaviour has mostly been explained in functional terms, often equated with economic behaviour and studied separately from social relationships and society (Dobres 2000: 32-46, 47-69; Edmonds 1990; 1995: 9-19; van der Leeuw 1993; Lemonnier 1993a; 1993b; *e.g.* Section 2.3.2). Social aspects have not been completely ignored. The relationship between technology and society has been restricted, however, to the study of the effects of technological systems on culture and society, reduced to matters of communication and style, or considered as secondary to technical/physical constraints (Conkey 1990). The idea that techniques are also, if not predominantly, embedded in social constructions has mostly been overlooked. This disassociation is mirrored in the concentration on tools, rather than on tool-makers (*cf.* Creswell 1990; Dobres 1995; Ingold 1990; 2000: 346; Sinclair 1990).

The last idea is that the evolution of technology is a unilateral process from simple tools to complex machines, which in turn has been linked to simple and complex social organisation. This stems from an evolutionist viewpoint in which the (modern) concept of technology is the logical outcome. In turn, 18th and 19th century ways of thinking, in particular the Enlightenment, have been shown to underlie the evolutionist perspective (Dobres 2000; Gero 1991; Ingold 1990; 2000: 312-322, 362-372; Pfaffenberger 1988; 1992).

2.1.2. A social approach to technology

From the 1990s onwards the environmentally dominated view of technology has been challenged and a social approach to technology that emphasises the active role of people, societies, and cultural (social) influences on technology has been advocated (Brumfiel 1992; Dobres 1995; 2000; Lemonnier 1993a; Loney 2000; Pfaffenberger 1988; 1992; Sinclair & Schlanger 1990). These approaches have been inspired by the earlier work of French scholars, especially the anthropologists Mauss and Leroi-Gourhan. Mauss's notion of technology as a "total social fact", Leroi-Gourhan's creation of the term *chaîne opératoire*, and the emphasis on the organic, fluid, nature of techniques and actions that could lead to tradition and change, have become particularly prominent theoretical cornerstones (Edmonds 1990; Graves 1994; Schlanger 1990; 1994; see Section 2.2 below). Moreover, the term 'technology', and its derivatives (techniques, technical and technological) as well as their relationships to knowledge, practice, tradition, and change, have become important topics of discussion (Dobres 2000: 90-95; Ingold 1990; 2000: 294-311; Pelegrin 1990; Perlès 1992b; Pfaffenberger 1992; Schlanger 1990; 1998).

In these new studies, technology has been redefined as a socially embedded practice. People, their interactions, performances, knowledge and skills, instead of artefacts, are firmly put in the centre of the conceptual framework. Subsequently, the meaning of the term 'artefact' has also changed. It no longer only refers to a physical object but also to rites, ceremonies, activities and gestures (Dobres 1995; 1999; 2000; Dobres & Hoffman 1994; 1999a; Hoffman 1999; Ingold 1999; Pfaffenberger 1999; also Schiffer with Miller 1999, although there people-artefact relations remain central). Furthermore, it is argued that all activities are constructed in, and themselves construct, human interaction and are therefore always socially meaningful. Thus, technology can no longer be seen as an external and objective aspect that influences, but is not influenced, by people. It instead is a dialectic of "cultural practices, beliefs, social relations, politics and material realities" (Dobres & Hoffman 1999b: 3).

The use of social theory has shifted the focus to people as skilled and knowledgeable individuals, and has also highlighted the reciprocal nature of the relationships between micro scale personal/individual views, motives and actions, and macro scale processes, the communal group/society or so-called 'world views'/cognitive-social templates (Dobres 1999; Pfaffenberger 1999). Habitual and routine daily-life decisions and acts are intimately linked with interaction between individuals and groups, forming traditions and leaving room for variability and diversity in conveying, confirming, and challenging personal and communal interests. These in turn are reflected in tangible and intangible acts and objects (Dobres 1999; 2000; Dobres & Hoffman 1994; 1999; drawing on Bourdieu's theory of practice and *habitus* concept 1977; 1990)

> even at the scale of the individual artifact or trace of a technical activity, products and technical agents are forever situated within social communities, systems of value, and historical conditions. (Dobres & Hoffman 1999b: 7)

With this greater emphasis on cultural instead of environmental determinants, the boundaries between practical behaviour (economic, functional, domestic) and socio-political, ritual, ideational behaviour now appear rather arbitrary (Lemonnier 1993b; Trigger 1991). This distinction was previously unproblematic, but today some researchers maintain that, while artificial, it should be kept with explicitly defined terms and types of analysis (Karlin & Julien 1994; Schiffer & Skibo 1987; 1997; Trigger 1991). Others, however, argue it should be dispensed with entirely (Creswell 1990; Dobres 1995; 2000; Graves-Brown 1995b; Hodder 1990; Ingold 1990; Lemonnier 1990; 1993b; Robb 1998; Schlanger & Sinclair 1990).

In sum, social approaches to technology redefine technology as a "verb of human action and interaction" (Dobres 2000: 83), an arena with the *opportunity* for the definition, expression and negotiation of different types of interests, and as socially situated human behaviour. As such, it is a useful conceptual and analytical framework for a wide variety of archaeological time periods and contexts, and has formed one of the main sources of inspiration for this thesis.

2.2. The *chaîne opératoire*: a conceptual and methodological framework

As noted above, the *chaîne opératoire* concept has become increasingly common. The term, first conjured by Leroi-Gourhan, has usually emphasised action, and has been defined as a series of technical acts and corporal mannerisms carried out on a daily repetitive basis (Dobres 2000: 154; Edmonds 1990; Schlanger 1990; 1994). In most modern lithic studies the concept is applied using one or two, or both, definitions. On the one hand, it is an analytical tool for the reconstruction of technical and sequential orders of actions in which raw materials are transformed into cultural artefacts. Secondly, it is a conceptual tool, which aims at understanding the relationship between human behaviour and lithic technology. As such, it is in varying degrees, comparable to other sequence models like the American reduction sequence, the Japanese *gihō* ('technique') and the more general concepts of artefact life history and design theory (Bleed 2001; Dobres 2000: 154; Hayden 1998; Shott 2003; Schiffer & Skibo 1987; 1997; Sinclair 1990). It can be used to reconstruct the reductive process of one nodule. On a wider scale it also comprises the actions involved in raw material procurement, implement production, (re-)use, and final discard. Attention is also given to post-depositional processes, post-recovery studies and display (Pèrles 1992a; Sellet 1993). While it is often associated with lithic technology, the *chaîne opératoire* is increasingly applied to other materials and activities (Bleed 2001: 106; Dobres 1995; 2000: 181-187; Kassianidou, Van Lokeren & Knapp 2003; van der Leeuw 1993; 1994; Perlès 1992b; Roux 1990).

Recently, Shott (2003) has argued that there is no real difference between the *chaîne opératoire* approach and the American concept of reduction sequence. He has called the European and more specifically British/French insistence on a difference between the two, "intellectual provincialism" (Shott 2003: 103). It is important to address this point, and to consider the extent to which the two concepts may differ. Shott has acknowledged that those advocating the *chaîne opératoire* approach discuss cognition more explicitly, although its value is not always convincingly demonstrated in his opinion. He has argued, however, that the *chaîne opératoire* proponents are unaware or have ignored the fact that most reduction sequence studies also recognise and study the importance of cognition and cultural context along with material constraints (Shott 2003). Much of his criticism is valid. Indeed if the aim of the *chaîne opératoire* and reduction sequence approaches are described as the study of the relationship between human behaviour and lithic technology, then there is no real difference between the two approaches. It is not just a question of studying that relationship, however. The underlying difference in these views on what conditions human behaviour, nature or culture, marks an important distinction between *chaîne opératoire* and reduction sequence studies.

In the majority of reduction sequence, *gihō* and artefact life or design theory studies, the environment is seen as an external, objective, conditioning factor of lithic procurement, production and use behaviour (*e.g.* Andrefsky 1994; Bradbury & Carr 1995; Kardulias & Yerkes 2003; Torrence 1989a; Rozen & Sullivan 1989; see Section 2.3 below). Most archaeologists consider the idea that nature fully determines human (technological) behaviour is too strongly phrased, yet it is still seen as the main conditioning or constraining factor, what Trigger (1991: 561) calls the "systematic limitation of social organisation" (see also Hayden 1998). Cultural traditions, while important, are considered less influential. On the other hand, as discussed above, the *chaîne opératoire* concept follows Mauss's idea of technology as a socially embedded practice (see Section 2.1 above).

Moreover, socio-symbolic dimensions of objects and actions are still often opposed to functional dimensions and technical actions/gestures (see for instance the practical versus prestige technologies in Hayden 1998; also Gravina 2004; Perlès 1992a; Sinclair 2000). This division is sometimes accompanied by a temporal and contextual correspondence. Elaborate Neolithic and Chalcolithic knapping technologies and tool types, such as prismatic blade production, bifacially retouched tools, or polished axes, are seen as embodied with socio-symbolic meaning. The so-called expedient or simple technologies, such as flake production and the bipolar technique, in particular for later prehistoric and historic periods, are considered functional (Edmonds 1995: 184-189; Pelegrin 1990). These 'socially meaningful' artefacts are primarily found in burials and ritual deposits, while 'functionally meaningful' artefacts are present on settlements, off-site contexts and/or special purpose sites (often defined as functional tasks related to hunting or pastoralism!). Similarly, to study elaborate knapping techniques as conceptually separate from the expedient ones leaves a potential relationship unexplored, particularly when both are known to be spatially and temporally contingent. To clarify, I do not doubt that the former are socially relevant but I do contest the view that the latter are not. I would argue that to deny certain artefacts social meaning is absurd and limits interpretation (*contra* Lemonnier 1990; 1993b, see also Dobres 2000; Ingold 2000: 346 and note 4; Robb 1998; Sassaman 2000). After all, artefacts defined as more than just physical objects, become socially relevant through human interaction. This conceptual stance does not suggest that this interactive practice is always archaeologically tangible, but more importantly, the *potential* for it exists. By adopting such a viewpoint it becomes a matter of study. Furthermore, whether or not these practices were consciously expressed and perceived by their makers/users also becomes a research question.

The above discussion may have created the impression that the distinction between these approaches is clear. This is not the case, and presumably this lack of clarity led Shott to his conclusions. *Overall*, the division is there, if often implicit. Similarly, the impression might exist that studies carried out using either approach are all in agreement. This is not so. It is worthwhile emphasising that, while most social technology proponents agree that the *chaîne opératoire* serves as a promising mechanism for understanding the cognitive/social meaning of artefacts, opinions vary as to whether, and to what the degree, this social meaning can be recovered (Dobres 2000: 155-157; Hodder 1990; van der Leeuw 1994; Sassaman 2000; contra Lemonnier 1990; 1993; Trigger 1991).

Moreover, while the effectiveness of the *chaîne opératoire* for reconstructing mental templates has been extensively discussed, particularly in Palaeolithic studies, it has recently been argued that the concept has remained mostly abstract (Dobres 2000: 111; for examples see Karlin & Julien 1994; Pelegrin 1990; Pigeot 1990; Schlanger 1994; 1996). In fact, because mental knapping templates have become associated with humanity, intelligence, organisational and planning abilities, the debates have been restricted to elaborate knapping techniques and elaborately retouched tools (*e.g.* van Peer 1991; Pelegrin 1990; Sinclair 2000). Often a (unnecessary) separation between thought and action is maintained (Edmonds 1995: 9; Ingold 2000: 171; Schlanger 1996).

Thus, until recently, archaeologists have only considered certain aspects of the social and cognitive dimensions of technology and the *chaîne opératoire* (*cf.* Dobres 1995; 2000: 111). Marcia Anne Dobres and Mark Edmonds, in particular, have begun to redress this imbalance. They have combined the concepts of social and gender theory, further developing the *chaîne opératoire* concept as an analytical and conceptual tool within social technology studies (*e.g.* Dobres 1995; 2000; Dobres & Robb 2000a; Dobres & Hoffman 1994; 1999b; Edmonds 1995; Gero 1991).

In conclusion, the *chaîne opératoire* approach combines a rigorous analytical set of methods, to study the sequential transformation of natural resources into objects, with a more abstract notion that human social interaction can be articulated in acts and objects. Thus, it is an excellent theoretical and analytical tool to gain insight into Sardinian lithic technologies as socially situated practices.

2.3. Lithic studies: procurement, production and use

Lithic studies fall primarily in the domain of prehistoric technology studies (Edmonds 1995: 12). In order to understand how and to what extent technology studies have affected the development of theoretical and methodological frameworks, as well as the subsequent directions lithic research has taken, it is necessary to examine current themes and approaches. This section evaluates key theoretical and methodological topics in three main areas of lithic behaviour: raw material procurement, artefact production, and use. These also represent the main transformative stages of all sequence models currently used in most lithic studies (see Section 2.2. above).

2.3.1. Procurement

Procurement studies were predominantly developed in the framework of traditional technology studies. They generally include research into raw material sources, their chemical composition, location, availability and distribution, as well as the means and organisation of procurement and its relationship to the organisation of lithic technology (*e.g.* Andrefsky 1994; Ericson & Purdy 1984; Nelson 1991). Subsistence practices, raw material availability, or the degree of sedentism/mobility have all independently been put forward as the main conditioning factor in the organisation of technology and procurement (Table 2.1). Other studies have pointed out that one factor is unlikely to condition the organisation of technology on its own. Local and multicausal relationships between aspects like core and tool reduction intensity, environmental/climatic changes, artefact transport, site function and duration must also be taken into consideration (Bamforth 1991; Kelly 1988; Kuhn 1991; Rolland & Dibble 1990). Two types of raw material procurement strategies are generally recognised archaeologically: direct and indirect. In direct procurement strategies raw materials are obtained either embedded in other, subsistence-related, activities, or in special purpose trips. In indirect procurement, raw materials are acquired via exchange networks (Binford 1979; Ericson 1984).

Two concepts are central in most procurement studies: expediency and curation (Table 2.1; also Section 2.3.2 below). It has been argued that expedient assemblages develop as a response to unforeseen events, whereby the production and use of stone tools is instantaneous. In contrast, curated assemblages are produced to anticipate future needs (Binford 1979; Binford & Stone 1985). It has been further argued that procurement strategies for both concepts differ. Expedient assemblages respond to the quantity of immediately available raw material, whereby high quantities lead to assemblages with little modification, highly variable reduction strategies, and high replacement rates.

Subsistence	Mobility	Technology	Procurement	Source use	Main references
EGALITARIAN GROUPS					
Hunter-Gatherers: Foragers	High	Curated	Direct, embedded	Local & non-local raw materials	Binford 1979; 1980; Binford & Stone 1985
Hunter-Gatherers: Collectors	Low: seasonal / annual	Expedient	Direct, embedded	Local raw materials	
Hunter-Gatherers	High	Curated	Direct, embedded / special purpose trips	Local secondary sources / non-local primary raw materials	Bamforth 1990; Cowan 1999; Ericson 1984; Gould 1985; Kelly 1992; Nelson 1991; Newman 1994; McAnany 1988
Farmers	Low: mostly sedentary	Expedient	Direct / Indirect: down-the-line exchange for non-local raw materials	Local raw materials	Andrefsky 1994; 1998; Bradbury & Carr 1995; McAnany 1988; Parry & Kelly 1987; Torrence 1986
STRATIFIED GROUPS					
Not applicable	Low: mostly Sedentary	Craft specialisation	Indirect: prestige / gift exchange for elites	Non-local primary source raw materials	Johnson 1996; Nassaney 1996; Shafer 1985; Torrence 1986
	Low: mostly Sedentary	Expedient	Direct: domestic use	Local secondary source raw materials	Edmonds 1995; Rosen 1996; 1997
STATE-LIKE GROUPS					
Not applicable	Not applicable	Craft specialisation	State / Elite control / prestige	Non-local materials	Johnson 1996; Peterson *et al.* 1997
		Expedient	Non-elite / domestic	Non-local materials	Johnson 1996; Peterson *et al.* 1997

Table 2.1. An overview of the main relationships between subsistence practices, social organisation, organisation of technology and procurement strategies.

Procurement for curated artefacts on the other hand was predominantly carried out while engaged in basic subsistence activities. In these so-called 'embedded' strategies, procurement costs are low (Binford 1979: 266-267). This line of reasoning has serious consequences for interpretations of non-local and/or exotic artefacts. In Binford's view they simply represent the range of exploited resources rather than special purpose direct procurement trips or symbolic and/or ideational representations of long-distance exchange networks. This triggered the 'righteous rock'/ 'exotic stone hypothesis' debate between Binford and Gould (Binford 1979: 259-261; Binford & Stone 1985; Gould 1978: 821-833; 1985; Gould & Saggers 1985). Unfortunately, one of the consequences of this debate and subsequent research is the consolidation of Binford's concepts into fixed binary oppositions. Expediency is contrasted with curation, sedentism with mobility, direct with indirect procurement and local with non-local or exotic. Links between these concepts are often proposed so that local is associated with secondary sources, direct procurement, and expedient technologies, while non-local or exotic materials are evidence for exchange, craft specialisation, and curated technologies (Table 2.1). This tends to ignore the fact that, first of all, it is very difficult to draw such clear-cut distinctions. Secondly, it leaves little room for the examination of interaction, and thirdly, it assumes unambiguous archaeological representations (but see Kelly 1992). With regard to distribution patterns, it is unfortunate to see that Binford's original, carefully formulated categories have become formalised and opposing entities, whereby sites are identified as either base camps or special-task sites (Andrefsky 1998: 201; Binford 1980; Van Reybrouck 2001). Today, the main explanation for the presence of local and non-local raw materials in hunter-gatherer lithic assemblages as well as for expedient and curated assemblages, is direct procurement embedded in subsistence activities or special purpose trips (Table 2.1; *e.g.* Féblot Augustins 1993; Morrow & Jefferies 1989; Seeman 1994). Sedentism, on the other hand, is associated with expedient assemblages. In non-egalitarian groups and state-like societies exchange and craft specialisation have been offered as the main explanations for non-local materials, curated, and specialised assemblages. This is often linked with the opportunity for expressing social inequality through control of either sources and/or exchange networks (Table 2.1).

Binary oppositions are also present in the studies of raw material availability and accessibility (Table 2.1). Primary sources are restricted in their distribution and often raw material is either deeply buried underground or exposed in high mountainous areas, preventing easy access and necessitating certain skills and tools for retrieval. Secondary sources, instead, are more widely dispersed across the landscape surface, allowing easier access and necessitating less time, effort and skills for their extraction (Bradley & Edmonds 1993; Gardiner 1990; Jeske 1989; Ricklis & Cox 1993). Besides physical restraints, social control can also affect accessibility. This can be organised along the lines of gender, age, kinship or social hierarchy and is not always recognisable in the archaeological record (Burton 1984; Gould & Saggers 1985; McBryde 1984; but see Bradley & Edmonds 1993 and Topping 2004 for persuasive archaeological examples). The effects of raw material availability, especially quantity, quality, size and shape, on reduction sequences and artefact design, have been studied in detail (Andrefsky 1994; Bamforth 1990; Bradbury & Carr 1995; Newman 1994; Seeman 1994). Some scholars have acknowledged, but not studied in any detail, the existence of deliberate raw material selection criteria (Bradbury & Carr 1995; Green & Zvelebil 1990; Kuhn 1995: 83; Zvelebil *et al.* 1992).

Thus, for hunter-gatherer procurement a predominantly techno-economic explanation is preferred while for the sedentary groups a socio-economic one is more accepted. This is entirely in line with the view that technology is a means to adapt to nature; hunter-gatherers are considered dependent on nature while sedentary groups are considered to control it (Ingold 1990; see Section 2.1 above).

2.3.2. Production and use

Production and use studies developed out of a similar traditional technology framework. Lewis Binford's questioning of the idea that differing tool types serve as cultural markers has been particularly influential (Binford 1978; 1979; 1980; Binford & Binford 1966). Despite originally being a discussion of Middle Palaeolithic (Mousterian) stone tool variability, the ensuing 'functional argument' (also called the 'Bordes-Binford' debate or 'archaeological behaviourism') has had a broad impact on lithic studies. Tool assemblage variability has often been used to infer site functions, activities, occupation span, as well as regional settlement/mobility and subsistence patterns (Rowland & Dibble 1990; Shott 1989b; see also Section 2.4 below). As a result, lithic studies have greatly expanded conceptually and analytically (Conkey 1990; Perlès 1992b; Sackett 1982: 63-67). Moreover, with the development of sequence models, many studies have examined specific tool production systems, and/or have concentrated on identifying production specific variables, artefacts and artefact classes, often with the use of controlled knapping experiments (*e.g.* Ammerman & Andrefsky 1982; Andrefsky 1998; 2001; Bradbury & Carr 1995; 1999; Kelly 1988; Perlès 1992b; Rozen & Sullivan 1985; 1989; Schlanger 1996; Shafer 1985). Others have focussed on establishing the factors that condition tool assemblage formation and variability, and on identifying archaeological correlates to determine site types/functions and tool morphology (*e.g.* Cowan 1999; Kuhn 1995: 14-17; Nash 1996; Odell 1996c; van Peer 1991; Sackett 1982; Shott 1996). Tool use-lives, tool curation, maintenance, recycling, dropping/discard rates, raw material availability, occupation span, task performances, and risk buffering have all have been put forward as particularly influential (*e.g.* Ammerman & Feldman 1974, Bleed 1986; Hayden *et al.* 1996; Kelly 1988; Nelson 1991; Shott 1989a; 1989b + comments; Torrence 1989b). These advances, however, are mostly methodological. With the development of the *chaîne opératoire* approach in the last decade, matters such as intention, cognition and social topics have come to the fore (Perlès 1992b, see Section 2.2 above).

The binary opposition of 'expediency versus curation/craft specialisation' is again strongly present and it is worthwhile to investigate these concepts in more detail. Expediency is the principal explanation for 'simple' production techniques and 'unstandardised' tool types, irrespective of archaeological periodisation. It is often simply defined as the opposite of curation/craft specialisation but with negative connotations (*i.e.* 'simple', 'unsystematic', 'unstandardised', 'non-specialised', 'informal': Table 2.2). Curation and craft specialisation are both used to explain 'complex' production and elaborately retouched tools. As a result, both use similar concepts, characteristics, and language (*e.g.* standardisation, rejuvenation, preparation: Table 2.2). As demonstrated above, chronological and resulting socio-political distinctions underlie the main differences between these two explanations.

	Expediency	Curation	References	Craft specialisation	References
Source use	Local	Local/Non local	Binford 1979; Nelson 1991	Non-local	
Type of production	Debitage production	Tool / core production	Bleed 1986; Kelly 1988; Perlès 1992b	Tool production and elaborate reduction sequences	Bamforth & Finlay in press; Pelegrin 1990; Perlès 1992b
Characteristics & concepts	Simple; informal; unsystematic; expedient; unstandardised; individual skills (talent versus learnt skills)	Efficiency; advance planning; maintainability/ reliability; flexibility; recycling; multifunctionality; maximum utility	Bamforth 1986; Bleed 1986; Eerkens 1997 1998; Hayden *et al.* 1996; Nelson 1991; Odell 1996c; Shott 1986; 1989a; 1989b; 1996	Standardisation & intensification of and control over procurement, production and distribution process; increased spatial and technical division of labour	Bradley & Edmonds 1993; Cherry & Knapp 1994; Gardiner 1990; Högberg 2002; Inizan *et al.* 1999; Pelegrin 1990; Topping 2004
Attributes	No/little standardisation in reduction; no/little retouch; no/little (core) preparation	High degree of retouch, high standardisation/ formalisation of retouch; high degree of rejuvenation; resharpening; size – thickness correlations	As above; but see Teltser 1991 who views expedient assemblages as flexible	High regularity & consistency; high level of skill (core preparation, precision and low error rates); rejuvenation; technical overinvestment; maintenance; workshops	Costin & Hagstrum 1995; Eerkens 2000; Eerkens & Bettinger 2001; Johnson 1996; Nassaney 1996; Shafel 1985; Shelley 1990
Industries	Bipolar; simple flake production; simple blade production	Prismatic blade technology; bifacial technology	Andrefksy 1998	Danish flint daggers; Solutrean points; Folsom points, Clovis points	Bamforth & Finlay in press: Figure 1; Sinclair 2000
Organisation	Household / individual/community specialisation	Household / individual/community specialisation	Binford 1979; Costin & Hagstrum 1995: table 1	Part time/full time specialists; apprentices and masters; independent/ attached specialists; workshops	Bradley & Edmonds 1993; Costin & Hagstrum 1995; Gero 1989; Torrence 1986
Social information	Socio-economic	Socio-economic	Binford 1979; Bleed 1986; Nelson 1991	Socio-political: elite status/ power symbols	Gero 1989; Nassaney 1996
Meaning	Functional / domestic	Functional		Symbolic	

Table 2.2. The associations between different elements of expedient, curated technologies and craft specialisation.

Curation is an explanation developed for early prehistoric (Palaeolithic and Mesolithic) egalitarian hunter-gatherer groups, interpreted in socio-economic and functional terms. Craft specialisation has mainly been discussed for later prehistory, in particular in exchange and social complexity studies, although notable exceptions exist, especially in recent studies that have examined Upper Palaeolithic blade production using the *chaîne opératoire* concept (*e.g.* Pigeot 1990; Sinclair 2000). Models often focus on socio-political interpretations (Section 2.1.1).

Curation, however, has developed within a specific context – the functionalism argument – and was initially broadly described as, "the practice of maximizing the utility of tools by carrying them between successive settlements" (Binford 1979: 263). While often used, there is still little consensus on its definition, archaeological correlates, associated concepts, and other factors influencing tool morphology. Shott, for instance, has maintained a restrictive tools-only attitude, arguing that they are the only objects being used (Shott 1989a; 1996: 266). Others, however, have pointed out that production processes can also be curated, and include core reduction and debitage analysis in their analyses (Hayden *et al.* 1996; Kelly 1988; Kuhn 1991; 1995; Nash 1996; Odell 1996c; Ricklis & Cox 1993).

Craft specialisation has been less restricted. It is studied across a wider variety of raw materials and has employed more variables and attributes. It is not solely focussed on tools but often includes production and procurement (Table 2.2). High degrees of standardisation and skills, increased intensification and scale, task-separation of production and tools, low diversity and error rates have all been put forward as archaeological indicators of craft specialisation (Bradley & Edmonds 1993; Costin & Hagstrum 1995; Gero 1989; Nassaney 1996; Shafer 1985; Torrence 1986). To date, most studies have focussed on the 'high end' of craft specialisation, primarily dealing with complex reduction sequences and adult male expert knappers (*e.g.* 'masters'/'apprentice workshops': Table 2.2; also Section 2.2). Domestic learning contexts, expedient technologies, and female knappers have largely been downplayed or overlooked (Bamforth & Finlay in press: 3; but see Gero 1991; Lindgren 2003; Weedman 2002).

Thus, in both curation and craft specialisation studies, only a small selection of artefact variables, artefacts, and/or artefact groups are attributed with social information (Table 2.2). The 'style/function' debate clarifies and illustrates this well. In the 'functional argument', 'style' was a residual feature that could only be studied after functional aspects like raw material, manufacture, and use, had been accounted for. Consequently, only a small selection of artefacts and attributes had 'style' and transmitted social information (Binford 1986; 'adjunct' style in Sackett 1982: 82-104). In the 1980s and 1990s researchers attempted to define style, locate its characteristic artefacts and attributes, and correlate it to specific types of human behaviour. Eventually, discussion was consolidated into two main approaches characterised by an active/passive binary opposition (Table 2.3).

Active style can be classified as a 'symbols as tokens' approach, where only a small number of artefacts/attributes intentionally convey social information. Such studies also tend to concentrate on a specific type of social information, namely social complexity, power, status, and boundaries (Robb 1998: 332-334; also Conkey 1990).

Type	Description	Social information	Artefacts	References
Emblemic/ iconological /active	Intentional transmission of social information	Explicit: social complexity, power, status and boundaries (symbols as tokens)	Certain objects / attributes	Conkey 1990; Gero 1989; Robb 1998; Sackett 1985; 1986a; 1986b; 1990; Wiessner 1983
Isochrestic variation / Passive	Passive trans-mission of cultural information. Equal relationship between social and functional requirements	Implicit: variation as result of passive human choices, conditioned by technical, social and ethnic/cultural traditions (symbols as girders)	All material culture	Conkey 1990; Sackett 1982; 1985; 1986a; 1986b; 1990; Robb 1998; Wiessner 1984; 1985; 1990

Table 2.3. The two main approaches to style.

Isochrestic variation on the other hand, accentuates the conditioning role of cultural structures in artefact variability and the passive nature of human choices (Table 2.3). Some elements, in particular the importance of learnt (technical) knowledge and skills and the presence of social influence in all elements of material culture, resemble Bourdieu's *habitus* (see Section 2.6) and the 'symbols as girders' approach (Robb 1998: 334-337). It is decidedly different from the latter in its insistence on the merely passive nature of human choice and its etic analytical values (Conkey 1990).

As for procurement strategies, these differences and developments can be understood within the underlying environmental determinist attitude and the evolutionist, progression-biased, stance to societal changes in traditional technology studies (Loney 2000; Pfaffenberger 1999). In particular its use of the somnambulistic approach in traditional technology studies first expanded but later restricted lithic research. Two main consequences can be seen. First of all, it has led to a division in production and use with an associated, and presumed straightforward, relationship to unretouched and retouched artefacts. While use wear analysts have questioned links between use and retouched artefacts, a straightforward 'use-as-function' approach is usually maintained (*e.g.* Odell 2001; for Sardinian obsidian see Hurcombe 1992a; 1992b; Hurcombe & Phillips 1998). In a recent ethnographic study on artefact variability and intentionality, Hiscock (2004) also cautioned, amongst other things, against the use=retouch association. Secondly, research of elaborate knapping activities and extensively retouched artefacts predominate, presumably also a consequence of our 'finished artefact fallacy' (Davidson 2002), or the more general (western/modern) distinction between art and technology (Graves-Brown 1995a; Ingold 2000: 348-361). Most lithic specialists have largely neglected the different strategies employed within larger sequences or have overlooked systemisation and variation in simple technologies and plainly retouched artefacts (but see Edmonds *et al.* 1999; Gero 1989; 1991; Lindgren 2003; Schlanger 1996; Wobst 2000; Section 2.2).

In summary, binary oppositions are ubiquitous to many lithic studies. While heuristically convenient, this concentration on two extremes of the spectrum has ultimately restricted research. Recent analyses have made it clear that a socially-situated, historically-specific, and engendered perspective to all lithic contexts, *i.e.* including local and secondary sources, simple primary and secondary flaking strategies and survey data, is viable and revealing (Bamforth & Finlay in press; Edmonds *et al.* 1999; Gardiner 2004; Högberg 2002; Lindgren 2003). The need for more of these nuanced viewpoints has also influenced the conceptual and methodological approach implemented in this thesis (Section 2.6).

2.4. Survey and landscape archaeology

Survey and landscape archaeology has had another important conceptual and methodological influence on this thesis. This section reviews regional archaeological projects in which survey and landscape studies have originated, focussing on recent approaches to landscape. Secondly, it discusses current themes and approaches in Mediterranean and British survey archaeology that are relevant to gaining an understanding of the *Riu Mannu* dataset, focussing on the changing nature of site and off-site concepts, their influences on fieldwork methodologies, and recent interpretative models for prehistoric off-site material.

2.4.1. Approaches to regional landscapes

Modern regional archaeological projects have their direct origins in processual and settlement archaeology, and in particular, in Binford's paper (1964) on the need for regional studies to understand cultural systems, and human settlement in relation to the environment (Fotiadis 1997; Knapp 1997: 3; Sherratt 1996). Early regional archaeological projects therefore concentrated on the role of the physical landscape, which was thought to determine or condition the socio-economic developments of cultures and societies (Trigger 1991). As a result, corresponding with their specific aim to gain insight in the (socio-)economic organisation of human groups, archaeologists have mainly explored the relationships between settlement locations, settlement patterns and systems, subsistence and resources (van Dommelen 1998: 37-39; Knapp 1997: 1-18; Ashmore & Knapp 1999). In the Mediterranean, the use of the Braudelian, and later the *Annaliste*, concepts of *conjectures, longue durée* and *mentalités* has offered a more subtle approach by combining the long-term influences of nature and technology with the medium and short term effects of social, economic, political, ideological structures and events (Barker 1991; 1995a: 1, 308; Bintliff 1991a; 1996; 2004; Delano Smith 1992; Lewthwaite 1988; Meyer & Knapp 2003: 8).

From the 1980s onwards these key views on societies and cultures, and particularly the conditioning factor of the environment on human behaviour, have been challenged and criticised (see Ashmore 2004 for a recent overview). The postprocessual reaction has pointed to the much more convoluted and interactive nature of the relationship between human action and the landscape, negating the idea of landscape as either a passive backdrop or prime factor in determining behaviour. It has also moved away from macro scale and universal analysis, instead allowing more room for the individual and the uniqueness of local traditions, customs, practices and perceptions. Likewise, it has disputed processual archaeology's claims to objectivity, instead demonstrating how the researcher's cultural and academic background influence data collection and interpretation (Bintliff 1991b; 1996; Fotiadis 1997; Meyer & Knapp 2003: 8-9; Sherratt 1996).

It should be noted that while processual and postprocessual approaches are often juxtaposed, or presented sequentially, both originate within two western 18th century lines of thought: the Enlightenment and Romanticism. Their influence on regional studies, and for that matter the western way of thinking and living, should not be underestimated (van Dommelen & Prent 1996; Sherratt 1996). Some have therefore argued for a convergence of both approaches rather than a separation (Bintliff 1996; Lekson 1996; Lemaire 1997; Roymans 1996; Sherratt 1996).

The majority of regional archaeological projects' approaches to the concept of landscape are explicit; the physical landscape exists alongside people's socio-symbolic perception of it. Recent developments in landscape archaeology on the other hand have emphasised an inherent approach to landscape where the natural landscape embodies, and thus cannot be separated from, cultural landscapes (Ashmore 2004; van Dommelen 1999b; Johnston 1998; Knapp 1997: 1-18; Knapp & Ashmore 1999). Instrumental in these developments has been the realisation that the concept of landscape itself is a modern, and predominantly western construct derived from landscape painting, and as such should not be automatically applied to pre-modern societies (Lemaire 1997 with comments by Bergue, Cosgrove & Ingold). Similarly, the term 'landscape' is not fixed, it has different connotations for each researcher (Johnston 1998; Knapp & Ashmore 1999: 6). As discussed above, in technology studies similar themes have been explored, in particular, regarding the role technology plays as a functional or social device in the relationship between nature and culture (Section 2.1; also Dobres 2000: chapter two). For this thesis, Tim Ingold's (1993: 162) redefinition of landscape as "the congealed form of the taskscape" has been particularly insightful (see Section 2.6 below). With 'taskscape', Ingold offers a key concept that merges, rather than opposes, the temporality and historicity of people's interlocking activities/tasks. Moreover, it emphasises a rhythmic and cyclic nature of (inter-)action, thus avoiding a linear, progressive, perspective, which often maintains a hierarchical distinction between fixed beginnings and endings (Ingold 1993; also 2000: 189-208).

2.4.2. Regional survey projects

Regional systematic surface explorations (surveys) were developed from the 1960s onwards, although unsystematic collecting of artefacts from the surface has always existed. It was argued that surveying has the advantage over excavation in allowing for coverage of large areas and thus significantly increasing the number of known settlement sites in regions. This, in turn, has permitted an improved assessment of spatial and temporal changes in settlement patterns (Ammerman 1981; Cherry 1983). In the last two to three decades, survey archaeology in the Mediterranean and elsewhere has changed substantially, although not without debate (Alcock & Cherry 2004; Ammerman 1981; Barker 1996; Bintliff *et al.* 2000; Cherry 1983; Flannery 1976; Hope-Simpson 1983; 1984; Keller & Rupp 1983; Terrenato 1996; 2000a). The following subsections discuss three developments in survey archaeology that are particularly relevant to this thesis: the changing nature of the concept 'site' and 'off-site'; their impact on fieldwork methodologies; and the recent theoretical discussion on the effectiveness of survey archaeology for the analysis of prehistoric material.

2.4.2.1. Site and off-site archaeology

One of the most influential changes in survey archaeology has been the reappraisal of the concept of 'site' and the introduction of 'off-site'. Archaeologists have become increasingly aware of a continuous spread of archaeological artefacts on the landscape surface, the so-called 'carpets' of finds (Bintliff & Snodgrass 1988: 506), ethnographic examples where high artefact densities do not represent settlements, and the impact of postdepositional processes on artefact distributions (*e.g.* Cherry 1983; Foley 1981a; 1981b; Gallant 1986; Isaac 1981; Rossignol & Wandsnider 1992;

Schofield 1991a; 1991b; Shennan 1985: 35). To articulate that understanding, a variety of terms like 'off-site', 'non-site', 'high density patches', 'low density scatters', 'siteless surveying', 'Places Of Special Interest' (or POSI) and 'Special Interest Area' (or SIA) have been introduced. Increasingly detailed artefact studies are used to infer use, function and chronology with the specific aim of understanding the different human activities across time in the physical and social landscape (Alcock 2000; Bintliff 2000a; 2000b; Cherry *et al.* 1991: 13-35; Given & Meyer 2003; Mattingly 2000; Schofield 1991b; 1994; 2000a; van de Velde 2001). The term 'site' is now no longer simply equated with settlement.

Few archaeologists deny the existence of off-site material but its interpretation is more problematic (Barker 1996; Bintliff 2000b: 208; Knapp 1997: 11-12). In the past several interpretations have been put forward where it is worthwhile to distinguish between interpretative models for lithics and those for pottery (Table 2.4). It is evident that lithic interpretations for off-site activities are less problematic and less often debated than those for pottery. In fact, lithic artefacts rarely feature in current theoretical discussions, which is surprising since the very notion of off-site came from hunter-gatherer and pastoralist studies that primarily used lithic surface material (*e.g.* Binford 1978; 1979; 1980; Foley 1981a; 1981b; Gallant 1986; Isaac 1981). Generally, it is through lithic analysis that a wide variety of off-site activities have been recognised in Europe and the Mediterranean, with dates varying from the Palaeolithic to the Iron Age. Artefact densities range from single isolated finds, such as arrowheads, to extensive high-density areas (Table 2.4). Thus, recording *lithic* off-site material is wholeheartedly accepted, if not always studied in detail (Bintliff 2000b; Fentress 2000).

Four main causes are often cited for low density pottery off-site material. The first, the 'broken pot scenario', is rarely considered seriously. The second explanation, activities taking place away from settlements, is more credible but also more generic. Few activities are identified in detail. The last two interpretative off-site models, which are the most recent, theoretically explicit and hotly debated, involve low density, prehistoric and classical pottery scatters (Table 2.4; see below).

	Ceramics	References	Lithics	References
Low artefact density	Accidental loss theory or the proverbial 'donkey or broken pot scenario'.	Bintliff & Snodgrass 1988: 507; Cherry *et al.* 1991: 50; Erdoğu 2003; Fentress 2000; Alcock *et al.* 1994; Bintliff & Snodgrass 1988: 507-508; Bintliff 2000b; Cherry *et al.* 1991: 50-53; Fentress 2000; Pettegrew 2001	Vestigal, localised activities	Edmonds *et al.* 1999; Jones *et al.* 1989
	Activities away from settlement: burials, gardens, storage sheds, animal pens, refuse dumping			
	Vestigial prehistoric sites or hamlets	Bintliff *et al.* 1999 + comments ; see text	Hunting, pastoralism, and/or small-scale field clearances	Barker 1995a: 8-104, 155-158; 2000; Erdoğu 2003; Loving and Kamermans 1991: 111-112; Malone 1994: Figure 3.7; Reynolds 1994; Schofield 1991c
	Residual classical scatters representative of less intensive or shorter-term occupation	Pettegrew 2001; 2002; but see Bintliff *et al.* 2002		
Medium/ High artefact density	Site 'haloes': decreased artefact distributions around high-density concentrations caused by modern ploughing, animal burrowing and erosion processes (for instance wind, water, and slope effects)	Ammerman 1985b; Bintliff & Snodgrass 1985; 1988: 508; Fentress 2000; Terrenato & Ammerman 1996; but see Cherry *et al.* 1991: 54 and note 7; Pettegrew 2001	Raw material procurement and production, butchering	
	'Manuring' hypothesis: field manuring caused widespread distributions of settlement-derived (in-)organic material, providing unique insights into classical, and later, land use and settlement patterns	Bintliff & Snodgrass 1988; Bintliff 2000b; Gallant 1986; Given 2004; Wilkinson 1982; 1989; 1994 including comments; 1998; but see Cherry *et al.* 1991: 50; Alcock *et al.* 1994; Fentress 2000		

Table 2.4. Current interpretative models for lithic and ceramic off-site material.

In light of these problematic aspects and the high costs of research-time it was recently argued that counting off-site *pottery* is not necessarily worthwhile (Terrenato & Ammerman 1996; Fentress 2000). Clearly, only counting off-site material is problematic because it does not allow for chronological distinctions. Studies with systematically collected and detailed post collection technological and typological analysis of off-site ceramic assemblages have shown valuable information can be obtained (van Dommelen 2000b; Given 2004; Given & Knapp 2003; Knikman-Stoetman 2000).

With the advance of landscape archaeology a much broader definition of 'site' is used in which many off-site activities are now often included in the 'site' approach (Knapp & Ashmore 1999). As van de Velde has recently noticed, this has resulted in an unacknowledged shift in the meaning of the term 'off-site' (2001: 29). Initially, the term complemented 'site', referring to activities carried out away from the main settlement or home base. Now however, it has settled into a binary opposition with material is more strictly interpreted as 'background noise' or remnant material that can no longer be understood and is without any obvious patterning (van de Velde 2001: 27-30, also note 1).

2.4.2.2. Influences on fieldwork methodologies

The increased importance of off-site material and artefact densities across landscapes has significantly changed fieldwork methodologies. Much time and effort has gone into investigating influences of natural and cultural (site) formation processes such as 'walker' and 'field' effects, 'ground' and 'archaeological' visibility, artefact densities and reconstructions of original settlement patterns. The effects of fieldwork methodologies on reconstructions of settlement patterns, and the subsequent integration of data interpretations between projects in, and across, regions, are also increasingly studied (Alcock & Cherry 2004; see also Table 2.5). Moreover, research interest and design, the existence of previous research, permission obtained for the type, extent and duration of fieldwork as well as the fieldwork costs for analysis and storage, vary widely per region and project.

Methodological concerns	Definition/examples	Solutions	References
'Walker' effects	Differential abilities to recognise certain material categories	Rotations, instructions on artefact recognition before fieldwork or surface clearance	Barker 1995a: 47-48; Bintliff *et al.* 1999: 146; Coleman 2003; Kardulias & Runnels 1995; Shennan 1985: 33-45; van de Velde 2001
'Field' effects	Ground visibility: influence of factors such vegetation, modern land use, weather conditions on find densities and material categories	Standardised categories reflecting surface visibility. Formulae to evaluate and/or adjust density distribution maps	Bintliff *et al.* 1999; Meyer & Schon 2003; Terrenato & Ammerman 1996; Terrenato 2000b; Verhoeven 1991; but see Schon 2000 and van de Velde 2001: 27-28's critique on use of multipliers
	Type and extent of factors involved in burial and exposure of artefact assemblages	Controlled experiments	Ammerman 1985c: 21-25; Foley 1981b; Given 2004; Schofield 1995b; 2000a; Wandsnider & Camilli 1992
	Relationship between surface scatters and subsurface (ploughzone)		Ammerman & Feldman 1978; Ammerman 1985b; 1985c: 26-37; Schofield 1991a; Steinbeck 1996
Site recognition or survival	Sites 'coming on and off like traffic lights': diversity, extent, density and interpretation of surface scatters and original settlement patterns	As above and repeated surveying	Ammerman 1995; Bintliff & Snodgrass 1988: 509; Shott 1995 and references therein; Terrenato & Ammerman 1996 but see Davis & Sutton 1995
'Archaeological visibility'	Effects of factors such as preferred locations for settlement, the type of settlement (nucleated versus dispersed), types and quality of material categories and differential survival rates, differential access to materials and/or differential intensity and frequency of activities	As above	Barker 1995a: 48; Bintliff 2000a; Meyer & Knapp 2003; Schofield 1991b
Interproject or interregion data integration & comparisons	Effects of increasingly intensive, small-scale and convoluted research designs, fieldwork methodologies and correction factors designed to deal with local circumstances on effectiveness of direct comparisons	Explicit and detailed explanations of methodologies. Agreed variety of basic reliable techniques or postprocessual 'field survey handbooks'	Alcock & Cherry 2004; Bintliff 2000a; Given 2004; Mattingly 2000; Schofield 1995c; 2000b; Shennan 1985: 3; Terrenato 1996: 217; 2004
Value & relevance of absolute counts	Influence of collection strategies on settlement pattern reconstructions	Count densities, selective collection of diagnostic artefacts. Collection of all artefacts	Ammerman 1985b; Fentress 2000;Given 2004; Meyer & Knapp 2003; Shennan 1985: 34; Terrenato 2004; van de Velde 2001

Table 2.5. Methodological concerns, definitions, solutions offered/examined and references for effects of various cultural and natural site formation processes on artefact densities and distributions.

To acknowledge these differences and to facilitate the comparison between projects in and across regions, survey projects explicitly detail their methodologies (*e.g.* Barker 1995a; Bintliff & Snodgrass 1985; Cherry *et al.* 1991; Davis *et al.* 1997; Given & Knapp 2003: 25-59; Loving *et al.* 1991; Malone & Stoddart 1994; Mee & Forbes 1997: 33-41; van de Velde 2001; Wright *et al.* 1990, for recent overviews and discussion of existing methods see Given 2004; Mattingly 2000). Clearly, relationships between artefact densities and settlement patterns might not be as straightforward as once hoped, but many of the concerns listed also affect excavated material. Moreover, in some ways the search for 'original' patterns is a fallacy. Not only is the term 'original' remarkably undefined, but it also implies a 'first' starting moment, which gives a false sense of fixture and purpose. Furthermore, use of correction factors clearly helps to understand which areas are less reliable in terms of artefact densities, but multipliers in themselves do not increase site diversity (van de Velde 2001).

To date, there is limited work on the potential of surface material for social inferences, or a phenomenological approach with an emic rather than an etic viewpoint (Barker 1996; Bintliff 2000a; Meyer & Knapp 2003). This might develop in time. Much of the critiques are recent and while adjustments have been made to project methodologies, their effects on analytical and theoretical models are slower since they take time to develop, and be published (but see van Dommelen 1998; Given & Knapp 2003).

2.4.2.3. 'Hidden' early prehistoric landscapes?

A recent theoretical discussion on the effectiveness of survey archaeology for understanding early prehistoric material illustrates the complexity of the increasingly dichotomist distinction between site and off-site, and the methodological concerns over artefact densities and distribution patterns very well. Bintliff and colleagues (1999; 2000, 2002) have argued in their 'hidden landscape' hypothesis that while the success of survey archaeology is evident for later prehistoric and historic periods, earlier prehistoric periods are under appreciated, disadvantaged, or only marginally present in Mediterranean datasets. Previously, others (*i.e.* Barker 1995a: 50-51; 1996; Bintliff & Snodgrass 1985) hinted at this phenomenon, but Bintliff and associates have argued the case most extensively and eloquently. Based on their long-standing survey in Boeotia and published data from other areas in the Aegean, they claim that the number of prehistoric sites and their distribution is so patchy and thin that little can be said about settlement patterns, settlement hierarchy, population density, and land use, despite ever more intense surveying. They offer three explanations: 1) frailty of prehistoric coarse wares has led to low survival and recovery rates, 2) due to the long(er) time span, geomorphological processes destroyed/buried early prehistoric sites more severely, leaving only traces of activities behind, 3) later historical activities 'swamped' prehistoric material, hindering its recognition and recovery. Many scholars acknowledge the existence of such patterns and the validity of the explanations offered. Few agree, however, with the final conclusions that what is commonly interpreted as off-site material in fact represents "the tip of a giant iceberg of many thousands of small and ephemeral occupation- and activity foci, shifting within small areas of landscape" (Bintliff *et al.* 1999: 165). The critiques are in particular directed at the inference that existing prehistoric datasets do not reflect original patterns. This has been strongly rejected or considered applicable only to Boeotia (Barker 2000; Davis 2004; Knapp 2003; Mee & Cavanagh 2000; Schon 2000; Thompson 2000; van de Velde 2001 but see Bintliff *et al.* 2000; 2002 for a rejoinder). Along similar lines, Edmonds and colleagues (1999) have called for a 'critical focus' to ensure recovery of single camp occupations (1999: 71), arguing that the British archaeological record, and by implication its interpretation, is biased towards repetitive multi-period lithic scatters. They have offered two explanations to explain the absence of small-scale lithic 'sites': 1) broad sampling methods fail to recognise low artefact densities, and 2) larger scatters have obscured small-scale, short term activities (see Section 2.5.2.3 below; also Section 7.2).

In conclusion, survey archaeology has matured as a sub-discipline with its own theoretical and methodological framework. With the systematic study of site and off-site distributions and the growing understanding of their relationships and functions, survey archaeology has helped gain a greater understanding of the extent, diversity, temporal, and spatial changes in human activity across the physical and, more recently, also social landscapes.

2.5. Lithics in survey projects

At first glance, the main focus of most lithic studies, which is the relationship between human behaviour and lithic technology, and that of survey archaeology, which is understanding the changing patterns of human activities across spatial and temporal landscapes, correspond well. Yet, survey material has rarely contributed to theoretical discussions in lithic studies and the converse is just as true. While most survey projects routinely include stone tool assemblages, lithic studies have rarely contributed to regional overview studies or larger synthesising volumes (Bintliff 2000a; Schofield 1995; 2000a). Several recently published volumes discussing trends in Mediterranean survey archaeology hardly feature lithics (Alcock & Cherry 2004; Athanassopoulos & Wandsnider 2004; Bintliff, Kuna & Venclová 2000; Francovich, Patterson & Barker 2000 but see Cherry & Parkinson 2003; Schofield 1991a). This is surprising, since lithic scatters are not only a common occurrence in the archaeological record, but also because as discussed above, some of the early debates on regional studies, surface material, and the very notion of off-site, came from studies that primarily used lithic surface material. This then begs the question, what are the problematic elements that caused this change? Two major interlocking problems can be identified: 1) how to find and to date lithics and 2) how to define and interpret lithic scatters.

2.5.1. Finding and dating lithic scatters

Lithics have been singled out as difficult to identify and are seen as particularly susceptible to 'walker effects' (Table 2.5), resulting in persistently low recovery rates. Coarse-grained materials like chert and quartz, too, are thought to be under-represented particularly in raw-material-rich areas, unless team-specialists are present or follow the team (Attema *personal communication* April 2003; Bintliff 2000a: 5-6; 2000b: 207-208; Bintliff *et al.* 1999). Not everyone agrees, for example Davis (2004: 25-29), who has compared find densities between lithic specialists and non-specialists and contrasted these with their presence in 'rich' and 'poor' areas on an inter and intra project level. Davis has demonstrated that high and/or low densities could not automatically be linked to the presence of lithic specialists. Perhaps this doubt is induced precisely because in some projects lithics specialists are absent. Others seem confident that their *overall* lithic densities are representative and, not unsurprisingly, have argued that their study has increased knowledge and understanding of prehistoric activities in various regions (Ammerman 1985c; Barker 1995a; Cherry & Parkinson 2003; Knapp 2003; Kardulias & Runnels 1995; Schofield 2000b; van de Velde 2001: 35).

Lithics are generally considered difficult to date. Absent, outdated or restricted typological schemes, a lack of diagnostic artefacts for certain periods, an over-reliance on type fossils, a disregard for the use of technical aspects as dating mechanisms, and an overall dependence on their association with other artefacts, have all resulted in generally coarse chronological divisions in lithic studies (Ammerman 1985c: 28; Barker 1995a: 86; Cherry & Parkinson 2003; Loving & Kamermans 1991; Schofield 1994; 1995b; Stuart 2003; Torrence 1991; Zvelebil *et al.* 1987). Admittedly, this is problematic for understanding temporal changes, but it is worthwhile recalling that virtually every assemblage, surface-collected or excavated, is a palimpsest of activities affected by accumulation and erosion (Edmonds *et al.* 1999; Foley 1981a: 173; Isaac 1981; Shennan 1985). In recognition of these chronological problems some people have tried to refine typological schemes and/or developed other dating mechanisms, in particular focussing on technological variables (Carter & Ydo 1996; Ford 1987; Loving & Kamermans 1991; Runnels 1985; Torrence 1991: Tables 7.1; 7.3).

An additional complicating factor is the continued use of lithics into late prehistoric and historic periods. This has been recognised and studied systematically in the last two decades both in the Mediterranean and Britain and precludes automatically assigning an early prehistoric date to sites with lithic assemblages (Brown & Edmonds 1987; Ford 1987; Ford *et al.* 1984; Hartenberger & Runnels 2001; Humphrey & Young 2003; Kardulias & Runnels 1995; Martingell 2003; Runnels 1982; 1983; 1985; Torrence 1991; Young & Humphrey 1999). Despite coarse chronological schemes, a number of studies have effectively used lithic analyses to explore changing settlement patterns, land use, and resource exploitation (Ammerman 1985c; Barker 1995a: chapters 5-7 on Palaeolithic-Bronze Age societies; Carter & Ydo 1996; Cherry & Parkinson 2003; Edmonds 1995; 1999; Edmonds *et al.* 1999; Kardulias & Runnels 1995; Schofield 2000a; 2000b; Torrence 1991; Zvelebil *et al.* 1987).

2.5.2. Definition and interpretation of lithic scatters

As noted above, increasingly blurred distinctions between 'site' and 'off-site', have focussed attention on artefact densities and distributions. For lithics, some researchers base their divisions and number of artefacts per square meter on recorded densities (*e.g.* Ammerman 1985c: 33). Other scholars decide single finds or anything with two, five, or more artefacts is a scatter/site (*e.g.* Reynolds 1994; Schofield 1994; Zvelebil *et al.* 1987). Criteria for site and off-site density boundaries are also dependent on research areas and material categories. In the Mediterranean, for example, pottery densities are generally higher than in northwest Europe, while the reverse seems to be the case for lithics (Bintliff *et al.* 1999).

I concluded previously that interpretations of lithic off-site data seem undisputed but many lithic specialists have stated that interpreting human behaviour from lithic scatters is fraught with problems (Kardulias & Runnels 1995; Schofield 1994; 1995b; Stuart 2003; Zvelebil *et al.* 1987). Too often, find locations are simply put on a period-specific distribution map reducing the lithic scatters to a simple 'dot on a map' (Barrowman 2003; Bintliff 2000a; Edmonds *et al.* 1999; Runnels 1983; Schofield 1991b; 1995c; 2000a). A good example of the extent to which this hinders synthetic overviews of land use and settlement patterns, is the current condition of the English archaeological lithic record. There it was shown that while broad chronological periods could be established, only 7% of all recorded scatters were interpreted or had specific activities attributed. A similarly low amount was found through systematic surveying and merely 6% had seen further work (Schofield 1994; 1995b; 2000a; 2000b). As I argued in chapter one, a comparable situation exists in Sardinia (Section 1.3). To examine the extent to which this is an inherent problem of lithic survey data or research lacunae, I next discuss if, and how, several survey projects from the Mediterranean have explicitly explored the role of lithic scatters in interpretative models.

2.5.2.1. The west Mediterranean

In the west Mediterranean, the majority of survey projects rarely seem to study lithics (*e.g.* Attema 1996; Attema & van Leusen 2004; Barker & Lloyd 1991; Carreté *et al.* 1995; Coccia & Mattingly 1992 but see Barker 1995a: 86-158;

Malone & Stoddart 1992; 1994). The Acconia survey is one of the few projects with a specifically prehistoric and lithic focus (Ammerman 1985c). For the most part, this may be a reaction to a traditionally strong research focus on proto-historic and classical archaeology. Environmental circumstances, too, are important in particular for Palaeolithic material, which may be either deeply buried or eroded away (Barker 1995c; 2000; Coccia & Mattingly 1992).

In the Acconia survey, distribution patterns and reduction sequences were the main analytical tools used to understand the dataset. For the two main raw material types, obsidian and chert, reconstructed reduction sequences were combined with microwear analysis, densities (*i.e.* frequencies, count, and weight), and spatial distribution maps. Differential procurement has been demonstrated. Obsidian was brought in as preformed cores while chert came in as blanks, and tool sets complemented each other. On the basis of spatial distribution and assemblage composition analyses, two main interpretations were offered: 1) not all sites played an equally important role in obsidian production, and 2) routes involved in exchange networks were sea-based rather than land-based (Ammerman 1985c: 60-82; 98-102; Ammerman & Andrefsky 1982; see Figure 2.1).

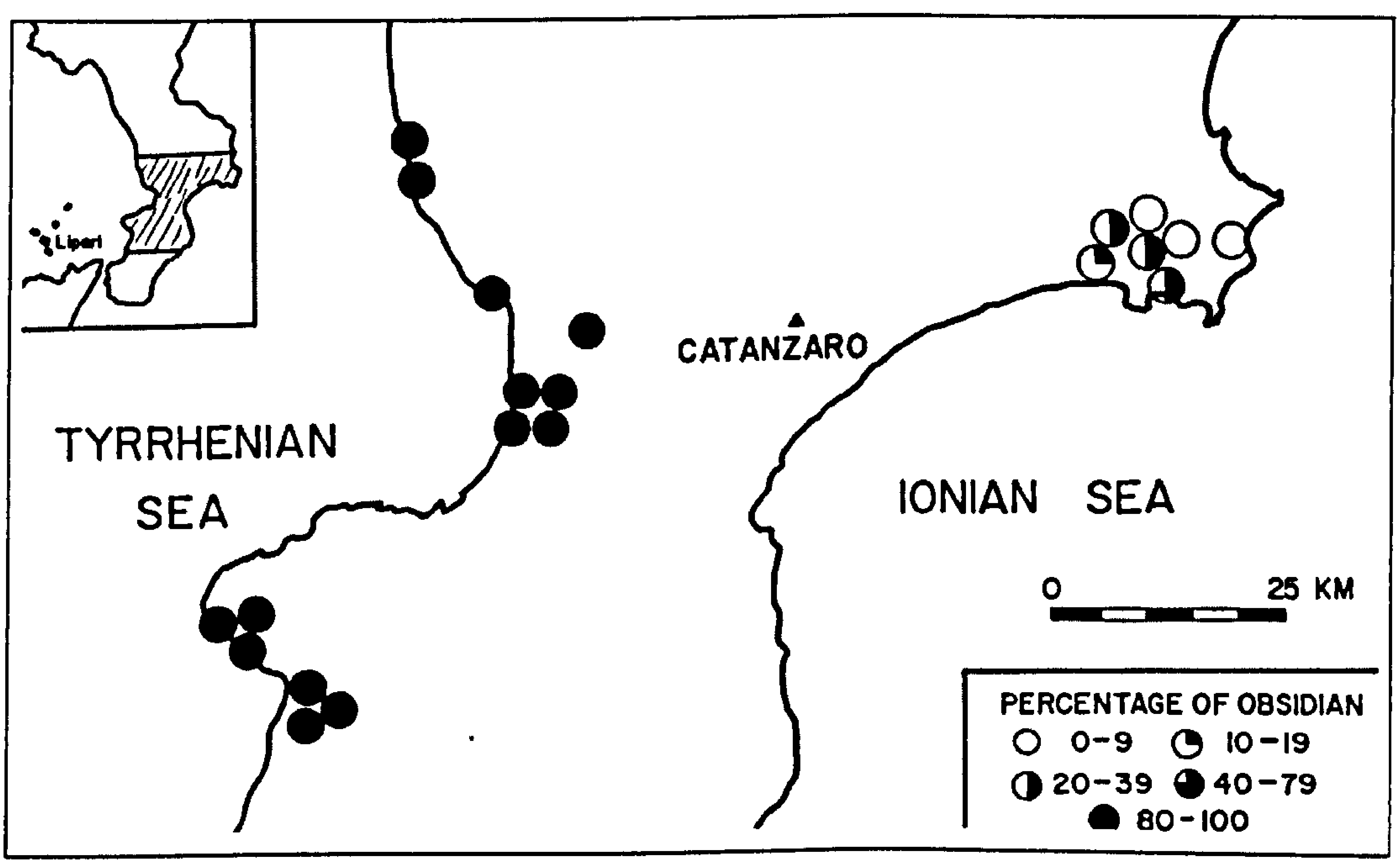

Figure 2.1. Percentage of obsidian in lithic assemblages of selected Neolithic sites in the central part of Calabria (Ammerman 1985c: Figure 7.5)

2.5.2.2. The east Mediterranean

In the east Mediterranean, in contrast to the west, the analyses of lithic surface scatters from numerous intensive surveys, such as Melos, Laconia, the Argolid, and Keos, have significantly increased our understanding of Palaeolithic, and in particular, Neolithic and Bronze Age human activities. Detailed artefact studies have brought to light new information about blade production and tool types (Carter & Ydo 1996; Cherry & Parkinson 1997; Kardulias & Runnels 1995; Runnels 1985; Torrence 1981; 1984; 1986; 1991). Comparisons of lithic densities and distribution patterns studied per raw material type and per period on inter and intra survey scales have increased our knowledge of patterns of lithic procurement, and in particular the distribution, production and exchange of Melian obsidian versus local chert sources. This has in turn enhanced our understanding of differential access to and/or control over raw material sources, knapping skills, and levels of standardisation. In particular the organisation of production and exchange, the absence or presence of lithic craft specialisation, and the role of lithics in the rising social complexity of the Mycenaean Bronze Age have been examined (*e.g.* Cherry & Parkinson 2003; Karimali 2005; Kardulias 1992; 1999; Parkinson 1999; Perlès 1992a).

Thus, in summary, the integration of lithic scatters within interpretative models on (inter-)regional scales depends greatly on successful interpretations of individual, microscale scatters. As can be seen above, previous attempts, especially in the west Mediterranean, have been hindered by a lack of understanding of the formation of lithic scatters and inconsistencies in, and/or lack of, systematically collected and studied assemblages. East Mediterranean studies on the other hand have demonstrated that insight into lithic behaviour increases when detailed technological analysis and assemblage variability are studied in combination with density plots and distributions over time and space.

Mediterranean survey projects commonly use sequence models as descriptive and analytical units to explore changing patterns of settlement and land use, on intra and inter-regional scales. Artefacts are often assigned to a particular stage of lithic reduction from raw material nodule to implement production, use, and discard. Sequence models are less often used to examine specific flaking strategies for assemblages (but see de Bruijn 2004; Cherry & Parkinson 2003; also below). Unfortunately, few studies go beyond economic or socio-political interpretations for lithic procurement and production (*e.g.* Kardulias 1992; 1999). Lithic survey data are rarely approached with a social perspective (but see Given *et al.* 2003; McCartney 2002; 2003). To be fair it should be noted that there is a backlog of modern survey publications as a result of detailed fieldwork methods and long-term (artefact) analyses. In the future, lithic studies can be expected to contribute more actively to social approaches to landscapes (also Cherry & Parkinson 2003).

2.5.2.3. A view from Britain and Ireland

In Europe similar trends can be observed. Two survey projects, which have inspired my research, deserve specific mention as they provide insight into how social lithic landscapes may be explored. The first study is the Bally Lough Archaeological Project, which was carried out in southeast Ireland in the 1980s. Zvelebil and colleagues use lithic actions as the starting point for analysis and data presentation, rather than chronology (Green & Zvelebil 1990; Peterson 1990; Zvelebil *et al.* 1987). By representing their lithic scatters as densities of types of action they avoided producing period-based density maps of main tool types. Instead they identified patterns of resource use, mobility and gained insight into the Irish Mesolithic-Neolithic transition (Figure 2.2).

Their model, however, primarily describes human behaviour in functional, socio-economic, terms. Environmental constraints also feature heavily in their explanations and there is little attention to social practices. Social agency, however, can be explored, since examination of similarities and variation within procurement, manufacture and use strategies may reveal subtle differences that cannot solely be attributed to adaptation to environmental conditions and risks (*e.g.* Dobres 1999; 2000; Edmonds *et al.* 1999). Moreover, Zvelebil and co-workers' association between artefact classes and types of behaviour is very strict and detailed (Table 2.6). Bipolar technology for instance, does not only indicate manufacturing or exhaustive behaviour but also procurement strategies, especially when applied to already produced flakes.

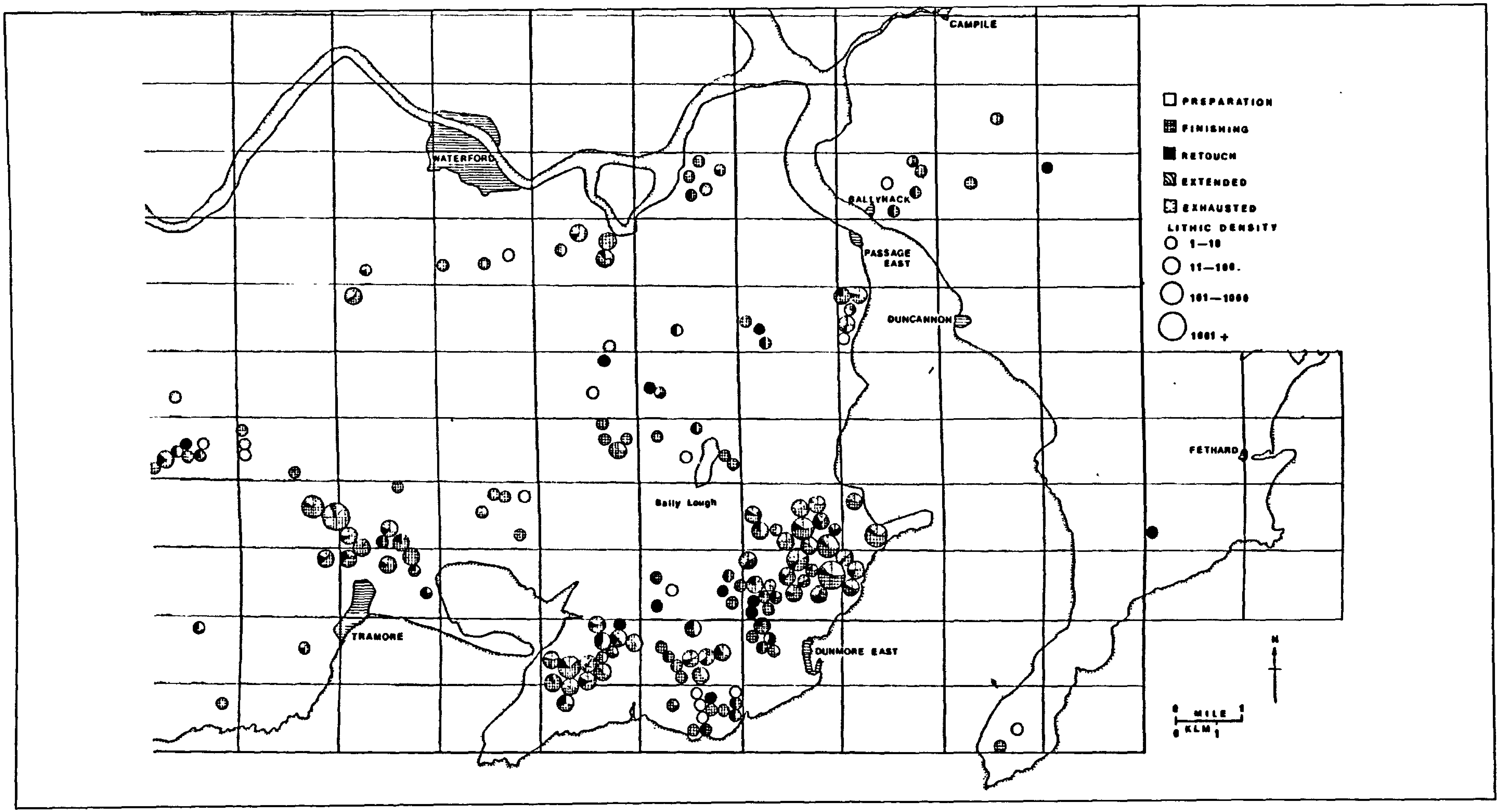

Figure 2.2. Lithic survey data displayed in terms of human activity (Zvelebil *et al.* 1987: Figure 1.5).

Stage	Inferred behaviours	Lithic evidence
Preparation	Raw material procurement, testing and preparation	Nodules Tested core Primary flake Failed core Split pebbles Ridged splinter
Production	Tool production and finishing	Hammerstones Platform cores 1- and 2-sided cores Secondary flakes Tertiary flakes Retouching flakes
Expedient use	Resource procurement, processing, tool maintenance	Retouched flakes Utilised flakes Utilised cores Utilised shatter Utilised pebbles Utilised splinters
Extended use	Retooling, curation	Formal tools Rejuvenation flakes Resharpening flakes Reused tools Elaborated tools Groundstone
Exhaustion	Discard of material	Exhausted cores, bipolar and platform Exhausted tools Broken tools

Table 2.6. Model of lithic behaviour according to Zvelebil and colleagues (from Peterson 1990: Table 1).

A second influential study is the survey and excavation programme carried out in the Cambridgeshire Fenlands. Particularly insightful is Edmonds and colleagues' combination of an explicitly social approach to technology and landscape with detailed artefact and spatial analyses (Edmonds *et al.* 1999). Through comparative analyses, spatial and technical relationships between similarities and variation have been examined, revealing subtle differences in sporadic, seasonal and/or more long-term (re)visiting of places for what would have commonly been interpreted as a single high-density, site. Their study has some interesting implications for the collection and interpretation of low density sites (see Section 2.4.2.3). Recently, in Scotland too, both the importance of knapping as a social act and the contemporary significance of lithic scatters for the cultural and historical appreciation of landscapes by the general public and academic community have been stressed (Barrowman 2003; Stuart 2003).

In conclusion, most Mediterranean survey projects have predominantly studied lithics using the traditional processual frameworks of technology and landscape. Two European studies, however, have provided some ideas for the study of social lithic landscapes, which I will now turn to in more detail.

2.6. Studying social lithic landscapes: discussion and definitions

This section discusses how I intend to explore the Sardinian lithic landscape in the next chapters by reiterating my theoretical position, and defining several key concepts used in this thesis (Figure 2.3).

Social approaches are increasingly prevalent in technology and landscape studies. Human behaviour is no longer seen as being purely conditioned by environmental constraints, but rather people's habitual, daily routines, interactions and cultural traditions play an important role in choices. In this thesis I follow this perspective and see technology as a socially embedded practice; following Dobres, it is both an active verb and an arena for social (inter-)action (Figure 2.3). Likewise, I see the *chaîne opératoire* concept, merged with recent practice and agency theories, as the most useful theoretical and/or methodological tool, because this, and its underlying interest in social rather than environmental constraints, separate it from other sequence models (Figure 2.3). I also use it as an analytical tool, but primarily to reconstruct flaking biographies rather than generalised reduction sequences (also Section 3.2).

Additionally, since these acts and interactions are likely to have left (some) traces in physical landscapes, the *chaîne opératoire* is an excellent means to explore the spatiality of lithic taskscapes: *i.e.* the lithic landscape. I follow Ingold (1993) in his use of landscape and taskscape (Figure 2.3.) and use three interlocking sets of lithic 'taskscapes', procurement, production, and use/discard, to structure my analyses. Data presentation, if not the theoretical framework of my lithic landscapes, is clearly inspired by Zvelebil and colleagues (see Section 3.3).

Chaîne opératoire	Conceptual and analytical tool that explores how and to what extent people's physical, mental, social (inter-)actions, and their (sub-)conscious choices are expressed in (in)tangible acts and objects, using a rigorous analytical set of methods
Technology	1) verb of and arena for social (inter-)action (Dobres 1999: 129; 2000: 83) 2) Analytical term describing production, comprising all artefacts with a broadly similar manufacturing mode
Taskscape	'An array of related activities' (Ingold 1993: 158)
Landscape	'The congealed form of the taskscape' (Ingold 1993: 162)
Procurement	Practice of obtaining raw material, whereby socially-situated, historically-specific skills and knowledge have shaped, and are simultaneously shaped by, already existing strategies, traditions and diversity
Production	Practice of primary and secondary knapping, whereby socially-situated, historically-specific skills and knowledge have shaped, and are simultaneously shaped by, already existing strategies, traditions and diversity
Use	1) Practice of choosing (knapped) objects for other activities, whereby socially-situated, historically-specific skills and knowledge have shaped, and are simultaneously shaped by, already existing strategies, traditions and diversity. 2) Context and meaning, including (un-)intentional discard
Practice	A process that is 'unaware of the principles that govern it and the possibilities they contain; it can only discover them by enacting them' (Bourdieu 1990: 92).
Knowledge	Conceptual tool that combines applied, practical or tangible knowledge, the know-how or *savoir-faire* and abstract knowledge, the *connaissance* or formal knowledge
Skill	Flexible process, that moves along differing scales of learning, training, abilities and knowledge; simultaneously interacting with age, gender, divisions of labour, and social status
Strategy or technique	Specific choices knappers have ([sub-]consciously) made, negotiating between raw material constraints, their socially-situated technical means, abilities and activity/task requirements (Perlès 1992b: 224)
(Archaeological) Tradition	Spatially (and temporally) recurring strategies which are created by, and in turn shape future, lithic practices *i.e.* through learnt, and subsequently learning, knowledge and skills

Figure 2.3. Definitions of the key concepts implemented in this thesis.

To avoid confusion, I should emphasise that lithic landscapes are *not* exact replicas of lithic taskscapes. Postdepositional processes, a 'work in progress' character and historicity constitute taskscapes and reflect the fundamental temporality of the landscape. In implementing this approach the traditionally linear chronological emphasis is avoided, while the interpersonal and interrelated cyclic rhythms of social time are accentuated (Ingold 1993: 160, also McGlade 1999; Preucel & Meskell 2004). From the above discussions it should be apparent that binary oppositions will be avoided in this thesis. These are strong in lithic studies, especially the discussions on expediency, curation and craft specialisation. I demonstrated that chronological and socio-political boundaries, and the view of technology as an evolutionist, nature-determined mechanism, underlie the distinction between curation and craft specialisation, as well as that between curation/craft specialisation and expediency. Binary oppositions are intuitively and heuristically convenient terms but ultimately have a restrictive character. I therefore prefer to avoid them and will instead explore human choice and interaction through a careful examination of procurement, production and use activities (also Section 3.2).

The relationship between procurement, production and use is usually seen as straightforward and unproblematic whereby insight in one area furthers understanding of the others (Section 2.3). Following Bradley and Edmonds (1993: 11), I consider procurement, production and use as socially embedded, historically-specific acts, whose relationships need to be critically investigated and clearly defined (Figure 2.3, also Hodder 1982; Loney 2000). In this thesis five key concepts are used to explore human choice and interaction, which need clear definitions: practice, knowledge, skill, strategy and tradition (Figure 2.3). Practice, while often invoked by anthropologists or archaeologists, is rarely explicitly defined, least of all by Bourdieu, who used it in at least six meanings: 1) practical sense, 2) practical action, 3) practical mastery, 4) domain or system, 5) any (un-)intentional behaviour, performance or occurrence, and 6) as emanating from *habitus* (*cf.* Warde 2004: 5-6, note 1; Bourdieu 1977; 1990: in particular 80-97). *Habitus* on the other hand is more clearly defined as a system of depositions; comprising the result of an organising action, a way of being or a habitual state, and an inclination (Bourdieu 1977: 72-95, also note 1; 1990: 52-65). In archaeology, practice and especially *habitus* are often linked with agency theory an equally often-evoked and ambiguous concept (*e.g.* Dobres 2000: 130; note 3; see Dobres & Robb 2000b). Practice is usually described as 1) practical mastery or skill, or in a wider sense as 2) indicating any kind of (un-)conscious (inter-)action. In either usage, *habitus* subsists in practice: people's repeated, reflexive, habitual ([un]conscious) learnt practices shape, and are shaped by, their daily-life engagement with everything and everyone around them (Ingold 2000: 162-163). Here, that wider meaning of practice is used, and as such, it exists in or *is* the socially situated connection of knowledge, skills, strategy (technique) and tradition. Practice is learning to (inter)act and by doing so, making it one's own (Figure 2.3). Thus,

> each generation contributes to the next not by handing on a corpus of representations, or information in the strict sense, but rather by introducing novices into contexts which afford selected opportunities for perception and action, and by providing the scaffolding that enables them to make use of these affordances. (Ingold 2000: 353-354)

It should be noted that practice and taskscape, while similar, are not identical. Simply put, practice is action/thought while taskscape is the sum of practices.

Knowledge is often separated into *savoir-faire* and *connaissance*, each accompanied by similar divisions into implicit or explicit learning contexts, action/gesture versus thought, technique or method, and skilled or unskilled knappers (Ingold 1990; Pelegrin 1990). These devices are heuristically convenient, but as has been recently pointed out, a thought/action distinction is difficult to maintain and many different forms and combinations of learning modes and skills exist (Bamforth & Finlay in press; Edmonds 1995: 9; Ingold 2000: 162: note 3). Therefore, this division is not maintained here. Similarly, skill is an often invoked, but rarely systematically studied, concept with a multitude of definitions. While diverse, most definitions see skill as a link between practical and abstract knowledge and stress its complex relationships with differing abilities and learning systems. Three archaeological approaches have recently been recognised: identifying skilled/unskilled knappers, gaining insight into the degrees of skill needed to make certain artefacts or sequences, and characterisation of overall skill levels of assemblages (Bamforth & Finlay in press: 3; also Ingold 2000: 349-361). Here, skill is studied on assemblage levels and seen as a flexible process for which a wide range of archaeological correlates can be explored (Figure 2.3; Section 3.2).

Lastly, strategy is synonymous with technique and indicates the physical realisation of practice, *i.e.* the smallest *chaîne opératoire* (Figure 2.3; Section 2.2). Please note that with this perspective I do not equate a single strategy with an individual knapper since my data are unsuited to such a fine-grained approach. From this follows the last key concept (archaeological) traditions, which are recognised patterns of strategies (Figure 2.3). It is important to note that neither the three lithic activities, nor the five key concepts, are linearly presented in distribution maps or exclusively associated with certain artefact classes. Analysis of chosen variables and attributes cut across such boundaries (see Section 3.2). Thus, with technology and traditions I focus on similarities. In the majority of the dataset they always comprise at least one, but sometimes more, knapping strategies. Moreover, because diversity enables one to study the existence and organisation of differential lithic skills and knowledge, I also examine variations from traditions and their interrelationships (following Edmonds *et al.* 1999).

2.7. Technology, landscape and lithic studies: conclusion.

This chapter has reviewed and discussed the changing nature of two key concepts in archaeology: technology and landscape. Particular attention has been paid to the fact that these recent insights are not objective or fixed entities, but are socially-embedded and historically-specific constructs. I demonstrated that traditional views on technology predominate in most lithic studies, and as a result, once innovative concepts have solidified into binary oppositions. I also evaluated the *chaîne opératoire* concept, examining how it has served as an analytical and conceptual tool in technology studies and addressing recent claims that it does not differ from other sequence models. I argued that a differing perspective on the roles of nature and culture distinguishes the approaches, even if the distinction is not always clear-cut. This chapter also examined how lithics have been studied in survey archaeology, demonstrating that there too the traditional view on technology prevails. I explored in detail why lithics no longer play a role in theoretical and methodological discussions in survey archaeology, and discussed two European studies that offer alternative approaches to the analysis and presentation of lithic survey data. In the final section I outlined my own theoretical stance, which uses Dobres's redefinition of the *chaîne opératoire* in combination with Ingold's notions of landscape and taskscape as conceptual tools used to explore the Sardinian lithic landscape. The next chapter outlines how these key concepts are used as methodological tools, and discusses them in relation to the case study.

Chapter Three

The Sardinian lithic landscape and taskscapes: the *Riu Mannu* case study

The previous chapter has reviewed the main themes and approaches in technology and landscape studies. I concluded that social approaches to lithic survey datasets are mostly absent in the Mediterranean, and I outlined which theoretical concepts I found useful to explore the lithic landscape from a social perspective. This chapter presents the background information to the case study used and presents the methodology. It consists of three parts. Firstly, it introduces the *Riu Mannu* Survey Project and discusses its field methodology in relation to four common survey problems, finding, defining, dating and interpreting lithic scatters. The second section discusses how the Sardinian lithic landscape may be explored, paying particular attention to the role of natural and cultural postdepositional processes. The final section details how three lithic taskscapes, procurement, production and use, are studied.

3.1. The *Riu Mannu* Survey Project

The *Riu Mannu* Survey Project has carried out fieldwork in west central Sardinia from 1992 to 1999, under the direction of Dr Maria Beatrice Annis and Dr Piet van de Velde from University of Leiden, the Netherlands, and Dr Peter van Dommelen, at the University of Glasgow. Over the course of fieldwork 25 transects were sampled in two key areas of west central Sardinia, the *Riu Mannu* estuary and the *Riu Mògoro* gorge (Annis *et al.* 1994; 1995; 1996; van de Velde 2001). The dataset studied in this thesis contains over 5000 lithic artefacts from eleven *Riu Mannu* transects (Figure 3.1: black rectangles; Table 3.1). Two main criteria have determined the selection of transects for study: 1) material from all three major physical landscapes are represented, and 2) transects differ in distance to the main source of obsidian, the Monte Arci.

The introduction of this case study consists of three parts. It first briefly presents the three main physical landscapes of the research area and the location of the studied transects. These three geographical areas form the basis for analysis and presentation in the next three data chapters (see Section

3.2.1 below). The second part introduces the dataset presents and discusses it in relation to the two main interlocking problems with lithics from survey projects identified in the previous chapter: 1) how to find and date lithic scatters and 2) how to define and interpret them (Section 2.5).

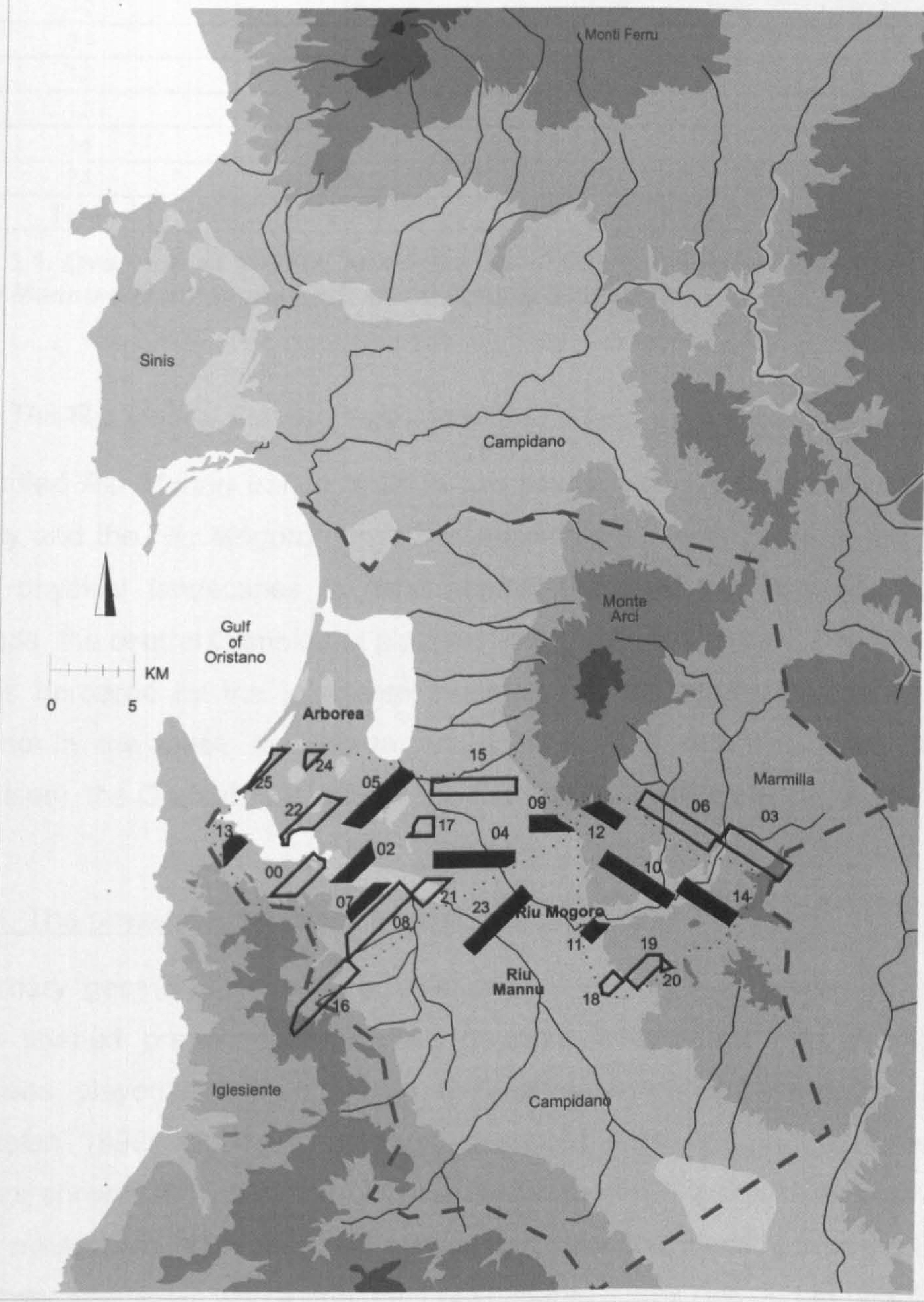

Figure 3.1. The *Riu Mannu* Survey Project research area and the unstudied (open rectangles) and studied (black rectangles) transects.

Key to map (and all following maps):
Small dashed lines: *Riu Mannu* Survey Project key areas
Large dashed area: wider *Riu Mannu* Survey Project research area.
Contour levels increasing heights with increasing darkness in colour): light grey = at coast level; at 100m a.s.l; at 300m a.s.l.; black= at 700m a.s.l.

Transect	Quantitative finds	Qualitative finds	Total
02	80	183	263
04	834	975	1809
05	19	25	44
07	108	220	328
09	122	140	262
10	357	515	872
11	177	4	181
12	7	50	57
13	1	58	59
14	1155	483	1638
23	121	157	278
Total	2981	2810	5791

Table 3.1. Overview of studied artefacts. Quantitative and qualitative finds refer to *Riu Mannu* collection methods see text for explanation.

3.1.1. The Riu Mannu Survey Project research area

All studied *Riu Mannu* transects lie in two key survey areas, the *Riu Mannu* estuary and the *Riu Mògoro* gorge and encompass one or more of the three major physical landscapes in west central Sardinia: the Arborèa coastal wetlands, the central Campidano plain and the Marmilla uplands. The research area is bordered by the Iglesiente mountains in the south, by the Gulf of Oristano in the west, the Monte Arci in the north and two *giare* (table mountains), the Giara di Gesturi and the Giara di Siddi, in the east (Figure 3.2).

3.1.1.1. The physical landscapes of west central Sardinia

Quaternary geomorphological degradation and aggregation processes have mainly shaped prehistoric to current physical landscapes, and geological processes played an important in the earlier landscape formation (van Dommelen 1998: 43-44). The maps presented here and in the following chapters show a reconstructed physical landscape for the first millennium BC to first millennium AD. Earlier periods, in particular the Neolithic, would have seen lower sea levels with a drier Gulf of Oristano. It was decided to use these maps as a basis for presentation because 1) chronology is not a structuring principle in this thesis – the dataset is multi-period and establishing contemporaneity between pottery and lithics has proven problematic (see below) and 2) these reconstructed maps represent a general picture of the physical landscape before the changed induced by early modern land reclamations. The section below only discusses the development of the three main physical landscapes and briefly outlines the position of the *Riu Mannu* transects.

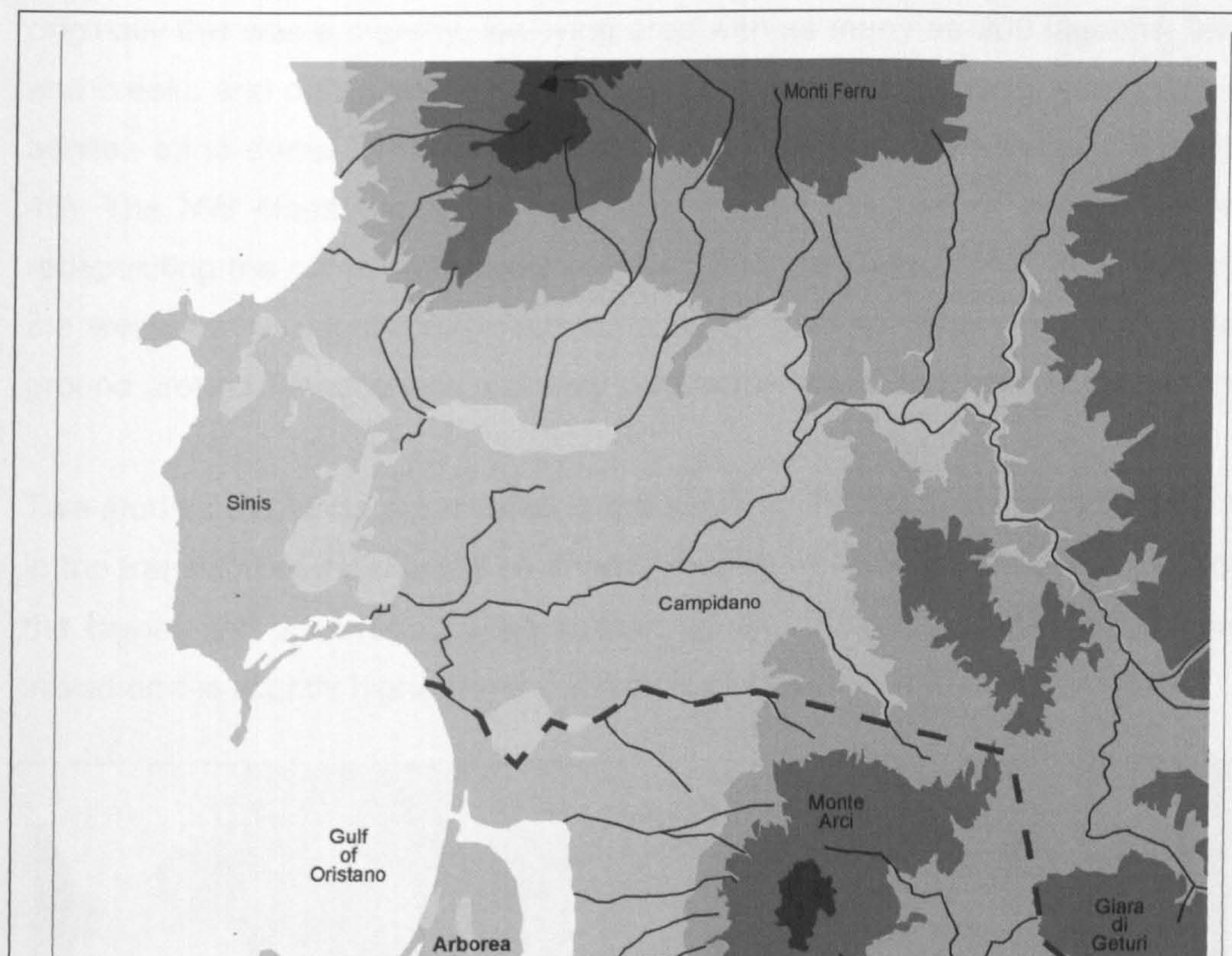

Figure 3.2. West central Sardinia, showing the *Riu Mannu* survey area (large dashed outline), with the two key areas (small dashes) and the main landscapes discussed in the text.

Coastal environment - the Arborèa

The Arborèa is mostly made up of fluvial and aeolian sediments. Fluvial sediments from the Mannu and the Mògoro rivers predominate in the southern part of this area. The Arborèa was drained and land reclaimed in the 1930s but originally this was a marshy, low-lying area with as many as 200 lagoons, fens and creeks and dunes and a slightly higher, predominantly Holocene, ridge of aeolian sand dunes in the East, around Terralba (van Dommelen 1998: 42, 46). The NW *Maestrale* winds have also shaped this part of the landscape, redepositing the older Würm aeolian sands into the Campidano. In prehistory, the wetter areas must have been suitable for grazing only, while the higher ground around Terralba was probably very fertile (van Dommelen 1998: 46).

Two studied transects are located in the southern Arborèa, transect 02 lies on in the transition of the marshy southern Arborèa, with the north eastern part on the higher and drier redeposited aeolian sands. Transect 05 is located more inland on the slightly higher (and drier) sand dunes of Terralba (Figure 3.3).

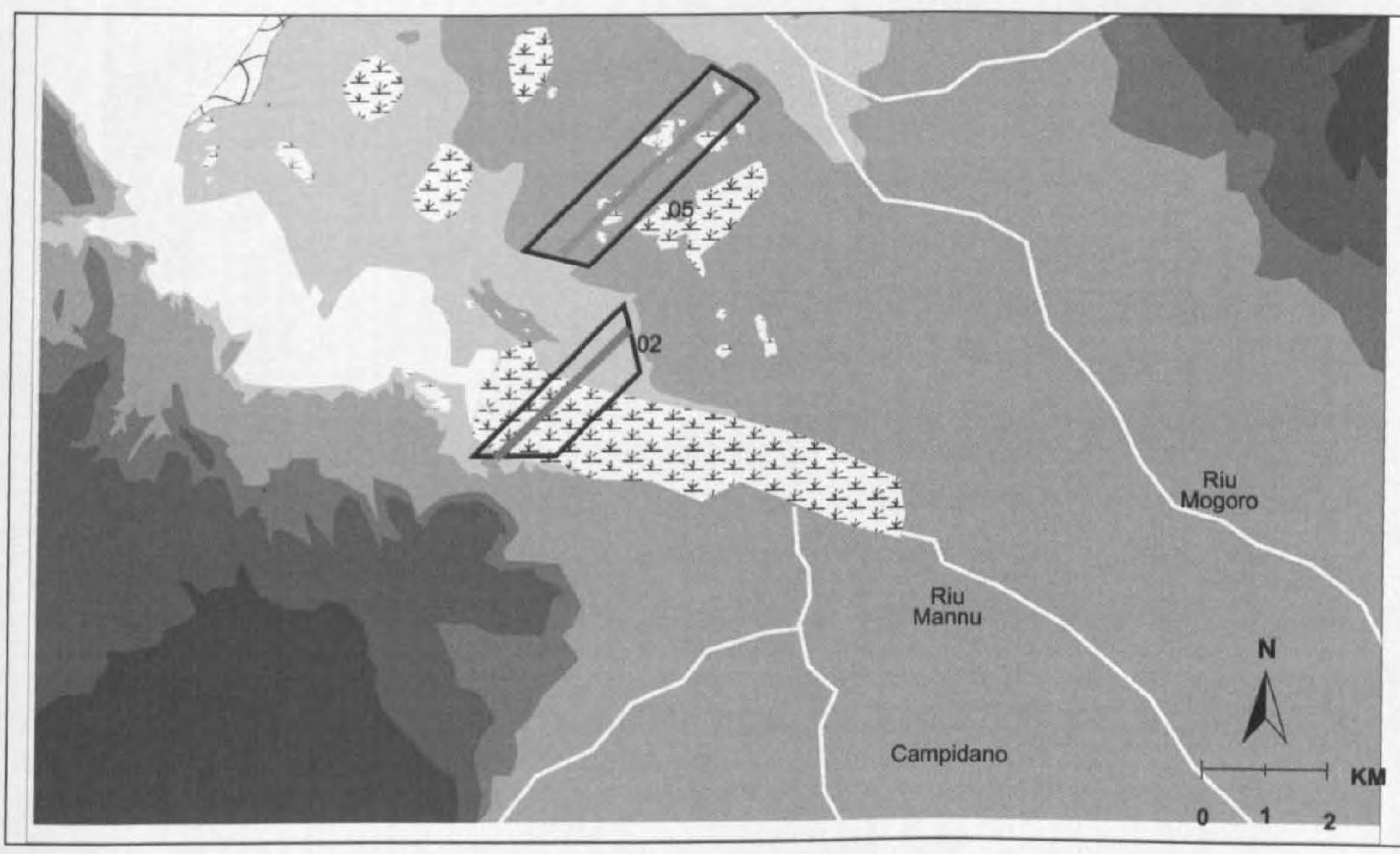

Figure 3.3. Detail of the southern Arborèa showing the location of *Riu Mannu* transects 02 and 05 (grey line = sampled grid; see text).

The plains - central Campidano

The plain, the central Campidano, constitutes the centre of the research area. This area has a long and complicated geological history. It is part of a complex *graben* system together with the northern Campidano, around the Gulf of

Oristano and the Sinis district and the southern Campidano around Cagliari. It was formed in the Pliocene and Pleistocene (5–0.1 million years BP) along the fault lines of a larger and older Sardinian rift system (Beccaluva *et al.* 1985; Casula *et al.* 2001; Cocozza & Schäfer 1974; van Dommelen 1998: 42-45). Volcanic activities, including the formation of the Monte Arci (3.8-3.2 million years BP) further reshaped the area. The Campidano slowly filled up from the Pleistocene onwards. Constant erosion of the Iglesiente mountains resulted in pediment formation on the western side. The east side saw glacis and terrace formation through erosion of the Monte Arci and the Marmilla. Likewise, the many streams running from the Monte Arci into the Gulf of Oristano dissect the northern half of the central Campidano (Figure 3.4; also van Dommelen 1998: 42; 51; Pecorini 1971a; 1971b; Seuffert 1970: 62- 66; 81-83).

Figure 3.4. Glacis and terrace formation from the Monte Arci into the east side of the Campidano. Photo Dr P. van de Velde.

Two main rivers have contributed extensively to the formation of the Campidano. The first is the river Mògoro. Its lower course has extensively been altered in the early 20th century AD, but originally it ran from the Monte Arci into the Sassu lagoon (van Dommelen 1998: 46). The river borders the northeastern side of the central Campidano. With its extensive tributary system, it has created the Mògoro gorge and filled up the eastern part of the

Campidano (Figure 3.5; van Dommelen 1998: 48-51; Pelletier 1960: 341; Puxeddu 1957; Seuffert 1970: 86). Towards the end of its course, going into the Arborèa, sedimentation thickness increased significantly.

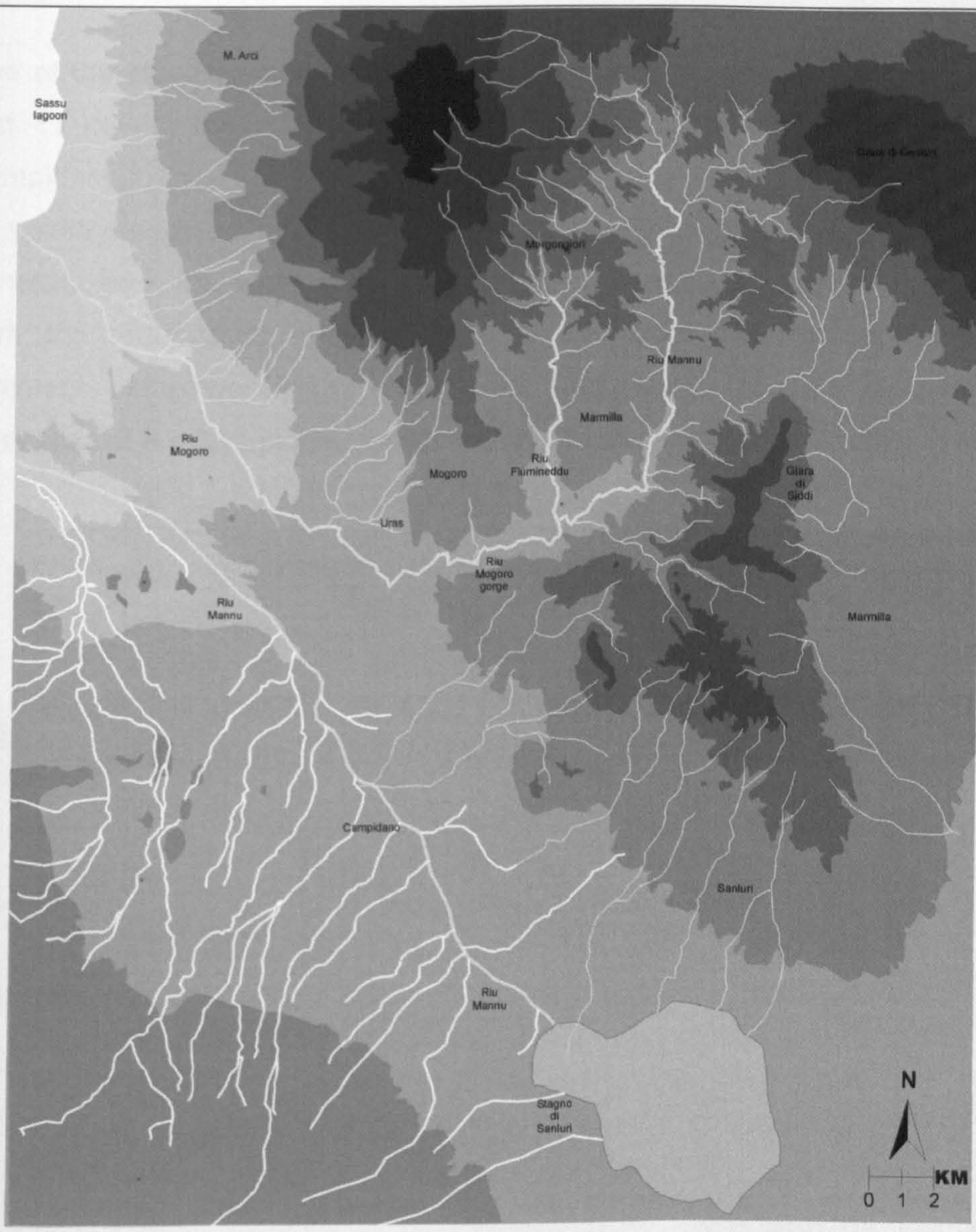

Figure 3.5. Detail of the southern part of the Central Campidano and the Marmilla, showing the erosion and pediment formation in the Iglesiente by the river Mannu and its tributaries, and the drainage of the Monte Arci and the Marmilla by the river Mògoro and its tributaries.

The river Mannu is the second important river. It runs in the middle of the central Campidano, from the San Luri marshes to the (nowadays) reclaimed San Giovanni lagoon. With an extensive valley system, it has filled the west side of the central Campidano, transporting material down from the Iglesiente (Figure 3.5). From the Holocene onwards, this river, too, has changed in character and has become more sedimentary, depositing thick layers of sediment (van Dommelen 1998: 45-52; Pecorini 1971b).

Five of the studied transects lie in the Campidano (Figure 3.6). Transects 07 and 13 covers the transition from the Iglesiente Mountains into the west Campidano. Transect 09 is also transitional, running across the east Campidano pediments below the lower Monte Arci basalts. The remaining two transects lie in the heart of the Campidano. Transect 04 covers the transition from the redeposited aeolian sands in the inner Arborèa to the fluvial sediments of the river Mannu in the central Campidano. Transect 23 covers the inner area of the Campidano, between the Mògoro and Mannu rivers.

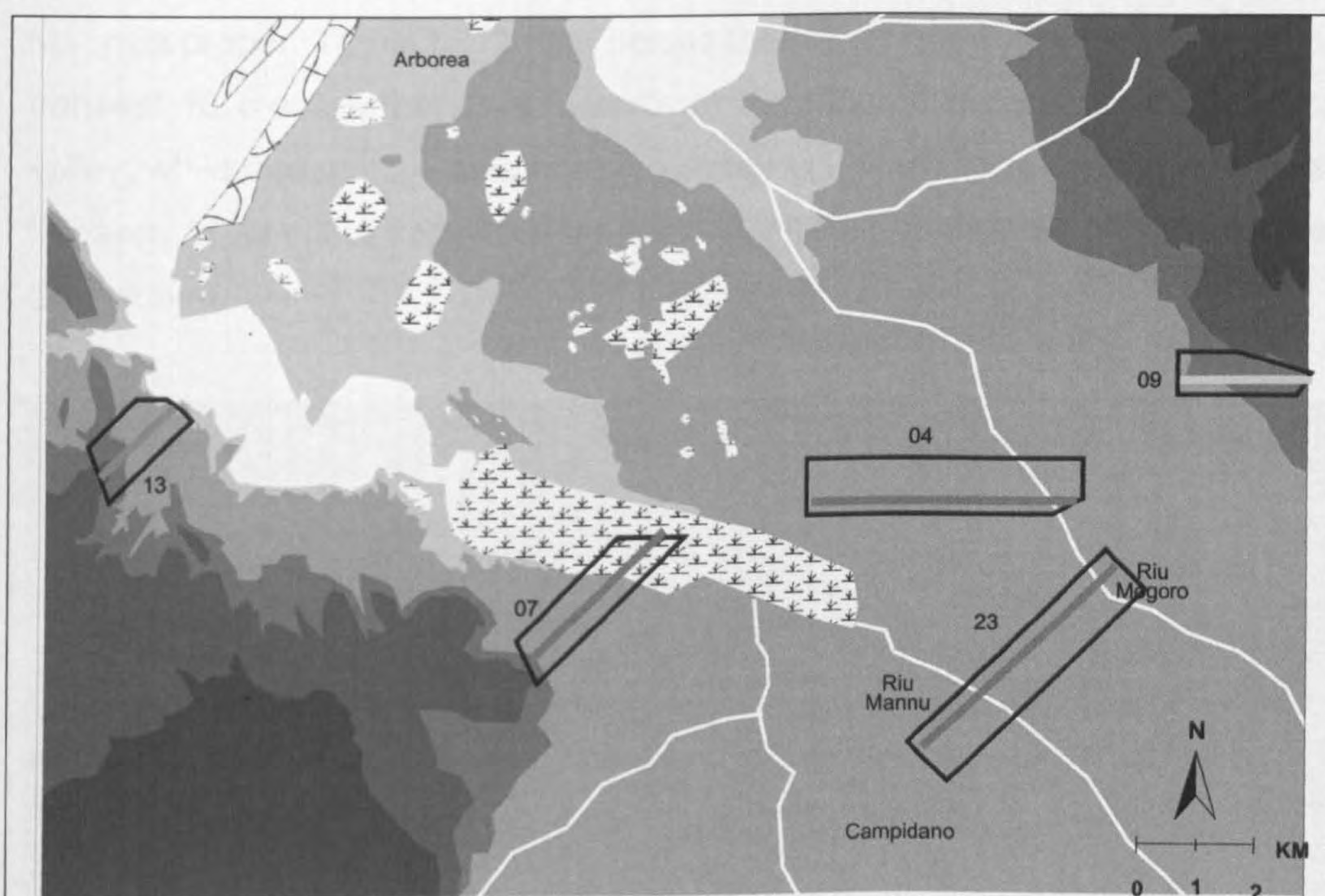

Figure 3.6. Detail of the Campidano showing the location of *Riu Mannu* transects 04, 07, 09, 13 and 23 (grey line = grid; see text).

The hills – Marmilla

The marl hills of the Marmilla 'proper' extent to the North and the Trexenta in the South, outside the *Riu Mannu* survey area. Within project boundaries, the Marmilla is the area between the Monte Arci, the table mountains of Gesturi and Siddi and the Campidano (Figure 3.3; van Dommelen 1998: 51). Two major erosion processes have dominated this region. First of all, two tributary Mògoro river systems, the Flumineddu and the Mannu (not to be confused with the one in the central Campidano) are important. The former runs closest to the Monte Arci and has drained its eastern side, while the latter has drained the rest of the Marmilla basin (Figure 3.5). Secondly, slope processes, such as rain-wash, soil creep and mudflow, have created the characteristic appearance of the marl hills. Despite the erosion, good arable land would have been available in prehistory. Fluvial sedimentation and redeposited material have created good strips of arable land along the river tributaries. Small alluvial planes at the crossing of rivers, as for instance at the joining of the Flumineddu and the Mògoro, would have also provided arable land (van Dommelen 1998: 52).

Four transects lie in the Marmilla (Figure 3.7). Three transects lie in the Marmilla proper. Transect 12 runs across the higher basalts of the Monte Arci, transect 10 crosses the lower basalts of the Mògoro gorge into the Mògoro valley, while transect 14 runs from the valley up to sa Costa Manna. The final transect, 11, is again transitional and crosses from the Marmilla into the central Campidano.

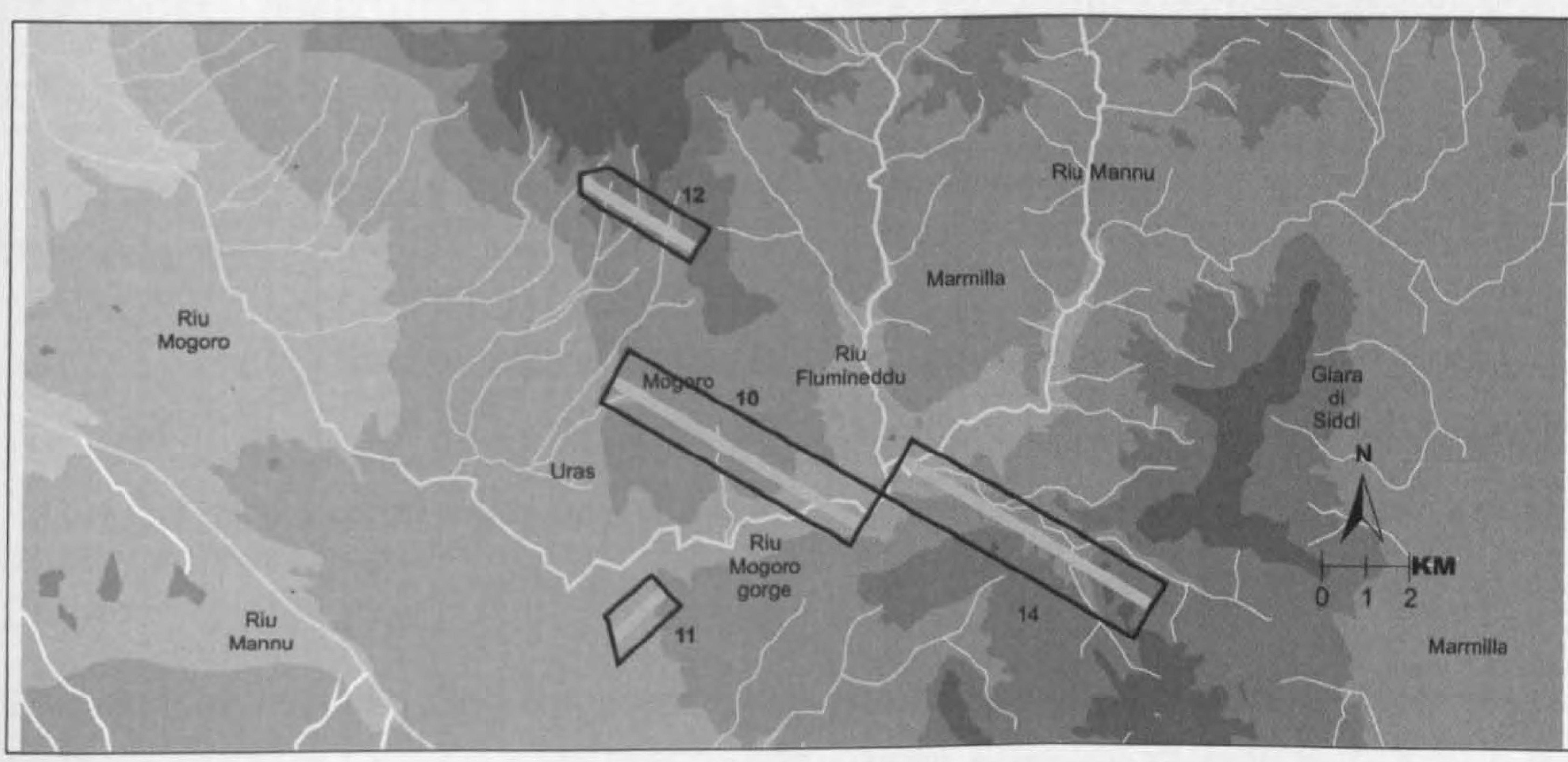

Figure 3.7. Detail of the Marmilla, showing the location of *Riu Mannu* transects 10, 11, 12, and 14 (grey line = grid; see text).

3.1.2. The Riu Mannu field methodology

Following survey trends elsewhere, the *Riu Mannu* Survey Project has developed a fieldwork methodology that is not merely focussed on settlement recovery but examines the distribution of a wide range of human activities across the physical landscape (see Table 3.2; also Table 2.5; also Annis *et al.* 1994; 1995; 1996; van Dommelen 1998: 60; van de Velde 2001). To this end, the project has implemented a system of continuous point-by-point recording that systematically documents the absence and presence of all archaeological finds at regular intervals. This, combined with ground surface clearance and full collection at each survey point further helps address the so-called 'walker and field effects' survey problems such as archaeological visibility and reliable recovery rates (for detailed discussion and statistical argumentation, see van de Velde 2001: 35-39).

Methodological concerns	Definition/examples	*Riu Mannu* solutions
Walker effects	Differential abilities to recognise certain material categories	Point-by-point full collection, surface clearance & student instruction on diagnostic artefacts / fabrics
Field effects	Ground visibility	Surface clearance for all points. Five standardised categories reflecting surface visibility: excellent, good, moderate, bad and very bad
	Type and extent of factors involved in burial and exposure of artefact assemblages	Recording current land use and geomorphology, sketching physical landscape for 120-metre strip
Site recognition or survival	Site/off-site distinction	Continuous recording and collecting: 1) all finds (including absence) from points (quantitative finds). 2) diagnostic artefacts (qualitative finds) in between points
	Sites 'coming on and off like traffic lights'	Visiting sites known from early publications, looking at amateur or early collections and revisiting several *Riu Mannu* locations

Table 3.2. *Riu Mannu* solutions to (some) common methodological concerns In survey archaeology.

Rather than investigating transects by line-walking, the *Riu Mannu* Project has implemented a point-by-point collection method that systematically samples a 120-metre wide strip within each transect. A randomly placed baseline ran along the length of each transect (the x-coordinates), which was set out in the field using an electronic distance meter (Figure 3.8: left; *i.e.* grey lines in transects of Figures 3.3; 3.6; 3.7). This baseline is the core of the 120-metre wide strip, from which samples have been taken with a 30-metre grid system.

Thus, every 30 metres along the 120-metre strip, collection points have yielded finds information. For higher artefact densities, the 30-metre grid was narrowed to a 10-metre interval. These gridded collections are represented by the transect number + capital letter, which was added in alphabetical order *e.g.* 04-B .In all tables, figures and appendices in this thesis. The width of the sample strip is always 120 metres. Lengths vary for individual transects, since these are geomorphologically, and not archaeologically, determined units (van de Velde 2001: 26).

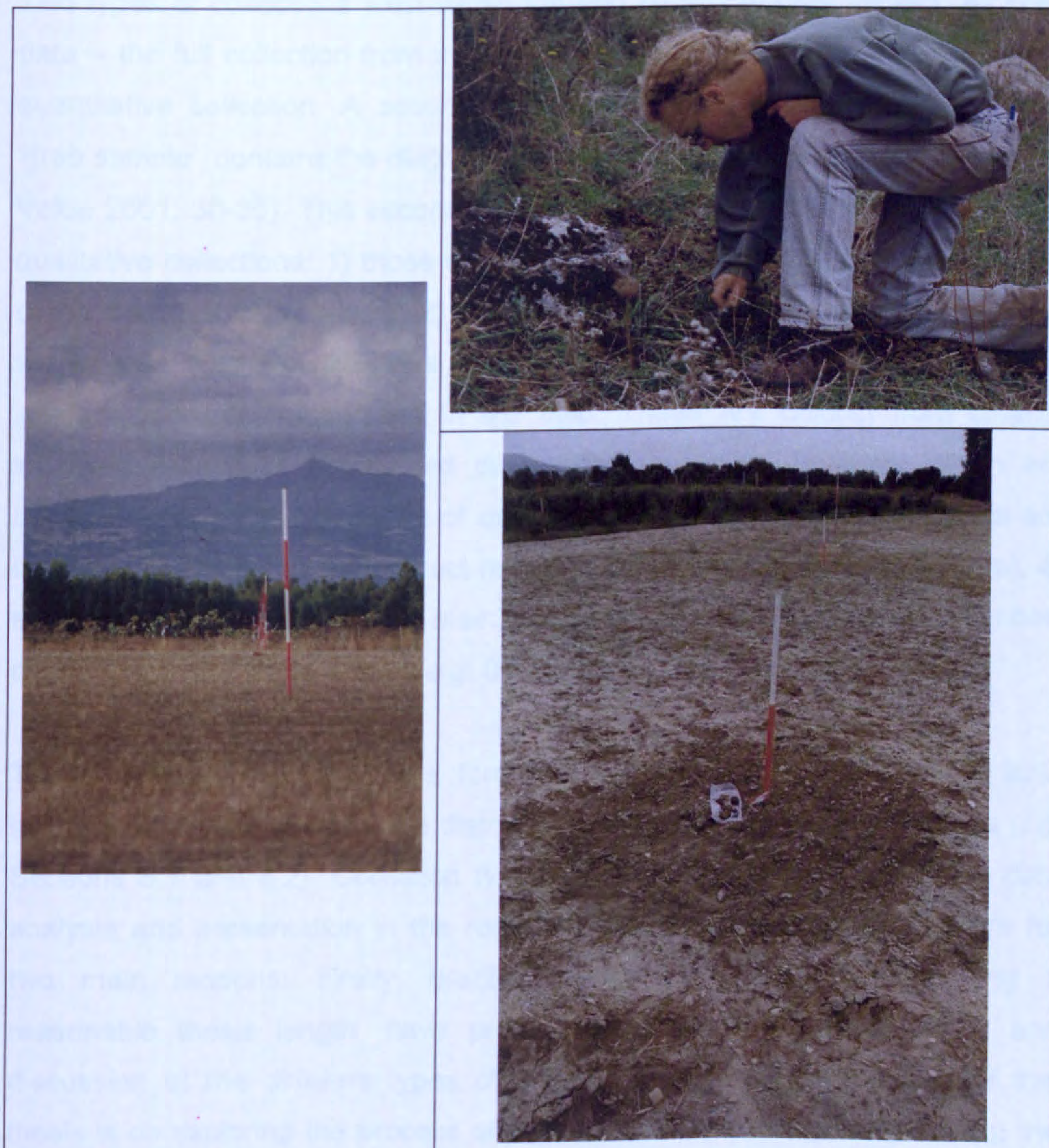

Figure 3.8. The *Riu Mannu* Survey Project fieldwork methodology: the baseline set out in the field with ranging poles (a- left), team member clearing a point (b- right above), a cleared point (c- right below). Photos: Dr P. van de Velde.

Team members were instructed to clear a standard (two square metre) surface for each collection point, collecting all archaeological finds or recording their absence (Figure 3.8: b-c). It should be noted that sieving was not included in the *Riu Mannu* collection methods, so that the smallest artefacts, in particular the primary and secondary flaking debris, have not been retrieved, which has particularly affected identification of *insitu* flaking locations.

3.1.2.1. Type of collections

Two types of collections exist within the *Riu Mannu* Survey Project. All point data – the full collection from the standard size cleared point – make up the quantitative collection. A second collection method, labelled 'qualitative' or 'grab sample', contains the *diagnostic* artefacts lying outside the points (van de Velde 2001: 30-35). This second group is further subdivided into five types of qualitative collections: 1) those collected on along the 'lines' of the five points of the main 30x30 metre grid, 2) those in the 'squares' in between the points of the smaller 10x10 metre grids of sites, 3) small localised concentrations of artefact densities, recognised in the field. These are distinct from smaller localised collections recognised during post collection analysis, which are based on the plotted densities of *quantitative* finds only. Both collections are identified in this thesis by transect number and lower case letter (*e.g.* 04-a), 4) all concentrations outside the main grid area, identified by transect number, capital letter and an asterisk * (*e.g.* 07-J*) and 5) revisits to sites.

The quantitative collection has formed the basis for the definition of lithic scatters, statistical density and distribution analyses in the data chapters (*i.e.* Sections 5.1 and 6.2). Collection types are not distinguished within the data analysis and presentation in the remaining sections of the data chapters for two main reasons: Firstly, practical reasons, especially maintaining a reasonable thesis length, have prevented the analysis, presentation, and discussion of the different types of collections. Secondly, the focus of this thesis is on exploring the process of lithic technology by beginning to map the range of traditions and variations in procurement, production, and use/discard strategies and their interplay, since this has rarely been examined in Sardinian lithic studies. Thus, analysing and presenting data with numerical precision and detail is of secondary importance. There are some overall important differences, however, between these collections that influence their reliability for interpretations and must be kept in mind throughout the thesis. Firstly, because 'diagnostic' artefacts are more frequent in qualitative collections, artefact quantities, percentages and variation in flaking strategies detailed in this thesis reflect maximum values. Thus, when it is concluded, for example, that technical mistakes in certain assemblages are low, it should be understood that they are low *despite* a specific collection focus on diagnostic pieces. The reverse is true for undiagnostic pieces, especially flaking debris, which are clearly under-represented in qualitative collections (Table 3.3). Thus, in areas that rely (heavily) on qualitative collections, such as the smaller localised concentrations or the sites collected outside the main grids, their absence and consequently the interpretations of that absence, (*e.g.* no *insitu* primary flaking or absence of core fragmentation), cannot be confidently supported.

Basic classification	Quantitative collections		Qualitative collections		04-B qualitative collections revisits	
	N	%	N	%	N	%
Flakes/blades	183	38.4	172	41.6	60	39.0
Cores	6	1.3	13	3.1	9	5.8
Core rejuvenation	3	0.6	10	2.4	1	0.6
Unifacial retouch on flakes/blades	21	4.4	42	10.2	28	18.2
Bifacial pieces	4	0.8	4	1.0	1	0.6
Possibly retouched flakes/blades	40	8.4	54	13.1	18	11.7
Debris	214	44.9	98	23.7	29	18.8
Pseudo artefacts	6	1.3	20	4.8	8	5.2
Total	477		413		154	

Table 3.3. Comparative counts and percentages for the basic artefact classification of the three different types of collections for concentrations 04-B.

For easy reading comprehension, I would offer that if placed on a scale of relative reliability, qualitative collection types 1 and 2 (the 'line' and 'square' collections) rank higher, with types 3, 4 and 5 decreasing in reliability. Moreover, the latter three types only constitute a small percentage of the dataset. In the data chapters transect analysis is therefore unlikely to be affected. This difference in reliability is emphasised throughout the thesis, especially in the interpretative chapters (see section 7.2.3).

3.1.2.2. Postdepositional processes shaping the *Riu Mannu* landscape

It is widely acknowledged that archaeological distribution patterns are not simply undisturbed reflections of prehistoric activity. Past and present natural and cultural postdepositional processes give the physical landscape a 'work in progress' character. General consensus notwithstanding, opinions differ on the impact of ongoing activities on archaeological visibility and recovery rates. The most common view is that these negatively affect the archaeological record, and that efforts must be made to recognise and/or correct these effects on the 'original' distribution pattern (see the discussion on 'original pattern fallacy' in Section 2.4.2.2). In Ingold's definition of landscape, however, the distinction between ongoing activities and the archaeological record disappears; the 'effects' are part of the landscape and equally worthy of investigation (Ingold 2000: 189; also Section 2.4.1). The *Riu Mannu* Survey Project has made a compromise between the two perceptions. Where recognised, ongoing activities have been recorded. In the sections where these activities were extensive, sampling points were cancelled without sampling. Corrections factors, however, have not been constructed. The sections below briefly details the main influences for all three main physical landscapes, and evaluates the degree to which *Riu Mannu* find densities may reflect prehistoric activity.

Arborèa

Riu Mannu find densities in the Arborèa are low (see Section 3.2 below). Postdepositional processes have strongly influences archaeological recovery rates (Table 3.4). In transect 02 the main grid was shifted to circumvent modern horse stables, while the start was cancelled due to modern river canalisation. Recent aeolian sedimentation and extensive modern quarrying activities have particularly affected recovery of archaeological remains in transect 05. More generally, large-scale land reclamation in the 1930s have changed the physical landscape and affected archaeological recovery rates. Thus, the studied transects provide a good insight into the current condition of the archaeological record. Their resultant small sample sizes, however, invalidate making any statistically sound interpretations of past (lithic) activities. At the moment, only tentative suggestions can be put forward.

	Transect 02	Transect 05
Landscape	Alluvial and aeolian sediments	Fluvial (Holocene) and (recent) aeolian sediments throughout transect. Sandy soils and some local depressions with marshy fills. Flat landscape.
Land use	Small vine yards, cultivated fields and fields in fallow	Cultivated and recently ploughed fields, fields in fallow, vineyards. Modern quarrying activities
Affected areas and nature of influences	Start of transect cancelled due to modem river canalisation and middle part of transect shifted to circumvent modem horse stables	Start and middle of transect influenced (*e.g.* sites 05-A-B) most archaeological material was covered up, has an eroded character and/or has been removed

Table 3.4. Overview of postdepositional processes in the Arborèa.

Campidano

Postdepositional processes and modern activities have not influenced recovery rates in the Campidano as strongly as in the Arborèa (Table 3.5). Two main natural processes, sedimentation and erosion, can be seen to impact artefact distributions locally. In transects 04 and 23, for instance, recent alluvial sedimentation has potentially buried archaeological material, while slope erosion and subsequent accumulation of material at the foot of slopes have mostly shaped the landscape at start of transect 07. Dense vegetation and slope erosion have shaped much of transect 13, where virtually all finds come from sites collected outside the main grids (see Section 3.2 below). Thus, the studied transects provide a good insight into the past (lithic) activities, with some local disturbances.

Marmilla

Archaeological recovery patterns in the Marmilla mostly follow the pattern seen in the Campidano, and provide a sound basis for interpretations of past human activities (Table 3.6). Dense vegetation has resulted in cancellation of some sections in transects 14, but in transect 12 it proved so impenetrable that quantitative collections were abandoned in favour of qualitative line collections. Localised slope erosion has affected distribution patterns in transects 10, 11 and 14. Modern quarrying activities and industrial terrains and roads have also had local impact on find recovery and distribution in transects 10 and 11.

	Transect 04*	Transect 07	Transect 09	Transect 13	Transect 23
Landscape	Alluvial sediments throughout with recent sedimentation on east bank of river Mògoro. Aeolian sediments in middle to end of transect.	Campidano/ Iglesiente pediments at start. Alluvial sediments, marshy conditions & aeolian sedimentation from the middle to the end.	Colluvial pediments at start. Steep slopes of basalt plateau. Thin soils throughout transect.	Iglesiente/Campidano pediments. Dense vegetation. Steep slopes, some soil formation in valleys.	Campidano/ Iglesiente pediments and recent Mannu and Mògoro fluvial sediments
Land use	Vineyards, cultivated fields and fields in fallow		Fields in fallow	Fields in fallow	Vineyards and cultivated fields
Affected areas and nature of influences	Recent alluvial sediments may have buried material at start	Erosion on steep slopes in first half. 'Site C' created by farmer. Sites B and C partially destroyed by deep-ploughing.	Start of transect cancelled due to modern town and motorway. Slope erosion	Erosion on slopes and deposition in valleys	Recent sedimentation along banks of river Mannu may have buried archaeology

Table 3.5. Overview of postdepositional processes in the Campidano. * = covers the Arborèa/Campidano transition.

	Transect 10	Transect 11	Transect 12	Transect 14
Landscape	Basalt plateau on Miocene limestone. Steep slopes at start and middle of transect. Mògoro valley at end	Marl hills with very thin soils at middle to end. Soil formation in valleys.	Steep slopes with very dense *macchia* vegetation. Thin soils on slopes, thicker soils in corresponding valleys.	Alluvium and colluvium sediments with heavy soils. Steep slopes at end with dense vegetation
Land use		Vine- and olive yards, cultivated fields and fields in fallow	Some vineyards and fields in fallow.	Small scale vineyards and orchards, some cultivated fields but mostly fields in fallow
Affected areas and nature of influences	Local erosion around basalt outcrops. Industrial terrain and road in middle	Cut of by motorway. Modern quarrying activities towards end of transect. Erosion on slopes	Virtually whole transect is affected by very steep slopes and dense *macchia.* Most of transect has been sampled qualitatively. Strong slope erosion.	Recent sedimentation around streams. Strong local erosion of slopes at end. Part cancelled due to dense vegetation and steep slopes

Table 3.6. Overview of postdepositional processes in the Marmilla.

3.1.2.3. Artefact condition, classification and interpretation

It is commonly acknowledged that long-term exposure to the natural and cultural surface processes strongly affect the condition of survey finds. Abrasion, patination, artefact fragmentation and edge damage are caused by natural processes such as wind, water or transport and cultural activities such as trampling or ploughing (Mallouf 1982; McBrearty *et al.* 1998; Pryor 1988). In turn, artefact classification and interpretations of human activity are affected.

This study has taken these problems into by recording the artefact condition, the degree of fragmentation and the presence of fresh edge damage for all artefacts. The latter was unfortunately not recorded systematically, but only appears in the comments section; it occurs on all artefact types and in all transects. In an attempt to make the problem of post depositional edge damage more explicit, the initial classification system made a basic distinction between intentionally retouched and possibly retouched pieces.

Artefact condition for the *Riu Mannu* artefact follows the main geomorphology of the regions (Table 3.7). Most artefacts in the Arborèa are patinated. Inland blown and subsequently redeposited sands have presumably created wind and sand patination. In the Campidano and Marmilla, abrasion is more common, where water abrasion, down slope transport, and trampling and ploughing are likely causes. The higher percentages of fresh artefacts in transect 14 may be exaggerated. This transect was studied first, and patination was added as an attribute towards the end of study of this transect.

Three of the basic artefact types are particularly affected, chunks and fragments (debris) and the pseudo artefacts (Table 3.8). It has proven difficult for these categories to distinguish between naturally and intentionally flaked material *on a piece by piece basis*. It was particularly problematic to separate natural from intentional flake fragments, core fragmentation from irregular knapping or bipolar cores, and abraded edge damaged flakes from bipolar struck flakes.

		Arborèa				Campidano										Marmilla								Total	
		02		05		04		07		09		13		23		10		11		12		14			
		QT	QL	QT	QL	QT	QL	QT	QL	QT	QL	QT	QL	QT	QL	QT	QL	QT	QL	QT	QL	QT	QL	QT	QL
Fresh	N	30	41	10	8	308	403	13	44	27	39	-	29	32	37	106	189	18	-	2	33	706	314	1252	1137
	%	38	24	52.6	33.3	38.3	44.1	12.3	20.4	22.1	28.3	-	50	27.8	23.7	34.6	40	10.7	-	28.6	68.8	61.6	66.2	43.6	42.5
Abraded	N	17	69	2	3	386	327	82	123	83	74	-	17	37	50	151	177	84	4	3	9	422	153	1267	1006
	%	21.5	40.4	10.5	12.5	48	35.8	77.4	56.9	68	53.6	-	29.3	32.2	32.1	49.3	37.5	50	100	42.9	18.8	36.8	32.3	44.1	37.6
Patinated	N	32	61	7	13	110	183	11	49	12	25	1	12	46	69	49	106	66	-	2	6	19	7	355	521
	%	40.5	35.7	36.8	54.2	13.7	20	10.4	22.7	9.8	18.1	100	20.7	40	44.2	16	22.5	39.3	-	28.6	12.5	1.7	1.5	12.4	19.5
Total	N	79	171	19	24	804	913	106	216	122	138	1	58	115	156	306	472	168	4	7	48	1147	474	2874	2674

Table 3.7. Condition of all qualitative (QL) and quantitative (QT) *Riu Mannu* artefacts per transect.

	Fresh				Abraded				patinated				Total	
	QT		QL		QT		QL		QT		QL		QT	QL
	N	%	N	%	n	%	n	%	n	%	n	%	n	n
Flakes/blades	600	56.4	656	53.6	324	30.5	306	25.0	139	13.1	260	21.3	1063	1223
Cores	22	48.9	35	41.7	13	28.9	26	31.0	10	22.2	23	27.4	45	84
Retouched flakes/blades	124	45.4	204	44.7	121	44.3	165	36.2	28	10.3	87	19.1	273	456
Bifacial pieces	13	54.2	26	54.2	10	41.7	21	43.8	1	4.2	1	2.1	24	48
Chunks	122	30.3	74	27.8	232	57.6	154	57.9	49	12.2	38	14.3	403	266
Fragments	351	39.6	112	22.6	437	49.3	282	57.0	99	11.2	101	20.4	887	495
Pseudo artefacts	28	14.0	30	29.1	135	67.5	52	50.5	37	18.5	21	20.4	200	103
Total	1260		1137		1272		1006		363		531		2895	2674

Table 3.8. Condition of all qualitative (QL) and quantitative (QT) *Riu Mannu* artefacts per basic artefact class.

A closer look at the debris category illustrates this problem well and shows that analysis on a wider assemblage level is more fruitful (Table 3.9). The majority of these pieces (64.2%) appear to be flaked by natural, non-human, circumstances. The second largest group of debris (34.1%) pieces may be primary flaking material, specifically flakes, flake fragments and medial flake fragments (71.6%), or core fragmentation, bipolar cores and irregular knapping (28.4%). These finds are unevenly distributed across the research area. Most core-related material (82.6%) has come from transects 04 and 14. Flakes are more widely distributed, although two thirds (77.6%) is concentrated in transects 04, 10 and 14. Qualitative data show a similar picture, although with a smaller mechanical portion (42.5%), and higher core and debitage percentages (respectively 18.3% and 37.5%). Distribution patterns are also similar, with two thirds of core material (75%) from transects 04, 10 and 14, and 74.4% of debitage in transects 04, 09, 10 and 14. Similarly, it has proven difficult to distinguish between edge damaged artefacts, (macroscopic) use wear traces and ad hoc retouch (see Section 6.3.2).

In sum, the *Riu Mannu* Survey Project has implemented a field methodology that allows find recovery, including lithics, to be as complete as possible. Field and walker effects are sufficiently eliminated. Assessment of the types of natural and cultural postdepositional processes, and the degree to which these have shaped the physical landscape and archaeological recovery rates, has demonstrated a scale of reliability for interpretations of human activity. Examination of the condition of artefacts shows that patination and abrasion are common, and brought several problems with artefact classification to light.

	Arborèa			Campidano									Marmilla								Total	
	02		05	04		07		09		13	23		10		11		12		14			
	QT	QL	QL	QT	QL	QT	QL	QT	QL	QL	QT	QL	QT	QL	QT	QL	QT	QL	QT	QL	QT	QL
Mechanical	11	8	1	63	30	7	8	25	11	2	4	5	34	15	63	2	1	5	97	15	305	102
Tested nodule / attempted knapping	-	-	-	1	1	-	-	1	-	-	-	-	2	-	-	-	-	-	1	-	5	1
Bipolar core	-	-	-	2	2	-	1	1	-	1	-	1	1	3	-	-	-	-	6	1	10	9
Core	-	-	-	5	7	-	2	-	1	-	-	1	-	2	-	-	-	-	5	8	10	21
Core fragment	-	-	-	6	1	-	-	1	1	1	-	-	1	3	1	-	-	-	9	7	18	13
Flake	-	2	-	10	1	-	2	4	-	-	1	1	3	2	1	-	-	-	1	2	-	10
Bipolar struck flake	-	-	-	1	1	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	4	1
Proximal flake fragment	-	-	-	4	-	-	-	-	-	-	-	-	4	1	-	-	-	-	1	-	9	1
Medial flake fragment	-	1	-	25	3	2	-	2	5	-	2	-	5	7	2	-	-	-	4	2	42	18
Distal flake fragment	-	-	-	3	1	-	-	-	1	-	1	3	3	4	-	-	-	-	-	-	7	9
Flake fragment	-	1	-	7	6	1	-	-	1	-	-	1	3	8	-	-	1	-	1	1	13	18
Flake/ flake fragment with hinges	-	2	-	1	3	-	2	-	-	-	-	-	-	-	-	-	-	-	12	5	13	13
Medial blade fragment	-	-	-	1	3	-	-	-	-	-	2	4	1	1	1	-	-	-	3	-	8	10
Blade fragment	-	-	-	-	9	-	-	-	1	-	-	-	-	-	-	-	-	3	-	-	-	13
Use wear /edge damage /retouch	-	-	-	1	-	-	-	-	-	1	-	-	2	1	-	-	-	-	5	2	8	4
Total	11	14	1	130	68	10	15	34	21	5	11	16	61	47	68	2	2	8	148	43	475	240

Table 3.9. Sub classification of all quantitative (QT) and qualitative (QL) *Riu Mannu* debris pieces.

3.2. Find distribution in the *Riu Mannu* transects

Five terms reflect the variety in the *Riu Mannu* find density and distribution: special interest area, site, site halo, localised concentration and off-site or isolated finds. Following Given & Knapp (2003: 35-36) Special Interest Areas are locations with dense artefact distributions, where it is difficult to distinguish between sites, site haloes, localised concentrations and/or isolated finds. Following trends in modern survey archaeology, the term site/concentration refers to any type of human activity not just settlements (Section 2.4.2.1). Site haloes are the low density artefact distributions around sites, and probably caused by past and present agricultural practices. Localised concentrations are artefact densities that, compared to *overall* find densities, are low with a limited dispersal, but nevertheless stand out from the *local* transect artefact densities. Off-site is used in the 'new' meaning *i.e.* isolated archaeological finds (van de Velde 2001: 29).

The next section presents the lithic distribution in the studied transects. This is done in relation to the overall ceramic distribution in the transects for two reasons: 1) pottery makes up 80% of the finds recovered, and has been the Project's main measure to define concentrations, and 2) pottery is the only reliable means of dating lithic assemblages (see below). Thus, a close examination of the *spatial* correlation between the two is important. Please note that it does not follow that the two find categories are chronologically contemporaneous. Dates and archaeological periods that are mentioned here pertain only to the ceramics. The temporality of lithic landscape is discussed elsewhere (Section 7.2). Also note that the maps are a summary of detailed find distributions in the transects (for an example of analysis on transect level, see Figure 3.9; Appendix 3.1 contains figures for all other transects).

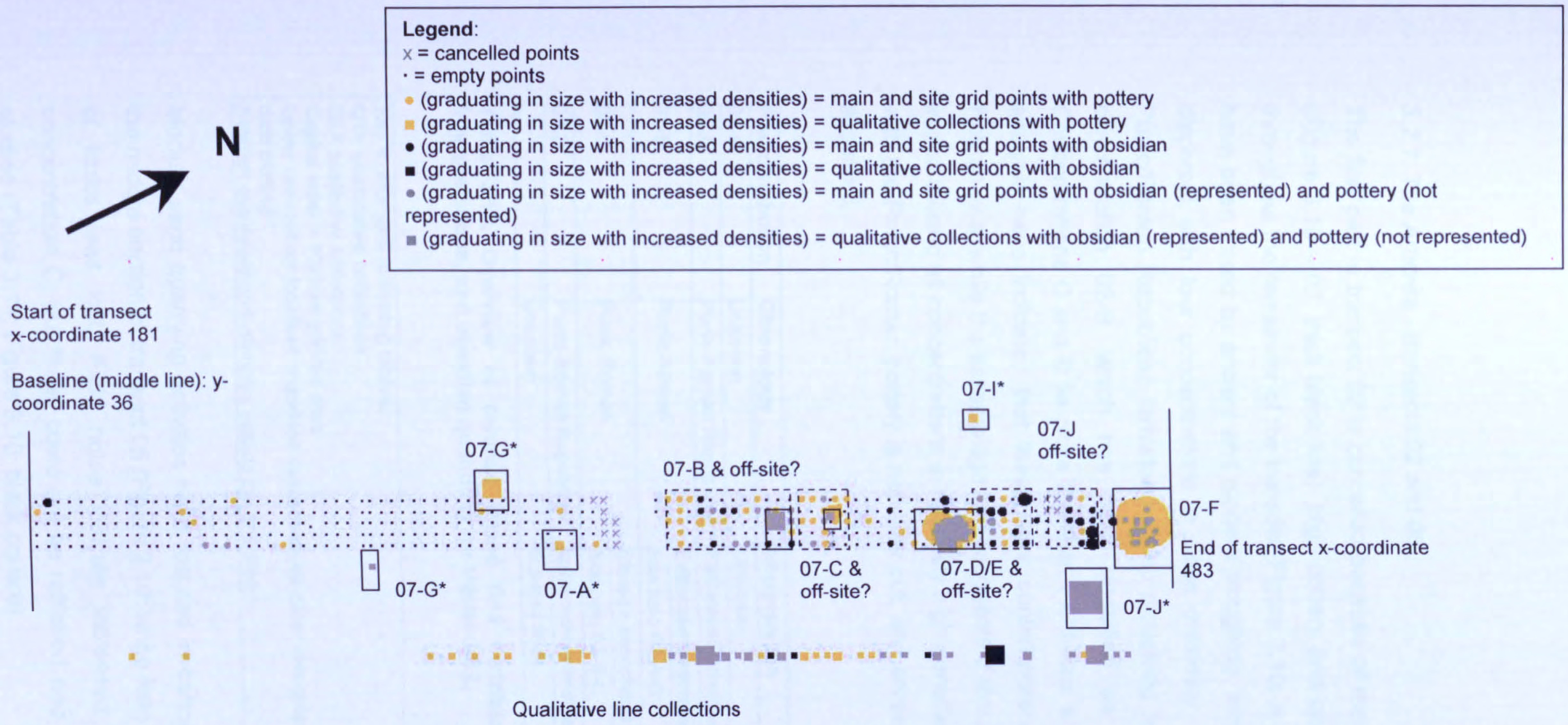

Figure 3.9. Pottery and lithic distribution plots for transect 07. See text for discussion.
Squares with solid lines= concentrations
Squares with dashed lines= site haloes
Vertical lines= the local x-coordinates
Horizontal lines= the local y-coordinates.
Qualitative collections along the y-coordinates are separate, without a y-coordinate since they were collected along the length of the x-coordinates

3.2.1. The Arborèa - transects 02 and 05

The first part in transect 02 is cancelled because of modern river canalisation (Figure 3.10 – 02: thick black line). High pottery and obsidian densities occur throughout the remainder of the transect (Figure 3.10: A-D; Table 3.10). These have been mixed by ancient and modern ploughing, resulting in a diffuse find dispersal with four concentrations in close proximity. Site 02-A is a large Punic/Roman Republican farmstead. Deep ploughing has destroyed most of concentration 02-B, which has been classified as a Punic farmstead. Concentrations C and D lie close together. Field data and subsequent pottery analysis have indicated that these were contemporaneous. Site 02-D is a Roman villa, while the assemblage for C suggests a storage area. Lithics occur in and around all concentrations in relatively high densities, but the relationship with the Punic/Roman pottery is not clear-cut, and contemporaneity cannot be assumed.

Find distribution	Chronology	Interpretation	QT	QL
02-a*	Unknown	Unknown	-	18
02-A	Punic-Roman Republican	Settlement-farmstead	6	29
02-B	Punic-Roman	Settlement-farmstead	22	38
		Site halo 02-A-B	6	20
02-C	Punic-Roman	Storage associated with 02-D?	4	25
		Site halo 02-B-C	11	26
02-D	Punic-Roman Republican	settlement-farmstead	2	4
	Unknown	Isolated finds	27	25

Table 3.10. Overview of ceramic based find distribution, chronology and interpretations, and obsidian quantities for transect 02.

Key to this and following tables:
QT= quantitative collections
QL= qualitative collections
Capital letter = 10x10m gridded sites
Lower case letter= localised ungridded concentrations either recognised during field work or after data plotting
Asterix= qualitative grab-samples outside the grid area.

Modern sand quarrying activities have resulted in cancellation of sampling in the middle section of transect 05 (Figure 3.10: white line). A substantial amount of lithics was lost. Field notes indicate increased lithic densities near concentration C, but these could not be retrieved and, thus, have not been studied (Table 3.11; Figure 3.10: black square).

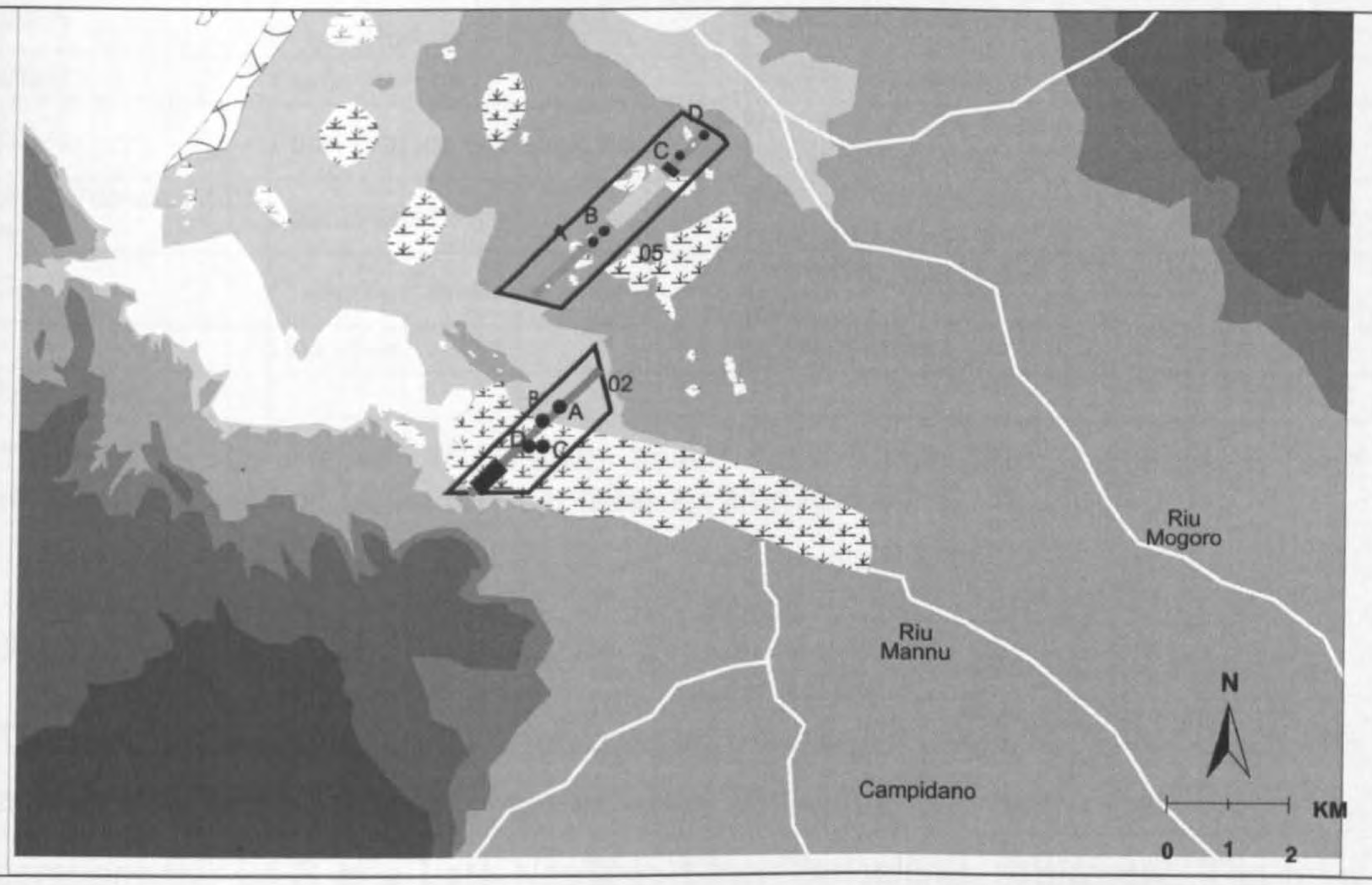

Figure 3.10. ***Riu Mannu*** **find distribution in Arborèa transects 02 and 05; see text for explanation.**

The largest ceramic concentration is 05-A, but the area is heavily disturbed by severe top-soil stripping. Some coarse sherds suggest a generic Final Bronze Age/First Iron Age presence, but a specific interpretation has proven problematic. Most evidence relates to a Punic/Roman Republican farmstead. The second location, 05-B, is also heavily disturbed. Only severely eroded sherds have remained, generically datable to Roman times. The third site, 05-C, lies partially outside the grid area, and a site halo is recognisable in the main grid. This entire area has been interpreted as an extensive Bronze Age village of isolated huts. A few obsidian artefacts have been collected but field notes caution against taking this low number for granted. To the team's frustration, shreds of black plastic seriously hindered recognising obsidian. The fourth concentration 05-D is a Punic/Roman cemetery with a nearby settlement. Overall, the relationship between lithic and pottery densities has proven problematic (Figure 3.10; Table 3.11). Few pieces clearly correspond to the site assemblages, with the exception of a concentration of lithics in 05-D. Most finds occur as isolated finds at either end of the transect (Figure 3.10: two white dots). Finds in and around concentration C, are particularly problematic given the absent obsidian sample.

Find distribution	Chronology	Interpretation	QT	QL
05-A	Final Bronze Age-First Iron Age; Punic-Roman Republican	Unknown; settlement-farmstead	1	2
05-B	Punic-Roman	Settlement-farmstead?	-	1
05-C	Final Bronze Age-First Iron Age	Settlement-extensive open 'village' with isolated huts	1	5
x-coordinates 430-442	Late Bronze Age?	Settlement? Heavily disturbed area, part of 05-C?	1	6
05-D	Punic-Roman Republican	Cemetery associated with nearby farm?	13	9
	Unknown	Isolated finds	3	2
Lost obsidian			25	21

Table 3.11. Overview of ceramic based find distribution, chronology and interpretations, and obsidian quantities for transect 05.

3.2.2. The Campidano: transects 04, 07, 09, 13 and 23.

Transect 04 contains four gridded concentrations (Figure 3.11; Table 3.12). 04-A is a late Roman Republican-Imperial settlement with Late Antiquity components. 04-B is a Late Neolithic–Late Chalcolithic settlement. The third concentration, 04-C, is dated to the Final Bronze Age/First Iron Age and is heavily disturbed. Concentration, 04-D lies close to C and the pottery assemblage indicates three successive phases.

Find distribution	Chronology	Interpretation	QT	QL
04-A	Roman Republican-Early Imperial; Late Antiquity	Villa? Settlement?	8	-
04-B	Neolithic-Eneolithic	Settlement	496	598
		Site halo 04-B	105	88
04-C	Final Bronze Age-First Iron Age	Unknown	7	12
04-D	Final Bronze Age-First Iron Age; Punic; Roman Imperial	Unknown; Punic farm; unknown	12	8
		Site halo 04-C-D	10	7
04-a	Unknown	Localised concentration	16	-
04-b	Unknown	Localised concentration	26	12
04-c	Unknown	Localised concentration	74	178
x-coordinates 020-113	Unknown	Isolated finds	26	29
x-coordinates 114-132	Unknown	Isolated finds	4	11
x-coordinates 192-237	Unknown	Isolated finds	37	12
x-coordinates 259-500	Unknown	Isolated finds	13	20

Table 3.12. Overview of ceramic based find distribution, chronology and interpretations, and obsidian quantities for transect 04.

A low, but consistent, number of lithics is broadly associated with late prehistoric and Roman sites, but nearly all finds come from 04-B (Table 3.12). Three ungridded localised lithic concentrations have also been recognised.

The first (04-a) lies close to site A, while the others (04-b and 04-c) are centred around concentration B (Figure 3-11: white dots). Lastly, there is a consistent but low spread of obsidian throughout this transect.

Transect 07 contains high artefact densities, particularly in the second part (Figure 3.9; 3.11; Table 3.13). Spatial and chronological boundaries are difficult to draw. Contemporaneous and consecutive settlements are in close proximity, and ancient and recent ploughing have diffused boundaries. In some cases, modern activities have severely disrupted distribution patterns, or created new concentrations (07-B, 07-C and 07-G; see Table 3.5; also Knikman-Stoetman 2000).

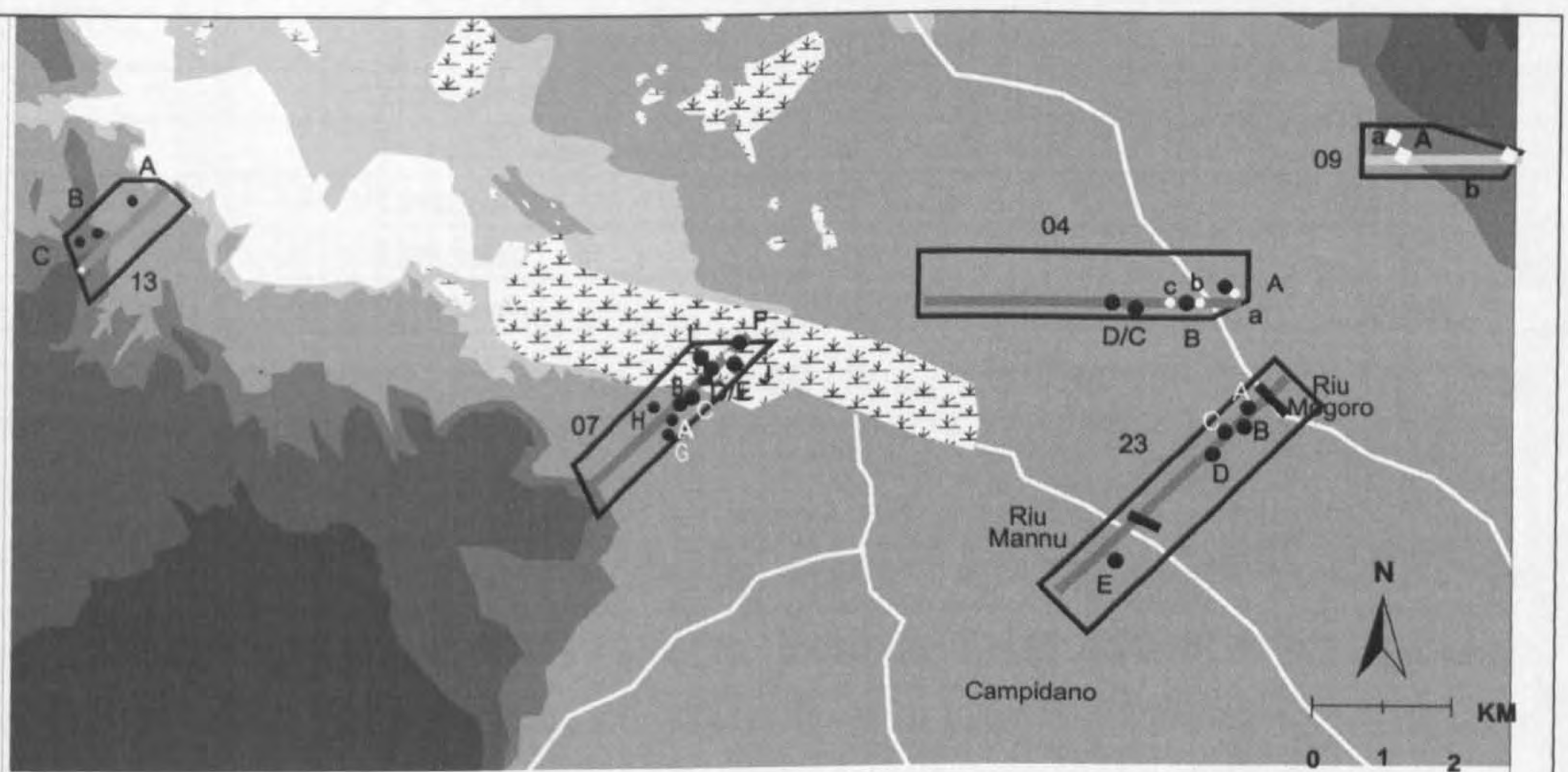

Figure 3.11. *Riu Mannu* find density in the Campidano transects 04, 07, 09, 13 and 23; see text for explanation.

Three gridded sites are Punic farmsteads (Figure 3.11: 07-D/E, F). 07-D and 07-E are broadly contemporary and have been interpreted respectively as a depository shed/storage area and a farmstead accompanied by some burials. Light pottery scatters in between these locations also date to the Punic period. Five additional concentrations lie outside the main grid area and have only been sampled qualitatively (Figure 3-11: A, G-J). One of these, 07-J, consists almost entirely of obsidian, and its corresponding halo is visible in the main grid (Figure 3.11: white dot). Overall, lithics occur in modest numbers with the highest densities in and around concentrations B, D/E, F and J (Table 3.13). Clearly, the high find densities, the close proximity of concentrations, the site haloes, and the invariable mixing of assemblages, however, has created convoluted relationships between ceramic and lithic assemblages, similar to transect 02.

Find distribution	Chronology	Interpretation	QT	QL
07-A*	Imperial Roman?	Shed?	-	-
07-B	Late Bronze Age?	Settlement?	2	15
		Site halo 07-B	12	32
07-C	Punic-Roman?	Domestic	-	3
		Halo 07-C	4	-
		halo 07-C-D	2	3
07-D	Punic-Roman Republican	Small subsidiary building to 07-E stable or depository	-	4
07-E	Punic-Roman Republican	Settlement-farmstead & burials	20	45
	Punic	Halo 07-D/E	28	17
07-F	Punic-Roman Republican	Settlement, large farm	15	8
07-G*	Bronze Age? Modern	Land owner compiled	-	1
07-H*	Nuragic-Roman	Construction	-	-
07-I*	Punic-Roman Republican	Settlement-farm	-	-
07-J*	Unknown	Unknown	-	70
	Unknown	Halo 07-J	22	21
x-coordinates 181-334	Unknown	Isolated finds	4	-

Table 3.13. Overview of ceramic based find distribution, chronology and interpretations, and obsidian quantities for transect 07.

Transect 09 contains only one gridded location, a nuraghe (09-A), which has been classified as generically Nuragic, because most pottery is undiagnostic coarse ware. A second section (09-b) is a stretch of $19^{th}/20^{th}$ century AD abandoned fields (Figure 3.11: black square). Sizeable raw material nodules, suitable for reduction, have been noted and qualitatively sampled along in two areas, one inside and one outside the transect area (Figure 3.11: white squares; also Section 4.1.2). Most lithics are associated with the Nuragic settlement. A small obsidian concentration (09-a*) outside the main grid has been collected qualitatively (Table 3.14).

Find distribution	Chronology	Interpretation	QT	QL
09-a*	Unknown	Unknown	-	29
09-A	Nuragic	Settlement-single tower nuraghe	64	80
		Site halo 09-A	12	2
09-b	19-20th century AD	Abandoned cultivated fields	34	19
x-coordinates 000-078	Unknown	Isolated finds	2	7
x-coordinates 100-200	Unknown	Isolated finds	10	3

Table 3.14. Overview of ceramic based find distribution, chronology and interpretations, and obsidian quantities for transect 09.

Archaeological material is unevenly distributed in the last transect in the Campidano, 23. The first part of the transect is virtually empty, most material has come from the area between the two rivers, gravitating towards the Mògoro terraces (Figure 3.11; Table 3.15). Four concentrations have been gridded. A fifth site (23-E) lies outside the main grid, and is heavily disturbed. Concentration 23-A is a Roman villa/farm with sheep pen, site 23-B is a Punic/Roman farmstead and 23-D is a Punic shed. 23-C is a dispersed distribution of obsidian.

The majority of obsidian is concentrated in 23-C, and the remainder broadly correspond to the sites. The close proximity of sites and the dispersed character of 23-C makes it difficult to establishing spatial correlations between ceramic and lithic distributions, especially for concentrations B and D. Raw material obsidian nodules are in abundance along both rivers, with some locations sampled for analysis and study (Figure 3.11: thick black lines; see Section 4.1.2).

Find distribution	Chronology	Interpretation	QT	QL
23-A	Roman, late Republican-Imperial	Villa + farm + sheep pen	7	4
23-B	Punic	Settlement-farmstead	18	25
23-C	Unknown	Exploitation-reduction?	25	42
		Halo 23-C	22	24
23-D	Punic	Shed	16	4
Off-site 23-C-D?	Unknown	Halo?	9	18
23-E*	Roman	Unknown	-	-
x-coordinates 000-360	Unknown	Isolated finds	23	37
x-coordinates 438-498	Unknown	Isolated finds	-	4

Table 3.15. Overview of ceramic based find distribution, chronology and interpretations, and obsidian quantities for transect 23.

3.2.3. The Marmilla – transects 10, 11, 12 and 14

Artefacts occur throughout transect 10, with two gridded high density concentrations (Figure 3.12: B-C; Table 3.16). A small localised, ungridded, obsidian concentration, 10-A, has been qualitatively sampled, and interpreted as a 'knapping event' by the field crew (see Table 7.7 for the re-interpretation). Raw material nodules were abundantly present but not collected.

Find distribution	Chronology	Interpretation	QT	QL
10-a	Bronze Age?	Eroded settlement?	17	7
10-A	Unknown	Knapping event	27	20
10-B	Final Bronze Age-First Iron Age / Punic	Nuraghe /adjacent settlement	162	305
		Halo 10-B	4	51
10-C	Final Bronze Age-First Iron Age / Punic	Nuraghe /adjacent settlement	67	89
		Halo 10-C	10	13
x-coordinates 033-180	Unknown	Isolated finds	16	4
x-coordinates 204-297	Unknown	Isolated finds	9	3
x-coordinates 327-342	Unknown	Isolated finds	12	-
x-coordinates 351-469	Unknown	Isolated finds	34	23

Table 3.16. Overview of ceramic based find distribution, chronology and interpretations, and obsidian quantities for transect 10.

Obsidian and pottery distributions closely correspond at the two gridded sites: 10-B and 10-C. These are complex *nuraghi* with long settlement histories. Both were inhabited during the Final Bronze Age/First Iron Age, and have a Punic/Roman Republican farmstead adjacent. Site 10-B has also yielded earlier Chalcolithic material (Monte Claro), further extending occupation, although the pottery sample is too small for an interpretation. Field records stress that Punic material is a local, spatially distinct, concentration (Figure 3.12: white dot). There is also a steady presence of obsidian throughout the transect. A severely eroded, possibly Bronze Age, settlement (10-a) is located on the edge of the terrace. Unfortunately, the most material has been washed away, leaving only traces of human activity behind (Figure 3.12: black dot). Site 10-C lies right outside the main grid. Point collections on the nuraghe were difficult. It is overgrown and partially re-used as a sheep pen, but some Bronze Age material was collected. Fields below the nuraghe have yielded a concentration of Punic material (Figure 3.12; white dot). The long settlement history on such a small area has made it difficult to attribute lithics to a particular occupation phase.

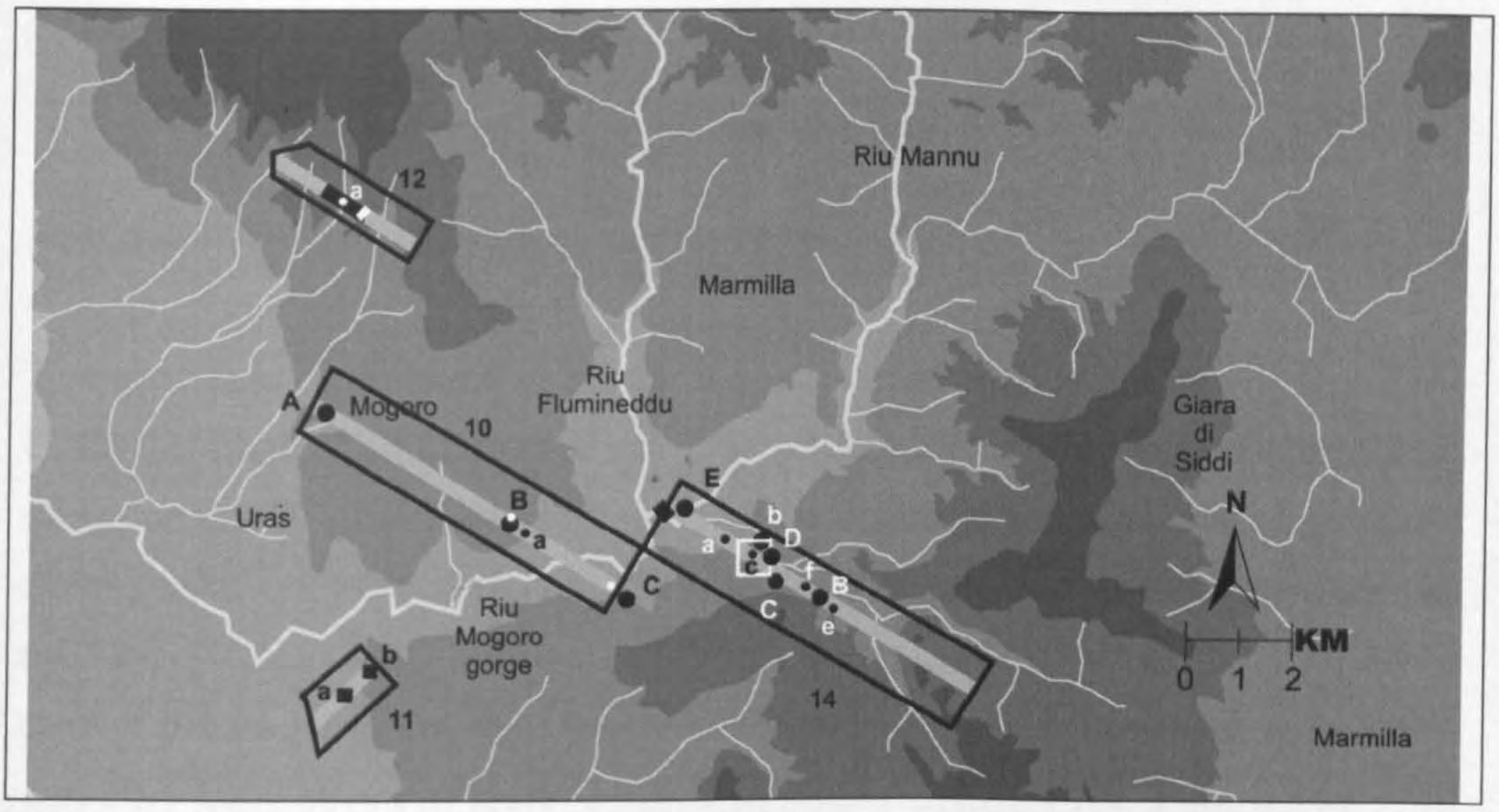

Figure 3.12. Find distribution for *Riu Mannu* transects 10-12, and 14; see text for explanation.

Transect 11 does not contain any gridded concentrations or high densities but has a steady presence of both pottery and lithics throughout. Pottery and lithic distribution patterns are mostly separate. Most ceramics date to the 17-20th century AD and two broad stretches of lithics have been recognised (Figure 3.12: a-b; Table 3.17).

Find distribution	Chronology	Interpretation	QT	QL
11-a	Unknown	Localised concentration	69	-
11-b	Unknown	Localised concentration	57	-
	Unknown	Isolated finds	51	4

Table 3.17. Overview of ceramic based find distribution, chronology and interpretations, and obsidian quantities for transect 11.

Transect 12 has yielded few finds, mostly as a result of dense vegetation and steep slopes and point-by-point collection was replaced by line walking (Figure 3.12: thick black line, also Table 3.6). Modern building activities have opened up one small area, where a small sample of obsidian (12-a) was qualitatively collected (Figure 3.12: white dot; Table 3.18). Field documentation has also indicated a steady presence of raw material, some of which has been sampled (Figure 3.12: white square; see Section 4.1.2).

Finds distribution	Chronology	Interpretation	QT	QL
12-a*	Unknown	Localised concentration	-	37
	Unknown	Isolated finds	7	13

Table 3.18. Overview of ceramic based find distribution, chronology and interpretations, and obsidian quantities for transect 12.

The main grid in transect 14 contains one gridded obsidian concentration (14-B) on the slope of sa Costa Manna. Two smaller concentrations (14-e and 14-f) surround site B, one of which (14-e) was recognised and sampled qualitatively during fieldwork. The first half of transect 14 is very complex. A low density mixture of Chalcolithic to Imperial Roman pottery and lithics occurs in the first part of the transect (14-a). Three sites outside the main grid area have been sampled qualitatively (Figure 3.12: C-E; Table 3.19). 14-E adjoins the main grid, and its halo is clearly recognisable in the grid. It is a Punic/Roman Republican settlement with a possible cemetery nearby. Two *nuraghi* 14-C and 14-D have also been grab-sampled, as well as the wider plateau around a nearby Eneolithic burial (14-b) up to nuraghe 14-D (Figure 3.12: large black dot).

Finds distribution	Chronology	Interpretation	QT	QL
14-a	Eneolithic-Roman Imperial	Isolated finds	13	16
14-d	Eneolithic-Bronze Age-Roman	Mixed material from 14-D, c-d	27	32
14-B	Neolithic?	Observation - tool maintenance	768	339
		Halo 14-B	226	1
14-e	Early Neolithic?	Localised concentration	70	22
14-f	Unknown	Localised concentration	30	4
14-E*	Punic-Roman	Settlement	1	8
14-D*	Nuragic	Construction	-	15
14-b*	Eneolithic (Monte Claro)	Burial structure	-	13
14-c*	Unknown	Unknown	-	8
14-C*	Nuragic	Settlement-complex nuraghe; isolated huts nearby	-	12
x-coordinates 138-171	Unknown	Isolated finds	10	9
x-coordinates 249-498	Unknown	Isolated finds	10	4

Table 3.19. Overview of ceramic based find distribution, chronology and interpretations, and obsidian quantities for transect 14.

Lastly, a small obsidian concentration (14-c) lies west side of the grid, which has been grab-sampled (Figure 3.12: small black dot). These nearby sites, with their corresponding site diversity and longevity have resulted in a dense and convoluted mixture of artefacts (14-d) inside the main grid (Figure 3.12: open white outlined box). Field teams have noted raw material along the Mògoro river but not collected any samples (Figure 3.12: black square; Section 4.1.2).

3.2.4. Find distribution: discussion

It is clear from the above that association between lithic and ceramic assemblages is not straightforward. This is unfortunate, because dating *Riu Mannu* lithics is primarily dependent on spatial association with pottery assemblages, given the current status of Sardinian lithic studies (Section 1.3). The alternative, hydration dating, was not an option. While the necessary comparative hydration rates are available for the Monte Arci sources, *Riu Mannu* artefacts have not been chemically sourced, so that their provenance, and subsequent hydration rates, cannot be securely established. Secondly, currently, hydration rates for secondary raw material sources have not yet been investigated, despite evidence for their use in the past (de Bruijn 2004; Michels 1987; see Chapter 4.1.2; 4.2). Finally, soil rates and relative humidity for find locations also need to be known to allow corrections of their effects (Stevenson & Ellis 1998). This is difficult to establish for surface material in general, and given the *Riu Mannu* field methodology, highly impractical.

It is clear that diversity in activities, in combination with spatially close and/or chronologically varied material, as well as cultural and natural postdepositional processes have resulted in complex and dense activity areas in several *Riu Mannu* transects. Likewise, ancient and modern ploughing activities have created site haloes in several transects and/or mixed assemblages. Ascribing lithics to one or the other area is therefore problematic, which clearly influences any discussion of temporal changes. Furthermore, when ceramics are scarce, association is not possible. This particularly affects the small localised lithics-only 'concentrations', which have been recognised in many transects either during fieldwork (*e.g.* 07-J, 09-a, 10-A, 23-C) or after plotting densities (e.g. 04-a-c, 14-e-f). Isolated finds and low density transects like 11 and 12 are also strongly affected. Excluding these finds from analyses would severely limit our understanding of the Sardinian lithic landscape. A more flexible methodology is needed to explore the full potential of the *Riu Mannu* survey data.

3.3. Spatial distribution

The above demonstrated what was previously argued on theoretical grounds. Traditional survey and lithic analytical methods do not suffice for a social approach to the study of the Sardinian lithic landscape. Spatiality and three components of lithic taskscapes, procurement, production and use, instead form the basis for analyses and interpretation, with density and chronology as additional variables. Clearly, the *Riu Mannu* material is well suited for this approach, as the field methodology allows for the combination of detailed technological, individual, artefact analysis with a fixed position in the physical landscape through the point-by-point collection.

3.3.1 Three types of distribution maps

With a larger emphasis on spatiality, the display of analyses and interpretations are essential. I have chosen to present these on three levels (Table 3.20). The Bally Lough Project in Ireland has inspired this approach, with some adjustments. Apart from the problematic aspects of the Bally Lough Project's theoretical basis (Section 2.5.2.3), the *Riu Mannu* dataset itself is unsuitable for a full presentation of information. The point-by-point fieldwork methodology is spatially too detailed to plot all the finds from all transects in one regional map, and the level of lithic information is also too detailed (see Section 3.4 below). Pie charts, when plotted for each individual find point, for instance, obscure each other due to their close proximity, *i.e.* every 30 metres. The *Riu Mannu* chronological range (Neolithic- Roman) is also much longer. Therefore, I have chosen to represent the basic lithic distribution for each transect in four separate maps, each displaying one of four artefact categories: raw material/pseudo artefacts, debris (chunks and fragments), diagnostic primary flaking material (cores, flakes. blades, core rejuvenation pieces) and secondary flaking (retouched and possibly retouched) pieces (Figure 3.13; in Appendix 3.2 each map is plotted on a single A4-sheet).

These categories are associated with three broad *chaîne opératoire* acts, procurement, manufacture and use, but it should be clear that relationships between them are *not* considered straightforward. Flakes, for example, are part of both manufacturing and use stages, while debris can encompass intentionally (*i.e.* through human agency) and naturally/mechanically flaked material (*i.e.* by natural agents such as water, or down-slope transport), and thus are part of manufacturing and/or procurement stages or raw material source locations. The individual transect plots are the first level of representation (Table 3.20). They are spatially the most detailed maps but show the most general lithic information; as such they complement traditional representations (*i.e.* Figures in Appendix 3.1).

Spatiality/lithic information	Display	Examples
High spatial information : low lithic information	Individual transect maps	Figure 3.10; Appendix 3.2
Intermediate spatial and lithic information	Map with one of three physical landscapes with specific lithic distributions *e.g.* core distribution, artefact characteristics (condition, raw material characteristics etc)	All figures in chapters 4-6
Low spatial information : high lithic information	Regional maps (research area) with procurement, production and use strategies distribution	All figures in chapter 7

Table 3.20. Relationships between levels of display of lithic and spatial information in the distribution maps in this study.

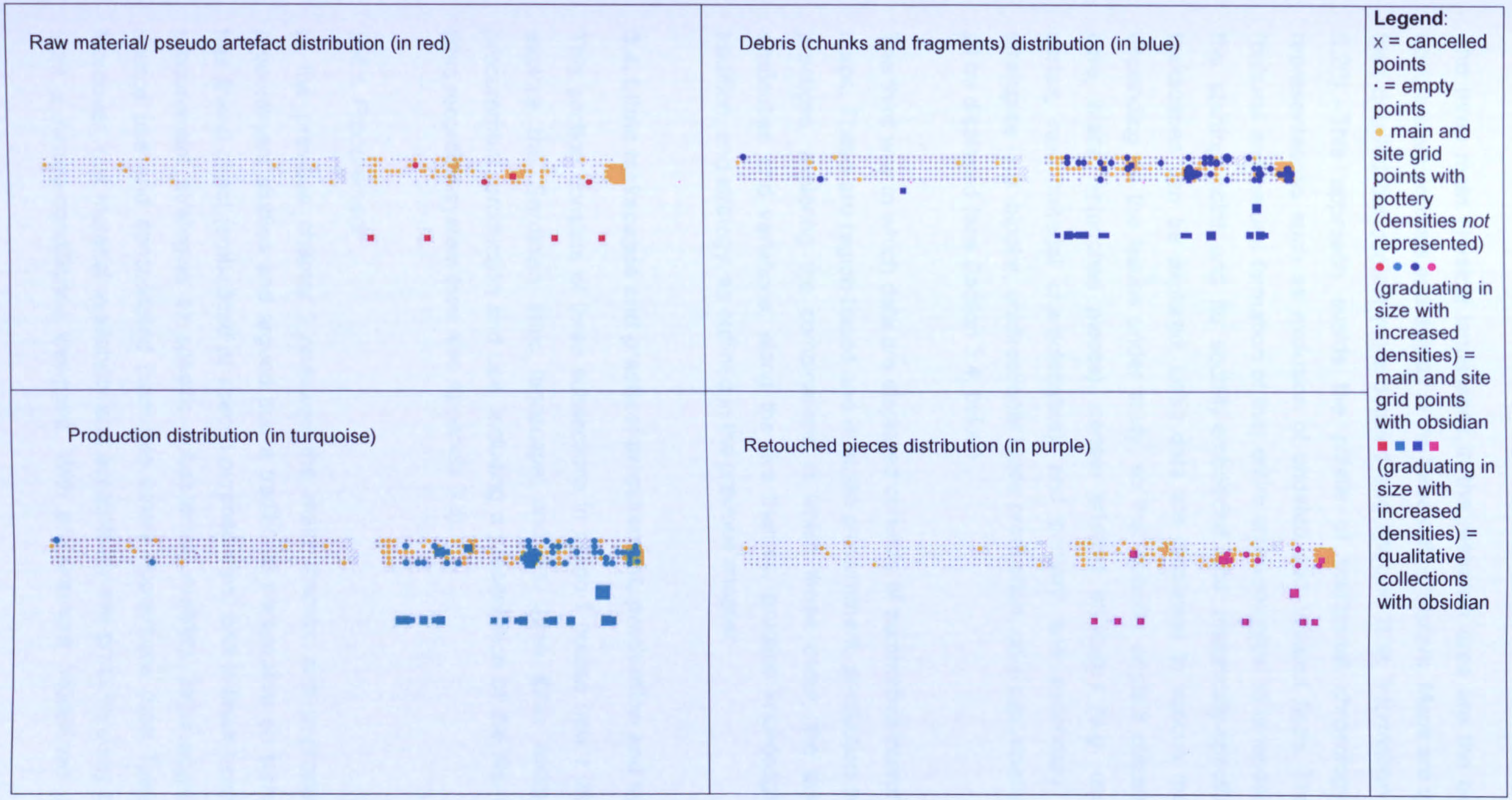

Figure 3.13. Schematic example of the lithic distribution maps for transect 07 (see the legend Figure 3.9).

The three main physical landscapes in the research area are the basis for comparative analysis and display in the three data chapters. Maps are spatially less detailed but contain more detailed and specific lithic information (Table 3.20). This approach avoids the pitfalls of traditional chronology-based representations such as exclusion of undated and isolated finds. Thus, the (cultural and natural formation of the) entire archaeological lithic landscape is the starting point and its socially-embedded and historically-specific lithic taskscapes can be explored. Lithic data are displayed in various manners, depending on the issues under study, so that specific artefact classes (*e.g.* core, blade, retouched pieces), certain artefact attributes (*e.g.* condition, cortex, raw material characteristics), and primary and secondary flaking strategies (*e.g.* bipolar, unidirectional blade production, core rejuvenation) can all be displayed (see Section 3.4. below).

The third way in which data are displayed consists of summative interpretative maps. These are region-based and illustrate procurement, production and use practices, exploring the combinations in which these occur, the densities, similarities and variations, along the five themes, practice knowledge, skill, tradition, and strategy, as outlined in the previous chapter.

3.4. Lithic taskscapes and practice: procurement, production and use

This section consists of three subsections in which I outline how I intend to explore the Sardinian lithic landscape and its three lithic taskscapes, procurement, production and use, including a presentation of the *Riu Mannu* lithic recording system (see also Appendix 3.3).

3.4.1. Procurement

In the previous chapter I reviewed the main themes and approaches in procurement studies and argued that a traditional perspective on technology has linked direct (embedded or special purpose trips) and indirect (exchange) procurement strategies to specific subsistence, mobility, technologies and source use and consolidated them into binary oppositions (see Table 2.1). Moreover, raw material availability and accessibility are predominantly studied from a nature-conditioned viewpoint. With procurement (re)defined as 'the practice of obtaining raw material, whereby socially-situated, historically-specific skills and knowledge have shaped, and are simultaneously shaped by, already existing strategies, traditions and diversity', however, social preferences are studied alongside materiality (see Figure 2.3). Therefore, raw material availability is discussed in relation to raw material use through the analysis of a number of specific variables (Table 3.21, also Appendix 3.3).

Variables	Attributes	Inferences
Cortex percentages	None	Raw materials & reduction *e.g.* size and shape of parent material, opening and flaking strategies.
	1-25%	
	26-50%	
	51- 75%	
	76-100%	
Cortex types	Type one	Raw materials *e.g.* source types and locations.
	Type two	
	Type three	
	Type four	
Raw material characteristics	Colour	Raw material *e.g.* source types, quality, and aesthetics.
	Texture	
	Translucency	
	Gloss	
	Fossil inclusions	
	Patterning/banding	
Cortex location	Descriptions dependent on position of artefact	Raw material & reduction *e.g.* opening and flaking strategies.
Pebble size*	Small	Raw material selection criteria (after Marshall 2000: 89).
	Medium (fist-sized) 10-20cm nodules	
	Large	
Pebble form*	Angular	
	Sub-angular	
	Sub-rounded	
	Rounded	

Table 3.21. Main variables, attributes and methods used to understand *Riu Mannu* procurement strategies, recorded for all artefacts. *Recorded for cores only.

Drawing on existing literature and this study, the following questions are addressed:

- Where are raw material sources located, and in what condition is raw material available (*e.g.* shapes, sizes of nodules, quantities and flaking quality)?
- Which raw material sources are used?
- Where is raw material reduced (*i.e.* at or away from the sources)?
- If transported, in what condition is material transported (*e.g.* nodules, preformed-cores, finished flakes/blades, retouched artefacts), and can selection criteria be recognised?

- How is raw material reduced (opening strategies)?
- What procurement strategies can be distinguished?
- Can spatial and temporal differences be recognised?

For the *Riu Mannu* data, five means of analysis are employed. First of all, types, percentages, and positions of cortex on all artefacts and estimation of pebble shape and size for cores are studied to gain information about the original types, shapes and sizes of parent materials (Table 3.21, also Bradbury & Carr 1995; Marshall 2000). When compared with the types, sizes and shapes available at raw material sources, it becomes clear if, and what, selection criteria existed. Secondly, core abandonment due to raw material size, the presence of internal flaws, sizes, the number and sizes of removal are also good indicators of raw material constraints, while an examination of the degrees in handling these help assess knapping abilities (see below and Table 3.23). Thirdly, by comparing and contrasting average artefact sizes and number of previous removals for cores, debitage and tools, discrepancies in the forms in which raw materials were brought in will become apparent. Fourthly, opening strategies are explored. Core platform type, orientation of reduction, percentages and position of cortex help understand how raw material is reduced. Moreover, the absence/presence of certain specific artefact classes in assemblages, such as primary opening flakes and crested blades, provides further information on opening strategies. Lastly, human preferences in aesthetic properties of raw material, such as colour, texture, banding, and translucency are examined, especially in how far these are combined with specific procurement and knapping practices (Tables 3.21; 3.22).

Thus, when opening strategies and raw material selection criteria are examined for all raw materials, and in particular how they relate to knapping strategies one can start to examine if direct procurement, embedded, or as part of special purpose trips, and/or participation in exchange networks can be recognised. By combining spatial and temporal information to these analyses similarities and differences in the social organisation of procurement strategies can be examined (Table 3.22).

Variables	Inferences	References
Sizes: average length, width & thickness in mm	Discrepancies in ratios raw materials: primary/secondary flaking strategies in relation to find locations	Bradley & Edmonds 1993; Inizan *et al.* 1999; Perlès 1992b
Types & number of previous removals		
Raw material characteristics with flaking traditions and strategies	Aesthetic selection criteria	Gero 1989
Source location and extent with procurement and production strategies	Source availability and use	Bradley & Edmonds 1993; Torrence 1986; Tykot 1995.

Table 3.22. The main comparative combinations of *Riu Mannu* variables used to understand procurement strategies.

3.4.2. Knapping practices: strategies, traditions, and skills

In chapter two I have argued that the traditional view on technology unnecessarily restricted production and use studies by primarily implementing generalised reduction sequences, focussing on finished artefacts and consolidating concepts into binary oppositions (Section 2.3.2). Instead of continuing these trends, lithic production and use taskscapes are explored through the five key concepts (practice, knowledge, skill, strategy and tradition) and the *chaîne opératoire* as the main conceptual and analytical concept (Sections 2.2; 2.6: Figure 2.3). As before, my interest is in examining *knappers'* choices, which are investigated through detailed reconstructions of primary and secondary knapping and by analysing a wide variety of specific variables and attributes. The following questions are central:

- Where do primary and secondary knapping occur, and can spatial and temporal differences be recognised?
- Which primary and secondary knapping strategies and traditions can be recognised, and can spatial and temporal differences be recognised?
- Do (some) primary and secondary strategies and traditions relate to different raw materials, and can spatial and temporal differences be recognised?
- Is knowledge about knapping strategies and traditions available to all, or can control be seen, and can temporal differences be distinguished?

3.4.2.1. Primary knapping: core biographies and dorsal scar patterns

To examine primary knapping strategies I have analysed a number of characteristics for cores, unretouched and retouched artefacts (Table 3.23). Instead of describing core typologies, which is the static end-result of all knapping stages, I have chosen to describe core biographies. These emphasise the dynamics of knapping by tracing the history of individual core reduction as represented by the type and number of knapping stages (following Finlayson *et al.* 2000). A stage is recognised when a change in type of removal occurred or if one set of removals was seen to partially overlie another, coming from a different direction and/or a different platform (Table 3.23; Figure 3.14; Appendix 3.3). For each stage I have recorded the type of stage, type of platform, type, number and maximum length and width of removals, and for each final core stage the extent of surviving platform surface (Table 3.23). By analysing these and comparing and contrasting assemblages on a spatial and temporal scale continuation of and changes in flaking traditions and variations become apparent.

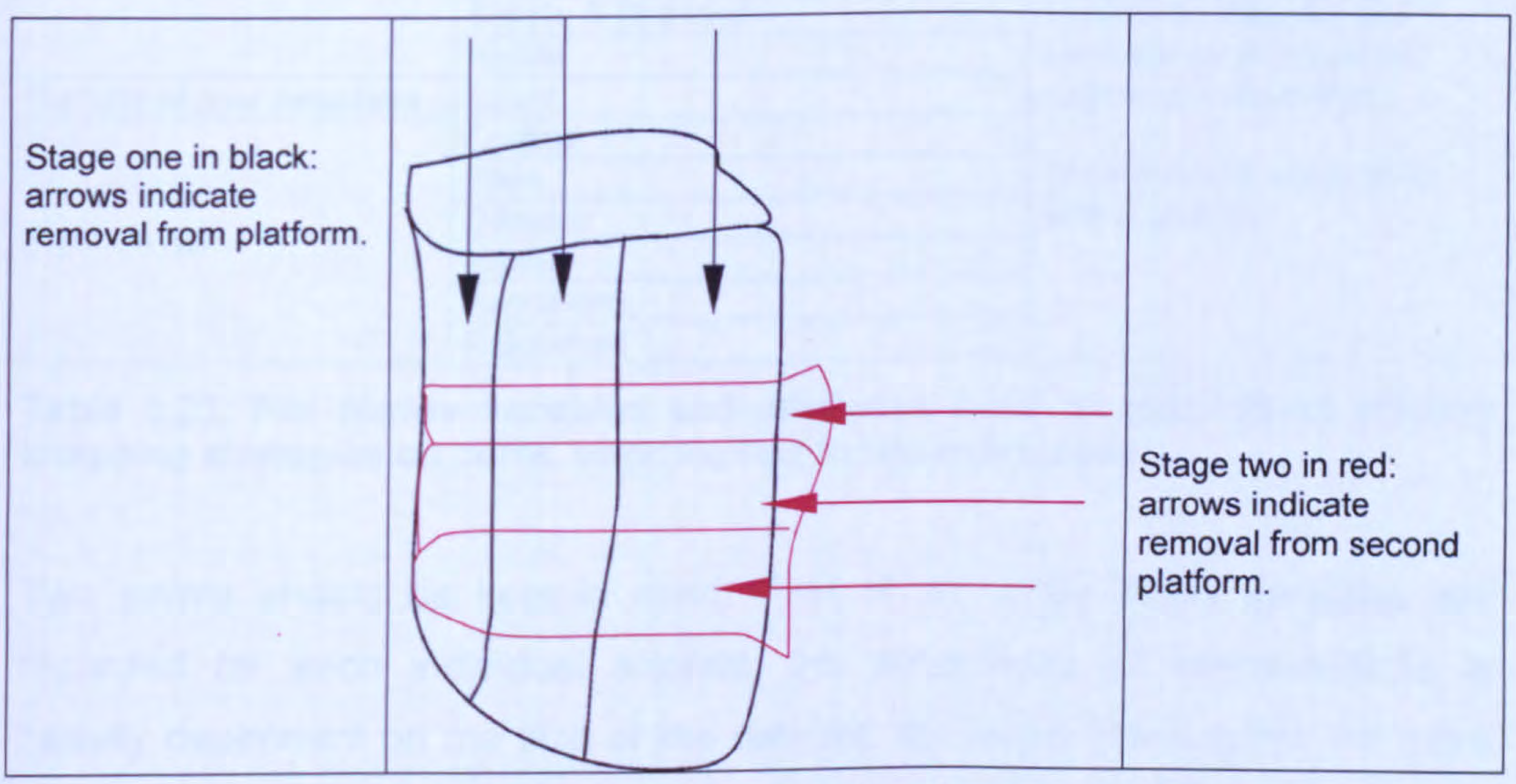

Figure 3.14. Schematic example of change in direction of core removal.

Similarly, dorsal scar patterns, numbers of previous removals and types of platforms on all flakes and blades are very informative for reconstructions of primary knapping practices (Table 3.23). Dorsal scar patterns indicate the orientation of a flaked artefact in relation to its previous removals, so that the amount of times cores have been turned during reduction can be reconstructed. Simple and side dorsal patterns, for instance show two-directional core reduction, one removal phase aligned to the artefact's own and one at any side-struck angle (Figure 3.15).

Variables	Attributes	Inferences
	CORES: INDIVIDUAL CORE STAGES	
Type	Bipolar	Existence of traditions and variations; intensity and consistency in reduction; degree of preparation [Raw material constraints: size & quality]
	Blade platform	
	Flake platform	
	Non-specific platform	
	Amorphous / Irregular knapping	
Predominant removals	Flake	
	Blade	
	Mixed	
Scars removed	Count	Intensity and consistency in reduction.
Length maximum scar	Measurement in mm	
Width maximum scar	Measurement in mm	
	CORES: FINAL CORE STAGES	
Platform area percentage	0-25%	Intensity of reduction
	c. 50%	
	c.75%	
	100%	
	UNRETOUCHED FLAKES/BLADES	
Dorsal scar pattern	Simple or convergent	Existence of traditions and variations; intensity and consistency in reduction; degree of preparation, [Raw material constraints: size & quality]
	Side	
	Opposed	
	Simple & Side	
	Simple & Opposed	
	Radial	
Number of scar negatives	Count	
Platform type	Cortical	
	Plain	
	Dihedral	
	Linear	
	Punctiform	
	Retouched	

Table 3.23. *Riu Mannu* variables and attributes used to reconstruct primary knapping strategies on cores, unretouched flakes and blades.

Two points should be kept in mind. First of all, while these variables are recorded for each individual artefact, the soundness of interpretations is heavily dependent on the size of the dataset: the larger the dataset the more potential for variation in flaking strategies. Secondly, although unretouched pieces are most informative, similar analyses will be carried out for retouched material when dorsal scar patterns are sufficiently visible.

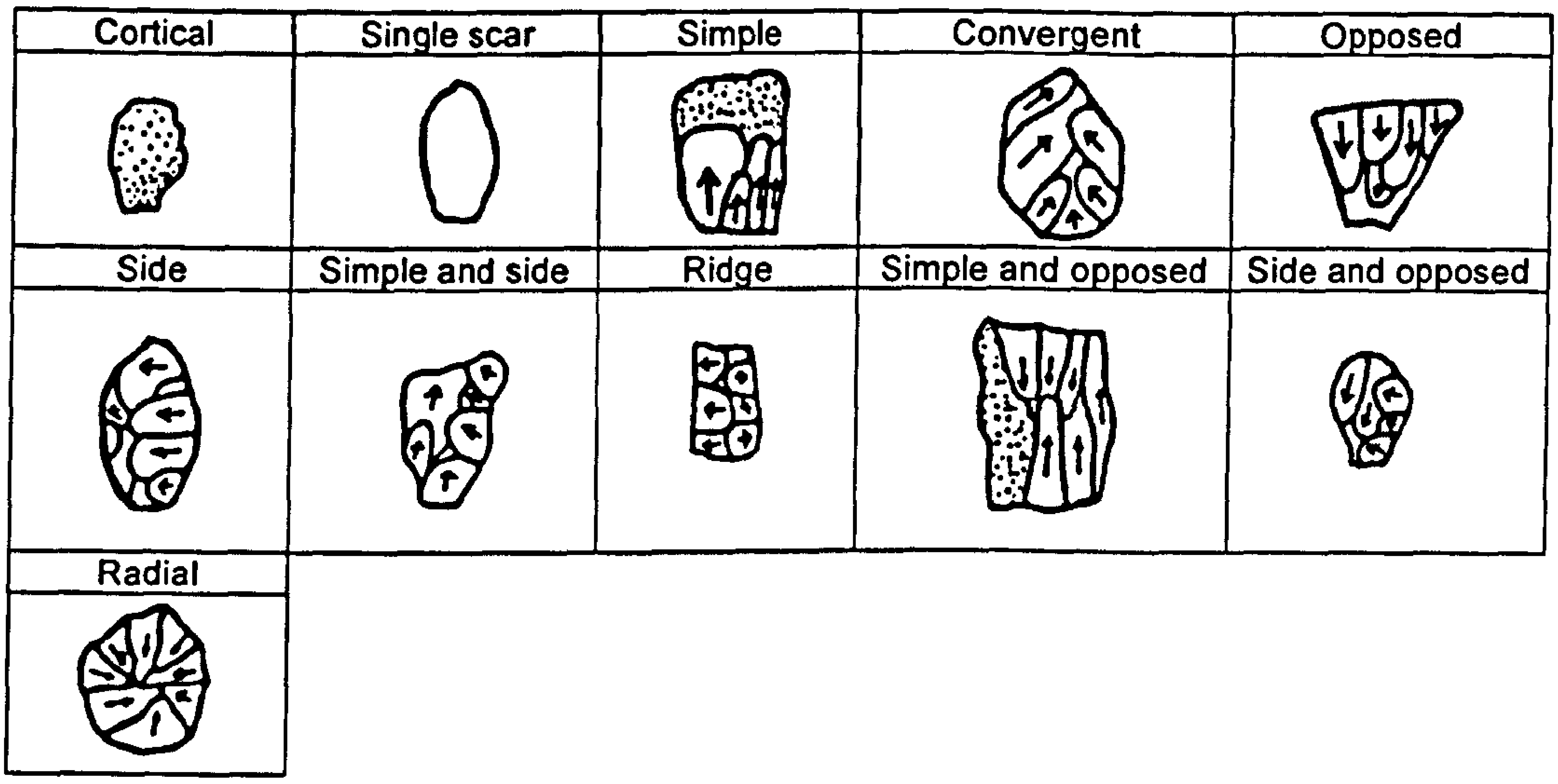

Figure 3.15. Examples of dorsal scar patterning, note that orientation of scar patterning is in relation to flaking direction of removed pieces (modified after Schlanger 1992).

3.4.2.2. Percussion and percussors

To gain insight into employed types of percussion (direct, indirect or pressure flaked) and percussors, statistical analysis on assemblage level is most effective, especially when compared with data from controlled knapping experiments (Gero 1989). While the latter are not available here, an effort will nevertheless be made. Analysis, however tentative, will provide some information on flaking kits, since percussors have not been found by the *Riu Mannu* Project. Moreover, once recognised, it becomes possible to explore if different techniques necessitated different skills and knowledge, and if correspondences with raw material types and flaking strategies existed. Artefact sizes, size/thickness ratios, development of percussion bulbs, flaking ripples, bulbar scars, types and degree of dorsal platform preparation, platform length/width ratios have been recorded for unretouched (and when visible, also for retouched) flakes/blades to see if direct or indirect percussion can be recognised (following Andrefsky 1998; Whittaker 1994). For individual core stages negative bulbs of percussion in removals have been recorded as either diffuse or marked. Similarly, recognition of indirect percussion or pressure flaking for bifacially retouched artefacts has been attempted (Appendix 3.3).

3.4.2.3. Secondary knapping

To examine secondary knapping strategies I have recorded various variables and attributes (Table 3.24). For unifacial retouch, blank selection, location and position of retouch on blanks, extent and type of retouch, edge shape and angle have received particular attention. It should be noted that I have recorded information at work edge level rather than for individual artefacts.

Variables	Attributes	Inferences
	*UNIFACIAL WORK EDGES**	
Blanks	Flakes	Selection criteria: Relationship primary -secondary modification: discrepancies in procurement and production.
	Blades	
	Cores	
	Fragments	
	Chunks	
	Rejuvenation flakes	
Location	Dorsal	Skills: consistency and extent of retouch; intensity; re-use; maintainability
	Ventral	
	Alternating dorsal/ventral	
	Bifacial	
Position	Proximal	
	Medial	
	Distal	
	Lateral	
Retouch Angle	<30°	Consistency and extent of retouch; intensity, re-use, processing activities
	30-60°	
	60-80°	
	>80°	
Edge Shape	Straight	
	Convex	
	Concave	
	Denticulated	
	Convergent/Pointed	
	Irregular	
Retouch Type	Feathered	Percussors used, care and skills required
	Stepped	
	Scalar	
	Notched	
	Burin	
	Denticulated	
	Irregular	
	Edge damaged	
Extent and patterning of retouch	Length & width of retouch in mm	Intensity; care; skills; technical overinvestments
	Marginal and continuous	
	Profound and continuous	
	Marginal and isolated	
	Profound and isolated	
	Irregular	

Table 3.24. Variables and attributes recorded for retouched *Riu Mannu* artefacts, * noted per work edge not per artefact.

Thus, a flake with retouch on its distal and lateral end has been recorded twice, but one with continuous retouch along two or more edges has only been recorded once. Irregular and/or marginal retouch cannot securely be regarded as indicative of use wear damage. After all, postdepositional edge damage is extremely likely for surface material.

I have also recorded a wide variety of attributes for bifacially retouched artefacts (Table 3.25; Figure 3.16). As for the unifacially-retouched artefacts, focus is on exploration of the skills, consistency and (disproportional) care with which artefacts are retouched. When present, additional information on hafted/tanged ends is also recorded.

Variables	Attributes	Inferences
	BIFACIALLY RETOUCHED ARTEFACTS	
Angle retouch / edge bifaces	<30°	Skills: consistency and extent of retouch and degree of shaping artefact, abilities in handling raw material constraints
	30-60°	
	60-80°	
	>80°	
Position edge biface / middle biface	Under / over middle	
	In middle	
Edge shape	Smooth / regular	
	Irregular / visible overshot/edge bites	
Edge Profile	Oval	
	Triangular	
	Stepped/hinges plateaus	
Artefact shape	Oval / rounded	
	Triangular / semi circular	
	Other	
Fragmentation	Description of absent parts (*e.g.* tips, edges)	Abilities in handling raw material flaws and quality
Break patterns	Lipped	Abilities in handling raw material constraints, distinction between breakage during knapping or in use
	Straight	
	Overshot	
	Impact fluting/burination	
	Tip crushing	
Retouch type	Feathered / long and thin surface covering	Percussors used, skills required and extent to which these are exercised
	Stepped / short and deep surface covering	
	Scalar	
Bulb of percussion in scars	Diffuse	
	Marked	
	HAFTED/TANGED BIFACIALLY RETOUCHED	
Measurements body bifaces	Length, width in mm	All of the above
Measurements haft/neck	Length, width in mm	
Measurements base	Width, in mm	
Type	Side notched	
	Lanceolate	
	Basal notched	
	Corner notched	
	Contracting stemmed	

Table 3.25. Variables and attributes recorded for *Riu Mannu* bifacially retouched artefacts (also appendix 3.3).

Attribute name	Description	
	From	To
BLL; blade length	Tip of biface	Tip of shoulder
NH; neck height	Neck	Base
HL; haft length	Top of haft element	Base
BLW; blade width	Shoulder	Shoulder
NW; neck width	Neck edge	Neck edge
BW; base width	Base edge	Base edge
SBC; shoulder to corner	Shoulder	Basal corner

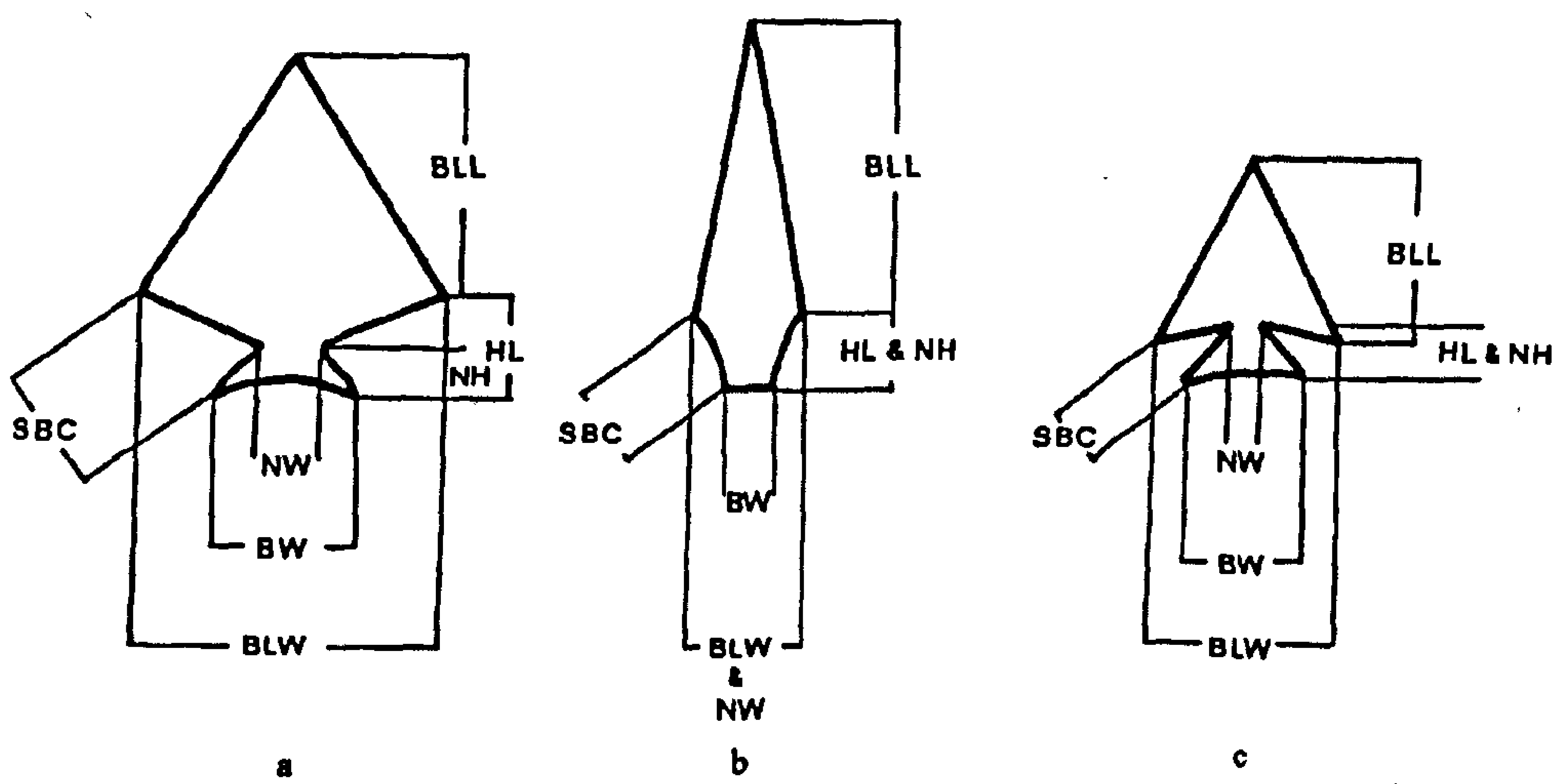

Figure 3.16. Example of measurements taken for hafted bifacially retouched artefacts (Andrefsky 1998: Figure 7.30).

Not only do these characteristics enable explorations of differing degrees of selection criteria and knapping skills, they also make it possible to compare the *Riu Mannu* tool typologies to existing ones (Tables 1.5; 1.8; see Section 6.1).

3.4.2.4. Knapping abilities

Skill is examined on an assemblage level, through a number of variables and attributes (Table 3.26). First of all, consistency levels will be examined within and across primary and secondary flaking strategies, traditions and variations. In particular the co-efficient of variation (the standard deviation divided by the mean), standard deviations, consistency levels in artefact sizes (*e.g.* length/width ratios, length/thickness ratio), number and types of removals, intensity of reduction are informative. Furthermore, analyses cut across artefact groups since this achieves a higher effectiveness (Bamforth & Finlay in press: Figure 1; Edmonds *et al.* 1999; Gero 1989).

Variables	Attributes	Inferences
CORES INDIVIDUAL STAGES		
Abandonment	Overshot	Skill/learning: degree, type and control over errors & corrections
	Stepping/hinging	
	Angle	
	Angle & stepping/hinging	
	Size	Raw material constraints
	Flaws	
Platform type	Unprepared (bipolar cores)	Knapping skills: e.g. intensity of reduction, degree of preparation, level of consistency, Rejuvenation
	Simple (single flake removal for platform)	
	Complex (more than one removal / facetted)	
Average flake angle	Flat (bipolar cores)	
	Angle in degrees	
Predominant removals	Flake	
	Blade	
	Mixed	
Scars removed	Count	Intensity and standardisation of reduction
Length maximum scar	Measurement in mm	
Width maximum scar	Measurement in mm	
CORES: FINAL STAGES		
Abandonment	As above	As above
Number of stages	One	Knapping skills: continuation of reduction, adaptation to technical errors. [Raw material constraints: sizes & quality]
	Possible more than one	
	Count of stages	
UNRETOUCHED FLAKES/BLADES		
Distal terminations	Feathered	Knapping skills, Degree of maintenance, correction attempts
	Stepped	
	Hinged	
Steps/hinges in dorsal scar pattern	Absent	
	Present	
Platform type	Cortical	Knapping skills: type and degree of preparation
	Plain	
	Dihedral	
	Linear	
	Punctiform	
	Retouched	
Dorsal platform preparation	Absent	
	Ground/Rubbed	
	Retouched	

Table 3.26. *Riu Mannu* variables and attributes used to reconstruct knapping skills on cores, unretouched flakes and blades.

Secondly, certain specific variables assist assessment of technical errors. For instance, abandonment of cores and core stages due to overshot features, steps/hinges, and steep platform angles are instructive. Furthermore, evidence for their corrections, such as the presence of platform rejuvenation flakes or continuation of core reduction, demonstrate the skilful handling of raw materials. Thirdly, core platform preparation, the numbers of removals and the degree of standardisation in removals in terms of types, direction and maximum sizes of removals also testify to knappers' abilities to manipulate the specifics of each raw material nodule (Table 3.24). Lastly, the absence and/or presence of steps/hinges in dorsal scar patterns of flakes and blades and type of distal ending, in particular stepped or hinged ones, are good indicators of knapping abilities (Shelley 1990).

3.4.3. Use and discard

I have previously argued that a somnambulistic approach to production and use has resulted in a deep-seated binary opposition, where their correlation with unretouched and retouched material respectively is seen as straightforward (Section 2.3.2). Likewise, the traditional technology perspective has made a distinction between 'use-as-function' and 'use-as-meaning' that is usually considered straightforward. This is mirrored in the common viewpoint that elaborate knapping activities and retouched artefacts are socially meaningful, while simple knapping activities and retouched artefacts are regarded as functionally meaningful (Sections 2.1.2, 2.2). In this study, however, *all* artefacts are socially meaningful, and it is recognised that not just retouched artefacts are selected for further use in other activities. And please note that the last part of that previous phrase is purposefully kept open-ended, as in this viewpoint a scraper used to process hides is as much 'used in other activities' as a core deposited in a burial. Thus, here analyses of use include examination of knapping as a social activity, and above all contextual analysis including (un-)intentional discard (Hodder 1982, see Figure 2.3 and below).

It is worthwhile reiterating that, as has been stated previously, while individual analyses of procurement, production and use/discard taskscapes are valuable, I am especially interested in the exploration of their relationships. By comparing and contrasting the entire scope of procurement, manufacturing, maintenance, use and discard practices, a much more comprehensive insight into the Sardinian lithic land- and taskscapes is gained (Table 3.27; also Bradley & Edmonds 1993: 200-206; Perlès 1992b).

The three data chapters each reflect one of the three basic stages of lithic technology and present all the analyses pertaining to these three taskscapes. Chapter four focusses on raw material, especially availability, source locations and source use and existing models of procurement for Sardinian obsidian. Chapter five examines all primary flaking material, concentrating on procurement and production analysis. Chapter six presents all secondary flaking material, focussing on retouch strategies, and the relationship between primary and secondary material. Drawing on these chapters, the three taskscapes and their relationships are examined in chapter seven and explores two key questions:

- Where do procurement, production, use and discard practices coincide, and are there temporal differences?
- Which procurement, production, use and discard practices coincide spatially and which do not, and are there temporal differences?

Comparison of variables	Inferences
Ratios of sizes, count and type of removals on cores with unretouched and retouched material	Intensity and standardisation of reduction, discrepancies in procurement and production
Patterns of removal / knapping strategies on cores with retouched and unretouched material	Discrepancies in production
Sizes & thickness of unretouched and retouched material	Discrepancies in production
Presence/absence of steps/hinges on cores with those in dorsal pattern of retouched/unretouched material with their distal endings and with types and number of rejuvenation flakes	Knapping skills, degree of errors and correction attempts
Similarities and variation in procurement, production and use practices with spatiality and historicity	Temporality of Sardinian lithic landscape

Table 3.27. Main issues discussed to explore lithic procurement, production and use taskscapes.

3.5. Sardinian lithic landscape and taskscapes: conclusion

In conclusion, this chapter has presented the background of the studied dataset and has outlined how a social approach to lithic survey data may be implemented. It has introduced the *Riu Mannu* Survey Project, briefly summarising the main characteristics of the three physical landscapes in the research area and the location of the studied transects. Furthermore, this chapter has reviewed how the *Riu Mannu* field methodology has dealt with common survey problems such as finding and defining lithic scatters. It has also discussed the main post depositional processes that have shaped the lithic landscape, and interpretations of lithic activity. The presentation of the overall find distribution in the *Riu Mannu* transects has demonstrated, what was already argued on theoretical grounds in the previous chapter. A traditional – chronology and density-based – approach to lithic survey data does not utilise the dataset to its full potential. Undiagnostic artefacts or scatters, sites where pottery is absent, or areas where it is not possible to distinguish between sites, site haloes, small concentrations and isolated finds are too often overlooked.

The second part of this chapter has discussed how a focus on the spatiality of the three taskscapes overcomes these problems, and the three levels of spatial analysis are introduced. The final section in the chapter has outlined how the social approach to technology is implemented, and has detailed how three taskscapes, procurement, production and use/discard are explored. A concentration on exploring human preferences and choices, in particular the establishment of traditions, types and extent of variations, and dispersal of knowledge and skills will help gain a better understanding of Sardinian lithic landscape.

Chapter Four

Raw material sources in west central Sardinia: an overview of current research and new *Riu Mannu* evidence

This chapter is divided into three parts. The first part briefly summarises the current state of research on the availability and use of raw material obsidian sources in west central Sardinia. It also presents new *Riu Mannu* evidence for the existence of secondary raw material sources along the river Mògoro away from the Monte Arci, the main source of raw material. The second part of this chapter explores whether or not the two types of source locations (the Monte Arci and the Mògoro sources) can be visually distinguished and discusses the current evidence for use of both types of sources and reviews existing procurement theories. The last part of this chapter outlines why and how visual characterisation is applied and linked to the three main obsidian types (SA, SB and SC) generally recognised for Sardinian obsidian.

4.1. Raw material source zones

As discussed earlier, most west Mediterranean obsidian exchange studies have a colonialist perspective towards Sardinia. The island is predominantly regarded as a raw material source, with little attention for local modes of procurement, production and use (Section 1.3.3). This section examines the current state of this research in Sardinia in more detail, and:

- Reviews the history and current state of research on the Monte Arci.
- Presents evidence for the existence and use of the Campidano and Arborèa source zones, and discusses some implications for existing theories on obsidian procurement.

4.1.1. Monte Arci source zone

Since the 19th century, the Monte Arci has been recognised as a source of obsidian for the island and elsewhere (Section 1.3.1). In the 1970s, several geological studies were undertaken to understand and date the Monte Arci formation processes in the sequence of volcanic activities in Sardinia and the Mediterranean (*e.g.* Assorgia *et al.* 1976; Beccaluva *et al.* 1974; 1976; 1985;

Montanini *et al.* 1994; Tykot 1995: 61-63; 77-81 for a brief English summary). The Monte Arci was formed in the Pliocene (at 3.8-3.2 million years BP) during renewed tectonic activities along the Campidano *graben* (see Section 3.1.1.1). Individual Monte Arci eruptions differ chronologically and petrologically, and their extent has been documented extensively. In summary, obsidian-bearing rhyolithic layers were primarily formed during the phase one eruption, while a later phase consisted of mainly basic basalt lava flows, forming the Mògoro and Uras basalts (Figure 4.1). Overall, the location of obsidian-bearing layers are well documented, but, unfortunately for archaeologists, the extent of sources, suitability for flaking, evidence for prehistoric source use, were rarely recorded or considered part of the research (Tykot 1995: 81).

Since the 1990s, as part of his larger west Mediterranean obsidian source localisation and characterisation programme, Robert Tykot has mapped and sourced obsidian-bearing locations on the Monte Arci. He has systematically matched and recorded primary and secondary locations on the Monte Arci with archaeologically determined subtypes (Figure 4.1; Table 4.1, also Appendix 4.1). Recently, the Monte Arci Project from the University of Cagliari has begun an extensive and long-term research project to expand and refine existing knowledge (Meloni *et al.* 2004; Poupeau *et al.* 2004; see also below).

Obsidian occurs in three different ways on the Monte Arci: 1) in primary, or *insitu*, setting and embedded in the original rhyolite and perlite matrices, 2) in secondary sources, where it has been naturally redeposited after eroding out of the original matrices (Figure 4.2), and 3) mixed with other pyroclastic volcanic material, such as pumice and perlite, and ejected out the volcano in bombs. More than 10 different chemical obsidian types and their locations are known, five of which have been found in the archaeological record (Figure 4.1: note that 'S' [*e.g.* SA, SB1, SB2, SC1, SC2] stands for Sardinia, with the second letter in alphabetical order). The main obsidian types on the Monte Arci, SA, SB and SC occur more in zones than in single locations. In summary:

- The SA source zone is located on the southwest flank. It occurs *insitu* in the Conca Cannas valley in a soft perlite matrix, and is abundantly present in secondary deposits along the streams in the valley. At Su Paris de Monte Bingias SA obsidian occurs redeposited on the surface.

It is found in sub-rounded to well- rounded nodules, weighing up to 10kg, and in smaller fist-sized nodules.

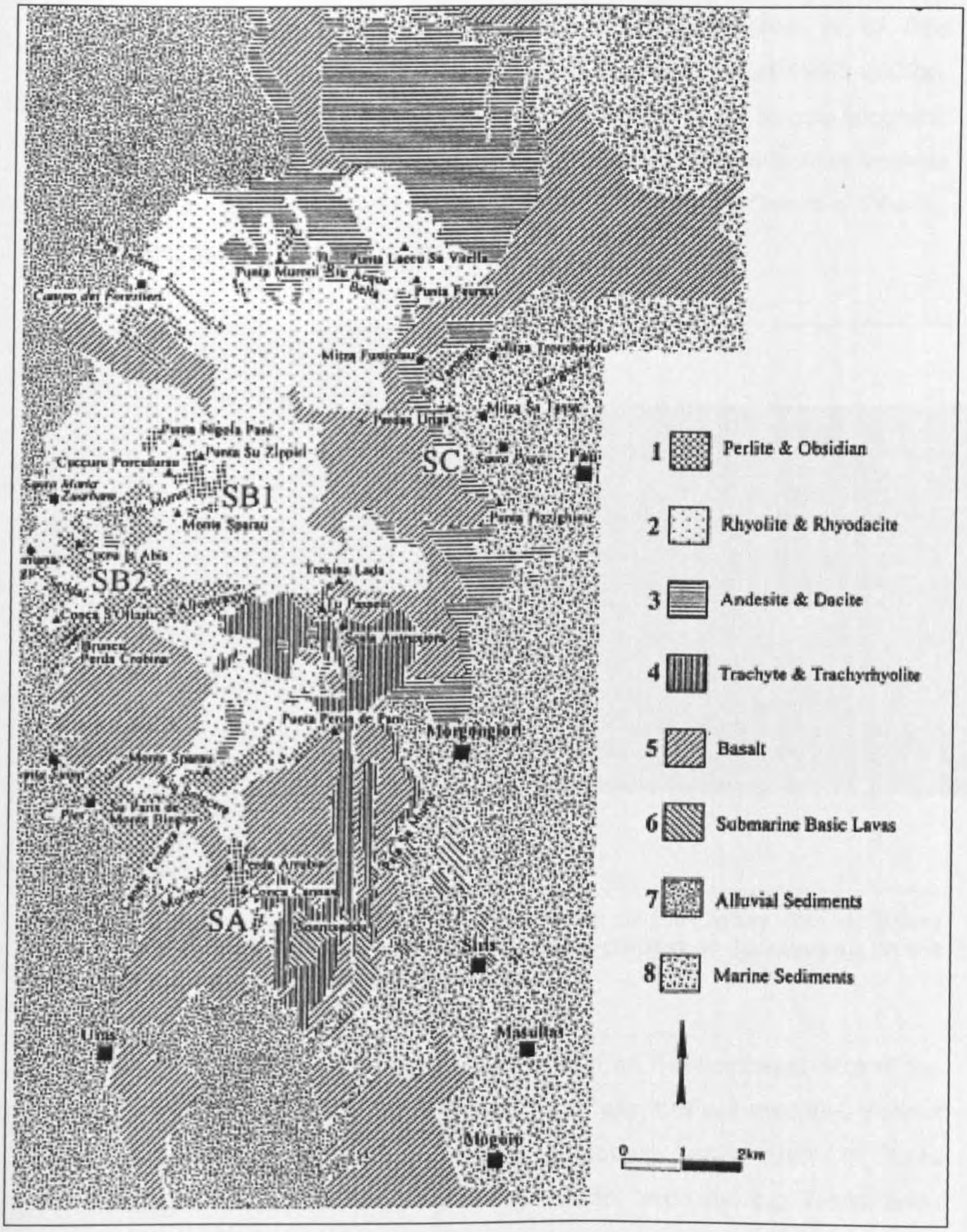

Figure 4.1. The main obsidian zones on the Monte Arci (Tykot 1996: Figure 2).

- SB obsidian is found in various locations along the west side of the Monte Arci (the Santa Maria Zuarbara zone). A chemical and spatial distinction exists. SB1 is mostly found in the centre of the Monte Arci, *insitu* at Cuccuru Porcefurau, Punta su Zipirri and Punta Nigola Pani, and in secondary deposits along the river Murus and on the north side of the Monte Sparau. It is chemically subdivided into three (SB1a-c), but its rare use in prehistory means this distinction is of little archaeological significance (Poupeau *et al.* 2004; Tykot 1997; 2002a). It occurs in sub-to well-rounded nodules weighing up to one kilogram. SB2 is found *insitu* at Bruncu Perda Crobina and Cucru Is Abis towards Futana Figu, as well as in secondary deposits around Conca s' Ollastu. It occurs in spheroid nodules, weighing up to five kilos.

Figure 4.2. Obsidian embedded in a perlite matrix at the Conca Canas Quarry (left, photo Dr P. van de Velde), and in secondary context at Sennixeddu, in the Perdas Urias source zone (right, photo author).

- The SC (or Perdas Urias) zone is situated on the northeast side of the Monte Arci and is divided into two chemically, but not spatially, distinct types. Type SC1 was found *insitu* at a modern perlite quarry at Punta Pizzighinu, but most locations are secondary deposits, *e.g.* Troncheddu and Cazzighera. Eroded-out obsidian is present below the whole ridge, from Punta Pizzighinu to Su Varongu. A mixed deposit of SC1 and SC2 was found at Santa Pinta (Table 4.1).

Source zone	Locations	Raw material occurrence	Extent/density/size	Archaeology
SA (Conca Cannas)	Conca Cannas valley	*Insitu* in soft perlite, rhyolite & trachyte matrices	Diffuse zone: unworkable material to the south and east, specks in matrix along river Cannas and more restricted area with 10-15cm nodules	Present
	Su Paris de Monte Bingias	Surface	Restricted area	Not known
	Canale Perdera Riu Solacera, Santa Suina, Punta Perda de Pani	Surface and *insitu* in perlite matrices	Extensions of Su Paris de Monte Bingias. Nodules >10cm at Canale Perdera and Solacera	Not known
	Monte Sparau South	Surface	Nodules 10-20cm length	Not known
	Perda Arrubia	Surface?	Not known	Present
SB1 (Santa Maria Zuarbara)	Cuccuru Porcufurau	*Insitu* in hard perlite, ryholite matrices	Large diffuse area. Blocks up to 30cm at 250-300m elevation	Not known
	Punta su Zippiri	*Insitu* in hard perlite matrix	Large diffuse area. High abundance of nodules 3-5cm at 500m elevation	Not known
	Punta Nigola Pani	*Insitu* in hard perlite matrix	Nodules 3-5cm at 350m elevation	Not known
	Monte Sparau North	Surface, specks in a perlite matrix	Workable blocks along river Murus	Not known
	Campo dei Forestieri	Surface?	Limited availability	Present
	Punta Muroni	None	Not known	Present
SB2	Brunca Perda Crobina	*Insitu* in hard perlite matrix	At 100m elevation in the west to a 400m elevation to the northeast. 15-17cm nodules	Not known
	Cucru Is Abis	*Insitu* in hard perlite matrix	At 230m elevation down west to Funtana Figu. 1cm nodules *in situ*	Not known
	Seddai	*Insitu* in basalt with trachyte, rhyolite matrix	Blocks up to 1m	Not known
	Conca s'Ollastu	Surface, *insitu* in perlite matrix		Not known
SC (Perdas Urias)	Punta Pizzighinu	*Insitu* in perlite matrix (type SC1)	Ridge from Punta Pizziginu to Su Varongu contains obsidian. Blocks of up to 17cm at 600m elevation	Not known
	Santas Pinta	Surface	Nodules up to 30cm	Not known
	Mitza Truncheddu	Surface	Nodules up to 30cm	Not known
	Cazzighera	Surface	Nodules up to 30cm	Not known
	Su Varongu, Truncheddu	Surface		Not known
	Tanca sa Tellura	Surface	Not known	Not known
	Riu Canali	Surface?	Not known	Present
	Perdas Urias	Surface	Not known	Present
	Mitza Fustiolua	Pyroclastics (pumice, perlite, obsidian)	Not known	Present
	Mitza sa Tassa	Surface	Extensive	Present
	Sennixeddu	Surface	Not known	Present

Table 4.1. The main Monte Arci source zones: sampled locations and available information on matrices, extent of sources, nodules sizes, and associated cultural material (see also Appendix 4.1).

4.1.2. Campidano and Arborèa: secondary sources zones

Evidence is growing that secondary sources extend beyond the Monte Arci into the Arborèa and the Campidano. *Riu Mannu* fieldwork has demonstrated four areas with substantial amounts of mainly unworked obsidian along the rivers Mògoro and Mannu (Figure 4.3: A-D). Several areas in five transects, 'sites' recognised either during fieldwork or after plotting find distributions, also demonstrate a consistent but low spread of unworked material (Figure 4:3: E-J). For this thesis, several locations in the areas Bau Ortu, Narboni Mannu, and Perda Lada were specifically visited to test the general presence of obsidian along these river systems in more detail. Puxeddu (1957, see also below) had previously located three collection centres in the latter two areas (Figure 4.3: a, b and d), and with the additional collections there (Figure 4.3: 3-5) and at Bau Ortu (Figure 4.3: 1), a low but consistent presence of raw material along the river Mògoro is confirmed. Serra Pontis (Figure 4.3: 2), along the river Mannu, was visited because local archaeologists repeatedly mentioned it as a major source area (Artudi, Perra and Melis *personal communication*).

Thus, a pattern emerges; most secondary source localities are located along either side of the river Mògoro and its tributaries. This river system has clearly transported obsidian nodules down from the slopes of the Arci, in the course of the glacis and pediment formation (Section 3.1.1.1; Figures 3.5). Puxeddu also noted copious obsidian nodules in various river streams, further supporting these observations (Puxeddu 1957).

More problematic are locations along the river Mannu (Figure 4.3: C, J, and 3). This river, nor any of its tributaries, are directly associated with the Monte Arci, and could therefore never have been directly responsible for obsidian distribution (Figure 4.3; also 3.7). Three explanations are possible: 1) more extensive Mògoro transport than previously thought, 2) exposure of deeply buried obsidian in Uras and Mògoro basalt layers and 3) human activity.

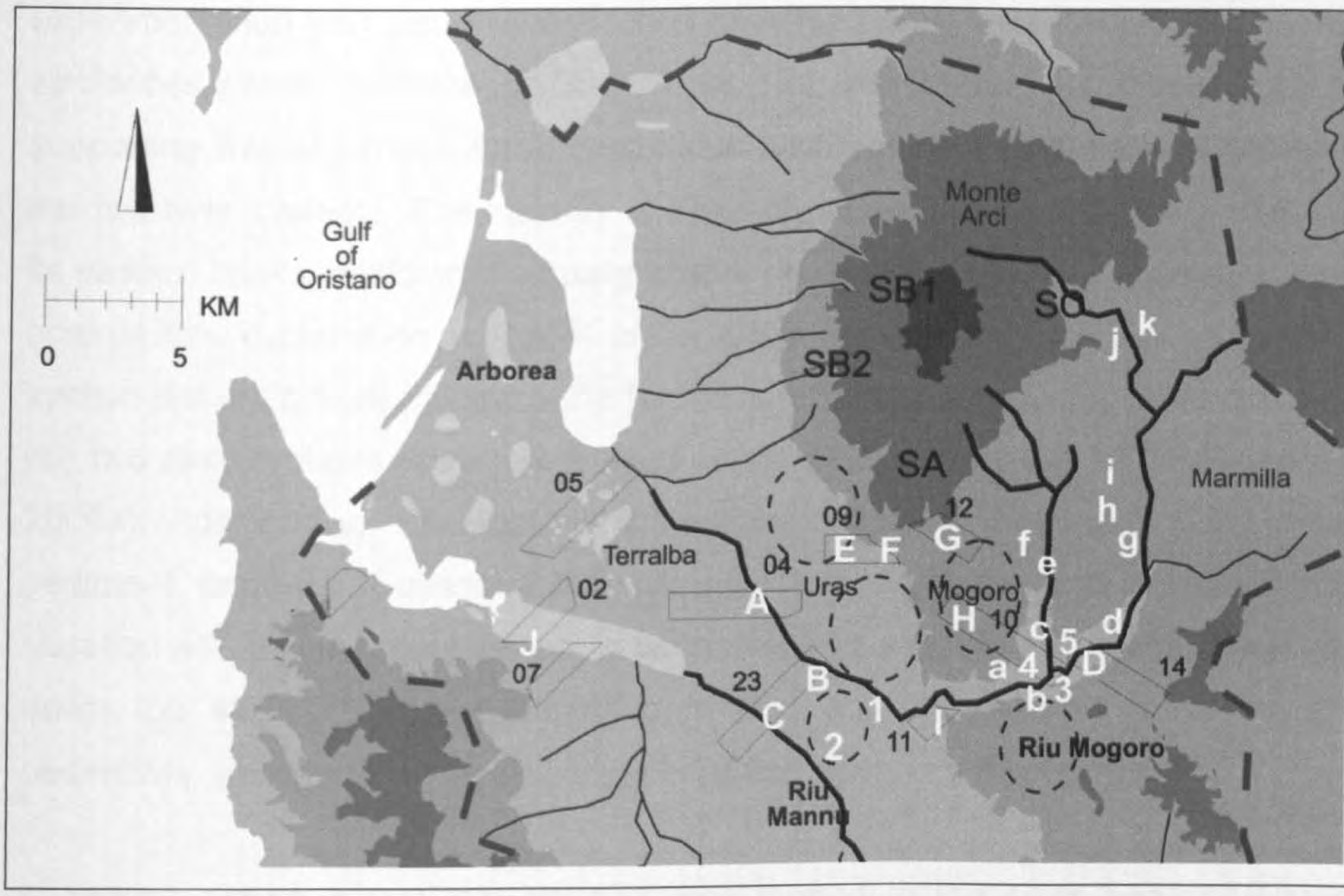

Figure 4.3. West central Sardinia, showing the primary and secondary sources of obsidian mentioned in the text (after van Dommelen 1998: Figures 3.2, 3.12; Montanini *et al.* 1994: Figure 1; Puxeddu 1957: Carta Generale A; Tykot 1997: Figure 2).

Key to map:
Contour levels (increasing in darkness in colour): at coast level; at 100m a.s.l; at 300m a.s.l.; at 700m a.s.l.
Small dashed circles= the approximate position of Uras and Mògoro basic basalts.
Large dashed line= the *Riu Mannu* Survey Project research area.
Rectangles= transects mentioned in the text.
SA, SB1, SB2, SC show the approximate location of primary and secondary sources of obsidian on the Monte Arci.
Secondary source locations are subdivided into research categories:
Locations within *Riu Mannu* Survey Project transects 04, 09-12, 14, 23 (A-J)
Locations from PhD research: 1= Bau Ortu, 2= Serra Pontis, 3= Perda Lada, 4= Narboni Mannu, 5=Narboni Mannu.
Puxeddu's *centri di raccolta*: a= Sa Perda de Acutzai, b=, Narboni Mannu, c= Perdixèdda, d=Is Noracèsus, e= Su Pònti de Flùmini, f= Masullas, g= Funtàna Cadèna, h= Còrti 'e Pròccus, i= Pappòi, j=Cròxiu Grussu, k= Mitza sa Tassa.

It is possible that the river Mògoro was responsible for obsidian re-deposition, extending deeper into the Campidano, onto the Uras basalts. Subsequently, the river Mannu and some of its tributaries on its east side probably partially cut into these basalts, creating the fluvial terraces and in the process further transported obsidian nodules. The main argument in favour of this hypothesis is the similarity in characteristics between nodules from all locations. Macroscopic observations showed no markedly different nodule sizes or shapes. Nor is there any striking disparity in variations in colour, banding, cortex or any other characteristics, and experimentation with visual identification of Serra Pontis material showed strong similarities with SC material (de Bruijn 1998: 120; see Section 4.4. below). Further supporting this argument is the continuous distribution of raw material between the two river systems. The majority of obsidian along the river Mannu occurs on its eastern banks, obsidian is virtually absent on its west side. The main argument against this explanation is that it is generally assumed that the Mògoro river system did not greatly influence the formation of the central Campidano and that the two river systems were relatively separate (van Dommelen 1998: 48; Lugliè 2000a). Additionally, it is possible that obsidian also formed part of the older pediment deposits. Subsequent fluvial activities might have complicated the situation with two main processes, in which the river Mògoro transported obsidian down the slopes to the Campidano border, and the Mannu reworked the pediments, increasing the availability of obsidian deep into the Campidano.

A second option is that this obsidian was formed in the Uras and/or Mògoro basalts instead of the known Monte Arci locations. Obsidian can occur in basic basalt (Tykot 1995: 58) but to date no one has reported any obsidian-bearing layers (Assorgia *et al.* 1976; Beccaluva *et al.* 1976; Montanini *et al.* 1994; Tykot 1997). Theoretically, however, the Mannu, when cutting its terraces could have eroded obsidian out of these basalts and transported it. If this is the case, it is expected that its chemical composition will differ from the known sources. Alternatively, rather than representing a new type of obsidian, the Mògoro and Uras basalts might have covered up earlier rhyolithic flows, which were subsequently exposed and eroded out by the rivers. The SA flow would be the most likely candidate, since it is closest and the most southern exposure, but, again, to date no obsidian-bearing layers have been observed along the rivers systems (Figure 4.3). Extensions of Monte Arci flows exist in the Arborèa, but are now covered by later aeolian deposits, and unfortunately both the depth and the type of flow are unknown (Casula *et al.* 2001: Figure 16, section B).

A third option is human (intentional) transportation but, if that happened, it is interesting that reduction primarily took place on nearby habitation sites and rarely at the sources (see below). To address these issues I have taken 31 geological samples at seven locations for chemical characterisation, but analysis is still ongoing and data cannot be presented yet (Appendix 4.2).

In conclusion, the river Mògoro and its tributaries have transported a mixture of material from the Monte Arci and the Marmilla deep down into the plain during the Pleistocene and Holocene, significantly expanding raw material availability. Unworked obsidian along the river Mannu is more problematic, and several options have been offered to explain the presence of obsidian. Only more extensive geological and archaeological research will resolve these issues. Recently, the Monte Arci Project has started doing just that (Meloni *et al.* 2004; Poupeau *et al.* 2004). Their first characterisation results, taken along the rivers Mògoro and Mannu, demonstrate a wide spread SC distribution, confirming that our first hypothesis is the most likely explanation (Figure 4.4: ■).

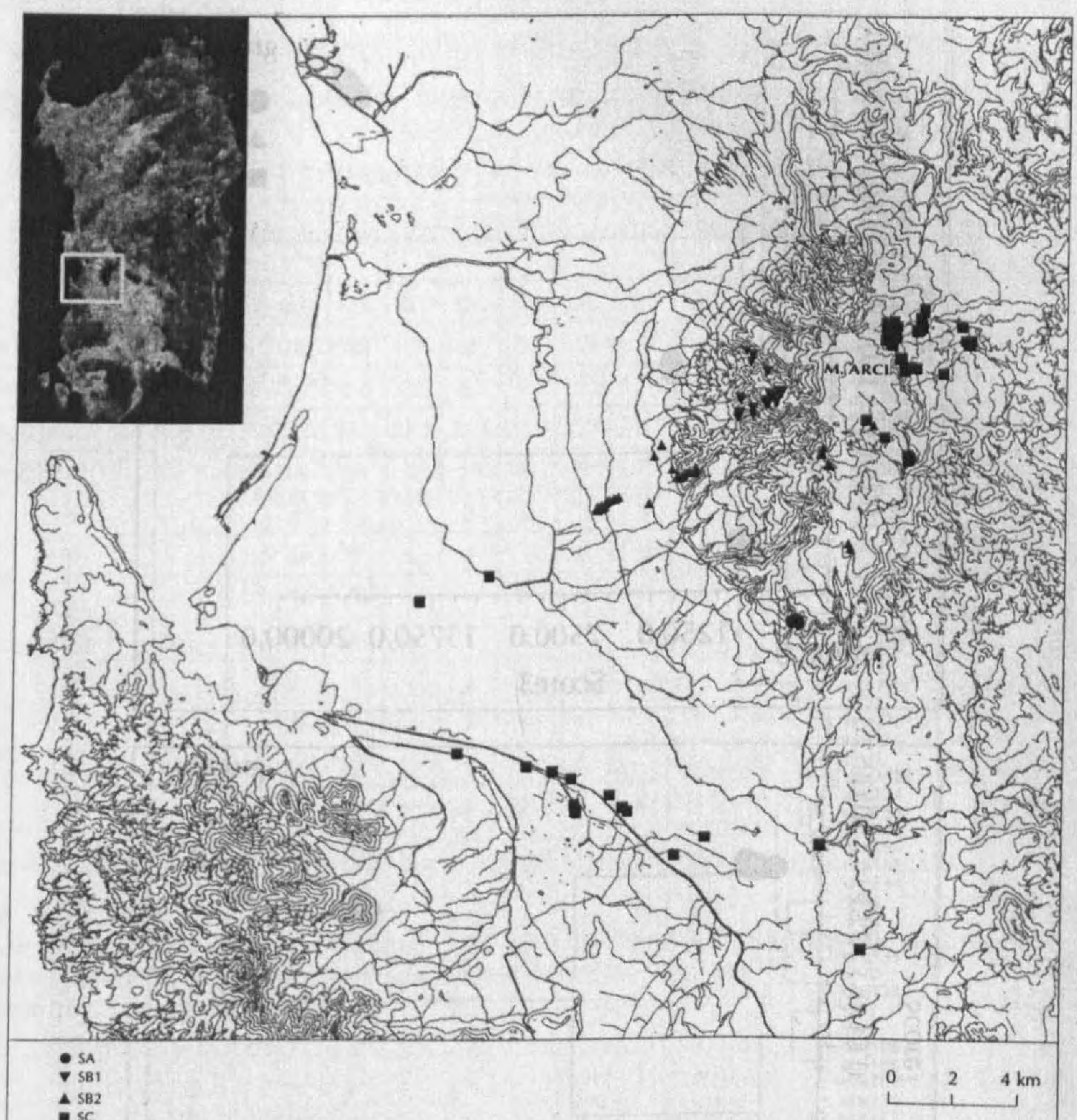

Figure 4.4. Distribution and characterisation of geological samples taken along primary and secondary sources areas (Meloni *et al.* 2004: Figure 1)

To avoid confusion, please note that from now on the phrase 'primary sources or primary source zones' refer to both *insitu* and secondary source on the Monte

Arci, while secondary refers to the Mògoro source zone, away from the Monte Arci.

4.1.3. Raw material in studied assemblages

Raw material is present throughout all but two (05 and 13) *Riu Mannu* transects. Percentages are generally low, with 9-12% for transects 02, 09, 10, and 23, and 2-4% for transects 04, 07, 14. Transect 11 (47%) is the clear exception, with 47% unworked material (Table 4.2). It may also be surprising that transects with secondary raw material source locations (*e.g.* 04 and 14) have low percentages for raw material. This is a collection bias, however, that directly results from the Project's explicit goal to collect *archaeological* material. All collected pieces were only classified as raw material after examination and are better termed 'pseudo artefacts'.

		Arborèa		Campidano								Marmilla						
		02		04		07		09		23		10		11	12		24	
		QT	QL	QT	QL	QT	QL	QT	QL	QT	QL	QT	QL	QL	QT	QL	QT	QL
Count		7	21	26	33	3	5	11	16	14	1	28	10	80	2	5	29	8
Percentage		8.9	12.3	3.2	3.6	2.9	2.3	9	11.3	12.2	0.6	9.1	2.1	47	50	10.4	2.6	1.7
Average MD		33.8	31.5	27.9	38.4	27.5	29.1	24.7	30.9	27.5	-	29.7	29.6	24	22.2	25.1	22.1	39.4
Av. weight		19	12	14	17	3	10	5	9	7	-	9	15	4	3	5	3	50
Cortex*	0	-	7	8	18	1	3	6	5	1	-	18	4	47	1	3	16	3
	1	1	1	4	6	-	1	1	2	-	1	3	1	17	-	-	5	2
	2	-	1	3	3	-	-	1	2	-	1	6	2	10	-	-	2	2
	3	6	4	10	5	1	1	1	4	-	2	-	2	6	1	1	6	1
	4	-	1	3	1	-	-	2	-	-	-	1	1	-	-	1	-	-
Artefact condition#	0	6	11	10	6	-	1	1	1	-	1	2	5	5	-	3	6	3
	1	1	4	16	23	3	1	8	4	-	11	25	4	54	2	1	23	5
	2	-	6	-	4	-	3	2	9	1	4	1	1	21	-	1	-	-

Table 4.2. Summary of recorded data for all studied raw material pieces.

Key to Table:
*Remaining cortex percentages: 0= none, 1= 1-25%, 2= 26-50%, 3=51-75%, 4= 76-100%.
#=Artefact condition: 0= fresh, 1= abraded/water-rolled, 2= patinated.
MD= maximum dimension in mm
Weight= in grams

This 'pseudo' character is born out by average size, weight, condition and cortex percentage data (Table 4.2; Appendix 4.3). Small sizes and low weights predominate, with a majority in 22-28mm and 3-9 grams categories. Most material is several abraded or patinated. The high percentage of non-cortical raw material (50% of all quantitative *Riu Mannu* data) further clarifies why material was initially presumed flaked. Another indication of the flaked-like appearance is their uneven distribution across transects. In most transects (*e.g.* 09, 10, 14, and 23) they are closely associated with sites. In others (*e.g.* 02, 04, 07, and 11) the association is less strong, and probably reflects unworked material naturally present in these areas (see Appendix 3.2).

4.2. Source use

Thus far, only raw material availability has been discussed. This section reviews current knowledge on source use in Sardinia. This evaluation is, of course, shaped by the state of Sardinian lithic studies (Section 1.3). Source use can occur directly at the source, as well as indirectly through exchange networks, and in different zones ranging from quarry-based to local and regional exploitation (Ericson 1984; see Section 2.3.1). In west central Sardinia, obsidian is accessible either on the surface or in deposits above ground. Thus, it is not unsurprising that extensive mining systems have not been found, and it is unlikely that they will. The nature of sources suggests that quarries are much more likely (*contra* Contu 1991). It is therefore disappointing that, despite intensive geological and archaeological research on and around the Monte Arci, information on direct source exploitation is very limited (Table 4.1; Appendix 4.1).

4.2.1. Source use on the Monte Arci: quarries and workshops

None of the *insitu* locations for any of the three Monte Arci source zones are reported to contain *unambiguous* evidence for extraction, either in the form of extraction pits, hollowed-out veins, or by associated flaking evidence (Table 4.1). The possibility that only unmodified material was collected and that reduction took place elsewhere also exists and will be discussed below (*e.g.* Sappington 1984). Some indications exist for the presence of archaeological (surface) material at SA and SB primary and secondary sources, but little appears to be conclusively associated with geological deposits. Extensive quarries are either not present or perhaps deeply buried below the surface. It is also possible that prehistoric quarries were quarried away, over the course of modern perlite quarrying.

There are more solid indications that procurement and reduction took place directly at various Perdas Urias source localities. Several prehistoric quarries are known, especially Mitza sa Tassa and Sennixeddu, with unambiguous and extensive evidence for reduction at the source. The Monte Arci Project from the University of Cagliari has recently started an intensive survey and excavation programme to gain insight into this area (Lugliè 2004a). A preliminary excavation was carried out at the Sennixeddu quarry in 2002, in which I participated, with a second season in 2005 (Tykot *et al.* 2003b; Lugliè & Tykot *personal communication* 2005). Preliminary results have indicated that much of the prehistoric quarry is buried below the surface, which might partially explain the lack of information in the other source zones. The Monte Arci Project has also begun excavating a nearby cave, which may be a probable and plausible settlement site location (Lugliè *personal communication* September 2002; November 2003).

In sum, there is a large discrepancy between evidence for use *at* the sources and use *of* the sources. The SA and SB sources show little to no evidence for exploitation and reduction at the source, while quarries and workshops are clearly present in the SC source zone. Yet, many sourcing studies have shown all three types were used in prehistory.

4.2.2. Monte Arci source use away from the sources: settlements

Chapter one showed that, while onsite reduction is attested to at many sites, little is known about actual procurement and production strategies, and the focus is mostly on Neolithic obsidian use (Section 1.3; Tables 1.5; 1.8). Until the start of the Monte Arci Project, Robert Tykot was one of the few people who offered a model for obsidian procurement. He has subdivided Sardinia into an open access and direct procurement supply zone, the Oristano province, while the rest of the island and the West Mediterranean obtained their material via simple, down-the-line exchange networks. The predominance of SA material in France may be an exception and suggests more complicated exchange mechanisms were in use simultaneously. His model predominantly depends on distance to sources, availability of material and percentages of represented sources in site assemblages (Tykot 1996; Table 4.3).

Time period	Source use	Procurement strategies
Early Neolithic	High percentages of SB source use, particularly in the North of the island, which is due to closeness to source zone and easy access, but no SB predominance in Oristano province	Following Binford (1979) procurement is 'embedded', free source accessibility for all, due to low number of settlements in supply zone
Middle Neolithic	Decrease of SB2	Increased settlement in Cabras and Oristano regions, start of exchange networks. Increased standardisation in production.
Late Neolithic/ Chalcolithic	Predominant SC use, increased SA use in the South, again as result of closeness to sources	Direct procurement in Oristano province, down-the-line exchange for remainder of island. Differential participation of sites (*e.g.* Puisteris) in networks.
Nuragic	Re-use of earlier material (evidenced by unexpected hydration dates *cf.* Table 1.8)	Restricted source access (Michels *et al.* 1984)

Table 4.3. Summary of current models for procurement (based on Tykot 1996; 1998; 1999; 2002a; 2002b; also Hurcombe & Phillips 1998).

His hypotheses follow processual approaches to procurement (see Section 2.3.1). Embedded procurement strategies are envisioned for semi-sedentary Early Neolithic communities. Some publications on Early Neolithic assemblages do indicate transport of unworked nodules to sites for further reduction (Table 1.8). The Middle Neolithic is a transitional phase, in which down-the-line exchange networks slowly replace the embedded strategy. In the Late Neolithic, exchange networks are consolidated, but source use patterns change. SC starts to dominate and SA becomes more important, especially in the South (Table 4.3). Increased agricultural activities, sedentism, a higher site density and the development of craft specialisation are thought to be the motor of these changes, although it is acknowledged that clear evidence for specialist production is lacking (Tykot 1996). In the East Mediterranean obsidian specialist production is debated. Torrence (1986) has argued that at best part time specialists visited the Melian quarries, although Pèrles disagrees (1992a). Others, too, have argued for specialist production in the Aegean Bronze Age (Section 2.5.2.2). In the West Mediterranean, as I have argued previously, a bird's eye perspective has resulted in the binary opposed associations of source area=near=functional, and non-source area=distant=symbolic=specialist (Section 1.3.3). Data for later prehistoric (Bronze and Iron Age) sites are even sketchier, although obsidian continues to be used. Re-use, however, further complicates understanding source use patterns and procurement strategies.

From the above it is clear that very little is actually known about procurement strategies, as the necessary technological studies have not been carried out. Ultimately, Tykot's efforts, too, suffer from this lack of information. His studies have greatly contributed to the overall view of obsidian use in the Mediterranean but his sole focus on characterisation limits his information.

4.2.2.1. Evaluating Puxeddu's site classification

As outlined previously, the value of Cornelio Puxeddu's work around the Monte Arci (1957; 1962; 1975) cannot be overstated. The continued use and the underlying cultural historical biases of his site classification, however, necessitate a re-evaluation. Until recently, this was rarely questioned or discussed in the context of current lithic studies (Section 1.3.1). Careful reconsideration of his work may contribute to gaining an understanding of the Sardinian lithic landscape. Puxeddu's research was centred in municipalities around the Monte Arci, some of which were intensively surveyed. For the whole area he has listed close to 400 obsidian sites, which were divided into four types (Table 4.4; Figure 4.5; Appendix 4.4; see also Puxeddu 1957; 1975 site lists).

Classification	Description‡	Sites (n)#
Giacimenti orginari o presumibili cave	Original layers or possible mines/quarries, with obsidian mixed with other material, rounded in form, or in pediments	6
Centri di raccolta	Collection centres, where blocks of obsidian, worked or unworked are abundant	13
Stazioni	Stations, where obsidian is found reasonably abundant, consisting of raw material and waste but surface material does not provide enough information for attribution to the other two site types. Generally, tools are missing at these sites	278
Officine	Workshops, where surface material clearly indicates a fairly extensive flaking centre. Tools, complete and incomplete, are found frequently	95
Total		**392**

Table 4.4. Puxeddu's obsidian site classification.

Key to Table:
Estimates based on site lists, map A and site discussions in Puxeddu 1957; 1975.
‡ Author's translations of original text.

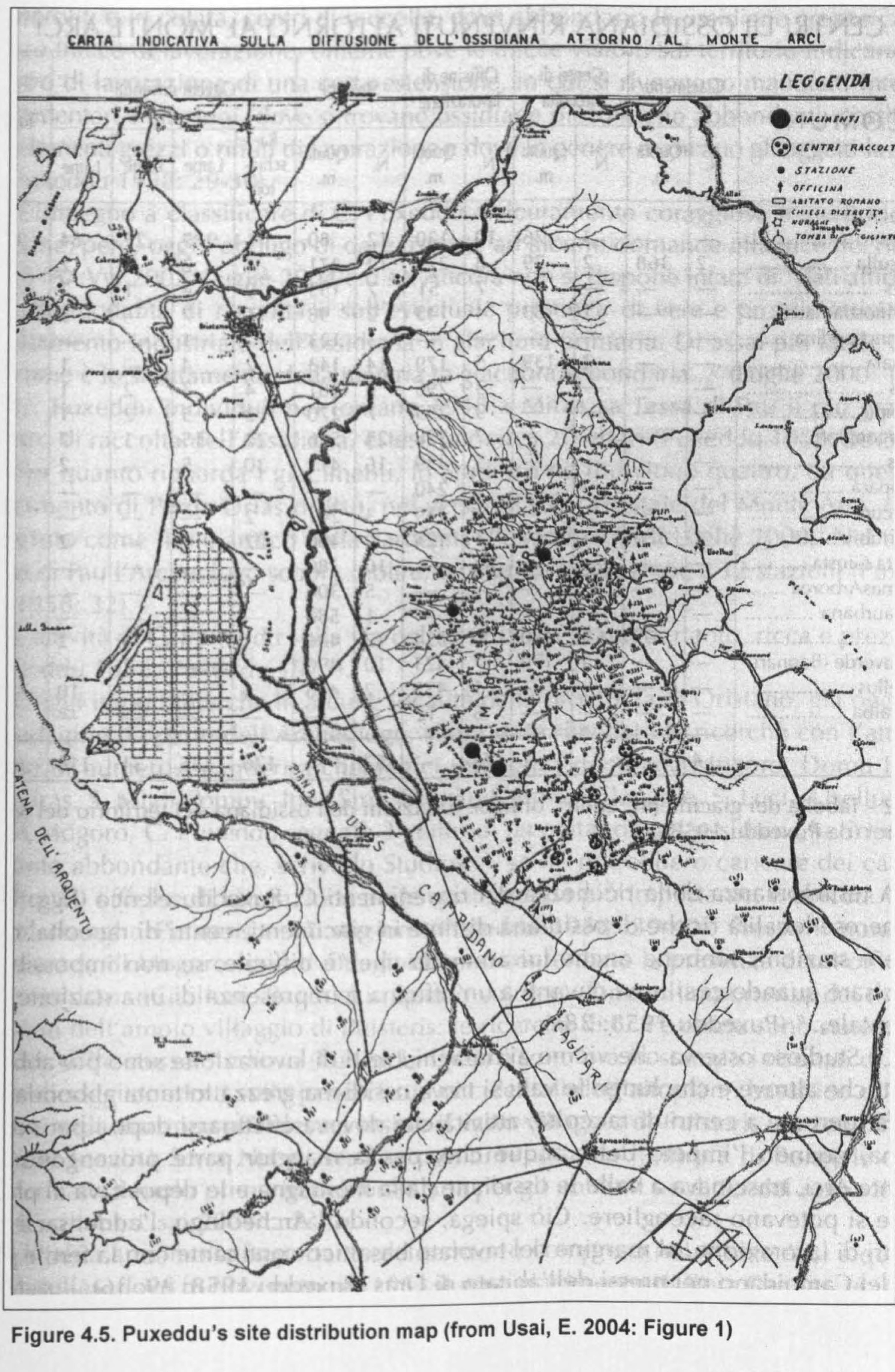

Figure 4.5. Puxeddu's site distribution map (from Usai, E. 2004: Figure 1)

Two main divisions exist in Puxeddu's site typology. In the first two types (*giacimenti* and *centri di raccolta*) raw material predominates, and archaeological material in the other two (*stazioni* and *officine*). A further distinction in the latter two categories is based on the presence or absence of retouched pieces ('tools'). Within these distinctions however, several problems arise.

Giacimenti* and *centri di raccolta

As discussed before, knowing the location and the distribution of primary and secondary sources is illuminating, as it enables study of spatially and temporally varying procurement patterns (Section 2.3.1). Puxeddu's first two site categories indicate where raw material is available, but, unfortunately, there is no clear-cut distinction between primary and secondary sources. It is also unclear, if, where, and to what extent, reduction took place at these locations. Puxeddu's view on the role of nature, in which there is no distinction between flaked and suitable-for-flaking raw material, underlies his classification. This is illustrated by his description of blocks of obsidian lying around in the riverbeds at the *giacimento* Roía Cannas, which he described as "natural rough outs, [...] and almost ready for use" (Puxeddu 1957: 35 my translation). It is also echoed by his interchangeable use of 'nodules' and 'cores', which nowadays distinguish between raw material (*i.e.* nodules found at all raw material sources) and flaked material (*i.e.* cores, found at quarries etc.). Tykot has recently distinguished between primary and secondary sources on the Monte Arci, but he focussed on Puxeddu's *giacimenti*, demonstrating that this category reflects both. The *centri di raccolta* are more problematic to re-interpret. Tykot did not include these as raw material sources and only refers to Mitza sa Tassa, which he interprets as a large primary reduction centre (Tykot 1995: 86). My fieldwork in the Mògoro basin, however, indicates that some of these locations are actually secondary sources, which was later independently confirmed by the Monte Arci Project (see above). Preliminary analysis showed that reduction was limited at these sites, and mostly restricted to testing nodules. Without a clear distinction between worked and/or unworked material, however, it is also likely that some locations are archaeological sites (see also below).

Stazioni* and *officine

The bulk of Puxeddu's material is archaeological, with 278 *stazioni* and 95 *officine* (Table 4.4; Appendix 4.4). The basic distinction between the two is the presence of 'tools', but this is not an exclusive criterion. Some areas with *stazioni* do contain retouched pieces, and his recording system prevents further linking tools to sites in areas with both site types, since it only lists finds and sites per municipality, not per find location. It is therefore necessary to look for other differences between these categories. Firstly, some *stazioni* have a high percentage of raw material, small flakes and shatter and secondly, the number of artefacts (tools and/or flaked material) is low. Thus, it is feasible that at least some of these localities are raw material sources rather than actual archaeological sites. At the same time, many are associated with *nuraghi,* and it is highly likely that their low tools count and a high raw material component in reality represent expedient flaking industries, which are common at later prehistoric sites. Unfortunately, the dearth of detailed artefact information does not allow a site-specific identification of these procurement and/or small-scale settlement sites. One of Poxeddu's *stazioni* also fell in the *Riu Mannu* research area, Nuraghe Siaxi (10-B). This is a settlement site with a sizeable and unambiguously flaked lithic assemblage that shows clear evidence for on-site reduction and flake production (see Table 7.1). *Officine* are the least problematic site category. Puxeddu has discussed one, Puisteris, in some detail and effectively described a settlement site (Puxeddu 1957; 1962). Tykot has translated the classification into reduction sites or workshops (Tykot 1996: 48). This, however, is misguiding. It implies a non-existent specialisation, as in lithic studies the term often refers to sites near quarries/mines, where initial core reduction takes place (Section 2.3.1). Preliminary results from recent excavations at other Puxeddu sites support the idea that the *stazioni* are late prehistoric Nuragic (settlement) assemblages, while the *officine* are earlier prehistoric sites (Usai, E. 2004).

Understandably, further attempts to separate out subtleties in flaking practice falls short. Puxeddu is unfamiliar with reduction processes, which is reflected by the lack of categories other than tools, and the occasional but interchangeable and undefined, use of the words nodules, cores, debitage and flakes. Moreover, only a small range of tool types was recorded or perhaps recognised: arrowheads (*punte di freccia* or *frecce*), scrapers (*raschiatoi*), end scrapers (*grattatoi*), burins (*bulini*), blades (*lame*) and knives (*coltelli*) (see Appendix 4.4). As discussed previously, these are still the most recognised and recorded tool types in many publications (Section 1.3; Table 1.5).

Similarly, some cautionary remarks pertain to Puxeddu's regional evaluation. Firstly, post depositional processes must be taken into account; these heavily influence archaeological visibility as well as site- and artefact recovery (Section 2.4). Secondly, many site distribution maps effectively demonstrate research intensity, and cannot directly be converted into settlement patterns (Needham 1993). Knowing that Mògoro is Puxeddu's 'home base', and that cars were less ubiquitous in the 1940-50s, it is not unreasonable to suggest that declining site numbers in areas away from Mògoro represent his research range rather than declining prehistoric settlements. Another important aspect is unsystematic collection methods. Puxeddu mainly visited monuments, *nuraghi* and *domus de janas,* and used relatively easily accessible roads or paths as starting points to locate sites. The amount of recovered sites was then considered as representative of preferences for these locations on *their* part. This is, as discussed previously, a common practice in Sardinian archaeology (Section 1.2).

In conclusion, two Puxeddu site types, *giacimenti* and *officine*, may be re-interpreted as secondary raw material sources and settlement sites respectively. The remaining two, *stazioni* and *centri di raccolta,* are more difficult to re-interpret. Both could be secondary raw material sources, nodule testing and/or initial reduction localities, or small-scale (later prehistoric?) sites. Unsurprisingly, cultural historical influences are strong in Puxeddu's work, as shown by the use of tool types to classify sites, and his intuitive interpretations. His examination of raw material availability, particularly the identification of many secondary sources, however, has provided valuable information.

4.3. Primary and secondary source use: the *Riu Mannu* Survey Project

With ample evidence for the existence of secondary sources, it is necessary to examine if, and to what extent, these were used in the past. Three main lines of evidence were explored to investigate the *general* use of secondary sources: 1) relationship between cortex type and source type and transport mechanism, 2) distance of archaeological sites to secondary sources, and 3) relationship between artefact size, cortex occurrence and artefact class (for detailed analysis and discussion see Sections 5.3.2.1; 6.4.2.1; 7.1).

4.3.1. Cortex sources and types

During the *Riu Mannu* Survey Project artefact study, I recorded four types of cortex. All are straightforward, except for Type 4, which can be difficult to separate from general weathering. To minimise inconsistencies, only those artefacts with intentional flaking after patination were classified as cortical (Table 4.5; Figure 4.6). A basic connection between cortex types and source locations has been observed (Appendix 4.5).

Cortex type	Description
Type 1	Coarse, grey coloured cortex
Type 2	Coarse, grey coloured, pitted and battered cortex
Type 3	Sandy or fine-grained, light (yellow/white) coloured cortex
Type 4	Glossy smooth patination

Table 4.5. Description of the four cortex types.

Types 1-2 primarily occur in and along the rivers Mògoro and Mannu, and it is likely that river transport has created these specific cortex types. Similarities with cortex on flint nodules in secondary riverine sources elsewhere further support this notion. Types 3-4 occur mostly in primary source areas. It should be kept in mind that these cortex types develop from one into the other over time. They are created by water and gravel transport and post depositional effects such as chemical weathering (soil effects) and wind gloss (Shelley 1993; Skinner n.d.). Combinations are therefore possible and do occur on some artefacts. For the majority, however, this distinction seems to hold true.

When the association between cortex type and source location is accepted, it becomes possible to assess to what extent these sources are present in the analysed assemblages (Table 4.6). On average, 30-35% of studied assemblages contain cortex, irrespective of type. Secondary source cortex (Types 1-2) clearly predominates in eight transects with an average of 75%, which is even higher in some cases. Only two assemblages (transects 02 and 12 contain more primary than secondary source cortex. Unfortunately, quantitative data for transect 12 and 13 are so low; that there is no statistical significance to their data.

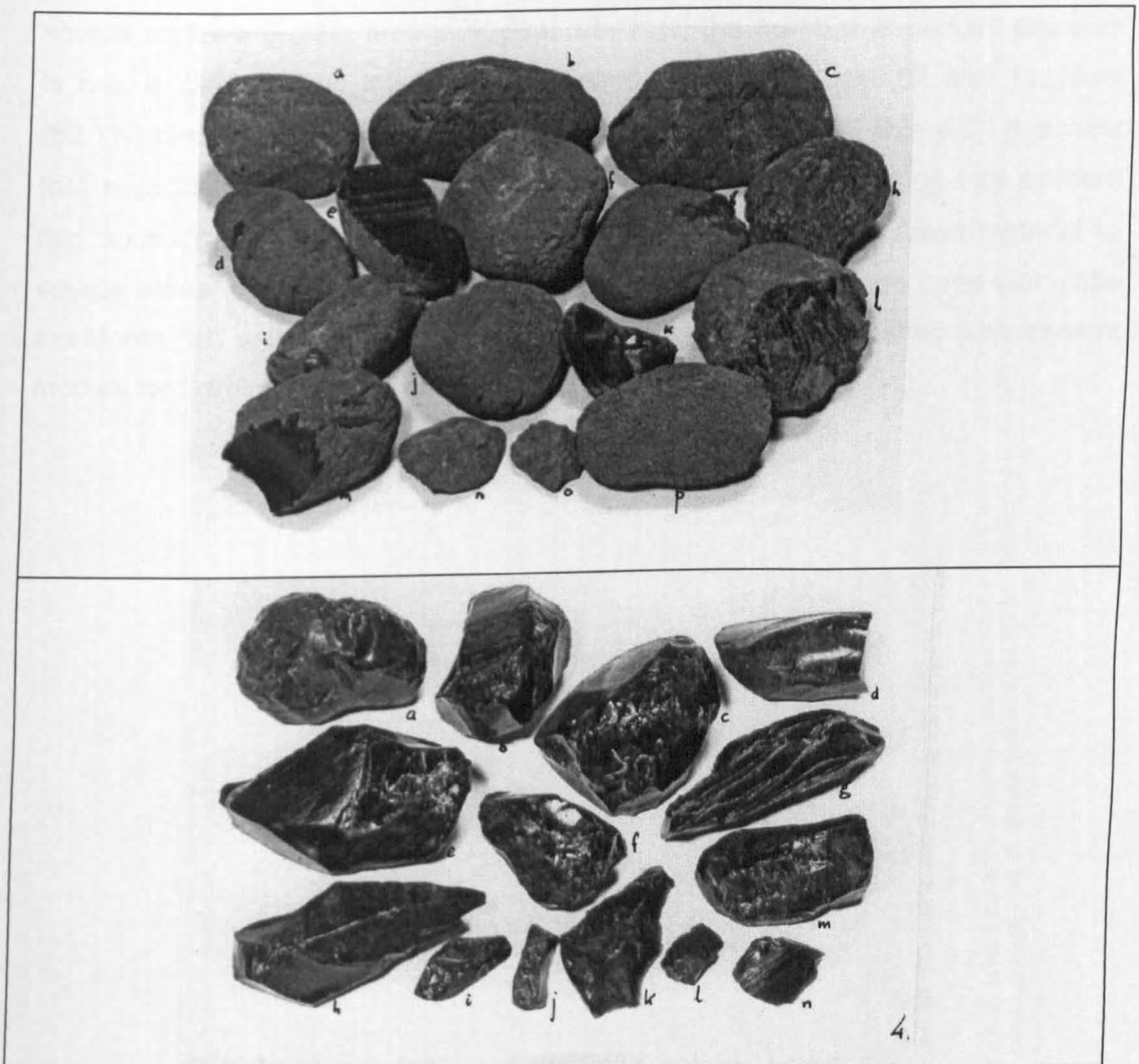

Figure 4.6. Cortex types 1-2 (top) collected at secondary source area Serra Pontis and cortex type 4 (bottom) from the Conca Cannas primary source area. Photos J. Pauptit.

Qualitative *Riu Mannu* data for these transects are mostly consistent with quantitative data, but some transects provide additional information (Appendix 4.6: Table 1). The slight primary source cortex predominance in transect 02 is reversed with a much higher secondary source cortex percentage (75%). Likewise, the slight majority for secondary source cortex in transect 05, is more pronounced in qualitative data. Quantitative and qualitative data for transect 14 show that primary and secondary source cortex percentages are virtually similar with the former occurring more frequently (48.4% *vs.* 51.6%). Qualitative data in transect 12 reiterate the quantitative data, and show a clear predominance in primary source cortex (88.1%). In transect 13 primary source cortex is slightly more prevalent (53.5% *vs.* 46.6%). Most quantitative pieces with secondary source cortex are clear archaeological artefacts; the number of pseudo artefacts is low, c. 5-10%. Two interesting exceptions exist, transects 02 and 11. Most (68.1%) pieces in transect 11 are, in fact, pseudo artefacts (Table 4.6). It is clear that secondary sources were used extensively, even when taking into account that sourcing based on cortex only attributes one-third of analysed material to source areas. The realisation that secondary sources have been used alongside the Monte Arci source zones necessitates a re-evaluation of existing procurement models for Sardinia and the wider Mediterranean (see Section 7.1).

	Arborèa				Campidano									Marmilla							
	02		05		04		07		09		13	23		10		11		12		14	
	N	%	N	%	N	%	N	%	N	%	N	N	%	N	%	N	%	N	%	N	%
Total obsidian	79		19		804		106		122		1	115		306		168		7		1147	
All cortex	30	38	7	36.9	283	35.2	24	22.6	42	34.4	-	42	36.5	107	35	51	30.4	1	14.3	337	29.4
Primary source cortex	13	56.7	3	42.9	64	22.6	6	25	9	21.4	-	10	23.8	11	10.2	4	7.9	1	100	135	39.8
Secondary source cortex	17	43.3	4	57.1	219	77.4	18	75	33	78.6	-	32	76.2	96	89.8	47	92.1			202	60.2
Flaked material with secondary source cortex	12	70.2	4	100	207	94.5	16	88.9	30	91	-	31	96.9	86	89.6	15	31.9	-	-	193	95.6
Pseudo artefacts with secondary source cortex	5	29.8	-	-	12	5.5	2	11.1	3	9	-	1	3.1	10	10.4	32	68.1	-	-	9	4.4

Table 4.6. Primary (types 3-4) and secondary (types 1-2) source cortex for all quantitative finds.

4.3.2. Distance to source areas

The relationship between distance to raw material sources and cortex percentages also indicate that secondary sources have been used in the past. It is generally believed that when material is reduced or prepared at the sources and is passed on in exchange networks, cortex percentages decrease as the distance to raw material sources increases. Overall cortex percentages, as well as those for primary and secondary source cortex do not, however, show the straightforward picture expected should only the Monte Arci have been in use. Three main trends can be seen (Figure 4.7; Table 4.6; for detailed data see Sections 5.3.1; 6.4.1; for discussion Section 7.1):

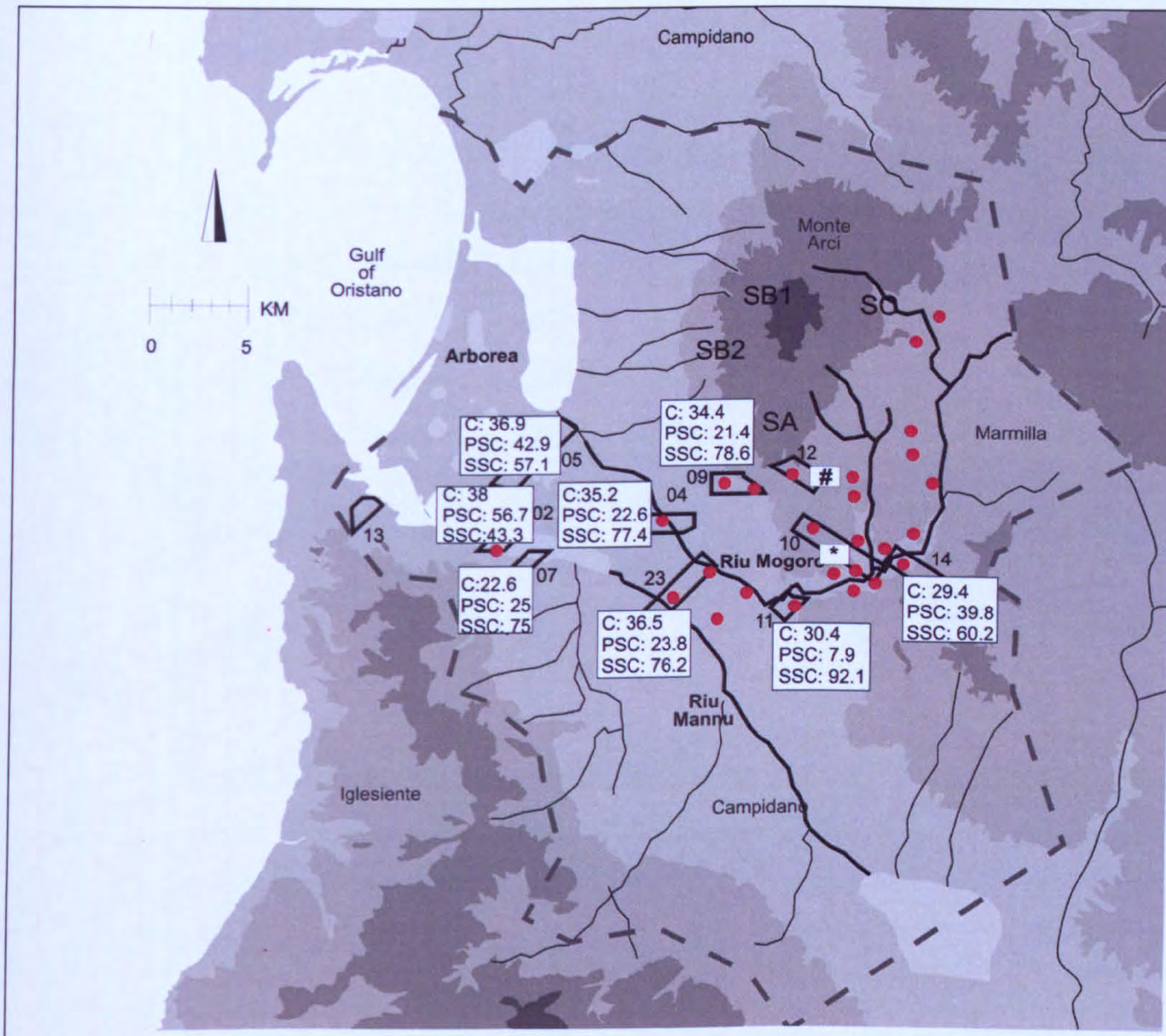

Figure 4.7. Distribution of the primary and secondary source zones and percentages of all quantitative primary and secondary cortical material.

Key to map:
Red bullets= all secondary source locations,
SA, SB1, SB2 & SC= Monte Arci source zones
C= overall cortex percentage of transect assemblage
PSC= primary source cortex percentage, SSC= secondary source cortex percentage
*= C:35, PSC: 10.2, SSC: 89.8, #=C: 14.3. PSC: 100

- Overall cortex percentages do not show a linear decrease.
- Secondary source cortex is predominant in the secondary source zone, but several transects also indicate use of primary sources, especially transect 02, 05 and 14.
- Proximity to primary sources notwithstanding substantial percentages of secondary source cortex are present in transect 09.

4.3.2.1. Riu Mannu evidence of reduction at primary and secondary sources

Riu Mannu evidence for source use, in the form of quarries or workshops, at primary or secondary sources is limited. Extensive quarries or workshops are completely absent, but small-scale nodule testing and reduction is seen at some secondary *Riu Mannu* sources (Figure 4.3: B, H-J *i.e.* 'sites' 02-a, 09-a, 10-A, and 11-a). Site 04-B is the only location where a settlement with clear evidence of onsite reduction lies in a wider secondary source location. Another site (12-a) is interesting in light of the earlier noted absence of quarries and workshops at the SA and SB primary source zones. This site is closest to Conca Cannas (SA source zone) and contains a qualitative collection that demonstrates blade core preparation and maintenance. It is the only *Riu Mannu* collection that suggests a spatial separation of primary reduction. Unfortunately, the collection's disturbed find context and purely qualitative nature limit its interpretative value. It does support earlier cautions that the absence of quarries and workshops cannot be taken at face value.

It is also worthwhile emphasising that the data presented here on secondary sources, source use at the sources and raw material percentages of assemblages are biased and in all likelihood under-represented for two main reasons. Firstly, the investigation of raw material sources or evidence for testing/primary reduction has never been an initial *Riu Mannu* Project aim. After realising that secondary sources existed beyond the Monte Arci, the Project focussed attention on examining their overall distribution, as well as establishing whether or not, and if so how, they correspond to the Monte Arci source zones and to provide initial confirmation for their use. Secondly, whilst students can (reasonably) easily be taught to recognise intentionally flaked material nodule testing is more problematic. Likewise, as became apparent earlier (see Section 4.1.3 above), the pseudo artefacts have demonstrated that the distinction between intentionally flaked by people and unintentionally flaked by nature is not clear-cut. Site 10-A also illustrates this point well. Field crew had initially interpreted this sites as a as a 'knapping event'. After detailed post collection analysis, however, it was re-interpreted as a secondary source area, with some retouched artefacts that were no longer *insitu* (see also Section 7.2.2; Table 7.7).

4.3.3. Comparative nodule sizes and shapes

The overall resemblance between reconstructed nodule sizes and shapes for the analysed assemblages and raw material nodules from secondary source areas also support that secondary sources were in use in prehistory. As noted above, a wide variety of sizes and shapes are reported for all source areas. Fist-sized, and larger, nodules are common and suitable for reduction. (Appendix 4.1). Similar observations were made by the *Riu Mannu* team and in my own fieldwork (Appendix 4.5). Preliminary *Riu Mannu* core and opening strategies analyses have demonstrated that fist-sized, sub-rounded to rounded nodules were selected for reduction (de Bruijn 2004; 2005). A brief general discussion follows below, detailed analysis is presented elsewhere (see Sections 5.3.1; and 6.4.1).

Secondary source cortex is present on all artefact types, suggesting that little difference exists between primary and secondary flaking stages (Table 4.7). Note that a lack of *cortical* secondary flaking stages is mirrored by a general lack of secondary flaking stages. This is a result of chronological and contextual differences as well as variation in flaking strategies (see Section 7.2). Qualitative data analyses further confirm these trends (Appendix 4.6: Table 2).

	Arborèa				Camipdano								Marmilla					
	02		05		04		07		09		23		10		11		14	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Flakes	7	58.3	3	75	100	48.3	7	43.8	11	36.7	25	80.6	39	45.3	3	20	70	36.3
Cores	-	-	-	-	4	1.9	-	-	-	-	2	6.5	1	1.2	-	-	3	1.6
Chunks/fragments	5	41.7	1	25	62	30	6	37.5	16	53.3	4	12.9	42	48.8	11	73.3	86	44.6
Retouched pieces	-	-	-	-	14	6.8	-	-	1	3.3	-	-	2	2.3	1	6.7	15	7.8
Possibly retouched pieces	-	-	-	-	27	13	3	18.8	2	6.7	-	-	2	2.3	-	-	19	9.8
Total	12	100	4	100	207	100	16	100	30	100	31	100	86	100	15	100	193	100

Table 4.7. Number and percentage of artefacts with secondary source cortex per artefact class. Quantitative data only.

The overall small artefact size points to the use of relatively small, rounded nodules, compatible with those noted at secondary sources. Most (86.1%) non-cortical, unretouched, flakes/blades range between 10-30mm, while 77.8% of cortical (irrespective of source type) flakes fall in the 15-35mm category. Non-cortical tool sizes are slightly higher; 67.1% measure between 20-35mm, with another 12.9% in the 15-20mm category. Cortical tools are more evenly distributed across size categories, 60% range between 20-30mm or 84.4% in the wider 15-40mm range. Virtually all non-cortical debris (95%) measures between 5-30mm, with 77.2% in a more restricted 10-25mm range, and 84.4% of cortical debris falls in the 10-30mm range. In fact, artefacts over 50mm, irrespective of classification, are very rare, only 0.8% of the non-cortical assemblage measures over 50mm, with 2.4% for the cortical artefacts (Figure 4.8).

In conclusion, there is ample evidence for existence and use of secondary raw material sources. The above however, only demonstrates general use of these sources, has left out any discussion of spatial and temporal diversity, and cannot be applied to non-cortical material.

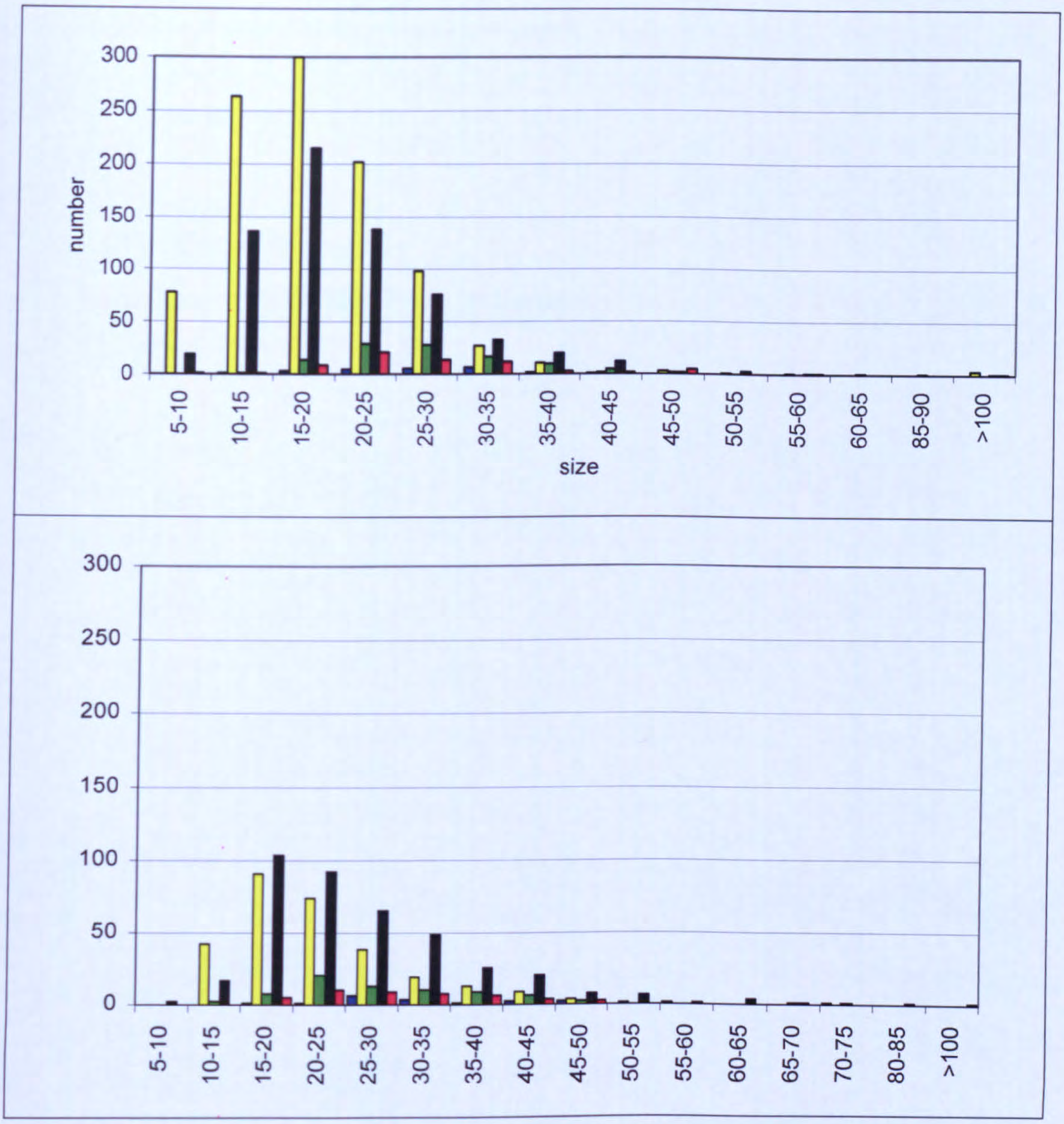

Figure 4.8. Size (maximum dimensions in mm) distribution for all quantitative (top) and qualitative (bottom) non-cortical artefacts.

Key to Figure:
Blue = cores
Black = flakes/blades
Yellow= debris
Green= possible retouched pieces
Red= retouched pieces.

4.4. Visual characterisation

As outlined previously, three main obsidian types have been recognised on the Monte Arci, and the Monte Arci Project has recently demonstrated that most secondary sources can be attributed to the SC source. Provenance analyses for

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further understanding of problematic issues. Results were promising. Using either system, 58.2% of material is attributed correctly to its source (Table 4.11: in bold). An additional 18.2% could be successfully attributed to a source, if choosing between one of two source options (Table 4.11: in red). Using only the *Riu Mannu* criteria, another 14.6% is correctly sourced (Table 4.11: in blue). Only 9% is wrongly attributed by either system (Table 4.11: in green). Again it is clear that SA and SC are best recognised, 30% of SB material was wrongly attributed, compared to 4.6% of SC material.

Known obsidian Types	Sources according to Tykot criteria	Sources according to *Riu Mannu* criteria						Total
		SA	SA/SC	SB	SC	SC/SA	SC/SB	
SA (n=29)	SA	**21**	1					22
	SA/SB	2						2
	SA/SC	5						5
SB1 (n=8)	SB			**5**			1	6
	SC				1		1	2
SC (n=13)	SA					2		2
	SA/SC	1						1
	SB			1				1
	SC				**2**		1	3
	SC/SB						6	6
SC (Serra Pontis) (n=5)	SC				**4**			4
	SC/SB				1			1
Total		29	1	6	8	2	9	55

Table 4.11. Comparison of successfulness of source attribution using Tykot and *Riu Mannu* classification system, set against original data.

Key to table:
Note that when two sources options are given, the first option is considered most likely.
Bold= Full matches
Red= Partial matches
Blue= Riu Mannu matches
Green= no match

When applied to two archaeological assemblages, however, code combinations from *Riu Mannu* experiment 2 were too rigid and restrictive, with too many new combinations. Only 45-50% of assemblages could securely be attributed to a source. The higher success rate of the initial experiment may partially be due to the small sample size. Most pieces derived from a single nodule, which probably left insufficient room to explore intersource variation adequately. Likewise, under-representation of SB localities undoubtedly explains why this source has proven difficult to describe (for more details, see de Bruijn 1998: 116-135).

4.4.1.1. Visual characterisation: this thesis

Given these problems, I therefore decided against using the *Riu Mannu* classification system in this thesis. Instead, each artefact is described individually, noting aspects such as banding, translucency, colour etc. The main aim is to explore whether or not aesthetic preferences play a role in raw material selection criteria, and whether or not these are associated with specific procurement, production or use practices (see Section 7.1.4.2.). They can, however, also be used to source artefacts to compare with and add to existing distribution models. As outlined above, this can only be done by approximation and some of the problems noted above are perceptible here, too. SA and SC obsidian can be recognised reasonably well, but as both share some characteristics with SB, it is difficult to assign artefacts with certainty to the latter (Table 4.12). If, for the time being, these correlations are accepted, some preliminary patterns can be observed in the studied dataset (for further analysis Sections 5.3.2; 6.4.2; for discussion see Section 7.1).

<table>
<tr><th>Material characteristics</th><th colspan="2">Suggested sources</th></tr>
<tr><td>Completely Translucent</td><td>SA</td><td rowspan="3">SA</td></tr>
<tr><td>Completely Translucent with Internal Patterning</td><td>SA</td></tr>
<tr><td>Glossy Black/Grey</td><td>SA?</td></tr>
<tr><td>Grey/Black Banding</td><td>SC</td><td rowspan="3">SC</td></tr>
<tr><td>Red Black Banding</td><td>SC</td></tr>
<tr><td>Possible Banding</td><td>SC?</td></tr>
<tr><td>Marginally Translucent</td><td>SA/SB2</td><td rowspan="6">SA/SB?</td></tr>
<tr><td>Marginally Translucent with Internal Patterning</td><td>SA/SB2</td></tr>
<tr><td>Translucent</td><td>SA/SB2</td></tr>
<tr><td>Translucent with Internal Patterning</td><td>SA/SB2</td></tr>
<tr><td>Glossy Black/Grey with Banding</td><td>SA/SB?</td></tr>
<tr><td>Glossy Black/Grey and Translucent</td><td>SA/SB?</td></tr>
<tr><td>Opaque Black/Grey</td><td>SC/SB1</td><td>SC/SB?</td></tr>
</table>

Table 4.12. Main raw material characteristics recognised in the *Riu Mannu* dataset, with the proposed source correlation as used in figures and discussion in text. Where two options are given, the first is considered most likely.

Arborèa

SA or SA/SB characteristics are most common in the Arborèa transects (Figure 4.9; Appendix 4.8: Table 1). This partially corresponds to expectations, given the proximity to the Monte Arci SA and SB sources. The higher SC and SC/SB features in transect 02 are not surprising either, since the transect lies in the Mògoro secondary source zone. Qualitative data for transect 05 show a more substantial SC and SC-like components, with 35% unambiguous SC features and an additional 25% for SC/SB characteristics (Appendix 4.8: Table 2).

Campidano

Transect 09 contains a high percentage of SA and SA/SB type features for quantitative and qualitative finds (95.8% and 92.2% respectively). A high percentage of SC and SC/SB characteristics is expected for the Campidano transects, given the abundance of SC raw material from the local secondary Mògoro source zone (Section 4.1.2). The visual characterisation data, however, suggest a more complex picture (Figure 4.9; Appendix 4.8: Tables 1-2). SA-type characteristics occur more frequently than expected. Transects 04, 07 and 23, in the heartland of the Mògoro source zone, contain relatively high quantitative percentages for SA obsidian (60.1%, 58.1 and 65% respectively). Qualitative data show similar figures. Quantitative data for transect 13 are statistically irrelevant; the single artefact has SC/SB characteristics. Qualitative data are more informative and have almost equal percentages for SA and SC-like characteristics (53.3% and 46.7% respectively).

Marmilla

Marmilla transect 12 predominantly contains SA-type characteristics, which is hardly surprising given its close proximity to the Monte Arci (Figure 4.9; Appendix 4.8: Tables 1-2). Quantitative data are less reliable than qualitative data, but both show high SA percentages (71.5% and 90.5%). Transects 10 and 11 lie in the secondary source zone, and are expected to contain high percentages of SC material. They do predominate but less than expected. In transect 10, SC and SC/SB constitutes 55.8% and 63.5% for the quantitative and qualitative data, but again substantial SA and SA/SB portions are present. Transect 11 shows a particularly interesting pattern. It was noted earlier that most material from this transect was not intentionally flaked, so that SC- characteristics are expected to predominate. Yet, 40% of the debris and pseudo artefacts have non-local (SA, SA/SB) characteristics.

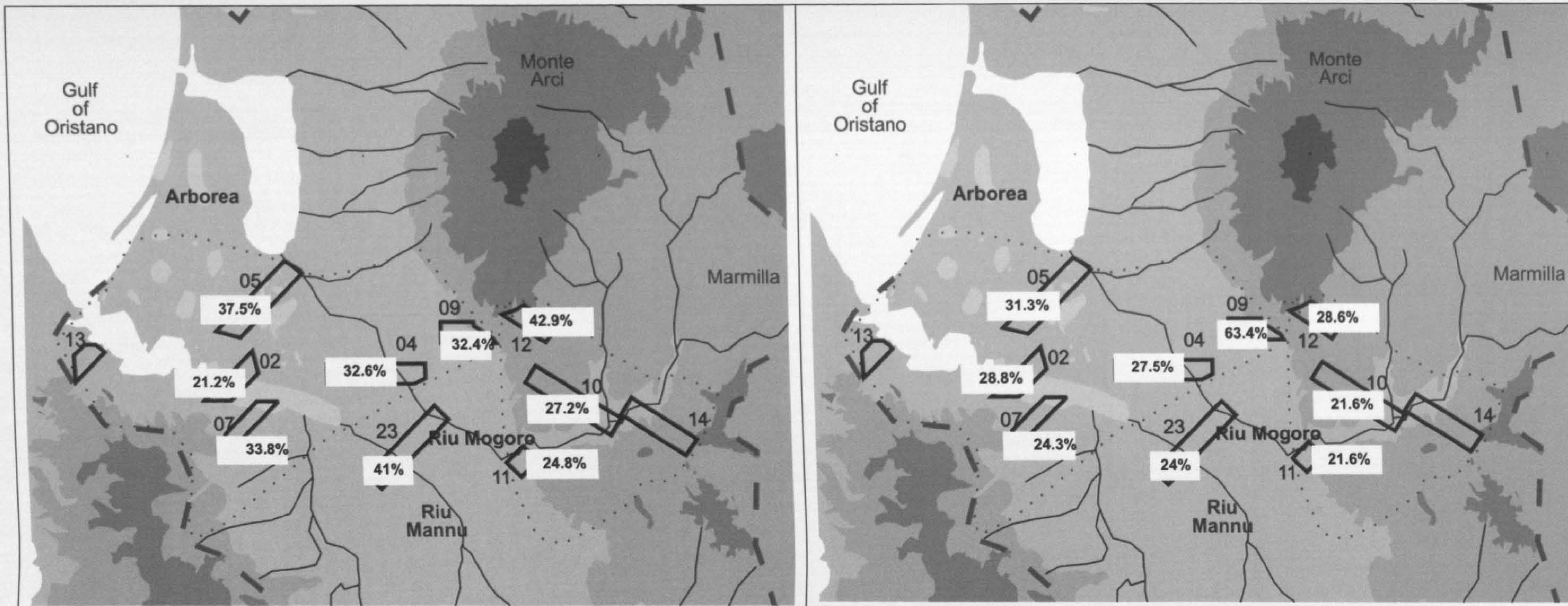


Figure 4.9. Source distribution based on visual characterisation for all quantitative *Riu Mannu* transects. SA (left) and SA/SB (right).

Data for transect 14 are unavailable

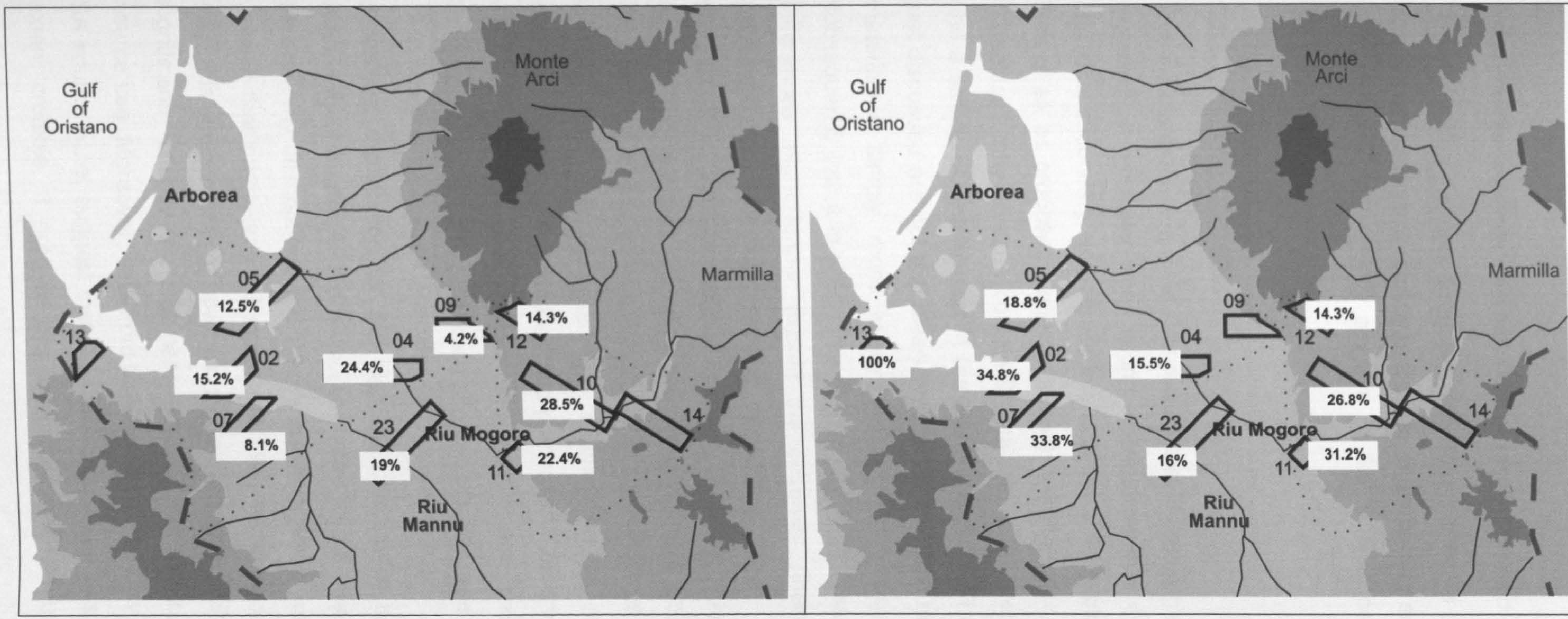


Figure 4.9. continued from previous page: Source distribution based on visual characterisation for all quantitative *Riu Mannu* transects. SC (left) and SC/SB (right).

Note: data for transect 14 are unavailable

4.4.2. Riu Mannu visual characterisation: discussion and conclusion.

Two interesting points of discussion rise from the above data presentation: 1) a high SA component in relation to the use of secondary source presumed to be predominantly SC, and 2) problem of the 'undiagnostic' SB type and its implications.

4.4.2.1. High SA component

The SA component in most Campidano and Marmilla transects is higher than expected, in particular when taking earlier presented evidence for extensive and local secondary, source use into account. Two explanations are possible. First of all, as proposed earlier, based on hydrology secondary sources in the Campidano may primarily contain SA material in the western part of the area, and a strong SC component in the eastern section. The distribution patterns just discussed are not that clear-cut. It could perhaps be argued that SA raw material is simply more widely distributed in secondary sources, and subsequently that it is used more extensively in the past. Moreover, temporal differences might further explain the observed phenomena, so that the presented data ostensibly support the original theory. The recent sourcing programme in the Campidano, however, invalidates that notion, as all their samples indicate that secondary sources contain SC obsidian (Section 4.1.2). This has an important implication, as it suggests that source use is more intricate than normally assumed. Examination of relationships between obsidian types, source locations and primary and secondary flaking strategies will help gain valuable insights into spatial and temporal differences in Sardinian procurement, production and use practice (see Chapter 7).

A second explanation for the high SA component is that artefacts were incorrectly attributed to the SA source. After all, as noted above, correlations between my descriptions and Tykot's are ambiguous, and Tykot has explicitly warned that particularly SB material is likely to be under-represented (Table 4.9). It is worth recalling, however, that an increased SB component does not significantly change the argument. Both SA and SB origins imply non-local source use. Moreover, data from transects 09 and 12, which are closest to the SA source zone, suggest that the used criteria and associations are to some extent credible. If not, we are confronted with an unexpectedly high SB component, there. A related explanation is that instead of an incorrect attribution to SB, SC material is under-represented. Re-deposition is known to affect the chemical composition of sources, and it is not unreasonable to suggest that physical characteristics also change, increasing inter-source variability (Shackley 1998).

4.4.2.2. Undiagnostic (SB) obsidian

Both Tykot's research and the two *Riu Mannu* experiments have indicated that SB material has few diagnostic characteristics, with the exception of phenocrysts. Translucent, and internally banded SB2 pieces are easily misclassified as SA material, while SB1 closely resembles plain SC attributes (Table 4.9). Interestingly, almost half of the entire dataset (47.2%) could potentially be attributed to the SB source (Appendix 4.8: Table 1). 26.8%, however, fall in the 'SA/SB' category, which is characterised by varying degrees of translucency. Even so, almost a quarter of the dataset does not contain any diagnostic physical features. Additionally, 21.6% of SA, and 2.2% of SC material do not exhibit any diagnostic features (*i.e.* 'SA?' and 'SC?' in Table 4.12). This raises an interesting question that merits further exploration: are there any spatially and/or chronologically differences that might suggest underlying social preferences (see Section 7.1.2.4).

4.5. Raw material availability and source use: conclusion

It has since long been known that the Monte Arci is one of the main sources of obsidian for Sardinia and the west Mediterranean. Attention has predominantly been focussed on locating and characterising the geological sources, and to matching these to archaeological artefacts to establish the extent of source distribution patterns. Recent research, including this study has demonstrated that raw material sources extend beyond the Monte Arci, deep into the Campidano and the Arborèa, here called the Mògoro secondary source area. This chapter has presented the *Riu Mannu* evidence for the existence and generic use of these sources. It has also proposed that cortex types may be used to distinguish Monte Arci and Mògoro sources use. A visual characterisation methodology has been introduced that allows both the correlation with existing distribution patterns of obsidian types, and exploration of aesthetic preferences.

Preliminary results using the proposed cortex and visual characterisation methods have indicated that existing procurement models are too one-dimensional and limited. They have focussed too strongly on the long-distance west Mediterranean Neolithic exchange networks and the source zones on the Monte Arci. Procurement strategies in Sardinia are more complicated than previously taken into consideration. Primary and secondary source use occurred simultaneously, at least spatially, and these are not easily tied to direct or indirect procurement (see discussion in Section 7.1). Visual characterisation of *Riu Mannu* artefacts do correspond with the source distribution patterns noted by Tykot, in which SA and SC obsidian predominate in central and southern Sardinia (Table 4.3).

It is clear that future research on the island and outside must take the wider raw material availability into account. The existence of secondary sources affects existing procurement models, especially those that posit increased control over obsidian sources and exchange networks as means for increased social complexity. Moreover, although the above has demonstrated generic primary and secondary source use, it is the exploration of the spatial and temporal relationships between source locations, obsidian types, and primary and secondary flaking strategies that will provide valuable insights into the Sardinian lithic landscape.

Chapter Five

Riu Mannu lithic practices: primary technology

Following on from the previous chapter where I presented evidence for the existence of secondary sources in the Marmilla and Campidano, this chapter develops the evidence for raw material use and examines two main aspects. It firstly focusses on where primary technology, i.e. cores, core rejuvenation flakes, unretouched debitage (complete and fragmented flakes and blades) and debris (chunks and shatter) have been found, and in what densities. Secondly, applying the framework outlined in chapter three, I present and discuss primary flaking practices in terms of traditions, strategies, skills and knowledge.

5.1 Primary flaking locations

Cores and core rejuvenation flakes are artefact classes unambiguously indicative of primary technology, and are discussed first. The other two other groups, debitage and debris, contain multi-purpose artefacts. Debitage (complete and fragmented flakes and blades) indicates primary technology but artefacts may also have been selected for other (use) activities. Debris (chunks and shatter) is an equally complex artefact class. Chunks and shatter are primary flaking material, such as smaller flaking debitage or core fragments, and they may also show traces of ad hoc knapping. Surface exposure, however, has often obscured anthropogenic flaking characteristics, blurring distinctions amongst raw material, human-made and natural flaking debris (see Section 3.2.4). In recognition of such complexity I examine whether, and if so where, debitage and debris distribution patterns overlap with those for cores and core rejuvenation material. Before turning to the discussion, please note that maps presented here are simplified representations, in particular around special interest areas (areas with sites in close proximity) 04-B and 14-B, where site haloes and nearby localised concentrations are included in 'site' counts. For detailed distributions at transect level, please consult Appendix 3.2.

5.1.1. Riu Mannu core distribution and density patterns

Cores form a small percentage of all quantitatively collected *Riu Mannu* assemblages (1.2%-2.8%) but their density and distribution patterns are interesting (Table 5.1, Figure 5.1: all black bullets; Appendix 5.1). They are clearly unevenly distributed across the research area. Only six of eleven transect assemblages contain cores and most (85.1%) are restricted to three transects (04, 10 and 14) in and along the Mògoro gorge, which intersects the wider Marmilla and Campidano landscapes. Low but steady numbers of cores are also present in inland Arborèa transects (*e.g.* transect 02, parts of transects 04, 07 and 23).

		02	04	07	10	14	23	Total
Percentage of total obsidian assemblage		*2.5*	*1.5*	*2.8*	*1.2*	*1.9*	*1.7*	*1.6*
Obsidian	Sites	2	8	3	1	18	-	32
	Haloes	-	1	-	-	1	-	2
	Isolated	-	3	-	3	3	2	11
Total		2	12	3	4	22	2	45

Table 5.1. Distribution and density of all cores per transect subdivided into finds context (sites, site haloes and isolation). Quantitative data.

Interestingly, cores are absent in transects close to primary source areas (*e.g.* transects 09 and 12), in transitional transects intersecting either the Campidano and the Iglesiente (*e.g.* transect 13, and part of 07), or the Campidano and Marmilla (*e.g.* transect 11), and in the more coastal part of the Arborèa (transect 05). Moreover, cores in transects 02, 04, 07 and 14 are mainly found in site contexts, while isolated cores (23.4%) predominate in transects 10 and 23. Furthermore, strong clustering is visible in the two high-density transects, since most cores are from single site contexts or from special interest areas (*e.g.* 04-B, 07-D/E, 14-B; see Figure 5.1; Appendix 5.1).

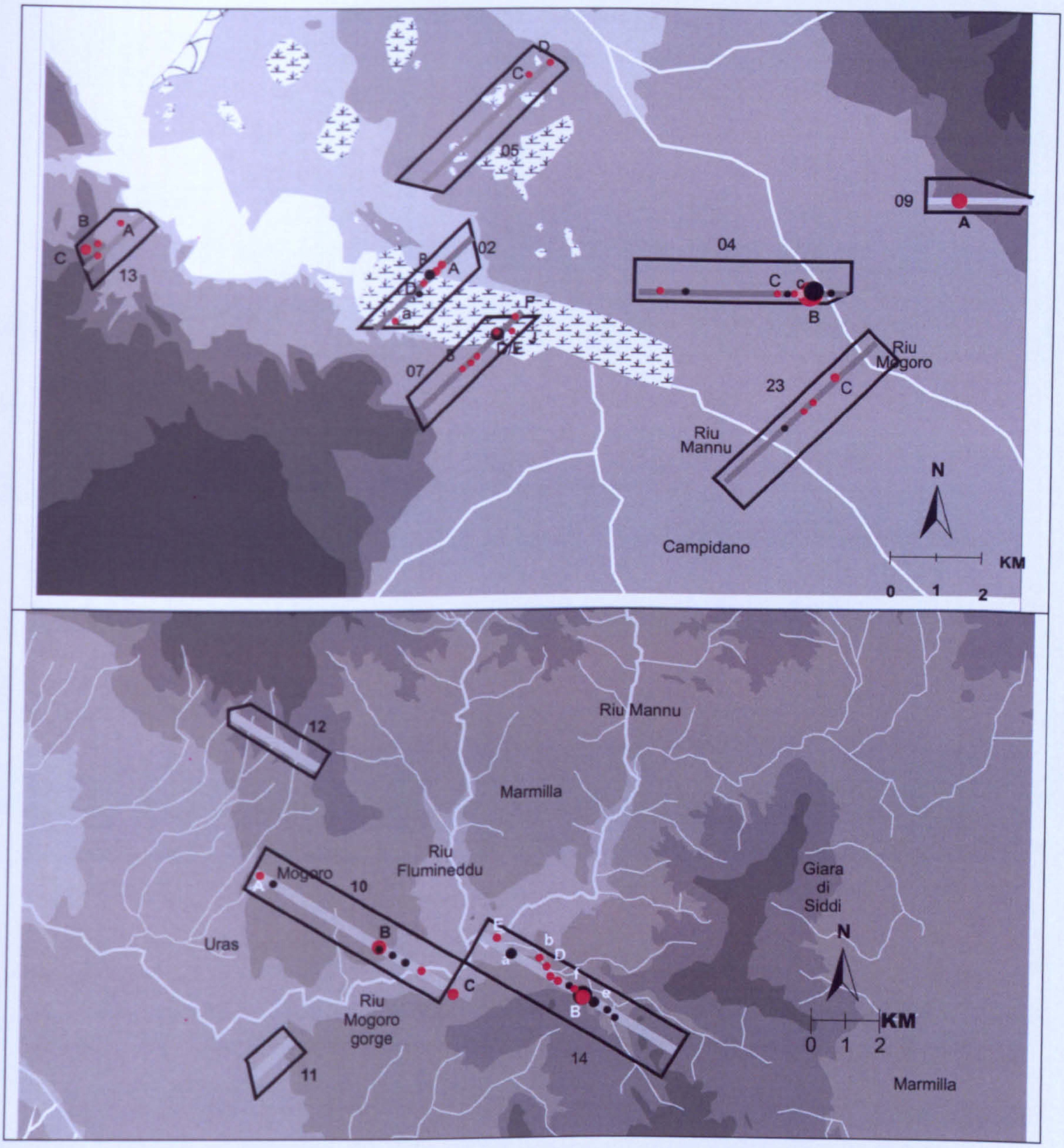


Figure 5.1. Core distribution and density in Arborèa and Campidano (above) and Marmilla (below).

Key to map:
Red bullets (graduating in size with increased densities) = qualitative finds
Pink bullets (graduating in size with increased densities) = qualitative finds
Black bullets (graduating in size with increased densities) = quantitative finds
Note: small and capitals letters indicate 'site' assemblages

Qualitative data both show similar trends and add extra information to this picture (Figure 5.1: red and pink bullets). Cores are still only a small percentage (2.5%) of the total qualitative sample, with individual assemblages varying between 1.2% and 8.3% (Table 5.2).

		02#	04*	05	07*#	09	10	13#	14*#	23	Total
Percentage of total obsidian assemblage		*1.4*	*3.0*	*8.3*	*3.4*	*5.5*	*1.3*	*25*	*3.4*	*1.9*	*2.3*
Obsidian	**Sites**	2	20	2	3	6	6	-	13	2	54
	Haloes	3	-	-	2	-	-	-	-	-	5
	Isolated	1	2	-	-	-	1	1	2	1	8
Total obsidian		6	22	2	5	6	7	1	15	3	67

Table 5.2. Distribution and density of all cores per transect, subdivided into finds context (sites, site haloes and isolation). Qualitative data. * Excluding cores from revisits. # Excluding cores collected in sites outside main grid areas.

Two thirds of all finds (66.2%) are again concentrated along the Mògoro gorge area, particularly in transects 04 and 14, and they are again consistently present, if in low numbers, in inland Arborèa. The noted prevalence of cores associated with site contexts is even stronger here, only 12.2% are found in isolation or low-density spreads, but this is unsurprising given the nature of qualitative collections (Section 3.1.2.1). Single site contexts (*e.g.* transect 09) or clustered sites (*e.g.* transects 02, 04, 14) predominate once more. The concentrated Mògoro gorge and inland Arborèa core distribution, however, is balanced out by the modest numbers of cores in previously empty main grids in Arborèa transect 05 and Campidano/Monte Arci transect 09. An additional ten cores were collected during revisits to 04-B, further emphasising artefact richness in this area. Sites sampled outside the main grids increase already dense artefact distributions in transects 02, 07 and 14. The 'outside' sites in transect 13 do provide extra information on flaking activity in the mountainous Iglesiente-Campidano region, given the virtually empty main grid.

5.1.2. Riu Mannu core rejuvenation distribution and density patterns

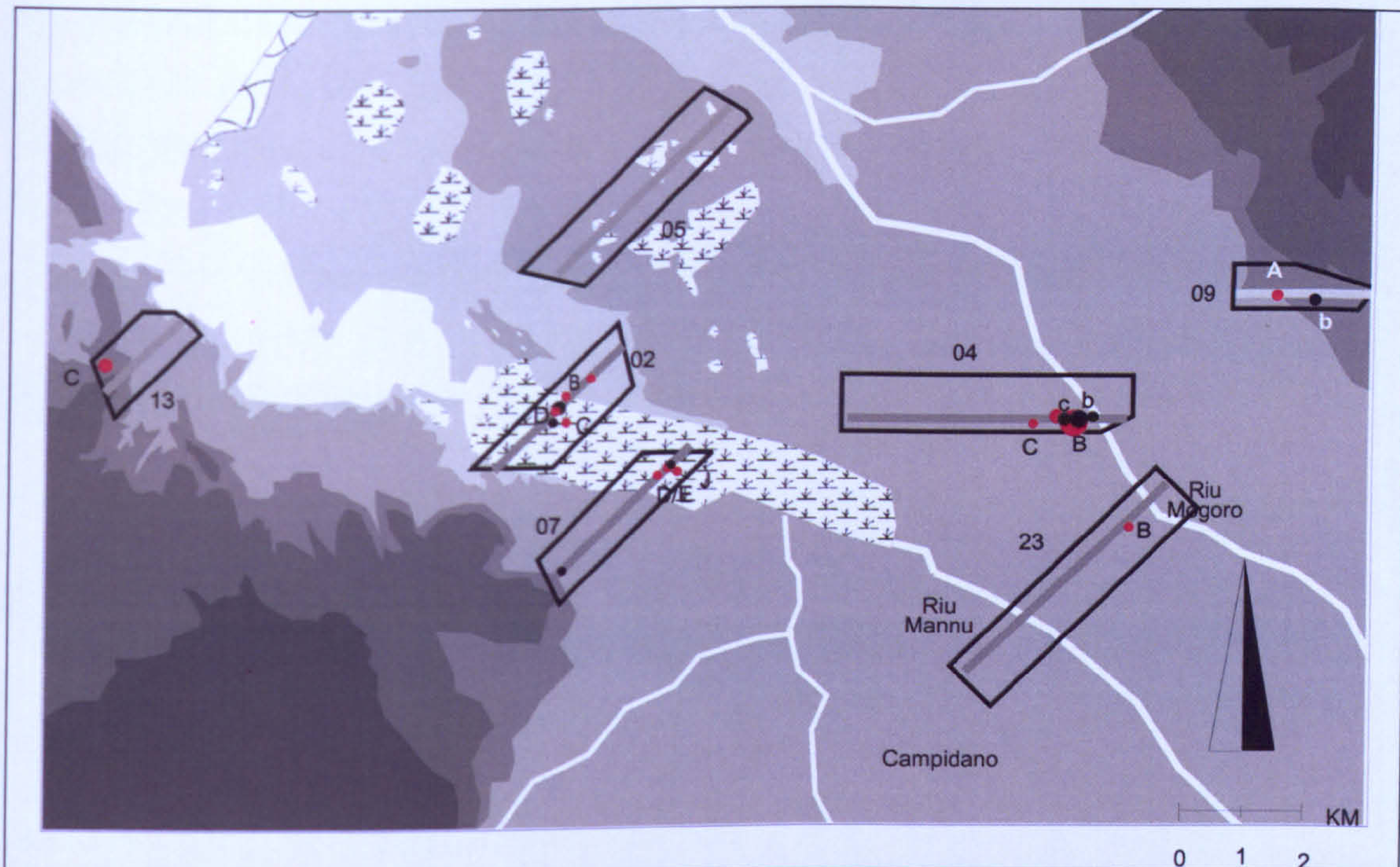
Three types of core rejuvenation flakes are generally recognised: 1) side-struck platform removals, 2) longitudinal core trimming, and 3) accidental overshot flakes. This section groups all three categories together and is focussed on their overall distribution (see Section 5.4.3.2). Core rejuvenation material makes up a small percentage (1.1%) of the total *Riu Mannu* quantitative sample. Individual assemblage percentages are low, around 1%, with the highest (3.8%) for transect 02, and lowest (0.3%) for transect 10. Density and distribution patterns are very uneven (Table 5.3; Figure 5.2).

		02	04	07	09	10	14	Total
Percentage of total obsidian assemblage		*3.8*	*0.7*	*1.9*	*0.8*	*0.3*	*1.6*	*1.1*
Obsidian	**Sites**	-	6	-	1	1	16	25
	Haloes	3	-	1	-	-	2	5
	Isolated	-	-	1	-	-	-	1
Total obsidian		**3**	**6**	**2**	**1**	**1**	**18**	**31**

Table 5.3. Distribution and density of all core rejuvenation flakes per transect and raw material types, subdivided into finds context (sites, site haloes and isolation). Quantitative data.

Most artefacts (80.6%) are concentrated in the wider river Mògoro area in three transects (04, 10, and 14) whereby 77.4% lies in two special interest areas: 04-B and 14-B. Low numbers of rejuvenation flakes are also found in inland Arborèa transects (02 and part of 07), on Iglesiente-Campidano terrain (part of 07) and on Campidano soils close to the Monte Arci (09). Interestingly, the latter is associated with a stretch of 19th/20th century AD abandoned field system (09-b). Lastly, virtually all pieces are exclusive to concentrations or haloes, suggesting that core rejuvenation was place-specific (Figure 5.2; Appendix 5.2).

Rejuvenation flakes also constitute only a small portion (1.3%) of the total qualitative assemblage (Table 5.4; Figure 5.2). Individual transect percentages correspond to quantitative figures except for transect 12. Distribution patterns are more dispersed than previously, but most pieces are once again concentrated in the Mògoro valley and its terraces, and in inland Arborèa.



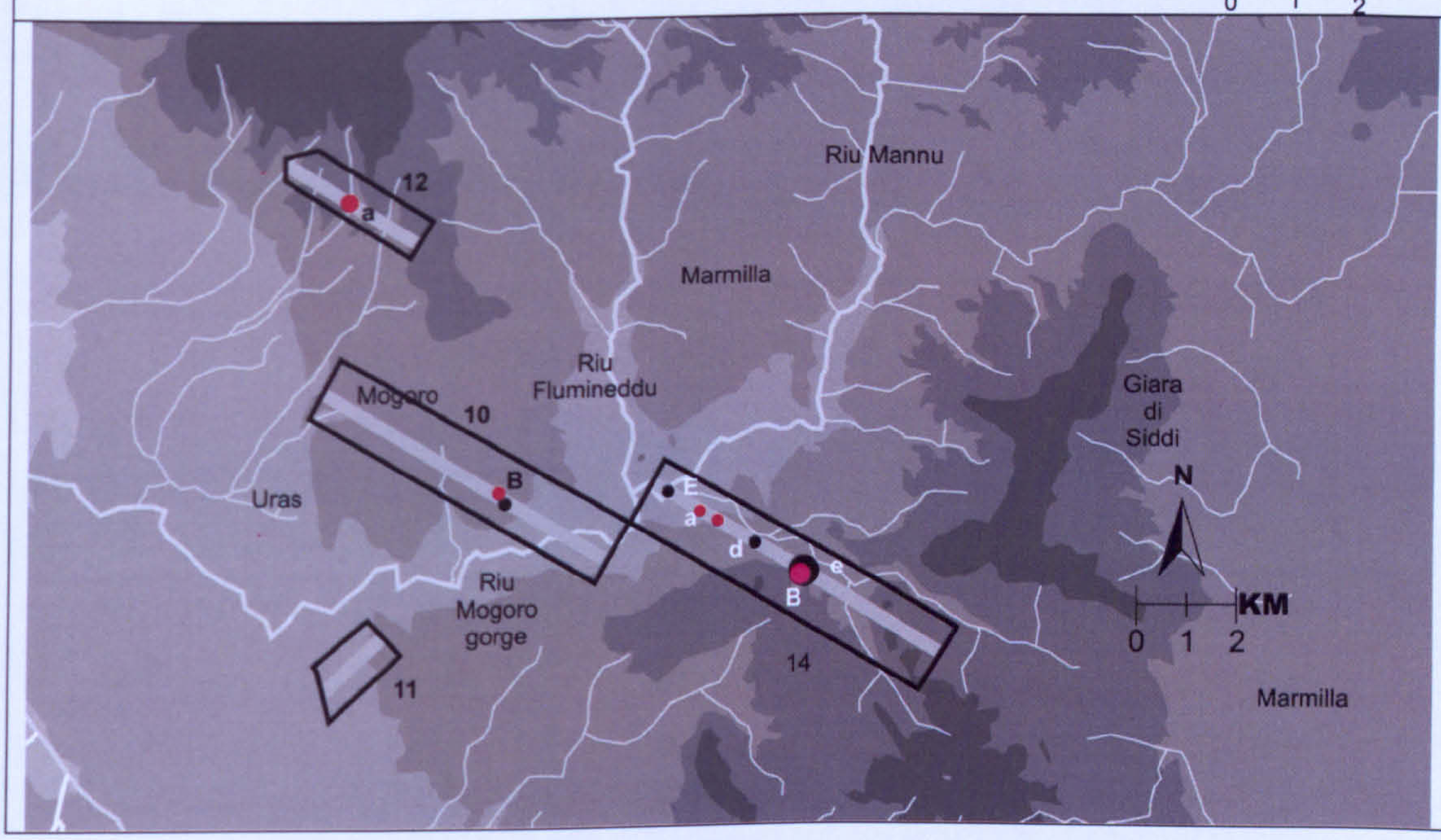


Figure 5.2. Core rejuvenation flakes distribution and density in Arborèa and Campidano (above) and Marmilla (below).

Key to map: (as Figure 5.1) Black= quantitative rejuvenation flakes Red = qualitative rejuvenation flakes

Despite the absence of cores, 13.5% of core rejuvenation flakes are found in two transects on the Monte Arci basalts (09 and 12), which may indicate spatially distinct phases of core reduction. As before, clustering is strong. In transect 04 all rejuvenation flakes but one come from the same area as quantitative data (04-B) and most finds in transects 12 and 14 are also limited to a small areas (*i.e.* 12-a and 14-B). A small number of rejuvenation flakes come from sites sampled outside the grid areas, whereby only transect 13 adds new information to the general view (Appendix 5.2). Thus, most rejuvenation pieces occur in three concentrated areas, 04-B, 14-B and 12-a. Interestingly, while core rejuvenation predominantly occurs in site contexts, only one (04-B) is a permanent settlement.

	02#	04*	07*#	09	10	12	14*#	23	Total
Percentage of transect assemblage	*2.7*	*2.1*	*1.4*	*0.9*	*0.2*	*8.3*	*1.8*	*0.6*	*1.3*
Sites	1	17	1	1	1	3	7	1	32
Haloes	1	-	1	-	-	-	1	-	3
Isolated	1	-	-	-	-	-	-	-	1
Total	3	17	2	1	1	3	8	1	36

Table 5.4. Distribution and density of all core rejuvenation flakes per transect, subdivided into finds context (sites, site haloes and isolation). Qualitative data. * Excluding core rejuvenation flakes from revisits. # Excluding core rejuvenation flakes collected in sites outside main grid areas.

5.1.3 Riu Mannu unretouched flakes/blades distribution and density patterns

Debitage (unretouched complete and fragmented flakes and blades) makes up a third (35.3%) of the obsidian quantitative dataset but percentages are more variable in individual transects (Table 5.5). As before, the majority of finds are concentrated in two areas. Dense find clusters lie in the valley and on the terraces of the river Mògoro (transects 04, 10 and 14) with a thinner distribution in transects 11 and 23. A second nucleus lies in the Arborèa, particularly further inland in transects 02, 05, 04, 07 and 23 (Figure 5.3; Table 5.5; Appendix 5.3). A steady but low number of artefacts is also found on higher Monte Arci basalts and Campidano pediments in transects 09, part of 10, and 12 and in the mountains on coarse Iglesiente and Campidano pediments in transect 13 and part of 07. Within these areas finds are also unevenly distributed. On the higher Mògoro terraces in the Marmilla, 80-90% of debitage is tightly clustered in one or two single areas (*e.g.* 10-B, 10-C, and 14-B). In the Campidano and inland Arborèa, finds are more dispersed (e.g. in 02, 07 and 23), although not everywhere (*i.e.* 04-B and surrounding areas).

	02		04		05		07		09		10		11		12		13	14		23		RM Total	
	FL	BL	FL	BL	FL	BL	FL	BL	FL	BL	FL	BL	FL	BL	FL	BL	BL	FL	BL	FL	BL	FL	BL
Percentage of transect assemblage	*32.9*	*2.5*	*33.8*	*7.1*	*47.4*	*31.6*	*34*	*3.8*	*24.6*	*0.8*	*28.3*	*0.6*	*7.7*	-	*57.1*	*14.3*	*100*	*34.8*	*0.5*	*47.1*	*6.7*	*32.3*	*3.0*
Sites	10	-	194	49	7	4	15	3	27	1	75	1	13	-	-	-	-	388	4	24	7	753	69
Haloes	8	-	37	4	1	-	20	1	1	-	8	1	-	-	-	-	-	7	1	17	-	99	7
Isolated	8	2	41	4	1	2	1	-	2	-	8	-	-	-	4	1	1	4	1	15	1	84	12
Total	26	2	272	57	9	6	36	4	30	1	91	2	13	-	4	1	1	399	6	56	8	936	88

Table 5.5. Distribution and density of all unretouched flakes (FL) and blades (BL) per transect, subdivided into finds context (sites, site haloes and isolation). Quantitative data.

		02#		04*		05		07*#		09#		10		12		13#	14*#		23		Total		Total
		FL	BL	FL	BL	FL	BL	FL	BL	FL	BL	FL	BL	FL	BL	FL	FL	BL	FL	BL	FL	BL	
Percentage of total obsidian assemblage		*33.1*	*2.7*	*37.4*	*12.5*	*58.3*	*8.3*	*39.3*	*2.1*	*28.4*	*2.8*	*40.7*	*0.8*	*29.2*	*12.5*	*50.0*	*33.5*	*0.5*	*47.4*	*19.9*	*37.4*	*6.6*	*44.1*
Obsidian	Sites	22	2	224	84	8	2	31	2	25	3	171	3	9	6	-	139	2	41	21	670	126	796
	Haloes	14	-	34	5	4	-	23	1	2	-	18	1	-	-	-	-	-	12	7	107	14	121
	Isolated	13	2	26	6	2	-	3	-	4	-	3	-	5	-	2	7	-	21	3	86	11	97
Total obsidian		49	4	284	95	14	2	57	3	31	3	192	4	14	6	2	146	2	74	31	863	151	1014

Table 5.6. Distribution and density of all unretouched flakes (FL) and blades (BL) per transect, subdivided into finds context (sites, site haloes and isolation). Qualitative data. * Excluding flakes/blades from revisits. # Excluding flakes/blades collected in sites outside main grid areas.

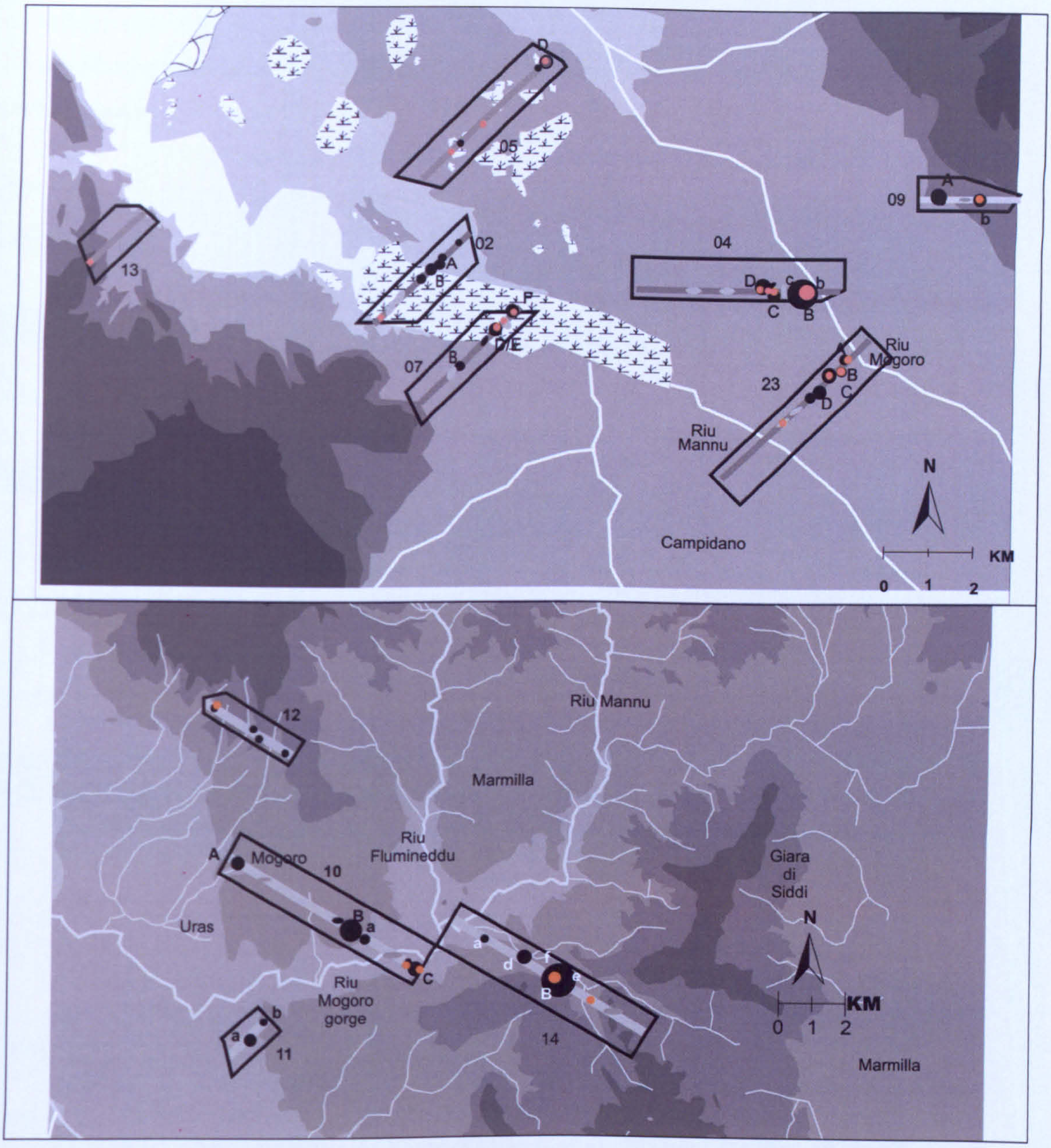


Figure 5.3. Unretouched flake and blade distribution and density in Arborèa and Campidano (above) and Marmilla (below). Quantitative data

Key to map:
Black bullets (graduating in size with increased densities)= flakes
Orange bullets (graduating in size with increased densities)= blades
Light grey ellipses (graduating in size with increased densities)= Composite isolated obsidian flakes
Note: small and capitals letters indicate 'site' assemblages

Unretouched flakes and blades also make up a sizeable portion (44.1%) of the qualitative data, with individual transect data ranging between 31.2% and 67.3% (Table 5.6). Once again, the majority of artefacts lie in the Mògoro valley (parts of transect 04 and 23) and on its terraces (transect 10, 14). A second, much smaller, concentration lies in the Arborèa, in particular more inland (*i.e.* transects 02, 05, parts of 04, 07 and 23), while individual small to medium-sized clusters indicate knapping activity in the Monte Arci and Iglesiente (*i.e.* transects 09, 12, 13 and part of 07; see Figure 5.4: red bullets).

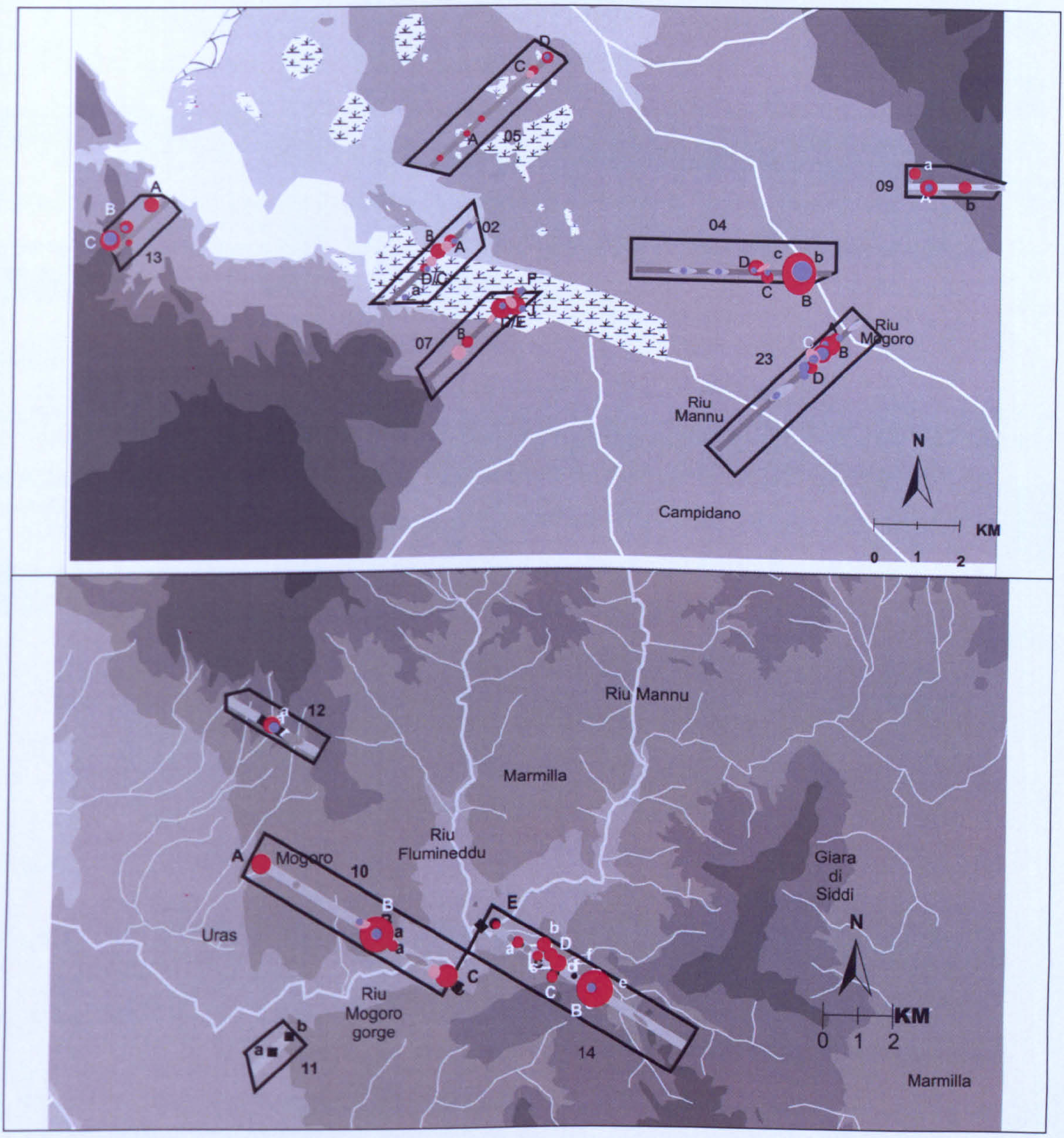


Figure 5.4. Unretouched flake and blade distribution and density in Arborèa and Campidano (above) and Marmilla (below). Qualitative data.

Key to map:
Red bullets (graduating in size with increased densities)= flakes
Purple bullets (graduating in size with increased densities)= blades
Light grey ellipses (graduating in size with increased densities)= Composite isolated flakes
Pink ellipses (graduating in size with increased densities)= Composite flakes in site haloes
Note: small and capitals letters indicate 'site' assemblages

Contrary to figures for cores, qualitative percentages for isolated debitage are similar to quantitative figures. Isolated debitage and debitage in site haloes predominate in the transitional Campidano/Arborèa landscape (transects 02, 07 and 23, and part of 04; see Figure 5.4: grey and pink ellipses). The majority of *Riu Mannu* debitage is comprised of flakes; only 3% of quantitative and 6.6% of qualitative data are obsidian blades (Tables 5.5-5.6). Lithic specialists (following Bordes & Gaussen 1970), usually consider blade indices of 20% as indicative of blade production. When using the blade index for unretouched *Riu Mannu* material (where unretouched blades, complete artefacts and fragments, are a percentage of all debitage) some interesting patterns become visible (Figure 5.5). High blade indices (over 20%) are recorded for four specific locations: 1) site 05-D in the Arborèa, which is a Roman settlement and burial, 2) site 12-a, close to a main primary raw material source area, 3) site 04-B, situated close to the Mògoro river, and 4) in closely associated sites 23-C and 23-D, also situated along the Mògoro river. Thus, a blade component is systematically higher for Campidano assemblages than those for the Marmilla.

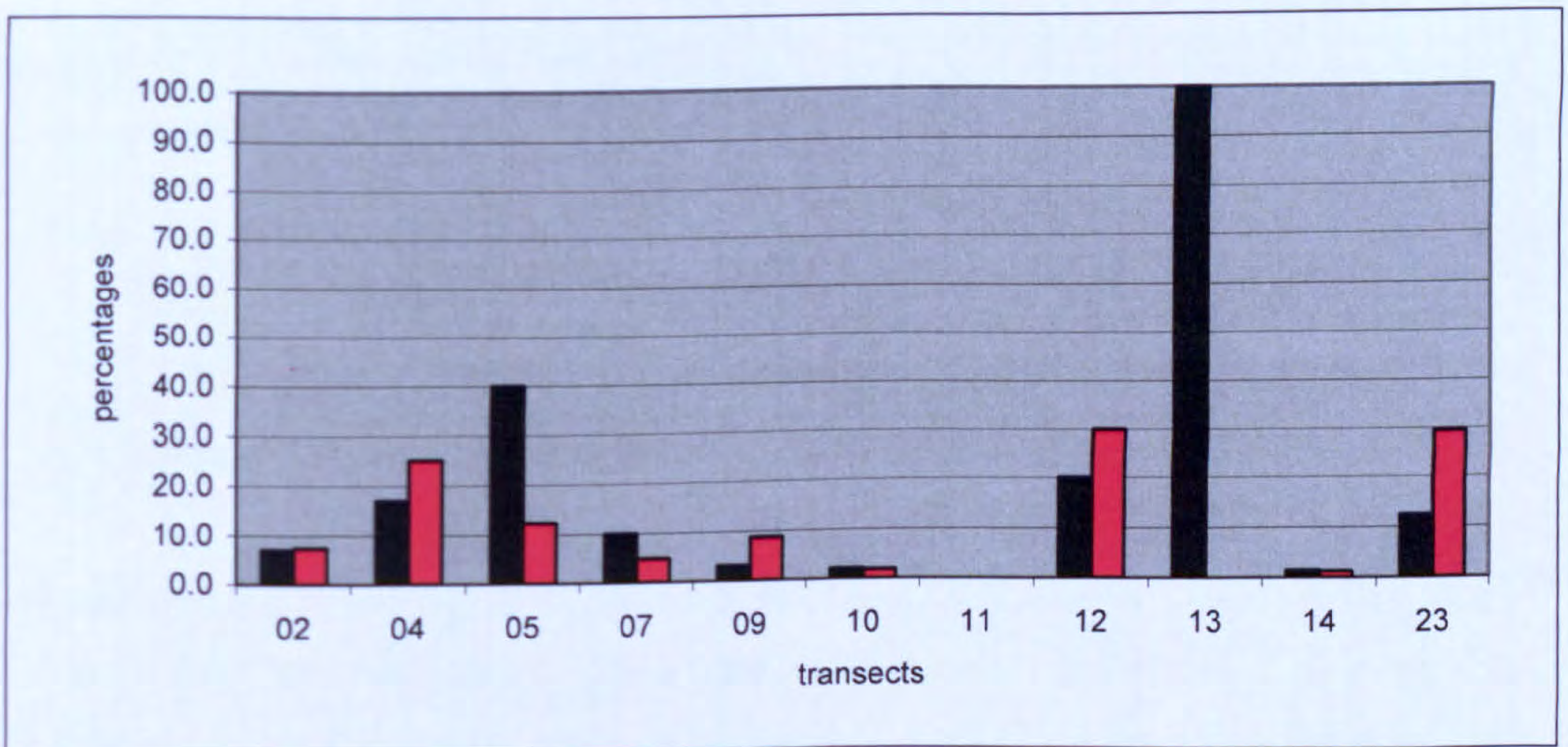


Figure 5.5. Blade indices for all transects.

- Quantitative blade index
- Qualitative blade index

Unretouched flakes and blades were also collected during revisits to 04-B, 07-J and 14-B, and from sites lying outside main grids in transect 02, 09, 13, and 14. Blades were collected in four transects with the majority found in transect 04. Qualitative blades in site assemblages of transect 13 (13-B and especially

13-C) and 07 (07-J) further emphasise the higher blade indices in the Campidano.

	02	04	07	09	13	14
Flakes	-	37	43	8	32	13
Percentage of transect assemblage	-	24.0	60.6	27.6	59.3	23.2
Blades	1	21	2	-	7	-
Percentage of transect assemblage	5.6	13.6	2.8	-	13.0	-

Table 5.7. Number and percentage of flakes in qualitative assemblages from revisits and sites outside main grid areas.

5.1.4. Riu Mannu debris distribution and density patterns

The last category, debris (chunks and shatter), is the largest (44.6%) and most widespread of all *Riu Mannu* quantitative data (Table 5.8). Individual transect assemblage percentages vary, with the highest figures for Marmilla and Campidano transects, in particular those in, or close to, primary and secondary source areas (*i.e.* 07, 09, 10 and 14).

		02	04	05	07	09	10	11	12	14	23	Total
Percentage of total obsidian assemblage		*43.0*	*40.2*	*15.8*	*48.1*	*49.2*	*51.6*	*44.0*	*28.6*	*47.4*	*27.7*	*44.6*
Obsidian	**Sites**	18	268	2	14	50	126	54	-	524	25	1081
	Haloes	2	41	1	34	6	6	-	-	9	5	104
	Isolated	14	14	-	3	4	34	20	2	11	3	105
Total obsidian		34	323	3	51	60	166	74	2	544	33	1290

Table 5.8. Distribution and density of all debris per transect, subdivided into finds context (sites, site haloes and isolated finds). Quantitative data.

The widespread presence of debris in source areas is unsurprising and is likely a reflection of the earlier discussed problematic distinction between raw material, (human-made) artefacts and pseudo or nature-made artefacts (*cf.* Section 3.1.2.3). Distribution patterns show a familiar picture. Once more they are densest along the river Mògoro, with a second smaller concentration in inland Arborèa (Figure 5.7; Appendix 5.4).

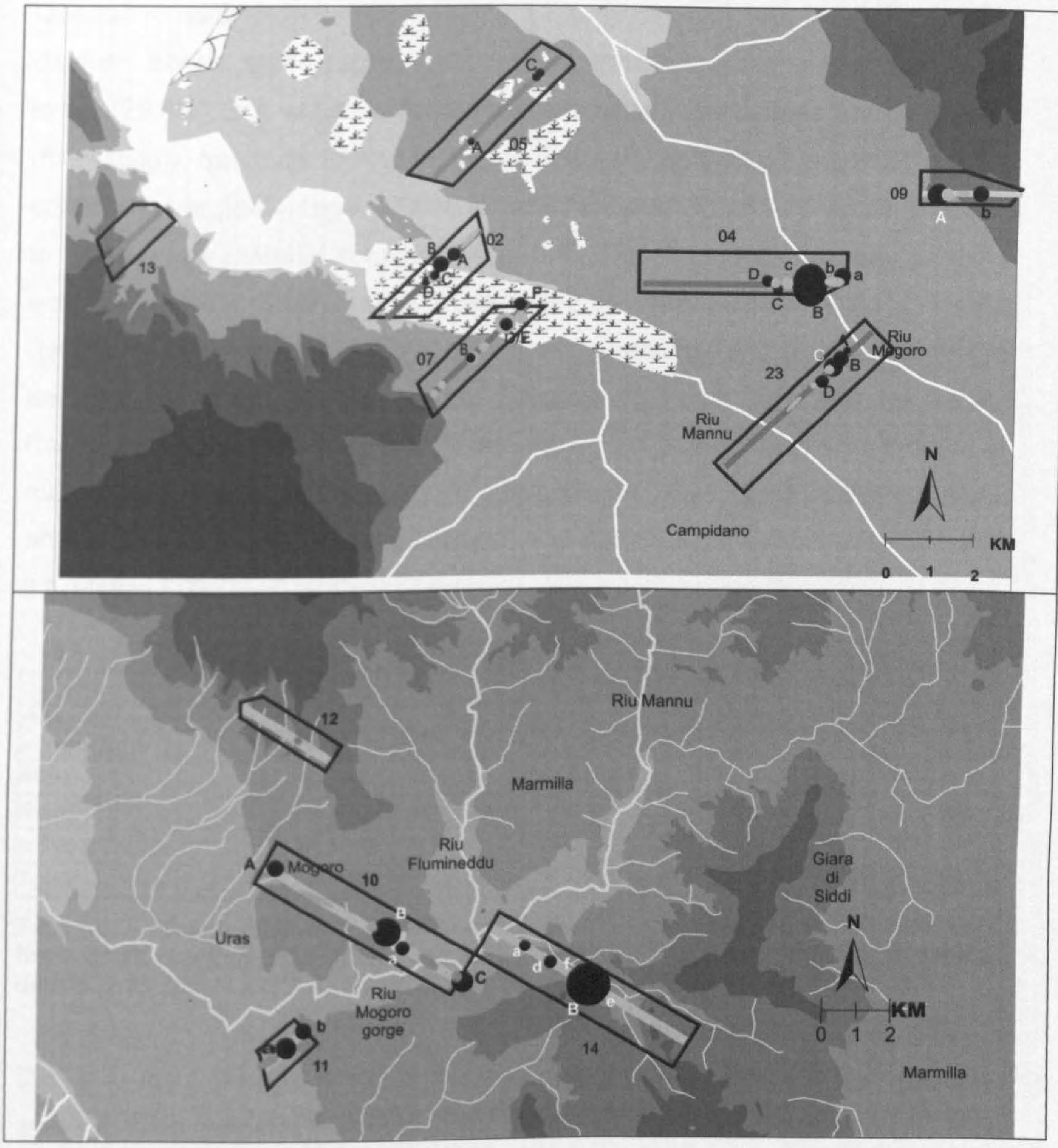


Figure 5.6. Debris (chunks and shatter) distribution and density in Arborèa, Campidano (above) and Marmilla (below). Quantitative data.

Key to map:
Black bullets (graduating in size with increased densities)= Obsidian debris
Light grey bullets and ellipses (graduating in size with increased densities)= Composite obsidian debris in isolation and site haloes
Note: small and capitals letters indicate 'site' assemblages

Within these regions most (83.8%) finds are generally found in site contexts, whereby it should be recalled that these include low-density and/or localised concentrations (*e.g.* transect 11). Finds along the river Mògoro are more strongly clustered, especially in areas 04-B and 14-B, than those more inland in the Campidano and the Arborèa where site haloes and isolated finds are more prevalent (e.g. transects 02, 07, 23; see Table 5.8).

Qualitative data show similar patterns. Unsurprisingly, given the nature of the dataset, debris percentages for individual transect assemblages are much lower (29.8%), but values differ across and within landscapes and transects. Interestingly, transects 02 and 07, which intersect the Campidano and Arborèa, contain higher percentages of debris than transects 09 and 12, which lie close to primary raw material sources (Table 5.9). Distribution and density patterns echo earlier observations. Most artefacts are concentrated in the wider Mògoro river area and inland Arborèa. Modest quantities and low assemblage percentages occur in the coastal Arborèa (transect 05) and Iglesiente/ Campidano pediments (transect 13 and parts of 07). A considerable amount of material (78.5%) is associated with site contexts, where just as before, more artefacts were found in isolation and in site haloes from transects 02, 07 and 23 (Figure 5.7).

	02#	04*	05	07#	09#	10	11	12	13#	14#	23	Total
Percentage of transect assemblage	*50.7*	*21.7*	*12.5*	*38.6*	*30.3*	*12.3*	*50.0*	*39.6*	*25.0*	*28.7*	*17.9*	*29.8*
Sites	58	128	1	24	30	146	-	15	-	122	16	540
Haloes	12	18	2	32	-	28	-	-	-	-	6	98
Isolated	5	19	-	-	3	7	2	4	1	3	6	50
Total	75	165	3	56	33	181	2	19	1	125	28	688

Table 5.9. Distribution and density of all debris per transect, subdivided into finds context (sites, site haloes and isolated finds). Qualitative data. * Excluding debris from revisits. # Excluding debris from sites outside main grid areas.

Debris is also present, albeit in low percentages, in collections from revisits and the sites outside the main grids (Table 5.10). The high percentage in transect 09 is from a specific location (09-a), which has been interpreted as a secondary source area.

	04	07	09	13	14	Total
Debris	29	10	14	8	12	73
Percentage transect assemblage	18.8	14.1	48.3	14.8	21.4	-
Total	33	10	14	8	12	77

Table 5.10. Number and percentage of debris in qualitative assemblages from revisits and sites outside main grid areas.

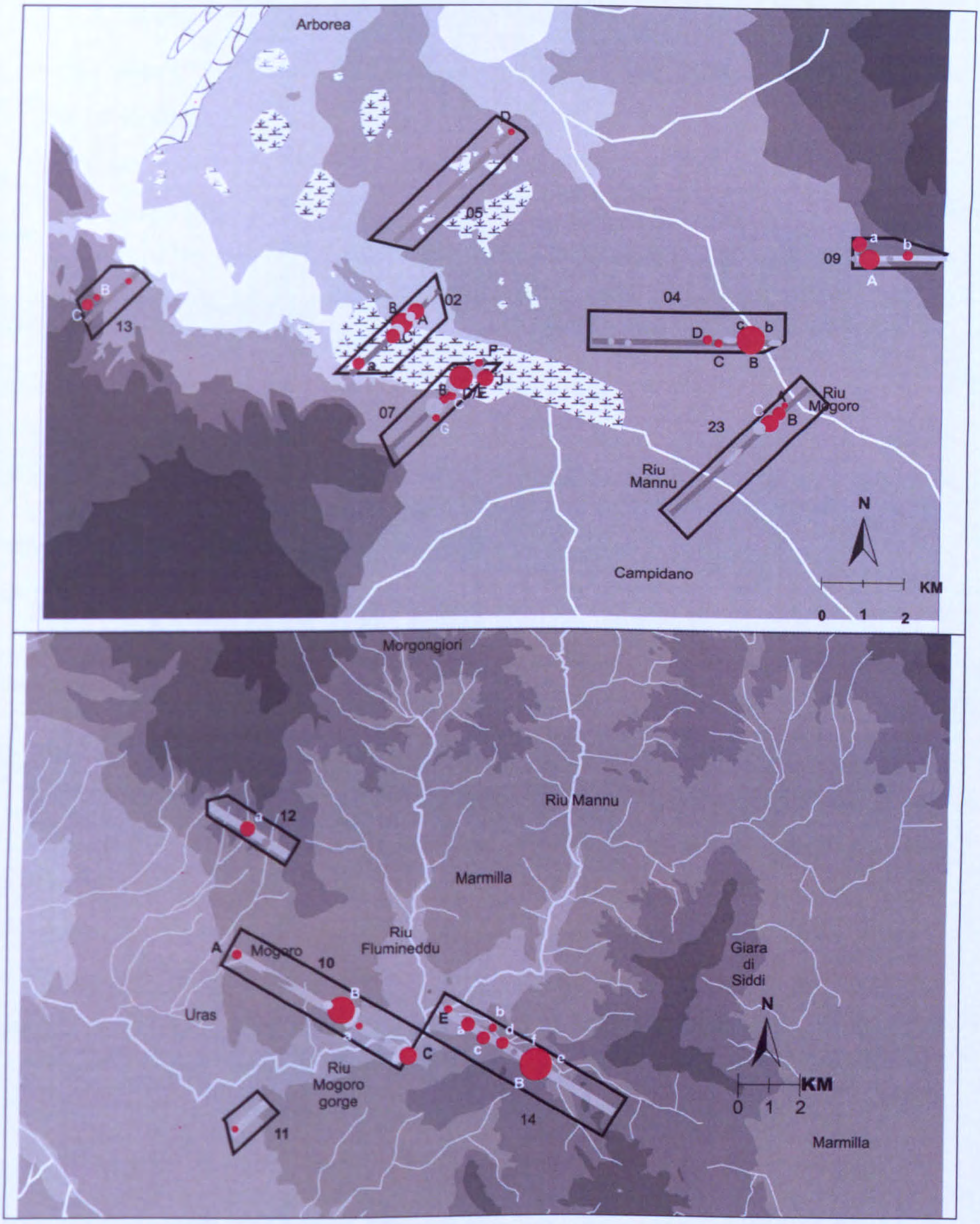


Figure 5.7 Debris (chunks and shatter) distribution and density in Arborèa and Campidano (above) and Marmilla (below). Qualitative data.

Key to map:
Red bullets (graduating in size with increased densities)= Obsidian debris
Grey bullets and ellipses (graduating in size with increased densities)= Composite obsidian debris in isolation and site haloes
Note: small and capitals letters indicate 'site' assemblages

5.1.5. Discussion and conclusion: primary flaking locations

In summary, distribution and density patterns are decidedly uneven. Most finds are concentrated in three areas: 1) in the wider area along the river Mògoro in the Campidano plain, 2) on Mògoro terraces in the Marmilla, and 3) in the inland Arborèa-Campidano transition. Within these areas further clustering can be seen. The densest area in the Mògoro-Campidano is a special interest area: site 04-B and its surrounding smaller clusters 04-b, 04-c. In the Mògoro-Marmilla three clusters can be discerned: sites 10-B, 10-C special interest area with site 14-B and the nearby localised clusters 14-e and 14-f. Likewise, on inland Arborèa-Campidano terrain most finds are concentrated in special interest areas, which consist of two or more closely associated sites in transects 02 (A-D) and 07 (D-J).

Distribution patterns for primary flaking artefact classes show some interesting differences. Firstly, cores are abundant in secondary raw material source zones with strong clustering in two specific areas, 04-B and 14-B, and a high percentage, nearly 25%, of isolated cores. They are, however, rarely found closer to primary source areas even when including qualitative data. Secondly, there is a noteworthy difference between the distribution of cores and core rejuvenation flakes. Not only are isolated rejuvenation flakes scarce, but the admittedly small cluster of rejuvenation flakes at site 12-a hint at spatially distinct reduction phases. Thus the high percentage of isolated cores, the highest of all primary technology categories, and the suggestion of spatially distinct reduction phases intimates a (longer and) more mobile life history for cores. Distribution patterns for debitage and debris offer some further support for this idea, as these do not always correspond to those for cores and core rejuvenation. Firstly, debitage and debris are more strongly clustered than cores, with only 9.4% and 8.1% found in isolation, although less so than core rejuvenation flakes. Secondly, their clusters are more widespread, often occurring where cores do not (*e.g.* 04-D, 05-D, 09-A, 10-C; transects 11-13, 23; see Appendices 5.1-5.4). Moreover, the close association of cores and core rejuvenation material in the Campidano secondary source zone (*i.e.* the wider Mògoro region across Campidano and Marmilla landscapes) suggests that different procurement and production strategies exist for primary and secondary source areas (see Section 5.5. below; Section 7.1). It is also worthwhile to highlight blade distribution and indices. In correspondence with other evidence, most blade material is located in and around 04-B, but several smaller clusters exist in unexpected locations (*e.g.* 05-D, 23-A-C, and including qualitative data; 13-C and 12-a). In fact, blades are strongly prevalent in the Campidano and Arborèa with very few in the Marmilla (Figure 5.5; Table 5.11).

	Arborèa			Campidano			Marmilla			Total
	N	*Region %*	*Class %*	*N*	*Region %*	*Class %*	*N*	*Region %*	*Class %*	
Cores	6	2.8	13.3	13	1.6	28.9	26	1.9	57.8	**45**
Core rejuvenation	4	1.9	12.9	8	1.0	25.8	19	1.4	61.3	**31**
Flakes	97	44.9	10.4	332	40.1	35.5	507	37.6	54.2	**936**
Blades	21	9.7	23.9	58	7.0	65.9	9	0.7	10.2	**88**
Debris	88	40.7	6.8	416	50.3	32.2	786	58.4	60.9	**1290**
Total	**216**	**100**		**827**	**100**		**1347**	**100**		**2390**

Table 5.11. Regional distribution comparisons for all primary technology.

5.2. Primary flaking practice: strategies, traditions and variations

Analyses have shown the existence of two main primary flaking technologies: flake and blade technology. Core data have moreover demonstrated four main types of removals: flakes, blades, probable flakes and mixed flake/blades. The first three types were also recognised as individual artefact classes. Despite this apparent uniformity, detailed analyses of core biographies and dorsal scar patterning on debitage and tools have revealed 17 different flaking strategies. Platform, bipolar and ad hoc knapping are carried out in single, double and multiple stages (Tables 5.12-5.13). Local and regional traditions and variations have been distinguished not only in knapping strategies but also in skill, source use, and aesthetic preferences.

5.2.1. Knapping strategies: blade and flake core biographies and dorsal scar patterns

Core biography analyses show that seven different knapping strategies existed for blade production (Table 5.12; Figure 5.8). Strategies 1 and 2, single-stage platform reduction for blade and mixed flake/blades are the preferred methods of reduction, and occur on 23 of 27 cores. Note that this includes single-stage platform flaking stages on double and multi-stage cores that are partially covered by other types of removals. The third and fourth strategies also consist of platform knapping, but in two successive stages. A distinction is made between initial (strategy 3) and final phases of reduction (strategy 4). The three remaining knapping strategies are non-platform reductions: strategy 5 is single-stage bipolar knapping, strategy 6 is single-stage ad hoc knapped mixed flake/blades, and the last is double-stage ad hoc blade removal (Table 5.12).

Thus, platform reduction is by far most common (83.8%), with only a small percentage of bipolar and ad hoc knapped blades or mixed flake/blades. Single-stage removal predominates (74.2%) amongst platform cores, and another 12.9% includes single blade removal stage which covers, or is covered by, other, perhaps also later, removals (for a discussion on the implications of re-use of cores, see below). Double-stage removal, either as initial or final stages of flaking, is rare (9.7%).

Knapping strategies	**Number**		
Single-stage cores (n=24)			
Platform (1)	13		
Platform mixed flake/blade (2)	9		
Bipolar (5)	2		
Knapping strategies	**Stage**	**N**	**Type of removals remaining stages**
Double-stage cores (n=7)			
Platform mixed flake/blade (2)	1	3	Stage 2: Bipolar flake (3*)
Platform (3)	1-2	1	-
Bipolar (5)	1	1	Stage 2: Bipolar flake (3*)
Ad hoc mixed flake/blade (6)	1	1	Stage 2: Bipolar flake (3*)
Ad hoc (7)	1-2	1	-
Multi-stage cores (n=6)			
Platform (1)	2	1	Stage 1: Platform possible flake (2*) Stage 3: Platform mixed flake/blade (2)
Platform (1)	5	1	Stage 1: Platform possible flake (2*) Stage 2-4: Platform flake (9*) Stage 6: Ad hoc possible flake (7*)
Platform (1)	3	1	Stage 1, 6: Ad hoc possible flake (7*) Stage 2, 4-5: Platform possible flake (2*, 10*)
Platform (1)	3, 5	1	Stage 1: Platform flake (1*) Stage 2: Platform possible flake (2*) Stage 4, 6-7: Bipolar flake (3*)
Platform (3)	1-2	1	Stage 3: Bipolar flake (3*)
Platform (4)	2-3	1	Stage 1: Platform flake (1*)

Table 5.12. Blade removal on single-stage cores (n= 24), showing flaking strategies, number of cores (first four rows), and double-stage (n= 7) and multi-stage cores (n= 6), showing flaking strategies, stage numbers, and remaining types of removals with their corresponding stage numbers.

Key to table:
Numbers in parentheses in the first column= the number of blade flaking strategies,
Numbers in parenthesis in the third column with an asterix * = flake knapping strategies numbers, see also Table 5.13.

Distribution and density patterns are uneven. Four interesting local and regional patterns can be seen (Figure 5.8; Appendix 5.5):

- Platform blade reduction on single, double, and multi-stage platform cores is most common and widely dispersed across the Campidano and the Marmilla.
- Most cores were found on the terraces along the river Mògoro in transects 04, 10, 14 and 23, with a high concentration at site 04-B.

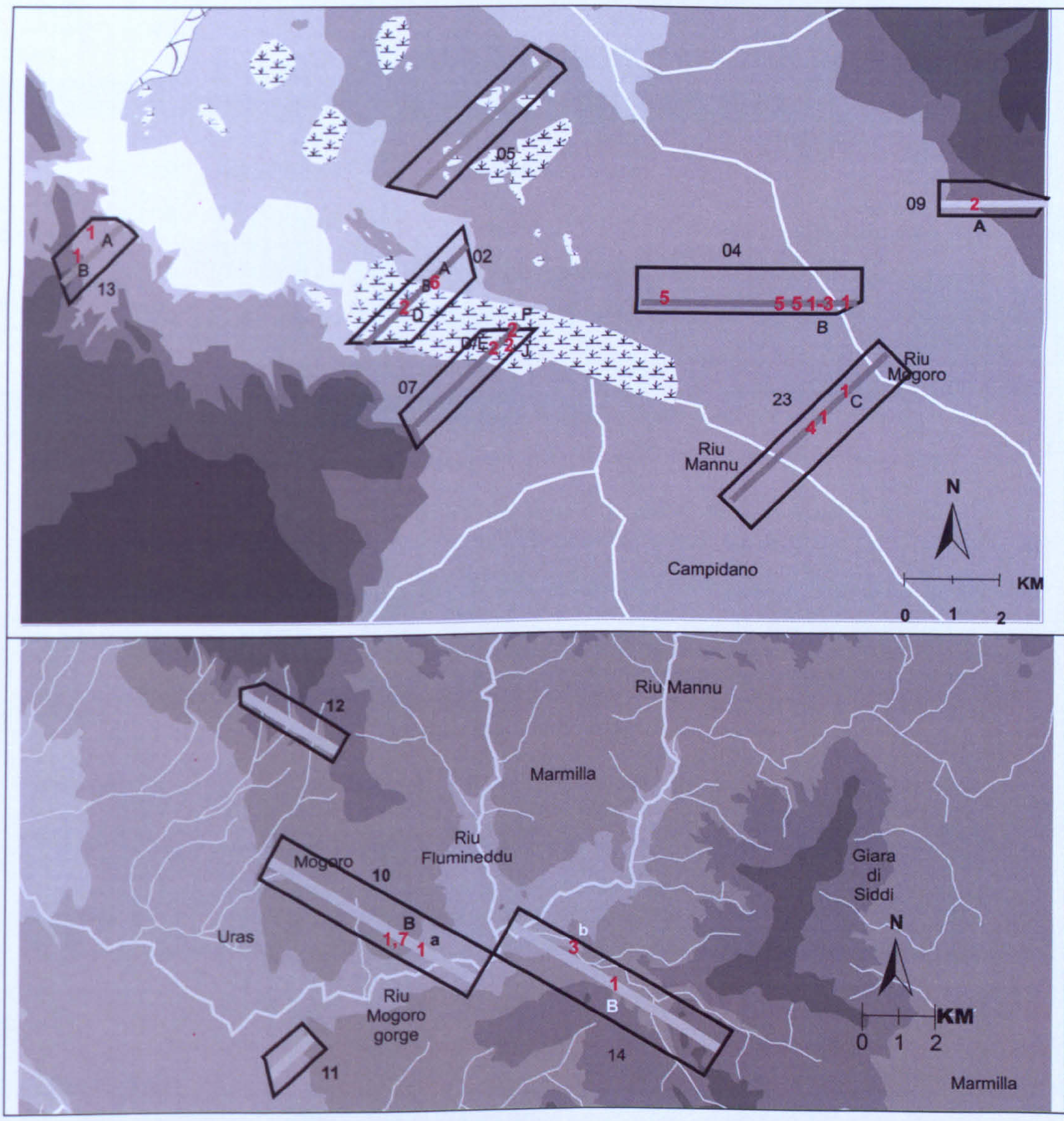


Figure 5.8. Spatial distribution of blade knapping strategies in the Arborèa and Campidano (top) and Marmilla (bottom) derived from core biographies. Letters indicate site assemblage, and numbers correspond to strategy numbers in table 5.12.

- In the Arborèa, blade production is rare. Cores are concentrated in transect 02 around *SIA* 02-A-D, and only show mixed flake blade removal. Mixed flakes/blades removal in single stages from platform cores is the preferred knapping strategy at *SIA* 07-D-J in transitional Arborèa/Campidano transect 07.
- Bipolar blade removal is restricted to transect 04. All are isolated finds.

Ten knapping strategies with flake production have been distinguished (Table 5.13):

1. Single-stage platform flake removal
2. Single-stage platform possible flake removal
3. Single-stage bipolar flake removal
4. Single-stage ad hoc flake removal
5. Double-stage, successive, platform flake removal
6. Double-stage, successive, bipolar flake removal
7. Single-stage ad hoc possible flake removal
8. Three-stage, successive ad hoc flake removal
9. Three-stage, successive, platform flake removal
10. Double-stage, successive, platform possible flake removal

Knapping strategies	**Number**		
Single-stage cores (n=49)			
Platform (1)	8		
Platform possible flake (2)	1		
Bipolar (3)	36		
Ad hoc flake (4)	4		
Knapping strategies	**Stage**	**N**	**Type of removals other stages***
Double-stage cores (n=25)			
Platform (5)	1-2	2	-
Bipolar (6)	1-2	18	-
Platform (1)	1	3	Stage 2: bipolar flake (3)
Bipolar (3)	1	1	Stage 2: platform flake (1)
Platform, possible flake (4)	1	1	Stage 2: bipolar flake (3)
Multi-stage cores (n=4)			
Platform flake (1)	1	1	Stage 2-3: bipolar flake (6)
Platform (1)	1	1	Stage 2: ad hoc flake (4) Stage 3: ad hoc possible flake (7)
Platform (5)	1-2	1	Stage 3: ad hoc flake (4)
Ad hoc flake (4, 8)	1, 3-5	1	Stage 2: ad hoc possible flake (7) Stage 6-7: platform flake (5)

Table 5.13. Flake removal on single-stage cores, showing flaking strategies, number of cores and finds context (first four rows), and double-stage and multi-stage cores, showing flaking strategies, stage numbers, and remaining types of removals with their corresponding stage numbers.

Key to table: * Excluding cores with flakes and blade stages, see table 5.12. Numbers in parentheses indicate the number of flaking stages

Again there are no distinctions between stand-alone single-stage flake removals and those on double and multi-stage cores that are partially covered by other, possibly later, stages. With only two cores showing successive double-stage flake removal, I have refrained from separating these further into initial or final core stages. Single and double-stage bipolar flake removal are clearly the most frequent primary flaking techniques (72.2%). Platform removal, flake or possible flake, is the second largest group of knapping strategies, with single-stage removal predominating. Ad hoc flaking is least common and occurs mostly on double or multi-stage cores. Interestingly, both bipolar and ad hoc flake removal also predominate on two thirds of double and multi-stage cores with blade production. In fact, flaking strategies 9 and 10 are exclusively found on these cores (Table 5.12).

Flake production is widespread and occurs across all three landscapes, but density and distribution patterns are uneven, and four trends are recognised (Figure 5.9; Appendix 5.5):

- Most finds are concentrated in and along the Mògoro gorge, in particular in *SIA* 04-B, site 10-B, *SIA* 14-B, and transect 23.
- All multi-stage cores are located in or near primary and secondary raw material source areas in Marmilla transects (10, 14) and the Campidano (04. 09, 23).
- Virtually all cores in the Arborèa show single and double-stage bipolar flake removal, while in nearby transitional transect 07, single stage platform reduction occurs alongside single-stage bipolar reduction.
- Single-stage bipolar or single-stage platform cores are found in isolation more frequently than their blade equivalents.

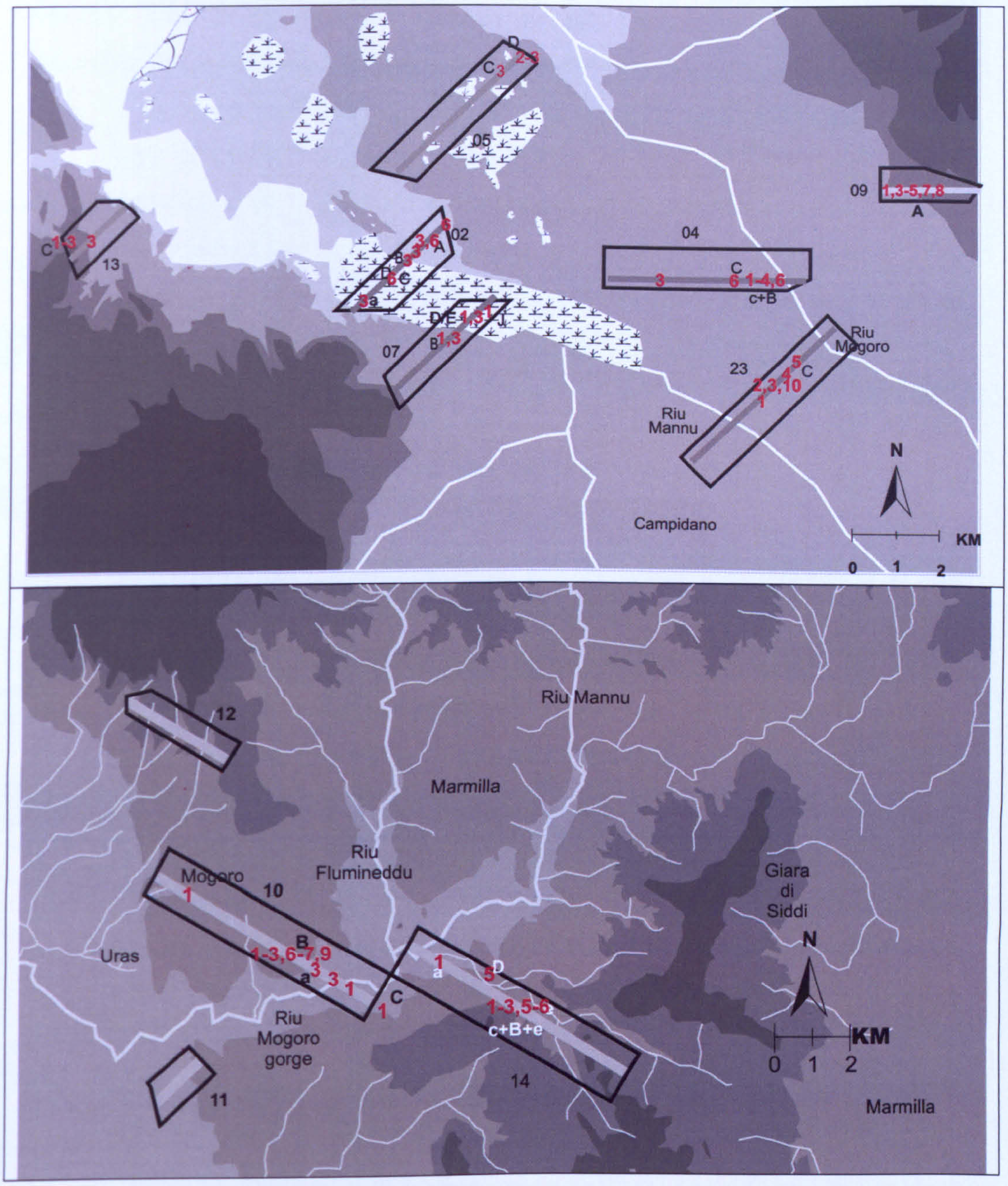


Figure 5.9. Spatial distribution of flaking strategies with flake production in the Arborèa and Campidano (top) and Marmilla (bottom) derived from core biographies. Letters indicate site assemblage, and numbers correspond to strategy numbers in tables 5.13 and 14.

5.2.1.1. Reworked cores

Despite the prevalence of single-stage cores, a sizeable portion of cores (37.1%) has been reworked. Three types of changes occur: 1) 32.6% demonstrate a change in type of removals (*e.g.* from flake to blade), 2), another 32.6% demonstrate change in flaking technique (*e.g.* from platform to bipolar), and 3) for 51.1% a change in orientation (angle of removal) is recorded. Four interesting trends may be seen:

- Double- or multi-stage cores with just blade production are rare (4.7%), and changes from mixed flake/blade to flake production are more common than those from blade to flake or flake to blade.
- On multi-stage cores with blade production the situation is more complex but some general observations may be made: 1) each individual core seems to have its own pattern, 2) changes from flake to blade, and flake to blade to flake, are most common as blade production is a first reduction stage only once, 3) possible flake removal from platform and ad hoc reduction is common and it has proven difficult to distinguish these further into initial core preparation, obscured (previously intentional) flake production, and novice knapping (see also Sections 5.2.2 and 5.4.3.3)
- Changes in flaking strategy occur more often on double and multi-stage flake than blade cores. A shift from platform to bipolar reduction is most frequent on double-stage flake cores, while on multi-stage cores, changes from platform to ad hoc and/or bipolar occur frequently.
- Changes in orientation are very common (80%), with a recorded angle of orientation for 76.7% of the double and multi-stage cores (Table 5.14). Three trends may be seen: 1) it is limited in blade production, reiterating the predominance of single-stage, single platform reduction, 2) 45 and 90-degree turns are most common, irrespective of flaking strategies, but 3) it is particularly consistent among bipolar flake reduction at a 45-degree, and to a lesser extent 90-degree, angle from the previous flaking stage.

Thus, single-stage cores predominate in both blade and flake technology (64.9% and 62%), and flakes predominate on double-and multi-stage cores. A clear division in flaking strategies exists. Bipolar and ad hoc flaking make up the bulk of flake cores (81.6%), while platform reduction is most frequent (91.7%) in blade technology. Flake production clearly outweighs blade production. This predominance, however, pertains to the number of core stages, and may not necessarily be reflected in cores/stages to previous removals ratios (see Section 5.4.2.1).

Type of core reduction	Turns	Total
Double-stage ad hoc blade production	90 degree angle	1
Multi-stage platform blade production	45 degree angle	2
Multi-stage platform mixed flake/blade production	45 degree angle	1
Double-stage bipolar flake production	30 degree continuous turn	1
	45 degree angle	15
	70 degree angle	1
	90 degree angle	4
Multi-stage bipolar flake production	45 degree angle	1
Double-stage platform flake production	130 degree angle	1
Multi-stage platform flake production	45 degree angle	2
	90 degree angle	2
Multi-stage platform possible flake production	45 degree angle	1
Multi-stage ad hoc possible flake production	45 degree angle	1
Total		33

Table 5.14. Recorded angles of orientation for double-stage and multi-stage cores.

5.2.1.2. Dorsal scar patterning

Dorsal scar patterning on unretouched and retouched material mirror trends in core data and show that (Table 5.15):

- Unidirectional removal clearly predominates for flake and blade removal.
- Multi-directional blade removals are rare (0.9%), but when present they occur virtually exclusively on unretouched material.
- A higher proportion of flakes show changes in flaking direction, with 18.6% for two-directional and 5% for multi-directional removal.
- Dorsal flake scars mirror the 45-degree turn in flaking orientation recorded for flake cores.

Two main points of contrast may be distinguished:

- Some blade scars (7.2%) show two-directional removal, with reduction at opposite angles (*i.e.* 90-degree turn) of the core occurring slightly more often than a 45-degree turn (*see* Figure 3.15 for corresponding patterns).
- There is a discrepancy between flakes and flake core data. The former mostly indicate unidirectional platform removal while bipolar reduction clearly predominates in the latter category (see below for discussion).

	Blade production				Flake production			
	MNI	*FRG*	*R*	*PR*	*MNI*	*FRG*	*R*	*PR*
UNIDIRECTIONAL REMOVAL								
Cortex	10	3	-	1	201	33	13	16
Plain	2	-	-	-	67	25	-	-
Simple	111	66	33	36	627	211	36	80
Convergent	30	5	13	12	137	30	14	31
TWO-DIRECTIONAL REMOVAL								
Side	1	1	1	1	95	35	5	14
Opposed	2	1	-	-	40	7	1	7
Simple & side	3	2	-	-	66	26	6	8
Simple and opposed	6	3	-	1	40	12	1	8
MULTI-DIRECTIONAL REMOVAL								
Radial	2	-	-	-	63	21	3	6
Opposed and side	-	1	-	-	4	1	-	2
Total	167	82	47	51	1340	401	79	172

Table 5.15. *Riu Mannu* flaking strategies deduced from dorsal scar patterning. Quantitative and qualitative obsidian all transects (n=2339).

Key to table:
Rows= reduction strategies
Columns= how many blades, flakes, and possible blades/flakes were produced.
MNI = minimum number of individuals (complete and proximal pieces only)
FRG= fragments (excluding proximal pieces)
R= retouch. PR= probable retouch.

5.2.2.1 Discussion: *chaîne opératoires*: tradition, variation and isolated strategies

Eight *chaîne opératoires* make up 81.7% of the 17 observed knapping strategies and may be subdivided into five traditions (defined as one or a consistent combination of more strategies occurring on 5 or more cores) and three variations (idem but less frequently *e.g.* on 3-5 cores). A fifth (18.3%) of the *Riu Mannu* core dataset consists of infrequent, or a unique combination of knapping strategies (Table 5.16).

The two most frequent *chaîne opératoires* on cores are single and double stage flake production through bipolar knapping. The following three are all single-stage platform reduction for blades, mixed flake/blades and flakes, which are, as noted previously, also the most common *chaîne opératoires* reconstructed for debitage and retouched pieces. Three less frequent *chaîne opératoires* are: 1) single-stage ad hoc flake removal, 2) double-stage reduction with platform flake removal followed by bipolar flake reduction, and 3) double-stage reduction with mixed flake/blade knapping followed by platform flake reduction.

Chaîne opératoire	N cores
Single-stage bipolar flake reduction	36
Double-stage bipolar flake reduction	18
Single-stage platform blade reduction	13
Single-stage platform mixed flake/blade reduction	9
Single-stage platform flake reduction	8
Single-stage ad hoc flake knapping	4
Double–stage: platform mixed flake/blade reduction & bipolar flake reduction	3
Double-stage: platform flake reduction & bipolar flake reduction	3
Single-stage bipolar blade removal	2
Double-stage: platform flake reduction	2
Single-stage platform possible flake removal	1
Double-stage: platform blade reduction	1
Double-stage: bipolar blade and bipolar flake removal	1
Double-stage: ad hoc mixed flake/blade reduction & bipolar flake reduction	1
Double-stage: ad hoc blade knapping	1
Double-stage: bipolar flake removal & platform flake removal	1
Double-stage: platform possible flake reduction & bipolar flake removal	1
Multi-stage platform reduction: possible flake & blade & mixed flake/blade	1
Multi-stage: platform blade (2 stages) & bipolar flake removal	1
Multi-stage platform reduction: blade & flake (2 stages)	1
Multi-stage: platform flake & bipolar flake (2 stages)	1
Multi-stage: platform flake (2 stages) & ad hoc flake removals	1
Multi-stage: ad hoc flake removal (stage 1, 3-5), ad hoc possible flake removal (stage 2), platform flake removal (stage 6-7)	1
Multi-stage: platform flake reduction, ad hoc flake removal & ad hoc possible flake removal	1
Multi-stage: platform possible flake, platform flake (3 stages), platform blade, & ad hoc possible flake removal	1
Multi-stage: platform flake, platform possible flake, platform blade, bipolar flake, platform blade, bipolar flake (2 stages)	1
Multi-stage: ad hoc possible flake, platform possible flake, platform blade, platform possible flake (2 stages)	1

Table 5.16. All *Riu Mannu chaîne opératoires* based on core data (n=115). Knapping stages on double and multi-stage cores are represented in the order of knapping.

Among the unique (combinations of) knapping strategies three trends may be recognised that merit emphasis:

- Most double and multi-stage cores share similar characteristics such as one or more (successive or alternating) platform flake and/or blade removals followed or preceded by one or more (successive or alternating) stages of bipolar flake removal and/or ad hoc flaking. Interestingly, most multi-stage cores are larger than single-stage cores, and as a result, novice knapping has been suggested for a small portion (see Section 5.4.3.3 below). Most, however, highlight that discrete choices in raw material shapes and sizes and knapping strategies existed.
- There is a high presence of ad hoc flaking and possible (or probable) flake removal on multi-stage cores. The last group has been interpreted

as a combination of earlier, now obscured, traces of flake/blade production and opening strategies and/or core preparation/rejuvenation. It has proven problematic to distinguish between the two, which appears to be reflected in the wider length/width ratios for unretouched flakes (Figure 5.11). Ad hoc knapping on multi-stage cores is infrequent and/or multidirectional but it has sometimes also been interpreted as novice knapping. Additionally, a small portion of the debris, especially chunks, also show traces of ad hoc knapping (see below).

- Several single and double-stage cores suggest 'blade' removal where the general shape of scar negatives resembles those of blades (*e.g.* long and narrow), but because of their unusual means of reduction, ad hoc and bipolar knapping instead of platform reduction, these are blade-like flakes, rather than 'proper' blades.

Until now I have discussed flake and blade production as if they were completely separate technologies, only occasionally hinting that the boundaries are not always so clear (Section 5.1.3). Five other lines of evidence suggest that the *Riu Mannu* blade data is a so-called 'informal', or blade-like flake, rather than prismatic blade industry:

- There are no crested blades.
- There is considerable overlap between the length/width measurements and ratios of pieces classified as flakes or blades, and there is also a substantial degree of consistency in and between their range and average length/width ratios (Figures 5.10 – 5.11; also Section 6.3.1).
- The high percentage of cores with mixed flake/blade removals.
- The presence of 'blades' as a result of ad hoc and/or bipolar knapping.
- Similar types of percussion are suggested by most of the flake and blade pieces (See 5.2.2 below).

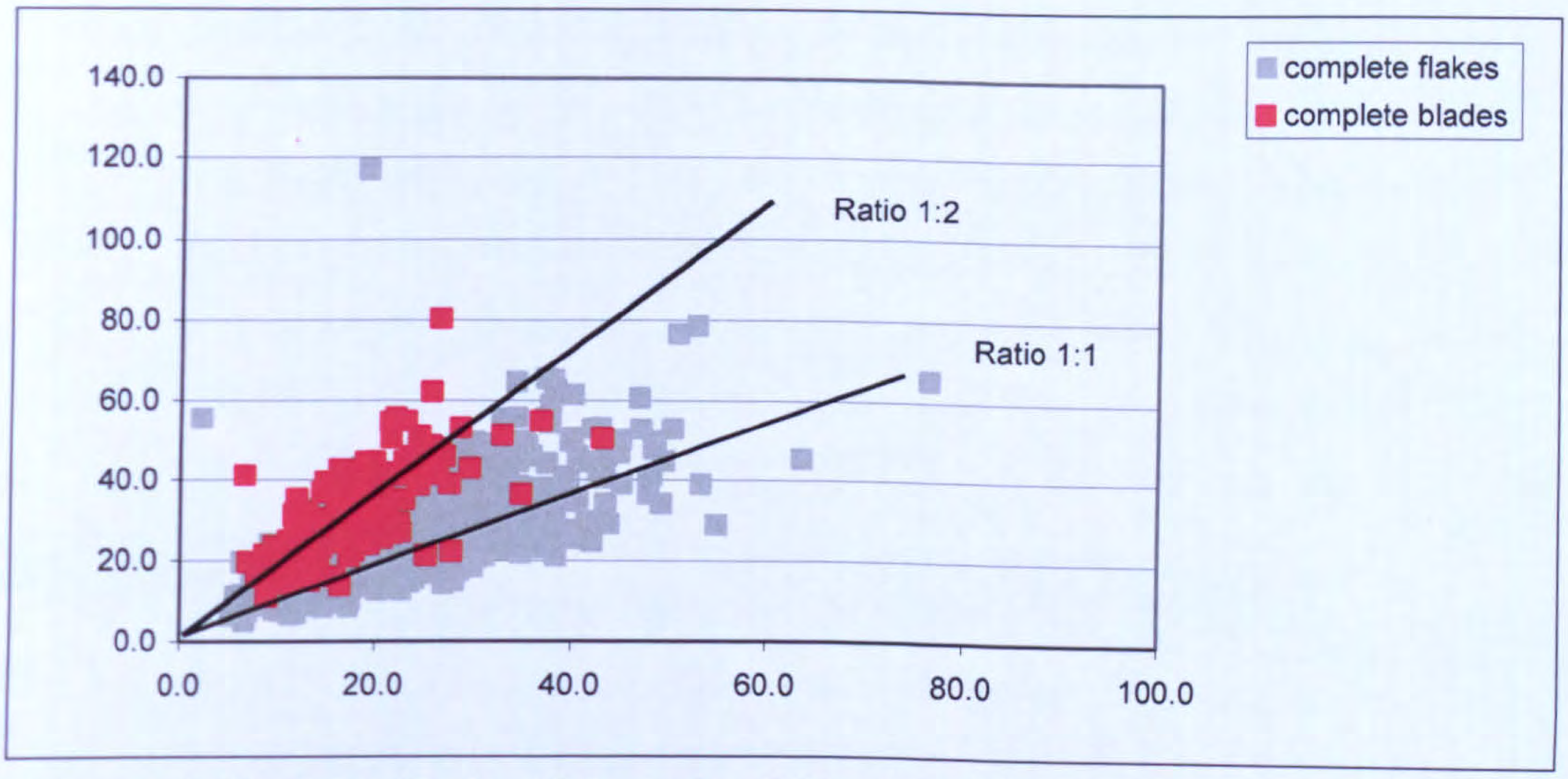


Figure 5.10. Length (y-axis) and width (x-axis) measurements (in mm) comparisons for complete unretouched flakes (in grey; n= 1113) and blades (in red; n=142).

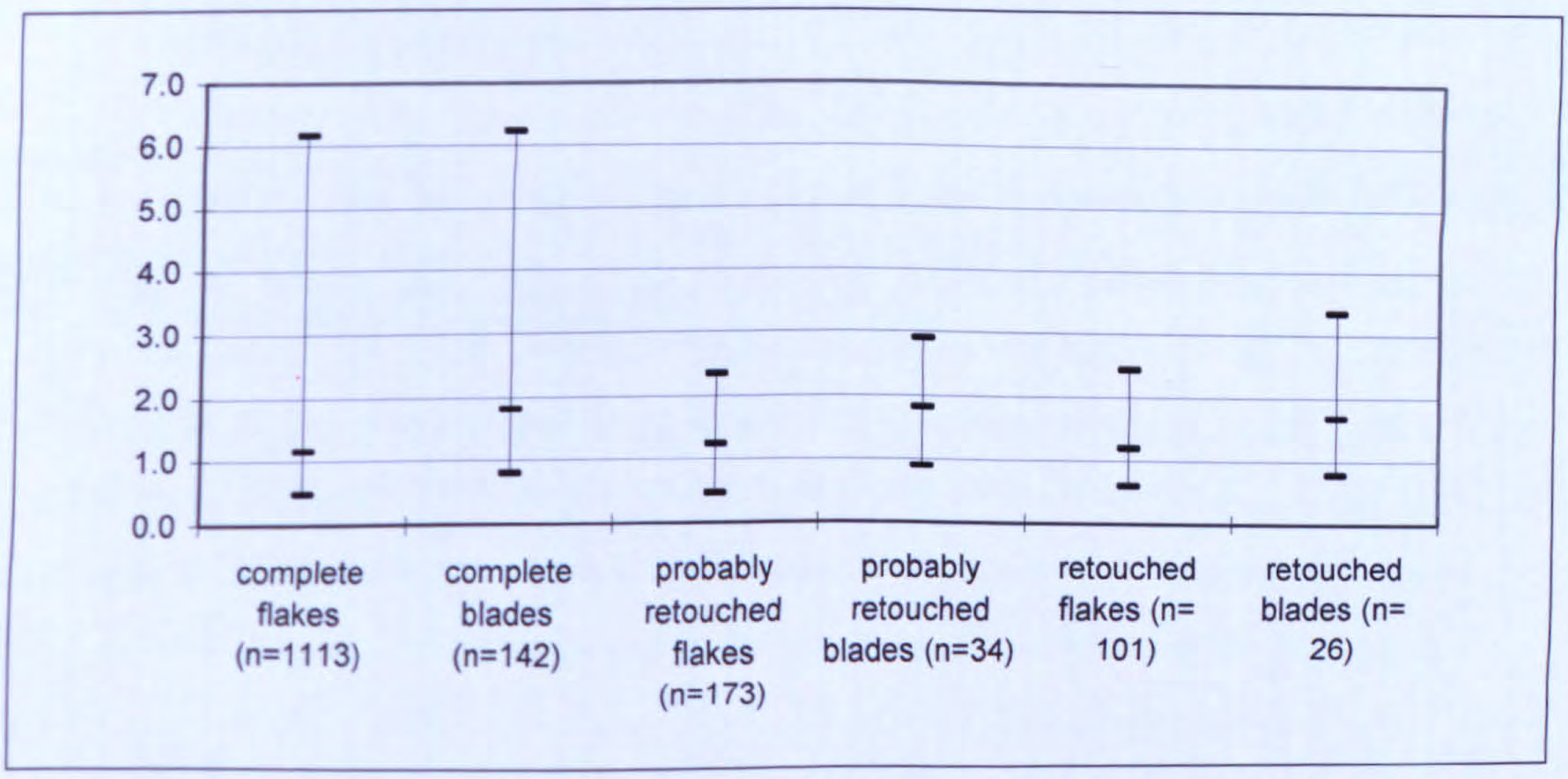


Figure 5.11. Maximum, average and minimum length/width ratios for all unretouched complete blades and flakes, retouched, and probably retouched pieces.

Exploration of the spatial distribution of the three 'types' of *chaîne opératoires* (traditions, variations and unique strategies) shows five interesting regional and local patterns (Appendix 5.6):

- Traditions are very strong (80%) and consistent in the Arborèa with only two unique knapping strategies. Traditions *on cores* consist of bipolar flake production and mixed flake/blade platform reduction, which also are the two common elements of the unique knapping strategies.

- Traditions are also very strong (79.4%) in the Marmilla, although more variation exists in the tradition types (*e.g.* single-stage platform flake and blade reduction and single and double-stage bipolar flake removal). Similarly, more diversity exists among the unique knapping strategies.
- The Campidano assemblages are most diverse, with less strong traditions and more variation and unique knapping strategies. Lower percentages notwithstanding, traditions are diverse and also contain the bulk of blade production.
- The bulk of the unique knapping strategies is found in the transects (04, 10, 14, 23) in the secondary raw material source zone of the wider Mògoro River and Gorge area.
- Variations in *chaîne opératoires* are very localised, one cluster (ad hoc flake production) is found in *S/A* 04, while the second (platform mixed flake/blade reduction followed by bipolar flake removal) is concentrated in transect 07

In summary, core biographies and dorsal scar patterning demonstrate that single-stage platform reduction is by far the most preferred *chaîne opératoire* irrespective of the type of technology. Single and double-stage bipolar flake reduction is the second group of important *chaîne opératoires.* Variations on *chaîne opératoires* are very localised in transects 04 and 07, while unique knapping strategies are more widespread. Both however, are concentrated in the secondary source zone of the wider Mògoro River and Gorge area.

5.2.2. Percussion and hammerstones

Exploration of percussors and types of percussion also provides information on flaking strategies. Unfortunately, information can only be deduced indirectly for the studied datasets, since hammerstones have not been found by the *Riu Mannu* Project. This might partially be the result of non-recognition by field teams since hammerstones can strongly resemble natural raw material nodules, although they are usually more battered. It should not be ruled out, however, that some of the cores contain signs of use as hammers, or that the debris category contain fragmented hammerstones. Unfortunately, at the time of recording I was not aware of these possibilities and thus did not look out for specific characteristics. Likewise, only a few hammerstones are known from

Sardinian lithic studies, as generally percussion is an overlooked topic (but see Luglië 2000b; 2004b). For the *Riu Mannu* dataset, I have explored percussion through examination of platform types, presence and degree of platform preparation, development of bulbar scars and flaking ripples, development of negative bulbs of percussion in core analysis, platform length/width ratios and size/thickness ratios (for references see Section 3.4.2.2).

It is generally thought that prepared (multifaceted, retouched, etc) platforms may be indicative of soft hammer direct percussion and/or indirect percussion, and five interesting patterns may be seen (Table 5.17; Appendix 5.7):

- Unprepared and single-plane core surfaces (*i.e.* a single flake is removed to create a core striking platform) predominate in both blade and flake assemblages (86.4% and 96.4% respectively).
- Nearly four times more blade than flake cores have prepared platforms (13.6% vs. 3.6%).
- Plain platforms are also customary among unretouched and retouched flakes and blades (84.9% & 81.7%). Low percentages notwithstanding, prepared platforms are more frequent on flake material than expected given flake core data (MNI: 20.5%; PR: 11%, and R: 11.1%).
- Average platform length and width ratios are very uniform (1:3) and show that platforms are generally robust, which is characteristic of direct percussion. Unsurprisingly, given the higher uniformity in *chaîne opératoires*, the range of ratios for blade material are more restricted than flake artefacts (Figure 5.12).

Thus, platform data corroborate unidirectional single platform removal for flakes and blades and indicates direct hard hammer percussion flaking. A small portion also suggests soft hammer direct percussion or indirect percussion.

	Blade production					Flake production				
	*C**	*MNI*	*IR*	*PR*	*Total*	*C#*	*MNI*	*IR*	*PR*	*Total*
UNIDIRECTIONAL REMOVAL / SINGLE STAGE CORES										
Unprepared core platforms / Shattered/incomplete platforms	3	18	1	2	24	37	150	7	6	200
Single flake-created core platforms / Single-plane (cortical / non-cortical)	18	109	21	23	171	11	671	26	71	779
Multi-flake-created core platforms / Multi-plane/ prepared platforms	3	25	3	6	37	1	202	5	10	218
Total	*24*	*152*	*25*	*31*	*232*	*49*	*1023*	*38*	*87*	*1197*
TWO-DIRECTIONAL REMOVAL / DOUBLE STAGE CORES										
Unprepared core platforms / Shattered/incomplete platforms	1	1	-	-	1	46	34	3	9	92
Single flake-created core platforms / Single-plane (cortical / non-cortical)	4	9	1	1	15	3	153	4	59	219
Multi-flake-created core platforms / Multi-plane/ prepared platforms	-	2	-	-	2	1	54	-	7	62
Total	*5*	*12*	*1*	*1*	*19*	*50*	*241*	*7*	*75*	*373*
MULTI-DIRECTIONAL REMOVAL / MULTI-STAGE CORES										
Unprepared core platforms / Shattered/incomplete platforms	5	1	-	-	6	1	11	-	2	14
Single flake-created core platforms / Single-plane (cortical / non-cortical)	7	1	-	-	8	9	40	-	1	50
Multi-flake-created core platforms / Multi-plane/ prepared platforms	3	-	-	-	3	2	16	1	1	20
Total	*15*	*2*	-	-	*17*	*12*	*67*	*1*	*4*	*84*
NO RECOGNISABLE REMOVAL DIRECTION										
Unprepared core platforms / Shattered/incomplete platforms	-	2	-	-	2	-	20	1	-	21
Single flake-created core platforms / Single-plane (cortical / non-cortical)	-	10	1	2	13	-	77	5	6	88
Multi-flake-created core platforms / Multi-plane/ prepared platforms	-	4	-	-	4	-	26	1	1	28
Total	**-**	**16**	**1**	**2**	**19**	**-**	**123**	**7**	**7**	**137**
Total All	**44**	**182**	**27**	**34**	**277**	**111**	**1454**	**53**	**173**	**1791**

Table 5.17. Platforms types per flaking direction for blade and flake production.

Key to Table:
C= cores
MNI= unretouched complete and proximal pieces
R= retouched pieces
PR= probably retouched pieces.
*= Including mixed flake/blade cores
#= including possible flake production.

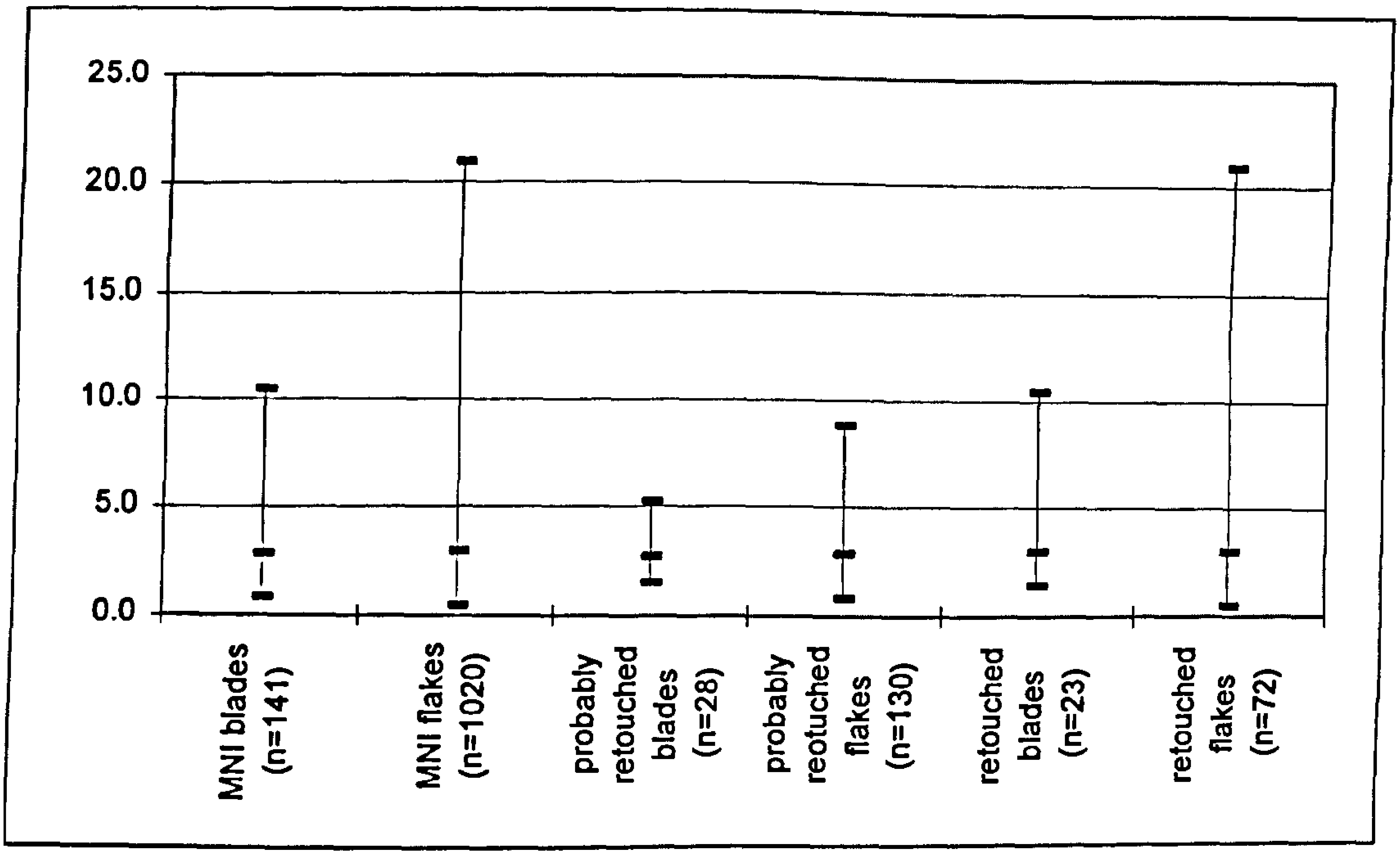


Figure 5.12. Maximum, average and minimum platform width/length ratios for flake and blade debitage, possible tools and tools.

Dorsal platform preparation, the manner in which the face of core platforms are prepared for removal by scrubbing and/or trimming, is present on a fifth (20.3%) of blade, and a tenth (9.9%) of flaked material (Table 5.18; Figure 5.13).

	Blade production			Flake production		
Platform type	*MNI*	*R*	*PR*	*MNI*	*R*	*PR*
UNPREPARED / SINGLE PLANE PLATFORMS						
Scrub preparation	9	4	4	31	2	11
Trimming	15	10	2	49	4	5
Total	24	14	6	80	8	16
% of category	13.0	28.0	11.1	5.5	7.9	9.2
PREPARED PLATFORMS (retouched/ dihedral, ground, punctiform and linear platforms)						
Scrub preparation	2	-	-	21	2	8
Trimming	7	1	-	25	4	7
Total	9	1	-	46	6	15
% of category	4.9	2.0	-	3.2	5.9	8.7

Table 5.18. Types of dorsal platform preparation for flake and blade removals with single-plane and multi-plane platforms. MNI= unretouched complete and proximal pieces flakes and blades. R= retouched pieces, PR= probably retouched pieces.

Most dorsal platform preparation is associated with unprepared and single plane platforms. The expected association between prepared platforms and dorsal platform preparation, which are both thought to be more prevalent with soft hammer percussion and/or indirect percussion, is non-existent. Again, data suggest that a small part of the *Riu Mannu* assemblage, especially blades, were knapped with soft hammer percussion or indirect percussion.

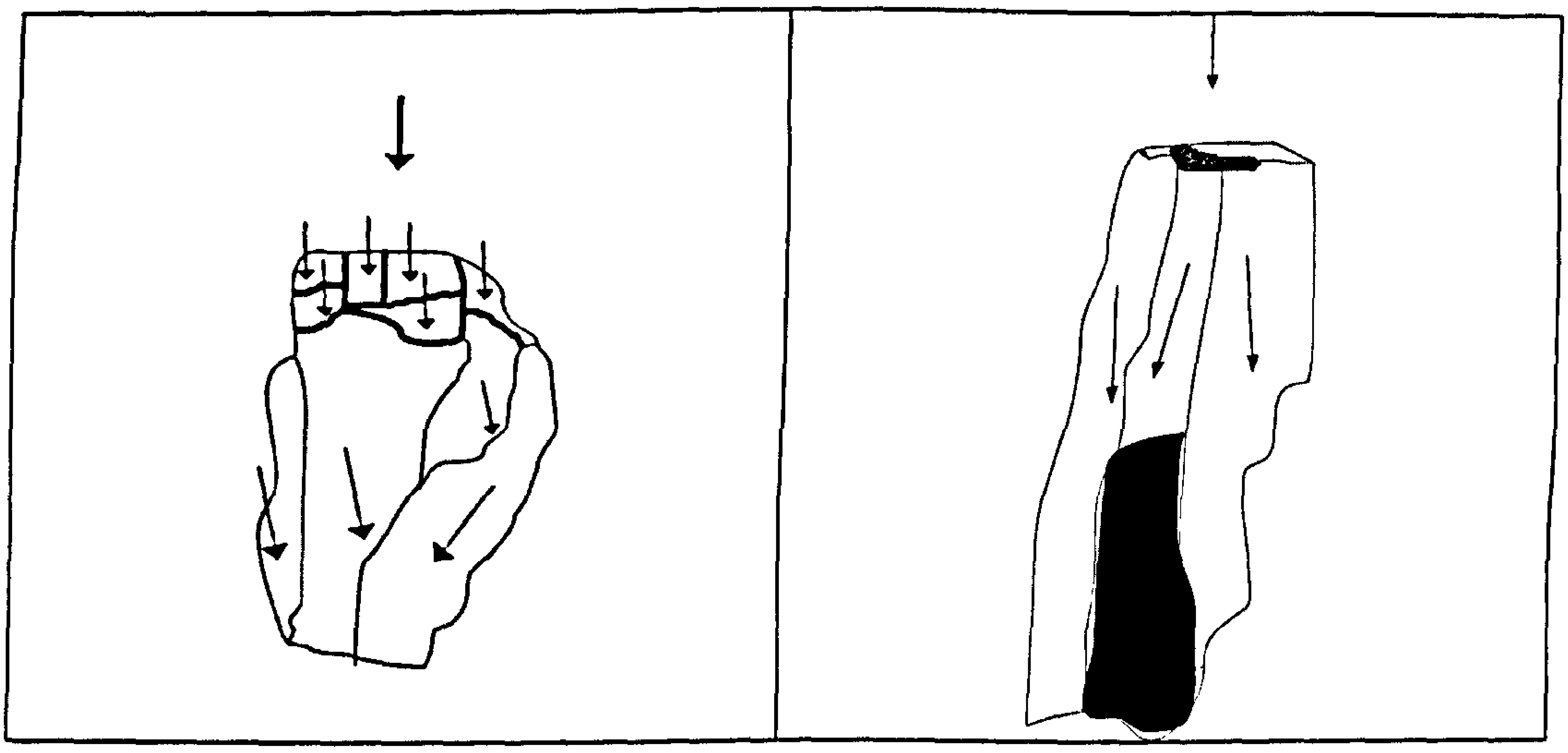


Figure 5.13. Blade fragments with dorsal scar patterning (arrows) and platform preparation. Left: trimming (thick black lines, small arrows indicate flaking direction). Right: scrubbing (shaded area; black outlined section = cortex). Arrows at top indicate direction from which blades were removed. Actual sizes. *Riu Mannu* finds: 04.08142.v.06 / 04.09138.v.09

Analysis of bulbs of percussion, *errailure* (bulbar) scars, and flaking ripples suggests that the latter category is not sensitive enough to distinguish types of percussion. High percentages of average to well developed flaking ripples are recorded for both blade and flake material (Table 5.19; Appendix 5.8). This presumably reflects flaking quality, which given the generally flawless nature of obsidian, is hardly surprising.

Technology		**Degree of development**			***Total***
		Poor	*Average*	*Well*	
Complete blades	N	6	59	78	**143**
	%	4.2	41.3	54.5	
Complete flakes	N	57	524	531	**1112**
	%	5.1	47.1	47.8	
Blade fragments	N	7	59	73	**139**
	%	5	42.4	52.5	
Flake fragments	N	79	439	309	**827**
	%	9.6	53.1	37.4	

Table 5.19. Degree of development of flaking ripples on primary *Riu Mannu* blade and flake material.

The development of bulbs of percussion and errailure scars seem more sensitive indicators. Well-developed bulbs of percussion are virtually always in the majority, but poorly to average developed bulbar scars occur more frequently (Figure 5.14; Appendix 5.8). On average 33% of the blade assemblage has poorly developed bulbs of percussion, and 47.3% contains poorly developed bulbar scars.

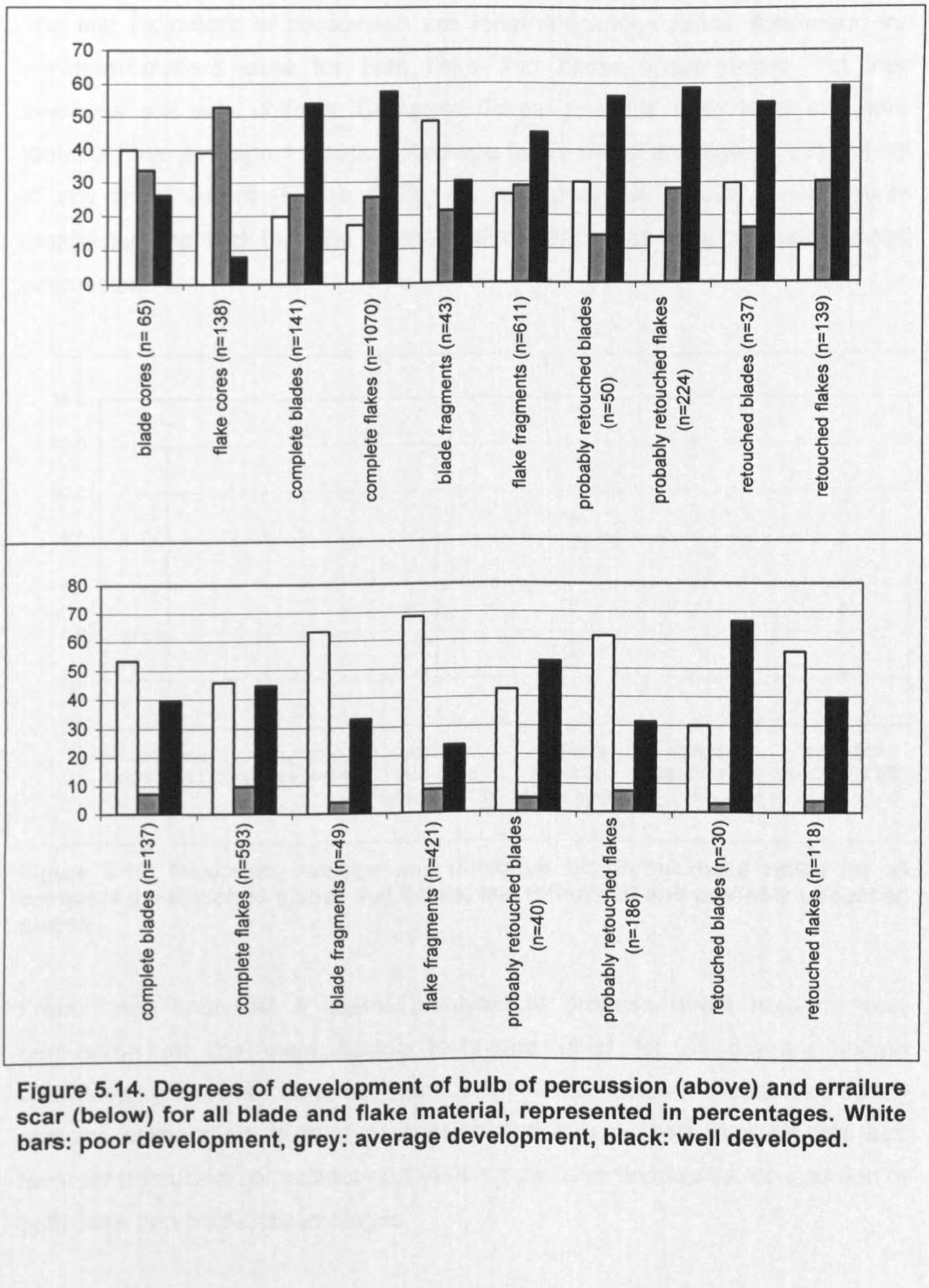


Figure 5.14. Degrees of development of bulb of percussion (above) and errailure scar (below) for all blade and flake material, represented in percentages. White bars: poor development, grey: average development, black: well developed.

Flake material has a lower average percentage of bulbs of percussion (21.3%), but a surprisingly high portion of poorly developed scars (57.8%), especially for retouched and probably retouched pieces. Both figures correspond to, or are higher than the percentages discussed earlier. This suggests soft hammer percussion or indirect percussion for a larger part of both assemblages, particularly flake material, than previously considered.

The last indicators of percussion are length/thickness ratios. Maximum and minimum outliers exist for both flake and blade assemblages, but their averages are very uniform. Complete flakes, possible flake tools and flake tools all have average 1:4 ratios. Average blade ratios are higher (1:5) but not to any great extent (Figure 5.15). As with previous results, these figures emphasise the fact that the majority of material was knapped using direct percussion.

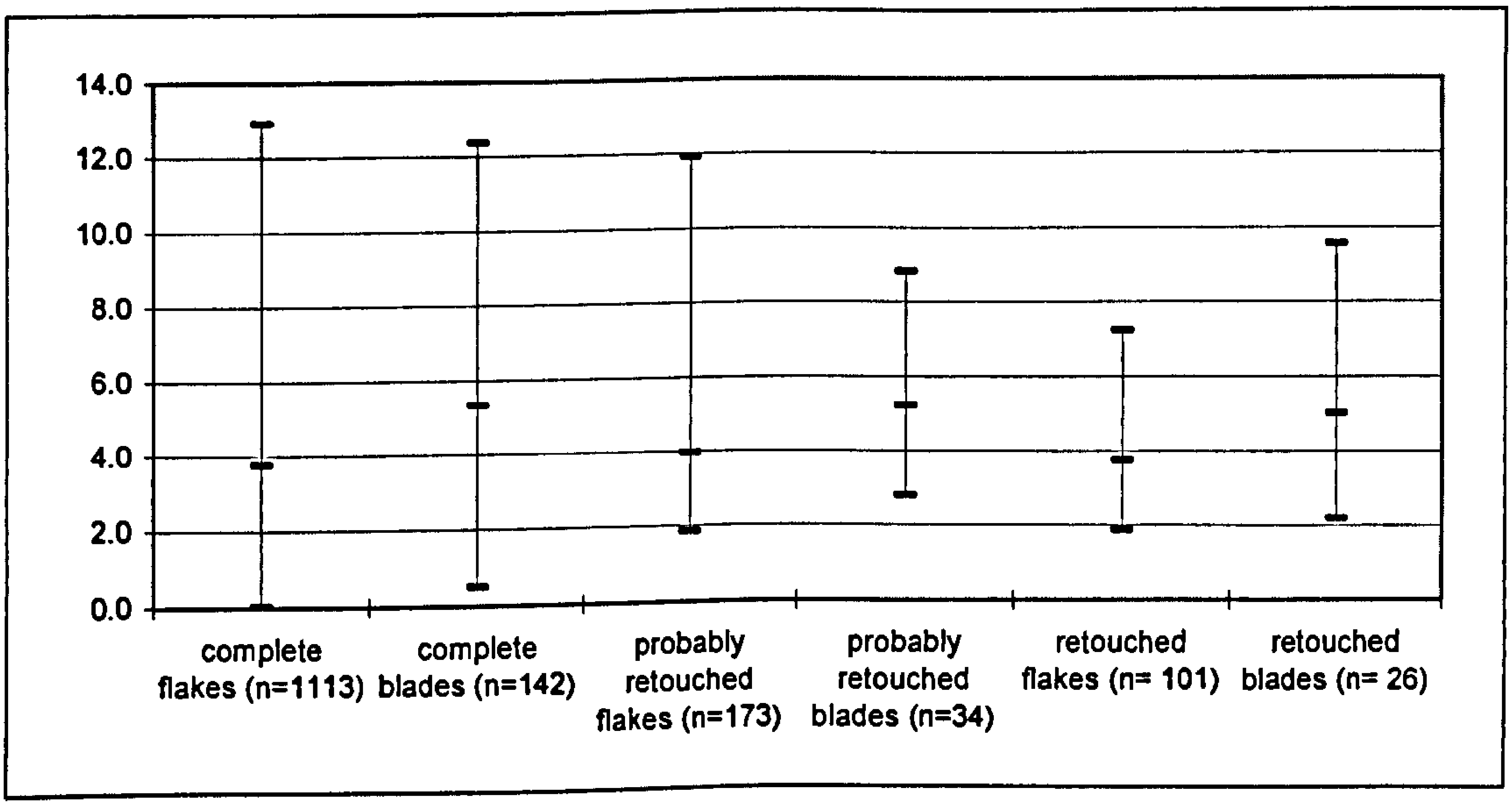


Figure 5.15. Maximum, average and minimum length/thickness ratios for all complete unretouched blades and flakes, and retouched and probably retouched pieces.

From these analyses, it seems plausible to propose direct hard hammer percussion as the main flaking technique used for all primary *chaîne opératoires*. Several features, particularly multi-faceted platforms, dorsal platform preparation, bulb of percussion and bulbar scars suggest that soft hammer percussion or indirect percussion may have been used for a portion of both flake and blade assemblages.

5.3. Raw material selection

Further to the exploration of knapping strategies and methods, it is worthwhile examining whether they may be linked to different procurement strategies. Parent material, opening strategies and source data may especially provide insight into raw material selection criteria, an important aspect of procurement (for references see Sections 2.3.1; 3.4.1).

5.3.1. Parent material

In the *Riu Mannu* dataset two main types of parent material may be observed: re-use of other flaked material and use of rounded pebbles and nodules (Tables 5.20-21). Cortical and non-cortical flakes, chunks, and to a lesser extent core fragments, are re-used most often. Platform flake or blade reduction constitutes only a small percentage (12.5%) of re-use. Single and double-stage ad hoc and particularly bipolar flaking strategies are more frequent, while multi-stage flaking is rare and restricted to chunks and core fragments. Flake production predominates, although some limited (8.3%) blade production occurs.

		Flakes	Cortical flakes	Chunks	Cores/core fragments
Tradition	Single-stage bipolar flake removal	10	5	11	-
	Double-stage bipolar flake removal	4	5	-	1
	Single-stage platform flake reduction	1	-	1	-
	Single-stage mixed flake/blade reduction	-	1	-	-
Variation	Single-stage ad hoc flake removal	2	-	1	-
	Double-stage platform flake reduction & bipolar flake removal	-	-	3	-
	Double-stage mixed flake/blade platform removal & bipolar flake removal	-	-	-	1
Unique strategy	Single-stage bipolar blade removal	-	-	1	-
	Double-stage ad hoc blade removal	-	1	-	-
	Double-stage flake removal	-	-	-	1
	Double-stage blade removal	-	-	-	1
	Double-stage ad hoc mixed flake/blade reduction & bipolar flake	-	-	-	1
	Double-stage bipolar flake & removal platform flake reduction	-	1	-	-
	Multi-stage platform flake & bipolar flake removal (2 stages)	-	-	-	1

Table 5.20. Types of non-nodule parent material per *chaîne opératoire* (n=53 cores).

Using the shape of the remaining cortical surface as a starting point, estimates about size and angularity or sphericity of used raw material may be made (Section 3.4). In the *Riu Mannu* dataset medium (fist-sized) to large nodules are more common than small ones, and sub-rounded to rounded nodules predominate (Table 5.21). Like analyses of non-nodular parent material, estimates of pebble sizes and sphericity mainly provide information on parent material for flake production.

Chaîne opératoires		Pebble Size			Sphericity		
		S	*M*	*L*	*SA*	*SR*	*R*
Tradition	SS bipolar flake removal	3	5	8	2	4	9
	SS platform flake reduction	-	1	4	2	-	2
	SS platform mixed flake/blade reduction	-	-	3	-	-	2
	SS platform blade removal	1	-	3	2	-	1
	DS bipolar flake removal	-	2	5	-	-	-
Variation	SS ad hoc flake removal	1	1	-	-	-	-
	DS platform flake reduction & bipolar flake removal	1	2	1	-	-	-
Unique strategy	SS bipolar blade removal	-	1	-	-	-	-
	DS platform flake removal	1	1	-	-	-	-
	MS platform reduction: possible flake & blade & mixed flake/blade	-	-	1	-	-	-
	MS: platform blade (2 stages) & bipolar flake removal	-	1	-	-	-	1
	MS platform reduction: blade & flake (2 stages)	-	-	-	-	-	1
	MS: platform flake (2 stages) & ad hoc flake removals	-	-	1	-	-	1
	MS: ad hoc flake removal (stage 1, 3-5), ad hoc possible flake removal (stage 2), platform flake removal (stage 6-7)	-	-	1	-	-	-
	MS: platform possible flake, platform flake (3 stages), platform blade, & ad hoc possible flake removal	-	-	1	-	-	-

Table 5.21. Recorded pebble sizes (n= 52) and angularity / sphericity (n=39) for cores to establish sizes and shapes of parent material.

Key to Table:		
SS= single-stage	S= small	SA= sub-angular
DS= double-stage	M= medium (fist-sized)	SR= sub-rounded
MS= multi-stage	L= large	R= rounded

The number of previous removals that are visible on the dorsal side of debitage and retouched material and artefact size distribution give additional insight into raw material selection criteria. Irrespective of flaking techniques, number of stages, artefact fragmentation, or retouch extent, few *Riu Mannu* pieces show more than six dorsal scars. Only one blade and 14 flakes contain seven or more scars. Most artefacts show between 2-4 previous removals (Figure 5.16 - note the different scales between blade and flake production; Appendix 5.10).

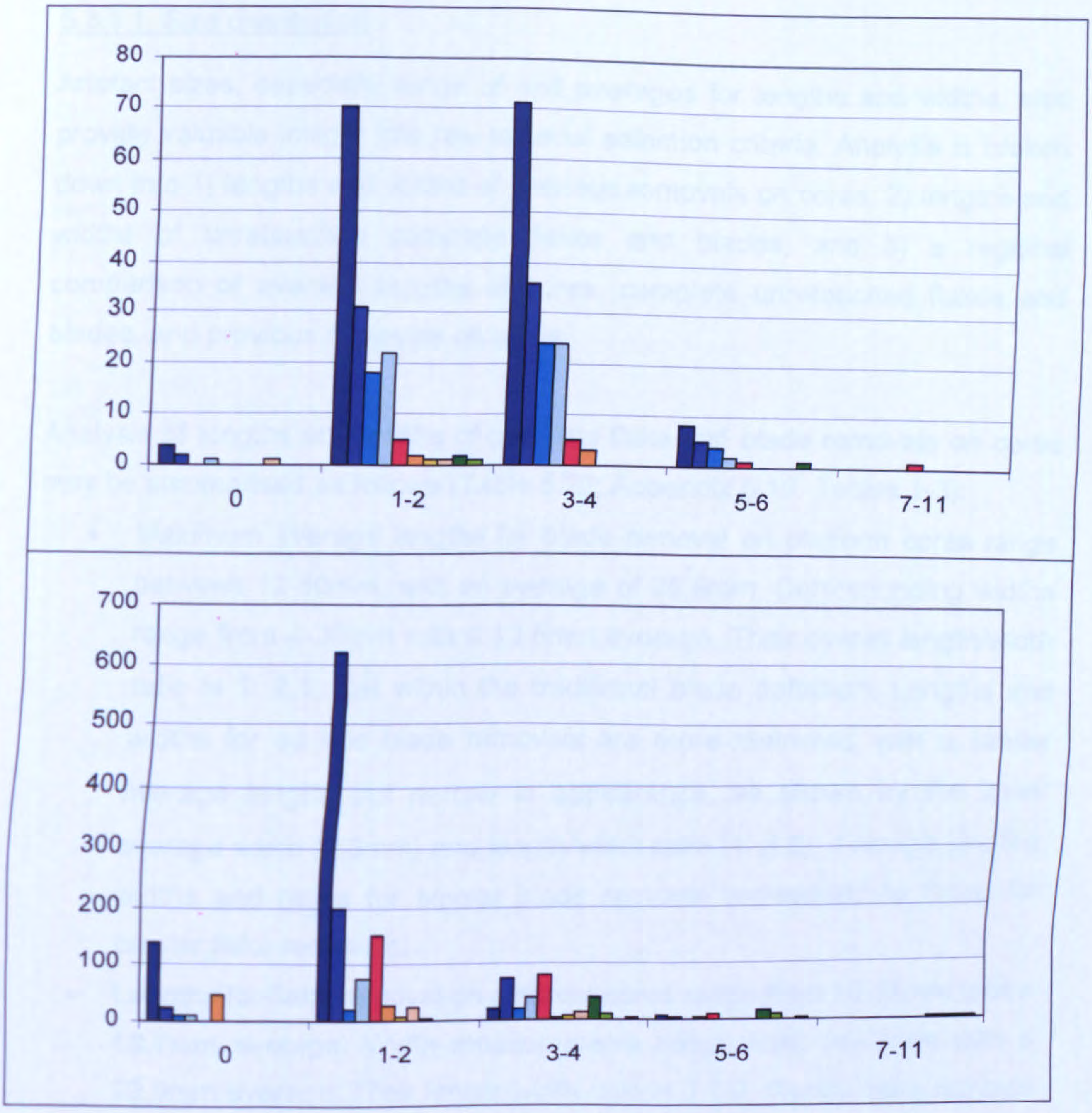


Figure 5.16. Number of previous removals on unidirectional, two-directional and multi-directional unretouched and retouched blades (top) and flakes (bottom).

Key to Figure:

- Unidirectional MNI unretouched blades and flakes
- Unidirectional blade and flake fragments
- Unidirectional probably retouched blades and flakes
- Retouched blades and flakes
- Two-directional MNI unretouched blades and flakes
- Two-directional blade and flake fragments
- Two-directional retouched blades and flakes
- Two-directional probably retouched blades and flakes
- Multi-directional MNI blades and flakes
- Multi-directional blade and flake fragments
- Multi-directional retouched blades and flakes
- Multi-directional probably retouched blades and flakes

5.3.1.1. Size distribution

Artefact sizes, especially range of and averages for lengths and widths, also provide valuable insight into raw material selection criteria. Analysis is broken down into 1) lengths and widths of previous removals on cores, 2) lengths and widths of unretouched complete flakes and blades, and 3) a regional comparison of average lengths of cores, complete unretouched flakes and blades, and previous removals on cores.

Analysis of lengths and widths of previous flake and blade removals on cores may be summarised as follows (Table 5.22; Appendix 5.10: Tables 1-3):

- Maximum average lengths for blade removal on platform cores range between 12-50mm, with an average of 25.9mm. Corresponding widths range from 4-26mm with a 12.5mm average. Their overall length/width ratio is 1: 2.1, just within the traditional blade definition. Lengths and widths for ad hoc blade removals are more restricted, with a similar average length, but narrow in appearance, as shown by the lower average width (7.3mm) and length/width ratio (1: 3.6). Average lengths, widths and ratios for bipolar blade removal correspond to those for bipolar flake removals.
- Lengths for flake removal on platform cores range from 10-36mm with a 19.7mm average. Width measurements range from 14-43mm with a 22.9mm average. Their length/width ratio is 1:1.2. Bipolar flake removal shows a similar average length, is slightly smaller (17.1mm), but flakes are shorter and more square with a lower average width (14.7mm), while their length/width ratio is similar to that of platform core removals (1:1.2). Ad hoc flake removals closely mirror length and width averages and ratios of bipolar-struck flakes. They indicate the production of shorter, square flakes.

Thus, while there is a slight size difference between cores for blade and flake technology, this does not appear to be so large as to suggest different raw material selection criteria. Neither are there any large or small 'outliers' in length and/or width measurements for removals, which would suggest alternative procurement strategies. In general, data supports earlier arguments for procurement of medium to large size parent material.

	BBR		ABR		PBR		BFR		AFR		PFR	
	L	*W*	*L*	*W*	*L*	*W*	*L*	*W*	*L*	*W*	*L*	*W*
Maximum	26.1	32.2	29.8	10.3	49.2	26.1	30.3	32.7	28.8	21.7	36.1	43.3
Average	16.7	13.7	26.5	7.3	25.9	12.5	17.1	14.7	18.6	13.6	19.7	22.9
Minimum	-	-	20.5	5.4	12	4	-	-	-	-	9.5	13.9
Mode	-	-	-	-	24	11	12.6	13.8	-	-	23.7	-

Table 5.22. Size comparisons of length and width measurements for flake and blade removals on cores per different flaking technique.

Key to Table:
BBR= bipolar blade removal
ABR= ad hoc blade removal
PBR= platform blade removal
BFR= bipolar flake removal
AFR= ad hoc flake removal
PFR= platform flake removal.

Length and width measurements for unretouched debitage, complete flakes and blades only, tie in with those recorded on cores (Figure 5.17: Appendix 5.10: Table 4):

- Blade length ranges from 11-81mm, with an average of 31.2mm. Widths range from 7-43mm, with an average of 17.7mm. The blade length/width ratio is 1:1.8, slightly lower than that recorded for core data and also below the traditional blade ratio. This confirms earlier observations that the majority of the *Riu Mannu* blade assemblage is an informal blade technology, not a prismatic one. Blade thickness falls in the 2-25mm category, with an average of 6mm.
- Length measurements for flakes show a wider range, from 5-117mm, and an average of 23.9mm. Flake widths too have a wider range, from 2-76mm with an average of 21.3mm. The length/width ratio (1:1.1) closely corresponds to that of core data. Flake data, which predominantly indicated platform removal as discussed above, shows a shorter, squarer, character than previous removals on platform flake cores. Presumably this is partially a result of not having further distinguished debitage flakes into bipolar-struck flakes and platform-reduced flakes. Flake thickness ranges from 0.4-70mm, or without the three outliers over 50mm, from 0.4-30mm.

Thus, lengths, widths and thicknesses of unretouched flakes and blades largely complement core data (for retouched and probably retouched pieces, see Section 6.4.3.). Some larger pieces were found, but these do not appear to be extremely unusual in size. It may be concluded that core and debitage data suggest similar raw material selection criteria. Likewise, size data supports earlier-made arguments for broadly similar production strategies.

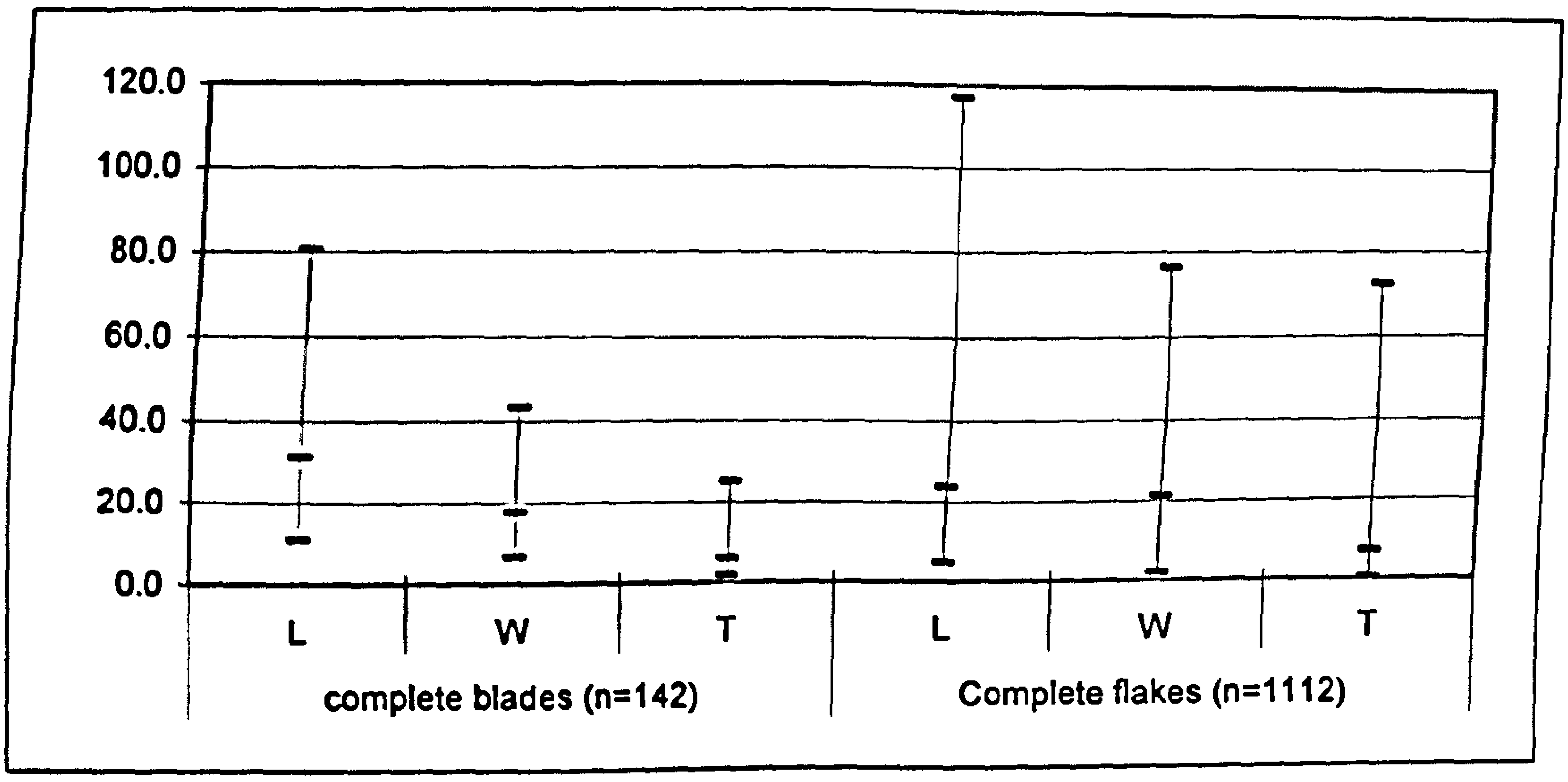


Figure 5.17. Maximum, average and minimum lengths (L), widths (W) and thicknesses (T) for unretouched complete blades and flakes.

Lastly, exploration of spatial distribution of core, debitage, and previous removal lengths, provides interesting insights into raw material use and procurement strategies. Eight interesting main trends may be recognised (Figure 5.18; Appendix 5.10: Tables 1-7):

- There is no clear relationship between decreasing core sizes and increasing distances to raw material sources. Four transects (02, 07, 09 and 10) do not show a linear pattern. Transects 02, 07, and 10 – despite being located in this secondary source – hold some of the lowest core length averages. Similarly, transect 09, despite its close location to primary source zones does not contain the largest cores. The four remaining transects do show a connection between distance to source and core size. Transect 13 is furthest away from both secondary and primary sources, and does contain the lowest core length average (28.6mm). Core lengths are also larger (38-41mm) in the Marmilla-Campidano secondary source zone for three out of four transects (04, 14, and 23) along the Mò goro River, which suggest local secondary source use.

- Size distribution of complete blades mirror the pattern from cores. Again, transects with longer blades (*e.g.* 04, 09, and 23) are closely associated with primary (09) and secondary (04, 23) raw material source zones, with those furthest away from source zones containing the smallest debitage pieces. Other transects, especially in the Arborèa, do not follow this trend (*e.g.* transects 02, 05).
- Platform cores with flake production show a slightly more consistent pattern. Average core lengths from both transects 04 and 09, located close to local primary and secondary sources, are high while those in transect 13, furthest from raw material sources, are lowest. As with blade reduction, however, intermediary transects (*i.e.* those in between primary and secondary sources – *e.g.* transects 10, 14 and 23) do not show a linear pattern with decreasing core sizes as distance to (primary) sources increase, suggesting instead localised use of (secondary) raw material sources.
- Average lengths for cores with bipolar flake removals are consistent across all three regions. They do not demonstrate a noticeable relationship between size and distance to raw material sources beyond having a low average length for transect 13 located furthest from sources, and a high average for transect 04, which is located on top of a secondary source. Remaining transects however, all in varying distances to primary and secondary sources, show a consistently similar size range between 25-30mm.
- The distribution of average lengths for previous removals on bipolar flake cores mirror the core data and lengths that are closely tied to local source use. The largest previous removals occur in transect 04 and 09, both close to if not within, raw material sources. The smallest previous removals lie in the transitional Arborèa/Campidano transects (02, 05, 07) that extend into the Campidano-Iglesiente (13). Platform cores with previous flake removals show similar correlations, where the highest lengths (24-29mm) are found in the Mògoro river and gorge area (transects 04, 10, 14 and 23). Transect 09 shows an interesting contrast, with small flake removals (15mm), probably due to the multi-stage removal and novice characteristic of the cores (see below).

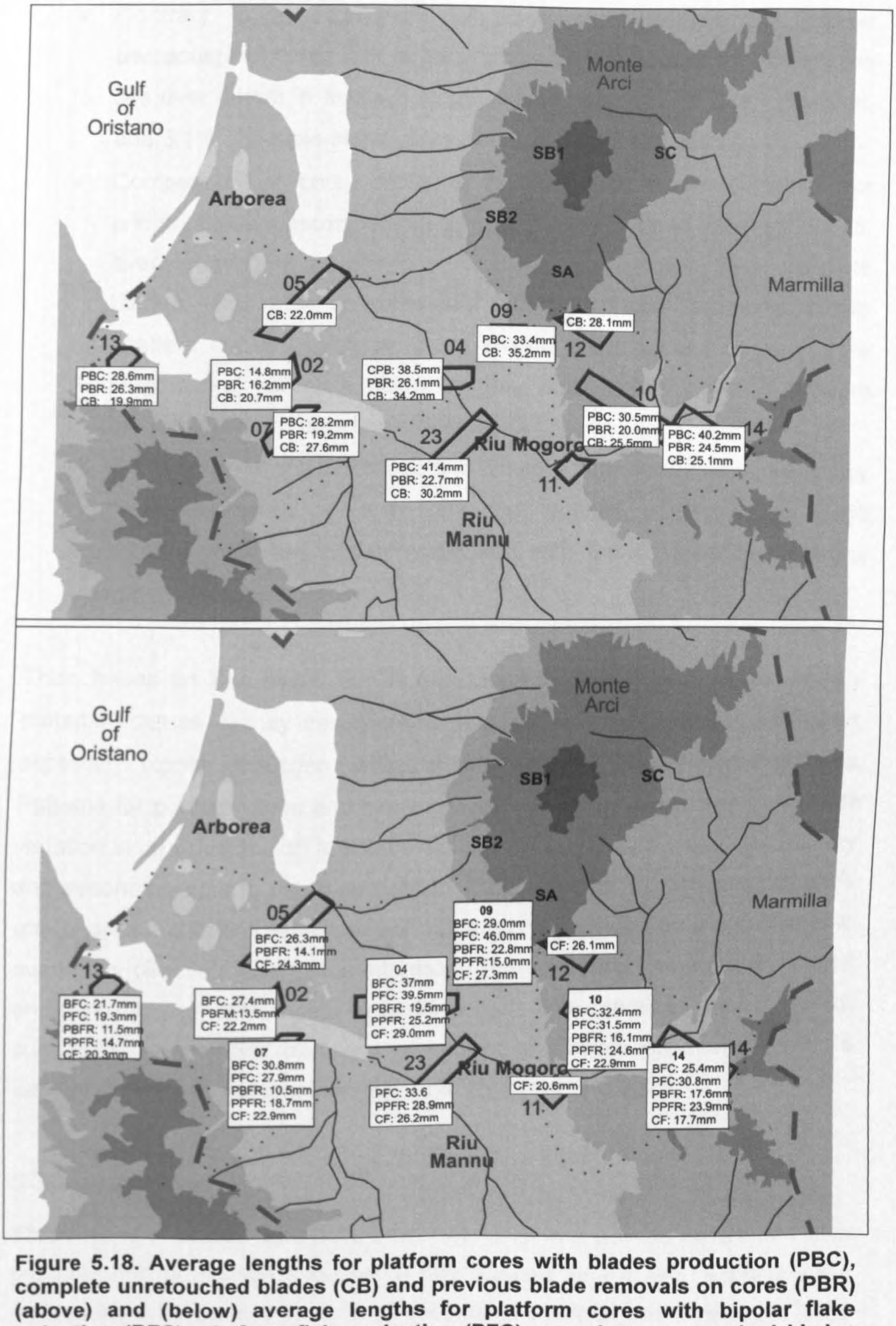


Figure 5.18. Average lengths for platform cores with blades production (PBC), complete unretouched blades (CB) and previous blade removals on cores (PBR) (above) and (below) average lengths for platform cores with bipolar flake reduction (BFC), platform flake reduction (PFC), complete unretouched blades (CF) and previous flake removals on bipolar cores (PBFR) and previous flake removals on platform cores (PPFR).

- Contrary to expectations, multi-stage cores contain the highest percentage of cores with large average lengths, where 63.6% of cores are over 44mm in average length, compared to 4.1% of single-stage, and 3.1% of double-stage cores (for discussion, see below).
- Comparison of core, debitage, and previous removal lengths for primary blade material, do not show any outliers. In all transects but 13, average lengths of previous removals are smaller than complete blades, which may be expected if reduction phases are not markedly spatially distinct. Likewise, there are no great outliers between core lengths and complete blade lengths, which might point to different procurement of production strategies.
- Comparison of core, debitage and previous removal lengths for primary flake material do not show any clear outliers, more so than blade material, they are closely associated with the distance to local raw material sources.

Thus, based on size distribution and distance to primary and secondary raw material sources, it may be proposed that raw material for flake production, especially bipolar reduction, was obtained at local raw material sources. Patterns for platform flake and blade reduction are less clear and show more variation in size distribution to source distance, suggesting a mixture of primary and secondary source use (see Section 7.1.). Variation in raw material sizes and shapes exist, and reflect earlier-noted sizes and shapes of raw material availability (Section 4.3.3). It is interesting however, that despite wide spatial and chronological differences, large differences between sizes remain limited, suggesting very strong traditions or evoking a strong sense of Bourdieu's *habitus* in raw material procurement, if not knapping strategies.

5.3.2. Source data

Three types of source data have been examined that provide insight into lithic procurement, production and use: 1) raw material source use, especially the relationships between primary and secondary sources and blade and flake technologies, 2) obsidian type use, particularly the relationship among flake and blade technologies, types of obsidian and specific material characteristics, and 3) flake and blade opening strategies, based on types, percentages, and location of cortex.

5.3.2.1. Source locations: primary and secondary source use

In the previous chapter I tentatively linked four cortex types with primary and secondary source zones, and presented general evidence for the use of secondary source material (Section 4.3). A closer look at the different cortex types on all primary technology flake and blade material shows that (Figure 5.19; Appendix 5.11: Tables 1-5):

- All cortex types are present on blade and flake material, and both assemblages have similar overall cortical percentages.
- Types 1-2, associated with secondary raw material sources, are more common on flake than blade material. Percentages for cores with flake production, and complete flakes in particular, are twice as high for secondary source cortex in comparison to percentages for cores with blade production and complete blades.

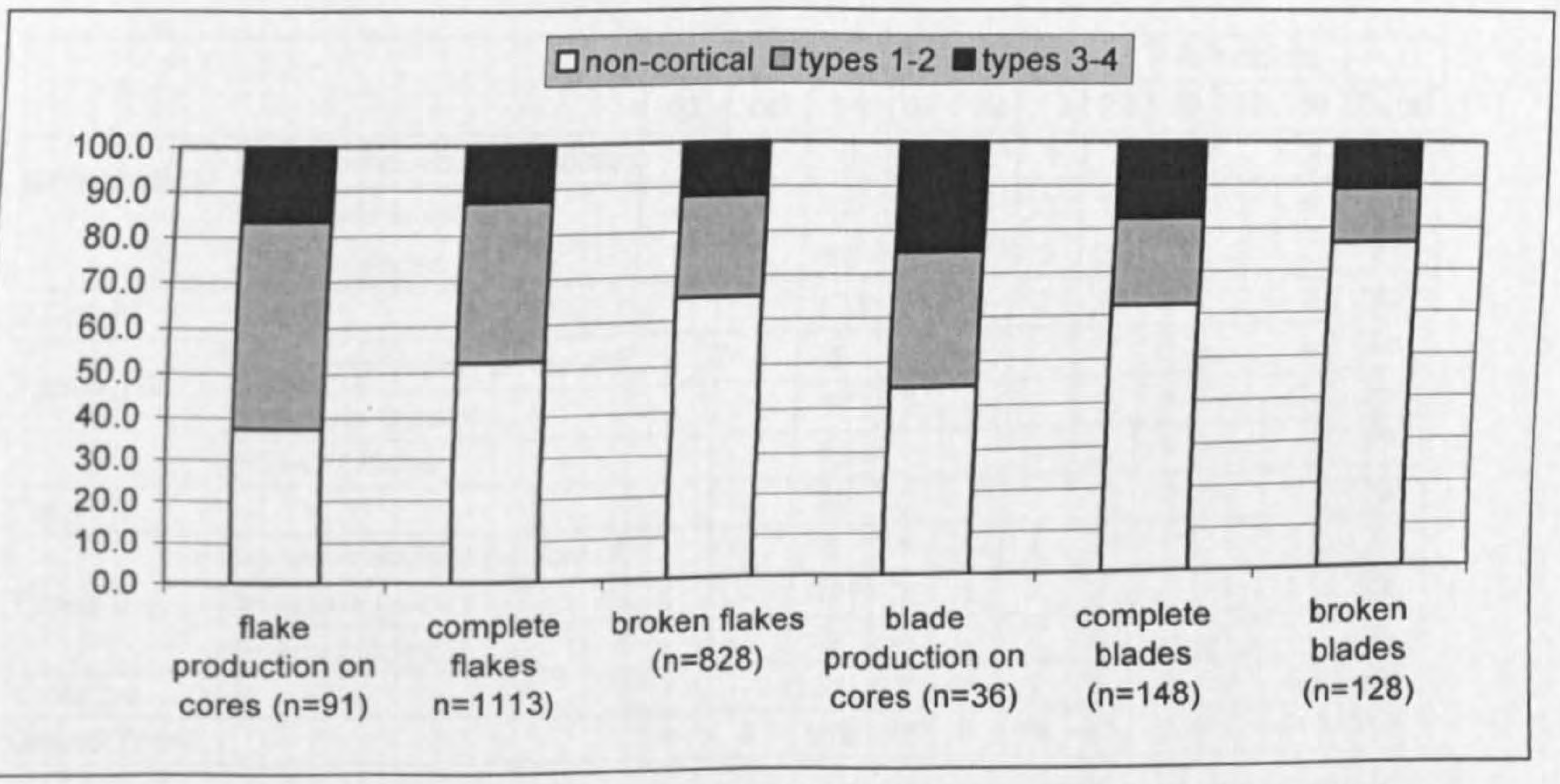


Figure 5.19. Percentages of non-cortical and cortical material for primary flake and blade technology.

Exploring regional patterns is more informative (Table 5.23-24), although it should be kept in mind that artefact numbers for blade material are low, particularly in the Arborèa and the Marmilla, so discussion of patterning remains fragmentary:

- There are clear differences between blade and flake material in the Arborèa. Cortical blade material is rare (18.8%), compared to flake material (58.8%), and the latter show a spatial divide for cortex types. Artefacts with cortex types 3-4 predominate in transect 05, while types 1-2 are more common in transect 02. Raw material source availability might explain this pattern for transect 02, as it lies close to the Campidano secondary source area. It is less applicable to transect 05 however, which is, while close to primary sources, similarly near secondary sources (see Figures 4.3; 4.7).
- Blade material is equally rare in the Marmilla but some interesting differences may be seen. Transect 12 primarily contains non-cortical complete blade or blade fragments. When present, only cortex types 3-4 occur which, given the transect's close location to the primary SA source zone, is unsurprising. Cortical material is more prevalent in transects 10 and 14 but, despite lying in the heart of the Campidano secondary source zone, cortex types 1-2 do not predominate. In fact, for transect 14 types 3-4 are more numerous.

		Arborèa		Campidano					Marmilla			
		02	05	04	07	09	13	23	10	12	14	Total
Non-cortical	*Blade production on cores#*	2	-	6	3	-	1	2	1	-	2	16
	Complete blades	4	4	55	6	1	3	11	2	2	5	93
	Broken blades	2	2	62	2	2	3	20	2	3	-	98
0 Total		*7*	*6*	*123*	*11*	*3*	*7*	*33*	*5*	*5*	*7*	*207*
Types 1-2	*Blade production on cores#*	-	-	8	-	1	-	1	1	-	-	11
	Complete blades	-	1	17	2	-	-	3	1	-	1	25
	Broken blades	-	1	13	-	-	-	3	-	-	-	17
Total 1-2		-	*2*	*38*	*2*	*1*	-	*7*	*2*	-	*1*	*53*
Types 3-4	*Blade production on cores#*	-	-	5	1	-	1	-	1	-	1	9
	Complete blades	1	-	17	2	1	2	-	-	1	1	25
	Broken blades	-	-	9	-	-	-	3	1	1	1	15
Total 3-4		*1*	-	*31*	*3*	*1*	*3*	*3*	*2*	*2*	*3*	*49*
Grand Total		**9**	**8**	**192**	**16**	**5**	**10**	**43**	**9**	**7**	**11**	**310**

Table 5.23. Regional distribution of non-cortical and cortical blade material. #Including cores with mixed flake/blade removals.

- Low artefact numbers notwithstanding, cortex data for flake material in Marmilla transects 11 and 12 contrast. The latter contains equal percentages of cortical - non-cortical material, while non-cortical material is more common in transect 11. The distribution of types of cortex closely mirrors raw material availability for all transects, except 14, with types 3-4 predominating in transect 12, and types 1-2 in transects 10 and 11.

- As with the other regions, non-cortical percentages are high for all blade assemblages in the Campidano, ranging between 60 and 77%. Non-cortical percentages for flake assemblages are lower (c. 50%) in transects (04, 09, 23) close to raw material sources, with one exception (transect 07). Transect 13, located furthest from sources, contains the highest non-cortical component (81.5%). Close associations between predominant cortex types on blade material and distance to source are only observed for 23 (*e.g.* types 1-2 and Campidano secondary source zone). Cortical percentages in transect 04, 07 and 09 are evenly distributed between types 1-2 and 3-4, despite being closer to primary sources (09) or secondary sources (04 and 07). In transect 13 cortex type 3-4 predominates. Different patterns can be seen for flake material, with a stronger correlation between distance to source and cortex types. Transects 04, 09 and 23 all contain high percentages (c. 80%) of the cortex types associated with nearby raw material sources. Transect 07 is the exception, with equal percentages for all cortex types, despite its close proximity to the secondary source zone. In transect 13 cortical flake data mirrors blade figures and types 3-4 are more common.

		Arborèa		Campidano					Marmilla				
		02	**05**	**04**	**07**	**09**	**13**	**23**	**10**	**11**	**12**	**14**	**Total**
Non-cortical	*Flake production on cores**	6	-	7	4	3	1	1	4	-	-	9	35
	Complete Flakes	25	8	154	66	18	10	36	68	5	5	184	579
	Broken Flakes	13	2	156	27	15	11	33	67	8	3	207	542
0 Total		*44*	*10*	*317*	*97*	*36*	*22*	*70*	*139*	*13*	*8*	*400*	*1156*
Types 1-2	*Flake production on cores**	2	2	11	3	3	1	3	7	-	-	3	35
	Complete Flakes	22	8	148	8	22	-	33	86	2	1	49	379
	Broken Flakes	5	-	66	4	7	-	20	47	1	-	40	190
Total 1-2		*29*	*10*	*225*	*15*	*32*	*1*	*56*	*140*	*3*	*1*	*92*	*604*
Types 3-4	*Flake production on cores**	-	-	3	-	-	1	-	1	-	-	7	12
	Complete Flakes	5	2	46	11	4	2	5	13	-	7	46	141
	Broken Flakes	6	25	3	5	4	1	4	7	-	1	42	98
Total 3-4		*11*	*27*	*52*	*16*	*8*	*4*	*9*	*21*	*0*	*8*	*95*	*251*
Grand Total		**84**	**47**	**594**	**128**	**76**	**27**	**135**	**300**	**16**	**17**	**587**	**2011**

Table 5.24. Regional distribution of non-cortical and cortical flake material. *Including cores with probable flake removal.

It may be concluded that cortical percentages are generally lower for blade than flake material, and correlations between proximity of raw material sources and the predominance of cortex type are not always clear. Close links do exist for flake and blade material in transects 02, 12, and 23, but not in transects 05, 13, and 14. Cortex types and distance to sources correspond for flake, but not blade material, in transects 04, 10, and 11, and for blade, but not flake, material in 07 and 09. This is a first indication that raw material procurement is variable and more complex than expected. It should be recalled, however, that debitage does not just represent production, but may also indicate use and discard (see Chapter 7)

5.3.2.2. Visual source characterisation and aesthetic preferences

Visual source characterisation helps understanding source distribution patterns (Section 4.4). Using the earlier established associations (Table 4.12), three basic patterns may be discerned (Table 5.25):

- Over half of all blade material can be attributed to either SA or SC obsidian whereby the second substantial portion of SA/SB artefacts suggests that most blade material might derive from the SA source zone.
- An intriguing distinction occurs among single-stage platform cores, double, and multi-stage cores with blade removal. The former are mostly assigned to the SA source zone whereas the latter are attributed to the SC source areas.
- Source data for flake material is less distinctive. SA and SC obsidian both occur in equal percentages, as do SA/SB and SC/SB characteristics. There are no clear links between knapping strategies and obsidian types.

Primary technology	Knapping strategy	SA	SA/SB?	SC	SC/SB?	Total
Blade production on cores	SS platform removal	9	6	5	-	20
	SS bipolar removal	1	-	-	1	2
	DS bipolar removal	1	-	1	-	2
	DS ad hoc removal	1	1	-	-	2
	DS platform removal	1	-	3	-	4
	MS platform removal	2	-	4	-	6
MNI blades		26	63	54	9	152
Blade fragments		20	34	17	9	80
Percentage		*22.7*	*39.4*	*32.2*	*7.2*	*100*
Total		**61**	**104**	**85**	**19**	**265***
Flake production on cores	SS platform removal	2	2	4	-	8
	SS bipolar removal	11	6	9	4	30
	SS ad hoc removal	1	1	1	-	3
	DS bipolar removal	8	3	11	-	22
	DS platform removal	1	1	1	-	3
	DS platform & bipolar removal	1	1	2	-	4
	MS flake removal	6	1	5	-	12
MNI flakes		208	275	276	198	957
Flake fragments		72	74	63	51	260
Percentage		*23.9*	*28.0*	*28.6*	*19.5*	*100*
Total		**310**	**364**	**375**	**253**	**1299***

Table 5.25. Source attributions based on material characteristics for primary *Riu Mannu* flake and blade technology. MNI= minimal number of pieces (complete and those with proximal ends only. * Excluding data for transect 14.

Exploration of spatial distribution provides further information (Figure 5.20; Appendices 5.12-5.13). Three patterns are visible for blade material:

- A clear SA obsidian predominance (>80%) is visible in transect 05, 09 and 12, which is presumably due to their close proximity to primary and secondary SA source zones.
- SA is still prevalent, but in lower percentages (50-60%) over SC material in transects 02, 04, 10, and 23. This pattern is interesting because these all lie in the Campidano secondary source zone, which predominantly contains SC raw material (see Section 4.1.2).
- Two transects are exceptions. Blade material in transects 07 and 13 is mostly (70%) in SC obsidian, in contrast to the other transects in the Campidano secondary source zone.

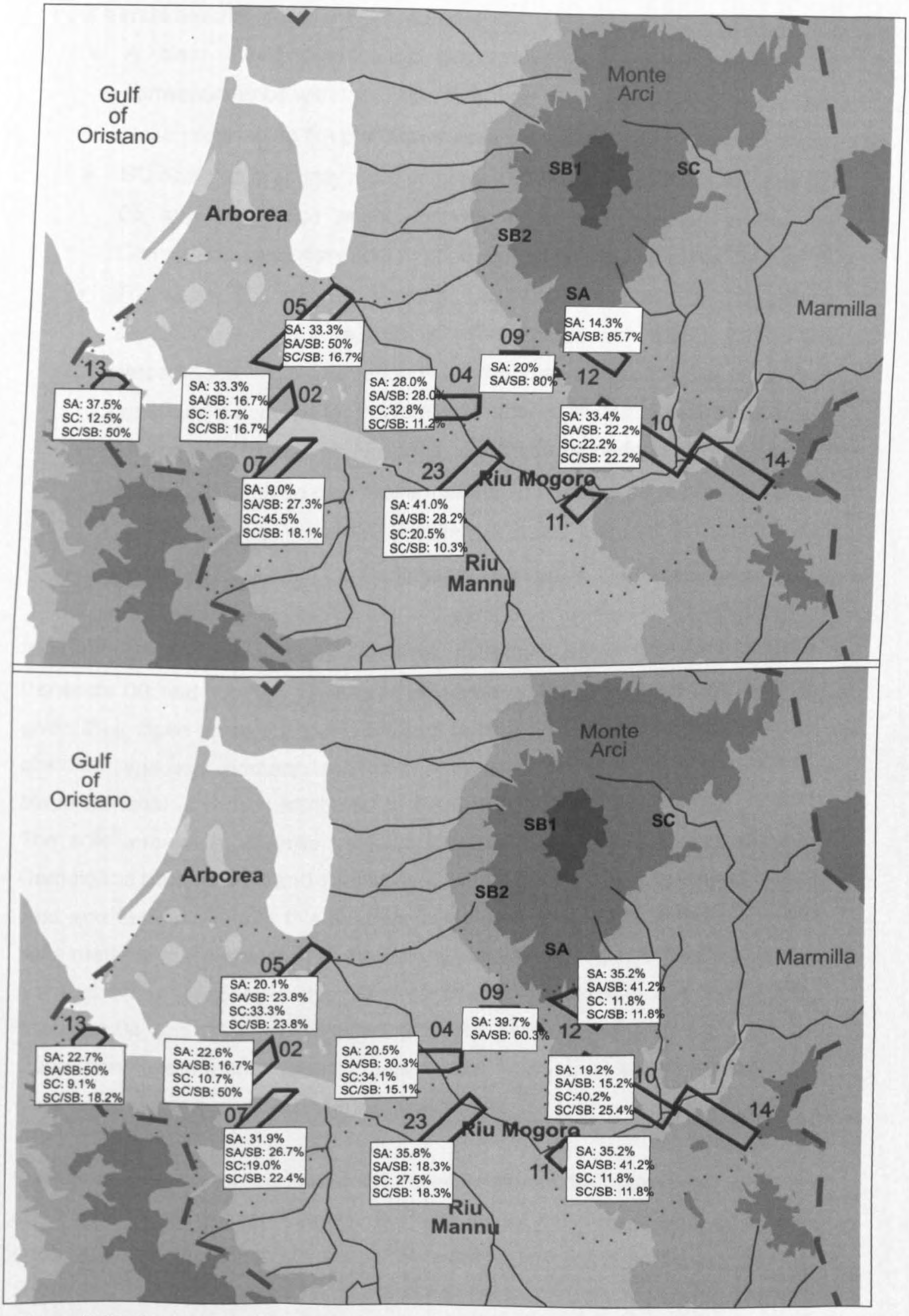


Figure 5.20. Source distribution (using visual characterisation) for primary blade (above) and flake (below) technology.

Four trends are observed for flake material:

- A clear SA predominance (>70%) in transects 09, and 12, in correspondence with the blade data, and again presumably due to their close proximity to SA primary sources.
- SC obsidian is slightly more common (50-60%) than SA in transects 02, 05 and 10, which might correspond to their position in the SC Campidano secondary source zone, but contrasts with blade data.
- Transects 07 and 23 similarly positioned in the SC Campidano secondary source area, contain assemblages with slightly higher SA percentages. This corresponds to the blade data for the latter, but constitute a contrast for the former. Transect 04 contains virtually equal SA and SC obsidian percentages, which corresponds to blade data.
- In contrast to blade data, flake material in transect 13 is predominantly (72.7%) SA obsidian. SA obsidian is most frequent in transect 11 despite its location in the Campidano secondary source area.

In sum, source data for blade and flake material closely mirror each other in transects 09 and 12. The clear predominance of SA obsidian is unsurprising given their close proximity to the SA source zone. An interesting link between obsidian type and primary technology may be seen in the Arborèa, where blade material is mostly attributed to SA obsidian, and flake material to SC. The sole remaining Marmilla transect, transect 10, shows a similar division. Campidano transects 07 and 13 display a similar relationship between obsidian type and technology, but this time blade material is predominantly in SC and flake material in SA obsidian. In the other Campidano transects flake and blade material show mirroring rather than contrasting patterns in obsidian types. Transect 04 and 23 show slightly higher SA percentages, and more so for blade than flake material. Clearly, these patterns cannot be simply attributed to distance to primary and secondary source zones.

Further insight into procurement strategies is gained from exploring whether correlations exist between cortex type and visual characterisation, as it has been proposed that there are associations with primary and secondary source zones and obsidian types. The four types of cortex broadly represent different stages of nodule weathering and transport, and although these occur at both primary and secondary sources with three obsidian types (SA, SB, SC), two basic geological patterns were observed: 1) primary source obsidian predominantly has cortex types 3-4 and secondary source obsidian types 3-4, and 2) secondary sources with SC obsidian seemed particularly widespread (Sections 4.1.2; 4.3.1).

Analysis shows that (Table 5.26):

- Primary source use is high for SA obsidian with the majority of cortical SA, SA/SB artefacts (65.9%) containing primary source cortex types 3-4.
- Secondary source use is high for SC obsidian with the majority of cortical SC, SC/SB (71.8%) containing secondary source cortex types 1-2.
- SB source use is difficult to assess since clear SB artefacts have not been recognised, most likely because of its visually undiagnostic characteristics. Those tentatively associated with SB obsidian show similar percentages (c. 36%) for primary and secondary source use.
- A third of cortical SA, SA/SB suggest secondary source use, while a fourth of cortical SC, SC/SB pieces indicate primary SC source use, since these artefacts contain cortex types 1-2 and 3-4 respectively.

		SA	SA/SB	SC	SC/SB	Total
Primary blade technology	*Non-cortical*	38	72	45	24	179
	Types 1-2	8	6	29	4	47
	Types 3-4	8	24	9	1	42
Primary flake technology	*Non-cortical*	171	212	146	145	674
	Types 1-2	108	64	192	108	472
	Types 3-4	37	80	22	15	154
Debris	*Non-cortical*	226	179	130	186	721
	Types 1-2	38	16	69	61	241
	Types 3-4	21	8	12	11	52
Total non-cortical		435	463	321	355	1574
Total cortex types 1-2		154	86	290	173	703
Total cortex types 3-4		66	112	43	27	248

Table 5.26. Correlation between cortex types and visual source characterisation for all primary technology.

It should be noted that these patterns specifically apply to cortical artefacts. It is much more difficult to examine whether or not non-cortical SA, SB and SC artefacts indicate primary or secondary source use. It is possible that they simply indicate primary source use, since obsidian does not naturally have cortex. In that case, *Riu Mannu* figures indicate the slight predominance of primary SA over SC source use (SA: 27.6%; SA/SB: 29.4%; SC: 20.4%; SC/SB: 22.6). Following from the connections derived above, it is equally likely that the SA artefacts indicate primary source use, and SC pieces suggest secondary source use. In that case, primary source use is more common than secondary source use (57% vs. 43%).

Material characteristics: aesthetic preferences.

Visual characterisation also helps exploration of selection criteria and potential (aesthetic) preferences. I have therefore systematically recorded diagnostic characteristics for all artefacts with the exception of transect 14. Preliminary analysis indicated that 40% of all finds contained undiagnostic features (Section 4.4). Further analysis shows that figures for primary blade technology deviate from this trend with two-thirds of the *Riu Mannu* assemblage containing one or both of two diagnostic features: translucency and/or banding (Table 5.27).

Material Characteristics	Flake technology (n=1436)	Blade technology (n=268)
Glossy Black/Grey	19.2	9.3
Completely Translucent	1.2	0.7
Completely Translucent + Internal Patterning	4.7	10.1
Marginally Translucent	6.1	3.4
Marginally Translucent + Internal Patterning	4.3	7.5
Translucent	1.3	1.9
Translucent + Internal Patterning	11.8	21.3
Glossy Black/Grey + Banding	1.3	2.2
Glossy Black/Grey + Translucent	2.0	1.9
Grey/Black Banding	23.3	24.3
Possible Banding	5.6	5.2
Red/Black Banding	0.2	1.5
Opaque Black/Grey	19.1	10.8

Table 5.27. Material characteristics for all primary flake and blade material in percentages (cores, core rejuvenation pieces, complete and fragmented flakes and blades).

Translucency ranges from marginal to completely translucent, and from clear to internally visible flow patterns, with the latter as a most common feature. The second large group is non-translucent but also has a distinguishing feature:

banding. A substantial part of blade material is banded, with or without translucency as a second feature. Clearly, raw material use is not solely dependent on availability but shows people selected raw materials to suit aesthetic criteria (for discussion see Section 7.1.2.4).

Spatial distribution shows much local variety with little regional patterning, but some broad trends may be observed (Figure 5.21; Appendices 5.12-13):

- Figures for diagnostic material characteristics of flake and blade material are similar in the Arborèa and in Marmilla transect 12, or show differences between c. 10-15% (transect 04, 07, 09, and 10), and higher, c. 25%, (transects 13 and 23). The lack of distinct differences between flake and blade material echoes similar patterns in raw material selection criteria and flaking strategies, and reconfirms that the *Riu Mannu* assemblage is a predominantly a blade-like flake industry.
- Regional figures for blade material show little patterning, suggesting local, time, and space sensitive preferences prevailed. Transects 02 and 13 contain the lowest percentages (c.29%) of blade material with diagnostic features while transects 04 and 12 contain high percentages (c.84%). It appears that proximity to raw material sources only partially explains these patterns.
- Data for flake material show mostly similar patterns. Arborèa transect 02 again contains a low (28%) percentage of diagnostic features. Transects 09 and 12 show highest percentages (c.82%). Remaining transects contain flake material with c. 60 or 70-75% diagnostic features.

Figure 5.21. Percentage of diagnostic material characteristics (banding and/or translucency) for primary blade (above) and flake (below) material. Transect 14 data excluded.

5.3.2.3. Opening strategies

To gain understanding of opening strategies I have recorded the percentages of remaining cortex for all *Riu Mannu* artefacts and the location of cortex for all finds, with the exception of transect 14 (see also Table 3.21).

As noted earlier, cortical percentages are higher for flake than blade material and there appears to be a relationship between source location and technology. Exploration of the distribution over four categories in percentages of remaining cortex shows two trends indicative of differential raw material selection and source use (Tables 5.28-5.29). Inter-source difference between flake and blade material is slight, with most cortical cores retaining less than 25% cortex, irrespective of cortex type or technology. The clearest indications for different source use are:

- Cores with flake production and cortex types 1-2, which contain a high portion of pieces with up to 50% cortex. These are predominantly single and double-stage bipolar cores, for which cortical flakes and chunks with retaining cortex on one side served as parent material (see Section 5.3.1 above).
- Cores with primary source cortex, irrespective of type of removal, generally have higher percentages (c. 85%) of cores with less than 25% cortex. Complete unretouched flakes and blades, however, show fewer differences between opening strategies for primary or secondary sources.

Intra-source difference is equally slight, but unretouched complete blades from both primary and secondary sources have lower percentages (10% vs. 30%) of high (>75%) percentages of remaining cortex. Before it may be concluded that semi or non-cortical material was procured from primary and secondary sources for blade material, other factors should also to be taken into account. These include discard patterns, the degree to which flake material forms part of a blade industry (Section 5.1.2), the extent of core fragmentation and lastly, spatial and chronological dimensions may provide further insight in these differences (see Chapter 7).

	Primary flake technology			Primary blade technology		
	Cores (n=41)	CF (n=342)	FF (n=147)	Cores (n=11)	CB (n=30)	FB (n=16)
1-25%	48.8	43.0	57.1	63.6	63.3	62.5
25-50%	48.8	20.8	19.0	36.4	13.3	25.0
50-75%	2.4	8.2	6.8	-	10.0	6.3
75-100%	-	28.1	17.0	-	13.3	6.3

Table 5.28. Cortex percentage for cortex types 1-2 for all primary flake and blade material. CF= complete flakes, FF=fragmented flakes, CB= complete blades, FB= fragmented blades.

	Primary flake technology			Primary blade technology		
	Cores (n=13)	CF (n=93)	FF (n=57)	Cores (n=9)	CB (n=26)	FB (n=14)
1-25%	84.6	36.6	40.4	88.9	53.8	50.0
25-50%	15.4	19.4	21.1	11.1	26.9	21.4
50-75%	-	12.9	10.5	-	7.7	7.1
75-100%	-	31.2	28.1	-	11.5	21.4

Table 5.29. Cortex percentage for cortex types 3-4 for all primary flake and blade material. CF= complete flakes, FF=fragmented flakes, CB= complete blades, FB= fragmented blades.

Examining the location of remaining cortex also reveals some interesting patterns that further illuminate the observed differences in opening strategies (Table 5.30):

- The wider diversity of cortex locations on primary flake over blade material for all cortex types is partially explained as being a result of more diverse knapping strategies and greater directionality. Since this variety is particularly associated with secondary source cortex (types 1-2) with twice as many locations for complete flakes than blades, it is possible that part of the secondary source raw material used for flake production was procured in a different manner.
- The already noted difference between opening strategies for flake and blade material is emphasised here by higher percentages of cortex on lateral sides for blades, and much lower percentages of near-complete cortical dorsal surfaces. Interestingly, this does not seem to correspond to source location.

Cortex Location	Types 1-2				Types 3-4			
	CF (n=342)	*CB (n=30)*	*FF (n=147)*	*FB (n=16)*	*CF (n=93)*	*CB (n=26)*	*FF (n= 57)*	*FB (n=14)*
Platform	10.8	20.0	8.8	-	6.5	11.5	8.8	7.1
Proximal	0.6	-	3.4	-	4.3	-	-	-
Lateral side(s)	22.5	36.7	38.1	25.0	25.8	50.0	29.8	50.0
Middle	3.2	-	4.1	6.3	4.3	-	7.0	-
Distal	13.7	10.0	15.6	56.3	7.5	15.4	14.0	14.3
Platform & lateral	9.6	6.7	6.1	-	4.3	3.8	1.8	-
Platform & distal	1.2	3.3	-	-	-	-	-	-
Proximal & distal	0.6	-	-	-	-	-	-	-
Proximal & lateral	0.3	-	2.0	-	-	-	-	-
Middle & lateral	-	-	0.7	-	-	-	-	-
Middle & distal	0.6	-	-	-	-	-	-	-
Distal & lateral	4.7	3.3	1.4	6.3	6.5	7.7	3.5	-
Platform, lateral & distal	1.5	3.3	-	-	-	-	-	-
All but proximal & lateral	0.3	-	0.7	-	1.1	-	-	-
All but proximal	3.8	-	0.7	-	2.2	3.8	-	7.1
All but lateral side(s)	4.7	10.0	1.4	-	5.4	3.8	5.3	-
All but distal	0.9	-	1.4	-	1.1	-	1.8	-
Edges	0.3	-	1.4	-	-	-	1.8	7.1
All dorsal	20.8	6.7	15.0	6.3	31.2	3.8	26.3	14.3

Table 5.30. Cortex location for cortical flake and blade debitage. CF= complete flakes, FF=fragmented flakes, CB= complete blades, FB= fragmented blades.

In conclusion, analysis of raw material selection has shown that parent material for bipolar flake reduction relied heavily on the reuse of artefacts. Reconstructed parent material for platform flake and blade reduction has suggested the use of medium to large sized, sub-rounded to rounded nodules. Analysis of the relationship between size distribution and distance to primary and secondary raw material sources has shown a strong correlation between bipolar flake production and local, secondary SC sources. This is supported by visual characterisation data based on cortex types and material characteristics. Greater variation in use of source location and obsidian types exists for platform flake and blade reduction. Primary source use, predominantly SA but also some SC, is generally prevalent for primary blade technology, although local variations exist. Secondary source use, SC and to a lesser extent SA, occurs more frequently among flake production, but a significant portion of the dataset also points to primary SA and SC source use. Examination of opening strategies through remaining cortex percentages and cortex location, has tentatively pointed towards different procurement strategies for flake and blade material, with semi-cortical or non-cortical nodules for blade production. Before it may be concluded that blade production was at least partially spatially separate, other factors such as use and discard must also be taken into account. Lastly, exploration of material characteristics for aesthetic preferences has shown that particularly blade material contains a high percentage of diagnostic features, translucency and banding, but little regional patterning exists.

5.4. Knapping abilities

As outlined earlier, I examine knapping abilities on an assemblage level rather than looking for skilled and unskilled knappers or the degree of skill needed for specific reduction sequences. Three elements that are particularly insightful have been examined in detail (for references see Sections 2.6; 3.4.2.4; for variables and attributes see Table 3.26):

1) Consistency and intensity in knapping
2) Degrees of nodule manipulation, core abandonment, and evidence for 'novice' knapping.
3) Presence of technical errors and evidence for corrections

5.4.1. Consistency and intensity of knapping

For the *Riu Mannu* dataset I have examined consistency and intensity of knapping through two main elements: size analysis and the ratio core stage to number of previous removals. Earlier size analysis showed consistent raw material selection criteria for the whole *Riu Mannu* dataset, despite widely varying sizes of available raw material (Section 5.3.1.1). Size comparisons are also useful for the study of consistency in knapping practices, in particular co-efficient of variation, standard deviation and length/thickness and length/width ratios.

5.4.1.1. Standard deviation and co-efficient of variation for artefact sizes

The co-efficient of variation[1] is increasingly used as a means to explore variation in archaeological assemblages, especially in craft specialisation studies (for discussion and references see Section 2.4.2; Table 2.2; and

[1] The co-efficient = standard deviation / mean (and x100 when presented in percentages)

Bamforth & Finlay in press; Eerkens 2000). Admittedly, excavated assemblages would be better suited for analysis due to the tighter spatial and chronological control, but it is worthwhile to explore survey data as a first means of assessment. Keeping this caveat in mind, some broad patterns may be noted for length and width (Table 5.31):

- Bipolar and ad hoc blade knapping as recorded on cores, while rare, does not appear to be unskilled. Standard deviation and the co-efficient of variation (C/V) for ad hoc knapped blade lengths are lower than for those knapped with a bipolar technique. In contrast, flakes made by ad hoc knapping have the widest variation in length and width standard deviations and co-efficient of variation, which might be because they are most frequently knapped off multi-stage cores.
- Standard deviations and the co-efficient of variation for length and widths of platform flake removal mirror those for platform blade removal and indicate similar low degrees of variation.
- Interestingly, the standard deviation and co-efficient is lowest for flake lengths on bipolar cores, the most common production method recorded on cores, while their widths correspond to data for platform reduced flake scars.

Thus, it may be concluded that while flaking techniques are simple, they are by no means completely non-standardised or unskilled (for further discussion see Section 7.1.2.3).

	BBR (n=11)		ABR n=5)		PBR (n=50)		BFR (n=79)		AFR (n=13)		PFR (n=27)	
	L	*W*	*L*	*W*	*L*	*W*	*L*	*W*	*L*	*W*	*W*	*L*
Average	16.7	13.7	26.5	7.3	25.9	12.5	17.1	14.7	18.6	13.6	22.9	19.7
Standard Deviation	8.0	9.2	5.2	2.6	8.5	4.9	2.9	5.4	11.1	8.5	8.2	6.9
Coefficient of Variation	0.5	0.7	0.2	0.4	0.3	0.4	0.2	0.4	0.6	0.6	0.4	0.4

Table 5.31. Average, standard deviation and co-efficient of variation for lengths and widths of flake and blade removals on cores, per main flaking technique.

Key to table:
BBR= bipolar blade removal
ABR= ad hoc blade removal
PBR= platform blade removal
BFR= bipolar flake removal
AFR= ad hoc flake removal
PFR= platform flake removal.
Note: in brackets is number of stages. (N flake cores= 75; N blade cores= 38).

Standard deviations and coefficient of variation for flake and blade debitage (complete pieces only) also show some interesting trends (Table 5.32):

- Variation for *blade lengths* is *higher* than core data, but figures for widths are lower. Variation for thickness is also low, undoubtedly as a result of the mostly uniform manner of reduction. Variation for flake length and width corresponds well with figures derived from platform flake cores and are generally low. Greater variation is seen in flake thickness, even when excluding outliers (C/V = 0.5), which might be because debitage was not further separated into bipolar-struck flakes and/or platform reduced flakes.

	Complete Blades (n=142)			Complete Flakes (n=1113)		
	L	W	T	L	W	T
Average	31.2	17.7	6	23.9	21.3	7
Standard Deviation	11.7	6.1	2.7	10.4	8.6	4.1
Coefficient of Variation	0.4	0.3	0.4	0.4	0.4	0.6

Table 5.32. Size comparisons for length (L), width (W) and thickness (T) *measurements for unretouched* debitage.

Exploring the spatial differences of overall co-efficients of variation, *e.g.* combining core, debitage, retouched and probably retouched data, shows that (Figure 5.22):

- Variation is high in the Arborèa, particularly for blade length and thickness in transect 05, which contrasts with previous suggestions for a single assemblage.
- Blade co-efficients of variation are very consistent in the Campidano, despite broad spatial and temporal differences. There are no noticeable differences between large assemblages (e.g. transect 04) and smaller assemblages (transect 02). Transect 23 is an exception (see below).
- Marmilla blade material is limited. Transects along the Mògoro gorge are consistent with the Campidano trends. Transect 12 is an exception.
- Transects 12 and 23 share seven similarities: 1) the majority of blade material is concentrated in a single area (12-a, and 23-B-C), 2) both are predominantly lithics-only sites and have proven difficult to date, 3) neither provide evidence for settlement, 4) both are located in or close to raw material sources, 5) both have high blade indices suggestive of a blade industry (40% and 24.7% respectively), 6) both consist predominantly of cores with blade reduction and unretouched blades,

and 7) both have very similar co-efficients of variation, with little variation compared to other collections. Points 1-6 support the idea that spatially distinct phases of blade reduction existed, while point 7 tentatively suggests higher-than-average knapping skills. *Tentatively* is the operative word here, and it is important to keep in mind that both assemblages are very small (for discussion see Chapter 7).

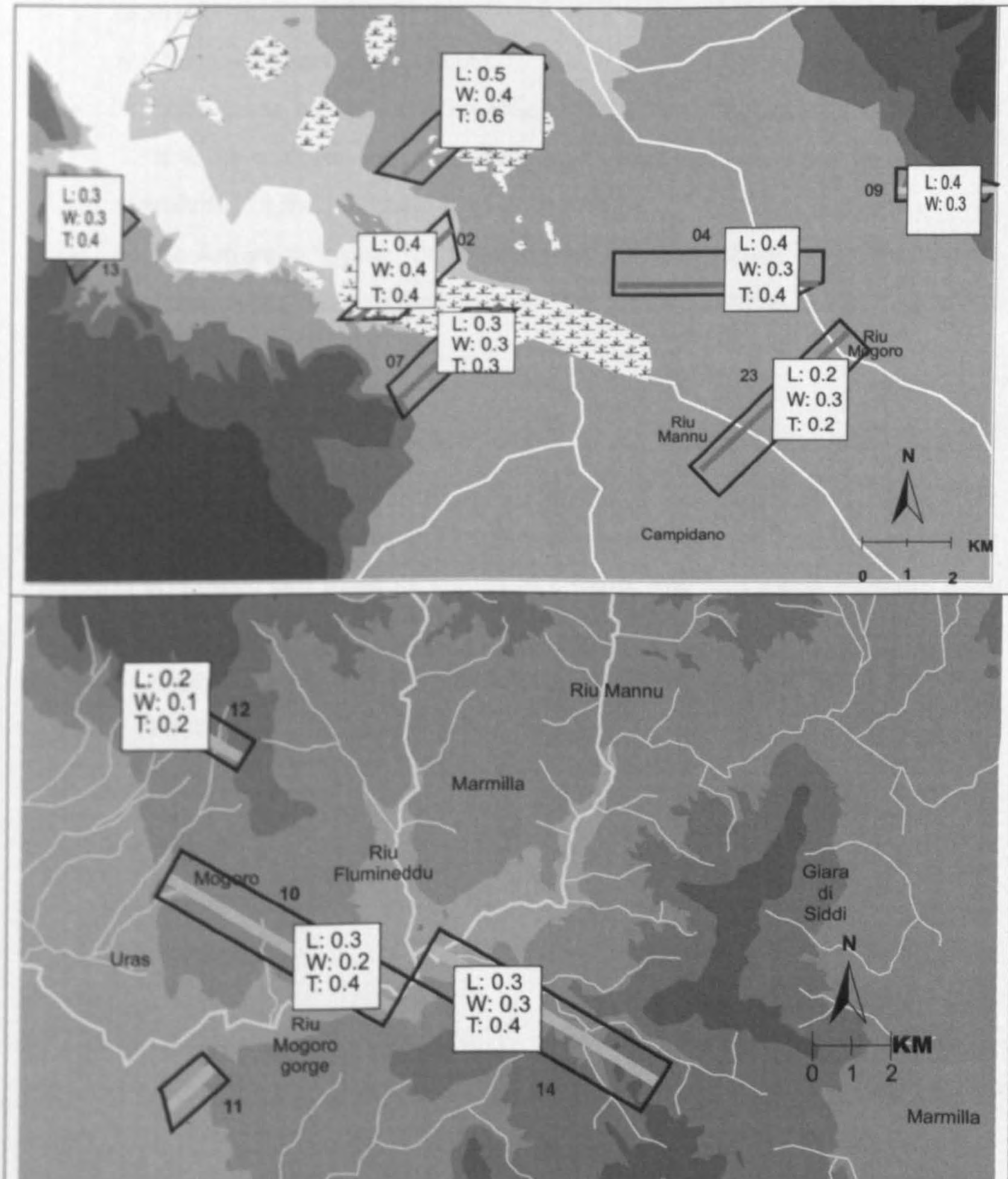


Figure 5.22. Blade co-efficient of variation in the Arborèa and Campidano (above) and Marmilla (below).

Co-efficients for flake data are surprisingly uniform across all three regions and show very similar levels of (low) variation despite more varied flaking strategies (Figure 5.23). Co-efficients for lengths are limited to 0.3-0.4, while figures for widths and thicknesses show slightly more variation (respectively between 0.2-0.4 and 03-0.5). Two similarities and one aspect that contrasts blade data may be summarised as:

- Blade and flake technologies in Campidano transects 04, 07, 13 and Marmilla transect 14, show similar degrees of variation (as expressed by the co-efficient of variation).
- As with blade technology, co-efficients for flake technology in transects 12 and 23 suggest less variation, albeit less distinct, since flake figures merely fall in the narrower end of the range.
- In the Arborèa, figures for flake material are clearly different from blade material with less variation for the latter despite higher artefact numbers.

It may be concluded that variation is low to moderate. Data also supports earlier-made observations that some primary flake and blade technology lithic practices are very consistent. *Habitus* is particularly strong in knapping traditions and basic raw material selection criteria, and is not easily tied to time or space. Choices in source use, both in terms of source locations and obsidian types, and aesthetic preferences, are more subject to spatial and temporal variation (for discussion see Chapter 7).

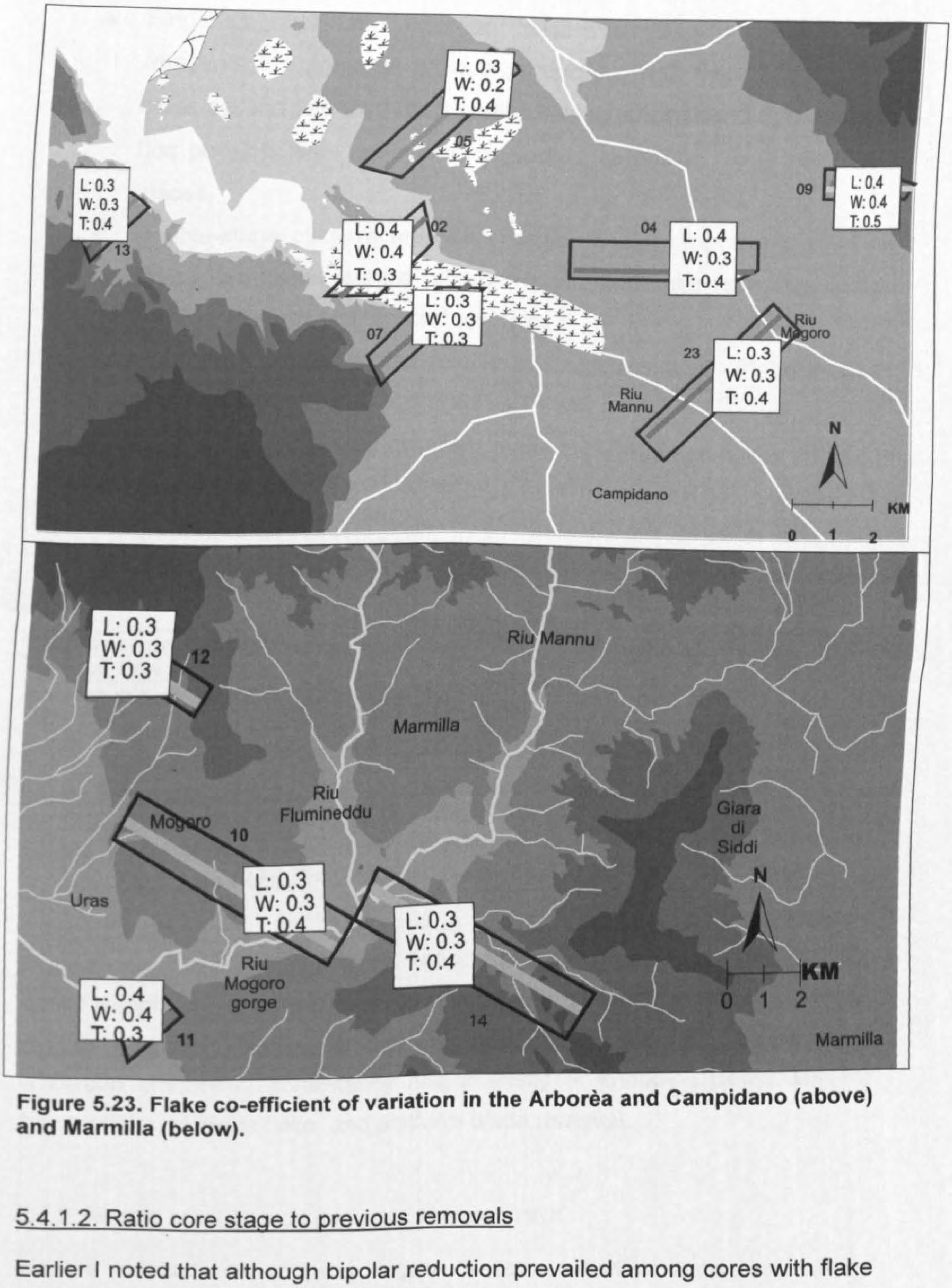


Figure 5.23. Flake co-efficient of variation in the Arborèa and Campidano (above) and Marmilla (below).

5.4.1.2. <u>Ratio core stage to previous removals</u>

Earlier I noted that although bipolar reduction prevailed among cores with flake reduction, this did *not necessarily* indicate knapping intensity or resultant high yields of debitage (see Section 5.2.1.1). In this respect, *examining the ratio of* core stages to number of previous removals may be more informative. Analysis shows that (Table 5.33):

- Single-stage platform reduction yields the highest number of (final) removals for mixed flake/blade production, with flake and blade as close second and third most prolific flaking strategies. Single-stage ad hoc possible flake removal also yields a surprisingly high number of pieces.
- Double-stage platform reduction results in fewer removals, whereby mixed flake/blade is most productive, platform flake reduction and ad hoc flake removal are second and third.
- Multi-stage reduction also results in fewer removals. Platform blade and mixed flake/blade yield most removals.
- Bipolar reduction does not yield many removals per stage but is the most consistent reduction method.

	Single–stage cores			Double-stage cores			Multi-stage Cores		
	S	*RM*	*Ratio*	*S*	*RM*	*Ratio*	*S*	*RM*	*Ratio*
Platform blade reduction	13	75	1 : 5.8	2	3	1 : 1.5	9	31	1 : 3.4
Platform flake reduction	8	48	1 : 6	9	30	1 : 3.3	14	29	1 : 2.1
Platform mixed/flake blade reduction	9	66	1 : 7.3	3	14	1 : 4.7	1	3	1 : 3
Bipolar flake reduction	36	65	1 : 1.8	45	66	1 : 1.5	6	10	1 : 1.7
Bipolar blade reduction	2	6	1 : 3	3	3	1 : 1	-	-	-
Ad hoc flake removal	4	8	1 : 2	2	6	1 : 3	12	13	1 : 1.1
Ad hoc possible flake removal	1	6	1 : 6	2	2	1 : 1	6	6	1 : 1

Table 5.33. Ratio core stage to previous removal for all *Riu Mannu* cores (n= 115) per main flaking strategy. S= number of stages, RM is number of removals.

In conclusion, analysis shows that knapping strategies, which are traditionally called simple or expedient *e.g.* flake and informal blade industries, can be skilfully knapped. There is, despite wide geographical and temporal variation, a certain amount of consistency and intensity of knapping particularly for bipolar flake, platform flake, and platform blade removal.

5.4.2. Nodule manipulation and core abandonment

Nodule manipulation and the degree of core reduction were explored by estimating what percentages of original platform areas have remained after the knapping final stages. Only a few core stages (8.2%) have less than 75% of the original platform area remaining. When excluding bipolar and ad hoc knapping, since these have by definition no formal or unprepared platforms, almost a quarter (14.3%) of platform-reduced core stages have less than 50%

of the original platform remaining (Table 5.34). These percentages are not surprising in a raw material rich environment.

Reduction	Stages	Unclear	0-25%	c. 50%	c. 75%	100%	Total
Bipolar flake removal	SS	20	-	-	-	17	37
	DS	19	-	-	-	26	45
	MS	3	-	-	-	3	6
Bipolar blade removal	SS	-	-	-	-	2	2
	DS	-	-	-	-	1	1
Platform flake removal	SS	2	1	-	1	6	10
	DS	3	-	-	-	6	9
	MS	11	-	3	-	3	17
Platform blade removal	SS	3	2	2	1	6	14
	DS	2	-	-	-	-	2
	MS	6	-	1	-	3	10
Platform mixed removal	SS	-	1	2	-	6	9
	DS	2	-	-	-	1	3
	MS	6	-	-	-	1	7
Platform possible flake removal	SS	-	-	-	1	-	1
	DS	-	-	-	-	1	1
	MS	-	-	-	-	1	1
Ad hoc flake removal	SS	1	-	-	1	2	4
	DS	1	-	-	-	1	2
	MS	6	-	-	-	1	7
Ad hoc blade removal	DS	2	-	-	-	-	2
Ad hoc mixed removal	DS	1	-	-	-	-	1
Ad hoc possible flake removal	MS	4	-	-	-		4
Total		92	4	8	4	87	195

Table 5.34. Remaining percentage of platform area for final core stages. All cores (n=115). SS= single-stage, DS=double-stage, MS= multi-stage cores.

When examining skill, it is also worthwhile to assess probable reasons for core abandonment. Analysis indicates that raw material characteristics and technical errors are the main reasons for core abandonment (Tables 5.35-5.36).

Size is a particular cause for abandonment, especially for bipolar cores. Only five cores were abandoned as a result of raw material flaws (fissures, inclusions etc). The generally flawless nature of obsidian is certainly a contributing factor, but human preference in raw material selection criteria also appears to have played a role. Reduction of raw material nodules containing clearly visible phenocrysts, which typically occur in SB obsidian, is rarely seen among any of studied *Riu Mannu* artefacts.

Type of reduction	Single- stage						Double-stage					Multi-stage		
	S	Fl	O	A	S/H	S/H/A	S	Fl	A	S/H	S/H/A	A	S/H	S
Platform blade	5	2	1	2	1	1	-	-	-	-	-	4	1	-
Platform flake	1	-	-	3	1	2	1	1	6	1	-	7	4	1
Platform mixed flake/ blade	3	-	-	1	1	2	1	-	-	-	1	1	-	-
Platform possible flake	1	-	-	-	-	-	1	-	-	-	-	-	-	-
Bipolar flake	19	2	-	4	2	-	14	1	16	3	1	1	-	-
Bipolar blade	2	-	-	-	-	-	1	-	-	-	-	-	-	-
Ad hoc flake	2	-	-	-	-	-	-	-	-	-	-	2	5	-
Ad hoc mixed flake/blade	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Ad hoc possible flake	-	-	-	-	-	-	-	-	-	-	-	1	2	-
Total	33	4	1	10	5	5	18	2	22	5	2	16	12	1

Table 5.35. Reasons for core stage abandonment.

Key to Table:
S= size
Fl= Flaws
O= overshot
S/H= steps/hinges
A= platform angle
S/H/A= steps/hinges and platform angle

Nine of 12 single-stage platform-reduced core stages were considered truly exhausted. All but two of these are cores with blade or mixed flake/blade removals (Table 5.36). This corresponds with other data that suggest a higher degree of core manipulation and fragmentation for flake production, such as size distribution and the low number of platform flake cores in relation to platform-reduced flake debitage.

Flaking strategy	Reason for abandonment	Total
Platform mixed flake/blade removal	Steps/hinges & angle	2
	Steps/hinges	1
	Size	1
Platform blade removal	Steps/hinges	2
	Size	1
Platform flake removal	Steps/hinges & angle	1
Platform possible flake removal	Size	1
Total		9

Table 5.36. Exhausted single-stage platform cores and reasons for their abandonment.

Abandonment due to technical errors predominantly consists of step/hinge terminations (22.2%). Overshot cores, where flake removal has accidentally removed the bottom part of a core, are rare (0.9% of all cores) although a quarter of rejuvenation flakes indicates it occurs more often (25.4%). Core abandonment as a result of too steep platform angles occurs predominantly on cores with flake removal, and less often on those with blade removal.

5.4.3. Technical errors and evidence for corrections

As noted previously, certain specific variables and artefacts assist assessment of technical errors. Here I examine step/hinge terminations in dorsal scar patterns as a result of erroneous previous removals, and as distal ends on debitage, absence/presence of core rejuvenation flakes, and evidence for 'novice' cores (see Section 3.4.2.4).

5.4.3.1. Step/hinge terminations

Step and hinge terminations are present on dorsal scar patterns of all flake and blade material (Table 5.37).

- Sample sizes are small, suggesting that relatively few mistakes were made. Blade technology contains higher step/hinge percentages than flake material, but is very concentrated. The only substantial number of artefacts lie in transect 04.
- Complete blades have fewer step/hinge terminations on dorsal scar patterns than complete flakes, but retouched and probably retouched blades have higher percentages than their flake equivalents.
- Regional differences occur, although there is no clear pattern. In the Arborèa step/hinge terminations only occur on dorsal scar patters of flake material. In the Campidano figures differ with overall low percentages (0-5%) in transect 23 and 09 and higher percentages (7.8-10.5%) in transects 04 and 07. In the Marmilla, the highest percentages are found in transect 12, but the very small sample size negates its statistical value.
- Only a small part of *Riu Mannu* debris (1.7%) contains step/hinge terminations.

	Arborèa		Campidano				Marmilla				
	02	05	04	07	09	23	10	12	14	Total	%
Complete blades (n=143)	-	-	7	1	1	-	-	-	-	9	6.3
Broken blades (n=139)	-	-	5	-	-	-	-	1	-	6	4.6
Possible retouched blades (n=54)	-	-	4	1	-	-	1	-	-	6	11.1
Retouched blades (n=49)	-	-	4	-	-	-	-	-	-	4	8.2
Total blades	-	-	**20**	**2**	**1**	-	**1**	**1**	-	**25**	
% of transect blade technology	-	-	*8*	*10.5*	*5.3*	-	*10*	*14.3*	-	*9.0*	
Complete flakes (n=1112)	2	2	20	10	1	2	19	1	23	80	9.7
Broken flakes (n=827)	1	-	10	1	-	2	3	-	16	33	3.0
Possible retouched flakes (n=271)	-	-	6	1	-	-	3	-	4	14	5.2
Retouched flakes (n=168)	-	-	1	2	-	-	1	-	3	7	4.2
Total flakes	**3**	**2**	**37**	**14**	**1**	**4**	**26**	**1**	**46**	**134**	
% of transect flake technology	*3.7*	*8.7*	*7.8*	*10.4*	*1.9*	*2.8*	*7.6*	*10.5*	*6.4*	*5.6*	

Table 5. 37. Presence of step and/or hinge terminations on dorsal scar patterns.

Distal ends that indicate technical mistakes are subdivided into: steps, hinges, and overshoots, and occur on debitage and where visible retouched and probably retouched pieces. Figures are estimated because it proved difficult to separate stepped/hinged ends from deliberate breakage and post depositional fragmentation. Likewise, it was not always possible to distinguish clearly between accidental core rejuvenation flakes, overshot flakes which have (accidentally) removed the bottom part of the core, and ordinary flakes that could be overshot or have a thick chunky distal end due to parent material morphology (*i.e.* pseudo overshot flakes). In recognition of these classification difficulties, the latter have remained in the ordinary flake category and are included in this discussion, while the former is discussed below.

Observed trends generally correspond to those noted for steps/hinges in cores and dorsal patterns although some differences exist. Analysis shows that (Table 5.38):

- Pseudo overshot flakes while rare, with only 31 pieces, have an intriguing spatial distribution. Transect 04 contains mostly unretouched pseudo overshot flakes, whereas in transect 14 most of these are retouched flakes.
- Mirroring data for step/hinge terminations in dorsal scar patterns, technical errors on distal ends are higher for blade than flake material (30.7% vs. 11.7%). A high percentage of complete unretouched

blades have step/hinge distal ends, which contrasts with the low figures for step/hinge terminations on cores and dorsal scar patterns.

- In contrast to dorsal scar pattern data, step/hinge ends on blades are more widespread and low numbers are found in virtually every transect. The bulk, however, is again concentrated in transect 04.

		Arborèa		Campidano					Marmilla			Total	
		02	05	04	07	09	13	23	10	12	14	N	%
Complete blades (n=143)	*S/H*	3	4	32	8	-	4	6	-	1	1	59	41.3
	PO	-	-	3	-	-	-	-	-	-	-	3	2.1
Broken blades (n=139)	*S/H*	-	1	10	1	-	-	1	1	-	-	14	10.1
Possibly retouched blades (n=54)	*S/H*	-	2	3	-	-	-	-	-	-	-	5	9.3
Retouched blades (n=49)	*S/H*	1	-	3	-	-	-	-	-	-	-	4	8.2
Total blade technology		4	7	51	9	-	4	7	1	1	1	85	*30.7%*
%of total transect blade assemblage		*57.1*	*63.6*	*20.3*	*47.4*	-	*44.4*	*14.9*	*10*	*14.3*	*12.5*		
Complete flakes (n=1112)	*S/H*	15	5	62	29	1	-	4	18	-	34	168	15.1
	PO	-	-	6	1	-	-	-	-	-	2	9	0.8
Broken flakes (n=827)	*S/H*	1	-	6	3	2	2	2	3	-	33	52	6.3
	PO	-	-	6	-	-	1	-	-	-	2	9	1.1
Possibly retouched flakes (n=271)	*S/H*	-	-	5	1	-	-	-	5	-	6	17	6.3
Retouched flakes (n=168)	*S/H*	-	-	3	2	1	1	-	-	-	7	14	8.3
	PO	-	-	1	-	-	-	-	-	-	4	5	3.0
	PO	-	-	1	1	-	-	-	-	-	3	5	1.8
Total of flake technology		16	5	90	8	4	4	6	26	-	91	279	
% of total transect flake assemblage		*19.5*	*21.7*	*12.3*	*24*	*3.9*	*12.9*	*4.2*	*7.3*	-	*12.6*		
Total		20	12	141	46	4	8	13	27	1	92	364	

Table 5.38. Distal ends for unretouched, possibly retouched and retouched flakes and blades. S/H= stepped/hinged, PO= possibly overshot.

- Some regional trends may also be seen. In the Arborèa, percentages for step/hinge terminations on distal blade material are exceptionally high (57-63%), which contrasts to figures for terminations in dorsal scar patterns. A similar difference exists for Arborèa flake material. Percentages vary between 10-47% in the Campidano, with the highest figures for transects 07 and 13, which are comparable to Arborèa data. In the Marmilla, step/hinge ends for blade material are extremely low, but the low artefact quantities (one for each transect) negates their statistical value.

- Percentages for step/hinge terminations on distal flake ends generally mirror those recorded for step/hinge terminations in dorsal scar patterns, and excluding Arborèa data, do not contain clear contrasts.

In sum, technical mistakes as evidenced by step and hinge terminations are low with higher overall percentages for blade than flake production. The bulk of evidence for technical mistakes in blade production is restricted to transect 04, while those for flake production are concentrated in two other Mògoro area transects, 10 and 14.

5.4.3.2. Core rejuvenation

Three main types of core rejuvenation have been recognised in the *Riu Mannu* data set (Table 5.39): 1) side-struck platform rejuvenation flakes, 2) longitudinal core trimming flakes and 3) overshot flakes. The first group contains flakes, which were often struck at a 45-degree angle to the core surface to intentionally remove (part of) a core platform, thus ensuring continuation of reduction. Observations on the types of cores rejuvenated were only made occasionally and therefore the number of cores with blade reduction is minimal. Most unspecified core edge rejuvenation flakes have been attributed to flake core rejuvenation by default. The bulk of finds are restricted to transects 04 and 14, and while artefact numbers for transects 02 and 12 are low, they are interesting given the paucity of cores (see Section 5.1.1). Longitudinal trimming flakes are the largest group of core rejuvenation flakes retrieved, and again are concentrated in transect 04 and 14. These are flakes or blades that deliberately remove a section of the core, for example to remove stepped or hinged sections. They are often struck along the length of the core in the same direction as other removals. It is not always possible to distinguish them clearly from regular flake removal. Core trimming flakes aimed at removing step/hinge terminations along the platform edge or in core bodies are more easily recognised (Figure 5.24). These occur in small percentages in *Riu Mannu* dataset and occur more often in unretouched blades than flake assemblages – 3.6% for complete flakes and 2.8% for broken flakes versus 7% for complete blades and 3.8% for broken blades (Table 5.39). Lastly, overshot flakes are flakes that have removed, often accidentally, the lower part of the core along with the flake, resulting in a very characteristic thick and protruding distal end.

	02	04	07	09	10	12	13	14	23	Total
(Flake) core edge platform rejuvenation	5	12	1	1	2	3	1	14	-	39
Blade core rejuvenation flake	-	1	1	-	-	1	-	-	-	3
(Blade) core trimming flake	-	1	-	-	-	-	-	-	-	1
(Flake) core trimming flake	-	1	-	-	-	-	-	2	-	3
Core trimming: stacked steps removal on complete blades	1	7	-	-	-	-	-	-	2	10
Core trimming: stacked steps removal on broken blades	-	4	-	-	-	-	-	-	1	5
Core trimming: stacked steps removal on complete flakes	1	12	4	1	4	-	1	14	3	40
Core trimming: stacked steps removal on broken flakes	-	5	3	-	3	-	2	9	2	23
Overshot blade	-	2	-	-	-	-	-	-	-	2
Overshot flake	1	4	-	1	-	-	1	8	-	15
Total	8	49	9	3	9	4	5	47	8	141

Table 5.39. Specification of *Riu Mannu* core rejuvenation flakes. Classifications in brackets indicate suggested core type.

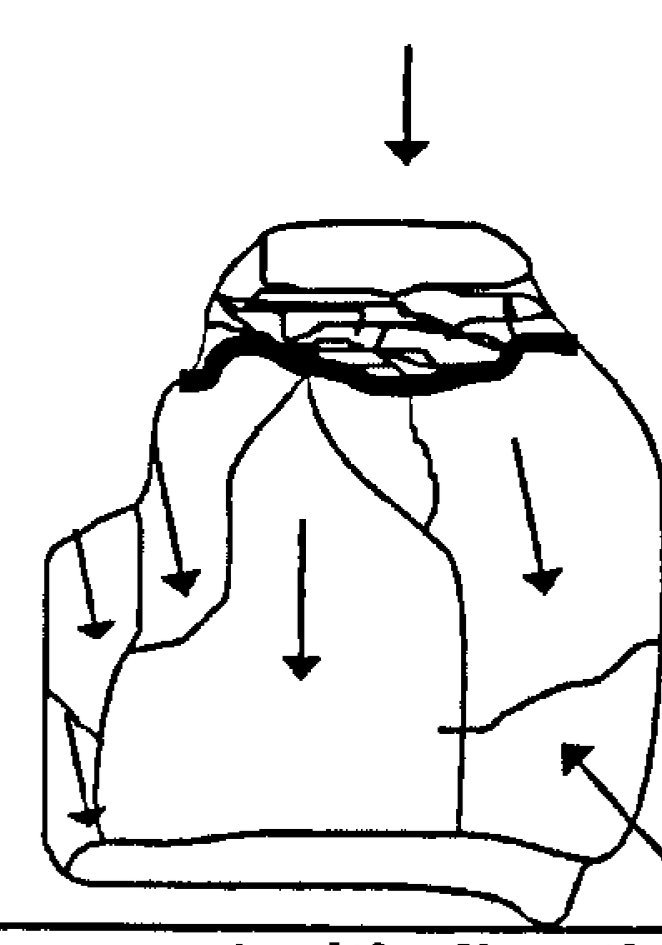


Figure 5.24. Proximal blade fragment with direction of previous removal (arrows) and extensive stacked steps at the platform (thick black line upwards). Arrow at top indicates direction from which blade was removed. Actual size. *Riu Mannu* find: 04.09143.v.01

5.4.3.3. 'Novice' core reduction

So far, this exploration of knapping skills has been carried out on an assemblage level, and has not tried to identify levels of skills – *e.g.* between masters and novices, or specialisation. During recording, however, four cores stood out as 'novice' cores (Table 5.40). They share similar characteristics such as having extremely battered edges, many attempts at removals, and countless steps/hinges along the edge of platforms and on core bodies. Flaking strategies are characterised by ad hoc flake and possible flake removals from many different directions (Tables 5.12-5.13). Interestingly, it appears that a number of multi-stage cores do not indicate more intensive use of raw material, but instead demonstrate several attempts at learning to knap. Their generally larger sizes support this interpretation (see Section 5.3.1.1).

Type	Flaking strategies
8-stage core	3 stages platform flake, 4 stages ad hoc flake and 1 stage ad hoc possible flake removals
5-stage core	4 stages of ad hoc possible flake and 1 stage of platform flake removal
3-stage core	2 stages platform flake and 1 stage ad hoc flake removal
2-stage core	Platform mixed flake/blade and platform flake removal

Table 5.40. *Riu Mannu* 'novice' cores.

A small percentage (4.3%) of debris also shows probable evidence for attempted removal of bipolar and ad hoc flaking, and potentially deliberately split nodules (Table 5.41). Spatial distribution shows that most of this material is found in transects in the secondary raw material source zone (*e.g.* transects 04, 10, 14). Moreover, some pieces were identified as fragmented cores, although here it should be kept in mind that the majority of debris might also represent core fragmentation. Given that direct, probably hard hammer, percussion has been suggested for most material, coupled with widespread use of bipolar technology, high percentages of chunky debris and shatter, core fragmentation is highly likely.

	04	07	09	10	11	13	14	23	Total
Possible ad hoc flaking	13	2	-	2	-	-	8	1	26
Possible bipolar removal	5	-	3	5	-	1	7	2	23
Possible core fragments	6	-	1	4	1-#	-	22	-	34
Possible split nodule	1	-	1	3	-	-	-	-	5
Total	25	2	5	14	1	1	37	3	88

Table 5.41. Possible flaking strategies recorded for *Riu Mannu* debris.

5.5. Conclusion: primary technology

Two main primary technologies, flake and blade, have been examined in detail focussing on where knapping occurred, and which knapping traditions, strategies, and skills could be discerned. Comparison of core, core rejuvenation flakes and flake and blade debitage distribution patterns showed that the majority of primary knapping took place along the valley and terraces of the river Mògoro in the Campidano and Marmilla. Distribution and density patterns are uneven, and an interesting discrepancy between core and core rejuvenation distribution was noted. The latter is much more place-specific than the former, as a significant portion of cores were found in isolation. Blade production was particularly restricted and even blade material occurs throughout all three landscapes. Blade indices only indicated blade technology for four specific locations, 04-B, 12-a, 23-B-C and 05-D.

A wide variety of knapping strategies have been recognised for the production of blades and flakes, which combined into five traditions consisting of single-stage platform flake, blade and mixed flake/blade removal and single-and double-stage bipolar removals. Three recurring variations were noted alongside a considerable number of unique (combinations of) flaking strategies. Interesting spatial patterning occurred, such as the bulk of unique strategies lying in the wider Mògoro area. Likewise, strong traditions were noted in mode of percussion. Direct percussion, presumably hard hammer, produced the majority of primary flake and blade material, although a number of variables suggested soft hammer percussion and/or indirect percussion may have also been employed. It was argued that although blade production occurred this was an informal and not prismatic blade technology.

Raw material analysis showed that types of parent material, especially size and shape, were very consistent despite broad spatial and temporal differences in the research area. Cortical flakes and chunks were (re-)used for bipolar flaking, and fist-sized to large rounded to sub-rounded nodules were selected for platform flake and blade reduction.

Comparative analysis of spatial patterning of core lengths, complete flake and blade lengths and average lengths of previous removals on cores in relation to distance to raw material sources, provided insight into procurement patterns. Parent material for bipolar flake reduction was locally obtained. Based on source and cortex data it was proposed that that SC and SA obsidian was procured from nearby secondary sources. Parent material for platform flake and blade reduction showed greater variation, and there is evidence for both primary and secondary source use of SA and SC obsidian. Broadly speaking, blade material is most frequently associated with primary SA, and to a lesser extent SC source use, although a significant portion of secondary SC and less frequently SA source procurement also exists. Raw material procurement for platform flake reduction indicates local source use. Primary source use occurs in areas close to primary sources, and secondary source use in secondary source areas. Opening strategies have shown a slight difference between platform flake and blade reduction. The higher cortical assemblage percentages, more artefacts with remaining cortex percentages over 50%, and a wider variation in cortex location demonstrate that cortical nodules were procured for flake reduction and taken to the site for reduction. Opening strategy data for blade material has hinted at spatially distinct knapping phases. Procurement, reduction and use/discard do not always occur in the same locations (for detailed discussion see Section 7.1).

Visual characterisation did not only reveal source use, but has also shown that diagnostics features such as banding and translucency was generally more common in blade material. The absence of any regional patterning suggests that local aesthetic preferences prevailed.

Assessment of knapping abilities showed that despite being 'simple' bipolar flake reduction, platform flake and blade reduction were generally skilfully knapped. It is interesting that the majority of technical mistakes, their corrections, and so-called novice cores, all occur in the same wider Mògoro area, in the heartland of secondary raw material sources.

It is clear from the above that many tantalising patterns have come to the fore. In the next chapter I first turn to a similar examination of secondary technology before turning in the last chapter to a more detailed discussion of procurement, production, and use strategies.