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Exploitation of allochthonous raw materials in hunter–gatherer contexts: Archaeological sites of Fagnano Lake, Tierra del Fuego, Argentina

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ABSTRACT

The exploitation of allochthonous raw materials has been registered in several archaeological sites of Isla Grande de Tierra del Fuego. The best-known examples are those of green obsidian (considered to originate from a source in the southern Magellan strait) and industrial glass (which was adopted after the Europeans' arrival). A new case is the Miraflores silicified tuff, identified at Kami 1 archaeological site (Late Holocene), on the southern shore of Fagnano Lake, which comes from an outcrop located to the north of the island, more than 200 km away.

Since the identification of this raw material in Kami 1, a techno-functional experimental program was carried out in order to characterize the properties of this Miraflores silicified tuff, particularly regarding manufacturing techniques, as well as behavior of edges during different utilization processes. Experimental tools made on samples from the Miraflores outcrop were used to work on various materials (wood, leather and bone) and analysed through low and high power microscopy.

This article has three main purposes. The first is to present the results of the experimental study. The second is to discuss the techno-functional analysis of lithic archaeological artifacts on silicified tuff from Kami 1. The third is to evaluate the causes for selection of this raw material for the tool morphologies and uses identified in the site, as well as possible acquisition strategies implemented by hunter–gatherer societies of the central area of Tierra del Fuego.

1. Introduction

The exploitation of allochthonous raw materials has been recorded in various archaeological sites of the Isla Grande de Tierra del Fuego. The best-known examples are those of green obsidian and glass. Green obsidian was discovered in archaeological sites of marine hunter–gatherers, on the southern coast of the Island towards the Beagle Channel, dating from around 6200 BP: the second component of Tunnel I, Imiwaia (layer M), and Binushmuka (Orquera and Piana, 1999; Álvarez, 2003). This green obsidian has also been documented in inland hunter–gatherer sites of the northern part of the island, but all belong to Late Holocene contexts: Avilés (Santiago, 2009), Porvenir Norte 28, Rio Caleta 4, Amalia and even many sites of Marazzi locality (Oría et al., 2010). A series of analyses confirms that all samples of green obsidian discovered in the region come from the same source (Stern and Prieto, 1991; Stern, 2000). Because of the spatial distribution of findings, most of the authors believe that this source was located somewhere towards the southwestern part of Magellan Strait (Morello et al., 2001, 2004). When obsidian is present, its concentration is extremely low, and it consists of bifacial points or large flakes, suggesting arrival of finished tools in foreign materials by some type of exchange.

Glass is a raw material of industrial origin, which came to Tierra del Fuego with the European expeditions, since the XVII century. Ethnographic literature and collections show that by the beginning of the XXth century, due to its properties for technology and use, glass had almost replaced traditional stone, especially for the manufacturing of endscrapers and projectile points (De Angelis and Mansur, 2010). Initially, glass was obtained from shipwrecks that left remains along the shores of the archipelago, and later from the European settlers. Glass as raw material appears sporadically in coastal sites dating from this period, such as Acatushún (Piana et al., 2006) and the recent component of Lancha Packewaia (Orquera

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et al., 1978) as well as in inland sites such as Tres Arroyos (Massone et al., 1993) and Kami 7 (Parmigiani et al., 2013). It is the only raw material represented at Ewan, a ceremonial locality belonging to a hunter–gatherer population, dating from the end of the XIXth century (Mansur and Piqué, 2012).

In this paper, we want to discuss a new allochthonous material discovered at Kami 1, a site located on the southern shore of Lake Fagnano, in the mountain region of the central area of Tierra del Fuego (Mansur et al., 2010; Mansur and De Angelis, 2013). It is a glassy silicified tuff, with a gunmetal color, dark gray streaks and some reddish impurities, from the Miraflores outcrop, located in the north of the island, over 200 km away (Fig. 1). Previously, this material had been recorded at sites in the north of Isla Grande, such as Marazzi, Río Torcido, Punta Catalina, Punta Baxa, Tres Arroyos, Estancia Dos Marías (Prieto et al., 2004), Laguna al Noroeste de Filaret (NOF), and Laguna Patria (Borrazzo, 2009, 2010; Borrazzo et al., 2010).

We have recently published a study where we discuss some hypotheses regarding the use of this raw material for the manufacture of small end-scrapers and micro-scrapers (De Angelis, 2012b). However, it was clear that an experimental program was required in order to understand the role of this material in the archaeological assemblage. The reasons were principally the large number of artifacts made out of this raw material found at Kami 1 site (5.7% of the assemblage, including 25 retouched tools and 411 débitage), as well as the particular characteristics of the retouched tools. We wanted to know the causes that made people choose this raw material and then, to evaluate them in relation to different aspects of resource management in the central strip of Tierra del Fuego.

For this reason, we designed an experimental program on techno-functional characteristics of Miraflores silicified tuff. Its main objective was to determine its quality for different manufacturing techniques (percussion, pressure, etc.), as well as the behavior of edges when they were used to accomplish different activities. We manufactured tools on samples from the Miraflores outcrop, and then we used them to work on different materials (wood, hide and bone).

Thus, this paper has three main purposes. The first is to introduce briefly some of the results from the experimental program concerning the technological and functional characteristics of Miraflores silicified tuff. The second is to present and discuss results of the techno-functional analysis of the archaeological artifacts on Miraflores silicified tuff discovered at Kami 1 site, in the light of the results from the experimental work. The third is to evaluate the causes for selecting Miraflores silicified tuff for the tool types, edge shapes and uses that were identified in the archaeological assemblage, and the possible ways in which the hunter–gatherer societies in the central strip of Tierra del Fuego managed to acquire this raw material.

2. Lithic resources management

The strategies for lithic resource management constitute one of the key points in production and social reproduction processes of many hunter–gatherer societies. Rocks were one of the most exploited resources, due to their importance as fundamental raw materials for the manufacture of tools, which in turn were used to process other resources. Partly due to this reason, lithic assemblages have become important sources of information for archaeological interpretation, because they allow us to get closer to everyday and subsistence activities, in which lithic tools were often involved. Besides, due to their manufacturing technique, which is extractive, the manufacture of lithic artifacts produces a great amount of waste from flaking (débitage). Therefore, by means of analysis of both tools and débitage, it is possible to infer techniques

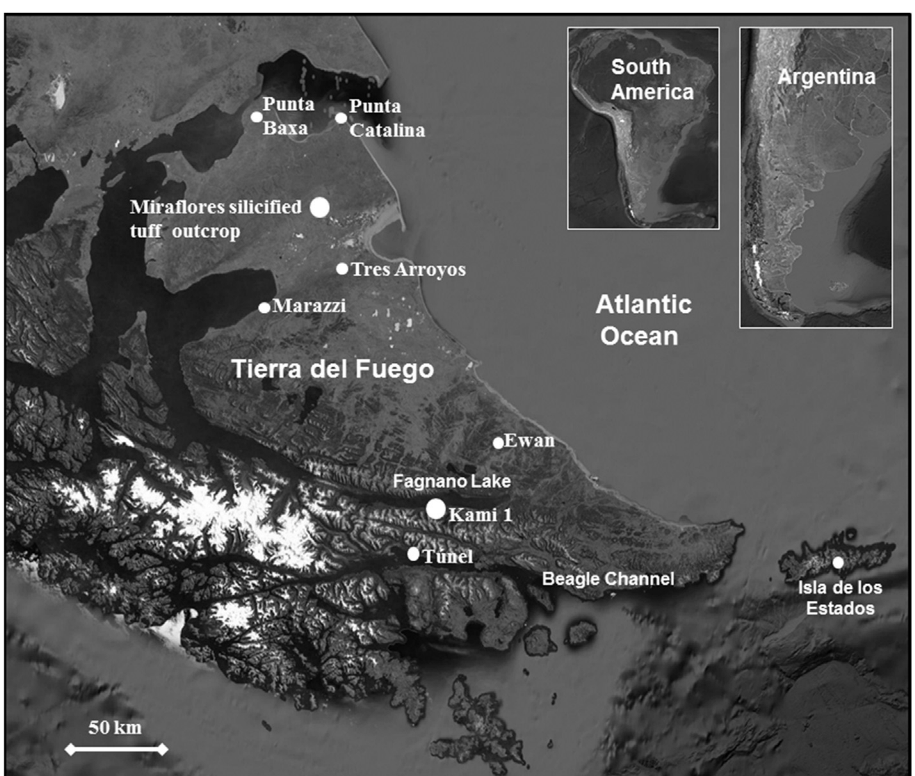

Fig. 1. Location of Kami 1 site and Miraflores silicified tuff outcrop and their spatial distribution. Upper: dorsal side. Lower: ventral side.

and strategies for tool manufacture and use, which involve decisions not only at a social level but also at an individual level (Tixier et al., 1980; Mansur-Franchomme, 1984, 1987). Because of all these reasons, as well as because of lithics' durability, the analysis of lithic material is one of the most important tools to assess resource management strategies implemented by past societies.

Therefore, studies on resource management in hunter–gatherer societies have principally focused on the management of lithic raw materials, even to the detriment of organic resources. They occupy an important place within the archaeological research since the first systematic studies applied to the European Paleolithic in the 1980s. These were approached from different angles, such as technology, use, circulation (including lithological determination), mobility, economics, and symbolism (Renfrew, 1977; Demars, 1982, 1994; Meltzer, 1989; Charlin, 2002; Flegenheimer and Bayón, 2002; Franco and Aragón, 2002, 2004; Franco and Cirigliano, 2009).

Concerning biotic resources, although their study is more difficult because of their perishable nature, sometimes it is possible to evaluate them directly from the archaeological record, as is the case with the preserved faunal remains. However, very frequently the inferences about the use of a certain type of resource can only be made based on the traces of use preserved on the lithic tools used to process them, such as in the case of manipulation of plant materials or hide treatments (Anderson-Gerfaud, 1981; Mansur-Franchomme, 1986–1990, 1986,; Clemente Conte, 1997; Álvarez, 2004; Leipus, 2004). In this work, the functional analysis of lithic tools is linked to the potential activities on perishable resources.

Studies on lithic technology have a main constraint, the link between tools and raw material. For all archaeological assemblages, the rocks represent a challenge, because their analysis requires identifying the sources, to explain why each one was selected, to understand the techniques and strategies that were implemented to obtain them, their supply, processing, and use. From our point of view of techno-functional analysis, these selections are not random: we believe that different kinds of rocks are frequently sought after in order to make specific products. Thus, the study of raw materials implies a detailed knowledge of different aspects, such as source types and their characteristics, origin, distribution, how they appear on the field, what types of rocks they produce, and their characteristics.

Based on the classic archaeological definition of potential lithic supply sources, they can be classified into three types: Primary, Secondary, and Tertiary (AGI, 1976; Nami, 1992; Church, 1994). Primary sources are those in which the rocks are found in their original position or outcrop. Secondary sources are those in which diverse erosive agents, such as rivers, glaciers, etc. fractured and transported the rocks and finally deposited them in a new place (Luedtke, 1979; Olausson, 1982–1983; Nami, 1992). Finally, tertiary supply sources are those formed by movement of rock by human actions. After being abandoned, these rocks can be exploited by other groups (AGI, 1976; Church, 1994).

The concepts of local or allochthonous are generally used in relation to provenience of rocks discovered in the archaeological assemblages. In most archaeological literature, the difference between local and allochthonous is made based on distance to the site, for example, 20 or 30 km, considering the distance that people are thought to walk in a journey. In the case of our study area, as well as for all mountain regions and islands, we believe that distance “per se” is not a relevant criterion, and that we have to take into account the topography and the presence of geographical accidents. In the case of the raw materials we refer to as “allochthonous” in this paper, they can be considered as “exotic”, as they come from other regions, at least 200 km distant.

2.1. Lithic raw materials in Tierra del Fuego

In Tierra del Fuego, the primary sources of the lithic raw materials most represented in the archaeological record are the outcrops of Yaghan (Cretaceous) and Lemaire (Jurassic) formations (Caminos, 1980; Caminos et al., 1981).

The Lemaire or Tobifera Formation extends across the Andes from the Magellan Strait to the Isla de los Estados. It is formed by epiclastic rocks (originally turbidites, conglomerates, chert, and black radiolarian and carbonaceous mudstones); acidic volcanic and volcaniclastic rocks (rhyolitic lava, pyroclastic flows, breccias, tuffs, and accretionary lapilli; subvolcanic quartz porphyries) and basaltic spillites. The main outcrops are found in the elevations south of Lake Fagnano, mainly in the Sierra Alvear. However, fragments of this formation can be found as clasts in Quaternary outcrops, usually of glacial origin, in secondary positions (Olivero and Malumián, 2008).

In the Yaghan formation, the main rock types consist of coarse breccias and conglomerates, sandstones, sandy and silty turbidites, black tuffaceous mudstones and tuffs, intruded by basaltic rocks of tholeiitic-calc-alkaline and spillitic affinities. The largest outcrops of this formation are located along the coast of the Beagle Channel. Rocks of the Yaghan Formation can be found in fluvio-glacial Quaternary deposits, in secondary position.

These rocks pose sometimes serious difficulties for their accurate determination to the naked eye. Therefore, for archaeological research purposes, they have frequently been classified in two main groups, named according to their genesis: metamorphite and volcanite (Orquera and Piana, 1986–1987; Mansur-Franchomme et al., 1987–1988; Terradas, 1996). Among the first, rhyolites and cinerites are the most used as raw materials in archaeological contexts, where they can represent more than 85%, due to their relatively good quality for flaking (Terradas, 1996; Orquera and Piana, 1999; Alvarez, 2003; Mansur et al., 2013). It is not always easy to distinguish them when they are analyzed to the naked eye, but identification is easy on a microscopic scale (even under reflected light microscopy), as they present differences in several aspects, the main one being granulometry.

Volcanites are mainly black and gray radiolaritic slates, with a banded structure and a very strong transverse lamination (Caminos, 1980; Caminos et al., 1981; Terradas, 1995, 1996). Their quality for flaking is low, and this is why their use for tool manufacture is rare (Terradas, 1995, 1996). Although they appear in some archaeological sites of marine hunter–gatherers of the Beagle channel coast, they are poorly represented in the archaeological assemblages from the central area of the island.

In addition to these outcrops, there are important rock accumulations in fluvio-glacial Quaternary deposits, corresponding to “secondary outcrops or quarries”. This is because different erosive processes heavily affected the rocks from these two formations after the rise of the Andes cordillera, and particularly the action of glaciers. Fragments of both formations were extracted and transported long distances, towards the southern coasts of the island and also towards the north, by the action of glaciers that deposited them in moraines. They also had a wide dispersion due to fluvio-glacial and later fluvial action (Olivero et al., 2007; Olivero and Malumian, 2008). Consequently, metamorphite pebbles of various sizes are easily available in the fluvio-glacial pebble formations, which function as secondary raw material sources (Borrero, 1998; Mansur et al., 2000, 2010; Mansur and Piqué, 2012).

Quartz is also a raw material represented in different archaeological contexts within the area. It is a relatively ubiquitous raw material. It appears in the form of veins and streaks, as for example along the coast of the Beagle Channel, and it is also present as small round pebbles in fluvio-glacial deposits (Mansur et al., 2000;

Olivero et al., 2007; Olivero and Malumian, 2008). Nevertheless it is not abundant in the archaeological series, principally because of its bad knapping quality (Mansur and Lasa, 2005; Mansur et al., 2013). When they are used, frequently quartz pebbles are opened by bipolar flaking technique and then used to make small endscrapers (Mansur and Lasa, 2005; Mansur, 2014).

Glass is an exotic material, of European origin. Nevertheless, we can consider as a secondary supply source remains of shipwrecks, brought to shore by the action of the sea. Glass was widely used in times immediately prior to and after the contact with the Europeans (Mansur and Piqué, 2012).

Finally, regarding tertiary sources, it might be plausible to include raw materials used for construction by the Europeans who were settling in different areas of the island. These materials, such as glass or metal, are worked many times as possible sources of raw materials (De Angelis, 2012a).

3. Materials in the Kami archaeological site

Kami 1 site is located on a high cliff, along the southern shore of Lake Fagnano (54°35′56.73″S, 67°59′47.4″W), in the subantarctic forest area of Tierra del Fuego (Fig. 1). It can be considered as an extensive site, as its area is more than 100 m^2. It showed some sectors where archaeological materials were exposed due to erosive processes, including forest decay and tourist trails. In order to study extensive sites, even when they have exposed sections, our field work approach is to fully sectorize the area in a grid of 2 m per side. Then we divide them into quadrants and subquadrants, which allow establishment of the excavation sections and surface collection in the sectors where material is exposed (Mansur et al., 2010; De Angelis, 2013).

Three combustion areas were detected during excavation, with large amounts of charcoal used for radiocarbon dating of the site. Dates obtained are 3210 ± 80 AP (LP 2164), 1130 ± 60 AP (LP 2163) and 1170 ± 60 AP (LP 2201). These results could suggest independent occupation events. The animal remains are very scarce, because of the poor preservation of bone material, which is affected by the acidity of the sediments and other taphonomical factors in the Fuegian forests (Mansur et al., 2013).

Kami 1 is characterized by the presence of abundant lithic material, surpassing 7500 pieces. Only 17.5% are elements larger than 2 cm (n = 1328), including retouched instruments, such as side scrapers (n = 39), endscrapers (n = 13), fragments of instruments (n = 24), fragments of projectile points (n = 7) for a total of 3 points, and only one compound tool.

In order to analyze materials from the techno-functional point or view, we usually classify products according to their size and their technological characteristics. Products longer than 2 cm include flakes (when they have butts that allow analysis of technological characteristics) and fragments, cores, and fragmented cores. Products comprised between 2 and 0.5 cm include small flakes and debris. Finally the smaller products, less than 0.5 cm, include microflakes and microfragments.

In this assemblage, débitage is mainly formed by small products (less than 2 cm). Products longer than 2 cm include flakes (n = 750), fragments (n = 395), whole cores (n = 4) and fragmented cores (n = 24) (Table 1).

Lithic artifacts under 2 cm constitute 85% (n = 6234). According to their technological characteristics, we classify them as small flakes (between 2 and 0.5 cm), microflakes (less than 0.5 cm), debris (between 2 and 0.5 cm), and microfragments (less than 0.5 cm). In this assemblage, the most represented are small flakes (n = 2589) and debris (n = 2126), then microflakes (n = 760) and microfragments (n = 738).

3.1. Silicified tuff series

The Kami 1 lithic assemblage includes artifacts made out of silicified tuff. Although this rock type is widely distributed along the Isla Grande de Tierra del Fuego (Borrazzo, 2010, 2012; Borrazzo et al., 2010), there is only one currently known outcrop of silicified tuff, that of Miraflores. The criteria used to attribute Kami 1 material to this source were, at the beginning, exterior characteristics such as color, brightness and fracture shape. Then, we used experimentation and reflected light microscopy in order to compare hardness, fracture, microsurface topography, and inclusions. Recently, comparative chemical analysis of a sample from the source and an artifact from Kami 1 confirmed the provenience of raw material from the Miraflores outcrop (K. Borrazo, 2014 pers. comm.).

The silicified tuff series is formed by 436 pieces. The majority of the artifacts are débitage, including debris and microfragments, followed by small flakes and microflakes, representing 86% (n = 375). The remaining 14% (n = 61) is formed by several types of scrapers (simple, atypical, doubles and triples) flakes, cores and fragmented cores, bipolar elements (cores and fragments), a bipolar technique flake, and a retouched tool fragment (Table 2).

There are several outstanding aspects in this series. One is the absence of cortex on flakes and débitage. Only 5 artifacts (2 debris and 3 small flakes), show surfaces that could correspond to the cortex, although this is difficult to assert because there are impurities within this raw material that are very similar to cortex.

Another outstanding aspect is the size of the artifacts. None of the pieces is larger than 5 cm. In fact, being mostly débitage, 39% is under 0.5 cm, 47% between 0.5 and 2 cm, and only 14% of the total assemblage correspond to pieces over 2 cm (core, instruments, flakes and fragments). The core are small bipolar masses, mostly exhausted, except for one that is of medium to small size and shows traces from direct percussion flaking (Fig. 2).

The series includes bipolar elements. Although scarce (n = 9) in relation to the whole silicified tuff series, it is important to mention them because of the overall small sizes of the artifacts, and especially taking into consideration that the raw material is not local. Despite being small, the bipolar artifacts represent diverse steps and elements of the operative chain, such as cores, flakes and fragments. Three of the simple scrapers are made on bipolar flakes. It is also possible that a part of the débitage under 2 cm could be the result of application of a bipolar technique, but it is not possible to confirm that due to its high fragmentation degree.

Regarding the retouched instruments, it is remarkable that this raw material has been used to manufacture only endscrapers. They are very small, as their largest size is between 1.2 and 2.5 cm: micro endscrapers (n = 19) and small endscrapers (n = 5), (Fig. 3). Retouched long edges (sidescrapers, knives) were not found, nor were projectile points, or retouch flakes in this raw material, that could suggest the manufacture of these types of instruments. The technomorphologic analysis of the endscrapers is presented below.

Kami 1 differs from most of the other sites studied in the central part of the island, especially concerning area, distribution, and abundance of lithic remains. In most cases, archaeological sites are smaller than Kami 1 and have lithic assemblages that also have lesser abundance and variability. They have been interpreted as campsites for short temporary occupations (Mansur and Piqué, 2009). This is the case for the Marina 1 site, for example, which was interpreted as a short term campsite where people developed various processing/consumption activities, such as processing of animal and hides (at least guanaco), finishing of lithic tools, repair or maintenance of damaged instruments, as well as replacement of

Table 1
Kami 1 Lithic assemblage detailed by sizes (over and under 2 cm) and technomorphological groups.

		Technological types	Hornblendite	Andesite	Basalt	Chalcedony	Chert	Cinerita	Indet.	Lutite	Slate	Quartz	Rhyolite	Flint	Silic. tuff	Total	%
Artifacts bigger than 2 cm	Retouched	Bifacial tool						1					2	2		5	
		Instrument fragment						4	2				15	2	1	24	
		Composite instrument											1			1	
		Projectile point						2		1						3	
		Side scraper (n = 39)															
		Double side scraper											1			1	
		Side scraper fragment											5			5	
		Lateral side scraper						3			1		11			15	
		Oblique side scraper		1									4			5	
		Transversal side scraper						1			1		11			13	
		End scraper (n = 14)															
		Atypical end scraper											1			1	
		Double end scraper						1								1	
		Simple end scraper				1	1	2				2			5	12	
		Total retouched		**1**		**1**	**1**	**14**	**2**	**1**	**2**	**2**	**51**	**4**	**6**	**86**	**1,10%**
	Unretouched	Fragment				3	1	67	17		17	5	263	5	17	395	
		Bipolar frag.					1	1				29			2	33	
		Bipolar hemi pebble										9				9	
		Bipolar flakes										13		1	1	15	
		Bipolar core										8			2	10	
		Flakes		2	2	8	1	150	7		8	3	556	8	5	750	
		Core											3		1	4	
		Core fragment			1	1	2	6					13	1		24	
		Total unretouched		**2**	**3**	**12**	**5**	**224**	**24**	**1**	**25**	**67**	**835**	**15**	**28**	**1241**	**16,40%**
		Total bigger than 2 cm	**0**	**3**	**3**	**13**	**6**	**238**	**26**	**1**	**27**	**69**	**888**	**19**	**35**	**1328**	**17,50%**
Artifacts smaller than 2 cm	Retouched	**Micro end scraper (n = 19)**															
		Triple end scraper													**1**	1	
		Atypical end scraper													**1**	1	
		Double end scraper													**1**	1	
		Simple end scraper			1							1			**16**	18	
		Total retouched			**1**							**1**			**19**	**21**	**0,30%**
	Unretouched	Small flake	1		3	85	10	1121	22	148	11	20	1061	19	**88**	2589	
		Debris			2	41	18	740	86	57	98	81	853	18	**132**	2126	
		Microflakes				55	1	416		37		22	166	3	**60**	760	
		Microfragment				15	1	360	18	1	2	30	207	2	**102**	738	
		Total unretouched	**1**		**5**	**196**	**30**	**2637**	**126**	**243**	**111**	**153**	**2287**	**42**	**382**	**6213**	**82,20%**
		Total smaller than 2 cm	**1**	**0**	**6**	**196**	**30**	**2637**	**126**	**243**	**111**	**154**	**2287**	**42**	**401**	**6234**	**82,50%**
		Total	**1**	**3**	**9**	**209**	**36**	**2875**	**152**	**244**	**138**	**223**	**3175**	**61**	**436**	**7562**	**100%**

Table 2
Technological types of tools made on Miraflores silicified tuff.

Kami 1		Squares						
		J 21	J 22	K 20	K 21	K22	L 21	Total
Technological types	Simple end scraper	3	1		7	2	8	21
	Atypical end scraper				1			1
	Double end scraper				1			1
	Triple end scraper				1			1
	Instrument fragment				1			1
	Bipolar core				1	1		2
	Core				1			1
	Flakes	2			2	1		5
	Bipolar flakes				1			1
	Bipolar frag.				1	2		3
	Fragment	2			5	6	4	17
	Small flake	2			47	22	17	88
	Debris	2			58	47	25	132
	Microflake	1	1	1	49	8		60
	Microfragment				84	18		102
	Total	**12**	**2**	**1**	**260**	**107**	**54**	**436**

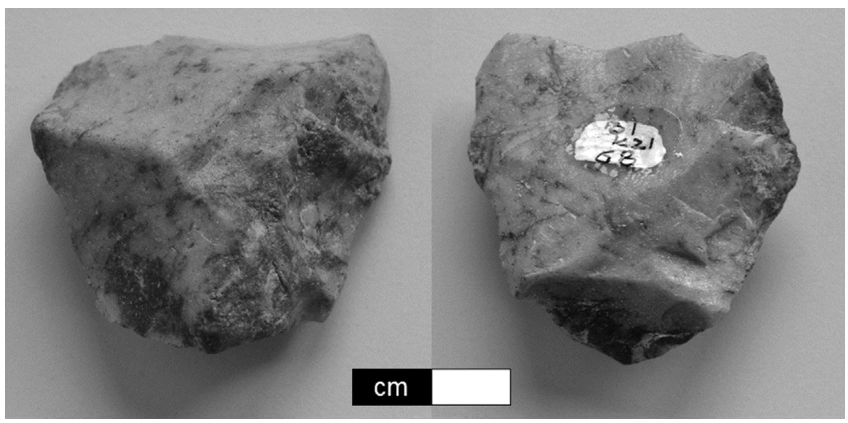

Fig. 2. Silicified tuff lithic Core. Left: dorsal side. Right: ventral side.

lithic projectile points in the arrow shafts (Mansur et al., 2000; Mansur and Piqué, 2009). Kami 1, however, is a large site where lithic remains are very abundant and varied; surface distribution in different concentrations, as well as different combustion areas and radiocarbon dates, suggest repeated occupation of this site. Based on distribution, technomorphologic and functional analysis, it was interpreted as a multifunction base camp (De Angelis, 2013; Mansur and De Angelis, 2013).

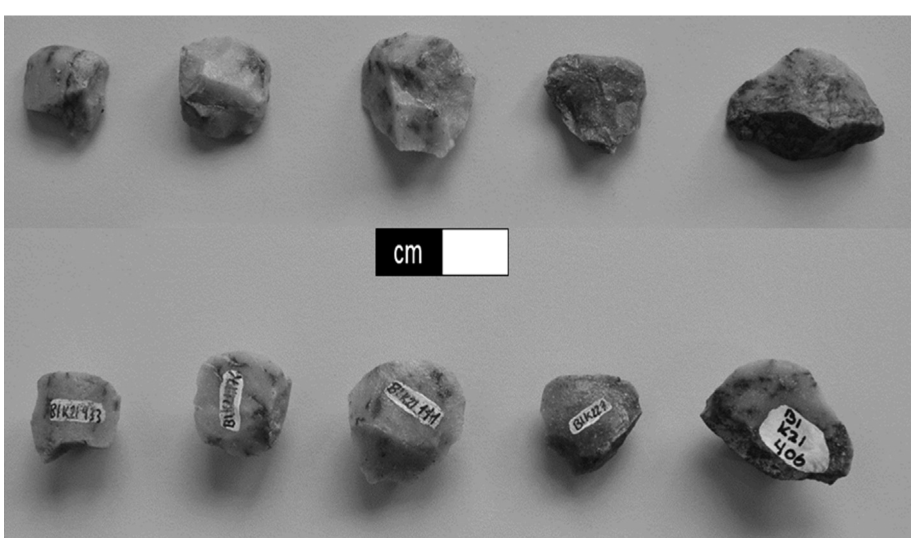

Fig. 3. Scrapers made on Miraflores silicified tuff.

4. Technological and functional experimentation on silicified tuff

The raw material used in the experimental program comes from the primary outcrop, the Neogene Palomares Formation (Prieto et al., 2004; Borrazzo, 2009; Borrazzo et al., 2010), located in the Miraflores river valley, Chile, west of the Cullen River source. The methodology used for the experimental program is the standard for techno-functional analysis (Semenov, 1964; Keeley, 1980; Vaughan, 1981; Anderson-Gerfaud, 1981; Mansur-Franchomme, 1984, 1986; Plisson, 1985; Beyries, 1988; Castro, 1994, 1996). It includes manufacture of experimental artifacts and their use to perform different activities linked to processing of resources, following specific experimental and analytical protocols. The interpretation of traces is done according to the model of usewear traces formation on heterogeneous materials (Mansur, 1999; Leipus and Mansur, 2007).

For the macro and microscopic study, the optical equipment utilized consists of a binocular Leica S6D magnifying glass (stereomicroscope) and an Olympus BH-2 reflected light metallographic microscope (with direct system for image capture and digitalization). The magnification used on these instruments varied from 5× to 50× for the magnifying glass and from 50× to 500× for the microscope.

4.1. Technologic experimentation

In order to test the quality of this material for manufacturing tools and edges comparable to those of the archaeological record, three simple end-scrapers with short distal edges were manufactured, and they were later used for the functional experiment. We had only a small sample of raw material from the source. Tool manufacture was done on flakes extracted by direct percussion, by means of direct retouch (from the ventral face towards the dorsal face), using a retouching tool with copper tip. The experimental scrapers were between 2 and 3 cm long and 2 cm wide. Front edges were convex in shape, with a maximum length of 2 cm and angles between 50 and 70°.

Experimental manufacture showed that the raw material is not flexible, and that it fractures easily. These characteristics limit its quality for knapping. Upon observation of the material under both the binocular magnifying glass and the reflected light microscope, it was possible to identify sectors with microporosity, probably responsible for the technological fractures (Fig. 4). Nevertheless, the edges obtained were very even, with a smooth surface and sharp edges (Fig. 4).

4.2. Functional experimentation

The main purpose of the functional experimentation was to see the behavior of edges made on this specific silicified tuff in different use processes. For that, we compared the results obtained in the experiments with the theoretical model about use-traces formation on heterogeneous materials (Mansur, 1999). The experimental scrapers were used to process fresh Lenga wood (gen. *Nothofagus*), fresh sheep skin (*Ovis aries*) and fresh cow bone (*Bos taurus*), with transverse kinematics and working angles between 45 and 70°. Use periods were 30 min, with observation and progress recording through digital microphotography at intervals of 5, 15, and 30 min.

The scraping activity presented no difficulty, due mainly to the low degree of crumbling and blunting of the edges, which allowed for even work for over 30 min. This is very different from the case of the rhyolites, which are the most used materials in the sites of the central area of Tierra del Fuego. The rhyolite edges are subject to a little more crumbling at the beginning of work, and then the edge starts to round off, although it is a very hard raw material with slower micropolish development (Clemente Conte, 1997; Mansur, 1999; Álvarez, 2003; De Angelis, 2013).

In the case of the Miraflores silicified tuff, the edges turned out to be stable, releasing splinters and microsplinters only at the beginning of the work (Fig. 5). During the second stage of use (15 min), the edges were rounded off and striations were formed, allowing determination of the kinematics of work (Fig. 5). The micropolishes correspond to the first stages of development, characterized by smoothing to almost obliteration of the technological traces. At the end of the third stage, microscopic analysis detected well developed micropolishes, characteristic of the material worked (Fig. 5). In the case of the skins, a strong rounding of the edge could be observed, extending practically along the whole edge portion involved in the process of use. In the instrument used on wood, the micropolish shows short extension along the edge, appearing only in some portions; it is slightly thick and shows characteristic striations. Regarding the work on bone, the edge showed bright micropolishes, although more restricted to the higher areas of the microtopography.

5. Techno-functional analysis of archaeological material

In the Kami 1 silicified tuff series, the only instruments in the site are scrapers ($n = 24$), characterized by their small size. From the technomorphologic standpoint, they represent a mostly uniform assemblage regarding size and shape, although diverse in relation to the technological types, including simple, atypical, double and triple scrapers (Table 2). Regarding the fragmentation of the assemblage, practically all the pieces are complete, with only a few showing some fragmentation ($n = 7$). Macroscopically, the degree of preservation is good, although it was possible to identify slight patinas.

In terms of sizes, the tools are fairly standardized, as all of them fall within the very narrow range between 1.2 and 2.5 cm maximum length. Thickness ranges from 0.4 to 1 cm, which, in relation to longitude, characterizes a small but thick assemblage. Among the supports utilized, we were able to recognize scrapers on flakes, bipolar flakes, fragments, and a natural backed flake.

The edges are mainly distal, convex and irregularly shaped, with angles ranging from 54° to 85°, but with most between 65° and 75°. Retouch is direct in 90% of the series and continuous in all cases. Morphologies of the group of end-scrappers, short and thick, and abrupt angles of the fronts could be an indication of re-sharpening. Unfortunately, no absolute evidence in this sense was found in the microscopic study, as with hafting. The small size of the tools indicates that they were used hafted: however, microscopic analysis showed that no hafting traces were preserved. Concerning tools utilization, the microscopic functional analysis determined that the 24 scrapers amount to 31 edges, from which only 6 showed typical use traces, 2 showed slightly developed use traces and the rest of the edges were undeterminable (Fig. 6).

Regarding the six edges with traces of use, only one of them was worked on wood, while the 5 remaining worked on hide. Two edges have slightly developed use wear traces, and one could have worked on soft animal tissue. In all the cases, the kinematic was transversal (scraping).

6. Discussion

The presence of silicified tuff in the Kami 1 site brings about several questions regarding provenience of this raw material, how it came to the site, what was it used for and if its choice is related to the manufacture of certain instruments or to a specific purpose. To

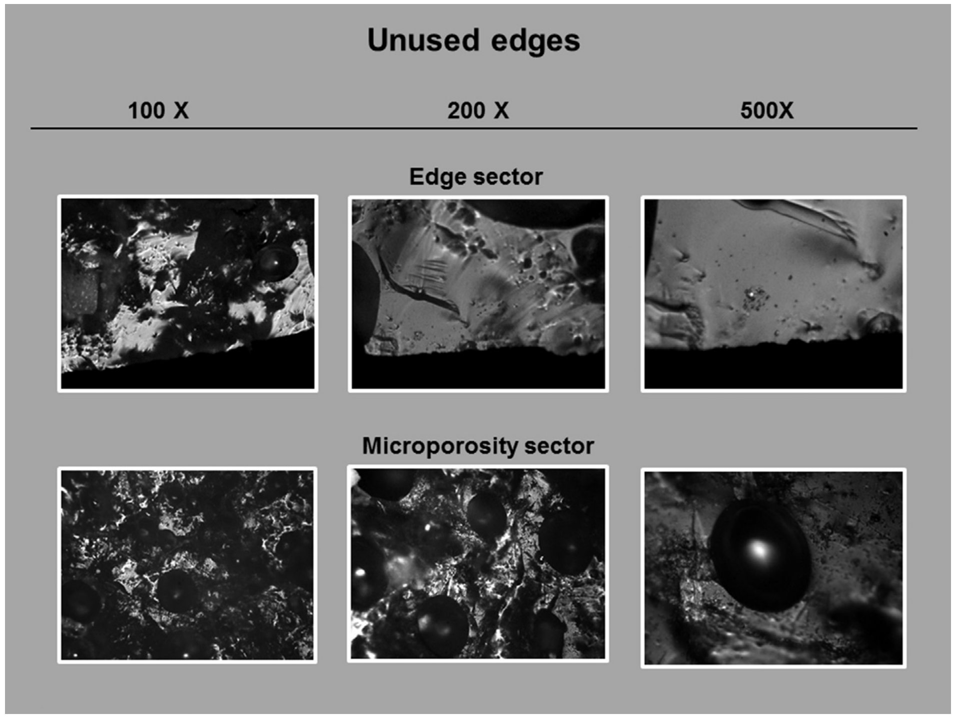

Fig. 4. Fresh edges and sectors showing microporosity. Photomicrographs taken at 100×, 200× and 500×.

try to answer to these questions, we present some results obtained through diverse theoretical–methodological approaches.

Regarding its possible origins, although there is silicified tuff in different places within the island, there is only one place where it was possible to identify a primary source where the material shows the same features as our archaeological samples, not only concerning texture but also colour, brightness, mechanical properties, and microtopographical characteristics. This source is the primary outcrop located in the valley of the Miraflores River, west of the Cullen river source, in the northern part of the island. The outcrop

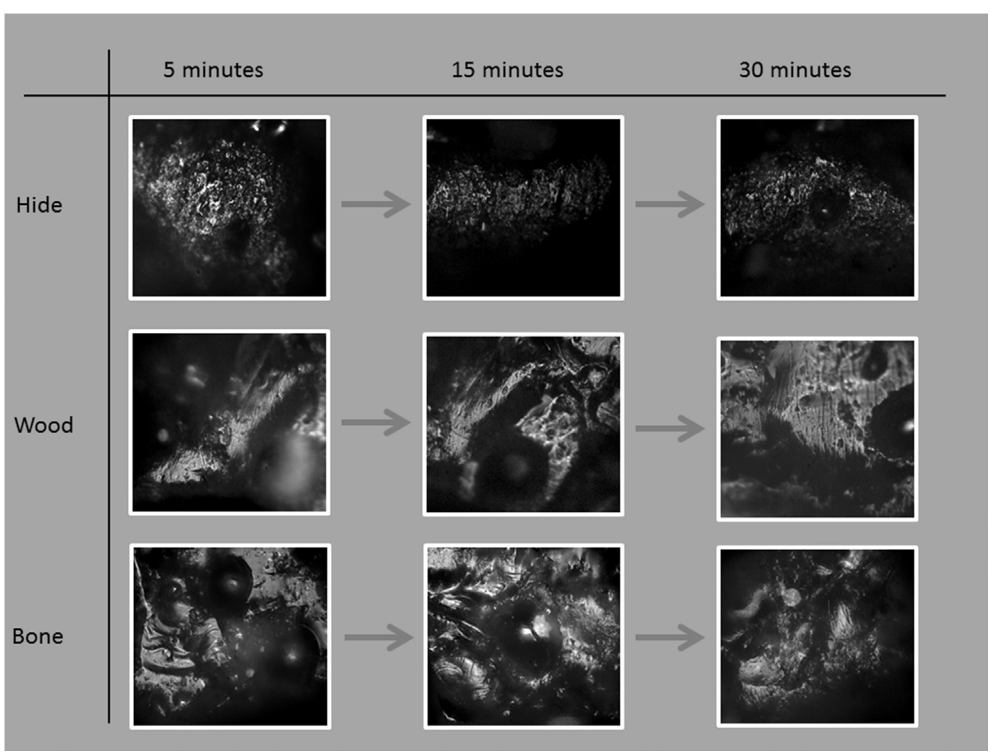

Fig. 5. Development of micropolish in three working stages. Microphotography at 200×.

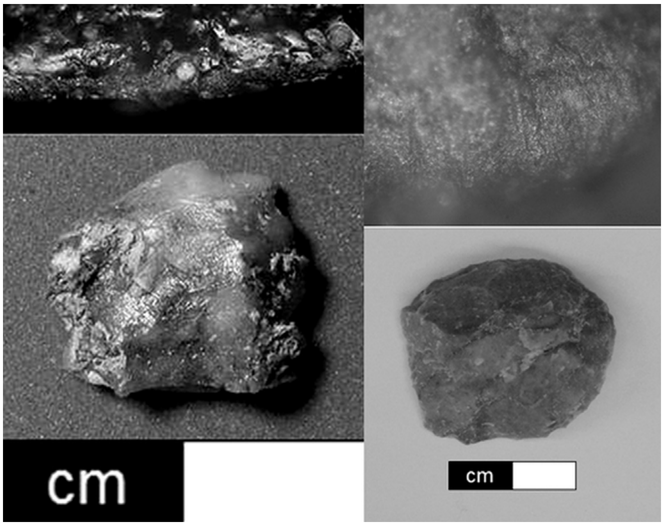

Fig. 6. Upper: micropolish produced by work on hide (microphotography at 200×). Lower: Silicified tuff micro-scraper.

belongs to the Neogene Palomares Formation, and has been studied since 2003 by several researchers (Prieto et al., 2004; Borrazzo, 2009; Borrazzo et al., 2010; De Angelis, 2012b; De Angelis, 2013).

Recently, chemical analysis have confirmed provenience from this source for the Kami 1 site samples analyzed. As the primary source is over 200 km away from Kami 1, in the northern steppe region of the island, and considering that previously this raw material had never been found in the assemblages of the central region, we believe that it can be considered as an “exotic” material.

The inhabitants of the Kami 1 site could have obtained this raw material directly from the outcrop, although it is a little improbable, due to both distance and different landscape units. In order to get to the source and assure provision of material, it would be necessary that the source be included in the mobility circuits for seasonal migration, or resource exploitation, of the group. Alternatively, the raw material could have been obtained through exchange with people from the northern part of the island, as this silicified tuff has been identified, in low quantities, in several sites north of the island of Tierra del Fuego (Prieto et al., 2004; Borrazzo, 2009, 2010; Borrazzo et al., 2010). To evaluate these and other alternatives, we considered the information from technofunctional analysis of the archaeological assemblage.

The assemblage's most outstanding feature is the high number of micro end-scrapers made out of silicified tuff, in relation to the total amount of scrapers from the Kami 1 site. Considering all the raw materials, there are 33 end-scrapers, from which 24 are made of silicified tuff, 70% of the assemblage. On the other hand, we have not found in the site any other types of formatted artifacts made on this raw material. Something similar happens in the northern part of the island, where artifacts made with this raw material were recovered in several sites, mainly scrapers, flakes, bipolar products, reactivation products and exhausted cores (Borrazzo, 2010, 2012).

One of the approaches used in this study was the experimental manufacture and use of tools to work different types of resources, which allowed us to tackle the archaeological material from the point of view of the use of an atypical raw material for the study area. In the functional experiments, after the first few minutes, it was possible to verify that the edge scarring by formation of micro splinters ceased. The edges started to regularize and to form well-developed micropolishes after 30 min of use. In relation to this, it was possible to observe that in the experiment on woodworking, the edge scarring was a little more important than in hide working, where there was a tendency to edge rounding. This behavior of the material is in accordance with the model of use wear traces formation on heterogeneous micro- or cryptocrystalline materials (Mansur, 1999), both in the characteristics of use wear traces and in their relative formation speed. Compared to homogeneous materials such as glass, the Miraflores silicified tuff can produce diagnostic microwear traces, including micropolishes, in a shorter period, as it does not produce much splintering during the process of use.

In terms of their effectiveness, the silicified tuff endscraper's edges were effective for working the different materials tested. They were used for periods of over 30 min and, along this time, they showed little crumbling and blunting of the edges, which allowed for even work. Rhyolite edges show a little more crumbling at the beginning and then the edge starts to round off, although it is a very hard raw material with slow micropolish development.

This hardness also influences the processes of knapping and retouching. Because of this, in order to select a raw material to manufacture small instruments such as microscrapers, for example, it could be more attractive to work with a rock that is easier to retouch and in which the edges are effective for the purpose desired.

Based on the results of the techno-morphological analysis of the archaeological silicified tuff assemblage, it was possible to identify the presence of two types of tool manufacturing techniques: knapping by direct percussion, and bipolar knapping. Several artifacts represent these techniques, from cores to micro waste, besides retouched tools. Bipolar technique has been proposed as a means to economize raw material. In this case, if we consider that the assemblage is characterized by small elements and a very low number of cores, and we take into account the distance from the raw material source, we would expect to find a major use of the bipolar technique, as a means to maximize this material. Nevertheless, as observed in the analysis, this technique was not the one used the most for blanc manufacture. Bipolar technique has been considered as an aperture technique for débitage of certain materials, especially pebbles (Mansur, 2006) or for production of supports with specific morphologies, as bipolar hemi pebbles (Mansur and Lasa, 2005).

In the case of Miraflores silicified tuff, we think that less utilization of bipolar technique could be due to the fragility or low flexibility of the raw material that we observed during the experimentation. Under these conditions, the bipolar flaking might not be the best option, as this could produce internal fractures hindering the manufacture of usable blancs. Bipolar flaking most likely would have generated a higher amount of flaking waste under 0.5 cm.

Beyond the knapping technique, it is evident that both the direct percussion as the bipolar percussion were applied in order to produce blanks that could be used for the manufacture of small end-scrapers and micro-scrapers. Functional analysis demonstrated that they were used almost solely to work hide.

7. Conclusion

The third goal of this work was to assess the causes for selection of the Miraflores silicified tuff for the forms and identified uses, and its possible forms of acquisition by the hunter–gatherer societies of the central area of Tierra del Fuego. This raw material proved to be more effective than heterogeneous materials, such as the rhyolites, not only for the microscrapers manufacturing process but also for their utilization. In the functional aspect, the edges in silicified tuff allowed for even work for 30 min, comparatively more efficient than edges in rhyolite. These features, experimentally observed, are entirely consistent with those recorded in the analysis of the archaeological materials, where most of the instruments used were utilized to work on hides. This correlation between specific types of raw material, end scraper manufacture and hide processing, has repeatedly been studied in the Middle and Late Holocene assemblages of the Pampas, Patagonia and Tierra del Fuego (Mansur and Lasa, 2005; Mansur, 2006; Leipus and Mansur, 2007).

This situation is very different from that of the two other allochthonous materials known in Tierra del Fuego. In the case of green obsidian, in all cases it is represented by only one or two finished pieces at each site. Tool types are only bifacial points and flakes; there is no evidence of débitage, showing that these products arrived as finished artifacts. This representation suggests a curated or conserved technological strategy. It usually produces assemblages with finished tools, frequently bifacial, débitage corresponding to the last stages of tool manufacture, retouch flakes, and resharpening flakes.

Concerning the provision and distribution strategies of green obsidian, two different scenarios have been proposed for marine hunter–gatherer–fisher populations of the southern coast of Tierra del Fuego and for inland or terrestrial hunter gatherer populations of the northern part of the island. In the first case, obsidian appears only in early Mid Holocene contexts, in the form of finished tools. This presence could indicate territories in exploration or new exploitation by early marine groups, especially considering that there are also other technological resemblances, especially in bone harpoons (Piana, 1984; Morello et al., 2004).

Another scenario corresponds to Late Holocene contexts of terrestrial hunter–gatherers of northern Tierra del Fuego. In these contexts, presence of green obsidian tools is believed to indicate contacts or exchanges between marine populations and terrestrial populations. The wide distribution of green obsidian remains in the northern territories indicates the extent of exchange networks (Oría et al., 2010).

In the case of the Miraflores silicified tuff that was used at Kami 1, distance and landscape make very unlikely direct procurement from the primary source. Until now, it is not possible to know if the raw material was found by chance in some secondary source nearby, or if it was obtained by exchange with other groups from the primary source. However, the first scenario also seems unlikely, due to the lack of flakes with cortex, something that does happen with the other raw materials discovered in the site. In any case, what we do know is that the sizes and technological types of débitage and waste microflakes are consistent with a conserved or curated technological strategy. We believe that this material was extremely scarce and therefore it was reserved for a specific use, the manufacturing of microscrapers.

The presence of raw materials from different regions in hunter–gatherer contexts demonstrates interaction between groups. Miraflores silicified tuff appears in several sites of the northern steppe region of Tierra del Fuego, in low quantities and the same tool types. Kami 1 is the first case suggesting interaction between people of the northern steppes with groups of the central forest.

The circulation of raw materials, especially good quality rare materials representing prestige goods, is a way to enhance social interrelations and help to consolidate alliances between different groups. We believe that circulation of Miraflores silicified tuff could be indicative of an important interaction network existing among distant groups during the Late Holocene.

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