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Lithic resource management in mountain environments: The Andean sector of Tierra Del Fuego

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A B S T R A C T

Lithic resource management is one of the most important variables for the analysis of technological organization in hunter-gatherer societies. As essential resources for the manufacturing of tools that are themselves involved in processing and consumption of other types of resources, lithic raw materials constitute the starting point of all production processes. Although well studied in different environments, lithic resource management is difficult to analyze in mountain contexts, especially due to problems of site formation and archaeological visibility. In this paper, we present the research strategies adopted in order to study lithic resource management in mountains and piedmont areas in the Andean sector of Tierra del Fuego.

We carried out a program of systematic surveys in different landscapes according to the methodology of distributional analysis and considering two different perspectives: location and characterization of raw material sources, and evaluation of land occupation by hunter-gatherer societies. Lithic materials were studied following a techno-functional perspective that includes the interrelated study of technology (raw materials and manufacturing techniques) and use wear (microscopic analysis). Then, results were confronted with those of excavated sites, which are located in different landscapes and landscape units and have different functionalities, such as campsites, ceremonial sites, etc. The results obtained confirm that local materials from secondary sources were the most used, although there are also some allochtonous good quality rocks, coming from sources located at different distances.

This research let us adjust field methods for surveys in wooded mountain environments, as well as discuss some more general aspects regarding the exploitation of lithic resources in mountain regions. These landscapes may seem, at a first glance, as ideal provision places for hunter-gatherers because of abundance of lithic materials. However, these are not always available in terms of visibility and accessibility; on the other hand, not all rocks can be used for the manufacture of all types of tools. We can then propose that hunter-gatherer societies that highly depend on lithic resources seek to exploit outcrops where visibility and accessibility are high, but that also search for a variety of raw materials with different characteristics that allow manufacturing of different artifacts. From these data, it is possible to discuss mobility, seasonality and interaction of hunter-gatherer groups.

1. Introduction

Archaeological research in mountain areas, especially in those that were occupied by hunter–gatherer societies, is a major challenge, due to various factors relating to the accessibility, visibility and formation processes of the archaeological record. These factors are particularly important in the case of mountain environments with forest cover (Folley, 1981a, 1981b; Bintliff-Snodgrass, 1988; Borrero et al., 1992; Mansur, 2002; Belardi, 2005). That reason could explain why most of the archaeological research in hunter–gatherer sites has been done in open areas of meadows and steppes. In the mountains, findings have usually been done in cave sites, in places where there are natural structures that allow location of archaeological sites.

From a methodological point of view, the approaches to archaeological work in mountain areas are diverse and have especially emphasized location of sites by means of different techniques such as aerial photography, magnetic survey, GPR

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survey, etc. (Conyers, 2004; Santiago, 2009; Mansur et al., 2013; Migliavacca, 2013; Santiago, 2013). However, the number of investigations done so far is not very abundant, as compared to research done in other environments, precisely because of the above factors that hinder research. It has often been thought that mountain areas have had little occupation in the past, or have only been walkways for hunter–gatherer societies (Mansur, 2002; Mansur and Pique, 2009).

However, a priori, it would be possible to think that mountain areas, where rocks are usually available, are ideal places for hunter–gatherer societies, whose technological organization often relies on lithic raw materials. The rocks are an essential resource for the manufacturing of tools that are themselves involved in processing and consumption of other types of resources. From this point of view, we consider lithic resource management as one of the most important variables for the technological organization of hunter–gatherer societies.

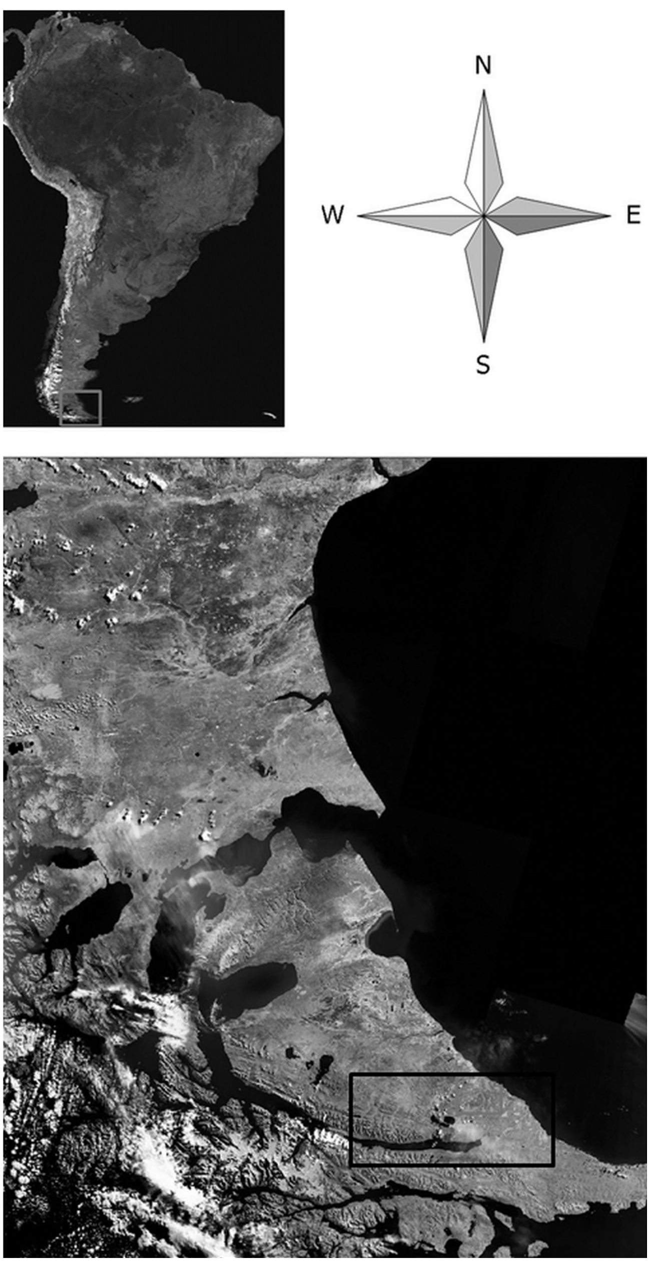

Fig. 1. Tierra del Fuego. Square indicates Fagnano Lake and the study area.

In this paper, we want to present the approach that we used for the study of lithic resource management in the central mountainous area of Isla Grande de Tierra del Fuego. This research was a part of a largest research project, the "Proyecto Arqueológico Corazón de la Isla", which seeks to assess the characteristics of human occupation in the area and their relationship to the exploitation of biotic and abiotic resources (Mansur et al., 2013). Within this research, one of the most important constraints were survey difficulties due to environmental characteristics of the study area. Consequently, the project included strategies in order to develop a systematic survey program with evaluation of resource availability.

The central area of Tierra del Fuego is a mountainous wooded environment (Fig. 1), where it is important to consider the factors of accessibility, visibility and formation processes of the archaeological record. Concerning accessibility, since the last part of 20th century, introduction of an allochthonous species, beaver (*Castor canadiensis*) has produced a progressive degradation of certain landscapes by inundation of valleys that difficult circulation within the forest and accessibility to archaeological sites. Archaeological visibility is extremely low, due to the presence of thick underbrush. Furthermore, the soil surface is covered by fallen trunks, branches and leaves, which remain long in this environment due to the low temperatures that slow the degradation processes (Lencinas et al., 2001). As for site formation processes and conservation of materials, the two principal variables are the climatic conditions and forest vegetation (Mansur et al., 2013). The soil is permanently covered with leaves and other decaying organic matter, and is also affected by roots and other factors of biogenic disturbance. Consequently, the conservation of archaeological materials is limited by these factors, primarily because of acidity of forest soil sediments with pH $\geq$ 5 (Bava, 1998; Frangi et al., 2004; Moretto et al., 2005).

The study area has a variety of landscapes. Therefore, it was necessary to implement different methodologies in order to study the distribution of human occupation and the resource use made by past societies. In our model, we proposed that an important variable that conditions hunter–gatherer movement in mountain nomadic circuits, is the availability of lithic raw materials, as their distribution is not uniform throughout the area (Mansur et al., 2013). Therefore, we expect:

a- residential camp sites to be located near sources of abundant good quality raw material;
b- Camp movements along year cycle to take into account places and seasons which are better for lithic raw material procurement (e.g. accessibility and frozen soils in winter)
c- Good quality raw materials to circulate among interrelated groups.

Therefore, we decided to approach this study from two perspectives: one for assessing human occupation in the area, another in order to search for potential sources of lithic raw materials, in three steps: geological identification of sources, field localization and testing. Results of this field research were followed by comparison to the archaeological record.

2. Geographical setting and lithic resources

In previous work, we have presented various aspects of this research project, including the general geographical context in which the study area is located, its various landscapes and the forest environment. These geographical traits are particularly important in order to evaluate the supply of resources and their modes of management by hunter–gatherer societies in the area (Mansur and Piqué, 2009; Mansur et al., 2013). Consequently, we will mention here only some aspects that are needed to discuss this approach to lithic resource management in mountain areas.

The Isla Grande de Tierra del Fuego forms the extreme southern tip of South America. During the last glacial event, it was united to southern Patagonia, but after the rise of sea level the separation was complete (Rabassa et al., 1990; Clapperton et al., 1995; Ponce et al., 2007). The most important geographical traits are the ranges of the Andes Cordillera, a series of sub parallel lines that extend E–W. They are separated by valleys and a main tectonic depression occupied by Fagnano lake. The southern slopes of the Andes sink in another depression occupied by the Beagle Channel, where they form an irregular coast of alternating cliffs and bays (Olivero et al., 2007). To the north, the northern mountain range gradually lowers in altitude, through hills and undulations modelled by glacier action, to a wide steppe plateau that extends to the coasts of the Atlantic ocean and the Magellan strait (Fig. 1).

The area we focus on for this investigation is the center of the island. Here are the main mountain ranges, intermediate valleys, glacial lakes and lagoons. The landscapes vary in different sectors, according with altitude, climate and soil development, which condition forest development (Fig. 2). According to Tuhkanen (1992) these are:

- Mixed forest: This is a landscape of mountain ranges and intermediate valleys in the Cordillera, with peat bogs and depressions filled by lakes, extending to the south of Lake Fagnano. It has mixed evergreen forest vegetation formed by *Nothofagus betuloides* ("guindo", perennial) and *Nothofagus pumilio* ("lenga", deciduous). It includes an important shrub layer composed mainly of *Berberis buxifolia* ("calafate"), *Pernettya mucronata* ("chaura"), *Berberis ilicifolia* ("michay") and *Ribes magellanicum* ("parrilla"), as well as grasses and rushes in the valley bottoms.
- Deciduous forest: The second is a landscape that retains the same principal characteristics of the above, but where the vegetation changes progressively to deciduous forest

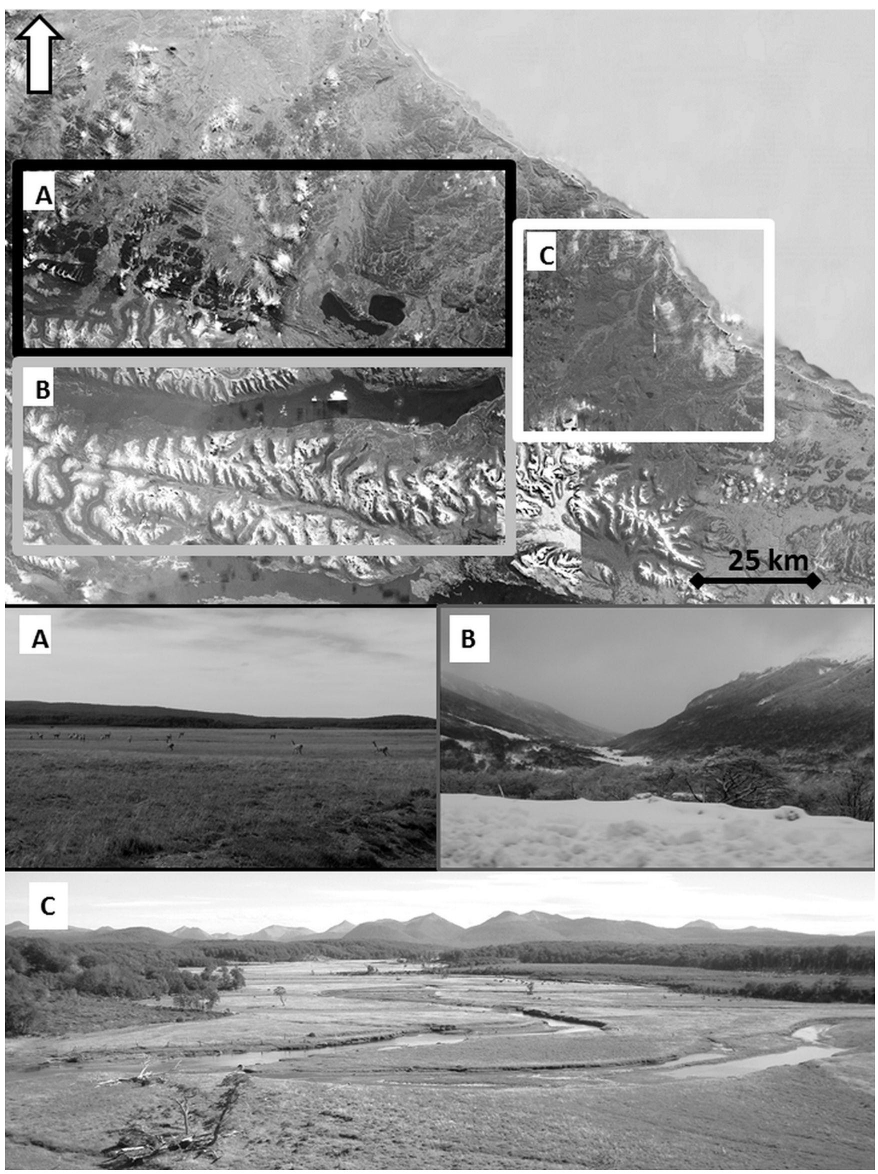

Fig. 2. Landscapes in the central part of Isla Grande de Tierra del Fuego. A: Woodland; B: Mixed Forest; C: Deciduous forest.

(*N. pumilio*). It extends along the northern coast of lake Fagnano, and on the slopes of the mountains to the south and east of Lake Fagnano, towards the Atlantic coast.
- Woodland: an ecotonal landscape with undulations and hills, stretching from the northern slopes of the mountains to the Río Grande. This landscape corresponds to the area of discontinuous deciduous forest of *N. Antarctica* and/or *N. pumilio* alternating with clearings and valleys covered with grasses and rushes.

The soils in the central area of the island are thin (10–40 cm) and are formed by a surface layer of organic mulch on a compact basal layer, developed on glacial sediments. These soils ("Acid Brown ground of the Forest", *sensu* Tuhkanen, 1992) are subject to freezing and thawing processes.

2.1. Lithic raw material sources

The study of technological organization in hunter–gatherer societies needs a deep analysis of interrelationships between tool morphology and technology with lithic raw material choice. This implies to analyse lithic raw materials characteristics, to identify their 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.

There is abundant research about the geology of Tierra del Fuego and the glaciofluvial processes that have modeled its landscape. For the northern part of the island, geological research by Meglioli (1992) and others (*e.g.* McCulloch et al., 2005; Kaplan et al., 2008; Clapperton et al., 1995) set the basis for analysis of provenience of archaeological raw materials (*e.g.* Borrazzo, 2012; Borrazzo et al., 2010; Borrero, 1998; Franco, 1998; Franco and Borrero, 1999). For all the mountain region of southern Tierra del Fuego, geological research (Caminos, 1980; Caminos et al., 1981; Olivero and Malumián, 2008; Olivero et al., 2007 and many others) set the basis for the analysis of archaeological materials from sites of the Beagle channel area (*e.g.* Orquera and Piana, 1986–1987; Terradas, 1995, 1996, 2001).

In our case study, in order to analyse provenience of raw materials for the contexts of the central part of Tierra del Fuego, we have adopted the classic archaeological definition of Potential lithic supply sources (PLSS) (*cf.* De Angelis and Mansur, 2015). It considers three types of sources: Primary, Secondary, and Tertiary PLSS (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 where rocks are in locations different from the original outcrop; they have been fractured and transported by diverse erosive agents, such as rivers, glaciers, etc. (Luedtke, 1979; Olausson 1982–1983; Nami, 1992). Finally, tertiary supply sources are concentrations of rocks due to human actions; they can be exploited as raw material sources by different groups (AGI, 1976; Church, 1994).

2.1.1. Primary sources

In central and southern parts of Tierra del Fuego, the primary sources of the lithic raw materials most represented in the archaeological record are the outcrops of Yaghan Formation and Lemaire Formation (Caminos, 1980; Caminos et al., 1981) (Fig. 3).

The Lemaire or Tobífera Formation (Jurassic) extends across the Andes from the Magellan Strait to the Isla de los Estados. The main outcrops are found in the elevations south of Lake Fagnano, mainly in Sierra Alvear. However, fragments of this formation can be found in secondary position in Quaternary fluvioglacial deposits (Olivero and Malumián, 2008). It is formed by acidic volcanic rocks, principally rhyolites and rhyodacites, and intercalations of marine sedimentary levels including lutites and dark slates. Although these rocks have been modified by regional metamorphism, they all preserve their original textures (Terradas, 1996).

Rhyolites and cinerites are the rocks most used as raw materials in archaeological contexts from the center of the Island, due to their fairly good flaking quality. It is not always easy to distinguish them with the naked eye; that is why in the past they were generally named as "metamorphites" (Orquera and Piana, 1986–1987; Terradas, 1996). On the contrary, identification is easy on a microscopic scale, because of different structure and granulometry. For this reason in our research we classify them after high power observation of surfaces with reflected light microscope (Terradas, 1996; Mansur, 1999).

Regarding the Yaghan formation (Cretaceous), the most important outcrops are located along the coast of the Beagle Channel. In this case as well, rocks of the Yaghan formation are found in Quaternary fluvio-glacial deposits, in secondary position. This formation is characterized by presence of black and grey radiolaritic slates with a banded structure and a very strong transverse lamination (Caminos, 1980; Caminos et al., 1981). Their quality for flaking is low, which is why their use for tool manufacture is rare (Terradas, 1995, 1996). Although they are present in the assemblages of some periods and sectors of the Beagle channel coast, they are poorly represented in the central area of the island.

2.1.2. Secondary and tertiary sources

Secondary raw material sources in the study area are principally rock accumulations that exist in fluvio-glacial quaternary deposits. These rocks include fragments of both Lemaire and Yaghan formations, that were transported long distances by glacial advances, towards the southern shore to the Beagle Channel and also towards the north. They also had an ample dispersion due to fluvioglacial and later fluvial action (Olivero et al., 2007; Olivero and Malumian, 2008). Therefore, pebbles of various sizes are easily available in these fluvio-glacial formations, which constitute potential secondary sources for raw material (De Angelis, 2013). To the north of the island, most of the pebbles available were transported by several glacial advances, since ca. 2 Ma (Meglioli, 1992), that contributed to the formation of secondary sources.

Other raw materials such as quartz, chert, etc. are sometimes present in different archaeological contexts within the area. Quartz is a relatively ubiquitous raw material. Even though it appears in the form of veins and streaks, as for example along the coast of the Beagle Channel, it is also present in fluvio-glacial deposits, as small round pebbles (Mansur et al., 2000; Olivero et al., 2007; Olivero and Malumian, 2008).

Another material sometimes used, especially in sites dating from the 19th and 20th centuries, is industrial glass. Glass was widely used immediately prior to and after the contact with the Europeans (Mansur and De Angelis, 2013). It was available for the native populations in secondary supply sources (pebble accumulations on the Atlantic coast, with glass fragments from shipwrecks that were brought to shore by the action of the sea). Finally, as for tertiary sources, they are the concentrations of materials made by human action; they include raw materials imported by Europeans who were settling in different areas of the island, such as glass, porcelain, metal, etc. (De Angelis, 2012).

3. Field methodology and raw materials testing

In the study area the archaeological visibility is low and site formation processes cause important deterioration of archaeological materials. For these reasons, we decided to survey the area based on the principles of distributional approach (Thomas, 1975; Foley, 1981a; Dunnell and Dancey, 1983; Ebert, 1992).

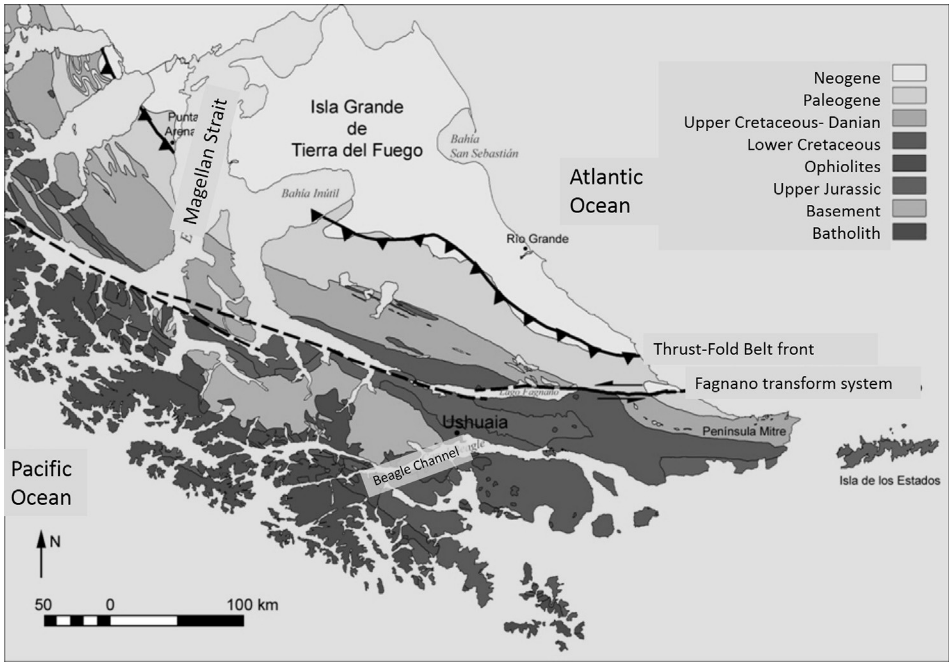

Fig. 3. Geological map of southern South America (modified from Olivero et al., 2007).

Distributional analysis is a methodology of spatial analysis that considers the artefacts as the basic analytical unit. The distribution of artefacts in space and its interpretation are made on the basis of "density" which refers to the relations concentration/dispersion and presence/absence of artefacts in the regional space. From this point of view, the distributional approach sees the archaeological record as a continuous distribution with places where artefact density is higher and others where it is lower. Therefore, the variability in artefact density is an expression of the character and the frequency of space use (Belardi and García, 1994; Belardi, 2005). Consequently, it is possible to propose a correlation between areas with high density of archaeological material and places with high resources concentration, that is where availability of resources is higher; and likewise a correlation between areas with a lower artefact density with places where resources are not critical, or where they are far from others, or they are very scarce.

3.1. Transect survey

To carry out a study of this type, it is possible to propose as a starting point the determination of several landscapes and landscape units in relation to human societies (Wandsnider, 1998; Anschuetz et al., 2001) and then rank them according to their diversity and frequency of resources. Therefore, to start a distributional study in the central part of the island, we choose the two landscapes with mountains and forest environments (Mixed forest and deciduous forest) and located several landscape units, seeking to cover the widest possible diversity: in mountain areas, in areas of forest and in valley environments, or directly associated with water sources (rivers, lakes and lagoons) (Table 1). As for field methodology, we set a series of transects (fieldwalking in grids or along lines) of 5 km in length, each surveyed by an observer, with a spacing of 3–5 m between each line. In transects the main biotic and abiotic resources were registered. Biotic resources were recorded in terms of presence or absence, habit and relative

Table 1
Transects in lakes and rivers.

Location	Linear mt.	Area	Environment	N	Density
Mixed forest					
Aguas Blancas Lagoon	3317	33,170	Lagoon shore	2	0.00006
Margarita Lagoon	5465	54,650	Lagoon shore	3	0.00005
Bombilla Lagoon (Kami 2 to 6)	5000	75,000	Lagoon shore	625	0.008
Palacios Lagoon (Kami 8)	5000	75,000	Lagoon shore	33	0.0004
Bahía Torito	5000	75,000	Lake coast	28	0.0003
Deciduous forest					
Negra Lagoon	5000	1,00,000	Lagoon shore	2	0.00002
Valdez lower reaches of river mouth	5000	75,000	Lake coast	38	0.0005
San Pablo lower reaches of river	5000	1,00,000	Valley	0	0
Lainez lower reaches of river	5000	1,75,000	Valley	1	0.000005
Azara lower reaches of river	5000	1,50,000	Valley	12	0.00008
Vasco lower reaches of river	5000	1,50,000	Valley	0	0
San Pablo upper course of river	5000	1,75,000	Valley	0	0
Lainez upper course of river	5000	1,50,000	Valley	63	0.0004
Irigoyen upper course of river	5000	1,50,000	Valley	84	0.0005
Irigoyen middle course of river	5000	1,50,000	Valley	1	0.000006

abundance (Berihuete, 2010). The lithic raw material was recorded considering rock type, size and abundance (Terradas, 2001); archaeological visibility was also recorded (De Angelis et al., 2013a).

This fieldwork was considered as a first preliminary analysis, therefore no test pits were excavated; however in the case of discovery of archaeological materials, systematic surface collections were carried out. The surface collection was conducted intensively in those cases when archaeological materials were in risk of loss or destruction, either because they were on the edges of ravines or because they appeared on walking roads. Otherwise, we carried out a sampling of surface material, which would give an overview of raw materials, types of artefacts, etc.

Table 2
Archaeological artifacts found in the surveys.

		Technological types	Chalcedony	Chert	Cinerite	Undet.	Lutite	Slate	Quartz	Rhyolite	Flint	Glass	Total	%
Bigger than 2 cm	Retouched	Instrument fragment			3			4	1	5			13	
		Projectile point										**1**	1	
		Side scraper			4	1	1			18	2		26	
		End scraper	1		12	1				13	2		29	
		Total retouched	**1**		**19**	**2**	**1**	**4**	**1**	**36**	**4**	**1**	**69**	**7.80%**
	Unretouched	Flakes	10	1	65	13	12	5		151	12		269	
		Fragment	11	5	54	18	5	70		133	8		304	
		Bipolar frag.			1								1	
		Bipolar hemi pebble								2	1		3	
		Bipolar flakes				1							1	
		Flakes with edge damage								7			7	
		Core			3					5			8	
		Discoidal core								3			3	
		Core fragment			1		2			7			10	
		Hammer								1			1	
		Stone anvil								1			1	
		undetermined			1								1	
		Total unretouched	**11**	**6**	**60**	**19**	**7**	**70**		**159**	**9**		**341**	**68.70%**
		Total bigger than 2 cm	**22**	**6**	**144**	**34**	**20**	**79**	**1**	**346**	**25**	**1**	**678**	**75.50%**
Smaller than 2 cm		Small flakes	9		34		4			37	9		93	
		Debris	6		54	4	2	18		30	6		120	
		Microflakes			1								1	
		Total smaller than 2 cm	**15**		**89**	**4**	**6**	**18**		**67**	**15**		**214**	**23.50%**
		Total	37	6	233	38	26	97	1	413	40	**1**	892	**100%**

3.2. Raw materials sampling

Systematic sampling of raw materials was mainly oriented to know the characteristics and the knapping quality of rocks in the supply sources (Nami, 1992; Aragón and Franco, 1997; Andrefsky, 1998; Ratto and Nestiero, 1998). In order to evaluate these aspects of raw materials, samplings were performed wherever the transects intercepted accumulations of pebbles whose sizes would allow direct percussion (minimum 10 cm in length). These samplings consisted in establishing sectors of one square meter; in each sector, 10 nodules were randomly taken and were knapped *in situ*, always by direct percussion. After that, we took samples of each raw material in order to generate a large systematic collection for the Laboratory. The variables that were recorded were: raw material quality for knapping, grain size, fracture type, cleavage, hardness, and size (De Angelis, 2013).

The supply sources are all secondary sources, generated by fluvio-glacial action, and therefore, materials are generally rounded pebbles of different rock types. These sources are located on the banks of the rivers, which in this area have a low gradient, are very sinuous and form meanders with sectors where there is accumulation of pebbles whose sizes are suitable for direct percussion flaking. On the shores of lakes and lagoons, it is also possible to find sectors with presence of pebbles with similar characteristics.

3.3. Analysis criteria

Materials were classified following the criteria that we usually use for techno-functional analysis. These have some differences with the classification criteria used by other researchers in Argentina, because we take primarily into account the size and the technological characteristics of lithic artifacts in function of raw material and use wear traces. 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 (*cf.* De Angelis and Mansur, 2015).

As for the identification or raw materials, it is easy to do on a microscopic scale, because of different structure and granulometry of the rocks used in the study area. For this reason, raw materials were classified after high magnification reflected light microscopic analysis (Mansur, 1999).

4. Results

4.1. Transect surveys

There are three main landscapes in the area. Two principally represent mountains and forest environments: Mixed forest landscape on the Cordillera, and deciduous forest landscape on the valleys and hills. The other one, Woodland landscape, or ecotone, represents the transition to the northern steppes (Fig. 4) (De Angelis, 2013; Mansur et al., 2010, 2013).

Transect surveys were conducted in both the Mixed forest and Deciduous forest landscapes. They included different landscape units, from lagoon areas, forest areas, riverbanks, to proximity of the sea coast (Tables 1 and 2).

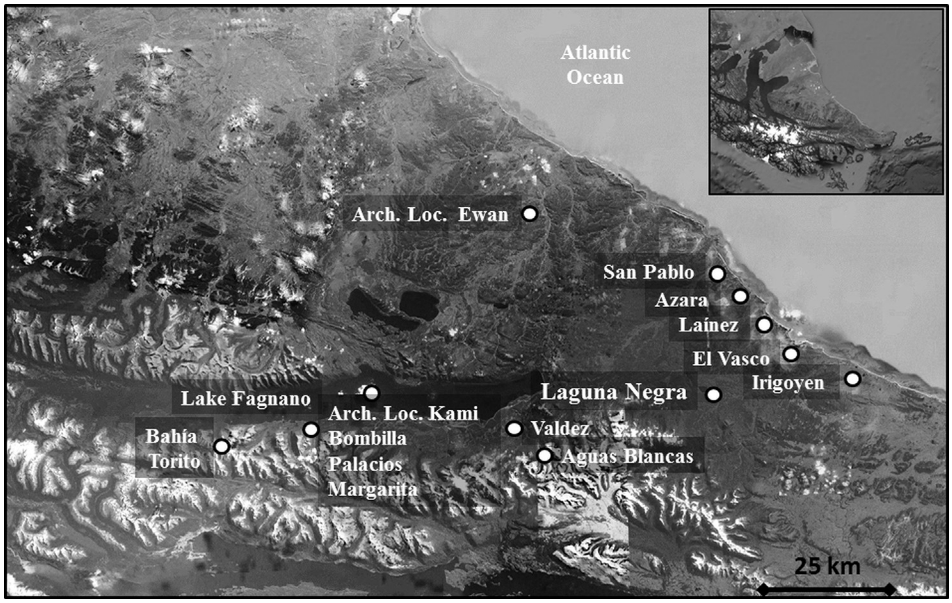

Fig. 4. Location of surveyed areas.

4.1.1. *Coasts of lagoons*

Transect design included a number of coastal areas and adjacent areas of glacial lagoons (Fig. 4; transects area and recorded densities are presented in Table 1). These lagoons are situated inside the forest, and then their archaeological visibility is very poor. However, the shores have small sectors where pebbles of various different sizes appear. Usually they are small, but in some cases there are some large, even exceeding 50 cm. Their knapping quality ranges from very poor to good quality (Nami, 1992; Aragón and Franco, 1997; Andrefsky, 1998; Ratto and Nestiero, 1998).

Aguas Blancas: The length of the coast (5 km) let us set 40 transects, with two isolated findings (transects area and recorded densities are presented in Table 1). In both cases, they are almost exhausted rhyolite cores.

Laguna Margarita: It has a maximum length of 2.5 km and its width reaches about 0.4 km (Table 1). Three isolated findings were performed in the upper part, located to the N and NE of the lake, separated from each other by several meters. They were a side scraper fractured into two parts (which were together) and two large end scrapers.

Laguna Negra: It has a circumference of 5 km. On the coast, a cliff covered by forest, two isolated findings were noted: a side scraper and a flake (See Table 1).

4.1.2. *South coast of Lake Fagnano*

The southern coast of Lake Fagnano is formed by a series of high cliffs that alternate with lagoons and bays. There are long sectors of the coast where secondary deposits of pebbles are very dense, with pebbles of various different sizes; in some cases they are large, even very large, exceeding 50 cm. Along the coast, we recognize a number of important concentrations of archaeological material. In each transect, observation revealed both archaeological sites and isolated findings. Therefore, we present the surveys done in this sector with different names, according to site denomination (Table 1).

Valdez River mouth: a transect of 5 km included the river mouth. Close to the river mouth, we could detect materials on the ground surface: two lithic tools (one side scraper and an end scraper, both made in rhyolite), one core (made of lithified siltstone) and a bone fragment (distal epiphysis of methapod – *Lama glama guanicoe*-). Following the transect, concentrations of lithic archaeological material were recognized, where we discovered 17 flakes and 2 cores. There was also a side scraper, one fragment instrument and an end scraper. Artefacts smaller than 2 cm are 7 small flakes and 2 *débris*.

Laguna Bombilla: Close to this lagoon is the first important archaeological locality that we found south of Fagnano Lake, that we called the Kami archaeological locality. It has a maximum N–S length of 0.6 km and E–O of approximately 1 km. During the surveys, different sectors with archaeological materials were detected, some dispersed and others forming important concentrations. Two of the smaller concentrations are located on the east coast of the lagoon. They did not show high density of artefacts on the surface; they are Kami 2 (12 retouched artefacts and 200 unretouched) and Kami 3 (4 unretouched artefacts). On the cliff, the coast sector that forms a point (Kami 6) showed an ample dispersion and high frequency of archaeological material, especially lithic artefacts. As for bone material, there were two possible bone retouchers, one on a distal epiphyse of guanaco metapod and the other on a guanaco long bone.

To the west of the lagoon, on the coast of Lake Fagnano, is Kami 1 site, a large site that was excavated from 2009 to 2011 (Mansur et al., 2010; Mansur and De Angelis, 2013). There are two surface concentrations: Kami 4 (5 retouched artefacts and 61 unretouched) and Kami 5 (7 unretouched artefacts).

Laguna Palacios is approximately 0.5 km long and 0.48 wide. To date, archaeological findings have been done in the inside part of the coast. However, on the upper part of the spear, that is the lagoon's western sector, there is a series of concentrations that extends for about 15 m. Two large concentrations are located in the forest, close to a sector of the coast of Fagnano Lake where there is an important deposit of pebbles: Kami 7 and Kami 8. Kami 7 has locus with different chronologies (Parmigiani et al., 2012; De Angelis, 2013). The lithic artefacts are 28 retouched tools and 311 unretouched. In Kami 8, material is principally formed by *débitage* (2 retouched artefacts and 31 unretouched). Testing of raw material quality in this sector of the coast revealed many good knapping quality pebbles.

At Bahía Torito, the survey concerned a strip along the coast as well as a series of walkways towards the forest. In both cases we found dispersed lithic material.

Fig. 5. Raw materials test. A. River San Pablo, medium course. B. Meander with accumulation of pebbles. C. Testing raw materials. D. Tested pebbles and flakes.

Then, a second visit to Bahia Torito was done after a forest fire that took place in 2012. This forest fire involved an extent of at least 2000 ha; the objective of our survey was to verify its impact on the archaeological record. We finished a transect of 5 km.

In this visit, the visibility of archaeological material was higher. Materials recognized in the transect were very abundant. We collected some of them to complete the sample. The results of this second survey are not taken into account in order to compare with all the other transects, because of the special situation after the fire.

4.1.3. Valleys and coasts of rivers

Surveys in the valleys and coasts of rivers (Vasco, Lainez, Azara and San Pablo) were started in the lower courses, where we explored the last 5 km from their mouth in the Atlantic coast. In general they are all very similar, with a grass carpet towards the valley bottoms and river banks, interrupted by wide peat bogs. Away from the riverbed, towards the hillsides, open woodlands are present.

Concerning lithic supply sources, in all cases we could identify concentrations of pebbles of different sizes, located in sectors of meanders where the river accumulates material. Density of raw material is low, as well as density of archaeological findings.

4.1.3.1. Upper and middle course of Rio Irigoyen. In the upper course of the Irigoyen, the transect intersected a concentration of materials of approximately 8 × 16 m. All the archaeological material was recorded and collected in a grid of 1 × 1 m. It includes flakes, cores and retouched tools (end and sidescrapers).

Close to the cliff on the riverbank, there were some isolated findings: a sidescraper, a cobble with percussion marks on one face and a polished sector on the opposite. Following this survey to the west, 150 m away, there were a small concentration of lithic artefacts (4 fragments, 3 flakes, 1 sidescraper), and one of burnt bone fragments.

In the middle course, the transect runs along the right bank of the river. There was a side scraper found on the cliff.

Table 3
Raw material knapping quality, according to different landscape units. MF: mixed forest. DF: deciduous forest.

				Quality		
Lands U	Landsc	Location	Outcrop	Good	Regular	Bad
Lake	M F	Kami 1	Secondary	6	4	0
Lake	M F	Kami 7	Secondary	4	4	2
Lake	M F	Sur 54°	Secondary	4	4	2
Lake	M F	Bahía Torito	Secondary	2	4	4
Lagoon	M F	Laguna Margarita	Secondary	5	3	2
Lake	M F	Valdez	Secondary	7	2	1
Lagoon	D F	Laguna Negra	Secondary	7	3	0
River	D F	San Pablo sup.	Secondary	3	4	3
River	D F	Lainez sup.	Secondary	2	3	5
River	D F	Irigoyen Sup.	Secondary	2	4	4
Total				42	35	23

4.1.3.2. Río Lainez upper course. The transect revealed two small concentrations with lithic artifacts on the surface. In one, there were some microflakes and a scraper. The other was the result of an alteration of the sediment produced by tree roots, that had exposed lithic artifacts.

4.1.3.3. Río San Pablo upper course. This sector corresponds to the sources of río San Pablo. It is a place with large peat bogs and is very altered by beavers. Transects were done on the right and left banks, with negative results.

4.2. Raw material testing

In order to program the raw material testing, we established square meter grids wherever transects intersected concentrations of pebbles whose sizes allowed flaking by percussion technique (minimum 10 cm long). We performed a total of 10 tests, distributed in the three landscape units that we wanted to survey: lagoon environment, shores of Lake Fagnano and river valleys. The testing consisted of arbitrary grids of 1 square meter, in which 10 rocks were selected at random (Table 3). They were knapped by direct percussion with hard hammer (stone) (Fig. 5). The objective of this testing was to study the accessibility to provision raw material sources, as well as to test the raw material knapping quality for each source.

Determination of rock type on the field was done by direct observation with the naked eye, followed by examination of fracture surfaces at high magnification with the reflected light microscope. In the test, qualitative variables were considered: knapping quality, macroscopic granulometry, fracture, cleavage plans, hardness and pebble size. At present, we are completing these descriptions with thin sections in order to determine petrographic structure.

4.2.1. Coasts of lagoons

Tests were developed in the transects done in Laguna Negra and Laguna Margarita. In both cases, the transects followed the morphology of the lagoons; therefore, they concerned the shores. In both lagoons, it was relatively easy to identify sectors of the shore with concentrations of pebbles whose sizes rendered them apt for percussion flaking. These sections measured around 1 km.

Knapping by direct percussion was done *in situ*. We could corroborate that rhyolite was the most abundant raw material. It was also the best quality material for direct percussion knapping. In these lagoon's shores tests, the relation good/bad quality for percussion flaking was 7/3, when in sources in the river banks this relation is lower, 5/5.

4.2.2. South coast of Lake Fagnano

In the south coast of Lake Fagnano, we made tests in the transects of Kami 1, Kami 7 and Bahía Torito. In all three cases, the shores had wide concentrations of pebbles of various sizes, that allowed knapping by direct percussion. Pebbles with good knapping quality were dominant. The most represented raw material was rhyolite.

4.2.3. River valleys

Concerning river shores, raw material supply sources were easily found in the upper course; in these sectors, they had larger pebbles and good flaking quality materials were more abundant. In the last 5 km (excepting the mouth where they flow into the ocean), rocks concentrations have pebbles of very small size, that are not adequate for percussion flaking, and sometimes too small even for bipolar percussion knapping. These characteristics are also a factor influencing the low visibility of these sources.

Tests were done in the transects of the upper courses of rivers Valdez, San Pablo, Láinez and Yrigoyen. In all cases, the accumulations of pebbles intersected corresponded to deposit of material in river meanders. These places are very important, because normal river flowing, as well as great river risings during snow melting periods, transport pebbles from the upper course and deposit them. Moreover, these places have good visibility, as they are not covered by forest.

Concerning the raw material knapping quality, within the samples tested there were more low quality than good knapping quality pebbles. As for raw material, rhyolite predominates.

5. Discussion

The results obtained in the transect survey concerning density and distribution of artifacts, as well as the results of testing of raw materials from secondary supply sources, let us discuss a series of characteristics of the archaeological record that are relevant to understand aspects of human occupation in the central area of Isla Grande de Tierra del Fuego. The transect survey was carried out including different landscapes and landscape units. They comprised the coasts of lagoons, the southern coast of Lake Fagnano and valleys and coasts of rivers.

If we consider these landscape units, there are differences in artifact density and distribution (Table 1). The lagoons are situated in the mixed forest and in the deciduous forest regions, and their archaeological visibility is very poor. In all the cases, the archaeological materials discovered in the transects were isolated findings. Their number is very small.

Along the southern coast of Lake Fagnano, artefact density is higher. In each transect, we could recognize many important concentrations of archaeological material (including archaeological sites as Kami 1 and Kami 7) and isolated findings.

Finally, surveys in the valleys and coasts of rivers revealed differences between the lower courses, which descend towards the Atlantic Ocean, and upper courses. In the former, materials detected in transects were scarce, mostly isolated findings. In contrast, in the sides of the upper and medium course, there were materials in concentrations as well as isolated findings; however, the density of archaeological artifacts is low, if we compare it with that of the southern coast of Lake Fagnano.

On the basis of these distribution densities, and considering data obtained from the analysis of lithic assemblages (De Angelis, 2013), we think that it is possible to get a new insight on management strategies of lithic materials in the area. Below, we will consider the results of the raw material source testing.

The results obtained in the secondary supply sources let us confirm some observations about availability and characteristics of lithic raw materials. In all the cases, the dominant raw material is rhyolite, followed by cinerite and slate and others (Table 2).

The shores of lakes and lagoons are the landscape units were identification of lithic raw material sources was easier and more frequent (Table 3), especially because of their visibility and accessibility. They consist of concentrations of pebbles modelled by fluvio-glacial processes, which conform secondary sources.

Concerning their abundance and sizes, pebbles from sources of the southern coast of Lake Fagnano are larger and more abundant that those from lagoon shores. As for their knapping quality, good knapping quality pebbles prevail over bad quality, in a relation of 7 to 3. On the other hand, in the case of sources associated to river banks, the relation is lower, around 5 good quality pebbles to 5 bad quality pebbles. Furthermore, in these cases the visibility is also lower, and the size of beaches (meanders) is smaller (De Angelis, 2013).

Consequently, we could say that raw material, even being present in widely spread secondary supply sources, is not distributed homogeneously. There are differences concerning accessibility, availability and quality in the different landscapes and landscape units.

Until recently, the evaluation of lithic resource management in the area had been made only taking into account the information of excavated archaeological sites, especially those of the southern coast of Lake Fagnano. The approach taken in this research includes the evaluation of characteristics of human occupation and availability of raw materials, through systematic transects. On this basis, it is possible to discuss the results obtained in this project with previous results of analysis of the excavated sites. To do so, we take into consideration the information generated in sites as Marina 1 site (Mansur et al., 2000), Kami 1 and Kami 7 site (Mansur et al., 2010; De Angelis, 2013; De Angelis et al., 2013a, 2013b; Mansur et al., 2013). The characteristics of these sites have been discussed in a previous presentation (Mansur et al., 2013).

The raw materials used in the lithic artifacts, both recovered in surveys and in site excavations, come essentially from two geological formations, the Lemaire formation (Jurassic) and Yaghan formation (Cretaceous). Those most commonly used are rhyolites and cinerites, and in lesser measure shales, characterized by their good knapping quality, mainly depending on rock particle size. Usually the best knapping quality rocks are cinerites and shales, although rhyolites are the most abundant.

Concerning the morphology of supports, lithic analysis of materials both from transects and excavated sites shows predominant exploitation of pebbles from secondary supply sources, confirmed by characteristics of fluvio-glacial modelled cortex.

Another characteristic of the assemblages is the predominance of local materials, although there are some allochthonous materials, coming from sources located at different distances. This is the case of a silicified tuff from a primary outcrop located at the Miraflores river, more than 250 km, first presented by Prieto et al., (2004) (Borrazzo et al., 2010; Borrazzo, 2012; De Angelis, 2012; De Angelis, 2014; De Angelis and Mansur, 2015).

If we consider the characteristics of lithic artifacts, the results of transect surveys confirm those obtained from excavated sites (De Angelis, 2013). Usually, archaeological assemblages from zones where there are important lithic sources with large pebbles, show precise characteristics suggesting important exploitation of raw material sources. In those cases, lithic artifacts are very abundant, they represent the whole lithic reduction sequence for each operating chain, and they include abundant cortical flakes and bipolar flakes and cores, indicating exploitation of pebbles as raw material. The best example for this is Kami 1 site, located close to a good source of raw material, on the Lake Fagnano southern coast (Mansur et al., 2010; De Angelis, 2013; De Angelis et al., 2013a, 2013b; Mansur et al., 2013).

6. Conclusion

From the results obtained, it is possible to discuss some more general aspects regarding the exploitation of lithic resources in mountain regions. These landscapes may seem, at first glance, as ideal provision places for hunter–gatherers because of abundance of rock materials. However these are not always accessible in terms of visibility and possibility of exploitation. On the other hand, not all rocks can be used for the manufacture of all types of tools. We can then propose that hunter–gatherer societies that highly depend on lithic resources seek to exploit outcrops where visibility and accessibility are high, but that also search for a variety of raw materials with different characteristics that allow manufacturing of different artifacts. From these data, it is possible to discuss mobility and seasonality of hunter gatherer groups, in relation to raw materials, availability of resources and activities.

In the introduction, we mentioned that in our hypothetical model, we proposed that the availability of lithic raw materials is an important variable that conditions camp movements of hunter–gatherer groups in mountain nomadic circuits. This surveys and raw material testings have confirmed that raw material distribution is not uniform throughout the area, as well as that characteristics of lithic assemblages vary according to characteristics of lithic supply sources (De Angelis, 2013).

Concerning functionality of sites, we could analyze the case Kami 1 site. In Kami 1, the abundance and characteristics of *débitage*, as well as the presence of complete lithic reduction sequences in the site, and the results of techno-functional microscopic analysis of tools, confirm that it can be considered as a residential camp site (Mansur et al., 2012). Surveys and testing of raw materials showed that it is located close to one important secondary lithic supply source on the coast of Lake Fagnano, where pebbles are abundant and include good quality raw material. In contrast, in regions where raw materials are scarce or where accessibility is difficult, the lithic series are smaller, and so are artifact sizes and technomorphological variability. As for *débitage*, the initial steps of the operating chain, as well as cores, are not well represented. This is the case of transects close to river banks, and of excavated sites such as Láinez or Marina 1 (Mansur et al., 2000).

We also expected camp movements along the year cycle, to take into account places and seasons which are better for lithic raw material procurement. For example, in the case of our study area, one of the most important constraints is accessibility and availability of secondary sources in frozen soils or under winter snow coverage.

We do not have yet final data concerning seasonality or duration of camps in the rivers or in the small lagoons. However, for the case of the Fagnano Lake, Kami 1 and Kami 7 sites, the archaeobotanical results suggest an occupation in spring–summer (Berihuete personal communication). Spatial analysis and chronology indicate that different sectors in this area were occupied and reoccupied. In Kami 1, radiocarbon dating of different hearths gave the following results: Kami 1: 3210 $\pm$ 80 AP (LP 2164), 1130 $\pm$ 60 AP (LP 2163) and 1170 $\pm$ 60 AP (LP 2201). In Kami 7, one hearth gave 1.217 $\pm$ 38 AP (AA94284); another 178 $\pm$ 34 AP (AA94285) and there is another one with industrial glass as raw material, dating from at least after the 17th century (Parmigiani et al., 2012). These chronologies suggest that the area was being used along at least one thousand years by hunter–gatherer groups who developed economic activities, as searching raw material, manufacture of tools, utilization to process different resources, capture, process and consume animals, etc.

Finally, we expected that good quality raw materials circulate among interrelated groups. Up to now, we had observed cases of use of allochthonous raw materials in sites of the Fagnano Lake, especially the Miraflores silicified tuff discovered in the Kami 1 site. This material is not very abundant in the assemblage, but it is very specific: it was reserved for the manufacture of micro end-scrapers (De Angelis and Mansur, 2015). Distance and landscape make direct procurement from the primary source very unlikely. It is not possible to know if the raw material was found by chance in some secondary source nearby. However, it also seems relatively unlikely, as this silicified tuff was not represented in the raw material test grids or other secondary sources studied until now. Moreover, the Miraflores silicified tuff assemblage found in the site is characterized by lack of flakes with cortex, something that does happen with the other raw materials discovered in Kami 1.

On the other hand, this material could have been obtained by exchange with other groups from the primary source. The sizes and technological types of débitage and waste microflakes are consistent with a conserved or curated technological strategy (*sensu* Binford, 1979). We believe that this material was extremely scarce and therefore it was reserved for a specific use, that was the manufacturing of microscrapers. Another case of circulation of especial or rare raw materials was the finding of a series of quartz crystals in Kami 7 site, but in this case provenance is still unknown (Parmigiani et al., 2012).

Utilization of allochthonous raw materials in hunter–gatherer contexts suggests interaction between groups. In the case of the Miraflores silicified tuff, it appears in several Late Holocene 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 that there was interaction among distant groups from the northern steppes and the central forest during Late Holocene times.

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