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Retouched artifacts production in three hunter–gatherer contexts from Tierra del Fuego (southernmost South America, Argentina): Avilés 1, Avilés 3 and Herradura 1

Lucas Turnes

CONICET-CADIC, Geomorphology and Quaternary Laboratory, Bernardo Houssay 200, Ushuaia, Tierra del Fuego 9410, Argentina

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ABSTRACT

This paper aims to identify technological decisions involved in the production of retouched lithic artifacts recovered from three Late Holocene archaeological sites located in the northeast of the Isla Grande of Tierra del Fuego (Argentina). More specifically, the main goal is to assess whether there is any relationship among raw material selection, retouching intensity, and the morphology of retouched artifacts. Through the analysis of several correlations between the knapping quality of the different raw materials employed and the index of invasiveness and curvature, it is inferred that raw materials were selected according to their homogeneous texture and convex shape in order to produce long retouched edges. As most of the retouched artifacts have been produced on unifacial blanks, using unipolar debitage techniques which does not require specific knapping skills, it is proposed that similarities found in the three archaeological sites can be explained as a result of oral transmission of basic technological knowledge.

1. Introduction

The archaeological record in the Isla Grande of Tierra del Fuego during Late Holocene represents the final stage of a long-term colonization process that began in the Pleistocene/Early Holocene transition (Borrero, 1989–90). In this sense, the Late Holocene is characterized by a population increment and the effective occupation of all the environments of the island (forest, steppe, Pacific and Atlantic littorals) (Borrero, 1989–90). Regarding the human settlements on the northeast of Tierra del Fuego, this timeframe is characterized by the abundance of low density and small sized archaeological sites (Borrazzo, 2010). This distribution of archaeological material can be explained as a result of the mobility pattern of the pre-European societies who lived in the area, which involved small groups with a high frequency of displacements along a spatially extensive territory (Borrero, 1985; Borrero et al., 2006). The archaeological sites located inland are homogeneously distributed over the steppe landscape (Santiago and Vázquez, 2012), and represent short term camps. A remarkable exception is the archaeological site of Las Vueltas 1, which has evidence of several episodes of massive hunting and processing of a wild South American camelid (*Lama guanicoe*) (Santiago and Salemme, 2009, 2010; Santiago, 2010; Colasurdo et al., 2012). On the other hand, coastal archaeological sites show evidence of manifold occupations, which indicate the relevance of littoral resources for Late Holocene societies (Borrazzo, 2004; Horwitz, 2004; Santiago and Vázquez, 2012). The main hunting prey in the northeast of the Isla Grande of Tierra del Fuego was *L. Guanicoe*, even in the coastal sites where other resources were consumed, such as pinnipeds, molluscs, and eventually stranded cetaceans (Horwitz, 2004; Borrero et al., 2006).

The regional lithic resource base is composed mainly of cobble deposits which have been classified as secondary sources. This means that raw materials have been transported from their primary sources, by the interaction of multiple natural agents, to different parts of the landscape (Nami, 1992). Secondary sources have been identified in the current beach, in Middle Pliocene gravel paleo-beaches (located at an altitude of 80–90 m a.s.l.) and Holocene beaches. Furthermore, cobble deposits can be found throughout the landscape due to the glacifluvial transportation processes (Bujalesky, 1998; Bujalesky et al., 2001; Bujalesky and Isla, 2005). Although secondary lithic sources are predominant in northern Tierra del Fuego, a primary source of silicified tuff has been identified in the Chorrillo Miraflores Valley, Chile (Borrazzo et al., 2010; Borrazzo, 2012). According to the distribution of

E-mail addresses: lturnes@hotmail.com, mardelpela@hotmail.com.

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secondary lithic resources, two main positions have been adopted (Borrazzo, 2012, 2013). On the one hand it has been proposed that raw materials are homogeneously distributed throughout the landscape due to the action of glacier-fluvial and coastal transport, suggesting a wide availability of lithic resources (Santiago et al., 2007; Oría, 2009; Oría and Pal, 2010). On the other hand it has also been sustained that although there are many available sources of raw materials, these are heterogeneous in many aspects, including density, size, and quality (Franco, 1998; Franco and Borrero, 1999; Borrazzo, 2004; Borrero et al., 2006; Borrazzo, 2010, 2012, 2013). This last position is based on systematic surveys implemented in the northeast of the Isla Grande, in an area circumscribed by the capes Espíritu Santo and San Sebastián (Fig. 1). According to the results of these surveys, three types of raw material distributions were defined: absent, scarce, and abundant (Borrazzo, 2013). However, archaeological sites located in areas with absolute absence of raw materials are very close to potential provisioning areas, at a distance ranging from 2 to 4 km (Borrazzo, 2013). Such a distance is not significant if stone provisioning ranges described for mobile hunter–gatherers societies are taken into account (Binford, 1980; Gould, 1980; Hayden, 1981; Kelly, 1983; Gould and Saggers, 1985). In this sense, lithic resources available at a maximum distance of 40 km from any archaeological site should be considered as local (Meltzer, 1989) and raw materials located within a radius of 10 km should be regarded as immediately available distance of 40 km should be considered as local (Meltzer, 1989) and raw materials located within a radius of 10 km from any archaeological site should be considered as immediately available (Bayón and Flegenheimer, 2004). Although some technological differences seem to respond to raw material density, there is also evidence indicating that lithic resources were plentiful throughout the landscape. For example, archaeological sites located in places with abundant lithic resources show a higher percentage of flakes and debris (Borrazzo, 2013). Nevertheless, both in scarce and abundant raw material areas, cores were not intensively reduced and retouched artifacts do not display differences in the number of retouched edges (Borrazzo, 2013). Thus, it is suggested that lithic resources were exploited with equal intensity in spite of raw material availability in the surroundings of archaeological sites. This strategy seems viable if stones sources are not scarce within a mobile hunter–gatherer society's immediate provisioning radio (c.f. Kuhn, 2004).

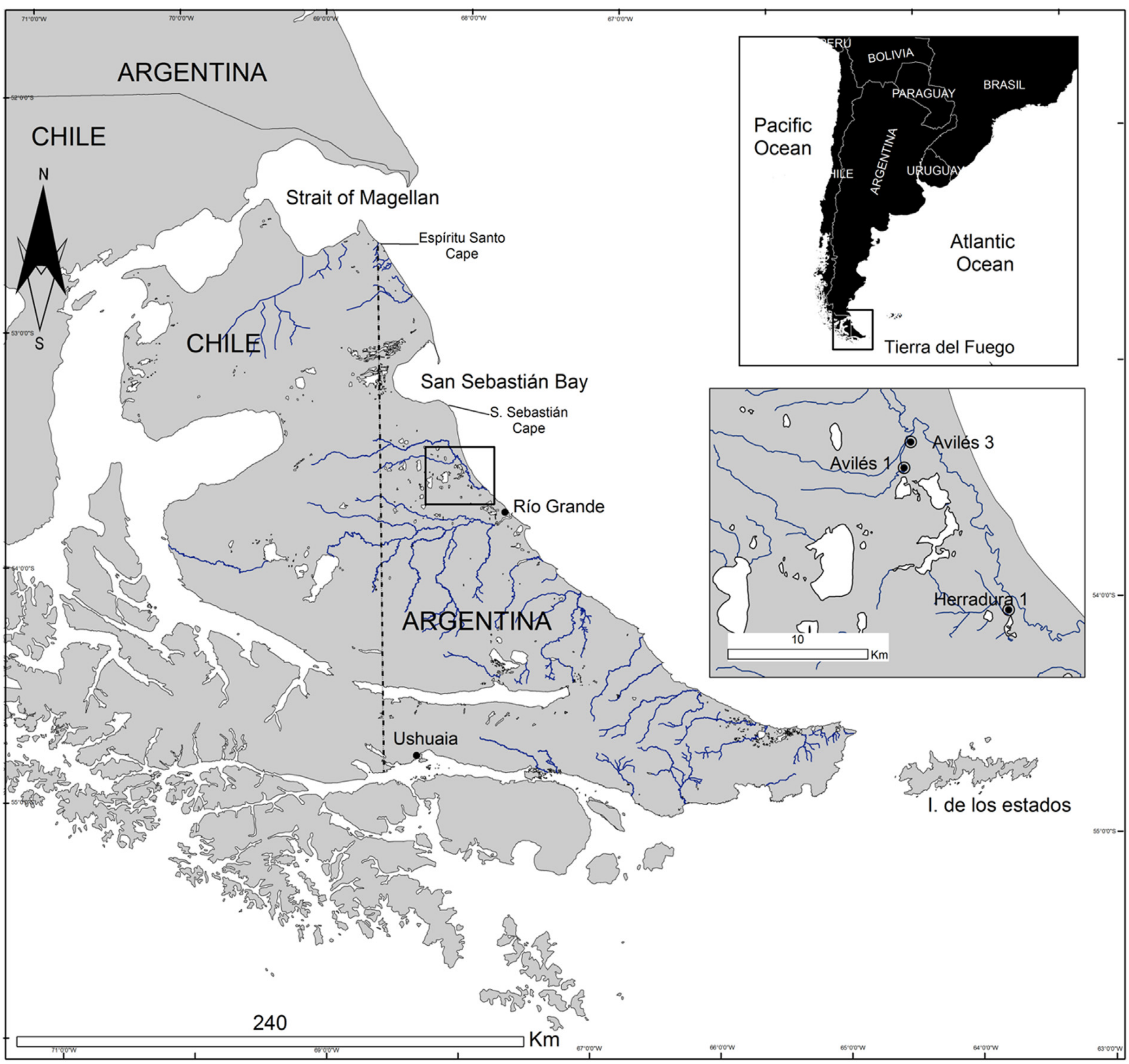

Fig. 1. Location of the three archaeological sites considered in this work: Avilés 1 (A1), Avilés 3 (A3) and Herradura 1 (H1).

It is noticeable that raw material qualities are heterogeneous, a fact that can be partially explained based on their geological origin. The rocks that compose secondary deposits in the northeast of the Isla Grande of Tierra del Fuego originated during the Upper Paleozoic-Mid Jurassic (basement rocks) and Mesozoic–Cenozoic Eras (Caminos, 1980; Kohn et al., 1995; Klepeis et al., 2010). The Mesozoic–Cenozoic stratigraphy includes multiple geological formations that were transformed by regional metamorphism processes during the Early-Late Cretaceous (Caminos, 1980; Kohn et al., 1995; Klepeis et al., 2010). As a consequence, many of the cobble beds on the island contains rocks which have been affected by metamorphism, and also weathering, and thus have undesirable features for flintknapping, such as foliation, quartz veins, and oxidation planes.

Cobble shape is another variable feature within available raw material deposits. With the objective of getting closer to a characterization of the morphological variability present in secondary sources, myself and two other team members of Geomorphology and Quaternary Laboratory from C.A.D.I.C. (Centro Austral de Investigaciones Científicas) conducted three transects with tours of an hour walk following north, west and east directions, starting from Herradura 1 (Fig. 1). During the prospecting, cobbles that exceeded a length of 5 cm were collected. These were used later as experimental cores, to have a deeper understanding of the knapping qualities of local raw materials. To date, the morphological characteristics of a part of this "natural" sample ($n = 163$) have been determined. This sample was divided into three categories, according to their shape: faceted (47.03%), spheroids (39.78%) and planar (13.19%). While this sample cannot be regarded as representative for the study area, it does indicate that there is morphological variability in immediately available raw material sources.

Within this framework, my research is addressed to unveil the technological responses developed by mobile hunter–gatherers in order to cope with a natural scenario that shows homogeneity in the distribution of potential sources and heterogeneity in the quality and shape of raw materials. In this paper, I will explore tool production technology and particularly the strategies used to extend raw material utility. To accomplish this aim, two distinct morphometric methods, the invasiveness (Clarkson, 2002) and curvature index (Hiscock and Attenbrow, 2005), were used on retouched artifacts recovered from three Late Holocene archaeological sites. It is proposed that both methods are useful to discern aspects involved in the selection of raw materials employed for lithic manufacture in unpredictable natural scenarios.

The initial expectation holds that best quality raw materials for knapping, homogeneous and isotropic stones, were the ones preferred for the manufacture of retouched artifacts. High quality raw materials allow greater control over the forms to be produced on lithic artifacts due to its ductility and fracture predictability (Cotterell and Kamminga, 1987; Andrefsky, 1998). Thus, these artifacts will have evidence of more intensive retouching in comparison with others produced on poor quality raw materials. A second hypothesis, derived from the first one, is that artifacts produced in high quality raw materials will show evidences of extended use, and consequently, of a gradual morphological change due to intensive edge trimming (Dibble, 1984; Hiscock and Attenbrow, 2005).

2. Technology as a social product

The chosen theoretical stance is based on the sociotechnical system concept proposed by Pfaffenberger (1992). From this point of view, it is sustained that lithic technology production processes and the produced objects involves social coordination between multiple actors. Therefore, its performance (effective action of the practices developed by individuals belonging to the same society and its material correlate) is the result of culturally specific ideas about how to organize society members around work (Basalla, 1988; Pfaffenberger, 1992). Another logical consequence of this theoretical proposal is that lithic technology cannot be assumed to represent a means of adaptation to the environment, because human needs are not straightforwardly imposed by the environment, but defined by societies themselves as a result of the social coordination of labor (Pfaffenberger, 1992). This does not mean that the environment has no influence over its inhabitants, but it is argued here that the natural constraints cannot by themselves explain the variability of human technological developments.

In sum, the theoretical stance used in this article sustains that lithic technology is a product of the interaction between labor, raw materials and knowledge transmission framed within social and environmental constraints. The study of lithic technology allows us to access to a fragment of the diversity of production processes performed within a particular society, which involves the materialization of knowledge of various kinds on specific objects. Moreover, knowledge or *connaissance* and know-how or *savoir faire* (Pelegrin, 1990) have been characterized as fundamental components of the technology concept (Pfaffenberger, 1988, 1992). Both terms, although intimately related, have different features:

> "… knowledge is an integral part of a recipe for action, it is a form of declarative memory and thus consists of theoretical information only, while know-how is an important part of the teaching framework, especially self-teaching by trial and error, since it is a form of muscle memory that can be acquired only through practice …"
>
> (Apel, 2008: p. 98).

Technological knowledge, then, has two dimensions: on the one hand it is a verbal and also non-verbal (observational) type of information, which may include criteria for selecting appropriate raw materials and knowing their location as well as technical recipes to manufacture lithic products. On the other hand it encompasses know-how, which needs implementation and internalization (i.e. embodiment) to be acquired (Schiffer and Skibo, 1987; Bamforth and Finlay, 2008; Bleed, 2008). Thus, the distribution of technological knowledge produced within a society, according to the particular psychomotor nature of its two constitutive dimensions, requires of different learning styles. Another variable that influences the way in which technological information is socially transferred is the skill degree required to materialize theoretical knowledge (Apel, 2008). Knapping techniques that require greater technical proficiency may only be acquired in contexts where apprentices were in contact with experts during prolonged periods of time and could gradually enhance their skill degree (Apel, 2008). On the other hand, knowledge about the location of suitable raw material sources or general technical knowledge to produce blanks that do not require practical mastery could orally spread across a broad spatial scale in a brief period of time, as long as the receivers of this knowledge decided to adopt it (Apel, 2008). Based on these theoretical principles it is proposed that both aspects of technological knowledge, *connaissance* and *savoir faire* (Pelegrin, 1990), were materialized in technological products and thus can be identified through the analysis of lithic artifacts recovered at archaeological sites.

In this article, two different methods, the invasiveness (Clarkson, 2002) and curvature indexes (Hiscock and Attenbrow, 2005), were used to analyze morphometric features surveyed in retouched artifacts. The results obtained are shown in order to discuss the nature of technological knowledge involved in lithic raw materials provisioning and tools production in the northeast of the Isla Grande of Tierra del Fuego during (at least) the Late

Holocene. The invasiveness index (Clarkson, 2002) is addressed to estimate the loss of mass in the artifacts as a result of intentional reduction. The methodological tools that provide a way of measuring retouch intensity (Dibble, 1984, 1988; Kuhn, 1990; Clarkson, 2002; Hiscock and Clarkson, 2005; Marwick, 2008; among others) allow archaeologists to approach to issues directly linked to technological decisions, as the degree to which various raw materials have been exploited may be associated to mobility, use of the landscape and economy of lithic resources. On the other hand, the curvature index (Hiscock and Attenbrow, 2005) enables inquiring about the causes of morphological variability recognized in the analyzed sets, which can either be produced due to the intensity and continuity of retouch on lithic artifacts or respond to a specific design for each tool, planned prior to the performance of the knapping sequence (Hiscock and Attenbrow, 2005). Both indexes are related, because it is expected that an increment in the intensity of retouching will impact in the augmentation of the curvature index, thus modifying the original shape of lithic artifacts. Here it is argued that the use of the invasiveness and curvature indexes together with the description of the knapping quality of raw materials (Aragon and Franco, 1997) allows identifying several technological decisions implicated in the production of retouched artifacts, including provisioning strategies used by Fuegian steppe societies.

In regards to raw materials procurement, Kuhn (1992, 1995, 2002, 2004) has proposed three types of strategies:

a) Transport tools and/or raw materials to the places where activities involving lithic artifacts will take place
b) Provisioning individuals with tools and raw materials
c) Producing lithic artifacts at the time when they are needed (i.e. provisioning activities)

Systems “a” and “b”, as Kuhn (2004) notices, are curated strategies because they involve provisioning and/or manufacturing of raw material prior to an activity that will be performed in the future. Thus, there are also technological consequences in the use of these strategies that will be materialized on the produced artifacts. In the first case it is expected that all different stages of lithic production will be found, from unused suitable raw materials to blanks and finished tools (Kuhn, 2004). With regard to the second strategy, mobility of individuals is the key factor, so probably a higher proportion of finished and intensively retouched tools (a lightweight toolkit) will be recovered (Kuhn, 2004). Finally, the third technological strategy seems viable in environments with wide availability of suitable raw materials (Kuhn, 2004) where there is no need of extending tools utility. Thus these should be produced, used, and discarded near to the place where the processing activities occurred. It is proposed that if similar lithic provisioning strategies are found in several archaeological sites within the same area, then it is possible to assume that the human groups that produced these archaeological records interacted within the same informational network, and shared common technological criteria.

During Late Holocene, the “c” procuring strategy seems to be the most frequent in northeast Tierra del Fuego. From a regional perspective, there is a recurrence in the expeditive production of lithic artifacts, using immediately available raw materials (Borrazzo, 2004; Borrero et al., 2006; Santiago and Oría, 2007; Oría et al. 2010). Most lithic assemblages are characterized by under-exploited cores with high percentages of cortex, although best flaking quality raw materials were reduced more intensively (Franco and García, 1994; Borrazzo, 2004). The most frequent retouched artifacts are long retouched edges produced by unifacial flaking on cortical flakes (Borrazzo, 2004). A variation of the “c” strategy may be present in Los Chorrilos locality, located south of San Sebastian Bay (Fig. 1), where reclamation of retouched artifacts and cores, as well as the presence of nodules without exploitation, was registered (Borrazzo, 2004). In this case, the provisioning strategy seems to respond to periodic reoccupations of coastal locations during Late Holocene. The emplacement of camps close to the Atlantic coast, where secondary rocks deposits are abundant, favored the transportation of raw materials over a very short distance (between 2 and 4 km), and thus lithic tools were produced at the time when they were needed and also discarded without extensive exploitation (Borrazzo, 2004). At the same time, these deposits of under-exploited artifacts and raw materials would have gradually provisioned coastal places with lithic resources. Through periodical reoccupations of the same loci, previously abandoned artifacts were reclaimed as part of a planned or opportunistic strategy (Borrazzo, 2004). In this case both “a” and “c” strategies could have been used alternatively. Regarding to non-local lithic resources provisioning, a rock petrographically classified as silicified tuff (ST) (Borrazzo et al., 2010; Borrazzo, 2012) was transported from its primary source, located in the Chorrillo Miraflores Valley (Chile), to several archaeological sites located at a minimum distance of 42 km (Borrazzo, 2010; Borrazzo et al., 2010; Borrazzo, 2012). Unmodified nodules of ST were transferred from its primary source and mainly processed to produce end scrapers (Borrazzo et al., 2010; Borrazzo, 2012). The localized source of ST in addition to its very low frequency in lithic assemblages of relatively distant archaeological sites, where other suitable raw materials were immediately available (Borrazzo, 2010; Borrazzo et al., 2010; Borrazzo, 2012), could be interpreted as indicators of an “a” type provisioning strategy.

In summary, diverse provisioning strategies were used by the inhabitants of northeastern Tierra del Fuego during the Late Holocene, although a predominance of local raw material procurement and expeditive production of lithic artifacts is observed. In this paper, it is argued that the analysis of retouched artifacts can provide useful information about lithic provisioning and manufacturing strategies, and thus provide a deeper understanding of technological knowledge transmission in high mobility hunter–gatherer societies.

3. Environmental characteristics of northeast Isla Grande of Tierra del Fuego and surface site formation processes

The northeast of Tierra del Fuego is characterized by a steppe landscape. Wind is the main modeling agent of the Fuegian steppe (Fig. 2), and consequently, it is reflected in the archaeological record. The predominant direction is west-southwest, reaching top speeds of 200 km/h (Santiago, 2010). The climate is temperate cold and wet, but nevertheless is the driest area in the sub-Antarctic phytogeographical province (Cabrera, 1971). The average annual temperature is 9.4 °C maximum and 1.9 °C minimum, higher than in continental Patagonia because of the ocean moderating effect on climate (Tuhkanen, 1992). During winter, snowfalls are often recorded, but wind intensity disfavors snow retention. Maximum annual rainfall is recorded during fall, and in summer seasonal drought occurs because the rainfall amount is compensated by an increase in wind intensity (Iturraspe et al., 1989). Visibility of archaeological sites is hindered due to steppe vegetation which is physiognomically dominated by coirón steppes (*Festuca* sp.) and shortgrass prairie (*Hordeum* sp., *Azorella* sp., *Elimus* sp., *Poa* sp.) alternating in mosaic (Bianciotto, 2006). This vegetation produces a homogeneous soil cover, affecting the conspicuity of cultural remains. Moreover, the processes that expose archaeological materials to surface conditions make them visible, but at the same time produce unfavorable conditions for their preservation. The most

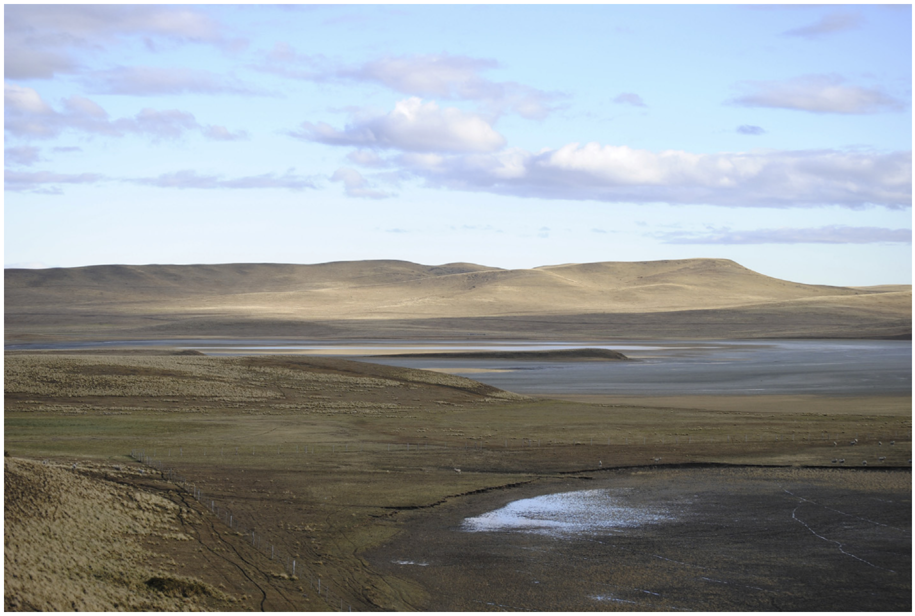

Fig. 2. Fuegian steppe landscape.

common of these processes are water level changes in lagoons and trampling generated by sheep, which also contribute to vegetation cover reduction because of their grazing intensity. The action of both factors reduces the vegetation cover in specific places of the landscape forming deflation hollows which may contain archaeological materials. Once exposed, archaeological sites continue to be affected by wind, ovine trampling, and precipitation runoff (Massone et al., 1993).

In this paper, three archaeological sites are considered: Avilés 1 (A1), Avilés 3 (A3), and Herradura 1 (H1). These are surface deposits, generated by the interaction of multiple taphonomic processes, which have already been described. Previous taphonomic studies developed in the Fuegian steppe indicate that the most affected archaeological materials are small sized bone fragments and microflakes, which can either be displaced or buried in a brief period of time (Santiago and Oría, 2007; Oría et al., 2010). However, this paper focuses on the analysis of retouched artifacts manufactured on medium and large flakes (sensu Orquera and Piana, 1986) ranging from 40 mm to 116 mm. Thus, it is improbable that these were affected by taphonomic processes with the same magnitude than microflakes. Another issue that must be taken into account is the fact that if archaeological items are displaced by multiple taphonomic agents, then superficial sites could act as natural "traps" for material remains (Oría et al., 2010). In northeast Tierra del Fuego, this phenomenon has been suggested for superficial archeological sites located near lagoons (Oría et al., 2010). Nevertheless, the archaeological sites considered in this paper are emplaced on elevated geoforms, and therefore the lithic material recovered in these locations could only have been deposited by anthropic agents.

4. Archaeological sites

The lithic artifacts considered in this article were recovered at three surface sites, A1, A3, and H1, located in River Chico basin (Fig. 1). Previous studies of these archaeological sites allowed delimiting their surfaces and also geopositioning and collecting all visible archaeological materials (Santiago and Oría, 2007; Santiago et al., 2007; Santiago, 2010).

The A1 site (53°34.394′S–68°04.673′W) is located on a hilltop composed of Early-Cenozoic sediments at 41.5 m a.s.l (Fig. 1). It is oriented towards the river floodplain and is approximately 3 km inland from the Atlantic Ocean. A1 is dated to 1609 ± 38 ^{14}C BP and covers an area of 1462 m^2. Although archaeological materials were found on Early Cenozoic sediments, this is clearly not their original context of deposition. Remnants of the aeolian sediments that contained cultural remains before exposure are visible in some sectors of the site (Santiago, 2010). A total of 167 lithic specimens and 104 faunal items were recovered (archaeological material density = 0.18 × m^2).

The faunal component included skeletal remains of three taxa: *L. guanicoe* (with cut marks), *Ovis aries*, and birds. Bone elements of *O. aries* were considered as "taphonomic rain" (sensu Borrero, 1988) as these would have been incorporated into the archaeological site due to natural causes. Lithic analysis results indicate that 65.26% (n = 109) of the assemblage corresponds to flakes, followed by cores (17.38%, n = 29), nodules (4.78%, n = 8) and retouched artifacts (12.58%, n = 21). The main raw materials used to produce lithic artifacts were rhyolite (52.1%, n = 87), followed by silicified tuff (27.5%, n = 46) and basalt (14.4%, n = 24) (Santiago and Oría, 2007; Santiago, 2010). This was interpreted as an ephemeral logistical camp, where at least one event of hunting and lithic manufacturing occurred (Santiago and Oría, 2007; Santiago, 2010). Lithic production was represented by an operational chain that included core reduction in situ as well as primary and secondary trimming (Santiago and Oría, 2007; Santiago, 2010).

The A3 site (53°33.399′S–68°04.254′W) is located 400 m away from the confluence of Avilés and Chico rivers, on top of a Cenozoic marine sediment geoform (Fig. 1). Although it has not been radiocarbon dated, the archaeological materials seem to come from a package of aeolian sediments, eroded in most of the site surface. These aeolian sediments are 1.5–2 m thick, and a similar sequence has been identified in another close archaeological site, Laguna Arcillosa 2, dated ca. 3500–5000 BP (Santiago et al., 2007; Santiago, 2010). Thus, the archaeological remnants recovered in A3 could have been deposited over an extensive period of time spanning the last 5000 years. Through a survey in selected sectors of the site, which covers an area of 2913 m^2, 782 lithic items and

10 faunal remains were recovered (archaeological material density = 0.27 × m^2). Most of the bone items have been identified as belonging to *L. guanicoe* (n = 6). The remainder included a *Balaenopteridae* vertebra, a metapodial bone of *Pinnipedia* and two items of unidentified birds. The lithic assemblage includes mainly flakes (76.9% $n = 601$), followed by debris (16% $n = 125$), retouched artifacts (4.6% $n = 36$), cores (1.9% $n = 15$) and nodules (0.6% $n = 5$). The most represented raw materials were silicified tuff (67.5% $n = 528$), rhyolite (21.1% $n = 181$) and basalt (8.1% $n = 63$). Other raw materials were identified, but with scarce significance considering the whole assemblage (1.2% $n = 10$). Taking into consideration the practical absence of faunal remains added to the concentration of cobbles beds in the site and its immediate surroundings, this archaeological site could be interpreted as a potential quarry and a workshop.

The H1 site (53° 39′ 48.38″ S, 67° 57′ 48.83″ W) is located on top of a hill of Cenozoic origin, at 52.5 m a.s.l. It is situated 2.8 km inland from the Atlantic Ocean coast. It covers an area of 1799 m^2, and archaeological materials were found lying in a deflated sector, over consolidated rock. Although no radiocarbon date is available for H1, because of the absence of organic material suitable for such purpose, the stratigraphic context (similar to A1) and the presence of a long triangular stemless arrow point might suggest at least one occupation of the site during the late Holocene (Santiago and Oría, 2007; Santiago, 2010). Lithic items (n = 446) and bone specimens (n = 18) were recovered (archaeological material density = 0.25 × m^2). The faunal component included remains of *L. guanicoe* and *Balaenopteridae*, and the latter taxon was represented by a rib with evidence of anthropic formatization. In the composition of the lithic set flakes predominated (69.5% $n = 310$), followed by cores (21.77% $n = 97$), retouched artifacts (5.60% $n = 25$) and nodules (3.13% $n = 14$). Lithic artifacts were manufactured using different materials which include rhyolite (41.3% $n = 184$), silicified tuff (27.4% $n = 67$), basalt (15% $n = 67$), quartz (9.4% $n = 42$), indeterminate stones (4.5% $n = 20$), microgranite (2% $n = 9$) and sandstone (0.4% $n = 2$) (Santiago and Oría, 2007; Santiago, 2010). Based on the virtual absence of faunal remains along with the presence of various stages of the knapping sequence, the site was interpreted as a workshop, where specific activities related to the manufacture of stone artifacts were developed (Santiago and Oría, 2007; Santiago, 2010).

In the three archaeological sites (A1, A3 and H1), the presence of retouched artifacts is a potential indicator of the use of stone tools, added to the evidence of multiple lithic manufacturing stages. However, use wear analysis of these items has not been done yet, so this can stand only as a hypothesis.

The features shared by the three sites (A1, A3, H1) can be summarized as follows:

a) Surface sites were chronologically assigned to the Late Holocene (and possibly also to Middle Holocene in the case of A3).
b) They are stationed in locations with a wide visibility of the surrounding terrain.
c) They have sparse findings.
d) Potential sources of raw materials are local and the sites are located directly next to them.

5. Materials and methods

The following analysis concerns all the retouched artifacts classified as single and double long retouched edges (Pal, 2012) recovered in A1 ($n = 11$), A3 ($n = 25$) and H1 ($n = 20$) (Figs. 3 and 4). This sample comprises all of the retouched artifacts previously classified as side scrapers (Santiago and Oría, 2007; Santiago, 2010).

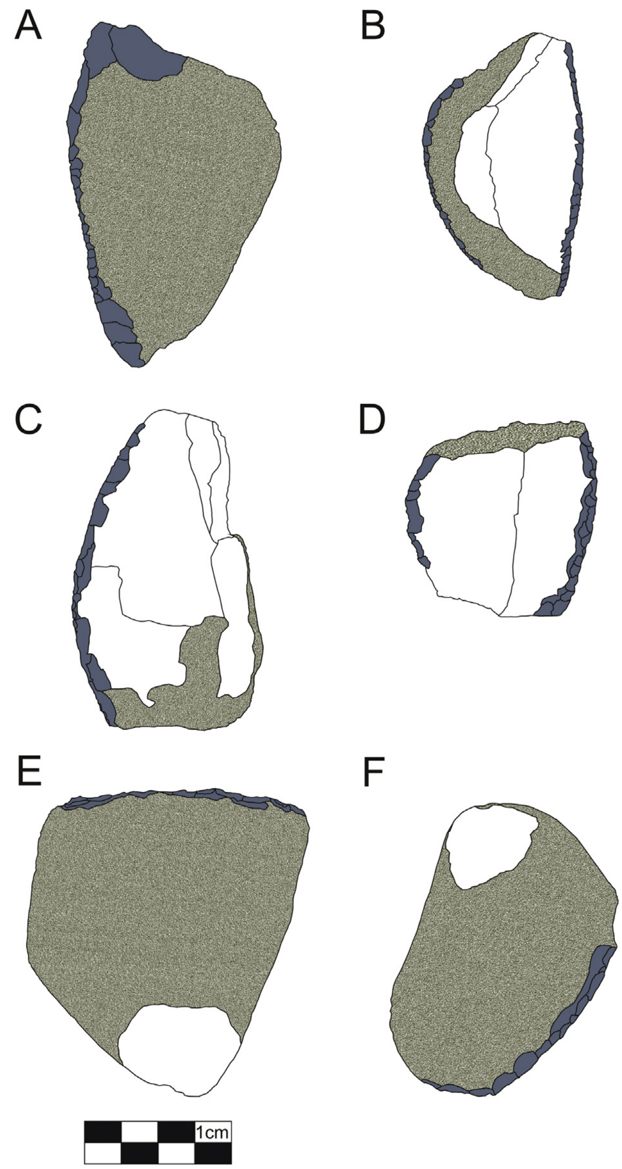

Fig. 3. Sample of single long and double long edges from A1 (A, B), A3 (C, D) and H1 (D, E). The light gray areas indicate cortex presence, the dark gray areas indicate retouched zones of the edge and the white color indicates previous extractions.

These tools were selected because they are the most frequent retouched artifacts registered in northeast Tierra del Fuego (Borrero, 1979; Horwitz, 2004; Borrero et al., 2006; Borrazzo, 2012, 2013). Thus, future comparisons between multiple lithic sets throughout a regional scale will be possible. Long retouched edges recovered at A1, A3 and H1 were produced using direct and bipolar percussion, and in most cases presented unifacial retouching, although bifacial retouching has been also registered. The typology herein applied is based on the characterization of morphological attributes that do not involve functional interpretations and it can be identified as a materialist classification, in the sense proposed by Hiscock:

> "A materialist classification is simply any system that divides an assemblage into categories based on the observable features of the objects without reference to notions of ideal forms, the mental predisposition of the maker, or the presumed goals of the artisan."
>
> (Hiscock, 2007: p. 201)

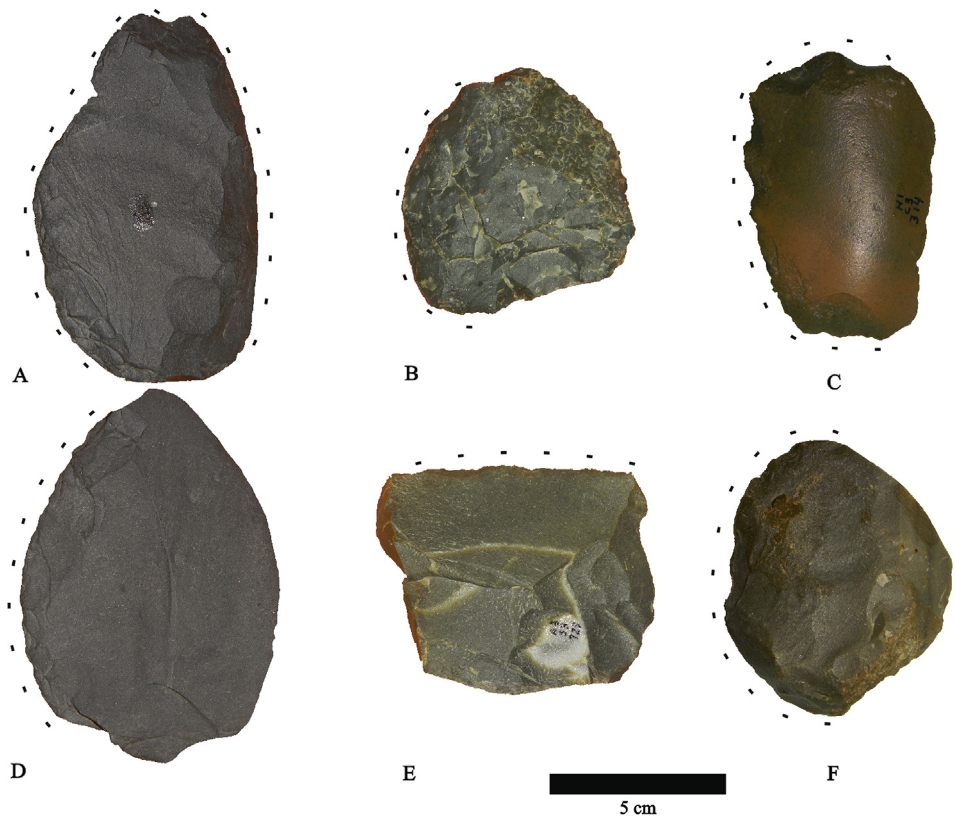

Fig. 4. Single (B, C, D, E, F) and double long edges (A) recovered at A1 (D), A3 (E, F) and H1 (A, B, C).

The use of typologies based on the description of metric characteristics, although it is not exempt of interpretive aspects, not only avoids the *a priori* assignment of functional attributes to lithic artifacts, but it is also compatible with other materialistic analytical tools such as the invasiveness (Clarkson, 2002) and curvature (Hiscock and Attenbrow, 2005) indexes. The invasiveness index (Clarkson, 2002) was calculated for the whole sample. In order to estimate this index it is necessary to subdivide each artifact into several segments, and assign a value to each of them according to the presence/absence of retouching and its depth. Subsequently, the result obtained is derived from the sum of the values assigned to the segments divided by the total number of segments considered, which varies according to whether the piece is unifacial or bifacial. Thus a value for the index is obtained ranging from 0, which indicates no retouching, reaching up to 1, which indicates deep retouching on all the artifacts edges (Clarkson, 2002). It is worth mentioning that for this study a modified version of Clarkson's original proposal was used, where a variation in the value assigned to the index divisor is entered in order to calculate with higher accuracy the retouch intensity (Hiscock and Tabrett, 2010).

Another unit of measure used is the curvature index proposed by Hiscock and Attenbrow (2005). The index value estimated by this method is a continuous quantitative variable that results from the relationship between the depth of the concavity or convexity of retouching and a baseline connecting the ends of retouching. According to the deepness of the retouch this measure can either overpass the baseline, thus assigned a positive value, or be contained inside the segment defined by the baseline, and be qualified as a negative value (Hiscock and Attenbrow, 2005). The curvature index result can be interpreted as a morphological description of the edge. This will be straight when equal to 0, concave if the index outcome is a negative value or convex if it results in positive values (Hiscock and Attenbrow, 2005). Thus, the curvature index is a methodological tool that allows comparing ranges of morphological variability within an archaeological set and provides information to assess whether the registered differences are due to gradual changes produced on originally similar blanks (Hiscock and Attenbrow, 2005).

Furthermore, the knapping quality of raw materials was estimated using the criteria proposed by Aragon and Franco (1997) who point out that rocks texture is the main property that determines the degree of quality for the manufacture of stone artifacts. Rocks texture is determined by the size and arrangement of grains or crystals: if all crystals have the same size then the matrix is homogeneous, otherwise, the matrix will be classified as heterogeneous. An increase in the heterogeneity of rock texture will produce a lower knapping quality. Aragon and Franco (1997) proposed a nominal scale considering four basic categories, which represent a continuum in the knapping quality rather than fixed types: 1) Very good quality; 2) Good quality; 3) Regular quality; 4) Bad quality. Knapping quality is a variable that can be correlated with the curvature and invasiveness index, in order to construct an interpretation considering multiple factors that may have been taken into account by humans for the production of lithic technology in the past.

6. Results

All of the analyzed tools exhibit low and moderate invasiveness index values, i.e. equal or less than 0.5. Therefore, the three lithic artifacts sets show scarce retouching intensity (Fig. 5). Regarding the curvature index, almost all of the analyzed artifacts presented convex edges (except one artifact with concave edges, recovered at A3), but with differences in the degree of convexity, as can be seen from the graphic description of each set (Fig. 6).

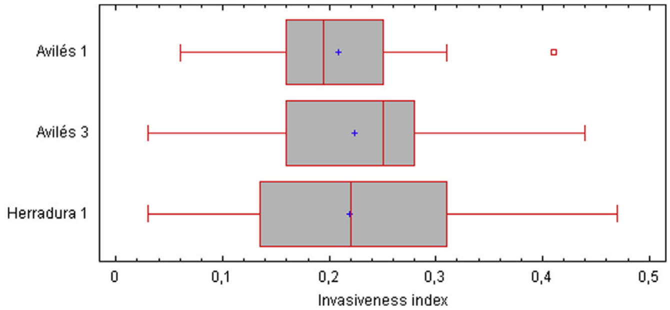

Fig. 5. Boxplot for all the analyzed specimens showing invasiveness index.

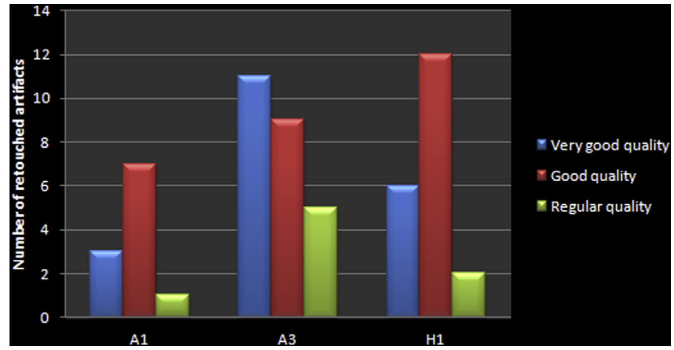

Fig. 7. Histogram showing the knapping quality of raw materials used for manufacturing retouched items on the three archaeological sites.

Taking into account raw material qualities, silicified tuff represents the best raw material for knapping, followed by basalt, unidentified sedimentary rocks and fine-grained rhyolite, categorized as good quality rocks. Coarse grained rhyolite was considered as a regular quality raw material (Fig. 7).

In A1, most of the retouched artifacts have been made on fine grained rhyolite, but there is considerable variability in the raw materials employed. These include silicified tuff, coarse grained rhyolite, basalt, and an unidentified sedimentary rock. (Table 1).

In A3, the raw materials used to produce lithic artifacts were silicified tuff, fine grained rhyolite, coarse grained rhyolite and indeterminate sedimentary rocks. A similar tendency to A1 has been noted in the selection of fine grained raw materials and the minor presence of heterogeneous texture rocks (Table 1).

In H1 the best represented raw material is fine grained rhyolite followed by silicified tuff, basalt, coarse-grained rhyolite and indeterminate sedimentary rocks. Rocks with homogeneous texture are predominant in this site. In sum, the types of rocks present in the three sites are almost the same, and there is also a tendency to select homogeneous texture rocks for the manufacture of retouched artifacts (Table 1).

Considering that in each one of the three archaeological sites the retouched artifacts manufactured in the same raw materials registered disparate values for the invasiveness index, a statistical analysis was performed so as to discern whether or not there was a trend indicating a more intensive use of any of the raw materials identified within each site. In order to achieve this objective a series of simple linear correlations were carried out using the Spearman Rho to assess whether or not there was a co-variation between the invasiveness index and:

- Knapping quality of raw materials.
- Curvature index
- Number of retouched parts of the edge.

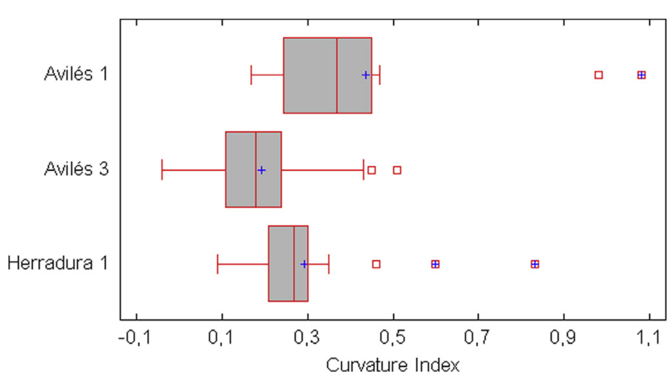

Fig. 6. Boxplot for all the analyzed specimens showing curvature index.

The Spearman's Rho test was selected as it allows assessing the level of co-variation between quantitative and qualitative variables and can also be applied to small samples, as in this case.

First, the correlation between the invasiveness index and knapping quality variables was assessed, recording a non-significant relationship for the three sets: A1 (rs = 0.21, df = 10, $p < 0.025$), A3 (rs = 0.12, df = 24, $p < 0.025$) and H1 (rs = 0.02, df = 19, $p < 0.025$).

Then, invasiveness index was compared to the curvature index, in order to evaluate whether there was a correlation between the increase in the invasion of retouching and a modification in the morphology of the retouched artifacts. The results were non-significant for all of the sites: A1 (rs = −0.1, df = 10, $p < 0.025$), A3 (rs = 0.04, df = 24, $p < 0.025$) and H1 (rs = 0.45, df: 19, $p < 0.025$).

Finally the number of retouched parts of the edge and invasiveness index variables were analyzed resulting in positive and statistically significant correlations for A1 (rs = 0.7; df: 10; $p < 0.025$), A3 (rs = 0.74; df: 24; $p < 0.025$) and H1 (rs = 0.81; df: 19; $p < 0.025$).

7. Discussion

All retouched artifacts classified as single and double long edges, recovered at three different archaeological sites, had a low invasiveness index. There are other reports of lithic artifacts showing scarce retouch intensity in archaeological sites dated to Late Holocene located in the northeast of Tierra del Fuego (Borrazzo, 2004; Borrero et al., 2006; Borrazzo, 2013). The non-extensive reduction of retouched artifacts indicates that it was not intended to exploit these tools intensively, a suitable strategy in environments where raw materials are plentiful (Kuhn, 2004).

Based on the results obtained by the correlation analysis between multiple quantitative and qualitative measures it is suggested that retouched artifacts recovered at A1, A3 and H1 showed non-significant associations not only between invasiveness index and knapping quality of raw materials but also between

Table 1
Types of raw materials used for manufacturing retouched artifacts.

Raw materials	A1	A3	H1	Total
Fine grained rhyolite	5	7	5	17
Coarse grained rhyolite	1	5	2	8
Silicified tuff	3	9	6	18
Basalt	1	0	5	6
Unidentified sedimentary rocks	1	4	2	7
Total	11	25	20	56

invasiveness index and curvature index. However, in the three analyzed sets significant positive correlations between invasiveness index and number of retouched parts of the edge were found. This means that as retouching deepened and the artifact lost more mass, retouching expanded into previously un-retouched parts of the edge. This trend did not depend on the knapping quality of the different raw materials employed. Furthermore, with the progressive retouching of artifacts, edges did not increase their curvature. If edges convexity did not increase with the intensity of retouching, but nevertheless its measurement indicates that they have a curved shape (Fig. 6), then selected blanks were naturally curved and their shape was not produced by trimming action. It could be questioned if this convex/rounded shape was conditioned by the morphological characteristics of available raw materials. However, the fact that available raw materials consist of cobbles deposits does not necessarily imply that all of the cobbles present near the sites have rounded shapes. Consequently, in order to obtain rounded blanks, the appropriate nodules must be previously selected.

Other evidence for the selection of specific cobbles within available rock sources is the high percentage of high quality raw materials. Local stone sources show heterogeneous knapping qualities, and thus suitable raw materials must have been intentionally selected for manufacturing long retouched edges.

8. Conclusions

Based on the results obtained from the analysis of raw materials quality along with curvature and invasiveness indexes, it may be suggested that the retouched artifacts recovered at A1, A3 and H1 show similar technological decisions:

a) Use of spheroids blanks obtained through the knapping of spheroid cobbles.
b) Selection of fine grained raw materials.
c) Non-intensive retouch on every raw material.
d) Progressive extension of the retouch over the length of the edges as the invasiveness of the retouching increased.

The results obtained from the statistical analysis of multiple morphometric variables suggests that different human societies that inhabited the Fuegian steppe during the late Holocene shared technological knowledge, including similar production techniques for manufacturing simple retouched artifacts and the same provisioning strategy. A question can be raised regarding technological choices described above: are these a result of similar individual experiences, produced independently within comparable environmental conditions (analogy), or a consequence of socially shared technological knowledge transmitted over generations (homology)? (Spencer, 1992). Although the results obtained are not conclusive, it is argued that theoretical and empirical arguments support the second position.

First, although the environment apparently offers the same resources for everyone that inhabits it, the possibilities for action within a natural milieu depends on the way it is perceived by the members of a particular society (Gibson, 1979). In this sense, the several technological decisions identified in the production of retouched artifacts not only indicate provisioning and production decisions, instead they represent an interrelated complex of perceptual values and a specific way of relationship with the environment which was socially shared and reproduced over generations.

Second, analyzed retouched artifacts have been manufactured on unifacial and bipolar flakes (Section 5), obtained by direct percussion. According to Pelegrin (1990), these products require little technical expertise, in other words, the theoretical aspect of technology (*connaissance*) is sufficient to obtain these lithic products without a practice framework (Schiffer and Skibo, 1987). If the knapping activities performed in the archaeological sites were of low difficulty, then they could have been easily replicated by those who had access to theoretical knowledge about how to select raw materials with suitable conditions and produce appropriate blanks in order to manufacture the types of artifacts characterized as single and double long edges.

Third, as Apel (2008) has proposed, wide spatial diffusion can allow identifying a kind of technological knowledge that does not need of technological expertise to be performed. In this sense, the presence of simple retouched artifacts in A1, A3 and H1 and also in other archaeological sites located in the northeast of Tierra del Fuego, suggests the existence of generalized knowledge between different social groups.

It is important to remark that many of the available raw material deposits contain cobbles of different sizes, shapes, and knapping quality. In contrast, all of the archaeological sites considered in this work contained artifacts that were produced using fine grained raw materials and rounded cobbles which provided convex blanks. This difference between the natural availability of lithic resources and the cultural selection of specific types of raw materials indicates that technological knowledge was used to identify desired properties on cobble deposits. Moreover, it is proposed that this knowledge allowed Late Holocene pre-Europeans societies to transform an unpredictable natural scenario as the Fuegian steppe into a landscape where the adequate raw materials could be identified and transformed in lithic tools when needed. This would explain the non-intensive use of good knapping quality raw materials: if basic technological knowledge related to the identification of suitable rocks was widely distributed and raw materials deposits were numerous, then lithic artifacts could have been manufactured using simple techniques at the time they were needed.

Throughout this article, a preliminary exploration of the information obtained through the study of retouched artifacts manufactured in the northeast of Tierra del Fuego during Late Holocene has been presented. The use of different methods provide novel sources of information that have the potential to get a deeper insight to the way of life of pre-European societies in Tierra del Fuego. It is also recognized that new excavations and analysis of extant lithic collections will be necessary to modify or reinforce the ideas discussed in this paper.

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