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# Spatial and temporal variability in the use of lithic raw materials for flaked stone technology in northeast Chubut Province (North Patagonia) during the Late Holocene

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ABSTRACT

This work presents and discusses the results of the presence of changes in the selection and use of raw materials for flaked stone during the Late Holocene in two areas of northeast Chubut Province: the north coast and the lower valley of the Chubut river (VIRCH). We considered two temporal blocks: 3000–1200 BP, and 1100–400 BP. Three hypotheses were tested: (1) in both areas, there was an overriding exploitation of locally available rocks; (2) rock exploitation was more diversified in VIRCH; and (3) there was an increase in raw materials of extra-regional origin post 1000 BP. Rock sampling aimed at characterizing the regional lithic resource base, and the results of the lithological classification of fourteen lithic sets made it possible to verify the predominant presence of artifacts made of local rocks, including silex and basalt, in both areas and both temporal blocks, and an increment in the record of artifacts made of chalcedony in the second temporal block. At a macro-regional level, the observed temporal tendencies point to similarities and differences with respect to models formulated for the northern and central coast of Patagonia.



## 1. Introduction

In the past few decades, technological studies about the archaeology of Atlantic Patagonian coast (from Colorado River and Magellan Strait), have focused on the characterization of the way in which the lithic resources are structured in the environment (sensu Ericson, 1984). Their importance resides in the fact that these studies provide the basic information that allows us to gain insight into: a) the strategies of procurement of raw materials in relation to mobility and the use of space; b) the influence of environmental and/or socio-cultural factors on the preferences or restrictions intervening in the selection of rocks; and c) the choice of different designs and reduction techniques (Binford, 1980; Nelson, 1991; Andrefsky, 2009). In this sense, it is important to mention that these strategies are many times less influenced by environmental and availability factors than by socio-cultural motivations (Flegenheimer and Bayón, 1999; Colombo and Flegenheimer, 2013). This approach makes it possible to integrate technological choices into the more comprehensive framework of general subsistence strategies and social organization (Nelson, 1991; Andrefsky, 1994).

Therefore, in this paper we will verify the existence of spatial variability and temporal trends in the use of lithic raw materials in northeast Chubut province during the Late Holocene. In order to assess the lithic resource regional base, systematic sampling was conducted in diverse geomorphological units. On the other hand, with the aim of exploring the technological human decisions and their relation with use of space, lithic resource availability and other socio-economic questions, fourteen lithic assemblages recovered from archaeological sites of different antiquity and origin were analyzed (Gómez Otero, 2006; Gómez Otero et al., 2010; Gómez Otero et al., 2013). Finally, the results of both studies are compared.

Two large sampling units (SU) have been chosen: 1) the northern coast (Coast), between 42° S and the north margin of the Chubut River, and 2) the mouth and lower valley of the Chubut River (VIRCH) (Fig. 1). On the basis of previous data (Gómez Otero, 2006), and in an operational manner, we also distinguished two temporal blocks (TB): TB1 corresponds to early Late Holocene (3000–1100 BP) and TB2, to final late Holocene (post 1100 BP). Three hypotheses will be tested: (1) in both areas, there was an overriding exploitation of locally available rocks; (2) the rock

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exploitation was more diversified in VIRCH, and (3) there was an increase in raw materials of extra-regional origin post 1000 BP.

## 2. Geological framework: landscape units and lithologies

Paleoenvironmental studies (Páez, 1993; Ichazo, 1994; Pardiñas et al., 2000) indicate that in the last two thousand years, current environmental conditions were already established. Therefore, the availability of local rock cannot have changed or suffered substantial variations since then.

The SU Coast includes the littoral area of the north Patagonian gulfs (San Matías, San José and Nuevo), as well as the open sea between Punta Ninfas and Bajo de los Huesos. The only potential rock supply sources come from secondary pebble deposits which are found in different geological positions (berms and coastal strips) and are widely distributed in the area. Plio-Pleistocene Rodados Patagónicos (Fidalgo and Riggi, 1970), of glaciofluvial origin, constitute thick layers of rounded acid volcanic gravel which cover terraces, ravines, and lowland. Beach ridges, which originated during the marine transgressions in the mid-Holocene (San Miguel Fm. sensu Haller, 1981), have pebbles up to 6 cm long of diverse lithologies: granite, quartzite, andesite, rhyolite, silex, and basalt (Gómez Otero et al., 1999). The only primary volcanic rock exposed corresponds to the Marifil Fm. (Malvicini and Llambías, 1974). It is composed of rhyolites, trachytes and ignimbrites associated with tuffs and breccias, and is 80 km northwest of San Matías gulf. However, isolated small ignimbrite fragments or pebbles can be found.

The SU VIRCH begins at Florentino Ameghino Dam and encompasses the lower course of the river to its mouth in Bahía Engaño. To the west, the valley is enclosed by volcanic rocks from Fm. Marifil; to the east, it is developed on sedimentary rocks mainly of marine origin (Ichazo, 1994). In this unit, secondary pebble deposits prevail. However, the joint action of fluvial, alluvial and marine processes promoted more heterogeneous lithological composition and distribution than along the coast. On the terraces, pediments, and foothills, there are deposits of Rodados Patagónicos (Fidalgo and Riggi, 1970) from the Montemayor Fm. (Yllánez, 1979) which include sub-rounded acid volcanic pebbles and cobbles, associated with andesite, granitoids, silex, and xylopal (Panza et al., 2002). Floodplains and terrace levels contain acid volcanics and pyroclastic pebbles from Gravas Morgan (Lapido and Page, 1979). The presence of Quaternary deposits is registered in the terraces (I to IV): the first ones (levels I and II) include pebbles (8–15 cm) and blocks (up to 40 cm) of acid rocks, porphyry, and rare milky quartz (Panza et al., 2002). The other levels (III and IV) contain silicified tuff, acid plutonics, basalt, and very few fine-grained greenish metamorphic rocks of smaller size (8–10 cm) and blocks up to 80 cm (Panza et al., 2002). The mouth has a raised paleo-estuary formed by a regressive sea which forms knolls and littoral chains parallel to the axis of the valley. Sedimentary deposits include pebbles of fluvial and marine origin, which are continuously transported, eroded, and altered by the geomorphological dynamics which become more active towards the Atlantic littoral area.

VIRCH offers greater availability and variety of raw materials. However, only through systematic sampling of rocks and their contrast with the archaeological record will we gain knowledge on the selection and use patterns of lithic resources.

## 3. Archaeological background

This area of study, located between 42° and 43°25′ S; 63°35′ and 65°03′W (Fig. 1), lies within the archaeological study carried out by Gómez Otero (2006), aimed at gaining a better understanding of spatial-temporal variability in the use of space and the diet in northeast Chubut province. The archaeological record indicates that the area was occupied at least from the Middle Holocene (7400 BP) to 200 BP. Research also showed spatial diversity in relation to the use of landscape. The highest archaeological density was registered in the estuary of the Chubut river, followed, in decreasing order, by the coast of the three gulfs (San Matías, San

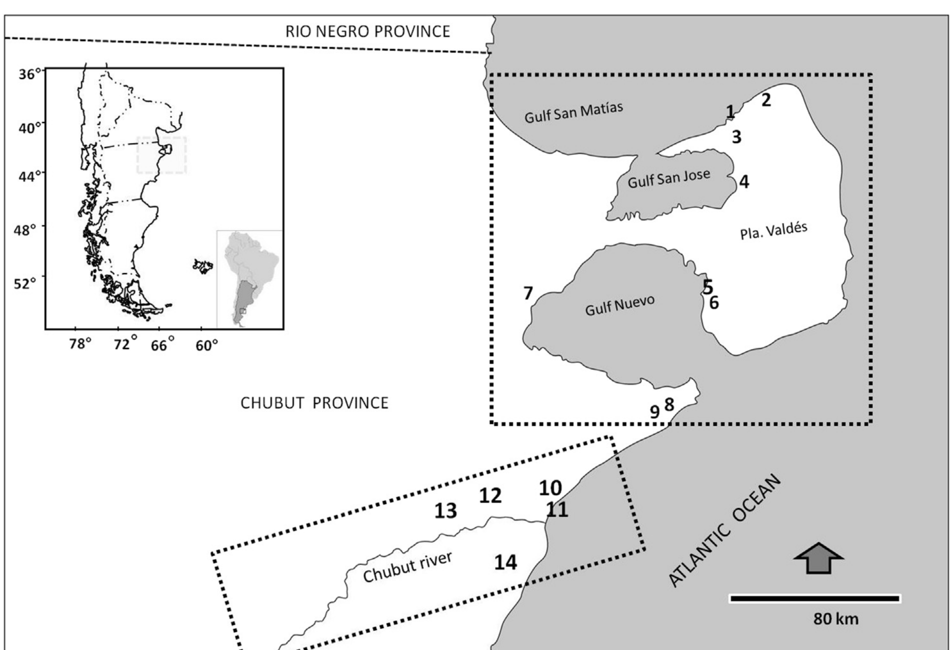


**Fig. 1.** Map of the study area indicating archaeological locations. References: SU Coast: (1) Las Lisas 2, (2) La Armonía, (3) San Román, (4) Flechero del 39, (5) San Pablo 4, (6) San Pablo 6, (7) Ecocentro, (8) El Pedral, (9) Punta León. SU VIRCH: (10) Barranca Norte 1, (11) Barranca Norte 2, (12) 5 Esquinas, (12) Loma Grande, and (14) Los Cangrejales.

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José and Nuevo) in Peninsula Valdes, the San Matías and Nuevo gulfs around Peninsula Valdés, and finally, by the open sea coasts. The more distance from the sea, the lower archaeological density, which indicates that the mobility and the settlement were mostly restricted to the coastal perimeter. For the last seven thousand years, the local hunter–gatherers populations maintained a close relationship with the littoral environment and moved frequently between coast and inland (Gómez Otero, 2006). There was a progressive increase in sites recorded from 2000 BP.

In relation to diet, zooarchaeological analysis, technological and $^{13}C$ and $^{15}N$ isotopic studies in human skeletal samples indicate that before the arrival of Europeans in the region, the food spectrum was generally broad and consistent with paleoclimatic variations and seasonal range of resources (Gómez Otero, 2007). The predominant diet was mixed (marine–terrestrial) including guanacos, mollusks, plants, and pinnipeds, supplemented with fish, crustaceans, birds, and small mammals.

With respect to lithic technology, previous studies have dealt with few contexts (Gómez Otero et al., 1999; Gómez Otero et al., 2010; Gómez Otero et al., 2011; Gómez Otero et al., 2013), and certain technological features were employed as proxies in order to determine the functionality and duration of occupations (Gómez Otero, 2006). The data show local pebble exploitation through direct and bipolar flaking, the presence of bifacial reduction technique from 2500 BP, and the application of expedient and curated strategies (sensu Binford, 1979). Geochemical analyses of obsidian indicate use of six varieties, three of which (PA; T/SC I and SI) come from known sources located 800 and 300 km distant, respectively (Stern et al., 2000; Gómez Otero and Stern, 2005). Finally, the record of: a) sumptuary objects made of extra-regional origin rocks as serpentine, turquoise, malachite, and manufactured metal artifacts in Late Holocene mortuary multiple contexts (Gómez Otero, 2003; Gómez Otero and Dahinten, 2008), and b) the identification of some projectile point designs similar to points designs from other Patagonian areas (Franco et al., 2010; Gómez Otero et al., 2011), indicate the existence of direct and indirect interchange mechanisms within and out of Patagonia.

## 4. Materials and methods

Fourteen lithic assemblages, which represent a total of 2300 lithic artifacts, were analyzed. In order to explore temporal trends, we selected those contexts which, although limited and unequal quantity in both SU, have radiocarbon dates (Table 1). The sets correlate with systematic subsurface samplings of 4 or 2 m on each side and stratigraphic samplings associated with hearth remnants (Gómez Otero, 2006).

Four general categories were selected for flaking technology analysis (Aschero, 1975, 1983): cores, flaking debris, natural-shaped artifacts and retouched tools (scrapers, side scrapers, raclette, knives, projectile points). Twenty percent ($n = 548$) are undetermined flake debris (Bellelli et al., 1985–1987) and were not taken into account to avoid enlarging the lithological lithic categories. In this work, we consider as local rocks those whose sources do not exceed 10 km radius from the settlements (Civalero and Franco, 2003), and as non-local those whose procurement sources exceed that distance.

In order to contrast the archaeological lithic record with the local raw material availability, several rock samplings were carried out in different sectors along the littoral, the estuary, and the lower valley, as well as on diverse landforms (berms, beach ridges, terraces, lowland and lakes). The sampling design consisted of the combination of two factors (Franco and Borrero, 1999; Franco and Aragón, 2004): time (15 min) *versus* quantity of obtainable nodules of good quality for flaking (Aragón and Franco, 1997). For each SU, we specified the availability and relative abundance of lithologies, sizes, and qualities. Subsequently, we calculated the relative performance and productivity (sensu Franco et al., 2012): high (100–75%); medium (74–50%); low (49–25%) and very low (24–0%).

The rocks were classified macroscopically with the support of background comparative samples of the Lithotheque from the Laboratory of Archaeology in CENPAT. In order to evaluate their use, we characterized each lithological set and established relative and absolute frequencies for each SU and temporal block. With the aim of testing the hypothesis of temporal changes in the use of raw materials, we made 2 × 2 contingency tables with the frequencies of the most commonly represented rocks, and then applied the statistical Odds Ratio test (Bland and Altman, 2000) which calculates the probability that an event (in this case, a temporal change in the use of a rock) will occur or not. Simultaneously, it allows us to identify the association between variables and to compare sets of uneven sizes.

## 5. Results

### 5.1. Regional lithic resources base

The results show an average of 20.66 pebbles for the coast and 26.5 in VIRCH. Greater lithological variability was registered in VIRCH ($n = 9$ varieties) than in the coast ($n = 6$ varieties), which included basalt, silex, rhyolite, ignimbrite, andesite, chalcedony, quartzite, xylopal, and tuff (Fig. 2). In Coast and VIRCH respectively, the best quality rocks are basalt (38 and 40%), sílex (39 and 21%),

**Table 1**
Archaeological site and lithic assemblages.

| Site | | n= | Sector | $^{14}C$ BP | References |
|---|---|---|---|---|---|
| Coast | San Pablo 4 M3 | 83 | Gulf Nuevo (Pla. Valdés) | 2930 ± 60 | Gómez Otero et al., 2013 |
| | Las Lisas 2 CH | 256 | Gulf San Matías (Pla. Valdés) | 2600 ± 60 | Gómez Otero, 2006 |
| | Flechero del 39 M2 | 175 | Gulf San José | 2640 ± 40 | Gómez Otero, 2006 |
| | El Pedral 1 M1 | 36 | Gulf Nuevo Sur | 2050 ± 70 | Gómez Otero, 2006 |
| | San Pablo 6 CC 2 | 47 | Gulf Nuevo (Pla. Valdés) | – | Gómez Otero et al., 2013 |
| | La Armonía M2 | 455 | Gulf San Matías | 470 ± 40 | Gómez Otero, 2006 |
| | San Roman 2 | 76 | Gulf San José | 1020 ± 60 | Gómez Otero, 2006 |
| | Ecocentro F1 | 42 | Gulf Nuevo | 840 ± 70 | Gómez Otero, 2006 |
| | Punta León 2 | 108 | Punta Ninfas | 1050 ± 50 | Gómez Otero, 2006 |
| VIRCH | Barranca Norte 2 N 2 | 174 | Estuary river Chubut North | 2960 ± 60 | Gómez Otero, 2006 |
| | Los Cangrejales 2 S4L 2 | 157 | Estuary river Chubut South | 2290 ± 80 | Gómez Otero et al., 2009 |
| | Barranca Norte 1 F1 | 70 | Estuary river Chubut North | 1040 ± 70 | Gómez Otero, 2006 |
| | Loma Grande 1 F1 | 60 | VIRCH | 1210 ± 60 | Gómez Otero, 1994 |
| | 5 Esquinas C-B N | 13 | VIRCH | 1260 ± 60 | Gómez Otero et al., 2010 |

**Fig. 2.** Rock samplings in each SU.

chalcedony (2 and 3%), and xylopal (3%, only in VIRCH). Among the top quality rocks are rhyolite (11 and 19%), quartzite (7–9%) and ignimbrite (4–3%). With respect to the nodule sizes, they are generally uniform with a predominance of guijarro (16–64 mm) and guijón (64–256 mm) types (Bonorino and Teruggi, 1952). The largest nodules were registered in VIRCH (61.4 mm median and 22.08 mm standard deviation (SD)), whereas, in the coast, we found a wider variation in size: median 48.05 mm and 40.7 mm SD. In both SU, the largest nodules are of basalt, silex, and rhyolite. The sizes of chalcedony and xylopal nodules range between 50 and 75 mm.

The averages of the nodule sizes varied in relation to the geomorphological unit: in the coast, the largest pebbles were found in terraces (92 mm), and the smallest ones in the coastal strips and berms (72 and 68 mm). In VIRCH, the largest pebbles were also found in terraces (87 mm) and the smallest ones in the paleo-estuary (67 mm) (Table 2).

### 5.2. *Lithological characterization among the artifactual assemblage*

Twelve (12) lithological varieties and an indeterminate one were identified; the latter at a very low frequency. In both SU, the most commonly utilized raw materials are of good quality for flaking: silex, followed by basalt and lastly, chalcedony (Tables 3 and 4). Silex is more abundant in VIRCH (52%) than in the coast (41%). Other rocks – rhyolite, xylopal, quartzite, and ignimbrite – show low frequency (less than 9% of the total). Artifacts made of non-local rocks such as obsidian and hematite are very scarce; the latter being found only in the coast. The presence of two types of obsidian (Gómez Otero and Stern, 2005) was determined macroscopically among both SU assemblages. They do not reach 4%: the greenish-grey type (similar to T/SC I type) predominates on the coast, whereas the black variety (similar to SI type) is more abundant in the valley.

### 5.3. *Temporal variations in the selection of raw materials*

A change was observed in the frequencies of the three main rocks (silex, basalt and chalcedony) in TB 2. In the coastal sector, silex (42–40.2%) and basalt (25–21.5%) maintain their proportions, while chalcedony increased from 13% to 22.4%; in VIRCH, basalt maintains the proportion (16–18%), silex decreases (59–37%), and chalcedony rises (7–23%). With respect to other rocks, xylopal and obsidian increase in VIRCH (1, 5–8 % and 0.3–4.8 % respectively), and ignimbrite almost disappears (11.7–2%). In the coast obsidian, xylopal and ignimbrite are present in very low proportions.

The observed tendencies were subjected to the Odds Ratio statistical test. The indexes showed that the temporal change probability in the frequencies of the three most exploited rocks is only valid in the case of chalcedony (Table 3).

### 5.4. *Artifact diversity and raw materials*

In the Coast, the typological categories, cores, flaking debris, natural-shaped artifacts, and retouched tools, are represented in almost all the identified lithologies, although silex, basalt and chalcedony showed greater indexes of artifact diversity, and the complete reduction sequence is represented (Table 4 and Fig. 3). On the basis of the residual cortex, it was recorded that 83% and 84% of the cores were highly carved. In every case, the most notable ones are those of high quality rocks. In line with these findings, the highest percentages of internal *vs.* external flakes correspond to rocks which have the best quality for flaking (Table 6). Among the cores, 17 are bipolar, 5 are discoidal, 1 is pyramidal, and 19 are indeterminate.

With respect to temporal variations, flaking debris predominates in both temporal blocks (57 and 81% respectively); followed by retouched tools (20.5% and 10%); natural-shaped artifacts (18.5% and 4%) and cores (4 and 5%). In the initial block, the retouched tools are mainly made of silex (50%); followed by chalcedony (27%) and basalt (10%). In the second block, silex decreases (29%) and is surpassed by chalcedony (30%), while basalt increases (22%). Within the group of the main retouched tools, there are end-scrapers, projectile points, side-blade knives, side scrapers, burins, and notches. The first two were made mainly on silex and chalcedony, whereas the side-blade knives, side scrapers, and burins were made on basalt. Regarding natural-shaped artifacts, in BT1 silex is in the majority (37%), followed by chalcedony (23%) and

**Table 2**
Lithological characterization, sizes (mm) and quality of the recovered nodules in each SU.

| | | Basalta | Sílex | Rhyolite | Chalc. | Quarz | Ignb | Xylop | Andes. | Tuff |
|---|---|---|---|---|---|---|---|---|---|---|
| Costa (*n*:56) | *n*= (%) | 21:38% | 21:39% | 6:11% | 1:2% | 4:7% | 2:4% | 0 | 0 | 0 |
| | Size (mm) | 40–130 | 30–140 | 50–80 | 65 | 55–90 | 65–80 | – | – | – |
| | Quality | High | High | Medium | Higher | Regular | Regular | – | – | – |
| VIRCH (*n*:70) | *n*= (%) | 28:40% | 15:21% | 13:19% | 2:3% | 6:9% | 2:3% | 2:3% | 1:1% | 1:1% |
| | Size (mm) | 30–100 | 50–110 | 70–120 | 50–75 | 30–85 | 55–65 | 60 | 85 | 90 |
| | Quality | Reg-high | High | Regular | Higher | Regular | Regular | Higher | Regular | High |

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**Table 3**
Odds ratio.

| | Coast (TB1 versus TB2) | VIRCH (TB1 versus TB2) |
|---|---|---|
| Chalcedony | Odds Ratio = **1.88** (95% IC, 1.4 to 2.55) | Odds Ratio = **4.11** (95% IC, 2.31 to 7.3) |
| Sílex | Odds Ratio = 0.92 (95% IC, 0.74 to 1.16) | Odds Ratio = 0.42 (95% IC, 0.28 to 0.63) |
| Basalt | Odds Ratio = 0.84 (95% IC, 0.65 to 1.09) | Odds Ratio = 1.19 (95% IC, 0.71 to 2) |

Temporal trends in the use of the principal raw materials: Odds Ratio between the to sample units.

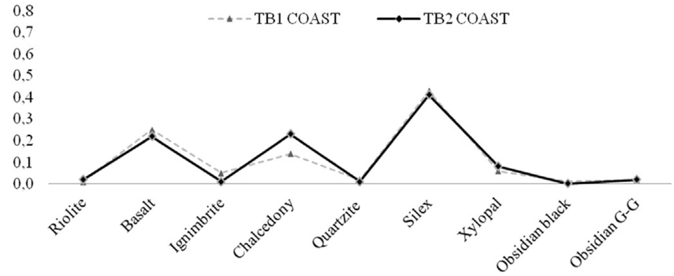


**Fig. 3.** Temporal tendencies in the use raw materials for SU Coast.

basalt (19%). In BT2, silex and chalcedony are common (33% respectively) and basalt artifacts (7%) are surpassed by xylopal (15%). Within this group, we found natural-shaped knives and natural points.

In the SU VIRCH, the four typological groups show a heterogeneous distribution among the different rocks (Table 5). The cores were only recovered in the initial block (2%), are intensively carved ($n = 7$), and correspond to high quality rocks (silex, xylopal, basalt). As to the shapes of the cores, we identified: discoidal ($n$:3), pyramidal and multi-directional ($n$:1 in both cases) and two indeterminate ones. Temporal variations were determined with respect to the level of core reduction and the percentage of cortex whithin the flaking debris assemblages. In TB1, where highly carved silex cores are in the majority, silex internal flakes reach 51%. In TB2, where no cores have been recovered, the frequencies of internal flakes vary: silex (32%); chalcedony (21%) and basalt (11%–15%) (Fig. 4 and Table 6).

In both periods, flaking debris makes up the majority (93% and 85%). The other categories show very low frequencies: natural-shaped artifacts (4 and 10% respectively); retouched tools (1% and 4% respectively). With respect to retouched tools, within the TB1 samples ($n = 4$) all are very good quality (two in chalcedony and in xylopal respectively). In BT2 ($n = 6$), there are two in basalt and xylopal, one in black obsidian and quartzite, and none in chalcedony. The uncommon tools include scrapers (made mainly in xylopal), burins and notches (in silex and chalcedony). Those with natural-shaped artifacts show similar proportions in the two TB (TB1 = 12, TB2 = 15): the more numerous are made of silex ($n$:8), then xylopal ($n$:2), basalt and black obsidian ($n$:1 in both cases). In BT2, we detected sílex ($n$:7), chalcedony ($n$:5), xylopal ($n$:2), and only one in basalt.

## 6. Discussion

The comparative study between the regional lithic resource structure and the lithological artifactual composition in both sampling units established spatial–temporal differences and tendencies in relation to the selection and exploitation of raw materials.

In regards to local availability of raw materials, firstly, the utilized sampling design allowed us to corroborate that there is no shortage of high quality rocks for flaking, as the different secondary pebbles deposits offer abundant raw materials of adequate qualities and sizes, especially basalt and silex. Other local rocks of lower quality were also registered, rhyolite, ignimbrite, and quartzite among them. Other rocks of better quality, such as chalcedony and xylopal, are in short supply. On the basis of relative abundance as well as the lithology, quality and size diversity of the nodules in each deposit, two situations were defined: medium productivity (70%) for both SU, but a higher output for VIRCH as a greater amount of nodules was collected, whose sizes are on average larger. The presence of a more diversified raw material assemblage in VIRCH could be related to fluvial dynamics, which might have transported and re-deposited rocks of different origins from the central stretch of the Chubut river to low areas such as the estuary. In summary, the presence of abundant pebble deposits in the area probably favoured the direct obtaining (at low acquisition cost) of raw materials which were suitable for flaking (Bamforth, 1986; Torrence, 1989).

The first hypothesis proposed overriding exploitation of the local high quality rocks in both SU. The predominant representation in all the assemblages of artifacts made of silex and basalt, the more abundant high quality rocks, matches with this hypothesis. However, even though silex and basalt were found at similar frequencies in the environment, silex prevails in the artifact sets.

In the SU VIRCH, the greater exploitation of this rock could be due to the variable quality of basalt (between good and regular); this would explain the preference for quality-assured silex. On the contrary, both rocks exhibit similar levels of quality in the coast, which is why further investigation is required into the causes for the preferential selection of silex, for example, criteria based on color, as suggested for early sites of the Pampeana region (Flegenheimer and Bayón, 1999; Colombo and Flegenheimer, 2013).

Given the high level of core exploitation, it was not possible to distinguish if the originally utilized nodules were maritime, fluvial, or Patagonian pebbles. Nonetheless, we detected a greater percentage of bipolarity in the Coast (6.4%) than in VIRCH (0.8%). This

**Table 4**
Lithological characterization and artifact diversity for the SU Coast.

| Coast | | Chalcedony | Silex | Basalt | Hematite | Xylopal | Obsidian Bl | Obsidian.G | Rhyolite | Ignimbrite | Andesite | Quarzite | Tuff | Indet | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temporal Blok 1 | Cores | 4 | 11 | 5 | 0 | 3 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 27 |
| | Retouched Tools | 15 | 28 | 6 | 0 | 3 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 56 |
| | Nat. shaped artifact | 10 | 16 | 8 | 0 | 5 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 43 |
| | Debris | 45 | 179 | 118 | 6 | 21 | 5 | 8 | 3 | 17 | 3 | 9 | 2 | 8 | 424 |
| | Total | 74 | 234 | 137 | 6 | 32 | 6 | 11 | 5 | 19 | 5 | 10 | 2 | 9 | 550 |
| Temporal Block 2 | Cores | 6 | 13 | 14 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 36 |
| | Retouched Tools | 23 | 22 | 17 | 0 | 10 | 0 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 76 |
| | Nat. shaped artifact | 9 | 9 | 2 | 0 | 4 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 27 |
| | Debris | 126 | 250 | 124 | 0 | 27 | 1 | 11 | 37 | 7 | 1 | 4 | 2 | 1 | 591 |
| | Total | 164 | 294 | 157 | 0 | 44 | 1 | 11 | 38 | 10 | 1 | 7 | 2 | 1 | 730 |

**Table 5**
Lithological characterization and artifact diversity for the SU VIRCH.

| VIRCH | | Chalcedony | Silex | Basalt | Xylopal | Obsidian Bl | Obsidian G | Rhyolite | Ignimbrite | Andesite | Quarzite | Indet | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temporal Block 1 | Cores | 0 | 4 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 7 |
| | Retouched Tools | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| | Nat. shaped artifacts | 0 | 8 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| | Debris | 21 | 184 | 50 | 0 | 0 | 0 | 6 | 39 | 1 | 0 | 7 | 308 |
| | Total | 23 | 196 | 52 | 5 | 1 | 0 | 7 | 39 | 1 | 0 | 7 | 331 |
| Temporal Block 2 | Cores | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Retouched Tools | 0 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 6 |
| | Nat. shaped artifacts | 5 | 7 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 |
| | Debris | 28 | 46 | 23 | 8 | 4 | 2 | 4 | 3 | 2 | 2 | 0 | 122 |
| | Total | 33 | 53 | 26 | 12 | 5 | 2 | 4 | 3 | 2 | 3 | 0 | 143 |

**Table 6**
Lithic assemblages: cores and flakes.

| Raw material | Coast | | | | | | | | VIRCH | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Temporal block 1 | | | | Temporal block 2 | | | | Temporal block 1 | | | | T. block 2 | |
| | Cores | | Debris | | Cores | | Debris | | Cores | | Debris | | Debris | |
| | Active | Not active | Ext. flakes | Int. flakes | active | Not active | Ext. flakes | Int. flakes | Active | Not active | Ext. flakes | Int. flakes | Ext. flakes | Int. flakes |
| Basalt | 0 | 5 | 32 | 86 | 2 | 12 | 46 | 79 | 0 | 1 | 15 | 35 | 5 | 18 |
| Hematite | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chalcedony | 0 | 4 | 20 | 28 | 2 | 4 | 15 | 111 | 0 | 0 | 4 | 17 | 2 | 26 |
| Sílex | 2 | 7 | 47 | 132 | 2 | 11 | 58 | 189 | 0 | 4 | 26 | 158 | 7 | 39 |
| Xylópal | 1 | 2 | 2 | 19 | 0 | 3 | 2 | 29 | 0 | 1 | 0 | 0 | 6 | 3 |
| Obsidian G | 0 | 2 | 0 | 8 | 0 | 0 | 1 | 10 | 0 | 1 | 0 | 0 | 0 | 2 |
| Obsidian Bl. | 0 | 0 | 3 | 31 | 0 | 0 | 14 | 17 | 0 | 0 | 22 | 24 | 2 | 8 |
| Other | 0 | 1 | 1 | 5 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 |
| Indet | 1 | 0 | 2 | 6 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 4 | 0 | 0 |

could be a consequence of the wider use of maritime pebbles in the coast because this technique is more adequate and efficient for small pebbles (Flegenheimer et al., 1995; Nami, 2000). On the other hand, in VIRCH, larger pebbles might have favored reduction by means of direct percussion.

Furthermore, both SU offered artifacts of good quality rocks with low availability, such as chalcedony (11 and 18%) and xylopal (3.5 and 6%) whose frequency is greater than that of other rocks which were more abundant but had a poor quality. The minimal availability of these raw materials in the samplings from secondary deposits indicates that nodules were brought from distant sources and, for this reason, were exhaustively exploited. Regarding chalcedony, the core exhaustion and the high reduction level of the artifacts prevents us from determining if the blanks correspond to tablets or pebbles. Nevertheless, added to the geological information which indicates the presence of veins of this rock in the Marifil Fm. (Massaferro and Haller, 2000), might allow us to infer its connection with these primary sources, which are between 100 and 150 km to the north and west of both SU. Regarding xylopal, the closest primary exposures (petrified forests *in situ*) are between 150 and 200 km away, in the middle valley of the Chubut river (Banegas et al., 2014).

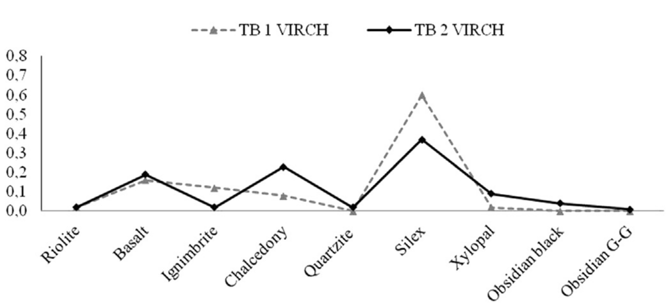


**Fig. 4.** Temporal tendencies in the use raw materials for SU VIRCH.

Regardless of their degree of availability, those artifacts whose process of fabrication was devoted a greater amount of energy were mostly made with raw materials of very high quality: in the coast, silex and chalcedony; in VIRCH, chalcedony and xylopal. This might indicate the application of strategies for the preservation of raw materials (Franco, 2004) in the cases of the two non-local rocks. These rocks were employed in the manufacturing process of specific tools (such as scrapers and projectile points). They were probably selected due to their intrinsic properties which made them suitable for the execution of particular tasks and activities (Nami, 1992; Ratto and Kligman, 1992; Aragón and Franco, 1997; Andrefsky, 1998). However, these tendencies are not so clear in the case of VIRCH given the low percentage of retouched tools. This could be attributed to extraction by non-professional collectors.

For natural-shaped artifacts the selection of rocks was more diverse, and rocks of different qualities were employed. In the case of local rocks, the greater representation of artifacts with a low investment of energy in their fabrication could be related to an expeditious use in the midst of subsistence activities, (Binford, 1979). In this connection, the presence of numerous burins could be linked to the processing of maritime resources (*i.e.* fish or birds). On the other hand, we observed the marked presence of natural-shaped knives in xylopal. The exploitation of xylopal tabular nodules probably facilitated the extraction of sheets with long blades, easily utilized as knives.

Regarding the second hypothesis, contrary to all expectations, lithic assemblage in VIRCH did not show a more diversified use of raw materials than in the coast. In order to find out if these differences are related to the differential quantity of items among coastal and VIRCH assemblage, Spearman's rank correlation test was performed. The result was $r = 0.46$ ($p < 0.05$). Hence, the lower

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variety recorded in the use of rocks does not correlate with the sample size.

With respect to temporal tendencies in the selection and use of rocks, even though the environmental availability did not vary along time, the selection of rocks is thought to have fluctuated. For both units, changes were registered in the frequency of the rock used: an increase in the use of chalcedony towards the final late Holocene, whereas silex and basalt continued as the most utilized ones, despite variations from the first period.

In relation to the hypothesis which refers to increased use of non-local rocks towards the final late Holocene, the results indicate different situations. Three rocks have been registered which can be attributed to non-local origin: chalcedony, xylopal, and two varieties of obsidian. The obsidian showed low representation in both sample units (less than 2.2%): on the coast, the greenish-grey variety predominates and in VIRCH, the black variety prevails. Neither exhibited a substantial increase in TB2. This allows us to infer, as in previous studies (Gómez Otero and Stern, 2005), that obsidian was not essential for the development of stone technology. It is probable that non-utilitarian reasons determined its employment in the study area. Therefore, according to the results presented above, we conclude that the third hypothesis is corroborated on the basis of greater frequency of chalcedony and xylopal in the second temporal block. This is reinforced by abundant evidence of the use of non-local rocks in the manufacture of other artifact groups during the Late Holocene. Among them are “bolas” (hematite), grinding stones (granitoids) and engraved lithic sheets (Gómez Otero et al., 1999; Gómez Otero, 2006).

At a macro-regional level, the observed temporal tendencies point to similarities and differences regarding the models formulated in the northern and central coasts of Patagonia. The greatest intensity in the use of chalcedony after 1000 BP is in line with the observations by Martinez (2008–2009), linked to technological innovations within a setting of population dynamics and reorganization. On the other hand, the absence of changes in the use of rocks in San Blas bay (Sanguinetti De Bórmida, 2000; Eugenio and Aldazábal, 2004) is similar to what was registered in the area in relation to basalt and silex. On the coast of San Matías Gulf, the main differences between the employed rocks and the artefact diversity and abundance were accounted for by particular environmental and ecological characteristics of the northern and western coasts of the Gulf (Cardillo and Scartascini, 2007; Borella and Cardillo, 2011; Alberti, 2012). In the northern coast of San Matías Gulf, a prevailing use of silex was detected as well as temporal variations in the frequencies of the three most utilized rocks: volcanic, silex, and chalcedony (Favier Dubois and Alberti, 2014). The differences in the use of rocks are related to a greater circulation of the groups in the environment and/or to an increased awareness of the locally available rocks (Alberti, 2012). In the southern sector of the river Deseado, (Ambrústolo et al., 2009; Ambrústolo, 2013) variation in the use of rocks concerns the availability and the manner in which rocks appear in different sectors: to the north, basalt from secondary deposits predominates; to the south, red chalcedony and vitreous rhyolite are available in primary vein-shaped exposures.

## 7. Conclusions

In this paper, we presented the first results of the regional characterization of lithic resources in two areas which are considered as potentially complementary. They, in turn, were compared to the lithological determinations of lithic sets assigned to two episodes of the late Holocene. The aim was to evaluate changes in the selection and use of raw materials, particularly during the final late Holocene. We verified hypothesis (1) regarding the predominant exploitation of locally available rocks, which include the highest quality and most abundant ones. The acquisition of these rocks is thought to have occurred in the frame of expeditious strategies, at low costs. With respect to hypothesis (2), there was no evidence of more diversified rock use in VIRCH, despite its greater diversity in raw material. In regards to hypothesis (3), which suggested an increase in the use of non-local rocks from 1000 BP, obsidian maintained its limited proportion in both temporal blocks, whereas the frequencies of chalcedony and xylopal increased towards the end of the late Holocene. However, silex and basalt continued to be the most utilized raw materials due to their good quality and local availability. On the other hand, the differences and similarities in the use of raw materials in the north and south of the area of study could be linked to the varied availability of lithic resources: predominance of pebble in north Patagonia and central-northern Patagonia, as well as primary exposures of volcanic origin and pebbles in the south. In the future, we expect to expand the number of analyzed samples, carry out petrological and geochemical analyses to determinate the sources of chalcedony and xylopal supply, and to investigate the causes for the intense exploitation of local nodules.

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