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An Ethnoarchaeological Study on Anthropic Markers from a Shell-midden in Tierra del Fuego (Southern Argentina): Lanashuaia II

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ABSTRACT
For many years the identification of activity areas has been carried out through the spatial distribution of lithics, zooarchaeological remains and specific features such as fireplaces. However, these data are rarely combined and integrated with results from specific analytical techniques such as phytoliths, organic matter, carbonates and multielemental analysis. This research presents the first results of an intrasite spatial analysis on a layer from the site Lanashuaia II, a shell-midden located on the Beagle Channel coast (Tierra del Fuego, Argentina). Ethnoarchaeology is used as a methodological tool to give content to the concept of anthropic markers by means of formulating archaeological hypothesis on the basis of ethnological information. This paper presents the application of specific anthropic markers, which have been designed and applied to identify ashy remains and waste areas through different combinations of proxies. The results show how an approach that integrates different techniques enhances data interpretation and allows to give visibility to activities that may not leave visible evidences.

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Anthropic markers; ethnoarchaeology; hunter-gatherer; spatial analysis; geostatistics; shell-midden

Introduction

The archaeology of hunter-gatherer sites

Hunter-gatherer sites are a major challenge for archaeology; as a result of their state of preservation or because of the research questions, they repeatedly become the arena where new techniques and methods are tested. Also, hunter-gatherer sites very often present some intrinsic problematics that are not shared with other archaeological contexts. The identification of their limits, occupation floors and activity areas are usually controversial issues (Malinsky-Buller, Hovers, and Marder 2011). The present research shows how anthropic markers are a very promising tool to explore these issues through a case study in Tierra del Fuego, Argentina.

Caves, which are usually naturally constrained, have been used as a paradigm of hunter-gatherer habitations (e.g. Walthall 1998; Bicho et al. 2000; Marean et al. 2000; Bar-Yosef 2002). On the contrary, open-air sites are more difficult to identify and delimit, and several studies reinstate the idea that hunter-gatherer sites are palimpsests where the possibility of distinguishing occupation floors or differentiate between activity areas is low (see Bailey 2007 and Milek 2012 and references therein). Notwithstanding, postholes and hearths have been used as features to structure space and study the range of variation inherent in the use of space (Koetje 1994; Vaquero and Pastó 2001; Mitchell, Plug, and Bailey 2006). However, several activities performed by hunters and gatherers leave forms of evidence that we need to recognise in the archaeological record to better understand these contexts. Therefore, the identification of remains such as ashy areas or clusters of materials that may have a specific archaeological meaning (e.g. flintknapping areas, consumption and refusal areas, etc.), are paramount in hunter-gatherer archaeology.

Archaeologists still very much concentrate their attention on lithics and bones as major constituents of hunter-gatherers sites, while many other materials, such as different perishables or their residues, are identified only occasionally (see Vellanoweth et al. 2003; Nadel et al. 2004 or Weiss et al. 2008 among others). In spite of this, the use of multi-element analysis, which is increasingly being considered a valid way to elucidate the function of areas or sites in archaeology (Middleton et al. 2010), offer a great potential for

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hunter-gatherer sites as well. This assumption springs from the idea that the different social actions of production, consumption or distribution cause variations in the chemical record within archaeological sediments. In this case, the variability of soil chemical composition is thought to be a valuable marker for detecting, identifying and analysing different activities in domestic contexts (Salisbury 2013; Rondelli et al. 2014; Negre, Muñoz, and Lancelotti 2016a).

Ethnoarchaeological approaches and the development of archaeological methodology

The development of techniques that help to increase the detection and identification of different materials, together with innovative ethnoarchaeological approaches, such as those conceptualising the remains as anthropic markers (Zurro 2011; Ruiz Pérez 2013; Rondelli et al. 2014), are becoming new avenues of research for widening the interpretation of the archaeological record and for identifying patterns of signals within sediments.

The ethnoarchaeological approach offers the possibility to directly link the activities performed with their physical remains in a known and controlled environment, thus building stronger interpretative models. The models connecting the concentration of different proxies such as chemical residues, botanical microrremains or the lithic and faunal record with the specific activities inferred from different information sources (archaeological experimentation, ethnoarchaeological hypothesis, etc.) are defined as anthropic activity markers (Rondelli et al. 2014). In fact, ethnoarchaeological contexts have been used to study spatial organisation since the appearance of pioneering works that aimed at understanding formation processes (Yellen 1977; Binford 1978; O'Connell 1987). Since then, remarkable advances have been made in order to better comprehend the spatial organisation of activity areas, such as mapping the distribution of certain combinations of chemical elements (Middleton et al. 2010; Salisbury 2013; Rondelli et al. 2014; Negre, Muñoz, and Lancelotti 2016a). The application of these techniques is increasingly being used together with the study of the distribution of archaeological artefacts and remains (such as hearths, bones, lithic or ceramics) to perform intrasite analysis. The reading of chemical differential concentrations in archaeological floors is not exempt from a critical reflection about its limitations (Terry et al. 2004; Dore and López Varela 2010; Wells 2010; Vyncke et al. 2011). Nonetheless, the use of geostatistical methods as a tool to model the results of these kind of analysis is increasing, thereby facilitating their interpretation (Lloyd and Atkinson 2004). Geostatistics provide a set of tools specifically designed for spatial analyses in which predictions are carried out over a region of interest where some observations have been taken. These techniques are based in the principle of spatial autocorrelation between observations (i.e. the closer the observations are, the more similar they are, and vice versa). Then, they can be applied to identify patterns in the spatial distribution of archaeological features resulting from anthropic activities and the use of space (e.g. Rondelli et al. 2014; Negre, Muñoz, and Lancelotti 2016a). In addition, the prediction error can be estimated based on the propagation of uncertainty (Krige 1951; Matheron 1963; Cressie 1993). Although these investigations are clearly a growing area of interest, most case studies are focused on agricultural and pre-urban contexts where existing structures often make research more affordable (e.g. Entwistle, Abrahams, and Dodgshon 2000; Hjulström and Isaksson 2009; Salisbury 2013; Courchesne, Turmel, and Chapdelaine 2015). Hunter-gatherer sites, on the contrary, constitute new scenarios where these methodologies ought to be tested, even though chemical analyses have already been performed in shell-midden sites (Holliday and Stein 1989; Stein 1992).

Aims of this research

The research presented in this paper addresses the analysis of activity areas in an open-air hunter-gatherer site and the identification of production and consumption through the distribution of phytoliths, organic matter (OM) content and chemical elements included in the soil matrix, as well as charcoal, bone and lithic remains. For this purpose, we focus on the Lanashuaia II archaeological site, a Late Holocene shell-midden located on the northern coast of the Beagle Channel, Tierra del Fuego, Argentina, in South America (Briz et al. 2009; Zurro et al. 2010). Hunter-gatherer and fisher societies inhabited this region since at least 7000 BP (Orquera, Legoupil, and Piana 2011). In the nineteenth century these communities were called Yamana or Yaghan, and their long-standing system started to collapse due to the arrival of Europeans (Gusinde 1937).

In this research we do not use an ethnoarchaeological approach as an archaeology of living societies but as a middle range theory builder, in which we use ethnological information to address the archaeological enquiry (Beck 2008; Skibo 2009; Yu 2014). We particularly use this approach to formulate hypotheses (Agorsah 1990; David and Kramer 2001; Briz and Vietri 2011) about which tasks could had been performed in the past and what residues these would have produced (Enloe, David, and Hare 1994; Middleton and Price 1996; Sullivan and Kealhofer 2004; Barba 2007). Despite the historical gap between Yamana communities and the groups that inhabited ancient settlements along the Beagle Channel, the ethnographic knowledge of the area has previously proved successful to formulate hypotheses about the functional use of social spaces (Estévez and Vila 1996; Briz 2010).

Ethnographic sources provide useful information about the organisation of daily activities performed by the Yamana society. Low temperatures and high humidity resulted in an intensive use of plant material as fuel (mainly wood coming from *Nothofagus* forests common in the area). However, plants were used for other purposes, including some berries and roots that were eaten as snack foods (see Villagran et al. 2011). In addition, Gusinde (1937) points to the use of tussock grass (*Poa flabellata* (Lam.) Raspail) as mattresses for conditioning the inside of the dwellings. Bundles of dried grass were used to create resting and sleeping areas. Ethnographic documents report that several different activities were performed inside the huts: from preparation and consumption of food resources ranging from whale blubber to shell food, fish, marine mammals or guanacos and different types of berries (Malainey et al. 2014) to tool and weapon making (Hyades 1885; Hyades and Deniker 1891). Outside the huts many other activities were performed, such as hide working (Gusinde 1937), canoe manufacturing (Snow 1857; Hyades and Deniker 1891; Gusinde 1937) or the primary processing of animal carcases (Gusinde 1937). Therefore, according to the ethnographic and also archaeological sources, we expect to identify chemical residues from the consumption of marine as well as terrestrial food resources. In addition, ethnographers described precisely the cleaning activities performed by the Yamanas, so that we suggest as a hypothesis the identification of 'clean' areas versus 'non-clean areas' (i.e. refusal and waste areas). For this purpose, different archaeobotanical remains could throw light on the dispersion of ashes (i.e. the identification of ashy areas) and the possible presence of plant material devoted to conditioning surfaces and isolating them from humidity. We define ashy areas as those areas where ashes appear as 'patches' (Cain 2005) or where they do not appear '(…) in the form of hearths' (Shahack-Gross and Ayalon 2013: 570).

The aim of this paper is to show that different techniques and methodologies may allow us to identify patterns in the distribution of archaeological materials, and that these patterns represent specific activity areas. This is a novel and exploratory study that aims to:

(1) Define anthropic markers based on general archaeological knowledge and local ethnographic knowledge using different proxies to detect (1) fireplaces and ashy areas and (2) refusal areas.
(2) Identify these activity areas by means of the defined anthropic markers in the archaeological case study.

This research assesses the reliability of different analytical lines to identify production and consumption areas as well as to make inferences about the spatial organisation of the site. This will demonstrate that the application of the proper techniques may lead to a profound change in our vision of the interpretative possibilities of hunter-gatherer archaeology.

Materials

Lanashuaia is an archaeological complex on the northern coast of the Beagle Channel (Tierra del Fuego, Argentina, South America; Figure 1) where a series of ring-shape shell-middens are found evenly spaced on a linear distribution along the isthmus that separates the inner and outer Cambaceres Bays (Piana, Estévez, and Vila 2000; Briz et al. 2009; Zurro et al. 2010).

Lanashuaia II is an annular structure formed by superimposed shell and humic layers with different proportions of lithics, bone tools, faunal remains, charcoal, ashes and pebbles. According to ethnohistorical and empirical information, the accumulation of detritus (mainly molluscs remains) around the perimeter of the dwelling space would produce the ring-shaped geoform after the decay of the hut (Figure 2).

To accomplish our aims, we focused on the basal layer of the site (B10), which developed right upon the palaeo-beach and is constituted by dark hummus and small pebbles (Figure 3). We chose this layer for two reasons. First, because its matrix composition was more suitable for the application of selected methods in comparison to what we specifically call shell-midden layers, which often are almost entirely composed by entire or fragmented shells with a very limited proportion of the mineralogical fraction; and second because there was no direct evidence in this layer of a spatial organisation like hearths or postholes, which made it perfect to test our methodology. Regarding the lithic and zooarchaeological record, we retrieved 181 faunal remains and 890 stone objects within this layer, which were coordinated using a total station theodolite. Altogether with B620, B630 and B640, this layer constitutes a single occupational event characterised by a radiocarbon dating of 1365 ± 35 years BP (CNA1057).

Layer B10 was selected for this preliminary exploratory analysis because it presented the most extensive horizontal exposed surface, which allowed the testing of the proposed methodology. The excavated area in Lanashuaia II was 55 m^2 (including the 90% of the shell-midden) and the extension of B10 is 30 m^2. While all soil samples were collected from a specific area within this layer and at a similar depth (see Figure 4), we included in this analyses available data about archaeological materials taken from the whole surface of B10 (see Figure 5).

For each squared metre, four subsampling areas were established. Once in the laboratory, a set of samples coming from different 45 locations was

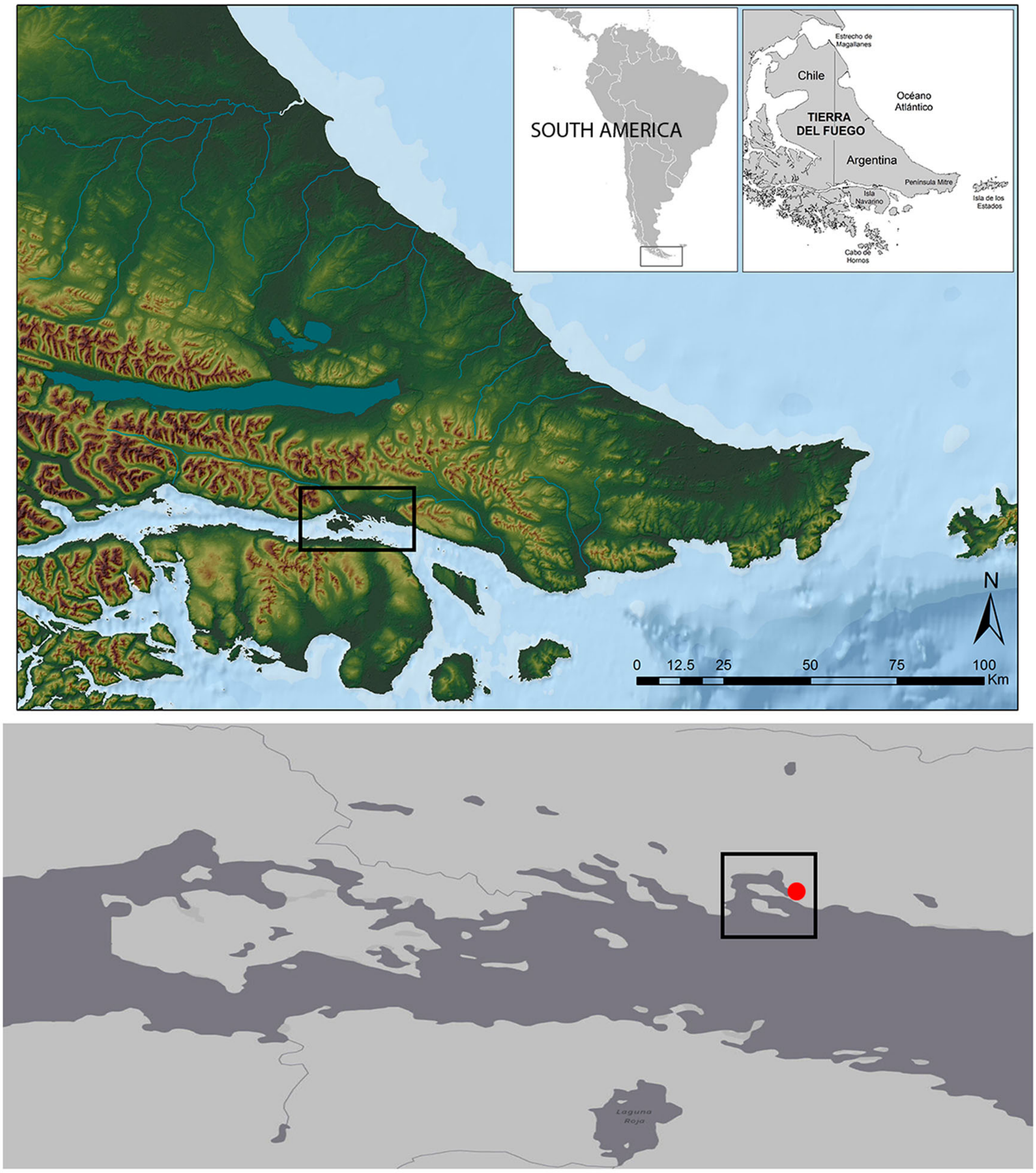

Figure 1. Location of Tierra del Fuego and of Lanashuaia archaeological area.

subsampled to perform the different analyses, comprising 13 samples for multi-element analyses (from 13 locations), 43 samples for OM content (from 42 locations) and 14 samples for phytolith analyses (from 13 locations) (see Figure 4 showing the location of the samples).

The configuration of the shell-middens in the area, in which shell-middens overlap and grow upon the extremes of previous shell-middens makes almost impossible to obtain control samples for layers such as B10, which appears right upon the palaeo-beach at the grounds of the stratigraphical sequence.

Methods

We implemented a set of tools in order to study several diverse proxies which, interrelated, enable the identification of possible activity areas at the site. The methodology, therefore, comprises (1) defining anthropic markers for selected activities, (2) identifying various proxies and archaeological materials and (3) using different statistical tools to assess the spatial distribution of proxies and materials in order to explore the possibility to apply the anthropic markers on this site.

Selection and definition of anthropic markers

In order to define the anthropic markers to be addressed, we decided to focus on activities that could be identified using the sampling procedures available. Moreover, according to the ethnoarchaeological knowledge of the area and general knowledge of hunter-gatherer sites, we proposed a plausible

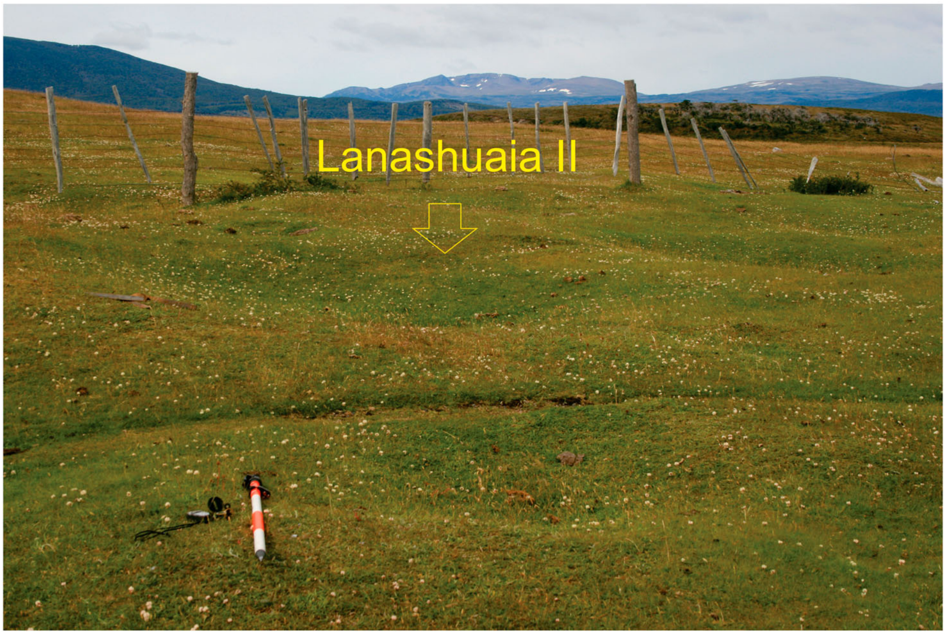

Figure 2. Photography of the isthmus that separates inner and outer Cambaceres Bay, showing the accumulation of ring shell-middens and the location of Lanashuaia II.

combination of proxies for each selected anthropic marker. The efforts focused on fireplaces and ashy areas, as well as on refusal areas as they are relevant for both this context and general hunter-gatherer contexts:

- Fireplaces and ashy areas

  The detection of ashy areas and fireplaces relies on the identification of Ca and P, (based on Humphreys, Hunt, and Buchanan 1987 and Karkanas et al. 2002), coupled with a relative increase in the concentration of phytoliths and a clear input of dicot phytoliths. Ash might have a different composition and might change depending on the material from which it originates (wood/grasses) and achieved temperature (Etiégni and Campbell 1991; Pierce, Adams, and Stewart 1998; Canti 2003; Regev et al. 2010). In spite of this, we decided to choose a simple combination (Ca and P) as these elements appear repetitively in different studies as the main components of ashes (Humphreys, Hunt, and Buchanan 1987; Etiégni and Campbell 1991; Schiegl et al. 1996; Karkanas et al. 2002; Goldberg and Sherwood 2006; Holliday and Gartner 2007;

Figure 3. Photography of an archaeological profile of the site (East profile), showing the position of layer B10 within the stratigraphy (bar is 30 cm).

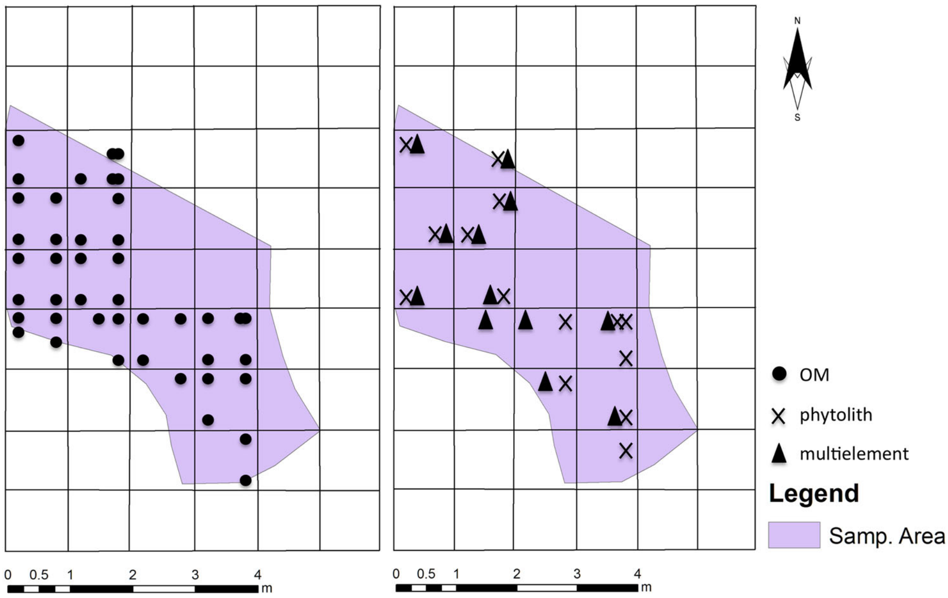

Figure 4. Sketch of layer B10 showing the archaeological grid and the sampling strategy together with the different analyses performed.

Oonk, Slomp, and Huisman 2009). We did not take into consideration organic matter, because even when it may appear in hearths, it is not necessarily expected in ashy areas.

- Refusal areas

  We decided to define an anthropic marker for refusal areas, which contain different types of discards that go from individualised remains to mixed waste (see a discussion about the use of the terms refusal and midden in Needham and Spence 1997).

Yamana diet included fish and meat; most hunted animals in the area (guanacos and sea mammals) are large prey that would need a big investment in butchering, probably leaving traces of these activities; fish consumption was also essential for the diet. For this reason we initially decided to include chemical elements associated with the presence of individualised foods such as meat (P and Mg, according to da Costa and Kern 1999) and fish (Na, K, Ba, Sr, P and Ca, for fish processing areas, see Milek 2007). Finally, plant remains are not considered essential in the identification of these areas as we know that consumption of plant resources as food was quite limited (Orquera and Piana 1999).

Secondly, as refusal areas may present a higher variability (mixed waste) as the result of several consumption events and long lasting processes, we selected food processing areas or kitchen middens (P, K and Mg, see Milek 2007) and a combination to identify waste areas (Ba, P and Mn, see Parnell, Terry, and Nelson 2002).

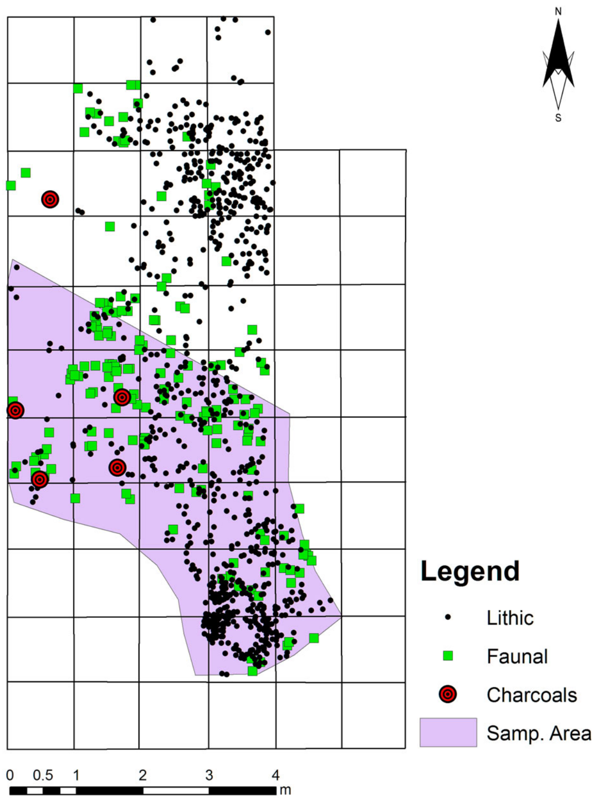

Figure 5. Distribution of lithics, zooarchaeological remains and charcoals in layer B10 and its distribution in relation to the area sampled for this study.

Applied techniques and analyses should enable us to discard or positively confirm identification of the different proxies that shape the anthropic markers at the site. For a summary of the combination of proxies used see Table 1 (see a similar methodology in Wilson, Davidson, and Cresser 2008: Table 9 and Parnell, Terry, and Nelson 2002: Table 3).

Identification of different proxies and archaeological materials

Four different approaches have been selected to identify existing remains: (1) phytolith analysis, (2) OM

Table 1. Anthropic markers selected for the present study with the proxies expected to be found in each of them (* charcoals have not been tagged as archaeobotanical remains as they are recorded in the study area as standard archaeological remains).

	Anthropic markers		
Proxies	Fireplaces and ashy areas	Refusal areas	
Archaeological materials	• Charcoals	• Fauna: higher presence (parts/ number species) discarded artefacts	
Elements according to bibliography	Ash Ca, P (Humphreys, Hunt, and Buchanan 1987; Karkanas et al. 2002)	Meat P, Mg (da Costa and Kern 1999) Fish processing Na, K, Ba, Sr, P, Ca (Milek 2007)	Waste Ba, P, Mn (Parnell, Terry, and Nelson 2002) Kitchen midden P, K, Mg (Milek 2007)
Archaeobotanical materials	• Higher variability (parts/number species) • Higher proportions of dicot phytoliths	• High variability (parts/number species)	
OM	+	+++	

content, (3) multi-element analysis and (4) the lithics, charcoal and zooarchaeological record.

For the multi-element analyses, samples were analysed by the ALS Laboratory Group in Sevilla (Spain). OM analyses were carried out in the Laboratory of the Department of Stratigraphy, Paleontology and Marine Geosciences (Faculty of Geology, *Universitat de Barcelona*) by M. Guasch and D. Zurro. Phytolith analyses were carried out by D. Zurro at the Institució Milà i Fontanals – Spanish National Research Council (IMF-CSIC).

Phytolith analysis

Phytolith analysis is possibly the technique that is most substantially changing what we know about hunter-gatherers use of plants and how we view hunter-gatherer archaeological sites (Cabanes et al. 2007, 2010; Zurro 2011; among others). Even though archaeological research in Tierra del Fuego has never particularly focused on archaeobotany (the few exceptions including Piqué 1999 and Berihuete-Azorín 2013), phytolith research has already proven its viability in this area's contexts (Zurro et al. 2009; Benvenuto et al. 2013).

For this work, sediment samples were processed following the Madella, Powers-Jones, and Jones (1998) extraction procedure. The opaline silica residues obtained were mounted on microscopy slides with Entellan® or Eukitt® permanent mountings. The scanning was done with an Olympus BX-51 optical microscope at 400x magnification. Phytolith concentration per gram of Acid Insoluble Fraction – AIF was calculated adapting the methodologies proposed by Albert et al. (1999) and Albert and Weiner (2001) (see Supplementary Material I).

OM content

The OM found in archaeological sediments is produced from plant and animal remains, as well as microbial products at different stages of decomposition and it is considered a strong signature of anthropisation (Kämpf et al. 2003). OM content was calculated by loss on ignition according to the Heiri, Lotter, and Lemcke (2001) procedure.

Multi-element analysis

For the multi-element analyses, samples were pre-treated with aqua-regia digestion and analysed with Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) to provide quantitative data on 35 main chemical elements. Those elements with values below the reliable detection limits were excluded from the analyses (see the data in Supplementary Material II).

Existing literature on multi-element analysis applied to archaeology shows a wide variety of combinations that may explain the same phenomena in different contexts. To select the combinations we would use, we lent on research that overlaps with our context of study as much as possible. We also decided to choose when it was possible basic combinations, trying to avoid those that include many elements. These combinations correspond to single materials (meat, ashes, fish) or to the result of specific activities (such as waste areas or kitchen midden, see Table 2). We decided to add a combination for seaweed taken from specialised literature (McHugh 2003) as we have not found any archaeological reference for identifying it. Regarding seaweed, we produced a combination that contains all elements that appear in the literature except for iodine, which was not included in the ICP-AES.

Concerning ashes, even though their major mineral component is calcite (Humphreys, Hunt, and Buchanan 1987), other studies point to ashes as a possible source of phosphorus (Karkanas et al. 2002, 722). In this case, we decided to create a very basic combination using both Ca and P. Combination corresponding to meat (P and Mg) comes from the research carried

Table 2. List of combinations of elements selected from published literature.

Combination	Elements	Reference
C1. Seaweed	K +Fe +Mg +Ca	McHugh 2003
C2. Ashes	Ca +P	Humphreys, Hunt, and Buchanan 1987; Karkanas et al. 2002
C3. Meat	P + Mg	da Costa and Kern 1999
C4. Fish processing area	Na + K + Ba + Sr + P + Ca	Milek 2007
C5. Kitchen midden	P + K + Mg	Milek 2007
C6. Waste areas	Ba + P + Mn	Parnell, Terry, and Nelson 2002

out by da Costa and Kern (1999) in the Amazon, where they investigated a Palaeo-indian site in a black earth context.

The combination choice (C6) corresponding to waste areas (Ba, P and Mn) comes from a hunter-gatherer context (Parnell, Terry, and Nelson 2002). Considering that waste areas may include a wide range of materials, we decided to explore other combinations that may recover specific trends corresponding to coastal areas and that were explicitly associated with waste; combinations for fish processing area (Na, K, Ba, Sr, P and Ca) and for food processing area or kitchen midden (P, K and Mg). Both combinations were taken from the research developed by Milek (2007) in Iceland and had previously been used in Arctic areas by Knudson et al. (2004), in environmental settings similar to the Beagle Channel.

Archaeological artefacts

All the archaeological remains including lithics, faunal remains and charcoal concentrations were recovered. The provenance of lithic cores, retouched lithic artefacts, unmodified flakes (size >2 mm), lithic concentrations, modified cobbles, identifiable faunal remains and charcoal concentrations was recorded with a total station. Archaeological artefacts come from an area bigger than that sampled for applying anthropic markers methodology (see Figure 5). This database was integrated into a GIS as to facilitate the spatial analysis of the materials.

Statistical analyses

The main goal of spatial-statistical and geostatistical methods is to identify between regularity and randomness, meaning between spatial heterogeneity and homogeneity in the distribution of the archaeological record over the site floors (see Balme and Beck 2002; Cook, Clarke, and Fulford 2005; Entwistle, McCaffrey, and Dodgshon 2007; Barceló and Maximiano 2008; Sweetwood et al. 2009; Rothenberg 2010; Maximiano 2012; Salisbury 2013 or Negre, Muñoz, and Lancelotti 2016b). The statistical analysis of the species composition of the faunal clusters was carried out through richness index (Shannon-Weaver) and homogeneity tests (Zar and Pielou), which proved to be valuable (Bobrowsky and Ball 1989).

Inverse Distance Weighting (IDW) interpolations were applied to phytoliths and OM data to detect patterns in their spatial distributions. IDW is a deterministic method which does not integrate the spatial structure of the data in the interpolation. It is especially useful when data is not spatially autocorrelated, as it is the case in this study. IDW interpolations were calculated on the basis of euclidean distances and a power parameter of 2.

We performed Kriging analysis to model a series of observations in a partial implementation of a stochastic process over a continuous spatial region (Negre, Muñoz, and Lancelotti 2016a). In the absence of physical demarcation within the working area, we assumed this process to be Gaussian, isotropic and intrinsically stationary (Cressie 1993). We used R packages *rgdal* (Bivand 2015) and *geoR* (Ribeiro and Diggle. 2015). First, an empirical plot was created to explore the histogram and statistical distribution of the chemical elements data. Second, 'variog' and 'likfit' functions were respectively used to compute empirical variograms and to fit the variogram models. We chose to fix the nugget to 0 and the fitting model to exponential, which was selected after an exploratory inspection of the data and comparison of the log-likelihood of the different variogram models. Finally, we applied the function 'krige.conv' to perform spatial predictions through ordinary Kriging by taking the required distance matrix and variogram model.

Results

Spatial analysis of the proxies has been used to identify the models (i.e. anthropic markers) that enable us to connect several combinations of those proxies with the specific activities inferred from different information sources.

Spatial distribution of proxies

The various proxies identified appear heterogeneously distributed in the area under study. For example, results from phytolith analyses show big differences among samples from different loci accordingly to what emerged from previous studies (Zurro et al. 2009). In this case, proportions vary from 400 phytoliths per gram of AIF in sample G11b to the richest sample, F10c, with almost 8,000 particles (see Supplementary Material I). Compositional distribution of the spectra also shows large differences among different areas of the analysed surface. Similarly, the OM and chemical elements also show different values in separate sectors.

The spatial-statistical analysis of the archaeological macroscopic record (mainly lithic and zooarchaeological remains) over the sampled surface area reported the existence of a semicircular-shape waste area. Bivariate distributions (related to the different activities performed, Barceló 2007; Negre et al. 2016b) were identified from four separate accumulations of lithic and zooarchaeological materials related to residue management activities. Zooarchaeological remains tend to cluster around a perfectly clean area in the south-west corner of the site, out of the present study area. This apparently intentional process is also corroborated by the lithic record, which shows the same pattern of accumulation over this area. This waste-ring displays a spatial division of its constituents: zooarchaeological remains are concentrated in the northern part, while in the southern there is evidence of abundant lithic material. This supports the hypothesis of the presence of different activity areas, both a food consumption area and a lithic working space, at the site (Negre et al. 2016b). The statistical analysis of the species composition of the faunal clusters through richness index (Shannon-Weaver) and homogeneity tests (Zar and Pielou) proved to be valuable as well (Bobrowsky and Ball 1989). It can be stated that the different clusters present in the waste area belong to different discard events from both a locational and compositional point of view.

Identification of anthropic markers

To facilitate identification of the different areas of the surface under study, we assigned names to the areas that recurrently seem to present specific trends, trying to avoid using their location within the grid or any geographical reference as much as possible (see areas A, B, C, D and E in Figure 6). Area F indicates the area from which, even though no sediment samples were available, there are data from lithics and zooarchaeological remains.

One of the clearest finds revealed by the different analyses performed is that the distribution of OM appearing towards areas A and B (see Figure 7). Regarding classical archaeological material, there is a clear pattern that separates faunal remains (mostly present in areas B and F, with a small accumulation in area E) from lithics that, though found spread throughout areas E and F, tend to appear concentrated around area E and next to the limit of the analysed surface.

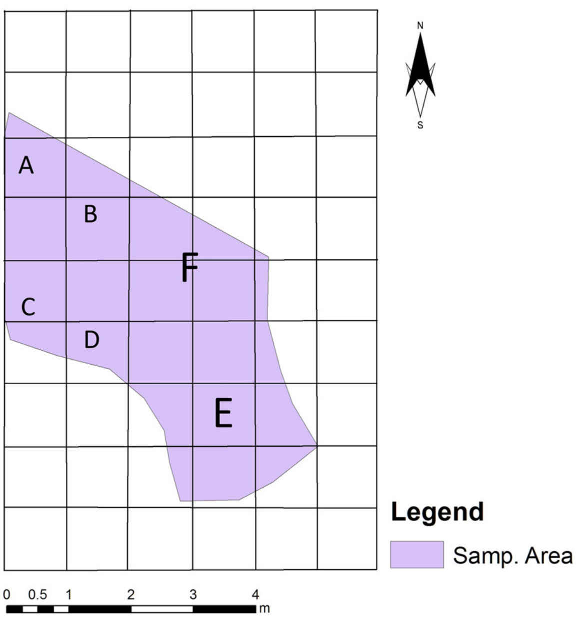

Figure 6. Location of areas A, B, C, D, E and F within the analysed surface.

AM – fireplaces and ashy areas

- AM - Fireplaces and ashy areas = C2 + Phyto + DICOTphyto

The application of this anthropic marker to the site has shown that these proxies appear overlapping in some areas while in some others only some of them have been identified.

Combination of elements C2 has been identified in different areas of the analysed surface, namely areas A, D and E (see Figure 8).

Phytolith results show that the spectra is mostly composed of monocot phytoliths, identified in area C, while dicot phytoliths have been identified in areas C and D.

The monocot input makes area C the richest, with samples showing the highest concentration of phytoliths (sample F10c has more than 8000 phytoliths per gram of AIF). On the contrary, area D shows no monocot signal and, consequently, is the poorest in absolute quantity of phytoliths (with samples with less than 400 phytoliths per gram of AIF, see Figure 8 and Supplementary Material I).

The most relevant result is that only in area D does the C2 combination appear together with relevant phytolith data. That means that where monocot and dicot phytoliths have been identified, no remains of ashes have been found (area C), while in the adjacent area, ashes are present together with dicot phytoliths (area D).

Finally, the presence of charcoals has been documented in this side of the analysed surface (areas C, D and B, see Figure 5). The three proxies identified as representative for ashy areas; charcoals, combination C2 and phytoliths (and more specifically, dicot phytoliths), overlap in area D, which is the only one that can be thus defined according to the proposed anthropic

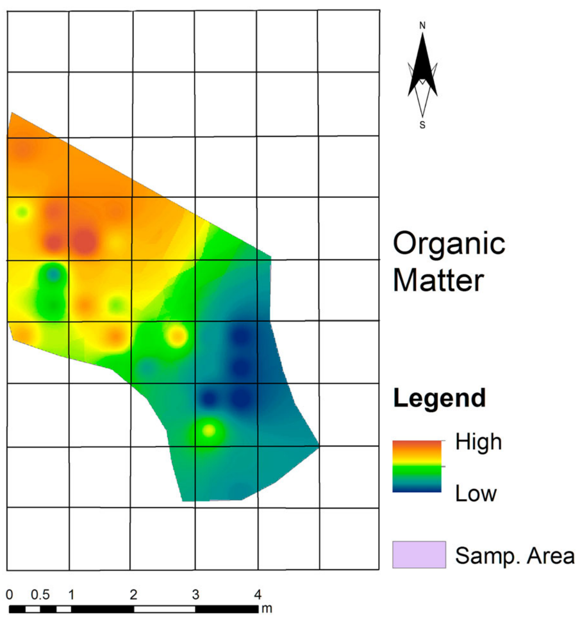

Figure 7. Distribution of OM.

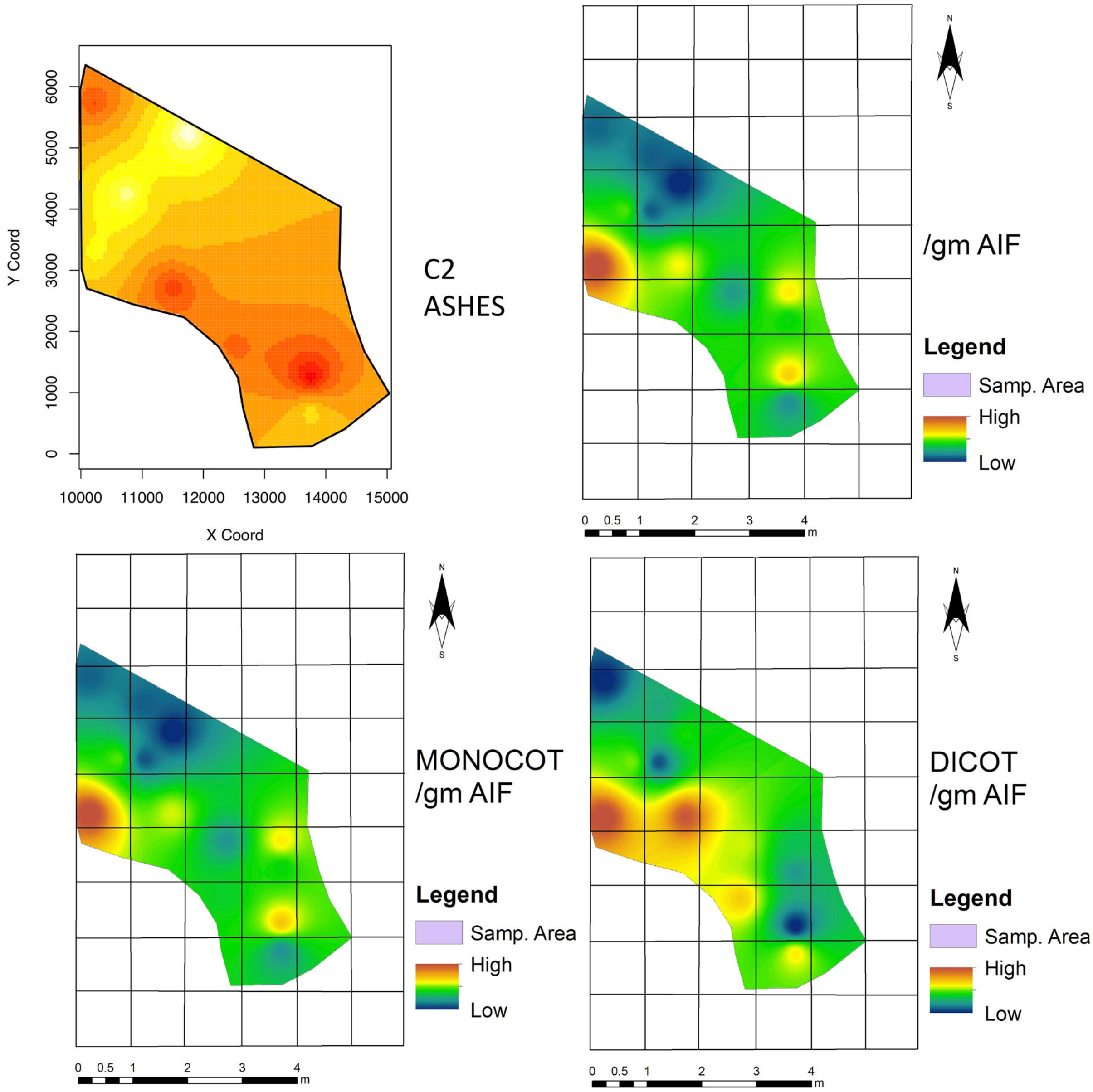

Figure 8. Distribution of combination C2 for ashes, together with the results from phytolith analyses, showing phytoliths per gram of AIF and monocot and dicot phytoliths per gram of AIF.

marker methodology. These results allow to identify a single area (area D) where the different proxies overlap (see Figure 9), while in the other areas, the interpretation of the results must be adjusted.

AM – refusal areas

- AM - Primary refusal areas = C3/C4/C5/C6 + faunal variability + high OM content + discarded artefacts

The zooarchaeological remains appear to be clustered in different areas, presenting higher densities of concentration in areas B, F and in the centre of E (Figure 5).

Regarding the chemical combinations, we can see that C3 (meat) and C5 (kitchen midden) overlap in area B, while C6 (waste) and C4 (fish processing areas) overlap in area A and in part of E (Figure 10).

The results show a very clear overlap of combinations of elements for meat and kitchen midden and OM content in area E, together with presence of seaweed. Closely, area A shows combinations typical of waste and fish processing, also overlapping with a high content of OM and seaweed and in this case without zooarchaeological remains. Waste and fish processing also appear together in the central part of E, in this case overlapping with a higher density of bone remains (see Figures 9 and 10).

This means that, within the general marker of refusal areas, we can identify a clear division between those areas where chemical elements are positively correlated with zooarchaeological remains and OM (e.g. areas B and E), and those where only chemical elements are present (area A). As in the previous case, these results allow to distinguish between two types of areas according to our definition of an anthropic marker for refusal areas; namely areas B and E where the different proxies overlap, and area A where only some of them appear (see Figure 9). A possible explanation for this pattern

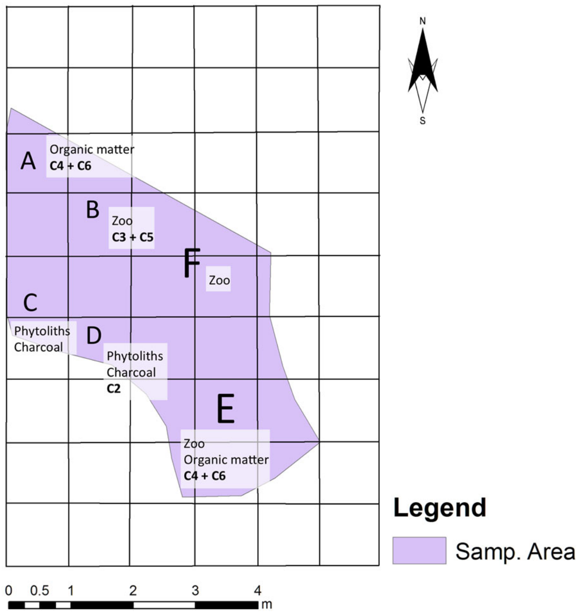

Figure 9. Distribution and results from the studied anthropic markers.

is that while area A could had been a consumption area or even a cleaned area (so that only chemical residues would remain), areas B and E could be interpreted as proper refusal areas, where residues and bones accumulate.

Discussion

The identification of activity areas is a controversial issue in archaeology, and while some authors have mentioned the inconvenience of identifying them solely on the basis of artefacts (Parnell, Terry, and Nelson 2002), others avoid using the expression itself (O'Connell 1987, uses for instance 'refusal clusters' instead of refusal area). Contrary to the initial approaches oriented to elucidate the spatial organisation of archaeological artefacts (Whallon 1973 and 1974; Binford 1978; Schiffer 1987), recent years have witnessed an increase in research focusing on other traces of anthropic activities, such as chemical markers and biological remains (e.g. Barba 2007; Evershed 2008; Pecci et al. 2013; Rondelli et al. 2014; Negre, Muñoz, and Lancelotti 2016a). While both lithic and faunal remains may be used as a heuristic tool for inferring certain characteristics of the site, visibilisation of the unseen micro-traces over archaeological floors provides a whole new view of their intrinsic organisation. Even though we face problems of equifinality, the combination of chemical elements is a useful proxy that may be used as a basis for establishing new hypothesis. See as an example the interpretation, in area C of the presence of monocot phytoliths as the result of an accumulation of grasses used as a matress, while in area D, where they appear together with dicot phytoliths, charcoal and ashes, are interpreted as fuel.

Some of these approaches (including lipid analyses) have rapidly spread in archaeology during the last decade, leading to new forms of interpretation of the archaeological record (see Antisari et al. 2013 and references therein).

We maintain that each anthropic marker presents different dimensions, enabling us to recover all the variability that we find in archaeological contexts (Figure 9). In addition, the set of techniques and generated proxies may be redefined as needed and improved as new data is collected. The combination of several proxies, based on a previously built model, allows us to refine the functionality of different areas finding diagnostic combinations of proxies. In this way, some samples or contexts will require the analysis of the full set of proxies, while others may work with only a selection of them. In conclusion, the versatility of the proposed approach enables us to find the optimal balance between the question to be investigated and the proxies to be used, thus achieving different levels of resolution according to the specificity of each context.

The detection of fireplaces and ashy areas is paramount in archaeological research. In this study this specific anthropic marker has been useful for identifying remains from burning in a context where almost no visible evidence (such as ashy lenses or the accumulation of charcoal) had been previously identified.

Several studies have used different combinations of elements to identify ashes, all of which indicate Ca as one of the main signals (see Pierce, Adams, and Stewart 1998 or Middleton et al. 2010, among others). Even though Lanashuaia II is a shell-midden, and we could expect Ca to appear spread all over B10 surface, Ca appears distributed heterogeneously. To solve any inconsistency derived from this, we found it especially necessary to use other data (phytoliths and charcoals) apart from the combination of elements. Similarly, the widespread presence of charcoal in area D would have been irrelevant if it had not been combined with the rest of proxies. These results reinforce the idea that the combination of proxies enhances interpretative capabilities.

Phytolith analyses results indicate specific concentrations of monocot phytoliths and dicot phytolith in areas C and D. The relative high proportion and spectral composition of phytoliths in area C could represent remains of grass mattresses, while in area D, where they appear together with combination for ashes, it could be as result of burning such mattresses. Gusinde (1937, 408–410) reports that these mattresses were frequently renewed to prevent them from becoming mouldy or rotten. We hypothesise that these remains might have been thrown into the fire as part of maintenance activities, which is a well-known reported activity in hunter-gatherer sites (Sergant, Crombé, and Perdaen 2006). In addition, ethnographic information points to the

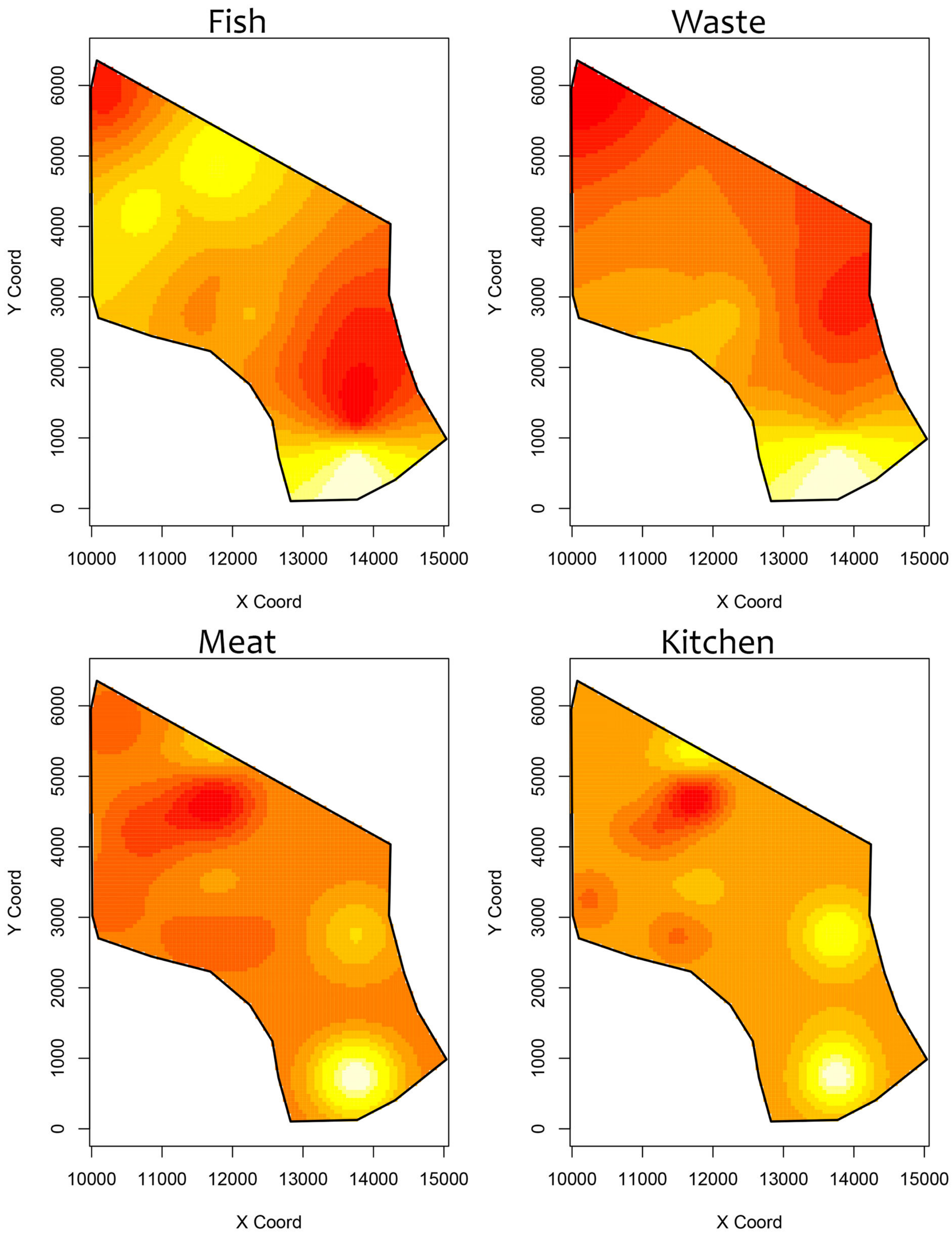

Figure 10. Distribution of combination for fish, waste, meat and kitchen midden.

intentional elimination of vegetation in areas where the Yamana had chosen to build their dwellings, (Bridges 1933, 334; Gusinde 1937, 408–410) so the possibility to interpret grass phytoliths as a natural input can be discarded.

Gusinde (1937, 408–410) reported that the Yamana threw residues from food consumption into the fire. This study shows that the appearance of plant remains as part of the ashes can be explained also as part of maintenance activities. From a methodological point of view, these results reinforce the idea that anthropic markers are a tool that need to be redefined and refined as we obtain archaeological results from testing them. Finally, the presence of OM in this side of the analysed surface supports the results achieved from the rest of proxies. Ethnographic information shows that animal fat and fish oil were very often melted over the fire with the aid of sticks or shells used as spoons (Malainey et al. 2014 and references therein). According to ethnographic sources, fat was also melted to prepare paints (Hyades and Deniker 1891, 415) so there was a continuous OM enrichment nearby fireplaces areas.

The identification of areas with rubbish, discarded materials and middens are common goals in archaeological studies, despite the difficulties inherent in defining and recognising whether they correspond to short or long accumulation processes (O'Connell 1987; Simms and Heath 1990; Kent 1999; Galanidou 2000; Beck and Hill 2004).

In our case we have been able to identify different patterns that allow to infer the presence of a variety of refusal areas. Spatial analysis showed important differences in both the quantitative and qualitative distribution of the anthropic markers related to refusal areas and we were able to identify the initial stages of the formation process of a main refusal area. While lithic and zooarchaeological records show an important organisation in their spatial distribution, the information they provide is not limited to this. The normal bi-variate structure shown by both records, enables us to understand them as material consequences of different intentional actions. Furthermore, both from a locational and compositional point of view, we can statistically separate these remains in different clusters, each one indicating different activities and related to different processes of formation (Negre et al. 2016b). For example, we observed that the northern side of this waste area abounds statistically with zooarchaeological residues, while the eastern- side is plentiful in stone fragments. These results allow us to hypothesise the existence of specific spaces for different activities, and thus identify a clear division in the use of space.

In combination with the analyses of OM and chemical signatures regarding meat or waste proxies, the hypothesis about the possibility to identify different areas in a hunter-gatherer site is reinforced. As stated above when describing the distribution of the proxies, different combinations of chemical elements associated with waste areas were detected overlapping with the circular structure of lithic and zooarchaeological remains. OM is more highly concentrated in the northern side of the dump, correlating closely to the faunal record. These data also help us to better understand the social space of the site beyond the excavated area, thereby providing valuable information for planning future archaeological campaigns.

Results from the richness index (Shannon-Weaver) and homogeneity tests (Zar and Pielou) allow to state that the different clusters present in the waste area belong to different discard events from both a locational and compositional point of view. In summary, the different remains show a heterogeneous distribution, with specific patterns of distribution and overlap among them.

Regarding the formation of waste areas, as Galanidou (2000) reports, several ethnological and ethnoarchaeological studies show the existence of specific patterns of distribution of debris, as we have reported in our case study. In spite of this, these patterns seem to be culturally imprinted. This means that even though we think it may be possible to produce general anthropic markers, ethnoarchaeological studies show that models may be improved and refined in specific contexts where more information is available. In our case, general knowledge about Fuegian sites points to the presence of ashes in shell-midden layers, while in other geographical contexts we should search for proxies indicating dung (see Lancelotti and Madella 2012 and Rondelli et al. 2014 as examples) or presence of metals (Hjulström and Isaksson 2009). Comparative studies about the use of space by different societies might allow us to build strong interpretative models than can be also applied to archaeology. In this perspective, we advocate for a further increase in the use of anthropic markers, and a thorough assessment of their applicability as well as the reliability of the results. As a consequence, we will be able to evaluate which anthropic markers can be applied more broadly and when.

Conclusions

This paper presented and discussed new developments in archaeological research that shed light on the interpretation of hunter-gatherer archaeological contexts. The results that we have obtained applying anthropic markers for fireplaces and ashy areas and for general refuse areas allow us to enrich the interpretation of the archaeological record of the context under study, Lanashuaia II, and thereby to enhance our interpretative capabilities for hunter-gatherer contexts in the Beagle Channel. In this specific case, this approach produced two results: they shed light on spatial organisation and they provided visibility to certain past activities;

- The methodology proved to be useful for identifying a clear different spatial disposition of the proxies, making evident which of them associate recurrently and which dissociate, producing new archaeological data on the basis of previous results. Moreover, this methodology has shown that areas may be labelled differently according to which proportion of proxies have been identified, offering the possibility to record the variability of the context under study.
- The methodology based on anthropic markers also allowed us to at least partially recover the original richness of the deposits, where perishable materials were an important part of the whole assemblage.

In our case this methodology allowed to identify remains from ashes in areas where they had not been detected during the excavation process. Furthermore, in a specific area one of the proxies (phytoliths) may indicate that the ashes contain remains that could come from cleaning processes of sleeping or resting areas covered with tussock grass (this result could be used for designing a new anthropic marker for mattresses).

There is general recognition in the specialised literature of the need to improve soil and sediment research methods in order to identify and interpret anthropogenic features, even at the macro scale (Walkington 2010; Certini and Scalenghe 2011; Salisbury 2013). The rapid development of analytical techniques must be accompanied by proper archaeological methodology and anthropic markers currently seem to be a useful compromise for giving archaeological meaning to these new datasets. The debate about the range of applicability of anthropic markers must still be addressed and the ethnoarchaeological approach, which has been recognised as paramount for identifying and interpreting working processes and activity areas, is becoming an essential step in the development of this methodology.

The results discussed here, illustrate the interpretative possibilities of applied methodology. Developments in elemental, phytolith and other microrremains analyses have shown significant progress in identifying and understanding activity areas in archaeological contexts. Moreover, combining several different proxies seems to increase their potential exponentially. For this reason, the application of specific methodologies based on the use of anthropic markers and their proper development through ethnology, ethnoarchaeology and experimental archaeology will enable us to reveal the full variability of the studied contexts. At the same time, the spread of these applications will allow us to refine questions related to equifinality and the strength the methodology. The specialised literature currently recognises that a mixed-method approach is the best way to generate robust results. Finally, the full potential of this approach remains to be evaluated by means of future and intersite comparative studies.

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