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Title: Vitrified wood charcoal and burnt bones from the pre-Hispanic site of Chasogo
(Tenerife, Canary Islands, Spain)

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Abstract:

Anthracological analyses from the highlands of Tenerife, known as Las Cañadas del Teide, are still very scarce and little is known about the diversity of human practices in this area. Thanks to accurate archaeological fieldwork at Chasogo, an indigenous site located at almost 2,000 m a.s.l., it has been possible to recover a large amount of vitrified wood charcoal fragments and burnt faunal remains from a specific structure. Previous experimental work aimed at increasing our understanding of the phenomenon of vitrification has not reached the refractive rates observed in many charcoal assemblages from archaeological contexts such as Chasogo. Wood charcoal analysis indicates the predominance of the Canary Island pine (*Pinus canariensis*) suggesting a closer location of extensive pine forests during the pre-Hispanic period. The combination of spatial analyses of the anthracological and faunal remains from the structure studied are presented here, contributing to the discussion regarding the possible causes of vitrification and suggesting some working hypotheses for future analyses, i.e. a prior biological degradation (the state of the wood used) and the combustion of high proportions of resin and / or fresh bones (sudden changes in the combustion conditions). These results suggest that it is essential to integrate the anthracological remains and their micromorphological signatures into the general archaeological discussion in order to understand the nature and human use of this pre-Hispanic structure.

Key words:

Canary Islands; pre-Hispanic; Charcoal analysis; Vitrification; Burnt bones; Combustion; Spatial analysis

1. Introduction

The Canary Islands, which are volcanic in origin, are located ~300 km off the coast of Morocco, NW Africa. Tenerife occupies the central area and is the largest island of this archipelago (1,917 km²). According to archaeological and genetic data, the indigenous population of the Canary Islands –called the Guanches on Tenerife– originally came from North Africa (Fregel et al., 2019; Maca-Meyer et al., 2004; Navarro-Mederos 1983; Rando et al., 1999). Little is known about the exact time when the first settlers arrived **and how**. In this regard, although the first human presence in the archipelago has traditionally been placed during the first millennium BCE, AMS radiocarbon dating of short-lived materials (**seeds**) supports a later colonisation of the Canary Islands dating to the first millennium AD (Atoche and Ramírez-Rodríguez, 2011; Morales et al., 2017; Hernández-Marrero et al., 2016). These Berber populations apparently had no knowledge of maritime navigation, remaining isolated from the mainland, and they had little contact with people from the other islands until Europeans arrived on the archipelago in the 13-14th century AD. Finally, the Crown of Castile gradually conquered the Canary Islands at the end of the 15th century AD.

The indigenous people of Tenerife had an agrarian lifestyle with some shellfishing and coastal fishing, but the economic system was fundamentally based on goat herding (Alberto-Barroso, 2004). Seasonal herding practices have been proposed for the Guanches, who would have moved to the cool highlands in the summer and to the warmer lowlands in the winter (Diego Cuscoy, **[1968]** 2008). The highlands of Tenerife are located at an altitude above 1,700 m and **this landscape is** characterised by the presence of Mount Teide and Pico Viejo, the volcanoes found on the central plateau of Las Cañadas (Criado, 2012; Rodriguez-Gonzalez et al., 2013). Specific climatic conditions are recorded at Las Cañadas, consisting of intense solar radiation, very low humidity and low rainfall (Criado et al., 2015, 2009; Jonsson et al., 2002; Rivas-Martinez, 1987), which contribute to the dryness of the area. Despite the tough climatic and geological conditions, this territory has been subject to extensive human occupation since pre-Hispanic times (Arnay de la Rosa and González-Reimers, 2007). Archaeological work carried out in this area yielded meaningful data about the exploitation of natural resources by the indigenous people (Arnay de la Rosa et al., **2017a, 2017b**; Arnay de la Rosa and González Reimers, 2006; Galván, 1991, 1988; Hernández et al., 2000; Machado, 1992; Machado and Galván, 1998). **In this sense, it**

should be highlighted that the absence of metalliferous minerals at the archipelago led to a process of adaptation using stone tools for woodworking instead of metal. Abundant archaeological evidence has been documented in this area, some from an altitude above 3,000 m (Arnay de la Rosa and González-Reimers, 2006). However, as yet little is known about human settlement at Las Cañadas, traditionally defined as a series of temporary occupations resulting from pastoral mobility and the seasonal use of resources. In fact, recent studies (Arnay de la Rosa et al., 2017a; Marrero et al., 2017) –including the present study– aim at reconsidering this traditional picture given the diverse nature suggested by these archaeological structures evidencing economical, funerary and household activities.

In this paper, we present anthracological data from Chasogo (Guía de Isora – Teide National Park), Tenerife, Canary Islands. As anthracological analyses from the highlands of Tenerife are still scarce, the site of Chasogo is an interesting place to study landscape dynamics, providing information about the use of woody plant resources by the indigenous population. Furthermore, the peculiar archaeological assemblage mainly composed of abundant vitrified wood charcoal fragments and burnt bones raises the question of the type of fuel used and potential factors that could have influenced the high vitrification rate. On the one hand, the causes of vitrification are still an unknown phenomenon in charcoal analysis, although vitrification has been traditionally related to combustion at high temperatures (Prior and Alvin, 1986), elevated levels of humidity (Thinon, 1986) or re-charring processes (Fabre, 1996). However, more recent archaeological and experimental studies ruled out a direct relationship between vitrification and high temperatures in open fires (Braadbaart and Pole, 2008; McParland et al. 2010; Théry-Parisot, 2001). On the other hand, the analyses of faunal remains showing burning damage have been carried within different chronocultural contexts to provide data about fire function and the combustible properties of bone (Cain, 2005; Costamagno et al., 2010; Schiegl et al., 2013; Théry-Parisot and Costamagno, 2005; Yravedra et al., 2005; Yravedra and Uzquiano, 2013). Thus, the goals of our study are to: 1) provide new anthracological data shedding light on the past landscape and firewood gathering practices by the pre-Hispanic population at Las Cañadas del Teide, 2) contribute to the archaeological discussion about this site by combining spatial analyses of vitrified wood charcoals and burnt bones and 3) discuss the possible causes

of the abundance of vitrified charcoal within this archaeological structure from Chasogo site.

2. Regional setting

2.1 Geographical and archaeological context

Chasogo is located at 1,943 m a.s.l. in the SW of Las Cañadas plateau, Tenerife, Canary Islands (Fig. 1). The site lies on the lava material derived from recent eruptions (2195-1769 BC) on the western slopes of Pico Viejo (Carracedo, 2007), and it comprises several archaeological structures (Fig. 1a). The archaeological sequence of the structure studied in this work (Fig. 1b) is represented by nine stratigraphic units for which three AMS radiocarbon dates have been obtained. Although radiocarbon dating seems to reflect an inverted chronology, the different nature of the dated samples and the old wood effect must be considered (Schiffer, 1986), i.e. a charred *Visnea mocanera* L. fil. seed from unit IX (Beta-443311, 500 ± 30 BP; 1405-1445 cal AD at 2 sigma), a charred *Hordeum vulgare* L. seed from unit VII (Beta-523054, 340 ± 30 BP; 1470 – 1640 cal AD at 2 sigma) –botanical identifications by J. Morales– and a non-identified wood charcoal from unit III sent to the radiocarbon laboratory prior to the flotation of sediments (Beta-383168, 800 ± 30 BP; 1220-1290 cal AD at 2 sigma) (Fig. 2). Considering the old wood effect, the archaeological sequence of Chasogo should be mostly framed within the 15-16th centuries, immediately before or during the conquest of the island by the Crown of Castile. This circular-shaped structure (Fig. 1b), with 4 m in diameter and almost 1 m of perimeter wall, presents abundant melted stones probably exposed to $> 800^{\circ}\text{C}$, as recent experiments have shown (Marrero et al., 2017). The lower part of the sequence (units IV-IX) is characterised by the presence of four combustion features with no temporal hiatus between them (Fig. 3) around which the different activities carried out are structured, and these are associated with a rich archaeological assemblage that is mostly burnt. Hearth H1, the central feature, measures 1 m in diameter and is partially delimited by stones (see Fig. 3), while Hearth H2 and Hearths H3-4 are smaller flat combustion features. A semi-carbonised fragment of pine timber was also preserved, probably indicating its use as a supporting element of a roof made from plant materials or leather (Fig. 1c). The upper part of the sequence (units I-III), with no combustion structures, represents the reoccupation of the structure after a temporal hiatus between units III-IV (Fig. 3) and prior to its abandonment, showing

different uses from those of the previous units. Thus, charcoal remains from these units mainly originate from the final destruction of the wooden construction elements. This upper section presented postdepositional processes (bioturbation produced by the action of roots) affecting especially in the area where Hearth H3-4 was located.

Fig. 1. Geographic location of Chasogo in the Canary Islands and Tenerife. a: General view of Chasogo with the location of the structures; b: The circular-shaped structure; c: Semi-charred pine timber.

Fig. 2. AMS radiocarbon dates from Chasogo, calibrated with OxCal software (Bronk Ramsey, 2017) and IntCal13 curve (Reimer et al., 2013).

Fig. 3. Dispersion of archaeological remains according to longitudinal transects.

2.2 Current climatic conditions and plant formations

Chasogo currently lies in the dry supra-Canarian bioclimatic belt with a mean annual temperature or MAT of 6 - 11°C, mean minimum temperature during the coldest month of -1 - 2°C, mean maximum temperature during the coldest month of 4 - 9°C and mean annual precipitation or MAP of 350 - 550 mm (Rivas-Martinez, 1987; Santos Guerra, 1984). Nowadays, the Canary Island pine (*Pinus canariensis* Sm. Ex DC in Buch) is the predominant woody taxon in the region, although its presence is mostly the result of reforestation between the 1960s and 1980s (González-Navarro, 2005). Besides this, the region is characterised by the strong presence of open shrubland with montane woody leguminous species (*Adenocarpus viscosus* Willd. Webb & Berthel, *Chamaecytisus proliferus* L.f. Link and *Spartocytisus supranubius* L.f. Christ ex G. Kunkel) (Rivas-Martinez, 1987).

3. Materials and methods

3.1 Sampling method

During the archaeological field seasons of 2013 and 2017, systematic soil sampling of the excavated surface was conducted by means of water flotation with the intention of separating macrobotanical remains from sediment. Systematic recovery of wood charcoal was achieved using sieves with mesh sizes of 1 mm for large residues and 0.25 mm for flotation samples, taking into account the scattered and concentrated nature of charcoal. Both charcoal assemblages were recovered and analysed separately following

the standard anthracological methodology (Chabal, 1997, 1992). While scattered charcoal is the result of several combustion events and shows a pattern of spread across human living surfaces, charcoal from concentrated contexts usually represents isolated combustion events. Thus, most scattered charcoal assemblages are representative of the local environment, since they are the result of cumulative processes throughout the archaeological sequence (Badal and Heinz, 1991; Chabal, 1997).

Abundant large pine wood charcoal remains (> 4 cm) with a high degree of preservation were hand-picked, recorded three-dimensionally and analysed. In order to provide data from homogenous samples, only wood charcoal recovered during the flotation of sediments was included for the fragmentation study, the microscopic observation of vitrification and the spatial plotting. Considering the high proportion of burnt bones recovered from this site, this particular faunal assemblage has also been included in this work. Thus, abundant zooarchaeological remains were hand-picked together with the recovery of the smallest fragments by dry sieving using 5 and 2 mm meshes.

3.2 Charcoal analysis

Each charcoal fragment was fractured manually to provide transverse, tangential and radial sections for taxonomic identification using a Nikon Labophot-2 bright/dark field incident light microscope with 50-500x magnification at the University of Las Palmas de Gran Canaria, Spain. Botanical identification was performed using specialised plant anatomy atlases (Jacquot et al., 1973; Schweingruber, 1990, 1976), in addition to the reference collection of modern charred woody taxa from the Department of Historical Sciences, University of Las Palmas de Gran Canaria. In order to evaluate the minimal number of charcoal fragments to be analysed we used a graphic display common in anthracology, the saturation curve, i.e. a regression curve showing the floristic evolution according to the number of analysed fragments (Chabal, 1997). Photography and detailed observations of the anatomical and taphonomical features were carried out using a Hitachi S-4100 scanning electron microscope (SEM) and ESPRIT 1.8 software at the Central Service for the Support of Experimental Research (SCSIE), University of Valencia, Spain. In order to study the degree of fragmentation, the wood charcoal material from the scattered contexts of Chasogo was classified into two size classes (> 4 mm and [2-4] mm). The analysis of vitrification was focused on *Pinus canariensis* fragments, excluding the few vitrified Fabaceae remains (< 5% of the total Fabaceae).

Thus, the transverse section of each pine wood charcoal fragment was observed and vitrification was recorded according to its location within the anatomical structure: non-vitrified fragments, type A (refractive appearance of earlywood tracheids), type B (refractive appearance of latewood tracheids) and type C (refractive appearance extended indistinctly in earlywood and latewood) (Fig. 4).

Fig. 4. Categorisation of vitrified wood charcoal fragments from Chasogo. a: non-vitrified fragments; b: type B; and c: type C. **Picture of type A is not included as this category is very rare and has not been observed in the anthracological record from Chasogo.**

3.3 Zooarchaeological analysis

The anatomical and **taxonomical** determination was carried out by comparison with the reference collection of the Department of Historical Sciences, University of Las Palmas de Gran Canaria. The distinction between *Capra hircus* and *Ovis aries* was established based on Boessneck's (1980) criteria. Visible stages of burning on bone were classified by colour. Three categories were established to assess the state of thermoalteration: moderate thermoalteration (brown, **intense orange**); high thermoalteration or carbonisation, meaning temperatures between 200 and 400°C (black); and total burning or calcination at temperatures > 600°C (**light grey**, white) (Albizuri et al., 1992; **Ellingham et al., 2015**; Nicholson, 1993; Stiner et al., 1995).

3.4 Spatial analysis

The spatial distribution of the **charcoal** and burnt bone remains was analysed using GIS software (QGIS v.2.14 Essen). Density maps were generated using statistical measures based on proximity calculations, including Kernel estimation and the nearest neighbour algorithm. The results presented here were obtained using a radius of 20 cm as a measure of the standard deviation of distances between points. A random coordinate was assigned to each non-3D located wood charcoal or faunal fragment (those corresponding to flotation or water sieving) according to the excavation units. This method, previously applied to faunal (e.g. Blasco et al., 2016) and charcoal (e.g. Vidal-Matutano, 2017) remains, allowed us to produce horizontal spatial distribution maps to observe the spread of firewood and zooarchaeological remains throughout the human occupation **areas**.

4. Results

4.1 Anthracological remains

A total of 1,673 wood charcoal fragments from units I-IX of Chasogo were analysed. Abundant material came from the combustion features, while scattered charcoal from each stratigraphic unit was less abundant but statistically representative of the samples.

4.1.1 Concentrated charcoal

657 wood charcoal remains have been analysed from the four combustion structures of Chasogo, thus representing the remains of the fuelwood used in the hearths (Table 1). Hearth H2 yielded the most abundant record (n = 206), while the poorest assemblage came from Hearth H4 (n = 100). The botanical identification of this material provided a minimum of 2 taxa: *Pinus canariensis* (Canary Island pine) (Fig. 5a-c) and Fabaceae (woody legumes), with more than 80% of the charcoal corresponding to pine. Regarding the botanical determination of woody legumes, we identified the taxon Fabaceae (Fig. 4d-g), as a preliminary morphometric study of samples from Chasogo compared with current individuals from the reference collection did not provide conclusive results in terms of anatomical discrimination. Thus, the taxon Fabaceae covers a range of possible genera and species at Las Cañadas (*Adenocarpus viscosus*, *Chamaecytisus proliferus*, *Spartocytisus supranubius*) with similar anatomical elements that tend to overlap, e.g. in the three species the ray width ranges from uniseriate to multiseriate (4-8 seriate) rays. In addition, a few fragments belonging to undetermined conifers and one undetermined angiosperm fragment (from Hearth H1) could not be identified with a higher degree of certainty due to their poor preservation.

Table 1. Anthracological data from the combustion structures of Chasogo.

Fig. 4. SEM pictures of the woody taxa identified at Chasogo. a: *Pinus canariensis*, transversal section (x150). Note the collapsed cells and the vitrification; b: *Pinus canariensis*, tangential section (x200); c: *Pinus canariensis*, radial section (x500) d: Fabaceae, transversal section (x150); e: Fabaceae, tangential section (x400); f: Fabaceae, transversal section (x150); g: Fabaceae, tangential section (x400); h: *Erica* sp., transversal section (x100); i: *Erica* sp., tangential section (x100).

4.1.2 Scattered charcoal

Even though a larger quantity of wood charcoal remains were studied within the scattered assemblages (n = 1,016), the same taxonomic diversity was found (Table 2). Indeed, the botanical determination of the Canary Island pine as the dominant taxon (80-95%), accompanied by woody legumes (< 20%), shows a palaeofloral picture that is consistent with the results from the combustion features. Only the presence of one fragment identified as *Erica* sp. (Fig. 5h-i) –consisting of *Erica arborea* L. (tree heather) or *E. platycodon* Webb & Berthel (Canarian heather)– from unit VI introduces the presence of a new floristic element that is absent from the concentrated charcoal record. Saturation curves from the scattered charcoal samples show that the minimal number of charcoal fragments was reached as the main tendencies are already perceptible after the study of 40 – 60 charcoals (Fig. 6). The anthracological material is mostly quite large (> 60% corresponding to the > 4 mm size class, with fluctuations between units), although a considerable proportion of smaller fragments ([2-4] mm) can be observed in unit IX, possibly due to post-depositional percolation of fine carbonised material due to natural and/or anthropogenic processes (Fig. 7).

Table 2. Anthracological data from the scattered assemblages of Chasogo.

Fig. 6. Saturation curves from the scattered assemblages of Chasogo.

Fig. 7. Fragmentation patterns from the scattered charcoal contexts at Chasogo.

4.2 Vitrified wood charcoal

Vitrification has been widely observed in archaeological charcoal samples, regardless of the geographic and chronological context (Chrzaszvez et al., 2014; Henry and Boboeuf, 2016; Marguerie and Hunot, 2007; Marquer et al., 2012; Ntinou et al., 2013; Théry-Parisot et al., 2010; among others). The process involves the homogenisation and fusion of anatomical elements, altering some of the criteria used in the taxonomical identification: disappearance of pits, merging of the rays, homogenisation of the fibres, etc. A high rate of vitrified wood charcoal fragments was observed at Chasogo. The vitrification of pine charcoal shows a similar pattern in both the scattered and concentrated contexts, i.e. type A is totally absent, about half of the record corresponds to type C (52-56%), while type B is present in an appreciable amount of remains (32-37%). Finally, only 10-11% of the total fragments show no evidence of vitrification.

Concerning the combustion structures, there are not many significant differences between the vitrification patterns from each feature, although H1 is the most affected by type C (almost 60% of the total) compared to its proportion in H4 (30%) (Fig. 8a). Greater fluctuations can be detected within the scattered charcoal assemblage, with a higher proportion of type C in two sections of the archaeological sequence: units V-VII and unit III (Fig. 8b).

Fig. 8. Vitrification patterns from concentrated charcoal (a) and scattered charcoal (b).

4.2.1 Spatial analysis of vitrified wood charcoal fragments

Density calculations for wood charcoal fragments from Chasogo show no significant differences between vitrification categories (type B and type C). Regarding the section of the anthracological sequence in units I to III, the charcoal concentrations are clustered into two groups: C1 and C2 (Fig. 9). Spatial analysis of vitrified wood charcoal from units IV to IX shows a different pattern, where vitrification seems to be linked to the spatial location of the combustion structures (Fig. 10).

Fig.9. Spatial distribution of vitrified wood charcoal fragments from units I-III. a: type B vitrification; b: type C vitrification.

Fig. 10. Spatial distribution of vitrified wood charcoal fragments from units IV-IX. a: type B vitrification; b: type C vitrification.

4.3 Faunal remains

A total of 11,799 faunal remains were analysed from units I-IX of Chasogo for taxonomic identification and anatomical representation. Due to the hyperfragmented nature of the sample, thermoalteration and its spatial analysis was focused on a reduced but representative bone assemblage (n = 7,972). Even though the livestock of the Guanches normally included goats, sheep and pigs, only goats and sheep were identified at Chasogo. This faunal assemblage, mostly concentrated in units IV-IX, is characterised by hyperfragmentation (ranging from 0.5 to 4 cm) and a high rate of thermoalteration (Table 3 and Fig. 11). In fact, 96% of the assemblage is highly or totally thermoaltered (Fig. 12a), demonstrating the remarkably high levels of burning damage in the sample. Considering that almost 85% of the assemblage consists of undetermined < 2 cm fragments (Fig. 11c), only 20% of the total could be identified at

species (*Capra hircus* and *Ovis aries*) or family (Ovicaprinae) level, leaving the remaining 80% as meso-mammals (Fig. 12b).

Fig. 11. Thermoalteration, fracture patterns and hyperfragmentation of bone remains. a: thermoalteration types; b: bone fractures and c: hyperfragmented remains. The scale bar in 11a and 11b represents 1 cm.

Table 3. Burning damage proportions of the faunal assemblage.

Fig. 12. Zooarchaeological data. a: Thermoalteration patterns; b: Taxonomic identification; c: Anatomical representation.

The skeletal representation within this bone assemblage is almost complete, despite the high values of unidentified remains (75.14%) due to hyperfragmentation of the assemblage (Table 4). Thus, unidentified remains are followed by small fragments of diaphysis of long bones (dlb, 11.12%), and by dental fragments (8.69%). This spectrum is completed by minor percentages (< 1%) of other anatomical units (Fig. 12c). The most representative alteration features are longitudinal and transversal fractures (Fig. 11b), which have often been related to combustion processes involving fresh bone (Théry-Parisot, 2002; Théry-Parisot et al., 2005). However, longitudinal fractures similar to those produced experimentally in dry bones with little organic matter have also been identified, suggesting possible successive exposures to fire.

Table 4. Anatomical units represented in the faunal assemblage. P = proximal; SH = diaphysis; D = distal.

4.3.1 Spatial analysis of burnt bones

Density maps of burnt bones from units I to III provided a similar spatial pattern to that of the vitrified wood charcoal. In this regard, thermoaltered bones are mostly concentrated in cluster C1, with a significant presence at the entrance of the structure (Fig. 13). Otherwise, the same consistency between the spatial distribution of burnt bones and vitrified charcoal fragments can be observed for units IV to IX (Fig. 14). In this part of the archaeological sequence, highly and totally thermoaltered bones (Fig. 14b-c) are also spatially related to the hearths, with a spatial pattern that is more extended across the surface than the anthracological remains. Finally, it is worth mentioning the high concentration of totally thermoaltered bones inside feature H1 and

in the adjacent area (Fig. 14c), as this combustion structure also provided the highest proportion of type C vitrified wood charcoal (Fig. 8a).

Fig. 13. Spatial distribution of burnt bones from units I-III. a: Moderate thermoalteration; b: High thermoalteration; and c: Total thermoalteration.

Fig. 14. Spatial distribution of burnt bones from units IV-IX. a: Moderate thermoalteration; b: High thermoalteration; and c: Total thermoalteration.

5. Discussion

5.1 Palaeoecological data and firewood gathering activities

The scattered charcoal assemblage from Chasogo is characterised by the strong presence of Canary Island pine (representing more than 80% in all the stratigraphic units), accompanied by a fluctuating but scanty presence of woody legumes ranging from 2 to 15% (Fig. 15). This anthracological record reflects a taxonomically poor assemblage compared to the data provided by other charcoal analyses from the island of Tenerife (Machado, 2007, 1999, 1996, 1992), although the geographic location of Chasogo at almost 2,000 m a.s.l. should be taken into consideration. Indeed, the situation of the archaeological site at the edge of Las Cañadas del Teide determines the floristic composition of the anthracological record, offering a picture of a highland vegetation characterized by a patchy landscape with open pinewood formations and montane leguminous species.

Fig. 15. Anthracological diagram of Chasogo. *AMS radiocarbon dating of the wood charcoal from unit III apparently indicates an older chronology than those of units VII and IX, although the “old wood” problem should be considered (Schiffer 1986).

Despite the current location of Chasogo in a supra-Canarian bioclimatic belt, the woody plant record from the site is indicative of a landscape characterised by predominantly dry meso-Canarian conditions (MAT of 11-15°C and MAP of 350-550 mm) (Rivas-Martinez, 1987; Santos Guerra, 1984). Canary Island pines are the characteristic arboreal formations of the dry meso-Canarian bioclimatic belt, forming a continuous area around the island between 1,200 and 1,800 m a.s.l., although scattered stands are also present down to sea level or at higher altitudes up to 2,000 m a.s.l. (Molina-Terrén et al., 2016). In addition to altitude, exposure to wind is another major determinant of vegetational variation on Tenerife, as it implies fluctuations in moisture and radiation

values (Fernández-Palacios and de Nicolás, 1995; Rivas-Martinez, 1987; Santos Guerra, 1984). Thus, the island is greatly influenced by the trade-wind regime that generates clouds over its northern slopes (Ceballos and Ortuño, 1951). The incidence of the cloud sea layer, which varies in altitudinal location throughout the year, produces changes in the altitudinal distribution of climate elements (temperature, precipitation, radiation, humidity) that can be seen in several altitude-specific plant formations, i.e. laurel forest and *Erica-Morella* heath (always within the cloud sea range), Canary Island pine forests (occasionally in the cloud sea range) and montane leguminous shrubs (above the cloud sea range) (Fernández-Palacios and de Nicolás, 1995). In view of this, two possible explanations can be put forward concerning the wood charcoal data from Chasogo. On the one hand, firewood supply areas could be extended from dry meso-Canarian to dry supra-Canarian belts, including both pine forests and montane leguminous plant formations. Other woody resources scarcely represented in the anthracological record (*Erica arborea* – *Erica platycodon*) may indicate their collection for uses other than as fuel, e.g. to manufacture implements or tools, as a roof covering, etc. In this regard, this taxon could be gathered at lower altitudes, in the middle area (500-1,300 m a.s.l.) of the windward slope of the island, which is an altitudinal range characterised by laurel forest and *Erica-Morella* formations (del Arco et al., 1987; Molina-Terrén et al., 2016). However, *Erica* may also be sparsely present closer to the site. On the other hand, and a more plausible explanation would be that even though the current treeline in Tenerife lies at 2,000 m a.s.l. (Gieger and Leuschner, 2004; Jonsson et al., 2002; Santos Guerra, 1984; Šrútek et al., 2002), in the past this treeline may have extended to higher altitudes, allowing the pine forests to develop closer to the location of Chasogo. Thus, the presence of extensive Canary Island pine forests close to the site –which are currently almost absent in the area due to deforestation– could explain the high proportion of *Pinus canariensis* in the anthracological record.

The anthracological diagram of Chasogo shows considerable homogeneity in terms of plant taxa without significant diachronic variations, which could be related with short-term occupations causing little impact on the forest cover (see Fig. 15). The Canary Island pine strongly predominates over woody legumes throughout the sequence, with two localised peaks in unit VII and units III-IV, which could be related to the different alternating phases of use and abandonment of the structure. Indeed, the peak from unit VII coincides with the period of greatest intensity in hearth use inside the structure,

while the highest values for units III-IV may correspond to the organic remains resulting from the dismantlement of the structure **previous to its temporary abandonment**. This anthracological spectrum shows significant differences with that of Chafarí, an archaeological site traditionally interpreted as a series of seasonal occupations by indigenous groups linked to transhumance (Galván, 1991, 1988). The Chafarí site, located at 2,080 m a.s.l. and also occupying the supra-Canarian bioclimatic belt in Las Cañadas, yielded a clear predominance of montane leguminous shrub taxa (> 80% of the total), with a minor presence of *Pinus canariensis* and *Juniperus cedrus Webb & Berthel*. (Canary Island juniper) (Machado, 1992). The upper part of the anthracological sequence of this site presented increasing values of woody legumes, interpreted by Machado and Galván (1998) as a sign of changes in the local landscape due to human activity, i.e. intensive grazing, development of forage plants, etc. Although **the Chafarí data** is consistent with anthracological studies suggesting that local landscape transformations can be detected after long-term occupations (i.e. 500 years) by farming groups regardless of the chronology (Badal et al., 2016), this is not apparently applicable to the anthracological sequence of Chasogo, **where no human impact in the landscape is detected**. Furthermore, unpublished anthracological data from Cruz de Tea, a quarry-mill workshop located at 2,200 m a.s.l. **with slightly older AMS radiocarbon dates (Arnay et al. 2017a)**, also present a high proportion of Canary Island pine (almost 60% of the total), followed by a notable presence of montane legumes (35%) and reduced values of tree heather (*Erica arborea-Erica platycodon*) **probably also indicating minor growths of this taxon at higher altitudes**. In this regard, anthracological analyses focusing on the area of Las Cañadas del Teide are still very scarce, although the available data suggest high variability in settlement patterns, where the sites of Chafarí, Chasogo and Cruz de Tea are probably not linked to the same human practices and functionalities. **In addition to this, charcoal analyses applied to this area are also evidencing a closer location of pine forests due to the position of the past treeline at higher altitudes than nowadays.**

5.2 Could burnt bones be related to vitrified wood charcoal at Chasogo?

Although vitrification has traditionally been attributed to combustion at high temperatures (> 600°C), **moisture content (Prior and Alvin, 1986)**, a combination of high temperatures and elevated levels of humidity (Thinon, 1992) or re-charring processes (Fabre, 1996), its exact causes still remain unknown. **Nonetheless, laboratory**

charring experiments at 900 – 1,100 °C in reducing conditions demonstrated that vitrification is not a function of high temperature (Braadbaart and Poole, 2008; McParland et al., 2010). Experimental combustions on an open fire and in a muffle furnace carried out by Théry-Parisot (2001) using firewood from different taxa in different physiological and phenological states and varying temperatures did not reproduce the vitrification rates observed in the archaeological record. Taking into account that the temperature reached in open domestic fires is usually between 400 and 500°C (Théry-Parisot, 2001), an increase in this variable is only possible by “closing” the fire and producing a more reducing combustion conditions (Trabaud, 1979). This observation has led some authors to consider reducing atmosphere combustion conditions as a possibly related factor, as high temperatures in an oxidising atmosphere would generate the total combustion of firewood (Théry-Parisot, 2001).

The vitrified fragments in units IV-IX of Chasogo, spatially concentrated inside and close to the combustion structures, suggest a relationship of this phenomenon with the combustion process (specific combustion conditions) rather than possible post-combustion processes. Regarding units I-III, vitrified wood charcoal fragments are mostly concentrated within two clusters: C1, where the semi-charred pine timber was located and C2, where bioturbation processes were detected causing the partial mixing of charcoal (see subsection 2.1). Thus, vitrification for units I – III (with densities significantly lower compared to those from units IV – IX) could originate from the destruction of roof structures and some mixed charcoals coming from Hearths 3-4. Considering the reducing/oxidising atmosphere discussion with regard to Chasogo, the abundance of large wood charcoal fragments (> 4 cm) and the evidence of combustion features inside the structure could suggest incomplete combustion in a semi-reducing atmosphere, although exceptional conditions of preservation could also be argued. Some considerations can be formulated with regard to the vitrified wood charcoal from Chasogo. On the one hand, the incidence of high temperatures has been suggested based on the highly thermoaltered faunal remains (> 600°C), although the aforementioned experiments with wood charcoal ruled out its direct connection with this phenomenon (Beresford-Jones et al., 2010; McParland et al., 2010). On the other hand, some researchers have claimed a possible relationship between the refractive aspect of wood charcoal and prior biological degradation caused by fungal decay producing the fused appearance of cells in latewood (Théry-Parisot, 2001; Badal and Carrión, 2004; Henry,

2011; Martínez et al., 2005). Thus, refracting zones could indicate areas where the wood was degraded by fungi and, therefore, an imbalance in the composition of cellulose and lignin (Henry, 2011; Irbe et al., 2006). In this regard, abundant pine charcoal fragments from Chasogo show fungal degradation features (Fig. 5a). Ongoing experimental combustions by Vidal-Matutano and colleagues with *Pinus canariensis* gathered in different states of decay (healthy, dead and rotten) promise to shed more light on this issue allowing in the near future a quantitative analysis of these anatomical alterations. In addition, although no vitrification was reported in charring experiments using *Pinus sylvestris* wood by McParland et al. (2010) and Braadbaart and Poole (2008), fire-setting experiments carried out by Py and Ancel (2006) using resinous Pinaceae produced a large amount of vitrified charcoal fragments, suggesting its possible relationship with the combustion of the resin, a substance with a very high calorific value that generates good inflammability. Given these results, which are especially relevant as most of the firewood used at Chasogo comes from *Pinus canariensis*, the authors make significant palaeoeconomic inferences, i.e. indications regarding the cutting season. Taking this into account, the high proportion of living cells in the *Pinus canariensis* xylem accumulating large quantities of reserve starch produces intense resinification processes in this species, especially in heartwood (Climent et al., 1998). The potential resin productivity of the Canary Island pine is in spring – summer, when the highest solar radiation and temperature values are recorded, whereas it decreases in autumn – winter (González-Navarro, 2005). Hence, if the resin content is related with charcoal vitrification, firewood gathering at Chasogo (and, therefore, human use of this structure) could be placed during spring – summer. Finally, sudden changes in the combustion conditions have also been proposed as possible influencing factors (Marguerie and Hunot, 2007; McParland et al., 2010), such as the use of fresh bone as fuel although experimental verification is still needed. Indeed, evidence of this comes from Palaeolithic contexts with a high proportion of vitrified plant remains related to bone-fuel hearths (Beresford-Jones et al., 2010). Taking all this into account, the phenomenon of vitrification is unlikely to be due to one specific factor but may result from the combination of several influential factors (McParland et al., 2010), although in our case the high proportion of resin contained in *Pinus canariensis* and its possible relationship with the occurrence of this phenomenon should be considered in future experimental studies under reducing and oxidizing conditions.

The distribution of burning damage on faunal remains can provide meaningful information about cooking practices, site maintenance activities or deliberate use as a source of fuel (Clark and Ligouis, 2010), among others. Regarding this issue, several studies have been performed to understand the presence of burnt bones in archaeological contexts. These studies focus mainly on the combustible properties of bone according to the portion of tissue (spongy vs. compact bone), the level of freshness and fragmentation (Costamagno et al., 2010; Théry-Parisot et al., 2010; Théry-Parisot and Costamagno, 2005), and colouration and structural changes of bone tissue according to the combustion temperature (Brain and Sillen, 1988; Nicholson, 1993; Shahack-Gross et al., 1997; Stiner et al., 1995). Although some researchers have justified the use of bone as fuel based on the scarcity/absence of wood charcoal (Schiegl et al., 2003) or as a result of a reduction in forest cover (Yravedra et al., 2005), detailed anthracological analyses and experimental works have dismissed a correlation between these arguments (Beresford-Jones et al., 2010; Clark and Ligouis, 2010; Gerbe, 2010; Mentzer, 2009; Théry-Parisot, 2002; Théry-Parisot and Costamagno, 2005). Indeed, extensive combustion experiments concluded that combustion of mixed fuel (bone and wood) is more effective as a source of heat than the exclusive use of wood and highlighted the preferential use of bone for activities that require the production of large durable flames (Costamagno et al., 2010; Théry-Parisot et al., 2010; Théry-Parisot, 2001; Théry-Parisot et al., 2004; Théry-Parisot and Costamagno, 2005). Moreover, those experiments indicated different combustion properties according to the skeletal elements (vertebrae / long bones) or portions (compact / spongy tissue), the moisture content and the degree of fragmentation. Thus, spongy parts (epiphyses) seem to be more combustible than compact bone (diaphyses), which has been related to the abundance of the former on many archaeological sites (Costamagno et al., 2010; Théry-Parisot et al., 2005; Théry-Parisot and Costamagno, 2005). Along with this, experimentation has also paid attention to the taphonomic processes affecting burnt bone assemblages, suggesting that spongy elements such as the ribs and vertebrae are more susceptible to fragmentation as a result of their lower density (Clark and Ligouis, 2010; Théry-Parisot et al., 2009). Hence, bone fragmentation occurs prior to (accidental or intentional breakage during butchering), during (fragmentation processes due to its exposure to fire) and/or after (post-depositional processes such as cryoturbation, trampling, hearth cleaning or freeze/thaw cycles) burning, where highly burnt bones are

especially sensitive to fragmentation (Gerbe, 2010; Mentzer, 2009; Théry-Parisot et al., 2009).

Regarding skeletal representation of the faunal assemblage from Chasogo, it could be concluded that it resulted from in situ butchering and consumption processes followed by food waste management strategies. Nevertheless, the scarcity of specific units (scapulae, pelvis and certain carpal and lower limb bones), usually observed in other thermoaltered faunal assemblages from the Canary Islands (Alberto-Barroso et al., 2015; Alberto-Barroso et al., 2017), suggests that a primary butchering operation would have been carried out in an outer area, probably nearby, followed by the consumption of some specific portions of meat inside the structure. In addition, the high level of thermal damage is not directly related to culinary practices. Indeed, it could consist of an alteration process due to its condition as detritus caused by intense heating of the remains during successive combustion events inside the structure. Fractures associated with fresh bone combustion are the most abundant. Therefore, as the animal portions were used for human consumption, the presence of muscle tissue still inserted into bones would be reduced, thus indicating that the bones would have been thrown into the fire soon after ingestion. Thus, the faunal remains would basically result from consumption in the form of food waste. Additionally, heating phenomena were also observed on dry bone, probably related to subsequent fires. The large number of burnt bones and the remarkable intensity of burning processes provide certain differences with respect to other domestic contexts from the Canary Islands where burning damage is significantly lower. Indeed, similar thermoalteration processes have only been documented in indigenous ritual contexts at archaeological sites on the nearby islands of La Gomera and El Hierro, located in the same archipelago (Alberto-Barroso, 2002; Alberto-Barroso et al., 2015), which radically differ from the patterns documented in domestic settlements. Hence, taking into account that the assemblages from Chasogo do not seem to be linked to ritual activities, it raises the question about the role of fire at this site.

Although bones can be burnt by means of several intentional or unintentional processes, their clear association with combustion structures suggests a non-natural fire. Indeed, the spatial distribution of moderate thermoalteration (see Fig. 14a) is consistent with their location on the periphery of the combustion area, which may indicate that these bone fragments were heated at lower temperatures than those exposed to the flames. In

contrast, highly burnt bones and calcinated remains are mostly distributed inside and close to the hearths (see Fig. 14b-c). It is worth mentioning the spatial relationship established between type C vitrified wood charcoal and highly burnt bone, both of which are distributed in the area where the combustion structures are located, possibly suggesting some sort of connection between these pieces of evidence. Taking into account the three main statistical categories (fuel, non-fuel and fuel/cleaning) proposed by Costamagno et al. (2009), the burnt faunal assemblage from Chasogo seems to fit fairly well into the third category, defined as the intentional combustion of bone without a preferential use of the most combustible portions, as it is characterised by a high proportion of burnt bones (96% of the total remains studied at Chasogo correspond to high and total thermoalterations), a high proportion of small < 2 cm charred remains (almost 85% of the total) and a low proportion of spongy bone (Table 4).

In this regard, although these peculiar components of the burnt assemblage from Chasogo effectively suggest an intentional combustion of bones inside the structure, its fuel condition can apparently be discarded. On the one hand, the combustion process could contribute to the underrepresentation of spongy bones as it has been suggested based on experimental studies (Costamagno et al., 2009; Costamagno et al., 2010). On the other hand, the evidence of these anatomical units in other thermoaltered faunal assemblages from the Canary Islands and its absence in Chasogo could suggest the possible transport of processed meat portions for human consumption. Several works focused on bone used as fuel identify a high proportion of the most combustible portions (Costa, 2016; Yravedra and Uzquiano, 2013). Nevertheless, spongy bones at Chasogo mostly correspond to proximal and distal portions of long bones, which are the anatomical units with a higher proportion of meat; although very small spongy portions could also be included in the 75.14% of indeterminate fragments (Table 4). In addition, despite the fact that bone used for fuel has not been documented for the indigenous populations of the Canary Islands to date, the presence of a large amount of bones in the fire and their combustible properties (higher temperature, large durable flames and slow combustion process) (Etxeberria, 1994) probably influenced the combustion process inside this structure (Etxeberria 1994; Perez et al., 2017; Yravedra and Uzquiano, 2013).

5.3 Fire-related unknown purposes in the highlands of Tenerife

The lower part of the Chasogo sequence (units IV-IX), corresponding to the highest presence of archaeological features and combustion remains, presents peculiar characteristics based on the faunal and charcoal records. On the one hand, the high degree of burning damage is mostly evidenced by a faunal assemblage consisting of high proportions of burnt remains spatially related to hearths, significant hyperfragmentation values and an almost complete skeletal representation with noteworthy scarcities and absences. On the other hand, abundant pine wood charcoal fragments showing high rates of vitrification with significant higher density values compared to those from units I – III were preserved.

Concerning the use of pine as fuel, the reasons for its preferential exploitation at Chasogo should not be interpreted *a priori* as the result of a specific selection but the human adaptation to the local plant availability. In this regard, fire-related activities carried out by the indigenous group that inhabited Chasogo could have been easily satisfied through the collection of the most abundant species in the local environment, i. e. pine. Regarding the lower values for leguminous species, their use has traditionally been interpreted by some authors as kindling for starting fires (Uzquiano, 2014); however, we should be cautious of this assumption, as pine branches and thinner twigs accomplish the same goal. Admitting the possibility that firewood could have been selected based on its high percentage of resin (Climent et al., 2007), experimental studies based on combustion of several taxa with different calorific values have identified the moisture content, the state of the wood and the calibre as the real determining factors (Théry-Parisot, 2001; Théry-Parisot et al., 2010). Considering this, firewood gathering strategies at Chasogo seem to have been oriented towards the most abundant taxon available in the past local landscape. Finally, regarding the possible relationship between vitrification of charcoal and the high rates of resin in *Pinus canariensis*, firewood collection could have occurred during spring and summer coinciding with the highest resin productivity of the Canary Island pine (Climent et al., 1998; González-Navarro, 2005). On this basis, this seasonal pattern at Chasogo would be consistent with the probable use of this structure during the warmer months of the year. Nonetheless, further experimental studies with Fabaceae taxa are needed for a better understanding of charcoal vitrification at Chasogo.

6. Conclusions

The anthracological data presented here have shed new light on the environmental conditions in the highlands of Tenerife and the exploitation of woody resources by the indigenous population prior or simultaneously to the Spanish conquest. Wood charcoal analysis suggests that the local plant landscape at almost 2,000 m a.s.l. was predominantly characterised by dry meso-Canarian conditions, even though Chasogo is currently located in the dry supra-Canarian belt. The strong presence of Canary Island pine wood charcoal throughout the anthracological sequence points out to a closer location of extensive pine forests due to the position of the past treeline at higher altitudes than nowadays. Abundant vitrified wood charcoal fragments, which are the focus of this work, seem to be spatially related to the combustion structures and the burnt bones suggesting the relationship of this phenomenon with the combustion process (specific combustion conditions). Although the exact reasons for this phenomenon still remain unknown, some working hypotheses for future analyses should concentrate on the microscopic observation of fungal degradation features in *Pinus canariensis* wood charcoal fragments (assumption of its possible relationship with prior biological degradation and the state of the wood used) and on experimental combustions combining high-resin species, such as *P. canariensis*, and fresh bones (assumption of its possible relationship with the combustion of resin and sudden changes in the combustion conditions). An intention to produce intense, blazing fires inside the structure at Chasogo –without any preferential use of the most combustible bone portions– has been suggested, although its specific purpose remains unresolved. Considering that the substantial burning damage does not seem to be related to culinary practices, other possible uses of the structure where fire and long-lasting combustion is required could be proposed, e.g. food waste management strategies. In this sense, it is worth noting that no metallurgical activity could be related as metalliferous minerals are completely absent at the archipelago. Finally, even though anthracological data from the highlands of Tenerife are still very scarce, the available results support the idea of a high variability in settlement patterns at Las Cañadas del Teide. Further research on charcoal from this area may provide significant information about woody plant management and differences in human practices deriving from several purposes, but also about past landscape and the effects of human impact on the pine forest dynamics through time.

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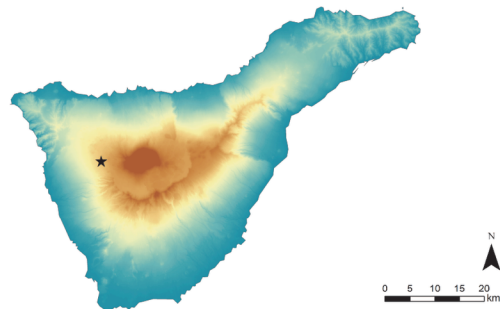
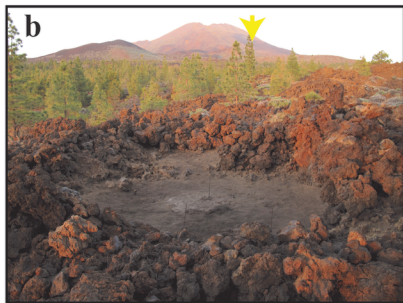
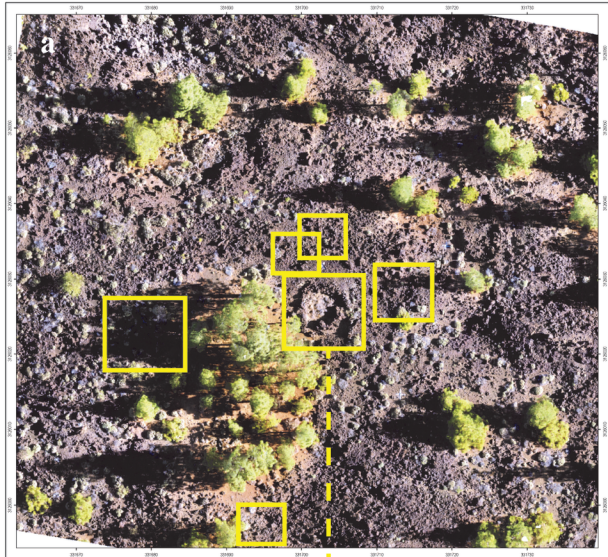
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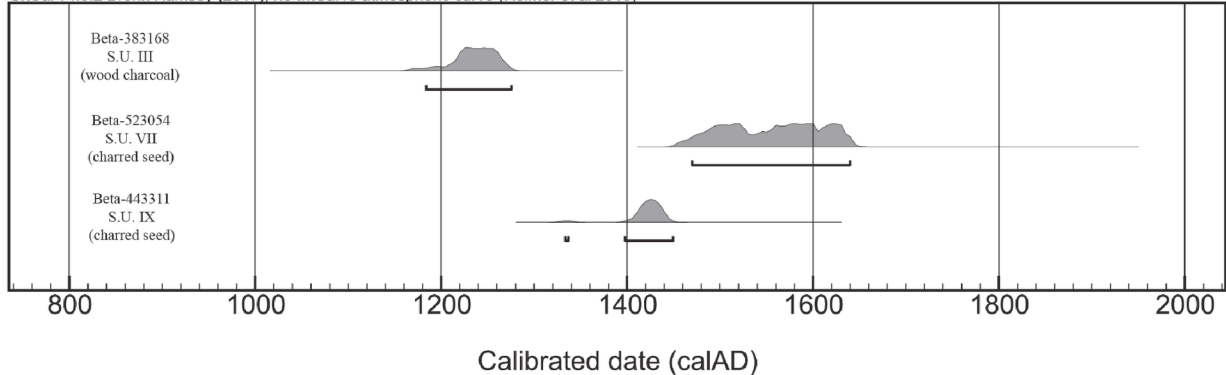
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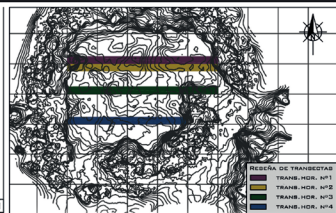
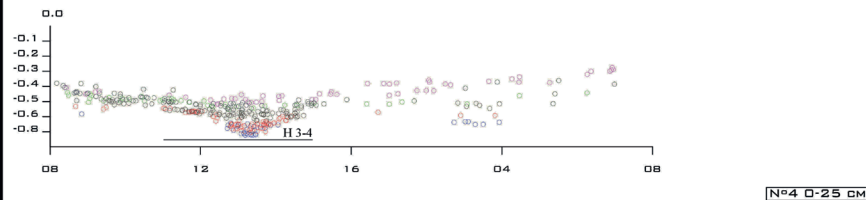
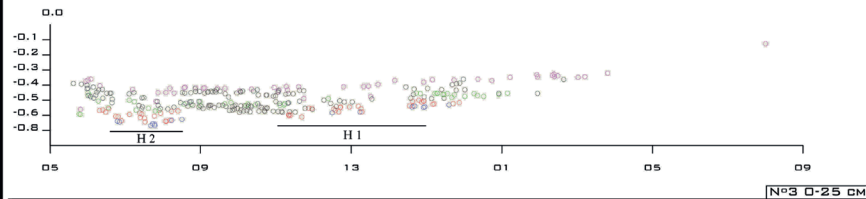
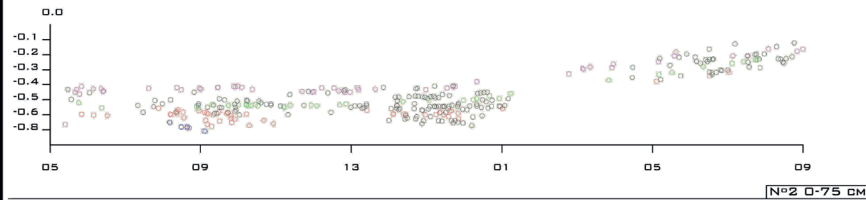
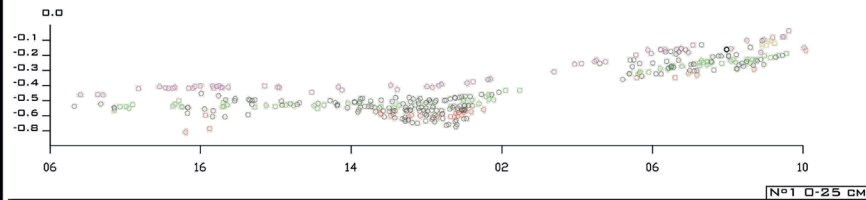
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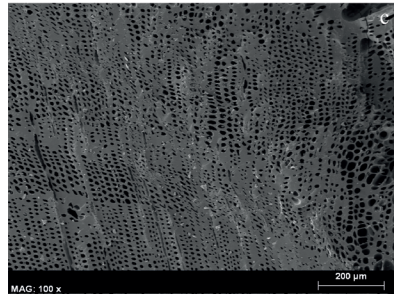
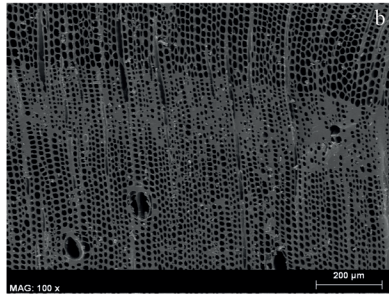
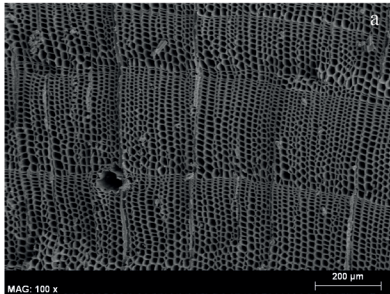
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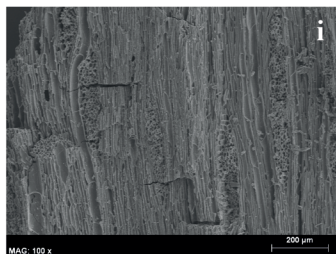
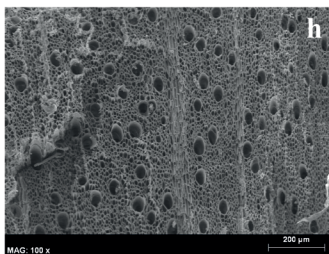
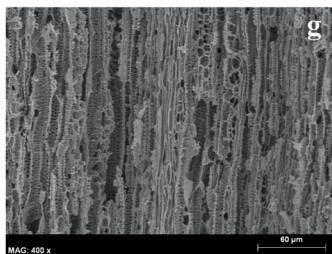
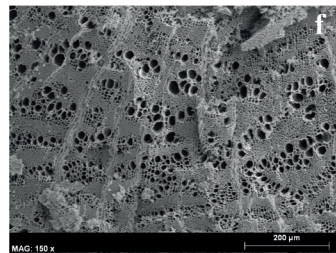
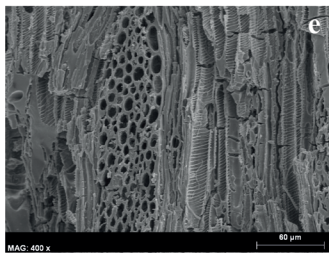
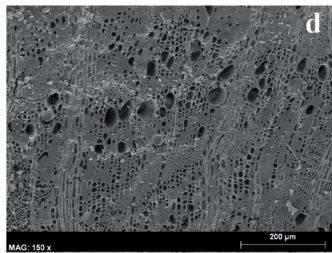
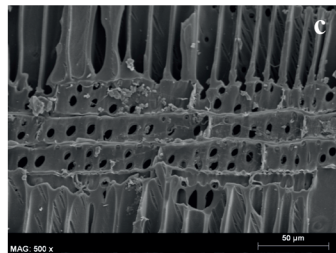
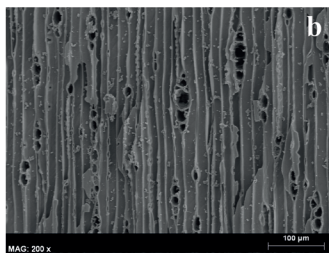
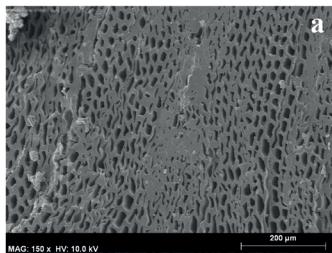


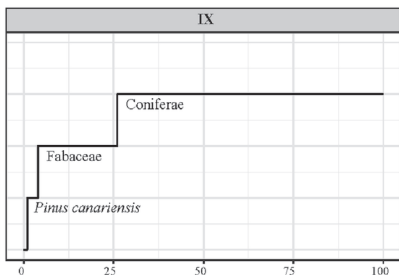
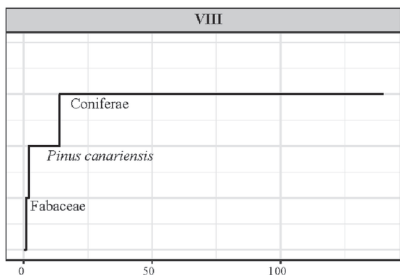
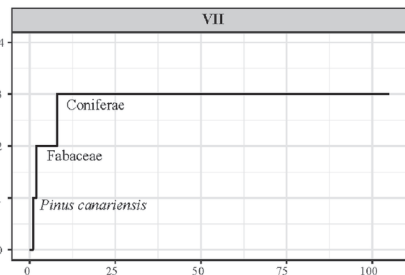
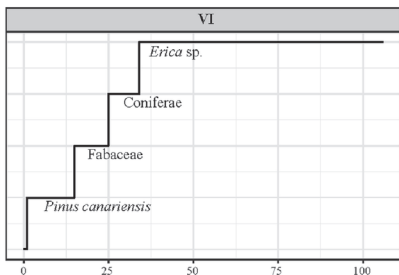
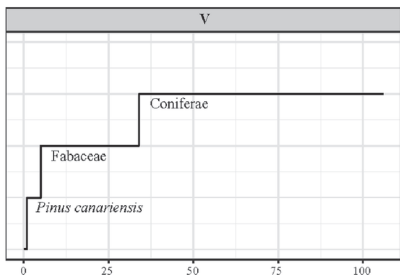
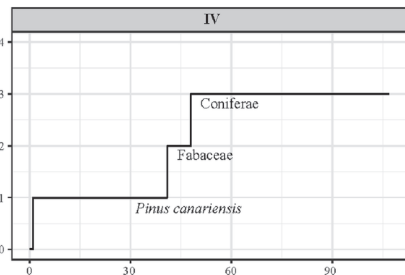
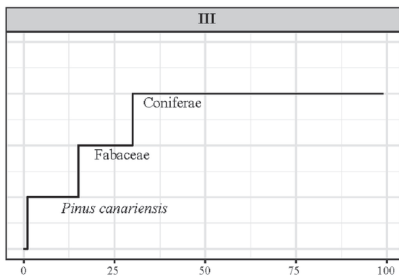
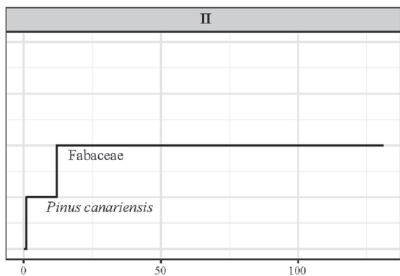
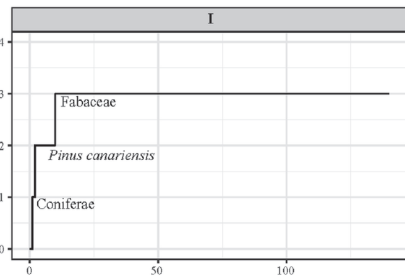


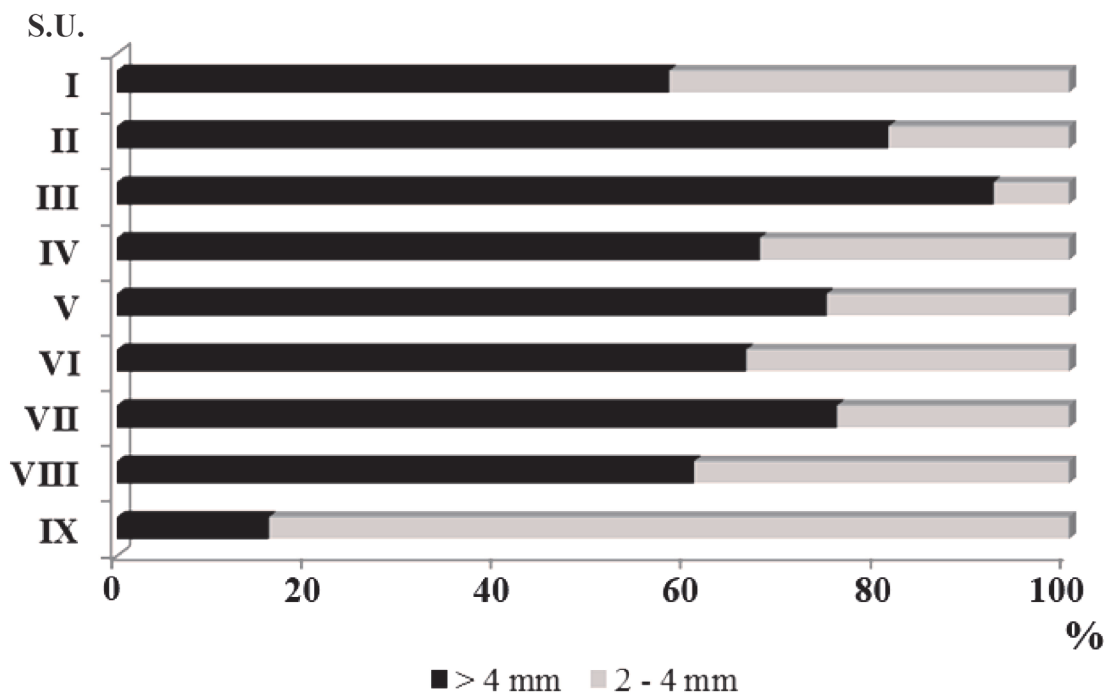
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- SU VIII
- SU IX

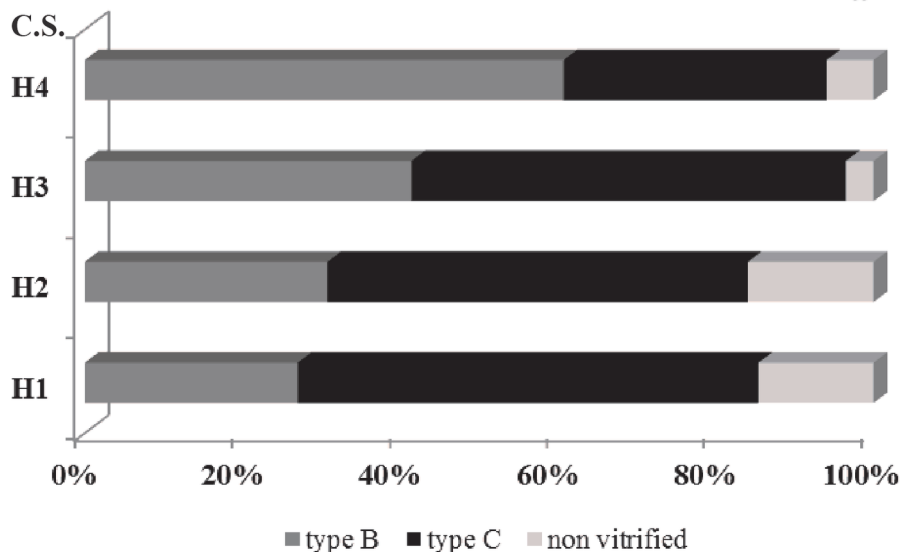
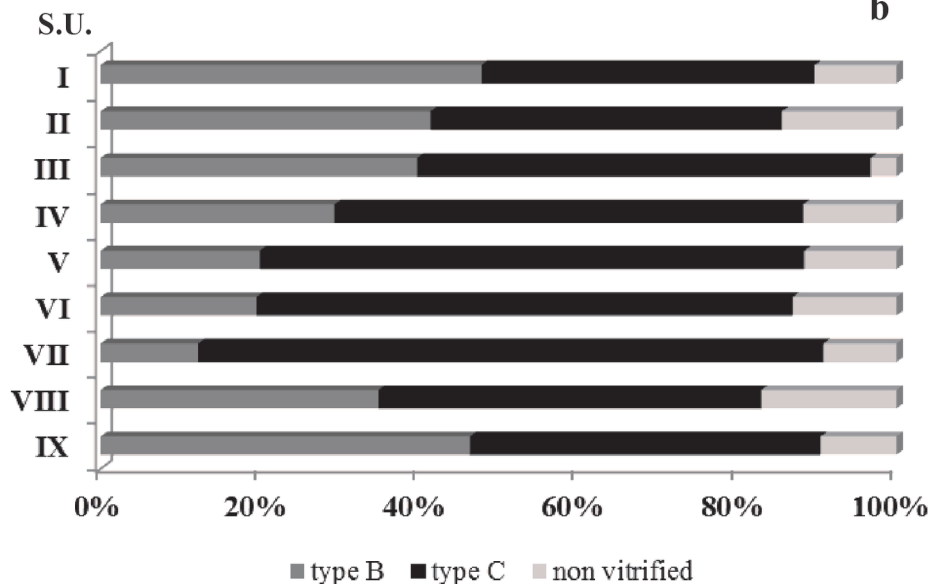


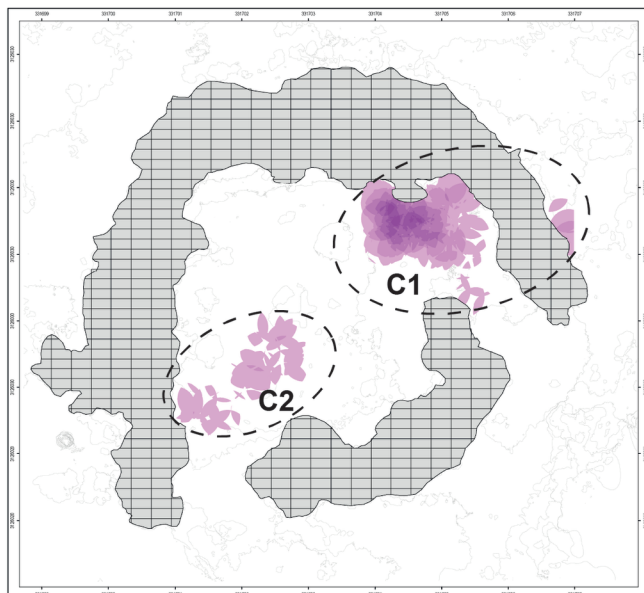








a**b**

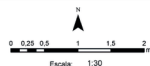
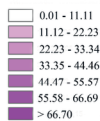


a

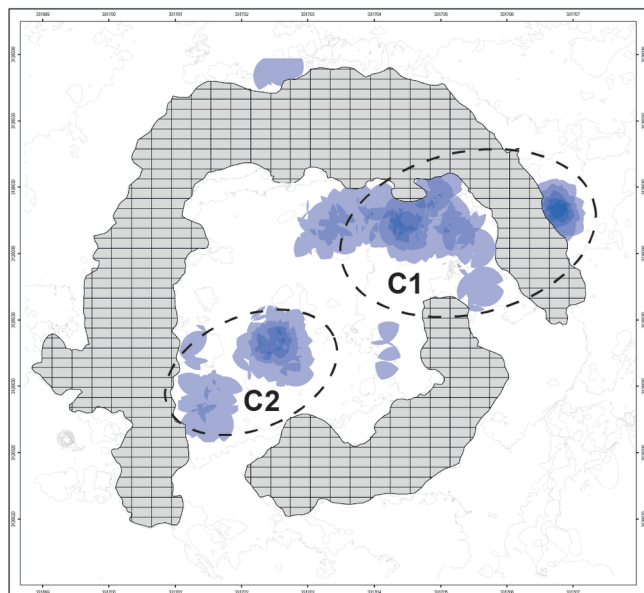
Type B vitrification S.U. I - III

Wall

Densities charcoal / 0.12 m²



TEIDE
PARQUE NACIONAL

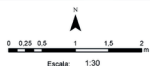
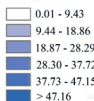


b

Type C vitrification S.U. I - III

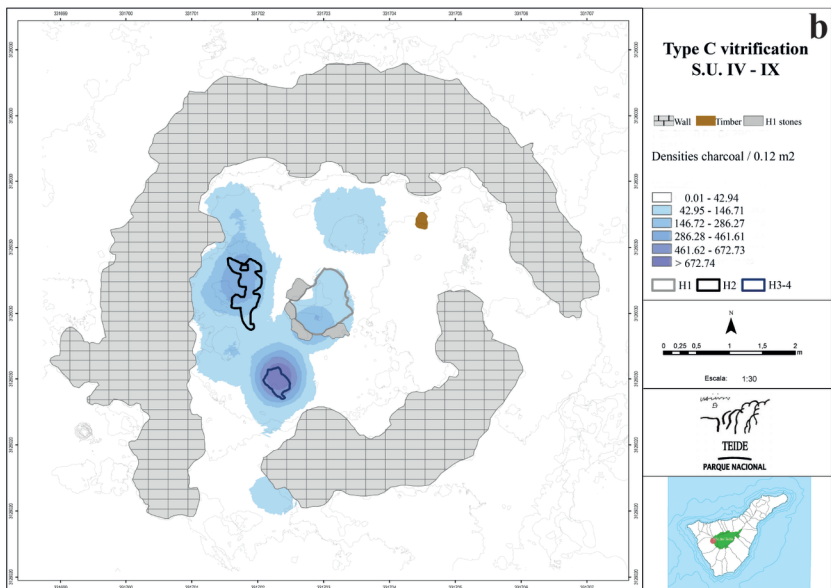
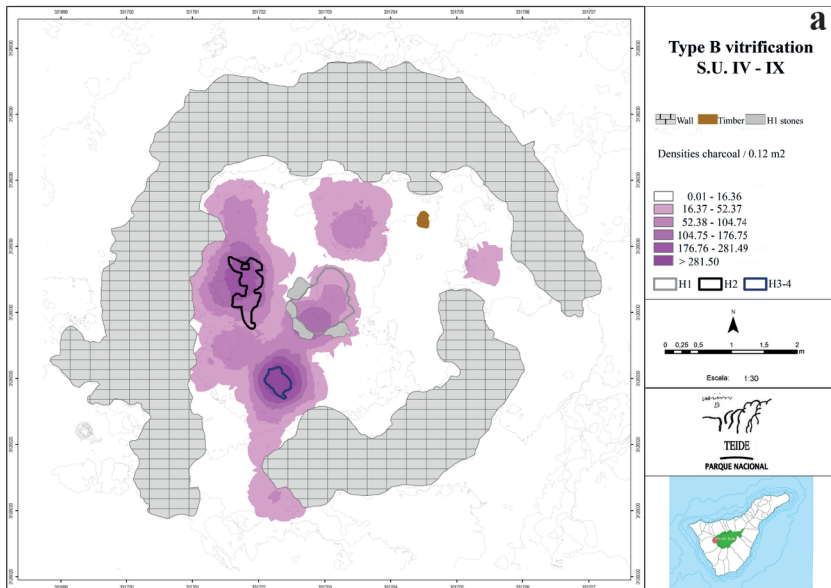
Wall

Densities charcoal / 0.12 m²



TEIDE
PARQUE NACIONAL





a

moderate
thermoalteration



high
thermoalteration



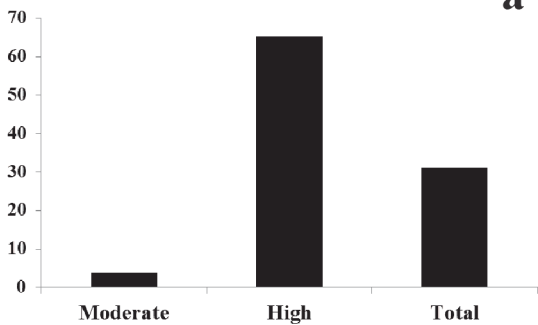
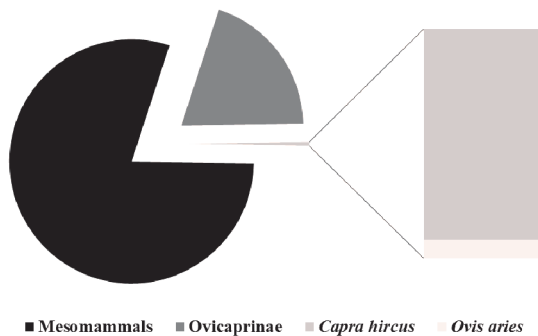
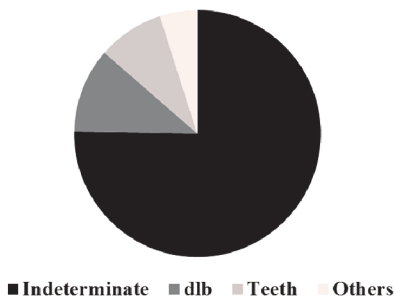
total
thermoalteration

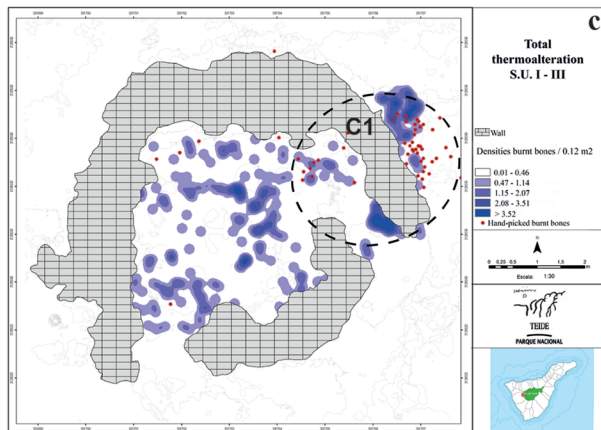
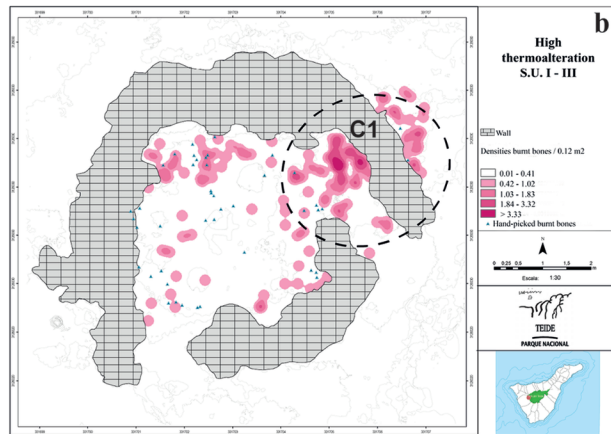
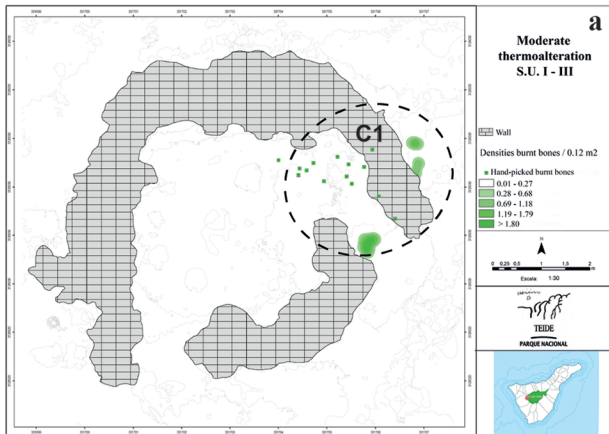
**b**

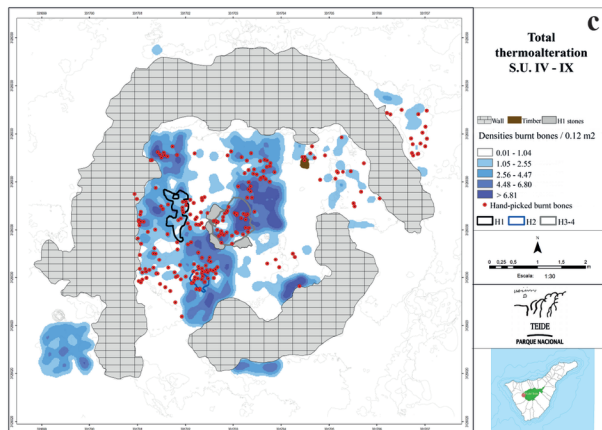
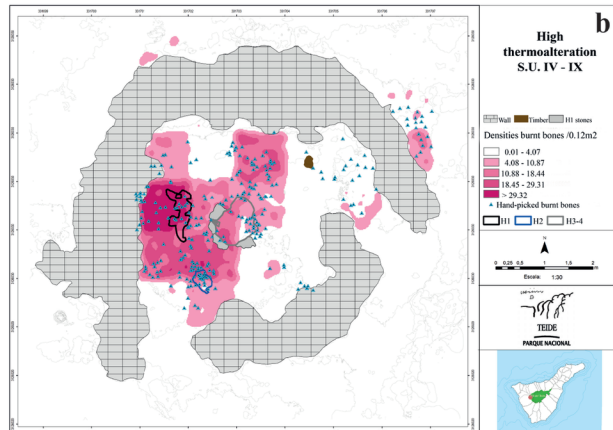
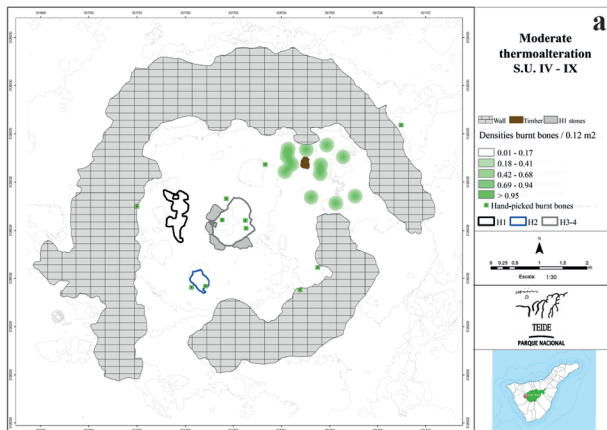
bone fractures

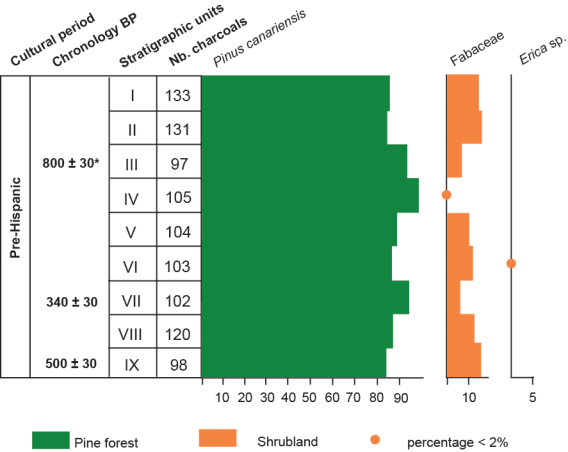
**c**

2 cm

a**b****c**







Combustion structure	H1		H2		H3		H4	
Taxa	n	%	n	%	n	%	n	%
Angiosperms	1	0.67						
Coniferae	17	11.33	11	5.34	1	0.50	2	2
Fabaceae	12	8	24	11.65	3	1.49	16	16
<i>Pinus canariensis</i>	120	80	171	83.01	197	98.01	82	82
Total charcoal	150	100	206	100	201	100	100	100
Total taxa	2		2		2		2	

Unit	I		II		III		IV		V		VI		VII		VIII		IX	
Taxa	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Coniferae	7	5			2	2.02	2	1.87	2	1.89	3	2.83	3	2.86	2	1.64	2	2
<i>Erica</i> sp.											1	0.94						
Fabaceae	19	13.57	20	15.27	7	7.07	2	1.87	11	10.38	13	12.26	6	5.71	16	13.11	15	15
<i>Pinus canariensis</i>	114	81.43	111	84.73	90	90.91	103	96.26	93	87.74	89	83.96	96	91.43	104	85.25	83	83
Total charcoal	140	100	131	100	99	100	107	100	106	100	106	100	105	100	122	100	100	100
Total taxa	2		2		2		2		2		3		2		2		2	

Thermoalteration	n	%
Moderate	308	3.86
Brown	253	3.17
Intense orange	55	0.68
High	5194	65.15
Black	5194	65.15
Total	2470	30.98
Light gray / blakish	2013	25.25
White	457	5.73

Anatomical unit	Goat	Sheep	Ovicaprinae	Meso-mammals	Total	
	NR	NR	NR	NR	NR	%
Horn	25				25	0.21
Skull	1		101	6	108	0.92
Hyoid			2		2	0.02
Jaw	1		84		85	0.72
Teeth	2		1023		1025	8.69
Vertebra		1	21		22	0.19
Rib			106		106	0.90
Scapula			2		2	0.02
Humerus (P)			11		31	0.26
Humerus (SH)			18			
Humerus (D)	1	1				
Radius (P)			2		19	0.16
Radius (SH)			13			
Radius (D)			3			
Ulna (P)			1		14	0.12
Ulna (SH)			13			
Ulna (D)						
Radius-Ulna (P)					27	0.23
Radius-Ulna (SH)	27					
Radius-Ulna (D)						
Trapezoid-Capitatum			3		3	0.03
Hamatum			2		2	0.02
Scaphoid			1		1	0.01
Metacarpus (P)			7		12	0.10
Metacarpus (SH)			4			
Metacarpus (D)			1			
Innominate			3		3	0.03
Femur			22		22	0.19
Patella			1		1	0.01
Tibia			10		10	0.08
Indeterminate tarsal			1		1	0.01
Calcaneus	1		3		4	0.03
Navicular-Cuboid		2			2	0.02
1 st , 2 nd , 3 rd cuneiform		1	7		8	0.07
Metatarsus (P)			5		15	0.13
Metatarsus (SH)			6			
Metatarsus (D)			3			
Metapodium (P)			10		35	0.30
Metapodium (SH)			17			
Metapodium (D)			8			
Phalanx (P)			15		38	0.32
Phalanx (SH)			2			
Phalanx (D)			21			
Long bone diaphysis			762	550	1312	11.12
Indeterminate			9	8857	8866	75.14
Total	58	5	2323	9413	11799	100