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CROSSING THE RIVER: THE DENTAL MORPHOLOGY OF CHALCOLITHIC POPULATIONS IN THE MIDDLE GUADIANA

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Crossing the river: the dental morphology of Chalcolithic populations in the Middle Guadiana

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Abstract

Dental morphological studies are based on the analysis of genetically controlled discrete traits, which are expressed on the morphology of teeth and bones of the oral cavity. Population studies at different geographical and chronological levels have demonstrated that frequency patterns of those traits differ in human populations. The similarities and differences in the distribution of those patterns can be statistically compared in order to calculate biological affinities of human populations.

Three human osteological samples were used in this study as proxies for dental variability of archaeological populations in the Middle Guadiana Valley. These series are chrono-culturally affiliated to the Chalcolithic (also referred to as Copper Age). Two of them were exhumed from tombs 1 (PDG1) and 2 (PDG2) in the Archaeological Complex of Perdigões, Reguengos de Monsaraz, Portugal. The third one comes from the tomb of Cerro de las Baterías, La Albuera, Extremadura, Spain. The human remains were excavated from collective burials in which most of the skeletonized elements were disarticulated. Anthropic and natural taphonomic alterations were limiting factors of the study. The main limitation introduced by taphonomy is the impossibility to identify craniomandibular compatibilities. Consequently, individual dentitions could not be isolated.

The main objectives of this research were: (I) to characterize the dental morphology of the samples; (II) to gather information on the biological affinities of these samples among themselves and to other series in comparative analyses at synchronic and diachronic levels; (III) to contribute to the resolution of their status in relation to major dental complexes; (IV) to identify possible exogenous contributions to the local phenetic profile; and (V) to provide useful data to future comparative studies on the dental morphology of local/regional populations.

The Arizona State University Dental Anthropology System (ASUDAS) was used to identify and evaluate almost all discrete traits used in the morphological analysis of the osteological series. The only trait not included in that method is a recently described variation for the human dentition, identified in the process of this study: Hypotrophic Roots of the Upper Central Incisors (HRUCI). This morphological variation is characterized by the occurrence of UI1 roots that are equal in length to or shorter than their respective crowns. In total, thirty two dental non-metric traits were employed in this analysis. Nine of those were registered on more than one type of tooth.

Simple descriptive statistics was used to calculate the frequency for each discrete trait and other data relevant to tooth morphology such as average tooth wear. Bivariate correlation (Kendall's *tau*-b) tests were used to evaluate the intra-observer error and inter-sample correlations. Principal Components Analysis (PCA) was used to calculate biological affinities of the samples among themselves and to other series published by different authors.

Results of the intra-observer error was based on two observations of the largest series. They indicate high precision for both non-dichotomized and dichotomized frequencies. Positive correlation among samples was stronger between PDG1 and PDG2 than between either of them and BT07. This result suggests that both samples from Perdigões were probably drawn from the same population or from biologically close related ones.

Average tooth wear in the three samples was low when compared to other series from geographically and chronologically similar contexts.

This dental morphological study on the three Chalcolithic series contributed to their inclusion within the Eurodont Dental Complex. They suggest a borderline position between the European and the North African expression of that dental complex. The European populations sampled in the Guadiana display North African influences in the distribution of some non-metric traits. These influences possibly result from genetic exchanges with North Africa in prehistoric times. Positioning of the samples here is compatible with the dental morphological cline in the expression of discrete traits between the Afridont and the Eurodont patterns.

PCA tests applied to the biological affinities of these populations to others indicate strong phenetic (and by proxy, genetic) similarity to the modern Portuguese population and to other Iberian archaeological populations. The Chalcolithic samples from PDG1, PDG2 and BT07 are biologically related to North Africans to a lesser extent. They share less phenetic similarities with prehistoric populations from the Italian Peninsula. Finally they seem to have little biological affinity with populations from eastern Mediterranean and North Europe.

Key words:

Dental anthropology; dental morphology; Prehistory; Chalcolithic; Eurodonty; Biological Affinities; Hypotrophic Roots of the Upper Central Incisors (HRUCI).

Resumo

Os estudos de morfologia dentária não métrica baseiam-se na análise de caracteres discretos geneticamente controlados expressos na forma dos dentes e dos ossos da cavidade oral. Estudos populacionais a várias escalas geográficas e cronológicas demonstram que diferentes populações humanas são caracterizadas por padrões de distribuição específicos para as frequências em que estes caracteres ocorrem. Estes padrões podem ser usados para calcular estatisticamente as afinidades biológicas entre as populações.

Três amostras osteológicas humanas foram analisadas para auferir sobre a variabilidade dentária de populações arqueológicas da região do Vale Médio do Rio Guadiana entre Espanha e Portugal. As três séries são crono-culturalmente atribuíveis ao Calcolítico (ou Idade do Cobre). As primeiras duas amostras provêm dos túmulos 1 (PDG1) e 2 (PDG2) do Complexo Arqueológico dos Perdigões, Reguengos de Monsaraz, Portugal. A terceira amostra foi exumada do túmulo de Cerro de las Baterías, La Albuera, Extremadura, Espanha. Os restos humanos estudados provém de contextos de inumação coletiva em que a maioria dos ossos estavam desarticulados. Alterações tafonómicas antrópicas e naturais foram fatores limitadores do estudo, impedindo inclusivamente a identificação de conexões crânio-mandibulares e consequentemente de dentições individuais.

Os objetivos principais deste trabalho foram: (I) caracterizar a morfologia dentária destas amostras; (II) obter informações sobre as afinidades biológicas entre estas amostras Calcolíticas e outras, ao nível sincrónico e diacrónico; (III) contribuir para a caracterização da relação entre as amostras estudadas e os complexos dentários macrorregionais; (IV) identificar possíveis contribuições exógenas ao perfil fenético local, e (V) fornecer dados úteis para futuros estudos comparativos da morfologia dentária de populações pré-históricas.

O Arizona State University Dental Anthropology System (ASUDAS) foi usado como metodologia de identificação e aferição dos caracteres discretos a serem usados na análise morfológica das populações estudadas. O único caracter discreto não constante nesta metodologia consiste numa variação morfológica recém-descrita para a dentição humana, identificada no curso deste trabalho: Raízes Hipotróficas do Incisivo Central Superior (Hypotrophic Roots of the Upper Central Incisors ou HRUCI). Esta alteração é caracterizada pela ocorrência de raízes com comprimento igual ou menor que o comprimento máximo da coroa em incisivos centrais superiores. Trinta e dois caracteres discretos dentários foram incluídos neste estudo. Nove destes caracteres foram aferidos em mais de um tipo de dente.

Estatística descritiva simples foi usada para a obtenção das frequências de cada caracter discreto, bem como para a obtenção de outros dados relevantes à morfologia dentária como a média do desgaste dentário. Testes de correlação bivariáveis (*tau*-b de Kendall) foram utilizados para avaliar o erro intra-observador e a correlação inter-amostra. A Análise de Componentes

Principais (PCA) foi aplicada para os cálculos de afinidades biológicas entre as amostras aqui estudadas e entre estas e outras publicadas por diversos autores.

A avaliação do erro intra-observador baseado na correlação entre duas observações da maior amostra osteológica resultou numa alta precisão tanto para frequências dicotomizadas quanto não dicotomizadas. A correlação positiva entre as amostras foi mais forte entre PDG1 e PDG2 do que entre ambas e BT07. Este resultado sugere que ambas as amostras exumadas nos Perdigões provavelmente provêm de uma mesma população ou de populações biologicamente muito próximas.

O desgaste dentário médio nas três amostras foi considerado baixo em comparação com outras séries geográfica e cronologicamente próximas.

O estudo morfológico das amostras contribuiu para o seu enquadramento dentro do padrão Eurodonte, evidenciado pela sua posição limítrofe entre a expressão Europeia deste complexo dentário e a expressão Norte-Africana do mesmo. As populações amostradas no Guadiana, apesar de geograficamente localizadas na Europa, apresentam influências Norte-Africanas na distribuição de frequências para alguns caracteres dentários. Estas influências possivelmente resultam de trocas genéticas com o Norte da África em períodos pré-históricos. O posicionamento das amostras aqui estudadas é compatível com a variação clinal morfológica na expressão de carateres discretos que ocorre entre os padrões Afridonte e o Eurodonte.

Os testes de PCA aplicados à afinidade biológica entre estas populações e diversas outras resultam em forte proximidade fenotípica (e indiretamente, genética) com a população portuguesa atual e com outras populações arqueológicas Ibéricas. Em menor grau, as amostras Calcolíticas relacionam-se biologicamente com populações arqueológicas Norte Africanas. Menor proximidade biológica é observável entre estas amostras e outras populações pré-históricas provenientes da Península Itálica. Por fim, as amostras Calcolíticas parecem ter pouca afinidade biológica com populações do Mediterrâneo oriental e do Norte da Europa.

Palavras chave:

Antropologia dentária; morfologia dentária; Pré-História; Calcolítico; Eurodontia; Afinidades Biológicas; Raízes Hipotróficas do Incisivo Central Superior (HRUCI).

Abbreviations:

AD – *Anno Domini*
aDNA – ancient DNA
BC – Before Christ
BKP - Breakpoint
BT07 – Tomb of Cerro de las Baterías
Cal. – Calibrated
Hg – Haplogroup
Kya – Thousands of years ago
LC – Lower Canine
LGM – Last Glacial Maximum
LI – Lower Incisor
LM – Lower Molar
LP – Lower Premolar
mtDNA – Mitochondrial DNA
SU – Stratigraphic unit
Sub-hg – Sub-haplogroup
UC – Upper Canine
UI – Upper Incisor
UM – Upper Molar
UP – Upper Premolar
PC – Principal Component
PCA – Principal Component Analysis
PDG – Perdigões Enclosure
PDG1 – Tomb 1 in Perdigões
PDG2 – Tomb 2 in Perdigões
Y-DNA – Y-chromosome DNA
Yrs – Years

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To Amanda Cunha Kachimareck

1. Introduction

1. Introduction

The following research deals with the dental morphology of three archaeological series of human remains chrono-culturally assigned to the Chalcolithic (also referred to as Copper Age) from the Guadiana River Basin in the Iberian Peninsula (see Chapter 2): tomb 1 (PDG1) and tomb 2 (PDG2) from Perdigões Archaeological Complex (Portugal), and the tomb of Cerro de las Baterías (BT07) (Spain). The Arizona State University Dental Anthropology System (ASUDAS, Turner *et al.*, 1991) is used to characterize the samples and to obtain data to be statistically compared to other populations from different regions and chrono-cultural contexts. Comparative data will be drawn from literature on the dental morphology of various samples representing diverse dental phenotypic patterns.

Comparative studies on discrete or non-metric dental morphology are based on two assumptions: (I) that the samples originating the data are representative of the population they derive from, and (II) that the phenetic expression of genetically controlled dental features they display provides an estimate of their genetic relatedness (Scott *et al.*, 1983; Scott and Turner, 1997; Irish, 1998a).

1.1. Research objectives

- To perform the dental morphological analysis of all oral/dental human remains from the three samples mentioned above, including all *ex situ* teeth;

- To characterize the dental morphology of the samples from three collective tombs from the Guadiana River Basin: tomb 1 (PDG1) and tomb 2 (PDG2) exhumed from the Archaeological complex of Perdigões (Reguengos de Monsaraz, Portugal), and the tomb of Cerro de las Baterías (La Albuera, Spain);

- To obtain information on the phenetic affinities of these Iberian Chalcolithic samples to others at both synchronic and diachronic level;

- To contribute to the resolution of the status of these samples (and consequently of the populations they stand for) in relation to the major dental complexes of the modern human dentition;

- To identify possible exogenous contributions to the phenetic profile of the samples;

- To provide useful data for future comparative studies on the dental morphology of prehistoric populations.

1.2. Structure of this dissertation

The main chapters in this dissertation follow the broad organization of scientific works of the kind.

The first chapter (Introduction) states the objectives of the work and provides information on dental variation and its use as sources of biological information on population studies. An introduction to the history of the study on Dental Morphology is also provided, as well as to the history of the ASUDAS method.

The second chapter provides the archaeological contextualization of the human remains analyzed here.

In the third chapter the materials and methods employed in this work are presented. Topics included in this chapter deal with the specificities of the human remains and the laboratorial treatment of the samples. A full list and descriptions of dental non-metric traits to be addressed are provided. The scoring procedures for each trait is detailed. Statistical methods and counting method employed are also presented in chapter 3.

The results of this PhD work are presented in chapter 4. These relate to the intra-observer error; asymmetry and trait correlations and; pre- and post-depositional alterations to the morphology of bones in the oral cavity and teeth that are pertinent to the study of non-metric variation. Major results of this work are also detailed in this chapter such as the Principal Component Analysis of biological affinities of the samples presented here as compared to other series of different chronologies and origins. The sub-chapter 4.4. (Summary data) reports ranked and dichotomized frequencies of all traits observed in the Chalcolithic Iberian samples of PDG1, PDG2 and BT07. This section provides the reader with comparative data to be used in future comparative population studies.

Chapter 5 delivers the discussion of results obtained during the course of this work. The author discusses the implication of bone exostoses on mandibles and maxillae to the present morphological study, as well as the possible functional inferences they might bear. An unexpected outcome of the present research, the proposal of a new discrete trait to the human dentition, is discussed. The morphological characterization of the samples and their position in relation to the Eurodont dental complex are also addressed in this chapter. Finally, intra-sample biological affinities, as well as biological affinities to other populations are discussed.

Chapter 6 addresses conclusions on the information gathered here and presents future perspectives of the work in terms of methodological standardization and further works to be done on the morphology of regional prehistoric populations.

1.3. On Teeth and Dental Variation

Each tooth is divided into two major components: crowns and roots. The crowns are projected into the oral cavity and thus exposed to the environment. The roots are embedded into the jaws (Hillson, 1996).

Crowns consist of smaller elements (cusps), sometimes augmented by the occurrence of occlusal and marginal ridges. Incisors are spatulate teeth while canines are single-cusped. Premolars are usually bi-cusped and molars multi-cusped (Scott and Turner, 1997). Other structures composing the topography of a tooth may include tubercles and cusplets, mamelons (on incisors), furrows and pits (Hillson, 1996).

The surfaces of teeth are named according to their position and uses. Canines and incisors have four surfaces: labial, lingual or palatal (for the upper teeth), mesial and distal, and an incisal ridge. Posterior teeth have five surfaces: buccal, lingual or palatal (for the upper teeth), occlusal, mesial and distal (Hillson, 1996; Nelson and Ash, 2012).

Roots are implanted in the alveoli interacting with the alveolar bone of the mandible or maxilla through the periodontal ligament. The anterior teeth and lower premolars are normatively single-rooted. The upper premolars tend to be single rooted although the first upper premolar (UP1) may predominantly be double-rooted in some human populations. Lower molars typically have two roots, while the upper ones have three (Hillson, 1996; Scott and Turner, 1997).

The boundary between the crown (*corona* in Latin) and root (*radix* in Latin) is named *cervix* (cervical margin or ‘neck’). Although the Latin terms for the first two are not normally employed, the latter maintains in anatomical literature. The cement-enamel junction (CEJ) marks the limits of crowns and roots. Although visible in loose teeth and on skeletonized human remains, CEJ is normatively covered by the gingival tissue in most living individuals (Hillson, 1996; Nelson and Ash, 2012).

In cross section, the innermost part of a tooth is occupied by the pulp chamber and root canal (in single-rooted teeth), or by the pulp chamber, pulp horns and root canals (in multi-radicular teeth). An apical *foramen* on each root allows the living part of the tooth to be vascularized. It also allows the passage of nerves into the pulp canal and chamber. Most of the mass composing the structure of a tooth is made of the dentine that surrounds the inner structure of the pulp. The dentine is covered by a thin layer of cement on the root portion and by enamel on the crown. The cement interacts with the alveolar bone through the periodontal ligament (Nelson and Ash, 2012).

While the pulp is highly vascularized and innervated, the dentine acts as insulating material protecting the fragile inner tooth structure. The enamel is mainly inorganic and composed by apatite crystals (hydroxyapatite and fluorapatite) (Hillson, 1996; Nelson and Ash, 2012). Hydroxyapatite, a calcium phosphate mineral, is also referred to as 'bioapatite' (Balasse, 2002).

The dentine contains 18% of organic material (collagen) and the cement 21% of that material. Because of its organic content, varied histological layers, function and interaction with the periodontal ligament and alveolar bone, the cement may suffer morphological changes when submitted to trauma or disease. Cement reacts by resorption or remodeling. Resorption may shorten roots, remodeling implies the deposition of cement tissue on the outer layers of the root. This deposition may result in hypercementosis in more severe cases (Hillson, 1996; Brezniak, 2002; Consolaro *et al.*, 2012; Kohli *et al.*, 2011; 2013).

When addressed by anatomists, teeth are approached under a normative view: form and number of teeth are described as a 'blueprint' in anatomical textbooks (Scott and Turner, 1997: 3). This blueprint establishes a dental formula representing the denomination and number of teeth characterizing a species. The denomination of each tooth is represented by its initial letter (I=Incisors; C=Canine; P=Premolars and M=Molars) followed by a horizontal line. The number of each type of tooth is placed above that line for the upper jaw and below the line for the lower one. The dental *formulae* for the deciduous and permanent dentition is (Nelson and Ash, 2012):

Deciduous dentition – $\mathrm{I}\,\frac{2}{2}\,\mathrm{C}\,\frac{1}{1}\,\mathrm{M}\,\frac{3}{3}$

Permanent dentition - $\mathrm{I}\,\frac{2}{2}\,\mathrm{C}\,\frac{1}{1}\,\mathrm{P}\,\frac{2}{2}\,\mathrm{M}\,\frac{3}{3}$

Due to its high mineral content, teeth are the hardest and usually the best preserved elements of the human skeleton in archaeological and forensic contexts (Hillson, 2005; Scott, 2008; Schmidt, 2008) and sometimes they are the only part of the skeleton preserved of human remains under extreme taphonomical conditions (Scott and Turner, 1997; Dupras *et al.*, 2006).

However teeth are subjected to wear from the time of eruption (Hillson, 1996 and 2005). They wear through attrition by the contact with opposing teeth and interproximally by the contact with neighboring teeth in the dental arch; through abrasion by the contact with food and soft tissues of the cheek, tongue and lips that may transport abrasive elements, or through erosion when exposed to acid elements in food, in vomit and less frequently acid airborne substances (Hillson, 1996 and 2005; Soames and Southam 2005; Kaidonis, 2008). Tooth wear may be minimal and involve only the obliteration of superficial microscopic structures of the enamel such as Tomes' process pits and perikymata in recently erupted teeth. Continuous exposure of surfaces to environmental agents mentioned above will cause progressive loss of matter (Hillson, 1996). This progressive process obliterates surface details on the enamel and it may successively affect the dentine layers and deeper structures within the tooth.

1.3.1. Teeth as Sources of Cultural and Biological Information

Human teeth are important information resources on the living and on the dead. They are easily observable both *in vivo* and in human remains from archaeological and forensic contexts and provide a multiplicity of data on biological and cultural aspects (Scott and Turner, 1997; Schmidt, 2008).

Teeth interact with the environment since they erupt besides being visible and accessible. Due to those characteristic, they can intentionally, incidentally or accidentally be modified as a result of human behavior (Scott and Turner, 1997).

Intentional modification of teeth is a worldwide phenomenon occurring in different cultural groups throughout the Prehistory and History of modern humans. Techniques include (but are not restricted to) pigmentation, ablation, filing, drilling, polishing and inlaying teeth with metal elements, pearls and gems (Saville, 1913; Tayles, 1996; Scott and Turner, 1997; Arcini, 2005; Williams and White, 2006; Finucane *et al.*, 2008; Lyrio *et al.*, 2011). Evidence of intentional modification of teeth provides cultural information on levels that range from the aesthetics and imagery of a population to cultural affiliation/relatedness among groups. It might be motivated by aesthetics, ritual or religious reasons and usually affects the anterior (more exposed) dentition (Scott and Turner, 1997). Nowadays the demand for cosmetic dental procedures drives a very lucrative industry.

Non-intentional but still related to body modifications, the use of labrets might lead to modifications on the form of teeth through abrasion. It might also favor pathological conditions and ultimately tooth loss (Torres-Rouf, 2003). Evidence of this kind of morphological alteration might be culturally as informative as intentional tooth modification.

Unlike other human skeletal structures, the exposed tooth crowns and mainly their enamel outer layer do not undergo remodeling once a tooth suffers loss of matter (Hillson, 1996; 2005). The marks left on tooth surface might be informative on their use for dietary mastication (Turner and Machado, 1983; Irish and Turner, 1997; Kullmer *et al.*, 2009; Machicek and Zubova, 2012) and for the use of teeth as 'tools' or as a third hand (Hylander, 1977). On that last function, several authors have used information recorded on the damaged surfaces of teeth and on the stress-modified structure of the bones in the oral cavity to infer cultural information on archaeological populations (see for instance Molnar, 1971; 1972; Molleson, 1994; Bonfiglioli *et al.*, 2004; Clement *et al.*, 2008; Molnar, 2008; Scott and Jolie, 2008; Molnar, 2011, Marado *et al,* 2014 among others). Work-induced modifications to the structure of teeth include fragmentation (chipping) of the enamel and dentine and hypercementosis on the roots. Work induced alterations on the structure of the mandibular and maxillary bone, usually involve the formation of *tori* (Halffmann, *et al.*, 1992; Hasset, 2006).

Teeth are also informative on the health status at both the individual or population level on extant and extinct populations. They can also provide parameters to characterize *in vivo* individuals, as well as humans remains from archaeological and forensic contexts regarding diet, mobility, age (or age at death), sex and biological affinities (Hillson, 1996; Scott and Turner, 1997; White *et al*., 2012).

Discrimination of sex based on metric characteristics of teeth has been proposed for both juvenile and adult individuals based on the premise that dimorphic differences may be expressed on the size of teeth (Black III, 1978; Galera and Cunha, 1993).

Age estimation of non-adults and young adults is possible though a number of methodologies based on the calcification and eruption of teeth (see for instance, Smith, 1991; Ubelaker, 1999; AlQahtani *et al.,* 2010). Age estimation of immature individuals is a current procedure when analyzing archaeological and forensic cases. Dental maturation proceeds at a chronological rate and is less influenced by nutritional and environmental insults. It reflects more stable estimations of age than other body structures, although there might be population differences in the attainment of stages of tooth maturation (Liversidge, 2008). Estimation of age at death for adult individuals based on teeth has also been proposed (see for instance, Constandse-Westermann, 1997; Gilmore and Grote, 2012).

Analyses of stable isotopes in bone and teeth tissues provide information on the diet and mobility of extant and extinct fauna (hominin included) (Sponheimer *et al.*, 2007). Enamel bioapatite has proven to be particularly useful once it is less susceptible to diagenetic alteration than bone or dentine (Balasse, 2002). Isotopic analyses of strontium ratios provide information on the geographic area the individual lived in, since strontium is incorporated into the organism from the water that plants and animals consume. Carbon and nitrogen isotopic ratios help reconstruct past diet because of the differential fractionation, between certain types of plant groups, of the carbon dioxide in the atmosphere during photosynthesis and of nitrogen during its fixation or absorption (Tykot, 2004).

Isotopic analyses on bone are performed on its collagen content and reflect the diet of the individual over his last years of life, since collagen is constantly being resorbed and replenished. The same analyses on tooth enamel reflect diet during the years of crown formation. Deciduous teeth begin to be formed *in utero* and the formation of permanent ones extends into adolescence. Isotopic analyses of the enamel can answer questions on changes in the diet of individuals from the same group as they progress from weaning to childhood and into late adolescence. Different teeth from the same individual might also help identify changes in diet in different periods of his life. The comparison of tooth and bone isotopic content from the same adult individual helps identify dietary change and mobility, once teeth reflect his juvenile diet and bone collagen his adult one (Balasse, 2002; Tykot, 2004).

Forensic odontology, a sub-field of forensic osteology, deals with information provided by the teeth in forensic contexts related to (I) violence and abuse (Lessig *et al.,* 2006; Alempijevic, *et al.,* 2007); (II) crimes against the human life involving single individuals or mass casualties (*i.e.*, those related to large scale disasters, genocide and wars) and, (III) human trafficking (Scheuer, 2002; Nuzzolese, 2014).

The use of dental records is a major resource in the process of identification of victims, although it may be limited or hindered if dental records are not available, if the victims are edentulous or for those with no dentistry intervention (Scheuer, 2002; Adams, 2003; Djuric, 2004).

Even when the identity of the victim cannot be established in forensic contexts, a biological profile might be constructed based on dental information helping narrow down the possibilities. Teeth might provide information on the age at death of victims, on their ancestry and dental idiosyncrasies such as: developmental and pathological conditions; acquired traits (traumata, unique patterns of wear, evidence of extra-masticatory use of teeth) and cultural practices (cosmetics, restorations and prosthetics) (Schmidt, 2008).

In living victims of human trafficking, the estimation of age might be required to determine if the victim is a juvenile individual or an adult (Alempijevic, *et al.,* 2007) and forensic medical examiners might resort to the patterns of eruption of teeth to determine that. Although teeth are not very dimorphic, DNA extracted from the pulp may help sexing of the victims even in contexts where human remains are extremely altered (Schmidt, 2008).

On the other hand, forensic odontology might help identify aggressors in cases of violence and abuse involving bites via the identification of bite marks in forensic cases (Lessig *et al.,* 2006).

Because of the physical properties of teeth (Hillson, 1996) their morphology is less sensitive to environmental factors than the morphology of cranial and post-cranial elements of the skeleton and thus it provides valuable data on genetically controlled morphological variation (Jackes *et al.*, 2001).

Population studies based on the dental morphology assume that phenotypic dental patterns reflect genetic variation, hence phenetic similarity approximates or is an estimate of genetic relatedness (Irish and Konigsberg, 2007), providing information on evolution and human dispersals from its cradle in Africa through other continents (Irish, 1998b; Irish and Guatelli-Steinberg, 2003; Irish, 2013), on population history and biological affinities (Scott and Turner, 1997).

Dental morphology deals with the study of discrete (or non-metric) traits on the human dentition and bones of the oral cavity. These traits are variations in the morphology (polymorphisms) of different aspects of both bones and teeth (crown and roots). They may be observed in different *loci* on the morphology of teeth and of the bones composing the oral cavity (Scott, 2008).

There are two types of morphological variations in the human dentition. The first one involves major deviations and includes: (I) deviations from the dental formula described above as some individuals present supernumerary (and more frequently congenitally missing) teeth; (II) fused (twinned) teeth; (III) conical lateral incisors and, (IV) 3-cusped upper premolars (Scott and Turner, 1997).

The second type of variations is more subtle and encompasses crown and root polymorphisms. Crown traits include alterations on the crown lobes, accessory occlusal or marginal ridges, cingular derivatives (such as *tuberculum* projections, Figure 1.3.1), occlusal tubercles, alterations in the extension of the cervical enamel line, supernumerary cusps and accessory ridges. Root traits include alterations in the form and separation of root cones (such as Tomes's roots in its range of degrees), fusion of radicular structures or presence of supernumerary ones. Traits affecting the bone structure of the mandible and maxilla, include those acting on the orientation of tooth alveoli (such as winging), the presence of epigenetic *tori*, supernumerary *foramina*, and other alterations on either the maxillary or mandibular bone (such as the presence of mylohyoid bridges on the posterior aspect of the mandible) (Hauser and De Stefano, 1989; Scott and Turner, 1997).

Figure 1.3.1 – *Tuberculum* projections on the lingual aspect of a left and right UI1 (compatible with a same individual) and a right UI1 displaying the no sign of that variation. All teeth are from the Neolithic levels in the burial cave of Cadaval (Tomar, Portugal) (Cunha and Silva, 2013). Inventory numbers (from left to right): CDV/Sup.SC160, CDV/N26-SC195 and CDV/M27-69. Scale in half centimeters.

Dental nonmetric traits might be mass-additive when trait expression implies the formation of dental tissue (such as dental ridges in shoveling), of supernumerary structures (such as supernumerary roots in LC) or of supernumerary teeth themselves (hyperdontia). On the opposite end, polymorphism might be expressed in the simplification or reduction of structures (such as the different degrees of peg-shaped teeth) or even the complete absence of one or more teeth (hypodontia) (Scott, 1997; Scott and Turner, 1997).

Dental polymorphisms tend to affect different members of a tooth field or tooth class (*i.e.,* Carabelli may be expressed in all upper molars) (Turner *et al.,* 1997; Scott, 2008). However, within each field one tooth is usually more stable in terms of morphology or size and displays less tendency to be subjected to *agenesis*. That tooth is usually the most mesial one in that specific class, except for the lower incisor field in which the lateral tooth is more morphologically predictable (Townsend and Brown, 1981). Studies of dental discrete traits usually focus on the more stable tooth in a field, named 'polar' or 'key' tooth, in order to assess morphological information. Focusing specifically on a key tooth allows the observer to avoid inter-field correlations (which can be caused by assessing the same trait twice in the same individual) and to collect data on the tooth that is more prone to genetic control within that district. However, there are exceptions to this targeting strategy, such as the use of UI2 to assess the *tuberculum dentale* (despite the high polymorphism this tooth presents) and the *hypocone*, usually assessed on the UM2, once its frequency for UM1 is too close to 100% in most populations. Less frequently, some traits might be expressed beyond field limits, such as the occurrence of *tuberculum dentale* in all the upper anterior dentition, affecting both the incisor and canine field (Scott, 1997b; Scott and Turner, 1997).

1.4. Teeth and their application in morphological studies of human variation

1.4.1. Genetics and Inheritance of non-metric traits

Teeth play an important role in the nourishment, hence in the survival, health and longevity of individuals. Such crucial structures in the human body tend to have its development highly controlled by multiple genes in different *loci* (Townsend and Brown, 1981; Scott and Turner 1997).

The evolution of mammalian teeth seems to be slow and conservative, probably neutral to natural selection and not affected by maternal influence *in utero*, once the majority of the development of human dentition (particularly the permanent teeth) takes place *post-partum*. Besides the slow evolution of dental traits, other factors such as their low sexual dimorphism and low level of inter-correlation favors their use in studies of biological distance (Tyrrell, 2000:294-296).

Although discrete traits do not provide adaptive advantages to the individuals either under or beyond the threshold of presence, tooth shape and size and their pattern of inheritance follow the general high genetic control to which tooth development is subjected (Townsend and Brown, 1981; Scott and Turner 1997; Scott, 2008) and is likely to be controlled by a small and stable portion of the genome (Tyrrell, 2000).

Discrete traits generally affect all the teeth in a tooth field. The concept of field model, derived from the studies of mammalian dentition, implies that the different categories of teeth are subjected to a primordial blueprint influencing the final form and size of teeth. It proposes that within a tooth class, a key tooth, usually the first to be formed, is more stable in shape and size. The farther away from the odontogenic field controlling center a tooth is, the more irregular its shape and size will be (Townsend and Brown, 1981).

The genetic basis and heritability of human skeletal discrete traits have been addressed by three major areas of investigation: distance matrix concordance; experimental animal data and, twin, familial and pedigree studies. All those are based on indirect evidence (Tyrrell, 2000). Although that tendency may be changing as new works begin dealing with the ontogeny and genetics of specific traits (see for instance, Kimura *et al.*, 2009).

The smile is a unique facial expression of primates (Pemberton *et al.,* 2005). Throughout human evolution the display of a complete set of teeth has been regarded as a sign of health and reproductive fitness, besides its functional importance in mastication and nourishment (Scott and Turner, 1997; Pemberton *et al.,* 2005). Dental non-metric variations have implications on Dentistry (Alt and Türp, 1998; Hillson, 2005) once some of those will affect the aesthetics or dental health of individuals. Dental medical studies that approach the genetics of traits of clinical interest (such as in Arte, 2001; Apajalahti, 2004; Pemberton *et al.,* 2005 among others) have been recently published as dentistry gains momentum not only as a scientific field in the health sciences, but also as a means to attain the western ideal of beauty (Scott and Turner, 1997).

Dental morphologic traits were, at first, believed to follow simple modes of inheritance (Scott and Turner 1997). However in the second half of the 20th century, the *quasi-continuous* polygenic model was proposed to explain the variability of most traits (Nichol, 1989; Scott and Turner 1997; Harris, 2008). Although different patterns of inheritance, from simple Mendelian to oligogenic, might be involved (Hillson, 2005), Nichol (1989) defends that the polygenic and major gene pattern best describe the inheritance of dental non-metric traits in humans. The polygenic nature of trait inheritance and the existence of significant genetic component in the expression of some traits are supported by twin studies (Scott, 1974; Scott and Potter, 1984; Townsend and Brown, 1981; Tyrrell, 2000).

The genotypic distribution subjacent to trait expression is continuous and involves multiple loci and/or alleles (Scott, 1997: 180). However, there is an underlying scale (absence) and a visible scale (presence) associated with its distribution, separated by a physiological threshold, conforming a model of *quasi-continuous* variation (Scott, 2008).

Dental phenotypes are inter-relatedly influenced by a combination of genetic, environmental and epigenetic factors (Townsend *et al.*, 2012). However, population studies have shown that dental discrete traits are not significantly influenced by environmental factors (Scott and Turner, 1997). Variations of trait frequency of discrete traits among different populations are most likely to occur due to gene flow (Scott and Turner 1997; Willermet and Edgar, 2005).

Studies on biological distance and/or affinity work on the bases that dental phenotypic variation reflects genotypic intra- or inter-population variability (Lasker, 1950; Scott and Turner, 1997). However, the comparison of dental non-metric traits and genetic variability in archaeological populations is rare. A recent intra-cemetery study (Ricaut *et al.*, 2010) on an archaeological population has tested the applicability of dental discrete traits when compared against genetic analyses. Working on the human remains from the Egyin Gol necropolis, Ricaut and co-authors (2010) used 63 intra-osseous (cranial, mandibular and infracranial) and dental traits observed on 66 individuals dated from the 3rd century BC to the 2nd century AD. Archaeological data on the sample indicated that it was composed by high rank individuals (hence a sub-sample) of the Xiongnu tribe. Three areas where identified in the site and one of them (area C) may have corresponded to Turkish gene flow into that group. Comparative genetic data available for that sample included genetic data for bi-parental [nine autosomal short-tandem repeats (STRs) for 49 individuals], paternal (eight Y-chromosome STRs for 27 individuals), and maternal [first hypervariable region (HVS-I) of the mitochondrial DNA (mtDNA) control region for 46 individuals]. The correlation between non-metric and genetic markers was statistically significant at the $P \leq 0.10$ level of confidence and at the $P \leq 0.05$ level for autosomal STR, in accordance with the autosomal genetic determinism of nonmetric traits. Phenotypic and genetic distance matrixes produced in that study “supported broadly the same conclusions” (Ricaut *et al.*, 2010). Although non-metric traits offer lower efficacy in detecting close relationships genetically identified at a genealogical level, it is an effective method at an overall assessment of intra-group (intra-cemetery) level detecting familial groupings, even considering the small size and homogeneity of the sample.

The work by Ricaut and co-authors (2010) provides genetic evidence that dental non-metric traits are valid tools in the investigation of population affinities in archaeological populations. In prehistoric contexts where the large number of individuals, the taphonomic specificities (preservation of DNA being only one of them) and the difficulties imposed by commingling of remains from multiple individuals (Silva, 2002) are restrictive to the application of genetic analyses to a statistically significant number of individuals, the study of dental non-metric traits may be an efficient alternative approach.

1.4.2. Dental morphology – history of the study and its application on the understanding the dispersal of human groups

Dental Anthropology is “the study of people (and their close relatives) from the evidence provided by their teeth” (Hillson, 1996:1). It is a sub-field of Physical/Biological Anthropology that encompasses finer levels of specialization, within which lies the area of dental morphological studies (Scott, 1997; Scott and Turner, 1997). The observation and description of variations in the form of teeth began being published in the 1800’s by anatomists and dentists such as Georg von Carabelli and C. S. Tomes, although the study of cranial intra-osseous discrete traits seem to predate those by over 100 years. Kerkring seems to have been the first to describe those variations (as ‘anomalies’) by 1670 (Silva, 2002).

The main purpose of the first anatomical studies on non-metric variation was the description of a norm and the occasional deviation to that (Hillson, 1996; Scott and Turner, 1997). The application of studies on discrete traits as indicators of genetic variability and its *quasi-continuous* nature would only be postulated in the mid-20th century with the works by Grüneberg and Lasker (Lasker, 1950; Scott and Turner, 1997; Silva, 2002). Although topics related to Dental Anthropology were addressed by those first works, the expression ‘Dental Anthropology’ as referring to this sub-field would be coined in 1958 (Scott and Turner, 2008a).

In 1920 Hrdlička laid the foundations for later approaches to non-metric traits when he recognized the existence of grades of expression for one trait (shoveling) and the need for the use of a ranked scale to measure those grades. The existing methods of register considered only presence/absence of variation regardless of the differences in the grade expression some traits present (Scott and Turner, 1997). Hrdlička’s background in medicine and profound interest and practice in anthropometrics (Schultz, 1944) was useful in rationalizing that ranks were the most appropriate way to describe a trait whose range would not be limited to a binary score system. His approach to the matter led to the development of ranked scales employed to assess non-metric dental traits and would be taken a step further a decade later with the works of A. A. Dahlberg (Scott and Turner, 2008a).

During the 19th century and for much of the 20th century the description and study of morphological features on the human skeleton aimed at distinguishing the ‘races’ of mankind. Most early works were dedicated to easily observed features such as skin color, body proportions and facial features. Craniometrical studies also began gaining *momentum* in the turn of the century, but dental traits were hardly ever dealt with. The influence of racial studies would be noticeable in the Gregory’s ‘primitive’ and ‘civilized’ dental morphological traits and in important works that attempted to define dentition patterns for human populations such as T. D. Campbell’s treatise on Australian Aborigines or J. C. M. Shaw’s on South African Bantus

(Scott and Turner, 1997; 2008a). Following this line, many publications came out in the 1920's and 1930's dealing with both root and crown traits as expressions of variability of human anatomy in specific populations: Hawaiians, Finns, Bushmen, Japanese and American Indians and their specificities in dental morphology were dealt with by different authors (Scott and Turner, 1997).

The 1940's and particularly the 1950's would bring more interest to the study of Dental Morphology in that, besides further developments on the study of comparative morphological variation, issues such as evolution, genetics and morphogenesis of teeth were addressed to by different authors (Scott and Turner, 1997; 2008a). In 1950, Gabriel W. Lasker suggested that, besides other inheritable attributes of teeth (such as their color, density, histology and pathology), the morphological features expressed on them and on the jaws had relevance for racial and evolutionary studies of man (Lasker, 1950; Scott and Turner, 1997; 2008a). Besides the genetic influence on the form of teeth, they were particularly important for the study of evolution given their durability in the fossil record in opposition to other body tissues (Lasker, 1950). The need for comparative family, twin and population studies is also suggested by Lasker. These research lines within tooth morphology would be widely explored in the second half of the 20th century.

A. A. Dahlberg and P. O. Pedersen were fundamental figures in Dental Anthropology not only through their works on different populations, but also through their efforts to promote the exchange of ideas from different professionals dedicated to morphological studies in different countries. It is the collective contributions of these authors and others such as C. F. A. Moorrees, K. Hanihara, B. Kraus, G. Lasker, H. Brabant among others that would set in motion the scientific bases for modern Dental Anthropology (Scott and Turner, 1997; 2008a).

In 1945 Dahlberg applies the concept of dental field to the human dentition dividing teeth into eight districts corresponding to the four kinds of teeth (or morphogenetic fields) in both dental arches: Incisors (I), Canines (C), Premolars (P) and Molars (M). The expression of a discrete trait in one tooth of a given district would be related developmentally to its expression in other members of the same field (Scott, 1977a; 1977b; Townsend and Brown, 1981; Scott, 1997; 2008).

As part of this mid-century revolution in the field, in 1956, Dahlberg devised a set of four standardized reference plaques to help observations of some crown traits of the human dentition: shoveling (based on the four-rank classification by Hrdlička), Carabelli's trait, *hypocone* and *protostylid* (Scott and Turner, 1997; 2008a).

Dahlberg's work would impact the study of Dental Anthropology through one of the many interests of a giant in the field: Christy G. Turner II. Fundamentally he was (in his own words) "an empiricist and an evolutionist" (Turner, 2013: 16), interested in Dental Anthropology and on the answers this field had for questions related to biological affinities, Prehistory, population History, evolution, peopling of the American Continent and cultural aspects inferred from the teeth or the evidence of their use (ranging from prehistoric cannibalism to the use of teeth as tools) (Turner and Machado, 1983; Turner, 1985; 1989, 1990; Irish and Turner, 1997; Turner and Turner, 1999; Turner, 2013; Turner *et al.*, 2013, among many).

Turner was not only the most prominent anthropologist in the field of Dental Morphology in the second half of the 20th century, he was also responsible for tutoring a number of students, some of which would become highly influential scientists in the area such as G. Richard Scott, Joel D. Irish, Christian Nichol, Shara E. Bailey and Edward F. Harris, among others. His partnership with K. Hanihara and other Japanese scholars helped integrate Western and Eastern Schools into the international anthropological debate. Among his many contributions to the study of mankind, his field work all over the world and his study of over 30,000 individuals would help understand human dispersal from Africa to all continents (Turner, 1990; 2013; Scott and Turner, 1997; 2008a; Turner, 2013).

Inferences on population history based on Phenetics require that these phenotypic similarities be based on variables under significant genetic control (Scott and Turner, 1997). From the 1960's on, dental genetics, affinity analysis, trait correlation and statistics applied to them become topics of increasing debate in scientific publications (Buikstra, *et al.,* 1990; Walker, 1997; Scott and Turner, 2008a). Racial studies and trait descriptions which were a frequent topic in the first half of the 20th century decrease (Buikstra, *et al.,* 1990). From the late 1980's Dental Morphology becomes a popular area of interest (along with Linguistics and Archaeology) greatly due to Turner's work focusing the human dispersal through Asia and the peopling of the American Continent (Turner, 1985; 1989; 1990; Scott and Turner, 1997; Turner, 2013; Scott and Turner, 2008a).

Despite using terminology previously employed in racial classifications (such as 'Mongoloid' or 'Caucasoid'), the dental morphological discussion implies only an "organizing principle to characterize biological variability" in that choice of words (Scott and Turner, 1997:168). There is no intention of expressing any further meaning to the terms than the dental phenotypic patterns expressed on teeth of specific populations. Under the biological perspective embodied by Anthropological studies nowadays, there is no scientific support or justification to postulate the existence of different human races based on phenotypic variability of the human skeleton (Cunha, 1997).

Dental Morphology was decisive in understanding of human dispersal from Africa through Europe, Asia, Oceania and the Americas (Scott and Turner, 1997).

The obvious phenotypic similarities among different populations in Asia have been recognized by naturalists since the 18th century and by anthropologists in the later centuries. This lead to the definition of a Mongoloid dental complex characterized by high frequencies of shovel-shaped incisors, deflecting wrinkles, *metaconules*, *protostylids* and *metaconulid* (Hanihara, 1967; Turner, 1990; Scott and Turner, 1997). Based on the morphological variability among populations from South and North East Asia and the mongoloid dentition of indigenous American groups, Turner (1990) recognized a dichotomy within the Mongoloid complex encompassing all these regions. He proposed the existence of two dental patterns in East Asia: the Sundadont and the Sinodont dental complexes.

Comparing recent and prehistoric samples, Turner (1989; 1990) was able to propose that the Sundadont dentition would be the oldest dental complex in the region. Around 100,000-90,000 BP, the first human groups colonizing the Sundaland (dry land formed by the Sunda continental shelf now submerged) displayed an archaic dental complex, Proto-Sundadont. The locally evolved Sundadont dentition spread through the Paleolithic Sundaland, a continental shelf now submerged that connected several islands of Southeast Asia.

Probably the first populations to drift from this root were Paleolithic groups migrating to Australian through sea between 60,000-40,000 BP. This separation would render native Australians apart from all other human groups helping their dental morphology derive into the Australo-Melanesian set of morphological features characterizing the Australian, Tasmanian and New Guinean native population nowadays (Turner, 1990; Scott and Turner, 1997).

Originally Sundadont populations occupied as far North as Japan, part of the continental South Asia, reaching Australia, whose native populations' dental morphology is more closely related to those than to Sinodonts. Turner's work suggests that the latter dental complex evolved out of the Sundadont (Turner, 1990; Scott and Turner, 1997; 2008a).

Sinodont populations would occupy regions formerly inhabited by Sundadonts, replacing them (such as what happened in most of Japan) or mixing with them in others such as in the South of mainland Asia (Turner, 1990) and reaching as far as the American Continent as migrating human groups occupied the lands beyond the Strait of Bering (Turner, 1985).

When compared to populations from other regions, both Sinodonts and Sundadonts present high frequencies of some traits (UI1 winging, UI1 shoveling, UM1 enamel extensions and LM1 deflecting wrinkle) and very low ones for others (UC Bushmen canines and LM2 Y-groove pattern) (Irish, 1998a). However when Sundadonts and Sinodonts are compared, they differ in frequencies of key dental traits which have been proven to present statistically significant mean differences: UI1 shoveling; UI1 double shoveling; single rooted UP1; UM1 enamel extensions; peg, reduced or congenitally missing UM3 (UM3 peg/missing); deflecting wrinkle; 3-rooted LM1; 4-cusped LM1. Paired comparison showed that UI1 shoveling, UI1 double shoveling, UM1 enamel extensions, UM3 peg/missing, deflecting wrinkle, 3-rooted LM1, are more frequent in Sinodonts than in Sundadonts. Sundadonts on the other hand present higher frequencies of 4-cusped LM1. Although both complexes present similar frequencies of single rooted UP1 over 50%, Sinodont populations generally display higher numbers (Turner, 1990).

Turner's contribution to the understanding of human dental morphology has been decisive. In his career at the Arizona State University, he has also influenced some of the most important dental anthropologists who are his former students (*i.e.,* Joel D. Irish, Richard Scott, Edward Harris, Shara Bailey, among many).

Since the 1970's Richard Scott has been responsible for important contributions to the study of dental morphology and population variation. His production both solo and in collaboration with Turner and other authors helped shape the present day scenario in this scientific area.

Aspects of hereditability of discrete traits were addressed to by Scott and contributors on family and twin studies (*i.e.,* Scott and Potter, 1984), so have trait correlations (Scott, 1977b; 1977c; 1978; 1979), dimorphism, association and population variation (Scott, 1977a, 1980; Lee and Scott, 2011) and the use of teeth as tools by archaeological populations (Scott and Jolie, 2008; Scott and Winn, 2011). Recently, Scott and Irish have collaborated directly with researchers of the University of Coimbra, leading to the proposal of a new discrete dental trait (Cunha *et al.,* 2012) and on studies related to the study of morphological traits in Prehistoric samples (Jackes *et al.,* 2001; Cunha *et al.*, in preparation) and on the use of teeth as tools in Portuguese samples (Marado *et al.,* 2014). However Scott's most important contribution to the field might be his effort (solo or in collaboration with Turner and others) to inform and educate (see: Scott and Turner 1988; Scott, 1997; 2008a; Scott, 2008). Scott and Turner's 1997 "Dental Anthropology of Modern Human Teeth" is a mandatory manual for students and reference material for anthropologists, dentists and other professionals interested in tooth morphology. This publication helped characterize the dental morphology for worldwide populations joining previous data to new information collected by Christy Turner, Richard Scott and Joel D. Irish. It allows the morphological comparison of populations to reference groups characterizing the dentition in worldwide regions. Once data collection follows a systematized process under detailed methodology (ASUDAS, see below), inter-observer and interpretation errors can be diminished (Turner *et al.*, 1991; Scott and Turner, 1997).

Scott has dedicated much of his effort to the study of Amerindians (*i.e.* in Scott and Dahlberg, 1982; Scott *et al.,* 1983; Scott, 1992; Scott and Turner, 2006; Delgado-Burbano *et al.*, 2010, among others). In time his interest for American Arctic Native populations was extended to archaeological populations of foreign origin such as Norse Greenlanders (Scott and Alexandersen, 1992; Scott and Jolie, 2008, among others) and later to the dentition of Western Eurasians.

In 1982 Mayhall and contributors defined the high- and low-frequency nonmetric traits for the Caucasoid Dental Complex working on a sample from Canada, although the term

'Caucasoid' had been previously used in morphological studies (Hanihara, 1967). Mayhall and co-authors (1982) dealt with a very specific sample of a population characterized by admixture from diverse European groups. As frequently repeated about European dentition, those authors' characterization of the Caucasoid dentition is based more on the absence of traits (namely of shoveling on the incisors, premolar occlusal tubercles, *protostylid*, LM1 C6 and LM1C7). Only Carabelli's trait and bilateral counter-winging are listed as frequent traits.

Building on his long research on Artic peoples and Northern Europeans (besides more recent research on Iberia), Scott has recently proposed the existence of another major human dental complex. In keeping with Turner's Sinodonty and Sundadonty that characterize Asian and Asian-derived populations, Scott and co-authors (Scott and Dorio, 2010; Scott *et al.,* 2013) propose the existence of the Western Eurasian Dental Morphological Variation (Eurodont).

Eurodont populations are characterized by having low frequencies of specific traits: UI1 winging and Shoveling; Bushmen canine; LM2 Y groove pattern; UM1 dental enamel extensions, LM1 supernumerary root, deflecting wrinkle, cusp 6, cusp 7 and protostylid. On the other hand, a number of traits present high frequencies when compared to non-Eurodonts: UM1 Carabelli's trait in its cusp/tubercle grade of expression; Three-cusped UM2; two or more lingual cusps on LP2; four-cusped LM1 and LM2 and two-rooted LC (Scott *et al.,* 2013).

Eurodont pattern characterizes the dentition of groups living in Western Eurasia, in a vast territory including Europe, the Middle East, North Africa and parts of India (Scott *et al.,* 2013).

The work by Joel D. Irish, another former student of Turner, was decisive for the understanding of the dental morphology of modern human groups all over Africa (Irish, 1997; 1998a; 2000a; 2000b; 2005; 2006; Irish and Konigsberg, 2007; Irish, 2008; 2010; Irish and Friedman, 2010; Gamza and Irish, 2010; Irish, 2013; Irish *et al.,* 2014). In his 1993 PhD work, Irish established the first systematization of the African modern dentition identifying two very homogenous dental patterns, characterizing Sub-Saharan and North Africans. Although populations within each group shared highly homogeneous frequencies of a number of traits, interregional differences were marked. A summary of that work was later published (*in* Irish, 1997) and the term "Sub-Saharan Dental Complex" (SSADC) coined. Two decades after his pioneering first systematization and after enlarging his Sub-Saharan sample from 966 to 2512 dentitions, Irish (2013) revisited the topic and proposed the term 'Afridonty' to characterize the human dentition of Sub-Saharans.

In comparison to populations from other regions, Afridonts are characterized by high frequency of nine complex and/or mass-additive traits: UC *Bushman* canines, 2-rooted UP1, UM1 Carabelli's trait, 3-rooted UM2, LM2 Y-groove pattern, LM1 C7, LP1 Tomes' root, 2-rooted LM2 and UM3 presence. On the other hand, their frequencies of UI1 double shoveling and UM1 enamel extension are among the lowest worldwide (Irish, 2013). Although Sinodonts as described by Turner (1990) are also characterized by complex dentition (relatively to Europeans), the traits expressing this complexity in the latter population (UI1 winging, UI1 shoveling, UI1 double shoveling, 1-rooted UP1 and UM1 enamel extension) diverge from the ones characterizing Afridonts.

In opposition to Afridonts, North Africans display a pattern of intermediate trait frequencies in a dental cline between the complex Afridont dentition and the simpler European one. North Africans and Europeans share similar frequencies of 4-cusped LM2, 2-rooted LC UI1 shoveling and UC DAR. But they do diverge from their northern neighbors having higher trait frequencies of 2-rooted UM2, LM C7, 3-rooted UM2, UC Bushman canine and LM2 Y-groove pattern. North Africans also have higher frequencies of Carabelli's cusp in its less expressive degrees but lower ones for the tubercle/cusp ranks. On the other hand, Europeans display higher frequencies of UI1 enamel extension and reduced or absent UM3 (Irish, 1997; 1998a; 2013). In summary, traits frequencies differentiating North Africans from Europeans are the ones expressing their similarity to Afridonts.

Irish´s work has also contributed to the understanding of the dentition of extinct hominins, how it evolved into the modern human teeth and the later changes of the morphology from the archaic dentition of the first Africans to the modern ones (Irish, 1997; 1998a; 1998b; 2000a; Irish and Guatelli-Steinberg, 2003; Irish, 2005; Guatelli-Steinberg and Irish, 2005; Irish, 2013). He observed that low frequency traits in Afridonts are rare or absent in extinct and extant hominoids and fossil hominins. The opposite relation happens to the high frequency features. According to that author, Sub-Saharans are the least derived dentally from a common ancestor of anatomically modern humans (Irish, 1997; 1998a; 2013).

Based on these phenetic similarities and on the biological divergence and its corresponding geographical distance of *H. sapiens* populations, Irish (1997) subjected data from different regions to Mean Measure of Divergence (MMD) analyses. His results (Table 1.2.1) suggest that Sub-Saharans are most similar to North Africans in terms of dental morphology. The latter would share much of the dental morphological phenotype with Europeans. Biological distance among regional groups increase the farther the population is from Sub-Saharan Africa, constituting a South-North cline. His analyses of intra- and inter-population variability and divergence support the existence of a broader cline from Sub-Saharan Africa to the Americas (also postulated by Turner, 1990). Although both Afridonts and Sinodonts display complex crown and root morphology and the presence of many mass-additive traits, the frequency of their most and least common dental traits reflect their opposition in the morphological spectrum. Highly frequent discrete traits for the first are extremely low for the latter and *vice-versa*. With the exception of a few traits, European and Sundadont dentitions present intermediate numbers between those extremes (Irish, 1997; 2013).

Table 1.1 - MMD values for samples from broad geographical regions (adapted from Irish, 1997:462-463).

Populations	MMD values
North Africans X Europeans	0.154
North Africans X Sub-Saharans	0.166
Sub-Saharans X Europeans	0.244
North Africans X Sundadonts	0.297
Sub-Saharans X Sinodonts	0.610
North Africans X Sinodonts	0.671

Although extensive works on dental morphology have been carried out in Russia, mainly through the efforts of Alexander A. Zoubov and his students since the 1960's, a great deal of this *corpus* of data remains unknown and unused due to the language barrier and poor circulation of Russian publications in the West (Scott and Turner, 2008a). Zoubov employed Dahlberg's standards for crown traits and a uniquely Russian method for the study of occlusal furrows which are genetically controlled: odontoglyphics. Because of its occlusal expression, odontoglyphics are best observed on unworn teeth hence, much of Zoubov's work on those features refer to sub-adult individuals (Hillson, 1996; Scott and Turner, 2008a; Turner, 2013).

The study of Dental Morphology in Japan was decisively influenced by Kazuro Hanihara. A pioneer in the field, Hanihara used Dahlberg's plaques on the study of Japanese dental morphology (Hanihara, 1967). His close contacts with the West and his collaboration at the University of Arizona, where he was a visiting scholar, helped the Japanese data permeate international scientific literature. Later work by Tsunehiko Haniraha and H. Ishida addressed morphological variance at a regional level but also at a broader scope dealing with major populations (Hanihara, 2008; 2010; 2013).

The work on dental non-metric traits in China is more recent, although it is considered an expanding field of study and major works have already been published by Liu Wu and other researchers (Scott and Turner, 2008a).

As a development of the use of the ASUDAS scoring procedures and reference plaques, comparable data crucial to population studies is now available for countries world-wide. Some of those were crucial for the present work.

Pilloud (2009) dealt with the dental morphology of Neolithic and Chalcolithic populations from Çatalhöyük and two minor sites (Aşikli Höyük and Musular) in Central Anatolia (Turkey). Pilloud discussed biological affinities at intra-site level comparing Neolithic and Chalcolithic occupation in Çatalhöyük. She could identify patterns of mobility into the flourishing village as it drew populations from different parts of Anatolia through time. She also investigated biological affinities among the different individuals buried in 'History' houses and other domestic levels and found out that social kinship was a factor of selection of burial place.

In Italy, Coppa, Vargiu and colleagues have addressed topics such as population continuity and biological affinities in the Italian Peninsula and its islands (Coppa *et al.*, 1998; Vargiu *et al.*, 2009) and the neolithization of that region (Coppa *et al.*, 2007). They observed that despite geological and geographical barriers Iron Age populations from south and north Italy shared close affinities and that time played a more important role in the divergence of groups than the difficulties imposed by the geological/geographical barriers (Coppa *et al.*, 1998). Dental discrete traits indicate that although Mesolithic populations were not replaced by incoming Neolithic migrants, the latter had a profound influence on the dental morphology of groups living in the present day Italian territory (Coppa *et al.*, 2007). Their work (Coppa *et al.*, 2009) also helped clarify that populations in Italian Chalcolithic were homogeneous throughout the Peninsula, while they diverged in Sicily.

Parras (2004; 2006) used the ASUDAS approach to try to identify possible migrants in Cyprus from the Middle Chalcolithic to the Early Bronze Age. In order to do so, he used data from the island and from the mainland (Syria and Greece). He argues that changes in the funerary architecture and material culture from the first period to the latter are a result of social factors rather than the arrival of immigrants, once the dental morphological traits indicate population continuity.

Comparative data on archaeological series are also available from diverse regions such as the Middle and Near East (Lipschultz, 1997; Ullinger *et al.*, 2005; Soltysiak and Bailon, 2013; Horwath *et al.*, 2014); India (Lukacs and Pal, 2013), Japan (Hanihara, 2008), Ireland (Weets, 2004), Scotland (Adler, 2005), just to mention a few sources, as the results of the use of the ASUDAS as a standard procedure.

1.4.3. The study of non-metric tooth morphology in Iberian prehistoric populations

In Portugal, the description of discrete traits according to the ASUDAS procedure was applied for the first time on a prehistoric (Chalcolithic) sub-sample from Cova da Moura (CM) by Silva (2000b). This collection comes from a collective burial context dated to 2255-2205 BC cal. 2σ (Silva, 2002). Although the human remains are disarticulated and fragmented, the funerary space was probably used for primary inhumation and the disarticulation (as well as the fragmentation) was caused by post depositional causes such as the reorganization of the skeletonized earlier remains during the burial of later individuals (Silva, 2000b; 2002).

The MNI in CM is 90. Silva (2000b) analyzed only fragments of mandibles containing molars *in situ*. Five traits were observed on those molars: cusp number, groove pattern, C6, C7 and *protostylid*. No case of the latter was found in the sample.

Sample size for LM1 C5 absence (4-cusped LM1) in CM is small (N= 7), but considering the frequency of 35% of C5 absence in LM2, that sub-sample is characterized by mass additive second molars. Figures for the reduction of C5 in Western Europeans (71.1%) are more than double (Scott and Turner, 1997).

LM1 C6 and C7 are low frequency traits in European samples (Scott and Turner, 1997). Both traits feature a frequency of 3.1% (N=32) in CM hence, within the expected figures for populations from Europe. On the other hand the frequency for LM2 Y-Groove pattern in CM (35%, N=20) is higher than the expected figures for Historic/Contemporary Portuguese, Northern and Western Europeans (20.2-27.2%) (Scott and Turner, 1997; Marado, 2014). Information on the sample from CM will be soon updated as Silva and Irish are currently analyzing recently found material from this site not addressed in Silva's previous works (Ana Maria Silva, personal communication, January, 2015).

The first comparative work on Prehistoric Portuguese populations employing dental morphological data was published in 1997 and dealt with matters of continuity of the regional genetic stock between the Mesolithic and the Neolithic-Chalcolithic (Jackes *et al.*, 1997). The same theme was addressed again in 2001 by the previous authors in collaboration with others (Jackes *et al.*, 2001). The latter work used a larger number of Portuguese samples and included North African populations.

Jackes and co-authors (2001) used frequencies of seven discrete traits: LM2 cusp reduction, LM1 Y-groove pattern, LM2 +-groove pattern, UM2 hypocone reduction, UM1 and UM2 Carabelli's trait and LP2 lingual cusp variation. Samples in that comparison were drawn from (I) nine North African sites ranging from the Epipaleolithic (Capsians) to the Neolithic; (II) two Canadian sites dated to the 15th-17th century, (III) a sub-sample of 104 individuals from the reference osteological collections of the Department of Anthropology in Coimbra, (IV) five Neolithic-Chalcolithic Portuguese sites (Cova da Moura, Dolmen de Ansião, Paimogo I, and the *hypogea* of Monte Canelas I and São Paulo II) and (V) two Mesolithic sites from Portugal (Moita do Sebastião and Cabeço da Arruda).

Although only a few traits were used by Jackes and coauthors (2001), dental data corroborates inferences from a previous work on cranial osseous morphology (Jackes *et al.*, 1997). Both indicate population continuity from the Mesolithic to the Chalcolithic and the existence of an "enduring gene pool in Central Portugal" (Jackes *et al.*, 2001:107).

In 2002, Ana Maria Silva presented the first paleobiological study of Prehistoric Portuguese populations using dental morphological traits as part of the characterization of regional past populations. In her PhD work (Silva, 2002) she analyzed samples from seven sites in the Portuguese Estremadura in the central region of the Atlantic façade of the Iberian Peninsula: Cabeço da Arruda I (CAI, 3310-2680 BC cal. 2σ), Cabeço da Arruda II (CAII, 3647-2555 BC cal. 2σ), Cova da Moura (CM, 3636-2205 BC cal. 2σ), Dólmen de Ansião (DEA, 3637-3094 BC cal. 2σ), Paimogo I (PM, 3077-3066 BC cal. 2σ), São Paulo II (SP, 2905-1950 BC cal. 2σ) and Serra da Roupa (SR, 3626-2917). In her comparison, Silva added data from Monte Canelas I (MCI, 3380-2890 BC cal. 2σ) from her previous work (Silva, 2002). Those collections were excavated from collective burial contexts dated to the Late Neolithic-Chalcolithic (4th-3rd millennium cal. BC). The series consisted of disarticulated and very fragmented human remains. All dental discrete traits included in that work were observed on *in situ* teeth.

Silva (2002) selected eight traits located on the lower teeth, two mandibular intra-osseous features and five located on upper teeth. These were submitted to MMD analyses. Inter-sample phenetic affinities expressed in the ZFT matrix and dendrograms in that analysis evidenced two clusters and an outlier. In the first one CM and SP display closer affinities immediately followed by MCI. The second cluster was formed by PM, SR and DEA. The outlier was Silva's sample from the reference Contemporary collection of Coimbra. These results demonstrate that the Portuguese Prehistoric samples show much closer affinities among themselves than between any of them and Contemporary Portuguese.

The influence of the school of Anthropology of Coimbra on the study of the dental morphology of archaeological and Contemporary populations is evident in the number of recent undergraduate (Simão, 2005; Gomes, 2005; Lucas, 2006; Pinto, 2006; Pombal, 2006; Costa, 2006; Fernandes, 2006; Costa 2007) and masters theses (Marques, 2007; Godinho, 2008a; Tereso, 2009; Gonçalves, 2010; Graça, 2010; Cunha, 2011; Leandro, 2011; Pinto, 2012; Jesus, 2012; Rodrigues, 2013) that include the collection of the dental morphologic data on historic archaeological samples, although not focusing specifically on the theme. Recent work by Marado (2010; 2014) on the other hand is directed to the understanding of the dental morphology of the Contemporary Portuguese population and his data were used for comparative purposes here.

A different amount of publications by the students of Coimbra deal with dental morphologic studies of prehistoric populations. Few master theses (Fernandes, 2013; Fidalgo, 2014; Pereira, 2014) include the collection of morphological data on prehistoric samples. This discrepancy in numbers may be related to the availability of prehistoric samples for the study, but it may also reflect the challenges researchers find when dealing with specific kinds of collections, particularly those from collective burials (Ana Maria Silva, pers. comm, April 2011).

In 2014, Howarth and colleagues published an article that, among other paleobiological evidences, used dental non-metric traits to assess biological affinities and population continuity between individuals exhumed from the Middle-Late Neolithic site of Feteira II and the Late Neolithic site of Bolores in the Portuguese Estremadura. They also compared the dental morphology of those samples to other populations from Europe and Africa. According to their results, there is no population discontinuity between those two samples, but the population from Bolores may have had genetic exchanges with peoples from Southern Iberia and North Africa.

So far, few works have attempted comparative analyses on the dental morphological of prehistoric populations from Portugal. The pioneer works by Ana Maria Silva (2000; 2002 [recently published *in* Silva, 2012]) and by Jackes and co-authors (1997; 2001) stand as the major publications.

Recent doctoral dissertations have dealt with the dental morphology of Spanish prehistoric populations (García-Sívoli, 2009; Oumaoui, 2009; Rivera, 2011).

García-Sívoli (2009) worked with prehistoric populations from the Balearic island of Majorca and Catalonia. The Majorcan samples were dated to the 4th millennium BC (S' Aigua Dolça), 1st millennium BC (Son Maimó, Son Real and S' Ilot des Porros) and to the 1st millennium AD (Can Reinés). The Catalonian samples were dated to the Epipaleolithic (Balma Guilanyà), Neolithic-Bronze Age (Mas d' Boixos) and Roman-Modern periods (Vila d' Madrid, Sant Pere, Plaça Vella). Besides assessing the morphological characterization of the archaeological populations in that study, García-Sívoli analyzed the biological affinities between the populations in both regions. That author defends the existence of close biological affinities among the peninsular and insular populations in his study and the consequent genetic exchange among those groups. When compared to other populations from the Mediterranean basin, García-Sívoli (2009) arguments that the dental morphological data supports close biological affinities among Catalonians, Majorcans, and populations from the Italian Peninsula and from the Levant. These affinities probably reflect migrations from those regions to the Iberian Peninsula and Balearic islands.

Oumaoui (2009) analyzed samples composed by individual inhumations from seven Bronze Age sites in Granada (Spain): El Castellón Alto, Fuente Amarga, Cerro de la Encina, Cerro de la Vírgen, Cuesta del Negro, La Navila and Motilla del Azuer. Those were compared to five medieval samples: three from Christian cemeteries in Castile and Leon, Spain (Villanueva de Soportilla, El Castillo and San Baudelio de Berlenga) and two Muslim cemeteries in Granada (La Torrecilla and Sahl Ben Malik). That author proposes that 'native' Bronze Age populations from Granada descend from Western Europeans and despite their common origin, the different groups diverged biologically as a result of either micro-evolutionary processes fomented by isolation (particularly in Motilla del Azuer) and by different degrees of genetic flow from North African populations into that region of South Spain. The three oldest samples from Granada (El Castelón Alto, Fuente Amarga and La

Navilla) would present the least North African influence, while the later Bronze Age sites of Cerro de la Encina, Cerro de la Vírgen and Cuesta del Negro would reflect admixture between the native stock and incoming foreign populations. That admixture would not represent an isolated phenomenon, but would continue through time.

However, when compared to medieval populations, Oumaoui's (2009) Bronze Age samples presented closer bio-distances, indicating greater local microevolution and more demographic isolation. medieval samples on the other hand, displayed larger biological distances and less micro-evolution. The latter would be more markedly influenced by incoming North African migrants as a result of the Muslim occupation of territories in the Iberian Peninsula during the Middle Ages.

Rivera (2011) analyzed 14 traits on the dentition of the individuals exhumed from the *hypogeum* of Longar, Basque Country (Spain). The funerary use of Longar was dated to the mid-3rd millennium BC (Late Neolithic-Early Chalcolithic). Rivera compared that to other archaeological samples from Southern Spain (García-Sívoli, 2009) and Italy (Coppa *et al.,* 2007), and to Contemporary Basques (Scott *et al.,* 2013, unpublished by 2011). Rivera's (2011) study identified close biological affinities among Longar and other prehistoric Iberian samples in opposition to those and prehistoric Italians. Contrary to the expected, Rivera found considerable biological divergence between the population excavated from Longar and Contemporary Basques, although the author does not elaborate on the possible causes for this dissimilarities.

In 2012, Ruiz and coauthors published a comparison between Mesolithic and Neolithic samples from Catalonia. The data presented was preliminary and part of a longer research project (Ruiz *et al.*, 2012). That publication has some methodological problems that may affect the accuracy of the results presented. Although the authors state they used the ASUDAS scoring method, some traits listed are not described in that methodology (*i.e.,* "disr14", "md. dist. cusp u.4" and "md. dist. cusp u.5" p. 83) and there is no indication of either the reference method or the polar tooth for their observation. Some traits are listed for the wrong key tooth/dental arch (Cusp 7 for the upper molars, for instance: 83) or refer to non-polar teeth on which the comparative literature does not offer comparable frequencies (*i.e.,* double shoveling for the lower incisors, same page). Besides that, four (out of seven) samples whose data is presented in the article have a very low number of observations. Between one and three individuals were observed for the sites of La Corona (N=1), La Braña (N=2), Cingle de Mas Nou (3) and Ca l'Estrada (N=1).

In 2014, Subirà and co-authors published the dental morphological data along with those related to diet and paleopathology from a Late Neolithic (3420-2640 cal. BC) series from the cave of Pantà de Foix, near Barcelona, Catalonia. MNI in this sample is 30 and very few traits provided a number of observations equal or over 20 for polar teeth. The dental morphology of Pantà de Foix sample was compared to Italian prehistoric populations (*in* Coppa *et al.*, 2007) and to other Mesolithic and Neolithic Catalonian samples in order to assess biological continuity from one period to the other. Subirà and co-authors (2014) argue that although there are changes in the material sites and funerary treatment in Catalonia from the Middle to the Late Neolithic (and to later Bronze Age), these are not reflected in biological differences, as population continuity is observed among the three Catalonian samples, independent of the chronology.

1.4.4. The Arizona State University Dental Anthropology System (ASUDAS)

Scoring procedures of dental discrete traits in the early 20th century were based on the presence/absence dichotomy. The limitations of nominal register procedures when applied to *quasi-continuous* traits led to the introduction of ranked scales such as Hrdlička's approach to shoveling (Scott and Turner, 1997; 2008a). In order to assess the expression of that kind of traits, a scoring procedure should allow the verification of quantitative differences (*i.e.*, the size of a cusp or the length of divergence in bifurcated roots) (Schmidt, 2008). Hrdlička's scale for shoveling and later plaques developed by Dahlberg (as discussed above) and by Hanihara (1967) for some traits on deciduous teeth enabled the register of a grade for the absence of traits and of different ranks for its presence (Scott and Turner, 1997).

Building on Dahlberg's work, Turner released scoring plaques for two more dental traits (LM cusp 6 and LM cusp 7) in 1970. Dahlberg provided his original plaques to be duplicated and distributed along with Turner's new material. That is considered to be the beginning of the Arizona State University Dental Anthropology System (ASUDAS) (Scott and Turner, 1997; 2008a; Scott, 2008).

ASUDAS is a standardized scoring system based on a selection of discrete dental and intra-osseous traits designed to assess phenotypic variation in human groups. Two scales of measurements of traits are used in ASUDAS: simple nominal categories of presence/absence and ordinal ranked scales. The traits included in this methodology are (I) easily and reliably observed; (II) preferably resistant to the damage naturally caused to the teeth during the lifetime of the individuals bearing them; (III) ideally resistant to taphonomic alterations (particularly useful when dealing with archaeological and paleoanthropological samples); (IV) not/very little affected by sexual dimorphism, and (V) very slowly evolving. These features allow the traits to be used in the characterization of affinities among human populations (Turner *et al.*, 1991; Scott and Turner, 1997).

Additions to the collection of reference plaques were made by Richard Scott during his PhD work defended in 1973. Scott developed the plaques addressing the *tuberculum dentale*, distal accessory ridge and cusp variation for the lower premolars. Particularly important for the

ASUDAS, he improved Hrdlička's ranking for shoveling from 4 degrees (zero representing absence of the trait and 3 grades of presence) to the 8 degrees grading system (zero standing for absence of the trait and 7 grades of presence) that is employed in ASUDAS nowadays. His approach to the trait helped understand the distribution of its frequency in more realistic numbers closer to the normal distribution. The previous grading system usually resulted in almost 100% frequencies in Asian and Amerindian populations. The changes proposed by Scott allowed more precise assessment of the traits in those populations (Scott and Turner, 1997; Scott, 2008).

In 1993, the scoring plaque for the lower molar middle trigonid crest was added to the ASUDAS (Wu and Turner, 1993). The most recent additions resulted from the Masters work of Scott E. Burnett, another former student at the Arizona State University (Burnett *et al.*, 2010).

Nowadays, 43 nonmetric traits are described in the ASUDAS (Turner *et al.*, 1991). The scoring procedure for eight traits is dichotomic for the presence/absence of the trait (*i.e.,* for interruption grooves or congenitally missing teeth). One trait is scored based on categorization of the feature on a nominal scale: the intercuspidal groove pattern of the lower molars which is discriminated by type of pattern (X, Y or +). The scoring of the torsomolar angle implies the measurement of the angle of rotation for the LM3. Six traits require the counting of tooth structures (roots and cusps). For 27 traits scoring is performed with the aid of plaster plaques providing the variability of ranks included in the methodology (Figure 1.4.1). This methodology was described by Turner and contributors (1991) with later contributions of more recently added plaques in Burnett and colleagues (2010) and by Wu and Turner (1993) (see Chapter 3 in the present work).

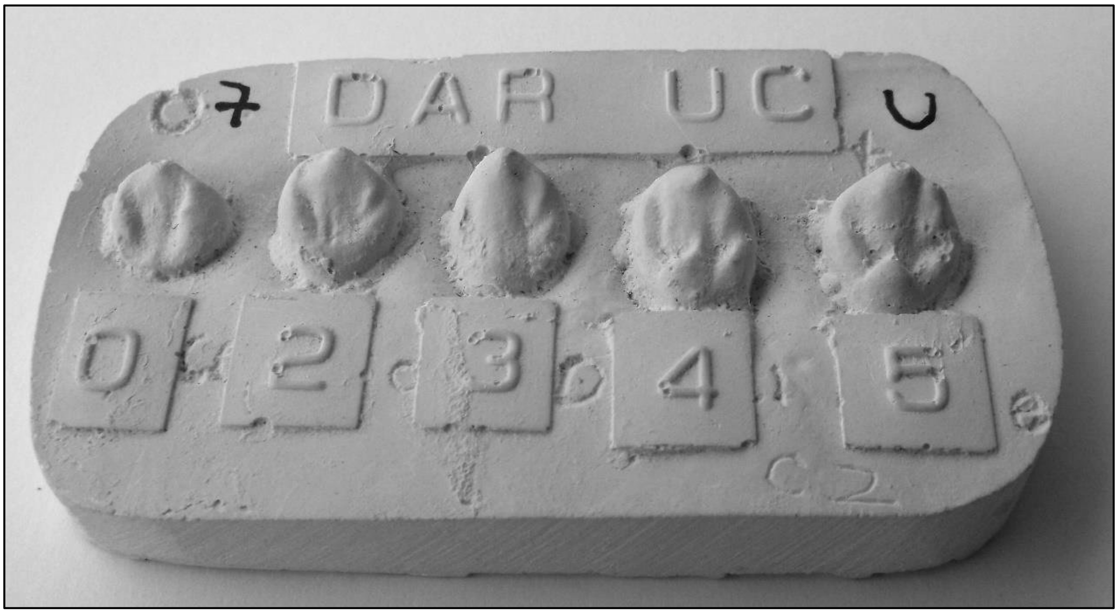


Figure 1.4.1 – ASUDAS plaster plaque used for the scoring of the distal accessory ridge on the UC.

Criticism as to the subjective nature of the ASUDAS approach has been raised given the difficulty in determining precise inter-degree differences when a scale is applied to *quasi-continuous* traits (Hillson, 2005), although the proponents of the method (Turner *et al.,* 1991) try to minimize this problem by providing detailed descriptions of differences characterizing each rank of expression. Turner and collaborators (1991) advise that the use of these scoring plaques should not be made without the aid of the written description of each grade. Since the grades of traits displayed on the plaques are methodologically designed breakpoints of *quasi-continuous* expressions of morphological variations, situations in which a tooth seems to be in-between two grades might happen. When that is the case, the written description of the different grades provided by the scoring procedures of the method (Turner *et al.*, 1991) usually helps make the choice of a scoring grade. Practice and experience of the observer helps minimize scoring inaccuracies and the employment of both intra- and inter-observer error tests are also strategies applied to reduce subjectivity in the use of the ASUDAS (Turner *et al.,* 1991; Scott and Turner, 1997; Harris, 2008).

2. Archaeological context of the osteological samples

2. Archaeological context of the osteological samples

The osteological samples in this work come from three collective tombs in two Chalcolithic (Copper Age) sites in the basin of the Guadiana River: one (BT07) from the site of Cerro de las Baterías (left margin of the Guadiana River), La Albuera, Badajoz (Spain) and two (PDG1 and PDG2) from the Archaeological Complex of Perdigões (right margin of the Guadiana River), Reguengos de Monsaraz (Portugal) (Map 2.1).

Map 2.1 – Location of the Chalcolithic sites of Perdigões (Portugal) and Cerro de las Baterías (Spain).

The Guadiana River feeds one of the main hydrographic basins in the Iberian Peninsula. It occupies an area of around 67,000 Km^2 reaching regions in both Portugal and Spain. Beginning its course in the Lake of Ruidera, Spain, it flows through around 810 Km (most of those in Spain) and it discharges into the Gulf of Cádiz between the Portuguese town of Vila Real de Santo António and the Spanish municipality of Ayamonte. The Guadiana flows from east to west in most of its course and it is served by a network of tributaries that converges to the main river from roughly north and south. After the city of Badajoz (Spain) it reaches the Portuguese border and deflects southbound. Tributaries then feed the main river from east and west. Ecologically it unifies two similar territories in its mid-course: the Portuguese region of Alentejo and the Spanish Extremadura. Both are characterized by relatively flat lands with semiarid climate whose effects are mitigated by the presence of the Guadiana and its tributaries.

The results of this river system is a landscape of shallow fertile lands favored by seasonal floods of the main river and its tributaries (Ribeiro *et al.*, 1988a; 1998b; Atlas OTALEX II, 2011).

2.1. Pits, ditches and enclosed sites

The osteological series of BT07 and Perdigões come from cultural contexts in which ditched enclosures play a central role. BT07 is an isolated tomb, probably in the proximity of a small settlement (Márquez-Gallardo, 2008) within the territory of a large enclosed settlement (La Pijotilla) as described by Hurtado (1999), while tombs 1 and 2 were excavated from within the ditched enclosure of Perdigões.

Archaeological sites containing excavated pits and ditches have been known in the Iberian Peninsula since the last decades of the XIX century (Márquez-Romero, 2007). The discovery of human remains in such negative archaeological structures has been recorded for over 100 years. The interpretation of these as intentional burials dates back to that period (Estácio da Veiga, 1886: 145-151; Estácio da Veiga, 1889: 371; Cruz-Auñon and Jiménez, 1985). It is not our intent to summarize all literature on this matter (nor is it the scope of the present work). However, we must notice that both sites addressed here are inserted in a cultural context whose evidence at a macro scale consists of an architectural tradition spread in the Guadiana basin (Hurtado, 2008), and beyond (Díaz-del-Río, 2003; Márquez-Romero, 2006; Orozco Kohler *et al.*, 2008; Valera 2008b; 2012b; 2012c; Valera and Becker, in press).

The prehistoric enclosures are a specific type of archaeological site included in this construction *modus*. They are characterized by having its limits enclosed by ditches, walls or both (Kunst, 2006; Márquez-Romero, 2007, Valera, 2012b; Díaz-del-Río, 2013). These sites are also characterized by the presence of negative structures of diverse typology, the most common of which are circular pits (Márquez-Romero, 2007; Valera 2008b; 2012a; 2012b; 2012c; Díaz-del-Río, 2013; Valera and Becker, in press). This combination of structures is considered "one of the most generalized settlement features in Neolithic and Copper Age Europe" (Díaz-del-Río, 2004b: 110) being interpreted by some as part of a European phenomenon (Márquez-Romero, 2007).

Ditched and walled settlements or enclosures differ in size and dimensions of their ditches, but they converge in shape (usually circular, oval or elliptical) (Díaz-del-Río, 2004b; Márquez-Romero, 2007; Hurtado, 2008). Ditches might be dug in regular lines or sinuously (Hurtado, 2008; Valera 2012c). These structures will frequently enclose or be associated with other anthropic constructions: domestic structures (houses, workstations, fireplaces); a variety of structures related to the funerary treatment of the dead and others whose functions are not clear (Márquez-Romero, 2001; Márquez-Romero, 2007; Hurtado, 2008; Valera, 2012a).

The local communities in the IV-III Millennia BC seem to have shared not only the way they shape and exploit the environment, but also many aspects of their material culture and the way they treated their dead (Gonçalves and Sousa, 2000; Silva, 2002; 2003; Gonçalves and Sousa, 2003; Gonçalves, 2003a; 2003b; 2003c; 2003d; Boaventura, 2009; Tomé, 2011; Diaz-Zorita *et al.,* 2012; Valera, 2012a; Diaz-Zorita, 2013). Inhumation of human remains (isolated bones, reductions, ossuaries, partial and complete skeletons) are common both in pits and ditches; in domestic and non-domestic areas in the settlements, and in megalithic tombs of different typologies in which prevail collective burials (Estácio da Veiga, 1886; 1889; Leisner and Leisner, 1951; Silva, 2002; 2003; Boaventura, 2009; Tomé, 2011; Diaz-Zorita *et al.,* 2012; Valera, 2012a, Diaz-Zorita, 2013; among others).

Different interpretations have been proposed for the construction of enclosures in Iberia (*i.e.* Díaz-del-Río, 2004a; Márquez-Romero, 2006; 2007; Hurtado, 2008; Valera, 2008b; Valera, 2012b). Much of the current debate on the enclosures in the Iberian Peninsula focuses on two aspects: (I) the political-economic context of these communities and how they would interact or relate on a regional level, and (II) the domestic component on the idea behind the building of such structures.

A careful review on the history of the political thought on enclosures, particularly on the Portuguese ones, is provided by Valera (2008b). He argues that the first attempt on understanding the political and aggregation patterns of the communities building this kind of site proposed an autarchic interpretation. That interpretation emerged from a materialistic approach in which "the site was the scale of analysis" (Valera, 2008b: 236). Under that perspective characteristic intergroup relationships lead to internal unity and cooperation at a site level, thus producing a fragmentary landscape of fortified settlements fending for themselves. A second approach would defend the existence of a hierarchic territory dominated by larger settlements over a local settlement network. Territories would compete against each other the same way villages would in the previous model. Valera (2012b) proposes a third model in which those communities would be linked by common cognitive-cultural ideologies, expressed in the way they occupied the land and modified the landscape. He believes that enclosures are "built places with the social role of organizing space and performing identity administration, aggregating and reinforcing cohesion over dispersed populations across a given territory" (Valera, 2012b: 244). Valera (2012b, 2012c) and Valera and Becker (in press) have proposed the existence of an architectural 'grammar' or a construction framework guiding the building of a series of sites in the south of Portugal characterized by their enclosure in ditched structures and by construction prescriptions related to cosmological phenomena and cardinal orientations. The pattern of orientation for the enclosure doors, tombs and other architectural features, including the positioning of the enclosures themselves would obey a set of established prescriptions.

In terms of the functionality of such sites, the discussion is polarized between a more materialistic or ritual approach to the reasons behind the construction of ditched and walled enclosures.

Under a materialistic approach, enclosures are understood as monumentalized habitation sites built by hierarchical communities in which elite groups would be able to recruit enough manpower to implement such large scale work, although there is limited direct evidence of specific individuals possessing socially valuable items. Hence, population growth and aggregation were required. Large villages worked as centers of regional power and they would have access to not only local goods, but also to exotic materials. Smaller settlements would be under the control of larger ones. In such scenario, there would be an increase of the use and dissemination of ideological and technological items of material culture (Díaz-del-Río, 2004a; 2004b; Márquez-Romero, 2007; Díaz-del-Río, 2013).

This approach emphasizes the evidences of domestic activities in the sites, such as the existence of habitat and defensive structures. Pits would serve a functional purpose (as storage units as part of living or working facilities), although they could be used for 'anomalous' non-functional depositions. Ditches would be understood as defense systems, as limits to specific areas within a settlement and to the settlement itself (Díaz-del-Río, 2004a; 2004b; Kunst, 2006; Márquez-Romero, 2007; Hurtado, 2008; Díaz-del-Río, 2013).

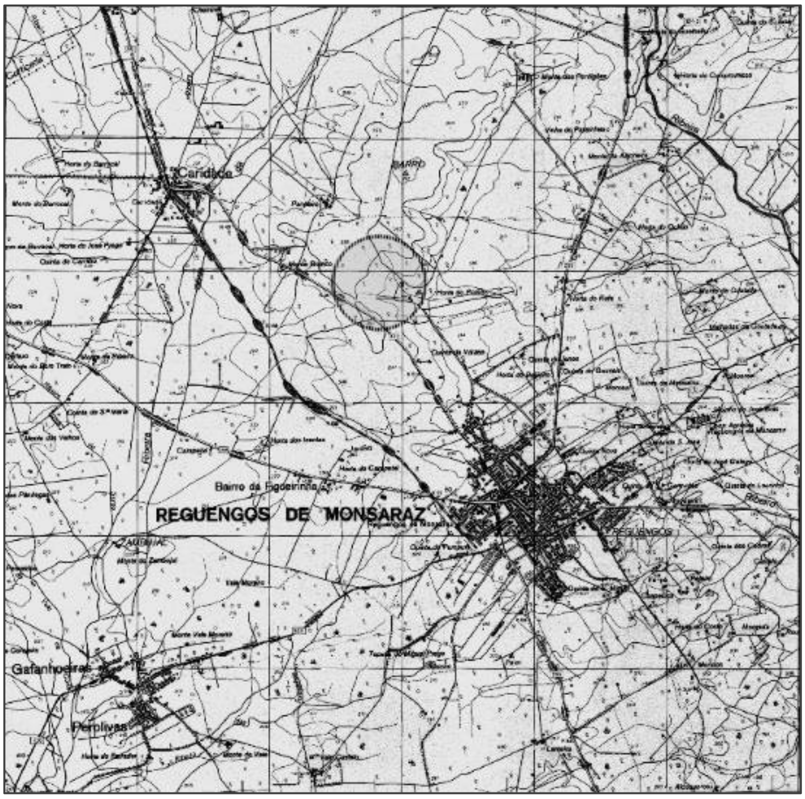
Díaz-del-Río (2004) argues that such a large scale phenomenon, varying in chronology, size, topographic position and features cannot be explained simplistically and interpretations should be processed on the basis of contextualized regional data.

The non-materialistic approach defends that the sequence of enclosures in sites like Perdigões or La Pijotilla are open and closed at a certain socially prescribed time. Pits and ditches would be made not for functional reasons, but for the intentional depositions of goods and skeletons of both animals and humans. Ditches are understood as unifying elements at the ideological level and as physical barriers expressing cultural limits for those allowed to or banned from certain areas within the enclosure. The communities which built the enclosures are seen as mobile farming groups far from hierarchical societies (Márquez-Romero 2001; 2006; 2007). Evidences of domestic features and uses of the sites are underestimated. Enclosures are considered a European scale phenomenon chronologically set between mid-4th Millennium BC to the 1st half of the 3rd Millennium BC and tend to be analyzed on this macro scale (Márquez-Romero 2001; 2006; 2007).

2.2. Perdigões location and description of the site

Located at 2 km northwest of the town of Reguengos de Monsaraz, Portugal (Map 2.2), the site of Perdigões (PDG) is a complex of several archeological structures. Its most striking features, a series of roughly concentric ditches, were discovered in the end of 1996 when the land owner plowed the area and uncovered a significant density of archaeological materials and darker soil marks (Lago *et al.*, 1998).

Archaeological works following the discovery produced solid data confirming the existence of what would become one of the most important prehistoric sites in Portugal (Lago *et al.*, 1998). The site covers an area of 16 ha in a sequence of smooth slopes converging to the shallow valley of Álamo creek on the east. Land survey of PDG was made in 1997 identifying areas of concentration of archaeological material and helping construct a first plan of the site, understood by then as a probable settlement (the ‘village’ of Perdigões).



Map 2.2.1– Location of Perdigões Enclosure (darker circle) in relation to the town of Reguengos de Monsaraz, Portugal. Adapted from: topographic map of Portugal, scale 1:25000, sheet 473 (Reguengos de Monsaraz) (IGEOE, 2008).

From a site perceived as a settlement, a more complex interpretation has evolved over the years. Geophysical studies of unexcavated large structures (Márquez-Romero *et al.*, 2011; Valera *et al.*, in press) and over a decade of punctual excavations in different areas within PDG have allowed archaeologists to defend that they are dealing with a composite of several structures constructed, used, abandoned and re-used for a period of ca. 1500 years (Valera *et al.*, 2014; Valera *et al.*, in press a).

The term ‘settlement’ was abandoned once no domestic context has so far been found in the site and the word ‘enclosure’ was adopted on the grounds that it would be “innocuous” and dissociated from an “essentially residential meaning” (Valera *et al.*, 2007: 59). Hence, the site has also been addressed to as ‘Perdigões Enclosure’ (Valera, 2008b) or ‘Perdigões Archaeological Complex’ (Valera *et al.*, 2000). The dichotomy between a funerary space and a probable ‘domestic’ area of the site would be radically changed, once funerary contexts are found in different areas in the enclosure (Valera and Godinho, 2009; Silva *et al.*, 2010; Silva and Cunha, 2011).

The site is geomorphologically inserted in the Alentejo peneplain, characterized by smooth topography. Geologically, the site is located on a patch of gabbro diorite surrounded by a much larger area where granodiorites and tonalites prevail (Map 4) (Carvalhosa and Zbyszewski, 1991). The composition of local relatively soft bedrock favors the excavation of the partially underground structures found in the site. The proximity of the site to the Álamo creek (only 2.5 km to the east) allows easy access to water even in dry seasons (Lago *et al.*, 1998).

Two very important characteristics of PDG, first noted by Lago and contributors (1998) would be crucial for the later interpretations of the site: (I) its location in the landscape suggested that the whole construction of these structures were intended to privilege the view to the east and (II) in that specific direction, the outer ditch (ditch 1) presented a semi-circular enlargement from its neighboring counterpart (ditch 2). Abundance of human osteological material, slabs of schist and votive objects on the surface area suggested the presence of a “necropolis” (Lago *et al.*, 1998: 58) in this restricted area and outside it (beyond ditch 1) to the east. Between 1998 and 2006 two sepulchers in the necropolis were completely excavated (Tombs 1 and 2) and a third one was surveyed only in its upper layers (Valera *et al.*, 2000 and 2007; Evangelista, 2003; Valera *et al.*, 2007; Evangelista and Silva, 2013).

In 2008 and 2009 a geophysical survey of the site was carried out covering most of its area (Valera *et al.,* in press; Márquez-Romero *et al.* 2011). A high resolution image of underground structures within the site provided more details to the already existing plan of the site (Valera *et al.,* in press). It also corroborated land surveys and test excavations (Valera, 2008a) by confirming: (I) the existence of thousands of pit-like structures in the site and outside it to the east and, (II) the existence of at least one ‘tholos-like’ structure just outside the limits of the necropolis.

The architecture of the site and theories on its use have been discussed in several recent publications (Valera, 2008b; 2012c; 2012b; Valera and Becker, in press, among many). These authors defend that there is a cosmological reason for the orientation of the site and for the entrances located in its ditches. These would be intentionally built to face cosmological events such as the sunrise and sunset at the solstices (but maybe also other celestial bodies or constellations). Valera (2012b: 179) argues that there is an underlying "general landscape semantics" implied in the strict orientation of this and other ditched enclosures in the Iberian Peninsula dictating their general orientation and insertion in the region. Valera (2008) believes that the site was planned to favor this particular orientation from the very beginning of its construction. He argues that once the inclination of the site that prevents full view to the west, all attention is directed to the lower lands on the east. Eastward, the Neolithic-Chalcolithic regional landscape would be marked by the human presence via hundreds of megalithic monuments and settlements.

2.3 Synthesis of funerary contexts in Perdigões Enclosure

Funerary contexts in PDG have been excavated in three of its sectors: Q, I and S. Human remains are present in pit burials (Valera *et al.*, 2007; Valera 2008a; Godinho, 2008b); in at least two of the ditches (3 and 4) (Valera 2008a; Valera and Godinho, 2010); in an atypical collective burial of cremated human remains (Valera, 2011; Silva and Cunha 2011; 2012; Silva *et al.*, 2013a; 2013b; Silva *et al.*, in press), and in at least two '*tholos*-like' sepulchers (Lago, 1998; Evangelista, 2003; Valera and Godinho, 2009).

Valera and contributors (Valera *et al.*, 2000; 2007; Valera and Godinho, 2009; Valera 2012a) have approached the funerary practices in PDG as a dynamic process in which individuals buried in the site would probably be submitted to manipulation and transport of their osteological remains from other funerary contexts into the collective tombs. Discussing the patterns of funerary treatments dispensed to the dead in Neolithic and Chalcolithic sites, Valera (2012a: 110-111) suggests the existence of "diversified treatment of bodies, using different scenarios, some of them possibly articulated in a sort of *chaîne opératoire* that might connect different practices and spaces".

The funerary treatment dispensed to the dead in burials of the local Late Prehistory seems to have included the re-visiting of the sepulchral space by members of the community which made use of those monuments. Archaeological evidence of that is the re-organization of bones and funerary goods in La Pijotilla (Hurtado *et al.,* 2000) as well as in a series of Late Prehistoric sites in Portugal (Valera, 2012a). Anthropological studies corroborate the re-visiting of funerary spaces, many of which have shown to be primary burials despite the generalized disarticulation of the human remains (Silva, 1996a; 2012; Godinho, 2008b; Miguel and Godinho, 2009; Tomé, 2011).

Evidences of possible interchange of osteological material from other funerary contexts into Tombs 1 and 2 have been found in the course of the present research. Although there is no register of fire *in situ* in the areas containing undisturbed levels of human remains in Tombs 1 and 2[1], a few bones and teeth from the sepulchers present alterations by fire. We cannot dismiss the possibility that they may come from the cremation contexts in the site or elsewhere. However interchange of human remains from different areas of the site must be taken cautiously in view of the incipient data available.

Absolute dates for funerary contexts in PDG (Valera and Silva, 2011; Valera and Márquez-Romero, in press; Valera *et al.,* 2014) are few, considering the monumentality of the site and the multiplicity of funerary treatments in it. Human and faunal osteological remains from the 3rd millennium BC come from different structures including both tombs studied here (Table 2.1) (Valera *et al.,* 2014).

Table 2.1 – Absolute dates for funerary contexts in Perdigões (Valera *et al.*, 2014)

Context	**SU***	**Species sampled**	**Lab Ref.**	**Cal BC 2σ**
Tomb 2 (atrium)	232	*H. sapiens*	Beta 308789	2459-2202
Tomb 2 (chamber)	458		Beta 308791	2860-2498
Tomb 2 (chamber)	429		Beta 308792	2469-2290
Tomb 2 (atrium)	231		Beta 308793	2575-2350
Tomb 1 (chamber)	173		Beta 327750	2836-2467
Tomb 1 (chamber)	93		Beta 327748	2840-2482
Tomb 1 (chamber)	84		Beta 327747	2872-2582
Pit burial 7	114		Beta-289265	3331-2922
Pit burial 11	76		Beta-289263	3096-2901
Pit burial 16	74		Beta-289262	2621-2350
Ditch 3	99	*Sus sp.*	Beta-285098	2851-2472
Ditch 3	58	*Bos taurus*	Beta-285096	2851-2472
Ditch 3	38	*Fauna*	Beta-285095	2618-2347
Ditch 4	90	*H. sapiens*	Beta-289264	2568-2299
Ditch 4	90	*Cervus elaphus*	Beta-285097	2618-2347
Ditch 4	18	*Sus sp.*	Beta-285099	3328-2918
Assemblage 1	109	*H. sapiens*	Beta-308784	2470-2296
Assemblage 1	177		Beta-308785	2575-2350
Assemblage 1	128		Beta-313720	2495-2206
Assemblage 1	263		Beta-313721	2831-2356

*SU=Stratigraphic Unit

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[1] There is a clay structure in the atrium of tomb 1 presenting evidence of fire, but it was not associated with *in situ* human remains (Lago *et al.*, 1998; Valera *et al.*, 2000).

2.3.1. Deposition of human remains in ditches

In 2007-2008, archaeological excavations carried out in Sector uncovered human remains in two kinds of context: ditches and in two pits (Figure 2.3.1 – numbers 1 and 2) (Valera 2008; Godinho, 2008b; Valera and Godinho, 2010).

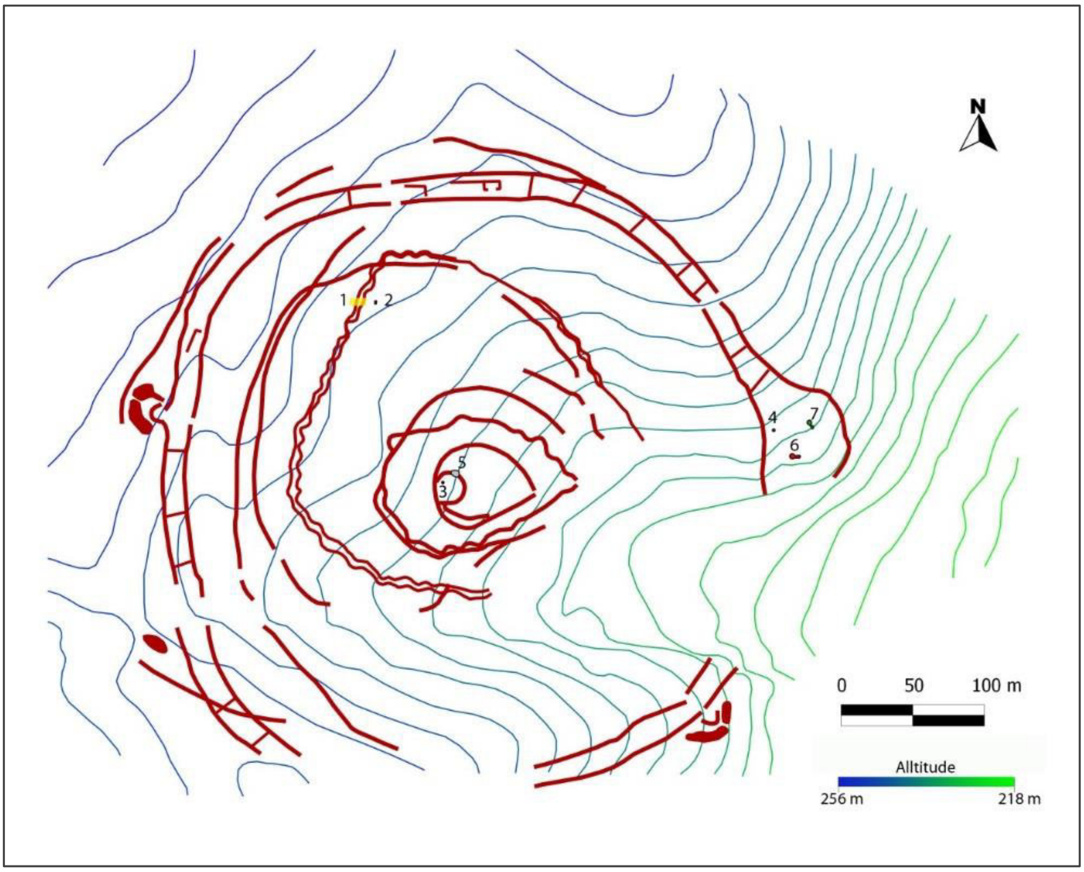

Figure 2.3.1 - Location of the funerary contexts excavated at Perdigões Enclosure: (1) deposition of human remains in ditches 3 and 4; (2) pit burials 7 and 11; (3) pit burial 16; (4) Tomb 3; (5) PDG-A1 cremation deposit; (6) *tholos*-like tomb 1; (7) *tholos*-like tomb 2. Image adapted from Valera *et al.* (in press a).

Although very few human remains were collected from those ditches, Valera and Godinho (2010) present different depositional situations for that material. A fragment of radius was recovered from the fillings of ditch 3 in apparently casual deposition in non-structured deposits. In the same structure a fragment of skull was probably intentionally deposited in a crevice excavated on the eastern wall of the ditch. MNI for this structure is 1.

Human bones in ditch 4 were recovered along with fauna. The distinction of taxa was only made during laboratorial study of the animal bones (Valera and Godinho, 2010: 32). The human bones consisted of an isolated phalange from stratigraphic unit (SU)18 and several bones from a different level (SU90) near the base of the ditch. The bones in this lower level included:

a fragment of left radius; a fragment of skull, 3 hand phalanges, 3 metacarpals (two of which consistent with a right hand) and some undetermined fragments of bones. Although the hand bones were found nearby (19 cm apart horizontally and 3 cm vertically), the excavators did not notice any anatomical connections of these bones. MNI for this structure is 1, three of the hand bones provided sex diagnosis (probably female). Age at death estimates for these bones are not accurate due to the very nature of the material, but Valera and Godinho (2010) believe the individual or individuals represented by the hand bones might have been over 16 yrs. of age. So far, archaeological evidence published for this kind of context in the site points to secondary deposition of unarticulated human bones, some of which might have been unintentionally carried along with other materials filling the ditches. However, at least for the skull from ditch 3 Valera and Godinho (2010) present solid evidence for an intentional deposition.

2.3.2. Pit burials

Articulated bones, in what seemed to be primary deposition, were found in pits 7 and 11 (Figure 2.3.1, above – number 2) (Godinho, 2008b). Osteological remains collected from these pit burials have recently had a thorough paleobiological analysis that included DNA sequencing of the individuals (Afonso *et al.,* 2013).

Combining the paleobiological information collected in the field (Godinho, 2008b) and in laboratorial procedures (Leandro *et al.,* 2013), MNI for pit 7 is 3: one adult female individual represented by two articulated legs (*tibiae*, *fibulae* and bones of the foot) compatible with right and left legs of one single individual; a partially articulated hand of a non-adult individual aged at 1-3 yrs., and cranial fragments from a second adult individual. It is interesting to notice that, although the legs belonging to the possible adult female were articulated, they were placed at different archaeological levels (SU 104 and 114) and in different orientations. Despite the lack of several portions of this individual's skeleton, there is no evidence of taphonomic alterations by exposure to weathering or faunal action (Godinho, 2008b). That author suggests that the decaying of the soft tissues of this individual probably took place at an open space in the pit and that allowed the decaying corpse to be manipulated and parts of it removed.

Pit 11 contained the remains of at least 3 individuals (SU76, SU77 and SU78) whose skeletons were partially articulated, all of them were deposited in lateral *decubitus* on a layer of sterile clay. All three skeletons were incomplete and SU78 had his lower limbs bent over his torso. This partial articulation is understood as evidence of manipulation of the limbs while they still retained some soft tissues. There is no evidence of exposure of the osteological remains to weathering or fauna, which may be an indication that, at least for part of the funerary treatment of the corpses, they were kept in an open space probably in the pit, suggesting the existence of some protective structure that prevented the action of natural taphonomic agents while allowing visitation and the manipulation of the bodies. However, there is no evidence of such structure in the archaeological record. All individuals faced east and at least two of them (SU76 and SU78) had their hands above their heads (Godinho, 2008b).

The three individuals in pit 11 were sexed by DNA analysis as male and not matrilineally related (Afonso *et al.*, 2013). Age at death estimates for individual SU76 is around 13-14 yrs. old, while individual SU77 is a non-adult around 6 +/- 2 yrs.(personal observation) (Ubelaker, 1999). Finally, individual SU78 was probably around 15 yrs. old at time of death.

In each of these burial pits an articulated partial limb of *Sus sp.* was found along with the human remains (Moreno-Garcia and Cabaço, 2009). In pit 7 the faunal foot was laid beside a human leg (Valera, 2008a). In pit 11 the hand of a juvenile pig lay behind the pelvis of one of the sub-adult individuals (Valera, 2008a; Moreno-Garcia and Cabaço, 2009). The faunal remains did not present cut marks and it is possible that they were still articulated with upper bones of the limbs when first deposited in the pits. Moreno-Garcia and Cabaço (2009) proposed that these parts were possibly disarticulated from the remaining of the limbs during the process of *postmortem* manipulation of both human and faunal remains in the pit before its final filling with sediments.

Godinho (2008b) and Valera (2008a) suggest that the missing bones of individuals exhumed from the pits may have been removed as part of the funerary ritual for later deposition at a secondary location (probably in the collective sepulchers in the necropolis area of PDG). Valera and Godinho (2009) propose that pit burials such as pits 7 and 11 might constitute only a phase of the burial ritual of the individuals exhumed from these contexts. Primary treatment of the deceased would be performed in these circular tombs. However this would be only one of the stages of an articulated complex process in which the sepulchers of the necropolis would play a role in receiving part of these human remains. So far there is no published physical evidence of this relation and dates for the human remains in those pits are two or three centuries older than the ones published for the sepulchers (Valera *et al.*, 2014, Table 2.1, above). After the anthropological study of the human remains from the pits, Ana Maria Silva (pers. comm., January 2014) disagrees and points that the lack and displacement of bones may have been caused by prehistoric and historic post-depositional processes: the opening of subsequent pits in the same area and mechanical damage caused by plowing.

In 2010 excavations in Sector Q of the enclosure led to the discovery and digging of Pit 16 (Figure 2.3.1, above – number 3). Cremated human remains belonging to several individuals along with cremated fauna and burnt industry were deposited in this structure (Valera and Silva 2011). Radiocarbon dates for the human osteological material buried in this context place them in the middle of the 3rd Millennium BC, contemporary to the latest depositions of human and faunal remains in ditches 3 and 4 (Valera & Silva, 2011; Valera *et al.,* 2014) (Table 2.1, above).

Although large quantities of charcoal and ashes were found in the deposit, the exposure to fire did not happen in the pit once there were no signs of fire *in situ*. The several SU in the pit were consistent with a 'cone' of deposition formed as the ashes and burnt material were thrown into the cavity. The presence of fragments of teeth and other very small pieces indicate a careful recovery of these remains from the place where the cremation took place, as well as the use of some kind of container for their transport to the final place of deposition (Silva *et al.*, 2013b).

The human osteological material was very fragmented and presented taphonomic alterations compatible with exposure to fire at different temperatures and time intervals (Valera and Silva 2011). Silva *et al.* (2013b) observed that most material was subjected to high temperatures over 900°C. All parts of the body were present in the sample in proportions that implied no apparent selection of body elements to be excluded from the funerary treatment. Human remains exhumed from pit 16 seem to have been cremated in different stages of decomposition (Silva *et al.,* 2013b).

The analysis of these human remains produced a MNI of 9 for pit 16. Six were adults and 3 non-adult individuals. Non-adult individuals were aged at 6-7, 11-12 and around 14 yrs. old respectively. At least one of the adults was aged around 20-25 yrs. old at death while another might have been a senior bearing cranial sutures that were almost obliterated (Silva *et al.*, 2013b).

Tomb 3 (Valera *et al.*, 2007) may probably be classified within the burial pits in the site, although this classification is uncertain since the monument was not completely excavated. During the excavation works in the necropolis, the archaeologists in the field opened a test area to confirm the existence of a third sepulcher. Investigation of this third monument was also intended to confirm or deny the homogeneity of architectural solutions within the necropolis and to broaden the knowledge of this particular area. Tomb 3 (Figure 2.3.1, above – number 4) is described as "a pit-like simpler structure (when compared to Tombs 1 and 2)" (Valera *et al.*, 2007: 55), 2 m in diameter and which lacks evidence of being connected to a more complex structure. Only superficial levels were excavated. Most of these consisted of disturbed layers and contained osteological materials, rich lithic industry, funerary ceramics similar to those excavated from Tomb 1 (globular vases fragmented *in situ*), beads and an idol figurine made of a faunal phalange.

The osteological sample recovered from the upper layers of Tomb 3 was rather small and very fragmented. MNI is 14, four of which are non-adults. Due to taphonomic constrains no other demographic data are available. The same limitations prevented morphological and paleolapothological analyses of the bones. As for the dental sample, no cariogenic lesions were observed. Tooth wear varies between medium and low degrees and enamel hypoplasias affected a little over 3% or the total sample (N=150) (Evangelista and Silva, 2013).

Finally, under the funerary levels of Assemblage 1 (see below) another pit containing human remains started being excavated in 2012 (Pit 40). Anthropological data for this funerary context are extremely preliminary (Silva *et al.,* 2013). See discussion below.

2.3.3. The atypical collective burial of Assemblage 1 (PDG-A1)

Assemblage 1 (Valera 2012a) is a funerary context in sector Q of Perdigões (Figure 2.3.1 – number 5). It has been under excavation since 2009, being successively enlarged due to new findings in its limits (Valera, 2011). By the time of the writing of this work, this context is still under excavation so data available so far is partial.

The upper levels of this funerary context lacked constructed limits (either positive or negative structures) (Valera 2012a: 111; Valera *et al.,* 2014) and held cremated and very fragmented human remains, fauna and industry (ivory figurines, arrowheads, beads and ceramic fragments) along with ashes. Very few 'raw' (uncremated) human bones and a single ivory figurine not submitted to fire were recovered. There is evidence of fire on fresh and dry bone (Silva and Cunha 2011; 2012; Silva *et al.*, 2013a). Different colors and shades exhibited by the osteological material (both human and non-human) point to a variety of time and intensity of exposure to fire (Walker *et al.,* 2009). The lower levels reached in 2012 seemed to contain a larger number of uncremated bones (Silva *et al.*, 2013a).

The osteological material and funerary pack were dispensed over a roughly circular structure made of middle-sized and large irregular stones covering and area of approximately 10 m^2. The lower levels which started being excavated in 2012 were held within a circular negative structure (Pit 40) (Valera *et al.,* 2014). Paleobiological data from these levels are included in PDG-A1 once the upper layers of human remains in Pit 40 overlapped its borders (Valera *et al.,* 2014: 22-23), composing the lower layers of what was up to 2012 defined as PDG-A1.

This is a secondary context bearing is no evidence of fire *in loco*. Despite that, very small pieces of osteological material (teeth, phalanges, unfused epiphyses, etc.) and industry (beads, small arrowheads) were exhumed from the deposit. This implies careful recovery of the material from the original cremation place (Valera, 2011; Silva and Cunha 2011; 2012; Valera, 2012a; Silva *et al.*, 2013a), as well as the possible use of containers to transport the cremated human remains and industry from the cremation site to its final place of deposition. Several large fragments of pottery containing incrustations of human remains and ashes were excavated from this context (Silva and Cunha, 2012). Those may have been part of the containers used in the transport of the human remains.

Teeth in this sample are highly altered by exposure to fire and most were fragmented. Thus, the identification and study of this material are extremely compromised. It is possible to notice that immature teeth with open apexes tend to resist fragmentation better than fully formed teeth (Silva and Cunha, 2011): fragmentation might be favored by pressure over the enamel of the crown due to the expanding and deforming dentin of the tooth under the action of fire. Open apexes might have allowed some relief of pressure, hence helping preserve the morphology of immature teeth.

Paleobiological data available (Silva and Cunha 2011; 2012; Silva *et al.*, 2013a) is partial and hindered by the taphonomic alterations of the osteological material. However, some preliminary information on the individuals buried in PDG-A1 can be inferred. Partial MNI in the sample was 105 (as by the end of the 2012 excavation campaign) and all age groups are present, including at least one fetus or neonate (40 gestational weeks, as estimated by measurement of the pubis) (Schaefer *et al.*, 2009).

Because of the fragmentation of bones, sexual diagnosis was possible in only one case. Applying the methodology proposed by Silva (1996a), a *talus* was determined as belonging to a male individual (Silva and Cunha, 2011).

The observation of alterations to the bones by both pathological processes and stress markers was limited. However, some cases of infectious diseases (*periostitis*), degenerative conditions (mainly osteoarthritis in the foot/hand bones) and traumatic lesions were found. Most cases of trauma were on foot phalanges. One case of trauma, possibly a trepanation, was found on a fragment of parietal bone. Bone remodeling in the margins of the lesion indicate that the individual survived the trauma long enough for the formation of regenerative new bone tissue (Silva and Cunha 2011; 2013; Silva *et al.*, 2013a; Silva *et al.*, in press).

2.3.4. Collective burial tombs in the 'necropolis'

The first systematic archaeological survey of Perdigões enclosure defined a dichotomy between a 'domestic' area and a 'necropolis' of what was then considered a settlement (Lago *et al.*, 1998). Despite the change in the interpretation of the site, the term 'necropolis' is still in use to determine a semicircular area between ditches 1 and 2 (Figure 2.3.1, above), although as Valera (2012a) points out the term has lost part of its meaning once human remains and evidence of funerary practices are dispersed in several areas of this site. This space between the outer ditches seems to have been built with "the specific purpose to include an area of inhumations perfectly structured in function of the spaces in which it is inserted" (Evangelista, 2003: 96).

According to Lago *et al.* (1998) the orientation of the necropolis eastward emphasizes the importance of that cardinal point "full of religious meanings", it establishes a relationship with the cromlech also to the east and it functions at the same time as a secluded space related to the ancestors and as an "entrance or passage" to the enclosure (Lago *et al.,* 1998: 146). The area location, orientation and symbolic analogies have been addressed and detailed by further literature (Valera *et al.,* 2000; Valera, 2008b; Valera and Becker, in press).

The necropolis covers an area of 4400 m^2. Surface survey indicated the existence of 7 or 8 tombs within its limits and the possibility of others beyond them. Posterior excavations confirmed the existence of at least 3 collective sepulchers and later geophysical survey of the area indicates that there must be at least one similar tomb outside its limits to the east (Lago *et al.*, 1998; Valera *et al.*, 2000; Valera *et al.*, 2007; Valera and Becker, in press).

Between 1997 and 2006 tombs 1 and 2 located in the necropolis were completely excavated (Evangelista, 2003; Valera and Godinho, 2009). Both monuments might be described as a '*tholos*-like' structures, fitting in what Valera *et al.* (2000: 94) consider "collective tombs [presenting] general architectural features slightly variable and common religious background", although both lack structural elements traditionally associated with typical *tholoi* tombs (such as a corbelled dome/roof).

A third monument in the necropolis was only partially excavated (Valera *et al.*, 2007). This monument was identified as a burial pit (see discussion above, on burial pits).

2.3.4.1. Tomb 1

Tomb 1 is a partially underground structure excavated in the soft local bedrock and located in the center of the necropolis (Figure 2.3.1 – number 6, above). It is divided in 3 spaces: a circular chamber, a short corridor and an *atrium* (Figure 2.3.2). There is no archaeological evidence of a *tumulus* or cairn covering Tomb 1 (Lago *et al.*, 1998; Evangelista, 2003). Its archaeological excavation took place between 1997 and 2001.

Figure 2.3.2 – Sepulcher 1 during excavation. Photography by Miguel Lago, adapted from Cunha *et al.*, 2013)

The chamber is a circular space measuring around 3.5 m in diameter and might have reached 1.6 m high. Its walls were covered with thin schist slabs placed vertically along the excavated walls. A layer of clay held the slabs against the rock and may have served as insulating material for the structure. On the north side of the chamber a small compartment was also made of schist slabs (Lago *et al.*, 1998; Valera *et al.*, 2000). This space was intensively used for successive systematic deposition of disarticulated osteological elements. Even during later stages of the monument, when some of the stone slabs had collapsed, deposition continued forming layers of osteological material over fallen slabs. Human osteological remains were distributed in 'clusters' containing several bones under no apparent selection criteria (Valera *et al*., 2000), as if there was the "intention of not perpetuating the memory of the individual beyond death who seems to be incorporated in the global collective of the community" (Valera *et al*., 2000: 103).

The funerary package excavated from the chamber included: ceramic and stone vases; arrowheads; flint knives; industry on bone and ivory (figurines, a staff, a decorated cup, etc.), and beads (Valera *et al*., 2000; Valera, 2010). Animal bones and a partially articulated skeleton of a fox were also deposited along with the human bones (Valera *et al*., 2000; Cabaço, 2009). Funerary items in the chamber also included quartz rocks as well as pigments (lime white, ochre and cinnabar) (Valera *et al*., 2000; Evangelista, 2003; Emslie *et al*., 2014).

The corridor is a sub-rectangular 1.8 m long passage oriented eastward (89.5°) towards Monsaraz hill. It was seriously compromised by historic taphonomic processes related to the use of the land for farming. The walls in this section were partially covered by schist slabs. There was no funerary use of this space and industry seems to be intrusive, brought into the corridor by post depositional processes. There is no archaeological evidence of any kind of permanent roof for the corridor (Lago *et al.*, 1998; Valera *et al*., 2000).

The atrium is a semi-circular area, also excavated in the bedrock measuring around 2 m in diameter. Its limits to the east were destroyed, but the excavators believe there must have been an entrance on that side (Lago *et al*., 1998; Valera *et al*., 2000). A badly preserved structure made of burnt clay was excavated at the bottom. This structure is similar to other fireplaces in the region and Valera *et al*. (2000) hypothesize its ritual use of fire in the first stages of the monument. By the time of that publication, the authors believed that there was no sign of fire on the bones and funerary items, a fact latter dismissed during the anthropological assessment that resulted in this work. In fact there is evidence of thermal alteration in few bones and teeth from both Tombs 1 and 2, none of which were excavated from the atrium.

Deposition of items in the atrium of sepulcher 1 consisted of votive objects: funerary ceramics, some of which seem to have been decorated with inlayed crushed bone material (Lago *et al.*, 1998; Evangelista, 2003; Odriozola, 2008); limestone vases; a lithic halberd, and *pecten* shells. Human bones are rare and probably deposited unintentionally by taphonomic agents (Lago *et al.*, 1998; Valera *et al*., 2000).

Based on the relative frequency of bones Lago *et al.* (1998) and Valera *et al.* (2000 and 2007) defend that the human remains buried in Tomb 1 are in a secondary context. The hypotheses Valera *et al.* (2000) put forward for the formation of the deposits in both tombs are:

A – The first burial and the consequent decomposition of soft tissues of the cadavers could have taken place in other nearby tombs and bones would then be transported to their final place of deposition in Tombs 1 and 2;

B – This first phase would take place in "perishable structures" (Valera *et al.,* 2000: 101) inside the enclosure. There would be almost no trace of such graves nowadays but some isolated bones lost during the first exhumation and transport to the tombs in the necropolis;

C – The first burial would have happened in places outside the enclosure, now undetectable, and bones would be given a second burial in Tombs 1 and 2 which would assume a specific symbolic role in the funerary process. Valera *et al.* (2007) propose that the individuals buried in Tombs 1 and 2 might have come from nearby villages, under the influence of PDG. Supporting this theory, the authors point to very little occurrence of 'sacred' or funerary evidence in nearby habitat sites.

D – Both first and second depositions would take place within each tomb and bones would be re-arranged after decomposition of soft tissues. However the authors had not found any evidence of the first phase in the sepulchers by then.

However, it is important to notice that the excavation of both tombs was not finished at the time these hypotheses were made (Valera and Godinho, 2009). Only after the publication by Valera *et al.* (2000) an articulated foot was excavated from Tomb 2 (Valera and Godinho, 2009) and it still presented the distal phalanges in skeletal articulation with the remaining bones (Evangelista, 2003: 104). Considering that the extremity of hands and feet are held in place by some of the most labile articulations of the human skeleton (Duday, 2006), that foot was probably deposited in the tomb prior to the decomposition of its soft tissues. There are no cut marks on the tarsal bones (personal observation). Valera *et al.* (2000) and Valera and Godinho (2009) are not clear as to which anthropological method was used to obtain the relative frequency of "dominant" bones used to support their thesis on the secondary nature of the deposit of human remains. Finally, during the course of lab analysis for this work, the author observed that inventory of Tomb 1 was partial, once not all bones had been removed from the sediment matrix and identified. Many bones and teeth were still *en bloc* in tin foil sealed packs from the field. Hence Valera *et al.* (2000) and Valera and Godinho (2009) must have based their assessment of bone proportion on a partial sample of identified bones and teeth.

A preliminary paleobiological study of the osteological material (Valera and Godinho, 2009) produced a partial count of 2054 identified teeth for Tomb 1 distributed among 60 fragments of mandible, 40 fragments of maxilla and an unknown number of loose teeth. MNI for Tomb 1 would be 101 based on the first lower molar, a number the authors say is compatible with the one produced by the first upper molar (N=99). The laterality of those teeth is not informed by Valera and Godinho (2009).

2.3.4.2. Tomb 2

Tomb 2 is a partially underground structure excavated in the bedrock. Located at 20 m northeast of Tomb 1 in the necropolis (Figure 2.3.1 – number 7), it is typologically similar to the previous monument (divided in 3 spaces: a circular chamber, a short corridor and an *atrium).* Tomb 2 is oriented to the southeast (130°) and there is no archaeological evidence of a *tumulus* or cairn covering it, neither of any type of rocky roof in any of its areas (Valera *et al.*, 2000). Excavation of this monument was carried out between 2000 (Evangelista, 2003) and 2006 (Valera and Godinho, 2009).

The chamber is a sub-circular room, 3 m in diameter, whose walls were covered in schist slabs. It is connected to the atrium by a short corridor flanked by 4 small orthostats (Valera *et al.*, 2000). The atrium presented ellipsoidal design and was heavily used for deposition of human remains (Evangelista, 2003).

The osteological material was deposited in the atrium along with limestone vases; a limestone figurine; industry on bone, ivory and antler (figurine, plaques, a knife shaft, pins); plain and decorated ceramics; very little lithic industry, and shells (1 *Pecten sp.* and 2 *Patella*). Ochre was used in the atrium of Tomb 2 (most of it yellow) (Valera *et al.*, 2000).

Ceramic industry in both tombs is characterized by the presence of small vases or parts of vases whose fragments are many times in connection, apparently configuring intentional deposition. These are non-domestic items. The fragments of domestic ceramics are small, weathered and their forms are not re-constructible leading the authors to suppose their presence in the sepulchers is not intentional. They offer 3 possible explanations for that: (1) these fragments might have been brought by taphonomic agents from possible nearby habitats; (2) they result from accidental events during phases of construction, remodeling and reconstruction of the monuments; (3) they were intentionally brought there along with sediments from habitat areas (Valera *et al.*, 2000).

The funerary use of Tomb 2 is divided into three or four phases (Valera and Godinho, 2009): the first one is characterized by the deposition of few sparse bones in the chamber; the second one is marked by the placement of a door sealing the passage from the *atrium* to the corridor increasing the deposition in the *atrium*; the third one starts when the door falls and deposition of human remains continue on the top of it; a probable fourth phase was a later re-utilization of the chamber delimited by a trapezoidal 'structure' made of schist slabs and a small menhir in the southwest area of the chamber containing human remains. The presence of fragments of gold plaques and a V-shaped ivory button associates this last phase culturally with Bell Beaker groups.

There is no paleobiological study for the human remains in Tomb 2 of PDG. The paleodemography of this sample remains unknown so far. However, the present work has revealed some data on that matter (see Chapter 5). The presence of both adult and non-adult individuals has been registered (Cunha *et al.*, in press). Afonso and contributors (2013) have also demonstrated via DNA analysis that both male and female individuals are found in this series.

2.4. The articulation of PDG1 and PDG22 with their surroundings and beyond – archaeological data

The study of the archaeological materials in the funerary pack accompanying the human remains exhumed from Tombs 1 and 2 has been explored as one of the sources of information on the communities that made use of those funerary contexts in PDG (Dias *et al.,* 2008; Schuhmacher, *et al.,* 2009; Odriozola *et al.*, 2010; Schuhmacher and Banerjee, 2012). The basic idea is that if PDG worked as a local or regional center for the funerary treatment of the dead, items deposited along with the human remains might help understand the origin of the people inhumated in the site.

Following this line of reasoning, the archaeometric analysis of ceramic samples from the site has been carried out by Dias *et al.,* (2008). Their work consisted of comparing the chemical composition of clay used to produce ceramics excavated in PDG with local raw materials available in clay deposits in different geological contexts in the region. Samples under study included: (1) "funerary ceramic items" from Tomb 1 (N=39) and Tomb 2 (N=10), and (2) "common ceramics" from Tomb 1 (N=29), "a pit nearby Tomb 2" (Dias *et al.,* 2008: 119) (N=10) and from the interior of the enclosure (N=44).

The definition of "funerary" and "common" or "domestic" ceramics is explained by Valera *et al.* (2000: 96-99) based on spatial and statistical analysis of ceramics recovered from PDG and on the study of the formation of archaeological deposits. The first category includes small objects whose morphology presents little variation and which have not been found in non-funerary contexts in the site. These are usually well preserved and fragments are *in situ*, allowing the reconstruction of forms/vases. On the other hand, the second category consists of fragments of larger objects, more varied in terms of morphology and present in both funerary and non-funerary contexts. These are usually very weathered and not *in situ.*

The results obtained by Dias *et al.,* (2008) show that ca. 50% (represented by both funerary and common ceramics) present chemical homogeneity. A second group (ca. 30% of the sample, including both common and funerary items) was characterized by more heterogeneous raw materials from different sources. A third group (ca. 20% of the sample) presented the most varied chemical composition and included only funerary items from Tomb 1. The ceramics in group 1 and 2 were made of clays from geological strata (gabbro diorites, granodiorites and tonalites) within a 5-km radius of the site. The ones in group 3 were produced with raw material from deposits beyond that radius. A single item, a funerary vase from one of the tombs does not come from regional raw material and was excluded from the analysis as an outlier, although the very fact that it comes from an even further region is significant to the point defended by the authors.

Although this study does not imply a necessary provenance for the people buried in PDG, it opens two possibilities: the site might have served for immediate and surrounding populations as a local of aggregation for some of the funerary uses (Valera *et al.*, 2007) or these goods were circulating locally in a system of regional trade. Both possibilities might have happened, once trade of exotic goods from even further regions is registered in the archaeological record of Perdigões.

One such example might have been the variscite beads excavated from Tomb 1 and 2 of PDG (Odriozola *et al.*, 2010). Variscite is a rare green green-bluish hydrated aluminum phosphate whose hardness (4.5 Mohs scale) (Kniep *et al.*, 1977) allows it to be polished. A sample of 20 green beads excavated from Tomb 1 (N=10) and Tomb 2 (N=10) were randomly selected from a set of over 3000 green beads recovered from each tomb. The sample was then analyzed using x-ray diffraction and x-ray fluorescence in order to obtain their mineralogical characterization (Odriozola *et al.*, 2010). Being a rare gem, the sources of variscite in the Iberian Peninsula are few (only five are listed by the authors) and the characterization of the minerals from each one is well known. Final results of this analysis have proven that 3 of the beads selected were not variscite. All the remaining beads were indeed variscite and the tests proved that they were compatible with raw material from the quarry of Pico Centeno, Encinasola, north of Andalucía, nowadays in Spanish territory (Odriozola *et al.*, 2010). Provenance of the raw material for the beads is located around 70 km southeast of PDG, implying some kind of trade, either direct or indirect with communities on the opposite margin of the Guadiana River.

Another kind of exotic material found in both Tomb 1 and 2 (and in other funerary contexts of the site) is ivory. This material may come from either faunal fossil remains or extant taxa. Three sources are locally available in the paleontological record: (I) *Elephas (Paleoloxodon) antiquus*, a native subspecies of elephant which was extinct by the Neolithic-Chalcolithic; (II) mammoth (*Mammuthus primigenius*), and (III) *Hippopotamus amphibius antiquus* (O'Regan, 2008; Schuhmacher *et al.,* 2009; Álvarez-Lao and García, 2012). Ivory may also come from extant sperm whales (*Physeter catodon*) locally available. Finally, it may come from exotic fauna as imports: hippopotamus (*Hippopotamus amphibius*), walrus (*Odobenus rosmarus*) and different species within the *Elephantidae* family (Schuhmacher *et al.,* 2009). Within this family ivory from two species has been found in Chalcolithic sites in the Iberian Peninsula: *Loxodonta africana* (African savannah elephant) and *Elephas maximus* (Asian

Elephant) (Schuhmacher *et al.,* 2009; Schuhmacher and Banerjee, 2012; García-Sanjuán *et al.,* 2013).

Ivory varies in hardness, translucency and chemical composition depending on the diet of the animal, as well as on the habitat and geology it lived in. Ivory tusks are composed by an outer layer of dentine and an inner layer of cementum surrounding the pulp cavity. The dentine is characterized by the presence of microscopic tubules radiating from the center of the tusk (Schreger structures) whose morphology is diagnostic for genera, species and subspecies of taxa using Fourier Transform Infra-Red (FTIR) techniques (Schuhmacher, *et al.,* 2009). Isotopic analyses have also been used to source ivory in archaeological contexts (Schuhmacher and Banerjee, 2012).

Although fossil ivory has been found as both raw material and finished objects, its figures are by far a minority when compared with other kinds of ivory in Chalcolithic contexts (Schuhmacher and Banerjee, 2012). That might be attributed to the quality of the fossilized material found in the Iberian Peninsula. Schuhmacher *et al.* (2009) argument that it is too fragile to carve when compared to 'raw' ivory from imports.

Objects in ivory are known to exist in archaeological contexts in Portugal since the XIX century. Estácio da Veiga (1886: 145-257) lists a series of objects from the tombs of Nora and Marcela (Cacela, Algarve, Portugal) made in ivory, presenting drawings for some of them. It is interesting to notice that one of these objects (a fragment of a decorated plaque) presents the same decorative pattern and roughly the same shape of a knife sheath also made in ivory from the Chalcolithic tomb of PP4-Montelírio (Valencina de la Concepción, Sevilla, Spain) (Garcia-Sanjuan *et al.*, 2013). In his 1889 work, Estácio da Veiga lists a series of ivory goods from the Chalcolithic settlement of Alcalar (Algarve, Portugal), besides pieces of raw material, including segments of tusks (Estácio da Veiga, 1889: 213-224). The author proposes three hypotheses for the existence of these goods and raw material in the south coast of Portugal: (I) the ivory would have arrived in Portugal from North Africa by maritime trade through the Mediterranean; (II) it could have been extracted from fossil ivory from possible paleontological deposits; (III) the ivory could have come from remains of a hypothetical local population of elephants still living in Neolithic times.

Some more recent studies have focused on the origin of the ivory found in several Late Prehistoric sites in the Iberian Peninsula including finished objects and debris from crafting of raw material from PDG (Schuhmacher *et al.,* 2009; Schuhmacher and Banerjee, 2012; García-Sanjuán *et al.,* 2013). The results of these studies point to the existence of different long range trade routes that would bring both African and Asian ivory into the Iberian Peninsula in the Late Prehistory (respectively from *L. africana* and *E. maximus*).

One of these routes would bring Asian ivory probably from or through Syria, since populations of *E. maximus indicus* (Indian elephant) are known to extend from India through

Mesopotamia and Syria up to the Mediterranean coast in Holocene times (Schuhmacher and Banerjee, 2012). This route would find trading centers in the great enclosures and settlements of Southeastern Iberia such as Valencina de la Concepción and Los Millares, being distributed along the Guadalquivir basin where ivory from *E. maximus* prevails in the archaeological record (Schuhmacher and Banerjee, 2012; García-Sanjuán *et al.,* 2013).

However in the western Chalcolithic sites of the peninsula in which the analysis has been carried out, most ivory comes from *L. africana*. Similarly to what happens in the east, Schuhmacher and Banerjee (2012) defend that key sites on the Atlantic shore (in the Portuguese Estremadura and Algarve), in the Tagus River Basin and in the Mid Guadiana basin would work as distribution centers for both raw materials and finished ivory goods. This ivory would come from North Africa, probably from the area of present-day Morocco where the archaeological record bears evidence to the existence of *L. africana* in Chalcolithic times. Both the crafting of this specific kind of ivory and Bell Beaker industry are found in this Maghrebian region, probably attesting the trade between Iberia and North Africa at the time (Schuhmacher *et al.,* 2009; Schuhmacher and Banerjee, 2012).

All ivory pieces from Tombs 1 and 2 (including both debris and finished objects) examined in the course of those studies have proved to come from *L. africana* (Schuhmacher *et al.,* 2009; Schuhmacher and Banerjee, 2012). Considering the location of the site and the kind of ivory excavated from it, we might infer that Perdigões was served by a long range trade network of African ivory in the Guadiana basin.

2.5. The archaeological context of Cerro de las Baterías in the third millennium BC

The site of BT07 is located in the flood plain of the La Albuera River and its two tributaries (the Nogales and the Pizarra Creeks). This river system is located in the western peneplain of the Guadiana and flow into that major river (Márquez-Gallardo, 2008).

In the Copper Age, BT07 would be in the territory of Tierra de Barros controlled by one of the largest ditched settlements in the Iberian Peninsula: La Pijotilla. This territory, as defined by Hurtado (1999: 51-52), is a roughly triangular area (Figure 2.6.1) protected in the north by the Guadiana River and beyond that by the natural topographic defenses of the Sierra Morena, and to the southwest and southeast by a series of fortified settlements (Hurtado, 1999). A well-defined pattern of regional occupation of this landscape has been established in the archaeological literature on that period (Hurtado 1986; 1999; 2008; 2010).

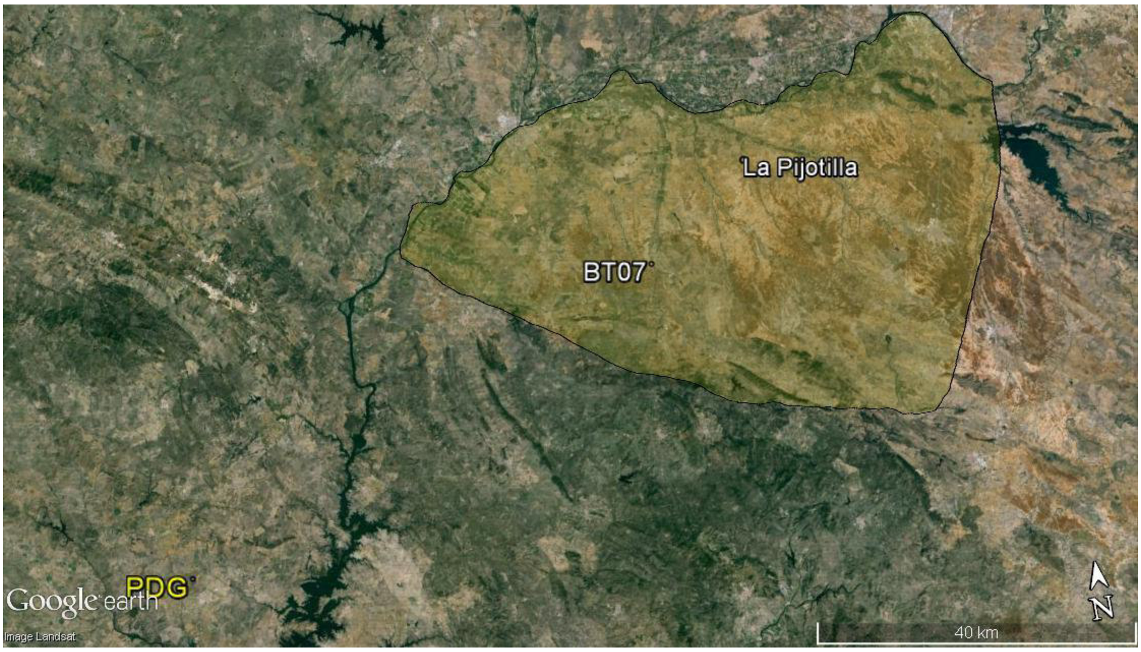

Figure 2.6.1 - Location of BT07 17.5 km to the southwest of La Pijotilla in the Tierra de Barros (highlighted), Badajoz, Spain. On the south west (across from the Guadiana River): PDG. Image adapted from: Google Earth™, date of caption: January 25, 2015.

In this geographical context, La Pijotilla is considered the largest and most important Chalcolithic village (Hurtado, 1999). The low-relief peneplain of Badajoz concentrate optimal lands for agriculture, one of the reasons suggested for its concentration of archeological sites associated with farming communities of the Late Prehistory (Hurtado, 1999). Between the end of 4th and the beginning of the 3rd Millennia BC the region reaches its largest demographic increase (Odriozola *et al.,* 2008).

In the beginning of the 3rd Millennium BC most of the population is concentrated in the north and south regions of the Extremadura peneplain (near the present-day border with Portugal). In the second half of that millennium, Copper Age communities spread their habitation sites through the tributaries of the Guadiana and smaller rivers, settling preferably in lands with high agricultural potential, but also in those less favorable. These communities benefit from the natural resources and technological improvements to consolidate the economy based on the surplus of goods. That helped maintain the hierarchical *status quo* of cohesion in the territory (Hurtado, 1986; 1999; 2008).

In such agricultural groups some level of hierarchical organization is expected in order to recruit enough manpower to farm the land and maintain the control over the territory. Population growth required and fomented the aggregation of families, clans and smaller groups into larger communities sharing a similar lifestyle and cultural background. These cultural traits are expressed in the material culture in the archaeological record (Hurtado, 1999; Díaz-del-Río 2004a; 2004b; 2013).

Smaller settlements are believed to have functioned as satellite communities in the political and economic range of larger villages. These latter worked as centers of regional power and as trade centers not only for local goods, but also exotic materials (Hurtado, 1999; Kunst, 2006; Schuhmacher and Banerjee, 2012; Díaz-del-Río 2013; García-Sanjuán *et al.*, 2013). In the Copper Age, there is an increase in the use and dissemination of ideological and technological items of material culture. Those are particularly visible in the items found in the funerary contexts (Hurtado, 1999; Márquez-Romero, 2007; Díaz-del-Río, 2013).

The outer ditch of La Pijotilla encloses an area of almost 80 hectares and has a diameter of around 940 m. Absolute dates obtained for the site settle its use between the last century of the 4th and the last quarter of the 3rd Millennium BC. The final phase of occupation in the site is characterized by the presence of Bell Beaker material culture in the center of the settlement and in the materials excavated from one of its tombs (Tomb 3) (Hurtado, 1986; Odriozola *et al.,* 2008). So far both domestic and funerary contexts have been excavated in La Pijotilla. Among the funerary structures found in the site there are pit burials in different areas and at least two kinds of larger collective sepulchers in its eastern section (Hurtado, 1986; 1999; Hurtado *et al.*, 2000). The presence of these tombs and surface evidence of others helped identify a zone of necropolis inside the outer ditch (Hurtado, 1986).

The collective tombs 1 and 3 are *tholos*-like structures excavated in the bedrock and clay soil whose corridors extend through two ditches conforming a V-shaped entrance to the monuments (Hurtado, 1986; Hurtado *et al.*, 2000). Both tombs are architectonically similar to the tomb of BT07: they are divided into a chamber and corridor and there is very little evidence of the use of schist in the construction (except for the presence of that material next to the entrance of the chambers). The tombs in La Pijotilla seem to have had some kind of corbelled dome/roof while there is no such evidence in BT07 (Hurtado, 1986; Hurtado *et al.*, 2000; Márquez-Gallardo, 2008). This absence in BT07 might be explained by the complete destruction of its upper levels (Márquez-Gallardo, 2008) or because like many similar *tholos*-like sepulchers (Valera *et al.,* 2000) this architectural element was never built for this tomb.

La Pijotilla´s collective tombs 1 and 2 were used for primary burials. Partial MNI for Tomb 1 (based on accounts in the field) is 100, in Tomb 3 it is 178, while for Tomb 2 MIN is 30 (Hurtado, 1986; Hurtado *et al.*, 2000; Diaz-Zorita, 2013). So far, there is no published anthropological study of the sample from Tomb 1. Tomb 3 on the other hand has been subjected to a recent paleobiological study (Diaz-Zorita, 2013).

Complete and partial skeletons, anatomical connections and the association of compatible bones in close distance have been exhumed from Tomb 3, indicating primary inhumations took place in this tomb (Diaz-Zorita, 2013). Whenever the original position of the body was observed, the individuals were placed in flexed position lying on either right or left side and most times oriented westward (towards the entrance of the chamber) (Hurtado *et al.*, 2000; Diaz-Zorita, 2013).

The disarticulation of most of the bones in these tombs is understood as a consequence of the revisiting and reorganization of human remains mainly in order to add later corpses to the funerary space (Hurtado, 1986; Hurtado *et al.*, 2000). Although bones exhibited signs of *post mortem* manipulation, there were no visible signs of weathering of the bone surface. That is considered as evidence that the decay of soft tissues happened in an open space inside the tomb protected from the action of taphonomic agents such as fauna, flora and weather (Hurtado *et al.*, 2000).

Tomb 2 of La Pijotilla is architectonically different from the other monuments, consisting of a circular chamber (roughly 3.8 m in diameter) presenting no corridor. The closest parallel to the architecture of this monument are the Bronze Age tombs of the nearby site of Guadajira (Hurtado, 1986; 1999; Hurtado *et al.*, 2000).

The funerary pack excavated from Tomb 2 is considered more varied than the ones excavated from the older two collective tombs. Besides the existence of types of items not found in the other sepulchers (a wider variety of figurines, industry on marble, etc.), Bell Beaker ware was found in this collective sepulcher of La Pijotilla. This kind of ceramic industry sets the relative chronology of Tomb 3 in the late Chalcolithic *i.e.,* more recent than Tombs 1 and 2. The architecture of this sepulcher along with the presence of later ceramics suggest the use of this monument to the end of the Copper Age (Bell Beaker Chalcolithic) (Hurtado, 1986).

The introduction of Bell Beaker industry in the region by the end of the 3rd Millennium BC would not bring drastic changes in social and economic contexts of the local farming communities. Although regarding the funerary aspects there is a noticeable change in the architecture of the funerary monuments: corridors disappear and monuments decrease in size. The funerary pack also becomes more sophisticated and the number of individuals per sepulcher decreases – a tendency that will lead to the individual burials in the Bronze Age (Hurtado, 1986; 1999; Hurtado *et al.*, 2000).

Figurines and anthropomorphized utensils were found in both funerary and non-funerary contexts in La Pijotilla. Rather than the objects themselves, the use of common formal aspects (as defined in Stokstad, 1995) in their execution (*medium*, form, style, and iconography) might be unifying elements linking a shared funerary/cultural imagery among the communities in the Middle Guadiana Valley (Hurtado, 1980; 1981; Valera and Evangelista, 2014).

The most sophisticated anthropomorphic elements of this kind are probably highly naturalistic figurines (Figure 2.6.2) depicted in a standardized ('canonic') posture (Valera and Evangelista, 2014) and sharing formal attributes such as: (I) large eyes sometimes framed by lines conforming cilia and eyebrows; (II) curved lines below the eyes suggesting either beard or facial tattoos; (III) zig-zag lines on the head and down the back (and sometimes front) of the torso. Whenever there is a suggestion of gender, the figurines bear depictions of genitalia and for the female ones small volumes in the upper torso conforming 'breasts'. Rarely details will also include ears. When the arms are depicted, they are usually represented folded on the torso and sometimes present details such as the suggestion of fingers. Some figurines are portrayed carrying a scepter-like object usually interpreted as a symbol of hierarchical power.

Figure 2.6.2 – Naturalistic figurine in ivory from the sector Q, Assemblage 1 cremation deposits, Perdigões (Reguengos de Monsaraz, Portugal).

The formal aspects of this imagery (form and style) are well described in the literature and its distribution is known to happen different *media* (lithic plaques and '*baetyls*', figurines, ceramics) in the most important Copper Age sites in Iberia (Lago, 1998; Hurtado 2006; Márquez-Gallardo, 2008; Hurtado, 2010; Valera 2011; 2012a). Its existence stands as a unifying cultural element which was sometimes employed in the funerary treatments of the dead, accompanying them in their funerary spaces. Geographically, it is spread through Iberia and neighboring France during the Neolithic and Copper Age (see among many others by: Arribas Palau, 1977; Hurtado 1980; 1981 Bécares, 1990; Enríquez-Navascués and Rodriguez, 1990; Enríquez-Navascués, 2000; Gonçalves, 2003; Hurtado, 2006; Cacho *et al.*, 2010; Valera and Evangelista, 2014).

2.5.1. The tomb of Cerro de las Baterías

So far, the archaeological information available on the tomb of Cerro de las Baterías (BT07) comes from the archaeological reports of the excavation of the tomb in 2007. Land survey of the surrounding areas evidenced a possible small Chalcolithic settlement nearby the sepulcher (Márquez-Gallardo, 2008).

The tomb of Cerro de las Baterías (BT07) is a funerary monument located on a small hill between the Nogales and Pizarra Creeks (tributaries of the La Albuera River), at an altitude around 255 m above sea level in the southern limits of the town of La Abuera, Badajoz, in the Spanish autonomous region of Extremadura (Figure 2.6.3).

Figure 2.6.3 – Location of BT07 on the south of the town of La Albuera, Badajoz, Spain. Image adapted from: Google Earth™, date of caption: January 25, 2015.

In 2007, during the construction works of the road N432 (Badajoz – Granada, in the vicinity of La Albuera), workers noticed the presence of bones when moving sediment in one of the sides of the older road to Jerez de los Caballeros. Those bones were later considered to be part of the human remains from an Early Middle Age cemetery (8th Century AD), partially destroyed by the construction of the older road. The construction was suspended at that section and heritage authorities at the Dirección General de Patrimonio (Junta de Extremadura, Spain) were notified. The archaeological excavation work was commissioned to Tera S.L. Archaeological Services, taking place between June and November of 2007. The collective sepulcher of BT07 was discovered only in the last month of excavation (Márquez-Gallardo, 2008).

The area affected by the construction works was a highly anthropized landscape even before the 2007 works. It had been modified by intensive agriculture, by the expanding urban area of La Albuera and by the construction of the road to Jerez de los Caballeros. This later alteration caused the removal of top soil in many sections of the land nearby. Contributing to the destruction of the archaeological remains, this area was looted for metal pieces in recent years (Márquez-Gallardo, 2008).

'Cerro de las Baterías' (Spanish for 'Battery hill') has particular historical relevance once it was the war theater of an important battle during the French invasions of Spain. Unfortunately the location of the 1811 battle and the artillery batteries set on top of the Chalcolithic funerary monument would have taphonomic implications on the conservation of the human remains buried in the site.

All information included in this section is presented in full on the excavation report by Márquez-Gallardo (2008), except when referenced otherwise. There was no anthropological specialist in the field, so most information on the funerary anthropology of this osteological sample comes from the archaeological notice and laboratorial conclusions drawn by Tomé (2011).

The archaeological survey established two zones for immediate intervention by the road. These would be completely destroyed by the construction works (Zone 1 and 2). Both areas were poorly preserved and most archaeological levels remaining consisted of either negative structures (silos, post holes, etc.) or lower levels of positive ones (floors and foundations of walls). Archaeological survey also detected a third area with archaeological interest closer to the town (Zone 3) (Márquez-Gallardo, 2008).

Zone 1 was characterized by the existence of an Islamic occupation (9th Century) including 27 storage silos. Zone 2 held more diverse archaeological levels from prehistoric and historic chronologies. The Chalcolithic tomb discussed in this study represented its oldest remaining archaeological levels (Márquez-Gallardo, 2008).

Bronze Age structures in Zone 2 included 13 silos or pits and an L-shaped ditch running north-south and east-west presenting a 5.84m 'gap' (maybe a door). Among the pits, two contained human remains. Pit 68-1 contained a fragment of a left human femur of an adult individual among osteological faunal remains (MNI=1). Pit 83 contained several bones consistent with a single adult individual (MNI=1). The archaeologists did not notice any skeletal connection. The only funerary item found in the sediment pack was a bronze ring (Márquez-Gallardo, 2008).

Early Medieval levels in Zone 2 belonged to a sepulcher by the road limits. Because of remaining funerary evidences, the archaeologists believed it could have been part of a cemetery destroyed by the construction. The only burial preserved contained most of the skeleton of a single adult individual (Márquez-Gallardo, 2008).

Later archaeological levels in this area consisted of an Islamic settlement. Archaeological structures of that phase included foundations, floors, hearths and 63 storage pits. Material culture sets the relative date for this occupation in the 9th Century. Stone construction materials in this region are scarce and most of the available rocks are pebbles from riverine deposits. Many of the Islamic pits were covered by them after condemned. This material was also used along with clay binders to build foundations of rammed-earth (*taipa*) walls and floors (Márquez-Gallardo, 2008).

Finally, Zone 3 was submitted only to survey and collection of archaeological materials on the surface. Material culture is compatible with a domestic Chalcolithic area, probably associated with the tomb excavated in Zone 2. Unfortunately Zone 3 was not subjected to further archaeological intervention (Márquez-Gallardo, 2008).

The Chalcolithic tomb of BT07 was discovered when archaeologists removed part of what was thought to be an Islamic structure made of pebbles and sediment (Figure 2.6.4). Among these, some very fragmented bones were recovered and the whole structure was found to cover the collective grave.

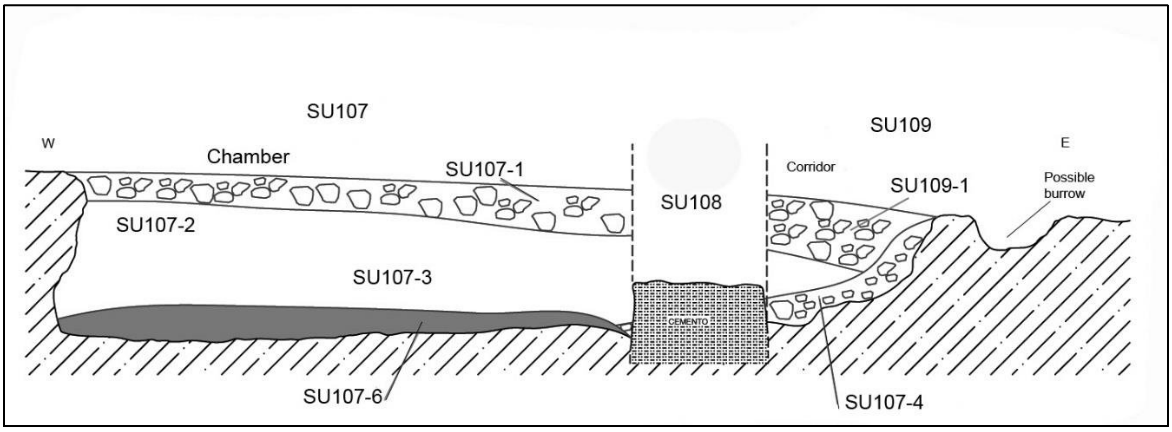

Figure 2.6.4 – Stratigraphic profile of BT07 tomb. Adapted from Márquez-Gallardo (2008), Plan 15/15.

The tomb was excavated in the local clay-silt sediment locally known as '*caleño*'. There is no evidence of stone materials used to cover either walls or floor except for a schist slab still standing by the entrance of the chamber during excavation. Some fragments of schist were also found among the human remains. The monument is divided into a circular chamber with a diameter of around 3.1 m and an irregular corridor oriented to the southeast. The chamber was around 80 cm deep and the deposit containing human remains was 54 cm deep. The corridor was affected by the construction of a Contemporary ditch for telephone cables. The remaining area of the corridor is 1.8 m long and 1.63 m wide. Human remains were mainly deposited in the chamber, but some were also excavated from the corridor where they were probably transported to by post depositional agents. The funerary pack included ceramic, lithic and bone industries consistent with regional Copper Age material culture from the beginning of the 3rd Millennium BC. Layers of ochre were used prior to the deposition of bones.

The monument was excavated using the methodology proposed by Harris (1997), hence the archaeological layers (or stratigraphic units, SU) were defined and excavated according to their depositional order (Figure 2.6.5). The human bones were highly fragmented and some were consolidated with the use of Paraloid® resin in the field before being collected. Drawings were made for the largest bones and *crania*. These were numbered in the field. Other graphic documentation of the sample includes photographs.

Figure 2.6.5 - BT07 during excavation. The disturbance caused by a Contemporary ditch (SU108) is seen in the intersection between the chamber and corridor. A single schist slab stands by the door of the chamber. Photography by José Márquez-Gallardo. Image repository at Tera S.L., Merida Spain.

Although the excavation was carried out with the best care by the professionals in the field, it had some constraints typical of salvage archaeological works such as pressing time limits. The lack of anthropological field work also contributed to the loss of important information on the funerary anthropology of this sepulcher.

C14 dates for the osteological material from BT07 are not available so far. An attempt was made to date the material, but the samples selected did not provide enough organic material to be processed.

The funerary pack excavated along with the human remains included: manual ceramics, both plain and decorated; ochre; lithic industry on flint (blades and arrowheads) and on quartzite (blades and cores); industry on bone, *Sus’s* teeth and antler, being the most common needles and ‘spatulas’; an engraved schist slab, and 143 beads which were found in clusters varying in number from two to thirty seven.

This funerary pack is typologically compatible with the one found in the Tomb 1 in the site of La Pijotilla (Hurtado, 1986). The industry on bone, particularly the decorated needles have parallels with the same kind of objects excavated from a house in the same site (Hurtado, 1986: 60). The objects described as ‘spatulas on bone’ by Márquez-Gallardo (2008) are morphologically compatible with very schematic figurines also found in La Pijotilla (type III, Hurtado, 1980: 170-171) (Figure 2.6.6). The same typology was recently found in PDG (Valera 2012d). Some industry on ivory was also found along with the human remains sent for laboratorial analysis (Almeida *et al.*, in preparation). Similarly to the tombs of La Pijotilla, and to Tomb and burial pit 1 in Perdigões, phalanges of large and mid-sized mammals were also included in the funerary pack excavated from BT07: *Bos*, *Sus* and *Cervus*. The presence of phalanges as part of the funerary packs in the sites of La Pijotilla and PDG has been reported in two different depositional situations: complete feet in anatomical connection and isolated phalanges (Hurtado, 1980; 2010; Cabaço, 2008; Moreno-Garcia and Cabaço, 2009). Isolated phalanges might be plain or bear anthropomorphic decoration (phalange ‘idols’ or figurines) (Hurtado, 1980; Lago *et al.*, 1998; Cabaço, 2008; Hurtado, 2010). Other votive faunal items excavated from BT07 include a single river shell (*Unio tumidiformis*) (Reis and Araújo, 2009) and an upper incisor from a *Bos*.

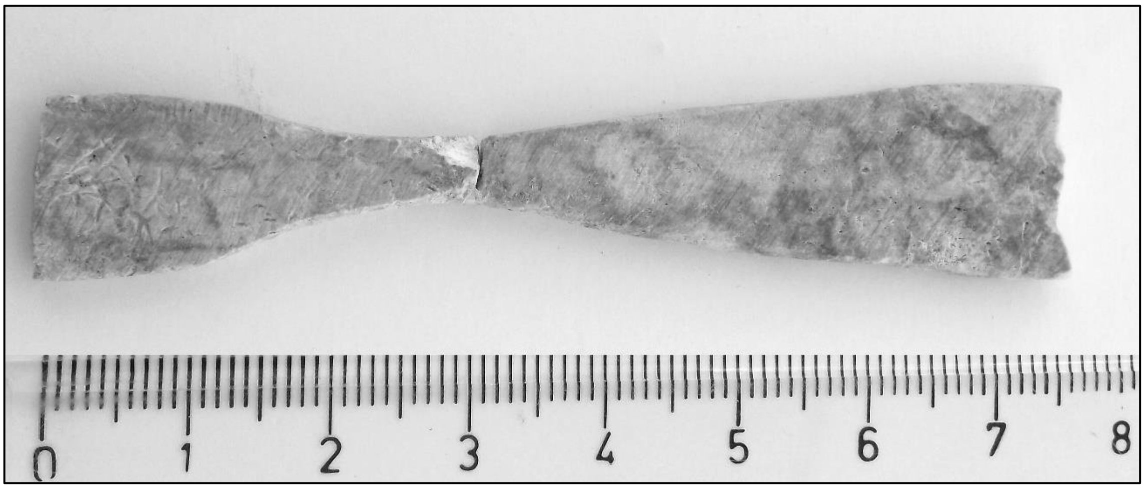

Figure 2.6.6 – Fragment of a highly schematic Almeriense anthropomorphic figurine made on bone from the funerary pack of BT07.

2.5.2. The anthropological study of the human remains from BT07

Between 2008 and 2010, the osteological sample from BT07 was submitted to a thorough paleobiological study recently published (Tomé, 2011). Besides that, the sample has been addressed in a series of articles resulting from that first study and the ones carried out in the course of the present work (Cunha, 2012; Cunha *et al.*, 2012; Cunha *et al.*, 2013; Cunha *et al.*, in press).

The poor conservation of the osteological sample from BT07 was noticed in the first paleobiological study (Tomé, 2011). Taphonomic alterations remain as the main limiting factors in the study of this collection. Most of the fragments in this sample (67%) represent less than 25% of the complete bone. Besides the expected fragmentation for prehistoric samples from collective burials (Silva, 2002), we must notice that the osteological material has suffered the very destructive impact of the artillery batteries that were placed on the top of the monument during the Peninsular War. Some fragmentation must also be expected due the pace of excavation required by the salvage archaeological work. In fact, fresh fractures were observed in many bones. There is no register of either plant taphonomic action or weathering on the bones and only one in over 8000 fragments presented bite marks resulting from faunal action (Tomé, 2011).

The top layers of the monument were probably disturbed in the Islamic period. The pebble coverage excavated by the archaeologists in BT07 was identical in technique and materials to sealing levels of surrounding Islamic constructions (Márquez-Gallardo, 2008). The lack of taphonomic alterations by weather, flora and fauna suggest that if the tomb was open at some point after its abandonment as a funerary monument, this episode did not last long.

Demographic data for this sample based on the bones was very limited by the fragmentation. Numbers from the field based on counts of crania estimated a MNI around 80 individuals. Numbers provided by the bones increased that estimate to 119 (61 adults, 58 nonadults) (Tomé, 2011). Sex determination was only possible based on fragments of crania, *humeri*, *calcanei* and *tali* and only for a few individuals (Tomé, 2011). However, it is possible to infer that both sexes were represented in the sample.

The paleopathological study of the bones was also limited by the fragmentation of the material. Although not very frequent in the sample, osteoarthritis was found to affect more the *vertebrae* than the limbs. Only two ulnas (one left and one right) were affected (6.6%, N= 30), both presenting the minimum degree of expression for the pathology, while osteoarthritis affecting *vertebrae* was more severe in terms of expression and affected 4.88% (N=123) of the bones. No case of traumatic pathology was identified in this sample, but that might be an underestimation due to its taphonomical conditions (Tomé, 2011).

There was no anthropological field work during the excavation of BT07, hence some aspects of the funerary context are not available. However, laboratorial analyses of human remains in such a case can help complement some of the gaps in data (Silva, 2002). Iberian collective prehistoric tombs containing large numbers of individuals are usually characterized by an apparent disorganization of bones (Silva, 1996a; 2002; 2012; Tomé, 2011). These contexts are frequently misinterpreted as places used for secondary deposition of human remains, although paleobiological studies (Silva, 1996a; 2002; 2012; Tomé, 2011; Diaz-Zorita *et al.*, 2012) and recent field works (*i.e.* Hurtado *et al.*, 2000; Miguel and Godinho, 2009; Valera, 2012; Filipe *et al.*, 2013) have proven that many of them were also used for primary burials. Archaeological and anthropological field data indicate that in different kinds of funerary contexts the Chalcolithic communities seem to have used different funerary formulas in the treatment of the dead that either required or involved re-visiting the tomb and in many cases the manipulation of the human remains in different stages of decomposition (Silva, 1996a; 2002; Oliveira 2006; Godinho, 2008b; Miguel and Godinho, 2009; Tomé, 2011; Valera and Godinho, 2012; Valera 2012a). Disarticulation and disorganization of the bones in a sepulchral space under such conditions does not necessarily imply a secondary funerary context (Duday, 2006), particularly when tombs are used over centuries.

Although the archaeologists had interpreted this context as a secondary burial resulting from a single event of deposition of skeletonized disarticulated human remains (Márquez-Gallardo, 2008: 98), a review of available photographs of the context has revealed the existence of at least some anatomical connections *in situ* (Figure 3.11). These included skulls and mandibles as well as parts of the appendicular skeleton of at least 3 individuals. Despite the lack of a field anthropological analysis, some inferences obtained from photographs of the excavation might prove useful. Some mandibles in anatomical connections in the photographs below display a slight displacement from the skull (see Figure 2.6.7, skulls 73 and 74) which would be expected as resulting from the decay of the ligaments and other soft tissues holding them in the anatomical position. That kind of displacement might be compatible with the decay of the corpses in an open environment (Duday, 2006).

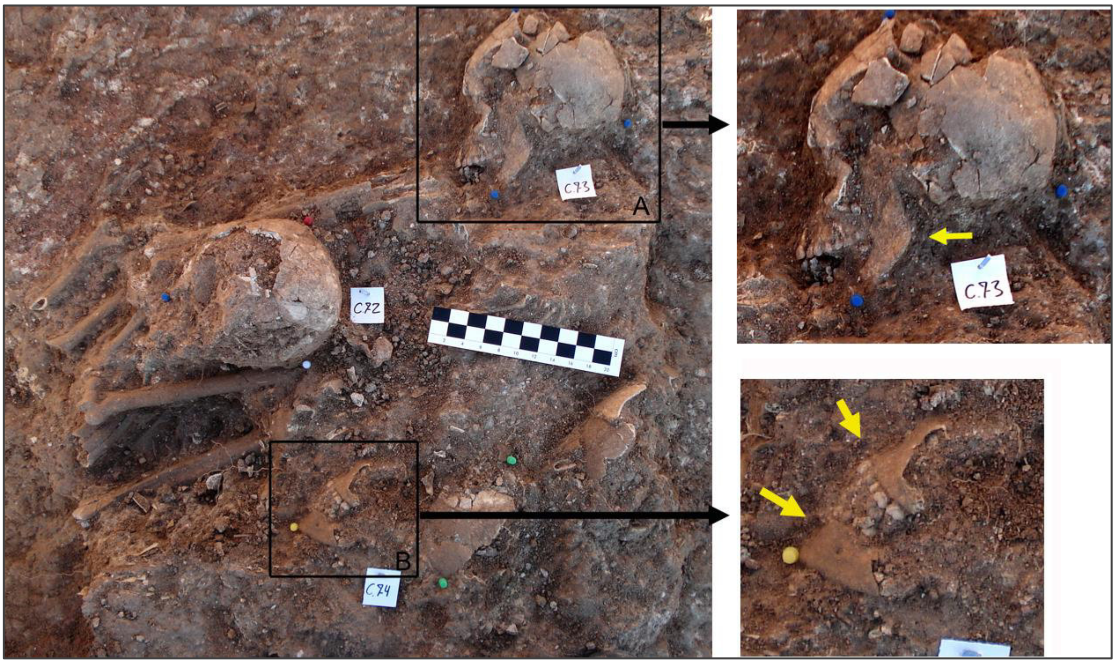

Figure 2.6.7 - Anatomical connections still *in situ* during the excavation of BT07. (A) Skull 73 is visible along with the mandible and (B) viscerocranium skull 74.

Small bones tend to be lost during the process of exhumation of skeletons in primary burial and subsequent transport for a secondary burial. There is always a risk that some bones might be destroyed during exhumation or either forgotten or left in the place of the first burial by the person or people excavating them (Duday, 2006). Hence, in a secondary funerary context, some bone parts are expected to be missing. Silva (1996a; 1996b; 2000a; 2002) has proposed a methodological approach for the study of collective tombs in order to infer either the primary or the secondary nature of those. That methodology is based on the bone weight and dental proportions expected in primary contexts. Comparing the values of bone weight per kind of bone to those provided by Silva and collaborators (2009), Tomé (2011) concluded that all kinds of bones are represented in this sample within the expected limits for a primary burial. Bones that are slightly under-represented constitute the most fragile parts of the skeleton due to their irregular morphology and bone structure (higher proportion of trabecular bone) and most likely to have being destroyed by taphonomic processes (Cunha *et al.*, 2013).

Tomé (2011) also identified 15 cases of secondary anatomical connections, *i.e.* cases in which two or more bones or fragments of bones are compatible with a previously existing anatomical connection (Silva 2000a; Duday, 2006). The fact that most of these connections involved tarsal or carpal bones, anatomically held together by labile articulations, reinforces the evidence that BT07 might have been a primary burial space.

The anthropological study of the human remains from BT07 (Tomé, 2011) indicates that this tomb was used for primary burials. The apparent disorganization of the bones may have resulted from the consecutive re-visiting and reorganization of the space by the groups which used it. One of the reasons suggested for this reorganization is the need to accommodate fresh cadavers in the sepulchral space.

2.6. Linking both sides of the river – similarities between the funerary contexts in PDG and BT07

Architectonically the monument of BT07 is similar to Tombs 1 and 2 in PDG. All three sepulchers might be considered *tholoi*-like structures or passage graves. Differences observed in the construction of these monuments, such as the more extensive use of schist in PDG might be explained by easier access to that material in the region of Reguengos de Monsaraz contrasted with its absolute absence in the geology surrounding BT07 (Atlas Otalex II, 2011). Other reasons may include a higher investment of resources in sepulchers serving a major enclosure (such as PDG) compared to another serving a possibly(?) peripheral settlement (such as BT07), or even regional differences or preferences hard to prove without more solid archaeological data.

The contents of the funerary packs excavated from these sites must also be reasoned in order to help situate all three samples culturally. As discussed above, funerary items found in all three tombs are consistent with the typical kinds of goods expected for the region and period. They all include industry (ceramics, lithics and other utensils) and non-utilitarian ideological elements (such as ochre, elements of body decoration and figurines) consistent with the Chalcolithic funerary world. The presence of a very small number of shells was registered for all three tombs included in this study. Besides the occurrence of these elements, the restriction of their numbers per tomb might suggest an intentional limited used of such items in the funerary treatment.

Similarly to what happened in other collective tombs in the site of La Pijotilla, at least some of the depositions of individuals in BT07 involved fresh cadavers or parts of them. Although the paleobiological study of the human remains from Tombs 1 and 2 at PDG is not complete, at least in Tomb 2 the presence of an articulated foot (including its distal phalanges) suggests that the deposition of articulated cadavers cannot be dismissed.

There seems to be no restriction in access to the sepulchral space in BT07 with regard to sex or age (which is coherent with the results for Tomb 3 in La Pijotilla). The lack of paleodemographic data from the collective tombs in PDG do not allow a direct comparison in this aspect. However age at death estimates already published for Tomb 1 in PDG (Cunha *et al.*, in press) and those resulting from this study suggest that age-wise there was no exclusion criteria to the deposition of the dead in that space.

3. Materials and Methods

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3.1. Materials

The human remains in this study come from three collective tombs whose archaeological context was detailed in the previous chapter.

There is no paleodemographic study on the populations exhumed from PDG1 and PDG2, although the first monument is currently undergoing its first complete paleobiological study as part of a PhD dissertation project by Lucy Evangelista at the Faculty of Life Sciences of the University of Coimbra. The paleobiological study of the individuals exhumed from PDG2 is also undergoing a laboratorial study by Ana Maria Silva at the same faculty. Thus, data available on the MNI and age at death estimates presented here are preliminary and based only on the bones of the oral cavity and teeth as described above.

BT07 on the other hand has been submitted to a paleobiological study (Tomé, 2011) and to a recent reassessment of the age at death for the non-adult individuals (Cunha *et al.*, in press). Both works suggest that the individuals exhumed from this monument are compatible with a natural population in which all age groups are represented. Tomé (2011) also defends that the tomb is the primary context of burial given the distribution of all types of bones and the proportion of mono and pluri-radicular teeth in this sample. Statistical analysis of both distributions point to the expected rates for primary burials as proposed by Silva (2002).

Bones and teeth are highly fragmented and either were not in skeletal articulation (such as in both tombs of Perdigões) or were collected without the anthropological approach that would help individualize the dental pieces (such as the tomb of Cerro de las Baterías). Most of the teeth are loose from their *alveoli* and bones of the oral cavity are severely fragmented. That hindered the identification of individual dentitions.

Given that sexing of the individuals included in this study is not possible due to sample restrictions, inevitably the samples in this work will include both sexes pooled together. Although sex dimophism is characteristic in higher primates, it plays a lesser role in the dental morphology of modern humans (Wood *et al.*¸ 1991). It affects more specifically the size of lower canines and the dentine-enamel ratio in mandibular canines and premolars (Rodríguez-Cuenca, 2003; Saunders *et al.*, 2007).

Sexual dimorphism does not play a significant role in the expression of dental discrete traits, except for the lower canine DAR (Scott, 1977; 1978; 1979; 1980; Turner *et al.*, 1991; Scott and Turner, 1997). Different human populations display random sexual dimorphism affecting different teeth with minor statistical significance at best (Scott, 1977; 1980; Scott and Turner, 1997). Hence, it is standard protocol to pool both sexes when analyzing dental discrete traits (Irish, 1998a: 243), even when sexing of individuals is possible. As a result of the low dimorphism of dental discrete traits, most studies on humans consider both sexes together (Hillson, 2005) and even when accurate sexing of the individuals is possible (see Marado, 2014) the use of an evenly distributed male/female sample would produce no significant error. Despite the occasional intra-sample dimorphism, when compared to other biologically unrelated series, both male and female sub-samples would cluster as a single population, once dimorphic differences on the distribution of frequencies are meaningless at this level of comparison (Marado, 2014).

A total of 8104 fragments were inventoried in the three Chalcolithic samples (see details in Table 3.1). The items listed as 'fragments' of mandibles and maxillae in Table 3.1 were considered informative on aspects related to discrete morphology or paleobiological data (thus contributing with relevant information on the MNI, age at death estimates and/or assessment of tooth wear). Non informative osseous fragments did not bring significant data to the study and were only submitted to cleaning and inventory. All permanent and deciduous teeth were identified, although only data on dental discrete traits for the permanent dentition are considered in this study. A large number of fragments of teeth from PDG1 (n=551), PDG 2 (n=104) and BT07 (n=741) were too small to provide any information on the discrete traits.

Table 3.1 – Summary of all pieces inventoried in this study.

	PDG1	**PDG2**	**BT07**
Fragments of mandible	76	57	133
Fragments of maxilla	58	26	65
Non-informative osseous fragments	349	232	876
Bone fragments (Total)	483	315	1074
Permanent teeth (*in situ*)	362	289	517
Permanent teeth (*ex situ*)	1113	465	1768
Permanent teeth (total)	1475	803	2285
Deciduous teeth (total)	82	49	279
Tooth Fragments	551	104	741
Empty *alveoli*	358	272	678
Number of fragments (Total)	2564	1247	4293

3.1.1. Minimum Number of individuals

Three approaches were taken to assess the MNI in the sub-samples here. The first one (as described above) was based on the repetition of non-compatible fragments of mandibles and *maxillae*. Excluding parameters included laterality, proportion of the fragment preserved and age at death. *Maxillae* were extremely fragmented in all samples and are underrepresented (Table 3.2). The best preserved part of mandibles were the distal end of the mandibular *corpora* and condyles, although many times the *rami* and coronoid processes corresponding to those were absent due to fragmentation.

Table 3.2 – MNI according to bone fragments (preliminary estimate based on dental pieces only)

Type of fragment	PDG1 (MNI)	PDG2 (MNI)	BT07 (MNI)
Mandible	39	34	71
Maxilla	21	13	30

The second estimation of the MNI was obtained by the most frequently represented tooth. Considering the simple repetition of the most frequent tooth MNI in PDG1 would be 78 (based on FDI 16), 38 in PDG2 (based on FDI36 and FDI47) and 104 in BT07 (based on FDI46).

However when age at death for the individuals is applied as a distinctive factor concerning the fragments of bones and teeth, those numbers increase as shown on Table 3.3.

Table 3.3 – MIN per age group considering all teeth and bone fragments

	PDG1		**PDG2**		**BT07**	
Age Group	N	%	N	%	N	%
0-4	15	14.2	3	6.5	28	16.5
5-9	14	13.2	7	15.2	33	19.4
10-14	3	2.8	4	8.7	28	16.5
15-19	1	0.9	1	2.2	10	5.9
Adults	73	68.9	31	67.4	71	41.8
Total	106	100	46	100	170	100

The MNI provided by the latter analysis seems to be closer to the actual demographic profile of the series, since it considers all bones of the oral cavity and teeth after submitted to a distinctive criterion: the age at death.

Figures obtained for the MNI are preliminary once this study did not consider post cranial remains of the individuals exhumed from the funerary monuments of Perdigões and Cerro de las Baterías. However, teeth are the best preserved part of the human skeleton in most collective burial contexts, thus MNI for collections containing commingled human remains are quite often based on dental remains (Silva, 2002).

3.1.2. Pre-treatment of the materials

Most of the materials submitted to the present study were brought to the laboratory in the condition they were excavated from the sites: the majority presented adhered sediment, some pieces were *en bloc* and a few were consolidated in gauze and Paraloid B72™ acrylic resin (Figure 3.1).

Figure 3.1 – Fragment of mandible from PDG1 (PDG1-90) consolidated in gauze after cleaning. In this case the gauze was not removed in order to prevent further fragmentation and to keep the morphological integrity of the mandible. Scale in centimeters.

All the bones, teeth and fragments were submitted to cleaning with dry soft brushes by the author. When the integrity of the osseous/dental pieces was not compromised, the Paraloid B72™ resin and gauze were removed. Some pieces were too fragile and only superficial dry cleaning was performed (such as the fragment of mandible in Figure 3.1).

Each tooth and bone received an inventory number and was kept in a separate container (plastic bag and/or box), except in cases where different fragments were compatible with a single tooth/bone. In those cases, all fragments were placed in the same container and identified by the same inventory number.

Whenever technically possible, the integrity of fragmented bones and teeth was restored making use of neutral glue (UHU™ Hart) soluble in acetone.

The osteological materials from BT07 were cleaned by Tomé as described in his 2011 dissertation. The present author aided as assistant technician in the first laboratorial treatment of this series. All the skeletal remains of this collection were brought to the laboratory in plastic bags within boxes separated per stratigraphic units.

A few cranial fragments and long bones from BT07 were assigned numbers during fieldwork and spatial data on those are available. The vast majority of the remains had no information on their original position prior to excavation other than the stratigraphic unit of origin. Although photographs of the excavation process at BT07 show several articulations of mandibles and *crania* (see previous chapter), the material was not collected as identified anatomical connections. Compatibilities between mandibles and maxillae could not be found in the laboratory. The lack of information on the provenance of mandibles and the fragmentation of the material prevented the association of specific mandibles to crania.

The materials from PDG1 and PDG2 resulted from different campaigns of excavations. Most pieces were accompanied by field labels including information on the year of excavation, origin of the piece (monument, *stratum* and/or quadrant), field number and sometimes a brief description and/or number of fragments contained in their respective container. The human remains were delivered at the laboratory in three kinds of packing/container. Some were wrapped in aluminum foil, others were kept in plastic bags or boxes. Alterations in color of the aluminum foil containing some bones raised questions as to the possible chemical reactions of this kind of package and it was replaced by other kinds of containers (plastic bags and boxes) after the treatment of the material.

For PDG1, 449 fragments (n=2047) were not assigned a field number or shared its number with other non-compatible bones and teeth; 173 fragments did not bear indication of stratigraphic unit (SU) and 69 had neither field number nor SU attribution. For PDG2, 233 fragments (n=1041) were not assigned a field number or shared this number with other non-compatible bones and teeth, 11 did not bear indication of SU and 32 had neither field number nor SU attribution. Considering those flaws, all fragments were re-numbered for data processing. Identification of each fragment included in the laboratorial data base contains an inventory number assigned during laboratorial treatment, besides other field information when available (Figure 3.2).

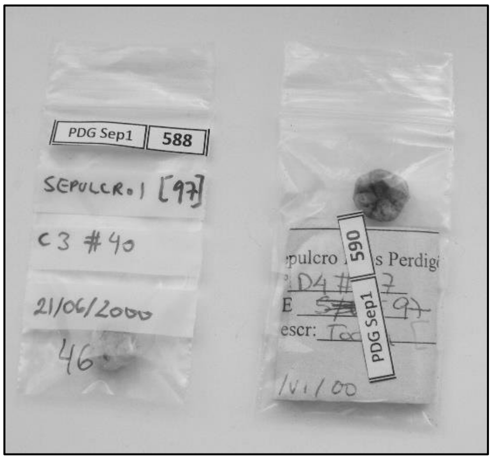
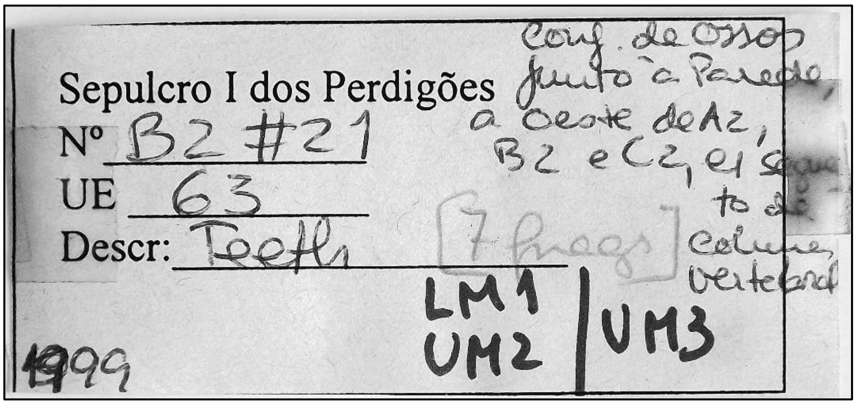


Figure 3.2 – To teeth from PDG1 after laboratorial procedures. Original field information was maintained when available and a label including each fragment´s inventory number was added to the containers.

From some of the field labels it was possible to gather (so far unpublished) information on the funerary anthropology of both monuments. For instance the possible presence of anatomical connections were annotated, such as the "segment of vertebral column" mentioned in the label in Figure 3.3, or the indication of bones submitted to fire accompanying a few cremated human remains.



Sepulcro I dos Perdigões
Nº B2 #21
UE 63
Descr: Teeth [7 frags]
1999
LM1
UM2 | UM3

Conj. de Ossos
junto à Parede,
a oeste de A2,
B2 e C2, e1 s
to d
Colune,
vertebral

Figure 3.3 – Label accompanying human remains from PDG1, indicating the identification of a segment of vertebral column.

Other containers had different fragments from the cranial and post-cranial skeleton compatible with multiple individuals. These were labelled as 'clusters' of bones. Those bones shared a same field number, indicating they were removed *en bloc*. After the laboratorial procedures, the material was stored in individual bags/boxes accompanied by field labels and information whenever those were available.

A thorough inventory of all fragments was made. Bones and teeth were registered in an Excel™ database containing field information (when available), anatomical identification and morphological data. Relevant taphonomical information was also included for some pieces. Paleobiological data relevant to the morphological study (*i.e.,* assessment of tooth wear) was also registered for the fragments.

3.2. Methods

3.2.1. Registry Procedures

Prior to the beginning of the dental morphological study, a registry protocol was created. This protocol included a database in Microsoft Excel™ 12.0 and print individual files for larger fragments of mandibles and *maxillae* containing significant information on nonmetric traits. All data pertaining to each bone and tooth were numerically coded in ordered to be analyzed with the aid of a statistical package. During the course of the study, IBM's SPSS 21.0

was found to be the best choice for working with the data given the amount and type of information gathered. Besides that all procedures required for both the descriptive statistics and data reduction analysis are contemplated within the options offered by that program (Marôco, 2011).

Due to the highly fragmented state of the human remains in all samples, small fragments bearing no data on discrete traits were only recorded on the database. Dental and osseous discrete traits were registered in both print files and database. Tooth wear and other anthropologically relevant data were also included in the digital and print files.

Teeth and bones were identified and recorded on an inventory. The identification of bones and teeth was carried out with the aid of literature on dental anatomy and human osteology (Hillson, 1996; Schaefer *et al.*, 2009; Nelson and Ash, 2012; White *et al.*, 2012). Intra-observer error on tooth identification was tested as described further in this chapter.

In few cases, compatibility of fragments excavated independently (hence bearing different field identifications) were found in the laboratory. Those compatibilities were registered, the field identification numbers were noted but the compatible fragments were inventoried within a same number in this study. Whenever applicable, a print file was filled out bearing all information collected from the compatible fragments.

The two-digit notation system developed by the Special Committee on Uniform Dental Recording of the Fédération Dentaire Internationale (FDI system) was used for tooth identification as suggested by the International Association for Dental Research (Harris, 2005; Nelson and Ash, 2010). The main reasons for this choice were the adoption of an easily recognizable notation system and its applicability in the translation of data into computing outputs (Harris, 2005).

Although dental discrete traits were observed only for the permanent dentition. All other data, including tooth identification was recorded for the deciduous teeth as well.

The assessment of the Minimum Number of Individuals (MNI) in prehistoric collective burial contexts is an extremely complex task that requires the use of different methodologies and strategies (Silva, 2002). It is performed based on the most repeated skeletal element after sorting by element and laterality (Adams and Konigsberg, 2008; Silva, 2002), although other excluding categorization such as age, sexual and size compatibility must be considered when dealing with large series including different sexes and age groups (Silva, 2002; White *et al.*, 2012).

Recent works have proven that all kinds of skeletal elements have to be taken as potentially useful, once the type of bone providing the MNI can vary in different contexts (Silva, 1993; 1996a; 2002). Given the rate of preservability of teeth, they are frequently the elements providing a MNI for a given site (Silva, 2002; White *et al.*, 2012).

This study was performed on a subsample of each osteological series: namely on all teeth and bones of the oral cavity recovered from the funerary contexts of PDG1, PDG2 and BT07. Hence, not all elements of the skeleton were available for the estimation of NMI. The approach followed to determine the MNI then had to be adapted from existing protocols employed by Silva in a number of works (*i.e.,* Silva, 1993; 1996a; 1999; 2002).

Mandibular and maxillary fragments from each monument were separated according to age group (adults versus non-adults). The assessment of age for each immature fragment was performed based on methodology by Ubelaker (1999). A MNI per type of bone was performed based on the laterality and compatibility of mandibular and maxillary fragments. Fragments were considered to belong to adult individuals when the third molar was present and fully erupted. Compatibility was assessed based on age at death, but also on the preserved proportion of the mandibular and maxillary arch, similarly to the methodology proposed by Herrmann and colleagues (1990), as adapted by Silva (1993) for long bones.

Loose teeth were identified and sorted according to the degree of calcification and maturity as estimated by the completion of the roots. Methodologies proposed by Moorrees *et al.*, 1963 (as adapted by Smith, 1991) and by AlQahtani and colleagues (2010) were used to estimate the age at death for each immature tooth. Teeth provided two kinds of MNI: a general number based on the repetition of the most frequent tooth and an age ranked MNI (as presented above).

Tooth wear may be a limiting factor in the observation of dental discrete traits, since they might contribute to the obliteration of features, particularly those located on the occlusal surfaces of premolars and molars, on the disto-lingual surfaces of canines and on the lingual aspect of upper incisors (Turner *et al.*, 1991; Scott and Turner, 1997). Tooth wear in this study was scored according to the procedure proposed by Smith (1984) as adapted by Silva (1996). Tooth wear was scored with the aid of diagram in Smith (1984: 46) and two codes were added for unerupted teeth (0) and missing data (9) when proceeding to the register in the digital database. Only results scored between 1 and 8 were considered in the assessment of mean tooth wear.

3.2.2. Discrete Traits Selected for the Study

The Arizona State University Dental Anthropology System (ASUDAS) (Turner *et al.*, 1991) was used for the scoring of most dental discrete traits considered in the present study. The scoring procedure for each trait is present along with its description below. For most of these features, ASUDAS employs ranked scales for trait expression. A few non-metric variations (*i.e.*, canine root number or the distal trigonid crest) however, are scored based on the presence/absence dichotomy (Turner *et al.*, 1991).

HRUCI, a recently proposed discrete trait (Cunha *et al.,* 2012) was also employed in this study although it is currently not included in the ASUDAS. It refers to alterations on the roots of UI1 as described below.

Thirty seven dental and intra-osseous discrete traits were selected in the original protocol for this study. They included dental traits located on the upper dentition, on the maxillary bone, on the lower dentition, on the mandibular bone and on both upper and lower dentitions.

Winging (ASUDAS scale: 1-4)

It is expressed in the bilateral mesio-palatal rotation of incisors, suggesting a V-shaped appearance when viewed from the occlusal surface (Irish, 1998a). This variation affects primarily both UI1. Winging refers to the orientation of teeth rather than the morphology of either the crown or the root (Turner *et al*., 1991; Scott and Turner, 1997). There is no reference plaque for this trait (Turner *et al*., 1991).

Although winging was initially selected in the protocol for this study, it had to be excluded after the inventory of the samples due to the fragmentary state of the collections. No observation of this trait was possible in either PDG1 or PDG2 and only six maxillae in BT07 had the anterior portion preserved allowing for trait observation.

Shoveling (ASUDAS scale: 0-6 [UI1]/0-7 [UI2])

This trait is characterized by the presence of lingual marginal ridges that extend from the incisal edge to the basal eminence of teeth affecting all the anterior dentition on both arches (Scott and Turner, 1997).

A recent genetic study (Kimura *et al*., 2009) has shown that a variant of the *ectodysplasin* A receptor (EDAR 1540C) might be related to the phenotypic expression of shovel-shaped incisors (Figure 3.4). This allele is strongly correlated to the trait and PCA analysis of over 7000 individuals has proven that its effects explain 18.9% of the individual's grade of shoveling expression.

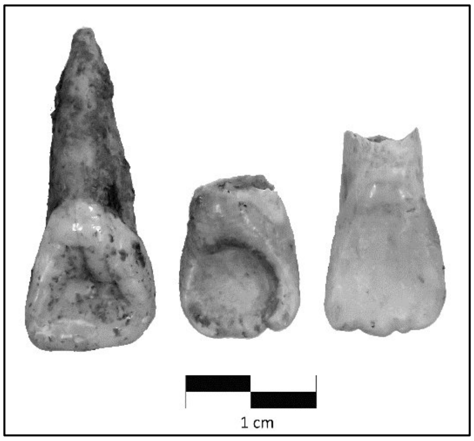


Figure 3.4 - UI1 from BT07 displaying no expression of shoveling (first on the right) and minimal expressions of the trait (center and left). Inventory numbers (from left to right): BT07/D66-107.3, BT07/D74-107.3 and BT07/D86-107.3. Scale: 1 cm.

A ranked scale for this trait was proposed by Hrdlička in 1920, but the first scoring plaque was only built in 1956 by Dahlberg (Turner *et al.,* 1991). The mesial and distal edges may exhibit different degrees of expression for this trait (sometimes more pronounced on the distal margin), however expressions on both margins are so strongly correlated that no considerable information is lost when both margins are scored together as one trait (Scott and Turner, 1997; Scott, 2008).

Interaction between shoveling within the anterior dentition on both the superior and inferior arches has long been corroborated by morphological studies, although heritability for shoveling on UI1 ('key tooth') is higher than on other teeth (Scott, 1977c).

Europeans are characterized by low frequencies of shoveling on the upper dentition. On the lower dentition the trait is rarer or absent (Scott, 1977c; Scott and Turner, 1997). Considering all samples included in this study are all European, the laboratorial procedure designed for this study included the scoring of shoveling only on the upper incisors. Regardless of that, the author noticed that no case of shoveling was observed either on upper canines or on the lower dentition.

Double Shoveling (ASUDAS scale: 0-6)

Presence of mesial and distal marginal ridges on the buccal surface of the anterior dentition and first premolars (Turner *et al*., 1991; Scott and Turner, 1997; Scott, 2008). It was proposed by Dahlberg in 1956 (Turner *et al.,* 1991). These ridges may be mesial and distal, the mesial one is more pronounced and may be expressed even in the absence of the distal ridge (Scott and Turner, 1997).

The key tooth for this trait is UI1, although the trait might be expressed on all teeth of the anterior upper dentition and lower incisors. ASUDAS Scoring rank: 0-6 (Turner *et al.*, 1991).

Labial Convexity (ASUDAS scale: 0-4)

The labial morphology of maxillary central incisors can vary from presenting a flat to a pronounced convex surface. The degree to which this curvature is expressed constitutes the variation for this trait (Turner *et al.,* 1991).

This trait is bilateral and asymmetry is moderate. Sexual dimorphism is not significant for its expression (Nichol *et al.*, 1984).

Midline diastema (<0.5mm present/>0.5mm absent)

A space (diastema) may be observed between right and left UI1 (Irish, 1998a). This trait is not included in the ASU system. Although very frequent in African samples, comparative studies among populations using this trait are rare once it is not routinely recorded in dental studies (Irish, 1998a).

Similarly to what happened to winging (trait 1 in this list), the assessment of midline diastema was excluded from the study due to the fragmentation of the human remains in the samples.

Hypothrophic Roots of the Upper Central Incisors (HRUCI) (Present if Root maximum length>crown maximum length)

During the course of this study, a possible new trait for the upper dentition in humans was described: the hypotrophic roots of the upper central incisors (HRUCI) (See Chapter 5 - Discussion). This feature was included in the final list of traits to be observed. This variation is characterized by the presence of abnormally short roots of UI1 with no other alteration to the shape of either crown or roots.

A preliminary study of prehistoric samples (Cunha *et al.,* 2012) and clinical observations (Ando *et al.*, 1967) suggest that this trait might be bilaterally expressed. The trait is considered present when the maximum length of the crown is superior to the maximum length of the root (both measured on the labial aspect) (Cunha *et al.,* 2012).

The scoring system for HRUCI (Figure 3.5) is nominal and based in the presence/absence dichotomy of the trait.

Figure 3.5 – Bilateral HRUCI on an individual from BT07 (on the right) and a UI1 from the same site not displaying the trait). Inventory numbers (from left to right): BT07/D07-107.2, BT07/D89-107.3 and BT07/D52-107.3. Scale in millimeters.

Although the existence and genetic etiology for abnormally short roots in UI1 has been suggested by clinical literature (Lind, 1972; Jakobsson and Lind, 1973; Apajalahti *et al.*, 1999; Apajalahti, 2004; Edgcomb *et al.*, 2011), few studies have so far approached this polymorphism as a discrete trait characterizing human populations (see this study and: Cunha *et al.,* 2012; Pereira, 2014; Fidalgo, 2014; Cunha *et al.,* in preparation).

Interruption grooves (ASUDAS scale: 0, M, D, MD, Med)

Interruption grooves (or corono-radicular grooves) are developmental interruptions in the normal formation of the teeth that dissect vertically the mid-point of the basal eminence, or the mesial/distal marginal ridges of the incisors, affecting the cingulum. Frequently the interruption continues down the root (Turner *et al.,* 1991; Scott and Turner, 1997).

Although the trait may occur on both central and lateral incisors, most population studies focus on the UI2 (Scott and Turner, 1997). For the present study only the polar tooth (UI2) has been scored, since there are more comparative numbers available for those. ASUDAS employs a nominal five ranked scale for this trait encompassing the absence of the groove, the presence of a single groove either on the mesio-lingual (M) or on the disto-lingual (D) border and the presence of grooves on both (Turner *et al.,* 1991), although comparative population studies only present total frequencies (+=M-Med) (See Scott and Turner, 1997; Coppa *et al.,* 1998; Irish, 1998a; 2005; 2007; Oumaoui, 2009, among many).

Pegged-shaped Reduced and Congenitally Missing Teeth

The occurrence of morphologically altered (pegged), reduced or congenitally missing teeth is usually discussed as varying degrees of a same phenomenon: hypodontia (Brothwell *et al.,* 1963; Suarez and Spence, 1974; Arte, 2001; Pemberton *et al.*, 2005). Although the ASUDAS works with these feature as separate non-metric traits. Both upper and lower dentition and teeth in different fields (incisors, premolars and molars can be affected by these morphological alterations (Turner *et al.,* 1991).

There is a continuum of morphological simplification and/or reduction of size that, in its most extreme cases, is expressed by the complete absence of the tooth itself (Turner *et al.,* 1991). These variations are usually treated as distinct categories of morphogenetic expression (Turner, 1990; Turner *et al.,* 1991). Genetic studies have corroborated an additive polygenic model of inheritance for this spectrum of dental variation and an interfiled correlation between the absence (hypodontia) of UM3 and the occurrence of other morphological alterations: hypodontia of other teeth, reduction of size of the dentition in general and simplification of crown morphology (Suarez and Spence, 1974; Arte, 2001; Pemberton *et al.*, 2005). Although the occurrence of both peg-shaped or absence of UI2, UP2, LP2 and UM3 are correlated, it is more frequent on UM3 (Figure 3.6), hence this is the polar tooth for the observation of the trait (Turner, 1990). More than 95% of all aplasias relate to upper and lower third molars and second premolars, upper lateral incisors, and lower central incisors (Alt and Türp, 1998).

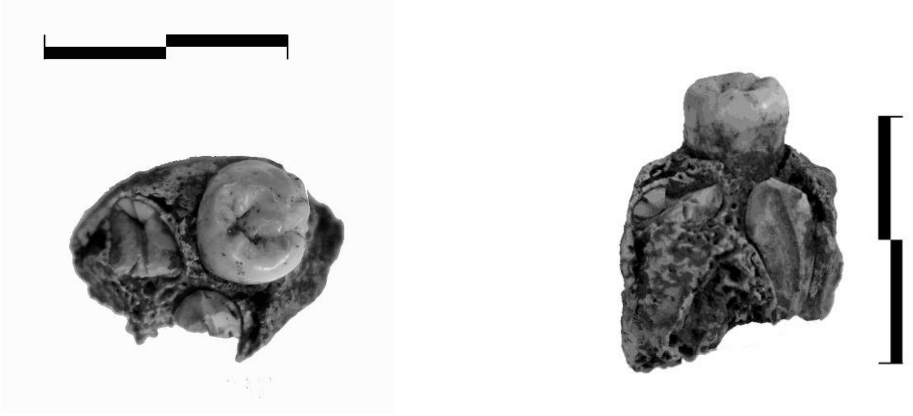


Figure 3.6 – Pegged left UM3 in a fragment of maxilla from PDG1. Occlusal (left) and mesial (right) aspects. Inventory number: PDG1-1455. Scale: 2 cm.

The most extreme expression of this continuum includes aplasia of one or two teeth (bilateral aplasia), oligodontia (absence of more than six permanent teeth) and anodontia (complete absence of teeth) which have important implications at clinical level, although these phenotypic specificities are usually not related to systemic disorders (Alt and Türp, 1998; Pemberton *et al.*, 2005). Family studies of hypodontia and oligodontia suggest the most unstable tooth on each dental field, usually the last developing one, is the most prone to be affected (Arte, 2001).

When dealing with archaeological series we must assume the possibility of observation error in classifying an ectopic tooth as congenitally missing, Turner points out that the outline of unerupted UM3 can frequently be seen just under the alveolar bone which minimizes the error (Turner, 1990). However, the occurrence of ectopic or impacted teeth might also be another aspect of the same phenotypic variation that includes their absence (Turner, 1990; Alt and Türp, 1998; Arte, 2001).

The scoring scale for peg-shaped teeth (ASU 0-2) includes its absence (0), the presence of a reduced tooth displaying a normal crown form (1) and the presence of a peg type as described before. According to the ASUDAS, only adult individuals should be scored for congenitally missing teeth and those are registered on the base of presence/absence dichotomy (Turner *et al.,* 1991).

The lesser manifestation of the trait, which consists of the reduction or pegged form of the tooth is observable as soon as the crown erupts even in non-adult individuals.

Pegged or reduced UI2 (FDI 12 and 22) and UM3 (FDI 18 and 28) were registered here, while the absence of teeth was registered for LP2 (FDI 35 and 45) and UP2 (FDI 15 and 25), UM3 (FDI 18 and 28) and LM3 (FDI 38 and 48). The lack of radiologic images may have introduced errors of interpretation in the hypothetical cases of unerupted teeth being considered congenitally absent.

Tuberculum Dentale **(TD) (ASUDAS scale: 0-6)**

Tuberculum dentale (TD) are cingular derivatives expressed on the lingual surface of the upper anterior dentition (and sometimes on the lower canine) (Turner *et al.,* 1991; Scott and Turner, 1997). It varies in size from a small groove to a large cusp with a free apex on UI1 (Figure 3.7), although the former are more common than the latter (Scott, 1977b). UI2 displays more variety in the form of TD including the formation of lingual ridges and multiple tubercles (Scott and Turner, 1997).

Figure 3.7 – *Tuberculum dentale* on a left UI1 exhibiting two small lingual cusplets (right) and another left UI1 displaying no signs of this variation. Both teeth from BT07. Inventory numbers (from left to right): BT07/D40-107.3 and BT07/D44-107.6. Scale in milimeters.

The correlation between the upper incisor and canine fields has been demonstrated by Scott (1977b). In fact, this trait was used by the author to exemplify the evaluative interaction of canines with the adjacent teeth.

Although Turner and coauthors (1991) indicate that UI2 should be the key tooth for TD observations, a later publication by two of those authors (Scott and Turner, 1997) admits that determining a polar tooth may be difficult and arguments to focus on any of the three upper anterior teeth can be valid.

Canine Mesial Ridge (*Bushman* canine) (ASUDAS scale: 0-3)

This trait is characterized by the presence of a more pronounced mesial ridge on the upper canine that is attached to the *tuberculum dentale* (Turner *et al.,* 1991).

This premolariform alteration to the *cingulum* is particularly frequent in Sub-Saharan populations (as the common designation implies) and entirely absent or rare in most human populations (Sakuma *et al.*, 1991; Irish and Morris, 1996). Irish (2013) considers *Bushman* canines an Afridont marker given its rarity outside Sub-Saharan Africa.

Canine Distal Accessory Ridge (DAR) (ASUDAS scale: 0-5)

This trait is characterized by the presence of a ridge in the distolingual fossa between the tooth apex and the distolingual marginal ridge of both the upper and lower canines. Although present on both UC and LC, DAR is more frequently seen on the upper ones (Scott, 1977a; Turner *et al.,* 1991; Scott and Turner, 1997). Because of its location, weaker forms of DAR are easily obliterated by tooth wear (Scott, 1977a; Scott and Turner, 1997). DAR is the most sexually dimorphic crown trait in the human dentition and males usually display higher frequencies and more pronounced ranks of expression (Scott and Turner, 1997).

Upper Premolar Mesial and Distal Accessory Tubercles (UPMDAT) (ASUDAS scale: 0/+)

This trait consists of small accessory cusps (or more frequently tubercles) which are observed at the mesial and/or distal ends of the sagittal grooves of the upper premolars (Figure 3.8). They are separated from both the lingual and buccal cusps by marked occlusal grooves (Turner *et al.,* 1991).

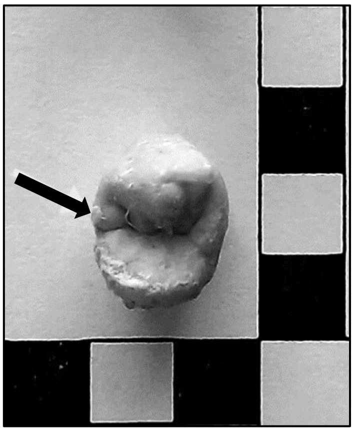


Figure 3.8 – UPMDAT on a left UP1 from BT07. Inventory number: BT07/D691-107.3. Scale in half centimeters.

No ranked scale has been developed for this trait. ASUDAS considers the presence/absence dichotomy of either tubercles or cusps for the assessment of total frequencies.

Maxillary Premolar Accessory Ridges (MxPAR) (ASUDAS scale: 0-4

This trait is characterized by the presence of ridges on the mesial and/or distal lobe segments of the upper premolars between the median occlusal ridge of the buccal cusp and the mesial and distal marginal ridges (Figure 3.9). It is described in Scott and Turner (1997).

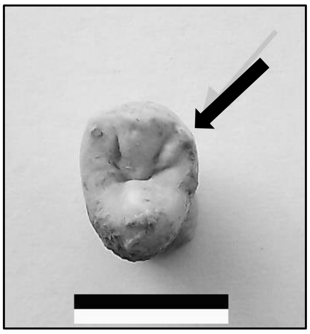


Figure 3.9 – UP accessory ridge on a left UP1 from BT07. Inventory number: BT07/D702-107.3. Scale: 1 cm.

In 2010, Burnett and coauthors detailed the scoring system for the trait introducing a new ASUDAS reference plaque made available for its assessment.

MxPAR displays no consistent sexual dimorphism and very low correlation with other discrete traits. Northeast Asian and Asian derived populations present the highest frequencies of this trait (57-80.2%). In the opposite end of the dental spectrum, Indo-European groups exhibit much lower figures (23.4-33%) (Burnett *et al.*, 2010).

Odontome (ASUDAS scale: 0/+)

Odontomes or tuberculated premolars are cone-like projections that are located on the median occlusal ridge of the buccal cusp in premolars (upper and/or lower). This structure involves the alteration of the enamel, the dentine and in about half the time of the pulp layers hence, even in moderately worn teeth the presence of the trait can be observed. There is no focal tooth for the trait and any of the four premolars can be used to assess its frequency (Turner *et al.,* 1991; Scott and Turner, 1997).

Although uncommon in all human groups, this trait displays a clear pattern of geographic distribution, being more frequent in Sino-American populations, particularly among indigenous groups of northern North America (frequencies between 4-7%). Native Australians, Melanesians and Sunda-Pacific populations display frequencies between 1-3% while in the rest of the world it is rare or totally absent (Scott and Turner, 1997).

Carabelli's Trait (ASUDAS scale: 0-7)

Carabelli's cusp/tubercle was the first discrete trait to be described for the human dentition and it has been the focus of hundreds of publications over the last century and a half (Scott and Turner, 1997). For a recent thorough review of the literature on this trait, see Marado and Campanacho (2013).

It is expressed on the lingual surface of the mesiolingual cusp (protocone) of all three upper molars, although more frequently on the first one (Figure 3.10), hence UM1 is the polar tooth for trait observation (Scott, 1980; Turner *et al.*, 1991; Hillson, 1996).

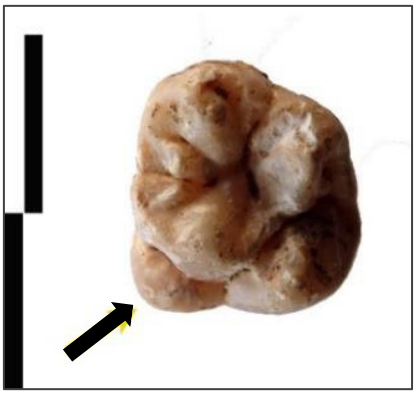


Figure 3.10 – Carabelli's cusp (ASUDAS degree 7) on a left UM1 from BT07. Inventory number: BT07/D809-107.3. Scale: 2 cm.

There are several systems of classification for this trait, which may hinder cross-population studies (Laatikainen and Ranta, 1996; Hsu *et al.*, 1999; Silva, 2012). In 1956, Dahlberg proposed an eight degree ranked scale for its assessment in which zero corresponds to trait absence and 1-7 correspond to its various degrees of presence. This scale was incorporated in the ASUDAS and increasingly used over the years (Turner *et al.*, 1991; Scott and Turner, 1997; Silva, 2012).

The various degrees of expression for Carabelli's trait include minor ranks consisting of slight distal deflections of the cingulum to the formation of a pit. Intermediate ranks include the formation of Y-shaped grooves and ridges. The three most pronounced degrees of expression for this trait in Dahlberg's scale involve the formation of a tubercle or cusp (Figure 3.10, above).

Sexual dimorphism for this trait is a matter of debate. While some authors deny its existence (Biggerstaff, 1973; Alvesalo *et al.*, 1975; Scott, 1978; Scott, 1980) others find reasons to support dimorphic differences (Khamis *et al.*, 2006; Kondo and Townsend, 2006).

Hypocone reduction tends to be associated with Carabelli's trait in which it precludes the expression of the latter; in other words, the reduction of one trait parallels the reduction of the other (Scott, 1979).

Marginal mesial accessory tubercles (MMAT) (Scale: 0/+)

This trait consists of the presence of a mesial tubercle (Figure 3.11)(independent of the mesial accessory ridge of the *paracone* in the upper molars) (Scott and Turner, 1997). Only the UM1, key tooth for this trait, was scored here. There is no ranked scale for MMAT and the scoring procedure here is based on presence/absence of tubercles.

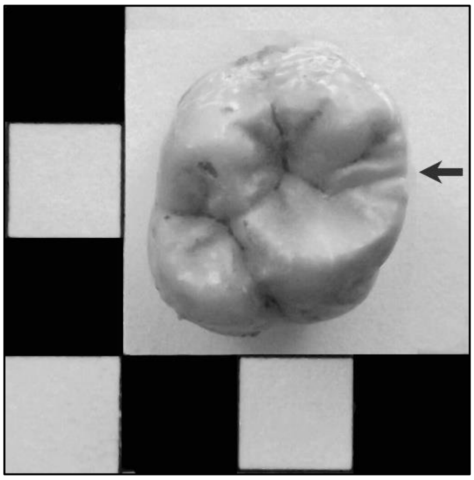


Figure 3.11 – MMAT on a UM1 from BT07. Inventory number: BT07/D808-107.3. Scale in half centimeters.

The trait seems to be mostly expressed on the enamel layers of the occlusal surface, thus tooth wear might obliterate it soon after tooth eruption (Kanazawa *et al.*, 1990).

The marginal mesial accessory tubercles were defined by Kanazawa and colleagues (1990). According to those authors they are more frequent in Japanese and Eskimo populations than in other human groups. Along with other anomalous tubercles and cuspules (particularly the *metaconule* (C5), those can be useful in understanding human microevolution once their diversity of frequencies among different populations suggest their origin may be phylogenetically and ontogenetically different (Kanazawa *et al.*, 1990).

Metaconule (cusp 5 or UM1 C5) (ASUDAS scale: 0-5)

This trait is characterized by the presence of a small cusp in the distal fovea of the upper molars between the *hypocone* and the metacone (Figure 3.12), being more common on the upper first molar (polar tooth) (Turner *et al.,* 1991; Scott and Turner, 1997).

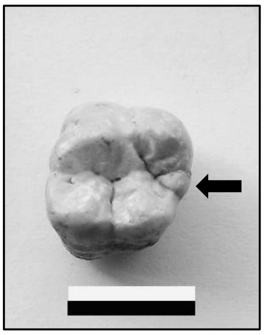


Figure 3.12 - C5 (arrow) on the distal margin of a right UM1 from BT07. Inventory number: BT07/D889-107.3. Scale: 1 cm.

Enamel extensions (ASUDAS scale: 0-5)

Enamel extensions are characterized by the presence of projections of the enamel border in the apical direction on the buccal aspect. This feature is usually less than 4 mm long, 1 mm wide, 0.5 mm thick and it might be associated with enamel pearls (Turner, 1990; Turner *et al.,* 1991).

Hypocone or C4 (ASUDAS scale: 0-5 including degree 3.5)

The distolingual cusp (C4) of the upper molars (Figure 3.13) was the last major cuspal addition to the morphology of upper molars during primate evolution (Scott and Turner, 1997). It is frequent in pre-sapiens hominids (Irish, 1998b), but in the course of later hominid evolution leading to the emergence of modern human dentition, it has undergone a pattern of reduction in size or total absence (Scott and Turner, 1997; Irish, 1998b). For most modern human groups its presence on UM1 is the norm, while its reduction or absence on UM2 and UM3 is variable in different populations (Scott and Turner, 1997).

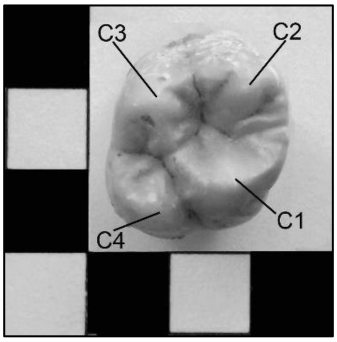


Figure 3.13 – *Hypocone* (C4) in its most expressive grade (5) on a right UM1 from BT07. Scale in half centimeters. Inventory number: BT07/D808-107.3.

Assessment of this trait is usually based on the degree of reduction or even the complete absence of cusp 4 on UM2 (key tooth) (Turner *et al.,* 1991).

Reasoning on the retention of ancestral traits, many authors (*i.e.,* Irish 1998a; 1998b; 2000a; 2000b; 2005; 2006; 2008; among many; Parras, 2004; Ullinger *et al.*, 2005; Oumaoui, 2009, and others) approach this feature in its most expressive degrees (usually 3-5 when a cusp is observable). The opposite logics (reporting lower trait grades) is employed in studies that focus on differentiation based on the simplification and reduction of forms (such as Scott and Turner, 1995; Silva, 2002; Rivera, 2011; Scott *et al.,* 2013).

***Parastyle* (ASUDAS scale: 0-6)**

The *parastyle* is a cingulum derivative that, in its most expressive forms, will lead to the formation of a paramolar cusp (Figure 3.14) or even a supernumerary conical tooth (Scott and Turner, 1997). It is most commonly present on the buccal surface of the mesiobuccal cusp (cusp 2) of the upper third molar (key tooth), although it might be present on the other molars as well (Turner *et al.,* 1991).

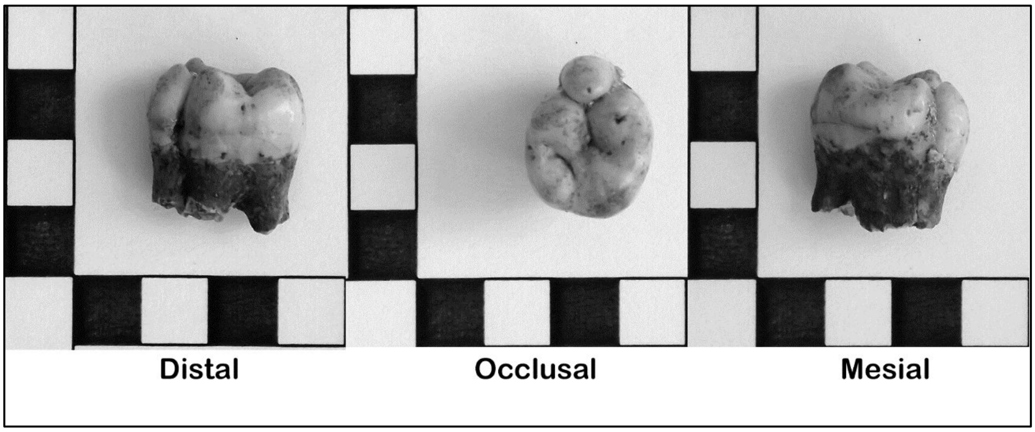


Figure 3.14 - *Parastyle* on a right UM3 from PDG1 in different views. Inventory number: PDG1-93. Scale in half centimeters.

A similar structure might be present on the surface of cusp 3 on upper molars. For Turner and coauthors (1991) this variability might be explained by the occurrence of *parastyle* in different *loci* on the buccal aspect of the tooth or that a different trait altogether has been mistaken for the *parastyle*. In the present study, only *parastyles* directly associated with cusp 2 were scored and the breakpoint applied to positive expressions of the trait only (tubercles/cusp expressions).

Palatine *torus* (ASUDAS scale: 0-4)

Palatine *torus* is a paramedian, rarely median bone exostosis that varies in size, form and extent and that may develop along the palatine suture of the maxillary bone (Hauser and De Stefano, 1989; Turner *et al.*, 1991).

The observation of this trait was not possible in this study due to the fragmentation of the human remains in the samples.

Lower Canine Root Number (ASUDAS scale: 0/+)

Lower canines usually have two roots in non-human primates, however in modern humans it is usually a mono-radicular tooth (Scott and Turner, 1997). In the latter, the presence of a supernumerary lingual root is a derived condition, found mainly on human groups from Eurasia (Lee and Scott, 2011). According to the ASUDAS scoring system, the variation (double-rooted lower canines) happens when a second lingual root is present bifurcating over at least one fourth of the total length of the crown (Figure 3.15) (Turner *et al.,* 1991).

Figure 3.15 - Double rooted lower canine from BT07. Inventory number: BT07/M17-4875-107.3. Scale in half centimeters.

Scott and co-authors (Scott and Dorio, 2010; Scott *et al.*, 2013) suggest that higher frequencies of this trait in Eurodont populations characterize this dental complex along with two other mass-additive traits (UM1 Carabelli's tubercle and multiple cusps on LP2) and three mass-reductive traits (3-cusped UM2 and 4-cusped LM1/LM2).

Sub-Saharan Africans are characterized by the absence of double-rooted canines. Asian and Asian derived populations display low frequencies of the trait between 0-1%, while Europeans provide frequencies of 5-8% (Scott and Dorio, 2010). Modern European populations such as Basques may reach figures close to 10% of frequency for the trait (Scott *et al.*, 2013)

Given this marked distribution, this trait's dispersion into western Asia and its absence in easternmost regions of that continent have been used as an argument to support the dispersion of European groups into Asia and its consequent gene flow (Scott and Lee, 2011).

Tomes' Root (ASUDAS scale: 0-5)

This trait is characterized by the presence of indentations on the mesial aspect of the roots on first lower premolars ranging from grooves in it less severe expressions to the presence of double roots in the extreme of the trait continuum (Figure 3.16) (Turner *et al.,* 1991).

Figure 3.16 – Indentations on the mesial aspect of roots (Tomes' roots) in two left LP1 (left) and one right LP1. All teeth from BT07. Inventory numbers (from left to right): BT07/D650-107.3, D307-107.3 and D591-107.3. Scale in half centimeters.

Multiple Lingual Cusps (LP2 Lingual Cusp Variation) (ASUDAS scale: 0-9, including grade A)

Both first and second lower premolars present variation in the number and size of lingual cusps. For the present study this trait was only registered for the focal tooth (LP2, FDI 35 and FDI 45). The lingual aspect of those teeth might display a ridge with no cusp-like elevation or one/several cusps. When one lingual cusp is present, it is smaller than the buccal one. FDI 35 and FDI 45 display more variability in the number and size of the lingual cusps and is considered the key tooth for the assessment of this variation (Turner *et al.,* 1991; Scott and Turner, 1997).

Scott and coauthors (2013) list the presence of multiple lingual cusps as one of the defining characteristics of the Eurodont pattern.

The ASUDAS scoring system for this trait was developed by Richard Scott (Turner *et al.,* 1991) during his PhD work. Grade A (not contemplated on the reference plaque) constitutes the absence of a lingual cusp. Grades 0-1 characterize the presence of one or two lingual cusps, being the distal cusp much smaller than the mesial one. Usually the latter is formed by a dentine fold and easily worn out by tooth wear. Grade 1 is then considered an "indecisive class". Grade 2 is characterized by the presence of two cusps (Figure 3.17), being the mesial much larger than the distal one.

Figure 3.17 – Presence of two lingual cusps on a right LP2 from BT07. Inventory number: D611-107.3. Scale in half centimeters.

The majority of authors consider Grade 2 as the breakpoint for trait expression - see for instance the several works by Irish (1998a; 2000; 2005; 2006; 2008, among many); Parras (2004; 2006); Coppa and coauthors (2007); Pilloud (2009); Vargiu and coauthors (2009); Scott and coauthors (2013); Marado (2010; 2014), among others.

Lower Molar Cusp Number (ASUDAS register: 4-6)

Human lower molars usually have five major cusps: *protoconid* (C1), *metaconid* (C2), *hypoconid* (C3), *entoconid* (C4) and *hypoconulid* (C5) (Figure 3.18). *Metaconulid* (C7) is a supernumerary cusp and should not be accounted for in the determination of molar cusp number while the presence of a 6th cusp (*entoconulid)* should only be scored on teeth bearing a C5 (Turner *et al.*, 1991).

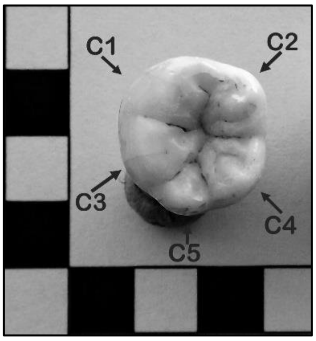


Figure 3.18 - Number of cusps on a left LM1 from BT07. Inventory number: BT07/D1026-107.3. Scale in half centimeters.

The later stages of hominid evolution of lower molars are marked by the simplification of form. Variation in cusp number involves the tendency of reduction in size of the disto-buccal cusp (C5) leading to the complete absence of that cusp (Turner, 1990; Scott and Turner, 1997; Scott, 2008).

Simplification of LM2 consisting of a 4-cusped tooth in North Africans and Europeans on the other hand reach 66.4% and 65.1% respectively in opposition to 24.1% in Sub-Saharans and 7.9% in Sinodonts (Irish, 1998a). Among the five major groups listed by Irish in that publication, Europeans and North Africans are the ones presenting the most simplified lower molars in what comes to the reduction of C5.

Anterior *Fovea* (ASUDAS scale: 0-4)

The *anterior fovea* (or precuspidal *fovea)* of the lower molars is a deep triangular fossa on the mesial marginal ridge complex that, when present, may intersect the groove separating the *protoconid* and the *metaconid* (Figure 3.19).

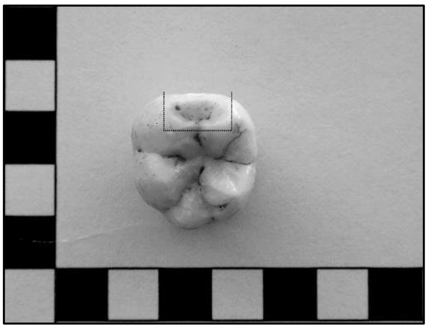


Figure 3.19 – *Anterior* fovea on a left LM1 from BT07. Inventory number: BT07/D912-107.3. Scale in half centimeters.

Although LM3 might display large forms of anterior *fovea*, the polar tooth for observing this trait is LM1 (Turner *et al.,* 1991; Scott and Turner, 1997).

Distal *Trigonid* Crest (DTC) (ASUDAS scale: 0/+)

DTC is a ridge or crest that extends bucco-lingually connecting the *protoconid* and the *metaconid* on the distal end of the *trigonid*, a prominent triangle on lower molars (Figure 3.20) (Scott and Turner, 1997; Hillson, 2005).

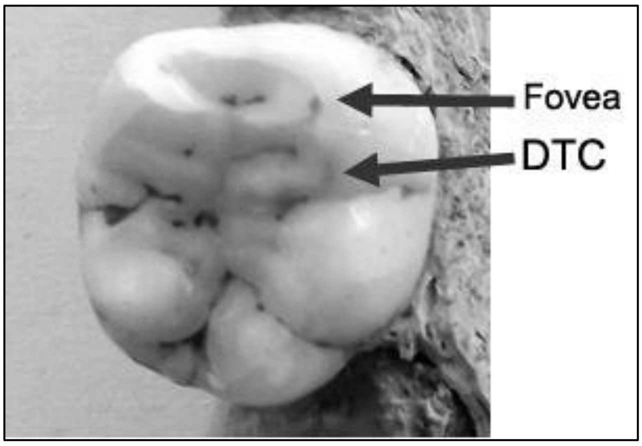


Figure 3.20 – DTC on a right LM1 from BT07. Inventory number: BT07/4844-107.3.

This is a rare trait in most human populations as frequencies for DTC are usually under 10%. In Sino-Americans it might reach figures close to 20%. Although the geographical pattern of distribution for this trait makes it useful in comparative studies, published data is scarce (Scott and Turner, 1997).

***Protostylid* (ASUDAS scale: 0-6)**

Protostylid is a paramolar cusp normally associated with the buccal groove between cusps 1 and 3, being more common on LM1 and LM2 (Turner *et al.,* 1991). Like other paramolar cusps, this trait is expressed in a continuum that ranges from a negative grade (pit-like form) (Figure 3.21) to a cusp with a free apex (Scott and Turner, 1997).

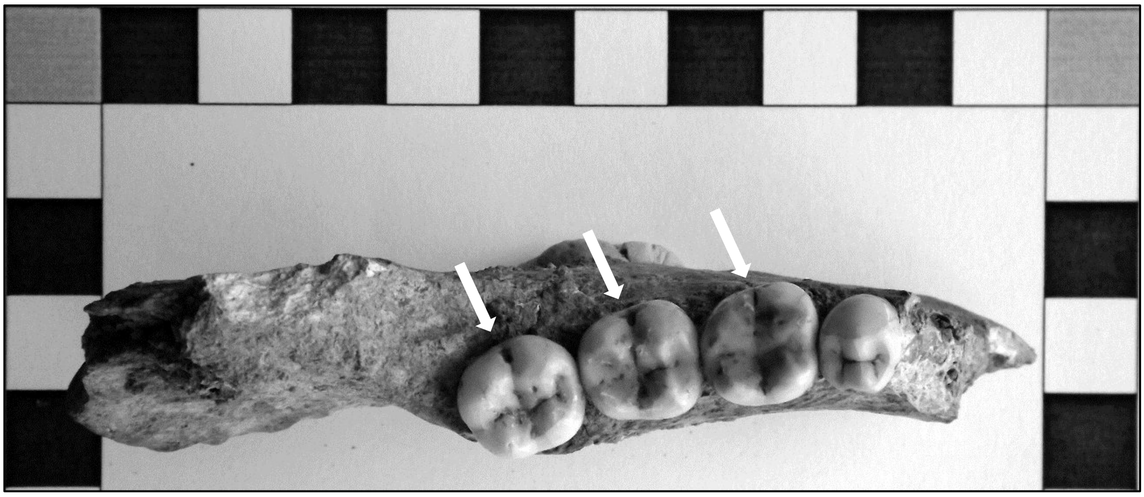


Figure 3.21 – *Protostylid* (grade 1, pit-like form) on all left lower molars of an individual from PDG2. Inventory number: PDG2-1825. Scale in centimeters.

This trait is more commonly found on LM1, the polar tooth for its observation, although the degree of expression of *protostylid* may be greater on LM2 and LM3 (Scott and Turner, 1997).

***Hypoconulid* (Cusp 5 or C5) (ASUDAS scale: 0-5)**

Hypoconulid is the disto-buccal cusp on lower molars (Figure 3.18, above). Evolutionarily this cusp tends to be reduced or absent in modern humans (Turner *et al.,* 1991; Scott and Turner, 1997). The assessment of this trait is useful in population studies once simplification of the dentition or the retention of more ancestral morphology can be employed to characterize human groups and related taxa (both fossil and extant hominids and hominins) (Scott *et al.,* 2013).

This trait is scored not only by the presence/absence of C5, but also by the size of that cusp using the ASUDAS reference plaque for the *hypoconulid* (Turner *et al.,* 1991).

***Entoconulid* (*tuberculum sextum* or Cusp 6) (ASUDAS scale: 0-5)**

This trait is characterized by the presence of a supernumerary cusp, the *entoconulid* (cusp 6) on the distal *fovea* of the occlusal surface of lower molars (Figure 3.22). This cusp is usually only a quarter to half the size of C5. Only in its higher ranks of expression (degrees 4 and 5 in the ASUDAS scale) C6 is larger than C5 (Turner *et al.,* 1991).

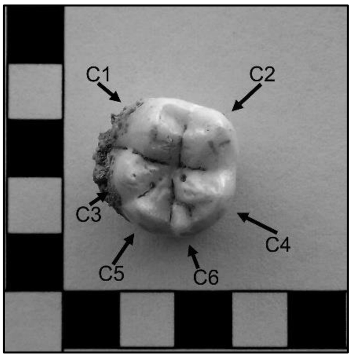


Figure 3.22 – C6 on a left LM1 from BT07. Inventory number: BT07/D464-107.2. Scale in half centimeters.

The *entoconulid* should be scored only on molars where a 5th cusp is present on the same tooth (Turner *et al.*, 1991). LM1 is the polar tooth for the observation of C6 (Scott and Turner, 1997).

***Metaconulid* (*tuberculum intermedium* or Cusp 7) (ASUDAS scale: 0-4)**

The *metaconulid* or C7 is a supernumerary cusp on the lingual groove of the lower molars between cusps 2 and 4 (Figure 3.23). Although located on the occlusal aspect of molars, this trait is scored even on moderately worn out teeth once the lingual half of these surfaces are less affected by tooth wear (Turner *et al.,* 1991).

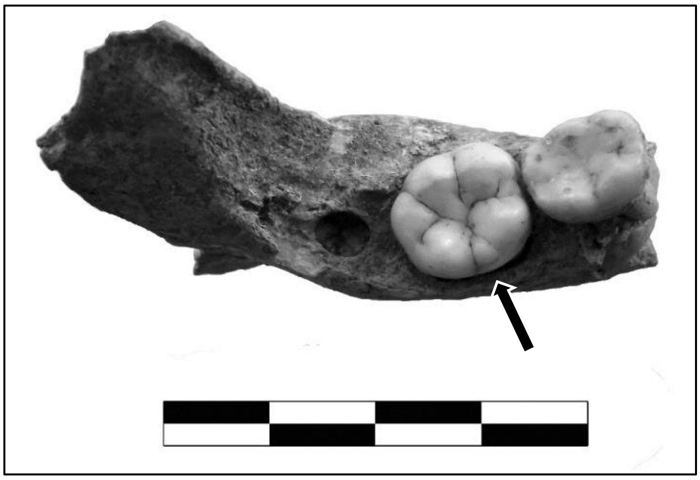


Figure 3.23 – C7 on a first molar of a non-adult individual from BT07. Inventory number: BT07/C73.4907-107.3. Scale in centimeters.

The scale for C7 developed by Turner (Scott and Turner, 1997) and applied in the ASUDAS (Turner *et al.*, 1991) consists of one degree of absence for the trait and five degrees of presence (including grade 1A, Figure 5.1.18, above). There are doubts if this degree, as described by Turner and co-authors, is actually an expression of C7 or a derivate of the lingual groove referred to as *post-metaconulid* (Scott and Turner, 1997). Some authors avoid the dispute by using degree 2 as the BKP for this trait (*i.e.*, Scott *et al.*, 2013) or by excluding grade 1A from the analysis (Marado, 2010; 2014).

Deflecting wrinkle (ASUDAS scale: 0/3)

Variation in the form of the medial ridge of cusp 2 in lower molars (Turner *et al.,* 1991). It is not a particularly distinctive trait, being uncommon in Western Eurasians and frequent in human groups from East Asia, Sunda-Pacific and Sahul-Pacific (Scott and Turner, 1997).

LM1 *Radix entomolaris* (3-rooted LM1 or 3RM1) (ASUDAS scale: 0/+)

Lower molars can have one to three roots, although they usually have two. The *radix entomolaris* (Figure 3.24) is a disto-lingual supernumerary root that may be expressed on any of the three lower molars, but is more frequently found on LM1 (polar tooth for the observation of this trait) (Scott and Turner, 1997).

Figure 3.24 - *Radix entomolaris* on a right LM1 of a non-adult individual from BT07. Inventory number: BT07/D05-109. Scale in half centimeters.

Torsomolar angle (No scale; measurement of the angle and direction of the rotation)

This trait consists in the rotation of the third lower molar either buccally or lingually (Turner *et a*l., 1991). Fragmentation of the human remains prevented the register of this trait during this research.

Groove Pattern (*Dryopithecus* pattern or Y-groove pattern) (ASUDAS scale: Y/X, Y, +)

The occlusal surface of lower molars is marked by different patterns of grooves depending on the configuration of their cusps and how they converge around the mesio-distal and linguo-buccal main grooves. The *Dryopithecus* pattern occurs when cusps 2 and 3 are in contact (Figure 3.25) (Turner *et al.*, 1991; Scott and Turner, 1997).

Figure 3.25 – Groove patterns on three right LM2 from BT07. Pattern X (left), Y (center) and + (right). Inventory numbers (from left to right: BT07/D985-107.3, BT07/D484-107.2 and BT07/D518-107.2.

Since the beginning of the 20th century this pattern has been recognized as an archaic trait present in both fossil and extant hominoids. In modern human populations the retention of the Y-groove pattern happens at different rates, hence its utility in population studies (Scott and Turner, 1997).

Y-groove pattern is highly frequent in LM1. Its observation on LM3 might be compromised by the presence of many supernumerary cusps and hypoplastic forms. LM2 displays more population variability and is the polar tooth for trait observation (Turner *et al.*, 1991; Scott and Turner, 1997). Two other patterns might be observed on lower molars. Pattern X happens when cusps 1 and 4 are in contact and pattern + when cusps 1 to 4 contact in a cruciform configuration (Turner *et al.*, 1991; Scott and Turner, 1997).

Mandibular *Torus* (ASUDAS scale: 0-3)

The formation of bone exostoses (*tori)* might occur on either or both lingual and buccal aspects of the mandible (Figure 3.26) and maxilla (Hauser and De Stefano, 1989). The mandibular *torus* as described in the ASUDAS scoring protocol is located on the lingual aspect of the lower jaw on the segment of the bone corresponding to the location of canines and premolars.

Figure 3.26 – Mandibular *tori* on both lingual and buccal aspects of a mandibular fragment from PDG1 (arrows). On the lingual aspect, the exostoses extend to the LM3 locus. Inventory number PDG1-948. Scale in millimeters.

The etiology for these exostoses has been under debate and different authors have suggested distinct causes for this kind of morphological variation. Genetic, environmental and functional etiologies have been proposed as either solo or combined agents in the formation of *tori* (Hauser and De Stefano 1989; Hassett, 2006). However, clinical and anthropological data (Hylander, 1977; Halffman *et al.*, 1992; Hassett, 2006; García-García *et al.,* 2010) suggest that multifactorial etiology might be involved in the development of such bony outgrowth, once genetic predisposition for the development of this kind of morphological alteration would be triggered by external environmental and/or functional factors (Hassett, 2006). When strong masticatory forces are involved in the formation of *tori,* other symptoms might be observed in association with the bony outgrowth, namely: severe tooth wear, chipping and hypercementosis (Hylander, 1977; Halffman *et al.*, 1992; Hassett, 2006).

Mylohyoid bridge (Scale: 0 – complete bridge)

The mylohyoid groove in the internal part of the *ramus mandibulae* serves as the passage for the mylohyoid nerve and blood vessels. It might present one or more osseous roof of varying length transforming the groove into a canal. It is absent in children and in adults, higher frequencies are associated with older age groups, indicating that the formation of the trait happens in adolescence (Hauser and De Stefano, 1989). The presence of such roof is considered a discrete trait.

The observation of this trait was extremely hindered because of two taphonomic alteration to the bones: fragmentation and obstruction of the locus by adhered sediments and salts on the surface of bone fragments. These problems resulted in low number of observation and thus this trait was eliminated from the study.

***Foramina mentale* (+ = more than one *foramina*)**

The aperture of mandibular canal carrying the inferior alveolar nerve and vessels is usually a single bilateral *foramen* located below the apex of the LP2. When more than one foramina is present in either side or bi-laterally the trait is considered to be present (Hauser and De Stefano, 1989). This trait was excluded from the present study for the same reasons presented for the exclusion of the observations on the mylohyoid bridge.

Six traits were eliminated from this study due to taphonomic constraints of the samples. The major factor limiting the analysis was the fragmentation of the mandibles and maxillae in the samples. Due to these limitations the following traits either could not be assessed in the samples or produced very few observations: winging, midline diastema, *palatine torus*, torsomolar angle, mylohyoid bridge and *foramina mentale*.

One of the selected traits, UM1 Deflecting wrinkle, was eliminated from this study for reasons other than sample limitations. This trait is better observed on unerupted molars and in individuals less than 12 years old, being easily obliterated by tooth wear (Turner, 1990). Adding to these expected limitations in the observation of the trait, the author did not feel comfortable enough in working with the ASUDAS plaque for this specific trait.

The final list of discrete traits considered in this study included a total of 32 dental traits, nine of those were scored on more than one tooth (*i.e.*, lower molar cusp number, DAR and shoveling, among others).

The term breakpoint (or the corresponding abbreviation BKP) will be used in this study as a methodologically established threshold beyond which a quasi-continuous trait can be considered present. Breakpoints in the literature vary according to methodological choices assumed by different authors. Comparisons of the samples in the present study to others from the literature had to be adequately adjusted to the published data.

3.2.2. Statistical treatment of the data

3.2.3.1. Intra-observer error – verification of precision

The assessment of the intra-observer error is fundamental for laboratorial work based on the observations of nonmetric traits. It should be designed prior to the study and might prove useful not only in determining possible discrepancies in the observation of samples, but also in enabling the reproducibility of the data (Hillson, 1996; Harris, 2008). The scoring procedures and dental plaques provided by the ASUDAS are tools to enhance observational precision (Scott and Turner, 1997) the main goal of which is the ability to replicate the same or similar results either by a single or by more than one observer. In this work all observations were carried out by the author, hence only the intra-observer error (or the intra-observer precision) could be tested.

In the present study, the assessment of intra-observer error (or intra-observer precision) was designed to be implemented based on one of the samples: BT07 (based on two observations). The first one took place between January and July 2011 and the second one between January and July 2012. Materials from the other two samples (PDG1 and PDG2) were not completely available until later (2013), hence time constrains did not allow a second observation of these two series.

Correlation between both observations was tested with Kendall's *tau-b* in order to assess overall precision and well as precision at dichotomized frequencies. Breakpoints used for the latter are the ones employed by Irish (1998a), except for traits not addressed by that publication: HRUCI whose dichotomy is explained by Cunha and colleagues (2012); UP DAR and LM1 C5 and C6 which were tested according to the BKPs proposed by Scott and Turner (1997).

3.2.3.2. Counting method, assessment of frequencies and asymmetry

When assessing dental morphology three methods can be used in the processes of scoring and the consequent assessment of frequencies: (I) Individual count; (II) side count, and (III) tooth count (Scott and Turner, 1997; Scott, 2008).

The individual count method, as the name implies, requires the existence of identifiable individuals in the samples. According to this method each trait is scored on both antimeres for each individual. In case of asymmetric expression on either of them, the most pronounced phenotype, considered to be the best reflection of the underlying genotype, is defined as the rank for that individual and used in the assessment of frequencies (Scott and Turner, 1997; Scott, 2008). If only one antimere is present it is common procedure to score it to represent the individual's phenotype in order to maximize sample numbers in collections with taphonomic issues (Irish, 2005).

The side count method considers only one side of the dentition of individuals in a given sample in order to assess trait frequencies. That side is predefined in the study protocols *a priori*. Similarly to what happens for the individual count method, some researchers might compensate the lack of the antimere designated for assessment scoring its counterpart in case the first is missing. Strictly applied, this method is supposed to eliminate any issues concerning asymmetry from the study (Scott and Turner, 1997; Scott, 2008). The existence of identifiable individuals is once again a *sine qua non* condition for the use of this method.

The tooth count method implies that all teeth are scored for the trait presence, independently of laterality. This method is the only one that can be applied to large samples of loose teeth in which antimeres cannot be matched (Scott, 2008). Such is the case of the samples in this study.

Interactions or correlations of traits have been suggested to hinder the analysis of biological distances among populations (Berry, 1976). Correlations of a particular trait within a same field (or tooth class) are frequent (Scott and Turner 1997), although this correlation is not always perfect and some traits (such as shoveling in the upper incisors) tend to be more strongly correlated than others (such as *hypocone* in the upper molars). This expected correlation supports that frequencies of the same trait should not be employed in a single comparison in order not to introduce statistical errors (Turner *et al.*, 1991; Scott and Turner 1997; Tocheri, 2002).

Using univariate and multivariate analyses, Scott and Turner (1997: 117) suggest that "tooth crown traits are largely independent on one another", with the caution to expect within-field correlation, statistical analyses are not to be hindered by correlation.

Considering that, as discussed above, (I) asymmetry plays a non-significant role in the expression of dental nonmetric traits; (II) sexual dimorphism is equally non-significant, and most important: (III) that all samples in this study have restrictions in what concerns the identification of individuals, the tooth count method was the only counting system of possible application. All teeth were assessed for discrete traits and frequencies of all traits were calculated for each tooth. Total frequency of each trait used in the analysis was defined by the antimere presenting the most number of observations. Once there are no identifiable individuals in the samples, questions on left/right side asymmetry or concordance per individual could not be tested.

All frequencies were calculated using software IMB™ SPSS 21.0.

3.2.3.3. Statistical comparison of samples - PCA applied to dental nonmetric traits.

Statistics applied to anthropological studies and on dental morphology particularly are no novelty in the field of Dental Anthropology. In his 2008 chapter on the topic, Harris reviews its use in the treatment of general anthropological data since pre-computer times in the 1920's and on dental morphology since the 1960's. A great deal of the production on statistics applied to dental studies, though, has focused on metric studies given the importance played by anthropometrics in the study of morphology to characterize human populations. Particular attention has been placed on the study of intra and inter-observer error since the replicability of measurements and the achievement of precision is crucial for the development of such studies.

Morphological dental traits are expressed as quasi-continuous polygenetic traits, hence its model of inheritance implies that a trait can be present or absent in an individual. When present certain traits can range from less to more expressive thus enabling its assessment through a ranked scale (Scott 1977; 1980; Scott and Turner, 1997; Turner *et al.*, 1991; Harris, 2008). Statistical treatment of this data however requires these ranked scales to be dichotomized with the use of breakpoints beyond which a trait is considered present (Scott and Turner 1997).

The aim of the statistics applied to dental morphological studies involving dental nonmetric traits has fundamentally been the measure of biological distances (relatedness or divergence of groups) and/or verification of biological affinities. In order to do so, statistics applied to other fields such as genetics (Nei, 1972) and social sciences were used in the study of teeth.

The frequencies of traits obtained from the samples in this study were submitted to Principal Components Analysis (PCA) in order to verify biological affinities among Chalcolithic Iberian populations and other groups in areas characterized by the presence of Eurodont and Afridont dental complexes.

PCA is a multivariate technique for data reduction which "assumes that all the observed variables can be re-expressed as fewer linear combinations of the original variables" (Harris, 2008: 54). For the last 3 decades, this non-parametric method has been widely used to the analysis of data at population level in both genetics (Patterson *et al.*, 2006; Ma and Amos, 2010; 2012) and dental morphology (Scott and Turner 1997; Irish and Guatelli-Steinberg, 2003; Delgado-Burbano, 2007; Coppa *et al.*, 2007; Oumaoui, 2009; Zubova, 2011; Ruiz *et al.*, 2012; Irish, 2013; Marado, 2014; among others). When the same data is submitted to PCA and other multivariate analyses (Maximum Likelihood Method) and measures of biological distance (Mean Measure of Divergence and Multidimensional Scaling) it produces similar valid results (*i.e.* in Coppa *et al.*, 2008).

Mean Measure of Divergence (MMD) is a dissimilarity measure in which low values (close to 0) indicate similitude and high ones (close to 1) indicate greater inter-sample phenetic distance (Irish, 2010: 378). It was designed by C.A.B. Smith and used by Grewal in 1962 to evaluate phenetic distance in mice (Harris and Sjøvold, 2004). Although it has been widely employed in anthropological studies after the work of Berry and Berry (Harris, 2008), MMD has received strong criticism in later years mainly due to sporadic incorrect use (Harris, 2008; Irish, 2010) and loss of information when ordinal data are dichotomized to be used in the MMD (Harris, 2008). However, when traits are appropriately edited and the MMD test correctly used, as demonstrated by Irish (2009), it is a solid tool in measuring phenetic distances. In fact, Irish has used this approach over the years to compare the dental morphology of different populations (*i.e.* Irish, 1998a; 2000; 2005; 2014).

Multidimensional Scaling (MDS) is an exploratory multivariate analysis that allows the parsimonious representation of the proximity (similarities/dissimilarities) among subjects/objects from a set of multivariate attributes measured or perceived (Marôco, 2011). Information on a MDS analysis is displayed in a distance matrix that places each subject/object in a (usually) bi-dimensional space in which distortion caused by the reduction of dimensionality is minimal (Pérez, 2004). Hence, MDS is an effective unbiased way to illustrate sample affinities (Irish *et al.*, 2014). It can be used for both metric and nonmetric variables (Pérez, 2004). MDS can be applied to MMD data to infer inter-population affinities (such as in Manabe *et al.*, 2011; Irish, 2000; 2005; 2014).

Another widely used statistic, Mahalanobis distance statistics (D^2) has also been employed to the study of dental morphology. This test was created to deal with metric data and later adopted to nonmetric traits (Irish, 2010). Although difficult to calculate by hand, computer statistic packages have made its use much simpler. However, as with the other statistics mentioned above, D^2 requires samples composed by individuals. Moreover, the dataset representing these individuals should preferably be complete, once missing values would require more complex multivariate equations to estimate those values (Harris, 2008).

In the present work, no identifiable individuals were found in the collections and the author had to resort to a statistical approach that could test the data but did not require the use of individual dentitions for a large number of teeth. PCA was the logical choice once the test can be performed under such conditions. Problems of possibly correlated data does not seem to affect the test either (Marôco, 2011; Pérez, 2004)

By reducing and re-expressing the original set of correlated variables into a smaller set of uncorrelated variables, the mechanics of PCA generates one or more 'components' that retain most of the information yielded by the original variables (Irish and Guatelli-Steinberg, 2003). Because the Principal Components (or Eigenvectors) reflect the variation on a given set of data, the pattern of clustering of individuals/samples expressed in its bi-dimensional and/or tri-dimensional scatterplots might be used to infer population relationships or within population structure (Irish and Guatelli-Steinberg, 2003; Ma and Amos, 2012).

Although the measurement of phenetic distances cannot always be expressed in a metric scale in its axes (Ma and Amos, 2012), PCA "allows the accurate testing of significance of a natural null model" (Patterson *et al.*, 2006: 2089).

Irish and Guatelli-Steinberg (2003: 123) point out that the use of frequencies in PCA is legitimate once "a zero point is inherently defined and ratio comparisons are possible". That makes it possible for the data to be treated in phenetic analysis, although the process of applying BKPs to partition data into single frequencies can facilitate the neglect of important biological information and allows the manipulation of breakpoints in order to bias the results (Harris, 2008: 45).

PCA helps display hidden structure in a data set, identifying how several variables work together in the underlying framework of a system. By reducing dimensionality of the data and decreasing redundancy it facilitates the interpretation of large amounts of data into comprehensible information (Marôco, 2011). Besides providing indication of inter-sample relationships, when applied to dental morphological analysis, PCA helps identify which traits contribute most in driving these relationships (Irish and Guatelli-Steinberg, 2003: 122).

Several valid PCA tests were produced in the attempt to compare the Chalcolithic Iberian populations in this study to other series. Only principal components generating *eigenvalues* above one were used to produce the component matrixes presented here. For all tests only the principal components dealing with the most variance (the first three in each test) were analyzed, hence avoiding the use of less important components and privileging those encompassing the most variance.

4. Results

4. Results

4.1. Intra-observer error

Intra-observer error tends to diminish as the observer becomes more experienced in the laboratorial work of scoring morphological traits, *i.e.*, as the observer's scoring precision increases guarantying the repetition of the same score for the same degree of expression of a given trait (Scott and Turner, 1997; Harris, 2008; Scott, 2008).

The intra-observer error results presented below were obtained from two observations of the largest sample in this study (BT07). The observations took part in 2011 and 2012 with a twelve month interval. The sample choice for this test was based on the large number of observations provided by BT07 and the access to the collection from the beginning of the study. BT07 provided the largest number of observable teeth (N=2563), larger than both the other series combined (PDG1, N=1522; PDG2, N=803).

The first problem when analyzing large osteological series from collective burials is the state of preservation of the samples. Anthropic and natural taphonomic factors will cause the fragmentation of bones, consequently most teeth will be loose from their alveoli (Silva, 2002). Identifying loose teeth is paramount to the proper assessment of their morphology. Hence intra-observer error of tooth identification was assessed on all permanent *ex situ* teeth from BT07 (N=1768). Precision of identification between the first and the second observations was 98%. When submitted to Kendall's *tau*-b test, correlation between both observations is strong, positive and significant at 0.01 level (τ-b= 0.989, p=0.000).

Table 4.3.1 shows the intra-observer precision and statistical significance for the comparison between the first and the second observations of the BT07 series. Precision is understood here as the correspondence of repeated scores of the same trait between both observations (Harris and Smith, 2009). The "Overall precision" results corresponds to the percentage of exact repetitions of the same score for the same trait/tooth in both observations. "Dichotomized precision" refers to percentage of teeth correctly classified as present or absent once submitted to a BKP. Correlation was tested with Kendall's *tau-b* and its coefficient is presented along with the asterisks standing for statistical significance for the 0.01 level (2-tailed).

Table 4.3.1 – Assessment of intra-observer precision.

Trait	N	Correlation	Overall precision %	BKP	Dichotomized precision %
UI1/UI2 shoveling	266	.992**	90.2	2-6	99.6
UI1 double shoveling	156	1.000**	89.7	2-6	99.4
UI1/UI2/UC TD	392	.996**	92.6	2-6	99.2
UI1 labial convexity	149	.997**	91.3	2-4	99.3
UI1 HRUCI	100	1.000**	100	0/1	-
UI2/M3 peg/reduced tooth	210	1.000**	100	ASU+	-
Interruption groove	121	.962**	99.2	ASU+	-
UC/LC DAR	172	.997**	86.0	2-5	99.4
UC *Bushman* canine	121	.969**	90.1	1-3	99.2
UP DAR	193	.961**	95.7	1-4	99.5
UM1 Carabelli's trait	113	.995**	90.3	2-7	96.5
UM1 C5	93	1.000**	100	2-5	100
UM1 MAT	64	.936**	96.8	ASU+	-
UM2 *hypocone*	88	.992**	87.5	3-5	98.9
UM3 *parastyle*	88	1.000**	100	1-5	100
UM3 congenially absent	83	.889**	98.8	ASU+	-
LC root number	70	1.000**	100	ASU+	-
LP1 Tomes's root	64	1.000**	97.2	3-5	100
LP2 cusp variation	106	.999**	88.7	2-9	100
LM1 C5	147	1.000**	89.5	0	100
LM1 C6	147	1.000**	98.0	1-5	100
LM1 C7	146	1.000**	93.8	2-4	100
3RM1	192	1.000**	100	ASU+	-
LM1 *anterior fovea*	91	.988**	97.8	2-4	97.8
UM1/UM3 *protostylid*	211	.991**	99.5	1-6	99.5
LM1/LM2/LM3 Y pattern	325	.965**	98.1	Y	-
LM cusp number	382	.995**	99.7	ASU+	-
LM1 DTC	113	.695**	100	ASU+	-

**. Correlation is significant at the 0.01 level (2-tailed).

The overall precision in trait frequencies ranges from 86% (for UC/LC DAR) to 100% (several traits) with a mean of 95.95%. The dichotomized precision is higher ranging from 96.5% (for UM1 Carabelli's trait) to 100% (several traits) with a mean of 99.3%. This increase in precision for the dichotomized values implies that minimal errors happening outside the limits of the threshold marking the presence/absence of the trait have lesser effect on the estimation of frequencies. Testing precision, Nichol and Turner (1986) reported lower figures with an average overall precision of 74.1% and dichotomized precision of 89.8%. On the other hand, Marado (2014) reported precision figures closer to the present work with dichotomized means over 90%. The means for differences greater than one grade between each observation reported by that author is also above 90%.

One possible explanation for the discrepancies in precision figures between Nichol and Turner's (1986) and the ones provided by this work and Marado's (2014) might be the object of the observation itself. Nichol and Turner (1986) worked on dental casts of native Kodiak indigenous individuals. Besides the technical problems sometimes introduced by cast imperfections (Nichol and Turner, 1986; Scott and Turner, 1997), the dentition of American artic native peoples (such as the Kodiak islanders) is highly affected by environmental modifications such as tooth wear (both dietary and non-dietary) and chipping (Hylander, 1977; Scott and Winn, 2011). Environmental and cultural modifications might introduce difficulties in the process of scoring morphological traits since many of those features are expressed on surfaces subjected to that kind of damage (Scott and Turner, 1997; 2006). And in fact, Nichol and Turner (1986: 312) attribute indecision in the process of scoring traits for LM1 to the presence of wear, caries and casting flaws.

The sample used in the present precision test on the other hand is characterized by low tooth wear with an average of 2.2 (n=2493) according to scale by Smith (1984). The less worn teeth in BT07 series may have helped better observation on traits located on occlusal and lingual surfaces.

The results of the precision tests are comparable to those obtained by Marado (2014) for the observation on teeth and higher than those published by Nichol and Turner (1986). Error figures between both observations ranged from 14% to 0% for the overall precision and from 3.5% to 0% for the dichotomized one.

The assessment of tooth wear between the first and the second observations was submitted to intra-observer error analysis. This procedure included all permanent teeth (N=2285). Precision of that assessment between the first and the second observations was 95.1%. When submitted to Kendall's *tau*-b test, correlation between both observations is strong, positive and significant at 0.01 level (τ-b= 0.977, p=0.000).

4.2. Asymmetry and Trait Correlations

Both sides of the human dental arches are theoretically symmetrical (Scott, 1977a; Groeneveld and Kieser, 1991): the structure, size, position and shape of the teeth should be identical. However, bilateral asymmetry is observed in the human dentition. It seems to be odontogenic and caused by environmental factors rather than genetic ones (Scott and Turner,

1997) as it has been demonstrated by twin studies (Scott and Porter, 1984). However, Scott (1980; 2008) and Scott and Turner (1997) defend that asymmetry specifically in dental discrete traits is extremely low and does not hinder the morphological analysis.

Testing matters related to asymmetry of dental discrete traits dictates that observations of both sides of the dentition in each arch be made for the same individual (Scott, 1977a; Groeneveld and Kieser, 1991). Due to the nature and limitation of the samples discussed here (see Chapter 3 - Materials and Methods), this aspect of trait expression could not be explored in the present work.

Berry (1976) suggested that trait correlations might compromise the analysis of biological distances among populations. That kind of interaction seems to affect particular traits within the same field (*i.e.*, shoveling on the upper incisors) and in different ones (such as the agenesis of different teeth in the same individual). However, most traits do not display intra-field correlations nor do it in non-significant levels (Scott and Turner 1997). Scott and Turner (1997) suggest that dental discrete traits are fairly independent and not statistically significant enough to hinder the analysis of biological relatedness among populations.

Testing this kind of interaction on a modern Portuguese reference sample, Marado (2014) found strong correlations (*tau* >0.4) between the number of cusps present in lower molars to that specific tooth's frequency of C5 and C6. That is expected once these cusps are independently scored, but their presence in any molar will affect the cusp number of that tooth. He also found strong correlation between the presence of UP1 and UP2 odontome (*tau* = 0.7). Besides being a rare trait in his collection and worldwide (Scott and Turner 1997), this correlation falls within the expected frequency interaction of the same trait within a given tooth field (Scott and Turner 1997).

The correlation between Carabelli's trait and *hypocone* has also been shown by different authors (Scott and Turner 1997; Moormann *et al.*, 2013; Marado, 2014). Given that this interaction seems to be minor when expressed intra tooth, the strategy adopted by Marado (2014) and this study involved scoring Carabelli's trait on UM1 and *hypocone* on UM2. Numerical results by that author show that intra-tooth correlation between those two traits is minor (*tau* =0.179; P = 0.000; n = 443).

The verification of intra- and inter-field trait correlation requires the analysis of individual dentitions. Due to the nature and taphonomic limitation of the samples discussed here (see Chapter3 - Materials and Methods), this kind of analysis is not feasible.

Inter- and intra-site correlation of trait frequencies was tested and results indicate that they are closely correlated at intra-site than inter-site level. When submitted to Kendall's *tau*-b test, positive correlation between trait frequencies in PDG1 and PDG2 is stronger (significant at 0.01 level, τ-b= 0.791, p=0.000) than between PDG 1 and BT07 (significant at 0.01 level, τ-b= 0.708, p=0.000) or PDG2 and BT07 (significant at 0.01 level, τ-b= 0.683, p=0.000).

4.3. Relevant Anthropological data regarding tooth morphology

4.3.1. Taphonomic alterations of the human remains

Taphonomy applied to human remains refers to the comprehension of multiple processes that are involved in the modification of a cadaver from the time of death and that might eventually lead to its disintegration. Natural agents such as weathering or biological activity promoted by both plants and animals may contribute to the process of degradation on human remains (Dupras *et al*., 2006; White *et al.*, 2012).

Human action on the deceased body may also work either for or against the preservation of human remains. The funerary treatment of a dead body may involve processes that help preserve or obliterate the physical evidence of cadavers or skeletonized remains (Pearson, 2005; Duday, 2006). Human action as a taphonomic agent is particularly important in collective tombs where the remains were subjected to manipulation (Silva, 2002). Although the extent and kind of damage caused by the handling of osteological remains as part of the funerary processes is difficult to assess (Silva, 2002), it definitely plays an important role in the extensive fragmentation of skeletonized material in series exhumed from collective burials (Silva, 1996a; 1996b; 2000; 2002; 2003).

Physical and chemical conditions of the environment where the human remains were deposited can either favor or prevent preservation. Dry environments are favorable to the preservation of soft tissues while wet acidic ones can accelerate the taphonomic processes (Schmidt, 2008; White *et al.*, 2012). Bones are usually better preserved in well-drained soils with neutral or slightly alkaline pH, in temperate climates and in deeper burials, however preservation will depend on the balance of several factors and might be differential within a cemetery or even in a single grave (White *et al.*, 2012).

Land use and geological processes posterior to the abandonment of funerary spaces are also responsible for taphonomic alterations as shallow graves might be damaged, obliterated or destroyed either by natural processes (such as alluvium or erosion) or by anthropic alterations such as those involved in farming the land (Pearson, 2005).

The human remains from BT07 do not present alterations by weathering. In over ten thousand fragments studied by Tomé (2011), only one displayed gnawing marks probably resulting from the action of fauna. None of the bones examined in this study presented evidences of taphonomic processes caused by either botanical or faunal agents. Fragmentation was the main taphonomic issue observed in this collection both by Tomé (2011) and by the present author. This kind of alteration probably results from three main processes: (I) the manipulation of human remains typical in collective tombs observed by Silva (2002); (II) the impact of heavy artillery placed on the top of the tomb in 1811 during the French invasion of Spain (Márquez-Gallardo, 2008) and, (III) the expected fragmentation during the exhumation and transport of the human remains from the field to the laboratory (Figure 4.3.1).

Figure 4.3.1 – Small fragment of mandible (BT07/4844-107.3) displaying margins of damage compatible with recent fractures.

Ochre was used on the human remains from BT07, probably as part of the funerary treatment of the human remains as verified both in the field (Márquez-Gallardo, 2008) and during laboratorial treatment of the osteological material (Tomé, 2011). That left red and yellow stains on some bones, mostly from the lower stratigraphic units.

The chemical qualities of the local *caleño* (clay-silt) sediment in which BT07 tomb was excavated (Márquez-Gallardo, 2008) do not seem to have caused important damage to the bones and teeth and these preserve the expected colors. In fact, the neutral pH of that kind of soil might have favored the preservation of the osteological material (White *et al.*, 2012).

The osteological collections from PDG were also very fragmented. Many agents might have contributed to the fragmentation of the bones from both sepulchers.

The first cause of fragmentation was probably the manipulation of the bones during the time of use of the funerary monument as suggested for other collective tombs (Silva, 1996a; 1996b; 2000; 2002; 2003; Tomé, 2011). As part of the original factors contributing to damage, different authors involved in the excavation of both tombs (Lago *et al.,* 1998; Valera *et al.,* 2000; Evangelista, 2003) mention that bones were crushed in between fallen slabs from the walls. In laboratorial conditions fractures caused by compression were indeed observed in some fragments of mandibles and crania.

Both tombs were partially excavated on the soft gabbro diorite bedrock (Carvalhosa and Zbyszewski, 1991; Lago *et al.*¸1998) and after the final abandonment of the site the tombs of Perdigões were covered by fertile farming lands. The site's topography and accessibility to water described by Lago and colleagues (1998) might have acted as taphonomic agents on the human remains. The area of the necropolis is particularly favored by permanent freshwater springs (c. 60 m from PDG1) and by the local draining system of the Álamo creek (as discussed in Chapter 2). The permeability of the bedrock and soil, favored by farming (at least in modern times) and by the topographic inclination of the site eastward may have contributed to movement of pluvial waters through the archaeological layers containing the human remains.

Two main taphonomic alterations on the bones might have been favored by these geological and anthropic aspects. Most bones and teeth display evidences of chemical alteration probably caused by acids, minerals and farming additives brought into the monuments by pluvial waters as the drainage profile of the site favors the movement of water eastward to the Álamo creek. The effects of chemical and mechanical alterations on human remains buried in farming lands are detailed by Haglund and colleagues (2001). The site of Perdigões was subjected to those taphonomic processes at least in historical times (Lago *et al.,* 1998; Evangelista. 2003).

The organic and inorganic alterations caused by the availability of water (even if seasonal) and by the farming by-products (Haglund *et al.,* 2001) carried into the tombs probably accelerated the natural taphonomic process of bone tissue modification. As explained by Piepenbrink (1989), this process involves changes in the chemical equilibrium of the mineral contents in the bones (hydroxyapatite), leading to the dissolution of that and its subsequent isomorphic or heteromorphic recrystallization. Crystals formed at this stage (such as brushite) lead to the cracking of bones. Acidic conditions, such as those created by the putrefaction of corpses in different stages in the collective tombs or by farming of the land (Haglund *et al.,* 2001) favor the formation of crystals. At a final stage, precipitation and crystallization of soluble salts such as calcite begin to deposit on the surface of bones. Two of those taphonomic changes are visible in Figure 4.3.2: (I) the cracking of the enamel on mandibular molars in the image is probably the result of recrystallization process of the organic matrix of the underlying dentine, while (II) the whole surface of the bone is covered by a thick layer of calcite.

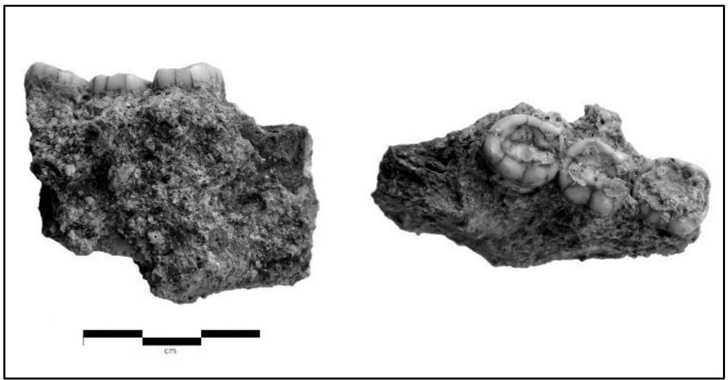


Figure 4.3.2 – Taphonomic alterations on the surface of a mandible fragment (PDG2-508) from PDG2.

The action of plants is observed in some of the bones from PDG1 and PDG2. Taxonomy of the plants is not available, but Lago and collaborators (1998) mention the partial destruction of the corridor of tomb 1 due to the existence of an olive tree.

As to my best knowledge, there is no taphonomical study of faunal damage to the bones exhumed from either PDG1 or PDG2. In the course of this study, bite marks were not observed on bones.

Similarly to the funerary treatment of the dead in BT07, ochre was also used in both PDG1 and PDG2 (Lago *et al.*, 1998; Valera *et al.,* 2000; Evangelista, 2003). Evangelista (2003) also mentions the presence of a whitish pigment probably made from limestone ("*caliça")* on some of the bones during the excavation of PDG1. High levels of mercury on the bones from several funerary contexts in PDG, including PDG1 and PDG2 suggest that part of the red pigment might have been cinnabar (Emslie, 2014). Cinnabar is a naturally occurring soft red mercury sulfide and its use as powder pigment and in the composition of paints is well documented in archaeological and historical contexts (Eastaugh *et al.*, 2004).

Ochre, as a raw material, is a naturally occurring substance in rocks and soils and is primarily composed by iron oxides or iron hydroxides. It can vary in color from shades of purple, red, orange and yellow. Red ochres contain hematite, yellow ochre (or limonite) contains goethite and/or minerals from the jarosite group. The shades of ochre can be thermally altered by roasting or cooking the pigment (Eastaugh *et al.*, 2004). Ochre is one of the best preserved prehistoric pigments because of the survival rate of iron oxides stains when bound onto mineral based supports (Bednarik, 1994).

Teeth and bones displaying alterations in color have been observed in all three samples. These changes might have resulted from stains of iron oxides adhered to the human remains. Thick superficial deposits of fine grained pigment were also observed on some of the human remains (Figure 4.3.3).

Figure 4.3.3 – Fragment of mandible (PDG2-530) from PDG2 with superficial deposits of pigments.

A few teeth and fragments of mandibles, skulls and *vertebrae* accompanying the material studied here had alterations by fire. The bones and teeth displayed fragmentation, shrinking (of the bone and dentine/cement structures) and changes in color compatible with fire at different temperatures (Figure 4.3.4) (Schmidt, 2008; Walker *et al.*, 2009).

Figure 4.3.4 – Fragments of teeth altered by fire at different temperatures from SU175, PDG1 (first three on the left) and a lower canine not altered by thermic action from SU97, PDG1. Inventory numbers (from left to right): PDG1-124, PDG1-157, PDG1-152 and PDG1-1419.

The destruction of tooth roots and bones by the different taphonomic agents discussed above was a limiting factor in the observation of radicular and intra-osseous non-metric traits in the samples discussed here. This led to a low number of observations of radicular traits such as LP1 Tomes' roots and double-rooted canines. It also led to the exclusion of intra-osseous discrete traits from the study. Finally, features related to the position or teeth in the *alveoli* (such as UI1 winging) had to be excluded for the same reason.

4.3.2. Tooth wear

Tooth wear may affect the observation and consequently the scoring of some discrete traits expressed on the crown, once the loss of detail on worn teeth might obliterate trait expression, particularly of those traits not involving modifications at dentine level (Scott and Turner 1997; Scott, 2008). The observation of other crown traits is little or not at all affected by tooth wear, once the existence of the trait is observable even in highly worn teeth. This is the case of interruption grooves and, to some extent, odontomes (Scott, 2008), pegged teeth or *tuberculum dentale* (Burnett *et al.*, 2013).

Significant tooth wear might also contribute to the decrease in the number of observations of a given trait in specific samples (Marado, 2014) once it is recommended that in case of uncertainty of the rank, the tooth/trait in question is not registered (Scott and Turner, 1997). Thus, intensive tooth wear may be an excluding factor when performing a morphological study.

Burnett and colleagues (2013) admit that, given the limited number of individuals in archaeological collections, comparisons should not be made among samples presenting high discrepancy in tooth wear, or should at least be taken cautiously.

The assessment of tooth wear of the samples in this study was performed as described in Chapter 3 (Materials and Methods). Detailed results of tooth wear for all three samples are presented in Table 4.3.2.

Table 4.3.2– Tooth wear per degree in PDG1, PDG2 and BT07.

Degree of tooth wear		**Site**		
		PDG1	**PDG2**	**BT07**
0	N	411	86	299
	%	28.5%	11.2%	12.0%
1	N	204	118	758
	%	14.1%	15.4%	30.4%
2	N	222	174	440
	%	15.4%	22.7%	17.7%
3	N	298	224	463
	%	20.7%	29.2%	18.6%
4	N	168	86	265
	%	11.7%	11.2%	10.6%
5	N	91	46	161
	%	6.3%	6.0%	6.5%
6	N	37	16	76
	%	2.6%	2.1%	3.0%
7	N	11	15	28
	%	0.8%	2.0%	1.1%
8	N	0	1	2
	%	0.0%	0.1%	0.1%
N		1442	766	2492

The lowest mean tooth wear among the samples in this study was provided by BT07 (2.52, N=2263). Age at death obtained from the pattern of calcification and eruption of teeth (Moorrees *et al.*, 1963, as adapted by Smith, 1991; Ubelaker, 1999; AlQahtani *et al.*, 2010) in BT07 indicate that the majority of individuals exhumed from that sepulcher (58.2%, N=170) were non-adults or juveniles. This proportion of young individuals in the sample contributed to the low mean tooth wear. Over 40% of all teeth observed in BT07 displayed minimal tooth wear (degrees 0-1).

Although PDG1 and PDG 2 display slightly higher figures for mean tooth wear (2.87, N=1031; 2.82, N=690, respectively), all three samples are among the lowest figures when compared to other Neolithic-Chalcolithic samples excavated from collective burials in Portugal (Table 4.3.5).

Table 4.3.3 – Mean tooth wear for 13 late prehistoric Portuguese and one Spanish (BT07) samples. Tooth wear measured according to Smith (1984) modified by Silva (1996).

Site	Mean tooth wear	N	Reference
BT07	2.52	2193	This study
PDG2	2.82	680	
Gruta do Cadaval (CDV)	2.83	224	Tomé, 2011
PDG1	2.87	1031	This study
Serra da Roupa (SR)	3.1	60	Silva, 2002
Gruta de N. Senhora das Lapas (GSL)	3.48	61	Tomé, 2011
Tholos of Paimogo I (PMI)	3.51	1094	Silva, 2002
Gruta dos Ossos (GRO)	3.61	409	Tomé, 2011
Cova da Moura (CM)	3.65	339	Silva, 2002
São Paulo II (SPII)	3.86	367	
Cabeço da Arruda I (CAI)	3.89	35	
Dolmen da Estrada de Ancião (DEA)	4.0	41	

There is no significant discrepancy in the degree of mean tooth wear among those samples. Most teeth in PDG1 (58%) and BT07 (60.1%) and almost half the teeth in PDG2 (49.3%) display tooth wear of 0-2 in the scale proposed by Smith (1984, modified by Silva, 1996). That implies at most (degree 2), tooth wear is minimal and the most affected areas of the tooth's topography are the incisal ridges of incisors and canines and the occlusal surface of premolars and molars. Incisors may have their mamelons obliterated. Canines' loss of enamel on the disto-incisal aspect is minimal and at most a small patch of dentine is visible on the apex of its cusp. Molars have their secondary grooves worn (Smith 1984, Hillson, 1996). Most discrete traits included in this study are not affected by this degree of tooth wear. Exceptions may be UM1 MMAT, UC and LC DAR, MxPAR and LM1 DTC. As shown by Silva (2002) valid morphological data can be obtained even when samples present much higher mean tooth wear.

The scoring of some traits are not affected by tooth wear: HRUCI, peg-shaped/reduced teeth, double-rooted LC, Tomes' roots, 3-rooted LM1 and mandibular *torus*.

Other features are rarely affected by that since they are not expressed on the normative incisal/occlusal surface: UI1 double shoveling andUI2 interruption grooves. Only the complete destruction of the crown or extremely atypical tooth wear would render these traits unobservable.

However, the observation of the other traits might be hindered by tooth wear, although, as observed by Marado (2014) the more heavily worn teeth tend to require more care in the scoring procedure and this leads to lower intra-observer error or to the exclusion of the tooth from the analysis.

4.4. Summary data – descriptive dental morphology of the samples

The frequencies of all dental discrete traits registered in the Chalcolithic Iberian samples exhumed from the tombs 1 and 2 of Perdigões (PDG1 and PDG2) and from Cerro de las Baterías (BT07) are presented in this section. In order to facilitate direct comparisons with relevant populations, figures for different series are also provided. The main objective here is to provide the reader with a clear vision on the similarities in frequencies that characterize the prehistoric samples of PDG1, PDG2 and Cerro de las Baterías (BT07), in comparison to reference samples and to specific samples that might relate or contrast chronologically, culturally and/or geographically with the populations excavated from those three monuments.

In order to do so, macro-regional samples from worldwide populations provided by Scott and Turner (1997) and by Irish (1998a) were used along with others considered as significant because of either geographical or chronological proximity (Lipschultz, 1997; Coppa *et al.*, 1998; Rivera, 2001; Parras, 2004; Weets, 2004; Adler, 2005; Coppa *et al.,* 2007; Oumaoui, 2009; Pilloud, 2009; Fidalgo, 2014; Marado, 2014; Subirá *et al.*, 2014; Cunha *et al.,* in preparation).

Eight European samples from Christy G. Turner's database will also be used in comparisons in this chapter and elsewhere in this dissertation. Information including frequencies for all ranked grades observed in these samples were generously provided by G. Richard Scott to the author via electronic mail on February, 7th, 2014. They come from Poundbury (England), Russia, Estonia, Denmark (Neolithic), Finland/Estonia (Karelians), Ukraine (Mesolithic-Neolithic), Arctic Europe (Saami) and Netherlands (Lent and Dorestad).

Thirty two traits are used in comparisons throughout this chapter. For 23 of these features, frequencies of macro-regional reference samples were provided, besides comparative numbers from specific series within the Eurodont and Afridont dental complexes.

Frequencies presented in this section are displayed per rank (raw data) and subjected to breakpoints (BKP) when compared to frequencies from the literature.

Shoveling

The occurrence of shoveling was registered for the upper incisors (UI1 and UI2) (Figure 4.4.1) in the Chalcolithic samples of PDG1, PGD2 and BT07.

Figure 4.4.1 – Fragment on maxilla from BT07 displaying shoveling on a left UI1. Inventory number: BT07/583-107.6. Scale in centimeters.

Most cases of shoveling registered in the Iberian Chalcolithic samples were graded at lower ranks of expression (Table 4.4.1), between 0-3 in the ASUDAS scale (Turner *et al.*, 1991).

Table 4.4.1 - Frequencies of shoveling for UI1 and UI2 in PDG1, PDG2 and BT07 (all ranks)

			PDG1		**PDG2**		**BT07**	
			UI1	**UI2**	**UI1**	**UI2**	**UI1**	**UI2**
Rank	**0**	**N**	18	14	17	13	47	32
		%	81.8	66.7	77.3	72.2	59.5	48.5
	1	**N**	2	3	1	-	13	17
		%	9.1	14.3	4.5	-	16.5	25.8
	2	**N**	0	2	3	2	15	10
		%	0.0	9.5	16.7	9.1	19.0	15.2
	3	**N**	2	2	2	1	4	5
		%	9.1	9.5	11.1%	4.5	5.1	7.6
	4	**N**	-	-	-	1	-	1
		%	-	-	-	4.5	-	1.5
	5	**N**	-	-	-	-	-	1
		%	-	-	-	-	-	1.5
	Total	**N**	**22**	**21**	**18**	**22**	**79**	**66**

Shoveling is highly frequent in Sinodont and Sundadont populations. In other dental complexes figures are much lower (Turner, 1990; Scott and Turner, 1997). In Eurodont populations (Western Eurasians and North Africans) UI1 shoveling usually affects less than 10% of individuals (Scott and Turner, 1997). The Iberian Chalcolithic series present frequencies of shoveling in intermediate figures between Sub-Saharans and North Africans and over three times those of Northern and Western Europeans (Table 4.4.2). This trait is absent in the Portuguese Contemporary population studied by Marado (2014).

Table 4.4.2 – Frequencies of shoveling on UI1 in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 3-6)

Sample	N	%	Reference
Coimbra (Contemporary Portugal)	262	0.0	Marado, 2014
Natufians (Levant)	59	1.7	Lipschultz, 1997
Northern Europe	46	2.2	Scott and Turner, 1997
Western Europe	186	2.7	
BASE, Bronze Age Serpa, (Portugal)[1]	29	3.4	Fidalgo, 2014; Cunha et al., in prep.
BT07	79	5.1	Present study
West Africa	41	7.3	Scott and Turner, 1997
North Africa	194	7.5	
PDG2	22	9.0	Present study
PDG1	22	9.1	
South Africa	220	9.3	Scott and Turner, 1997
Khoisan	155	13.3	

Considering the cline of shoveling from the prehistoric Iberians to later pre-industrial Northern and Western Europeans and Contemporary Portuguese, there is a possibility that the trait might have been affected by the simplification of the dentition through time as defended by Scott and Turner (1997) and Irish (1998a; 1998b; Irish and Guatelli-Steinberg, 2003).

Double shoveling

In the samples under study here the trait is extremely rare and totally absent in both tombs in Perdigões (Table 4.4.3).

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[1] From now on referred to as BASE (Portugal).

Table 4.4.3 - Frequencies of double shoveling for UI1 in PDG1, PDG2 and BT07 (all ranks)

			PDG1	**PDG2**	**BT07**
Rank	**0**	**N**	27	27	79
		%	100.0	100.0	98.8
	3	**N**	-	-	1
		%	-	-	1.3
	Total	**N**	27	27	80

When compared with other populations, prehistoric and historic Iberians display simpler morphology for this trait (Table 4.4.4) while North Africans and Levantine populations present relatively higher figures of this mass-additive trait, although Eurasians and Africans in generals are characterized by low frequencies of double shoveling (0-15%) (Scott and Turner, 1997).

Table 4.4.4 – Frequencies of double shoveling on UI1 in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 2-6)

Sample	N	%	Reference
Khoisan	79	0.0	Scott and Turner, 1997
PDG1	27	0.0	Present study
PDG2	27	0.0	
Feteira II, Portugal	43	0.0	Horwath *et al.*, 2014
Coimbra (Contemporary Portugal)	250	0.8	Marado, 2014
South Africa	437	1.1	Irish, 1998a
BT07	80	1.3	Present study
West Africa	39	2.6	Scott and Turner, 1997
BASE (Portugal)	31	3.2	Fidalgo, 2014; Cunha et al., in prep.
Western Europe	184	3.8	Scott and Turner, 1997.
North Africa	175	8.6	Irish, 1998a.
Natufians (Levant)	100	12.0	Lipschultz, 1997.

Labial Convexity

Labial convexity is marked in all three samples in this study (Table 4.4.5).

Table 4.4.5 - Frequencies of labial convexity for UI1 in PDG1, PDG2 and BT07 (all ranks)

			PDG1	**PDG2**	**BT07**
Rank	**0**	**N**	4	-	8
		%	16.7	-	10.3
	1	**N**	8	11	17
		%	33.3	42.3	21.8
	2	**N**	5	7	15
		%	20.8	26.9	19.2
	3	**N**	4	5	19
		%	16.7	19.2	24.4
	4	**N**	3	3	19
		%	12.5	11.5	24.4
Total		**N**	24	26	78

Convexity of the labial surface of UI1 is more marked in African and Asiatic Indian populations while Europeans display moderate frequencies and Native Americans the lowest ones. Although this trait is expressed in high frequencies in Sub-Saharans, it cannot be used as a discriminant feature for Africans/non-Africans because the trait is not frequently addressed in population studies and data on non-African populations is rare (Irish, 1998a).

Labial convexity seems to be extremely frequent in Iberian prehistoric populations (Oumaoui, 2009; Fidalgo, 2014; Cunha *et al.,* in preparation), intermediate in prehistoric East Mediterranean (Pilloud, 2009) and rare in Northern Europeans (Table 4.4.6).

Table 4.4.6 – Frequencies of labial convexity on UI1 in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 2-4).

Sample	N	%	Reference
Ukraine	65	0.0	Turner, unpublished data
Russia	42	2.4	
Estonia	113	3.6	
England	109	5.5	
Çatalhöyük (Chalcolithic)	53	5.7	Pilloud, 2009
Çatalhöyük (Neolithic)	76	19.2	
Merotic (100 BC-300 AD) Nubians	38	23.7	Irish, 1998a
BASE (Portugal)	28	39.2	Fidalgo, 2014; Cunha et al., in prep.
PDG1	24	50.0	Present study.
La Navilla (Bronze Age, Granada)	51	50.0	Oumaoui, 2009
PDG2	26	57.7	Present study

Table 4.4.6 – Frequencies of labial convexity on UI1 in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 2-4) (cont.)

Sample	N	%	Reference
San (Historic)	80	66.3	Irish, 1998a
BT07	78	67.9	Present study
El Castellón Alto (Bronze Age, Granada)	34	77.3	Oumaoui, 2009

PDG1, PDG2 and BT07 are characterized by very convex central upper incisors. This tendency is also observed in other prehistoric Iberians. Results of the present study and other studies listed in Table 4.4.6 suggest that expression of this trait reflects the cline in complexity of dental morphology from an African archaic (complex) dentition in Sub-Saharans to simpler Northern European features as proposed by Scott and Turner (1997) and by Irish (1998a).

Hypothrophic Roots of the Upper Central Incisors (HRUCI)

The numbers available so far for HRUCI (Figure 4.4.2) refer only to prehistoric Portuguese populations (Table 4.4.2) (Cunha *et al.,* 2012; Pereira, 2014; Fidalgo, 2014; Cunha *et al.,* in preparation).

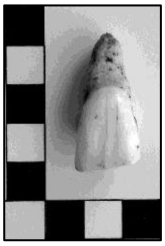


Figure 4.4.2 – HRUCI on a left UI1 (center) from PDG2. Inventory number: PDG2-573.

Table 4.4.7 – Frequencies of UI1 HRUCI in PDG1, PDG2 and BT07 in comparison with other samples (BKP = +)

Sample	N	%	Reference
Brinches, Portugal (Late Prehistoric)	10	0	Pereira, 2014
BASE (Portugal)	29	4.2	Fidalgo, 2014; Cunha et al., in prep.
São Paulo II (south Portugal)	66	15.2	Cunha *et al.,* 2012
Paimogo I (central Portugal)	108	15.7	
PDG1	5	20.0	Present study
PDG2	25	28.0	
BT07	33	36.4	

Comparative samples are very limited to infer population tendencies and more studies including this trait are needed to characterize its distribution in different regions in Iberia and farther. However, comparing frequencies of the trait in seven Iberian samples (Table 4.4.7, above), this feature seems to be more frequent in older series exhumed from Neolithic-Chalcolithic burial contexts than from the later Bronze Age pit burials (Brinches and BASE). Another pattern that was observed for the trait is its high frequency in inland Neolithic-Chalcolithic samples from the Guadiana Basin in opposition intermediate ones in coeval coastal populations (São Paulo II and Paimogo I). Only further studies including this trait might confirm its utility in characterizing human populations.

Interruption Groove

Total frequencies of this trait seem to be higher in Europeans than in Africans (Table 4.4.8).

Table 4.4.8 – Frequencies of UI2 interruption groove in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU +)

Sample	N	%	Reference
BT07	68	8.8	Present study
West Africa	48	10.4	Scott and Turner, 1997
Coimbra (Contemporary Portugal)	358	10.8	Marado, 2014
South Africa	301	12.0	Scott and Turner, 1997
Natufians (Levant)	92	13.0	Lipschultz, 1997
Khoisan	83	15.7	Scott and Turner, 1997
Feteira II, Portugal	42	16.7	Horwath *et al.*, 2014
PDG1	23	17.4	Present study
PDG2	18	27.8	
Northern Europe	100	30.0	Scott and Turner, 1997
North Africa	241	32.4	
BASE (Portugal)	36	33.3	Fidalgo, 2014; Cunha *et al.,* in preparation
Western Europe	224	42.0	Scott and Turner, 1997

Peg-shaped, Reduced and Congenitally Missing Teeth

Table 4.4.9 displays the total frequency of peg-shaped UM3 in comparison with other European prehistoric populations. Among those populations, this is a low frequency trait. The most recent sample in the batch (BASE) presents the highest frequency.

Table 4.4.9 – Frequencies of peg-shaped UM3 in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 1-2)

Sample	N	%	Reference
PDG2	24	0.0	Present study
BT07	55	0.0	
Greece (Chalcolithic- Bronze Age)	56	0.0	Parras, 2004
Cyprus (Chalcolithic- Bronze Age)	54	0.0	
Syria (Chalcolithic- Bronze Age)	15	0.0	
Italy (Chalcolithic)	386	0.5	Coppa *et al.,* 2007
PDG1	71	1.4	Present study
BASE (Portugal)	24	4.2	Fidalgo, 2014; Cunha et al., in prep.

Peg-shaped UI2 is a low frequency trait in the samples in this study and in other prehistoric and historic populations in Europe and Middle East (Table 4.4.10). It is considered rare in world populations in general, usually displaying frequencies between 0 and 5% (Scott and Turner, 1997). Considering those figures, BASE's frequency is relatively high.

Table 4.4.10 – Frequencies of peg-shaped UI2 in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 1-2)

Sample	N	%	Reference
PDG1	25	0.0	Present study
PDG2	18	0.0	
Feteira II, Portugal	44	0.0	Horwath *et al.*, 2014
Greece (Chalcolithic- Bronze Age)	79	0.0	Parras, 2004
Cyprus (Chalcolithic- Bronze Age)	116	0.0	
Syria (Chalcolithic- Bronze Age)	21	0.0	
Coimbra (Contemporary Portugal)	492	1.2	Marado, 2014
BT07	69	1.4	Present study
Çatalhöyük (Neolithic)	110	1.8	Pilloud, 2009
Çatalhöyük (Chalcolithic)	61	3.3	
Coimbra (Contemporary Portugal)	492	3.5	Marado, 2014
BASE (Portugal)	35	6.3	Fidalgo, 2014; Cunha et al., in prep.

Congenital absence of teeth is displayed in low figures in all three populations in this study. No case of aplasia of UP2 was observed. Absence of LP2 only affects a few individuals in PDG1 and PDG2 (Table 4.4.11). On the other hand, congenital absence of upper and lower third molars is registered only in BT07 and in figures between 4.2 and 6.8%.

Table 4.4.11 – Frequencies of congenitally missing UI2 in PDG1, PDG2 and BT07 (BKP ASU +)

	PDG1		**PDG2**		**BT07**	
	N	**%**	**N**	**%**	**N**	**%**
UP2	41	0	20	0	38	0
UM3	26	0	17	0	24	4.2
LP2	38	2.6	32	3.1	68	0
LM3	49	0	42	0	59	6.8

***Tuberculum Dentale* (TD)**

TD was registered for UI1, UI2 (Figure 4.4.3) and UC in this study (Table 4.4.3).

Table 4.4.12- Frequencies of TD for UI1, UI2 and UC in PDG1, PDG2 and BT07 (all ranks)

		PDG1			**PDG2**			**BT07**		
		UI1	**UI2**	**UC**	**UI1**	**UI2**	**UC**	**UI1**	**UI2**	**UC**
0	**N**	13	15	35	4	20	14	46	41	40
	%	59.1	65.2	79.5	22.2	90.9	53.8	56.8	62.1	65.6
1	**N**	4	-	3	1	-	7	11	1	8
	%	18.2	-	6.8	5.6	-	26.9	13.6	1.5	13.1
2	**N**	3	1	1	2	-	2	10	3	8
	%	13.6	4.3	2.3	11.1	-	7.7	12.3	4.5	13.1
3	**N**	-	5	1	6	-	1	7	6	3
	%	-	21.7	2.3	33.3	-	3.8	8.6	9.1	4.9
4	**N**	1	-	-	4	2	2	5	5	-
	%	4.5	-	-	22.2	9.1	7.7	6.2	7.6	-
5-	**N**	-	1	4	1	-	-	1	7	2
	%	-	4.3	9.1	5.6	-	-	1.2	10.6	3.3
5	**N**	1	-	-	-	-	-	1	2	-
	%	4.5	-	-	-	-	-	1.2	3.0	-
6	**N**	-	1	-	-	-	-	-	1	-
	%	-	4.3	-	-	-	-	-	1.5	-
Total	**N**	22	23	44	18	22	26	81	66	61

BT07 and PDG1 are characterized by intermediate frequencies of *Tuberculum dentale* in the range of those expressed in European populations (Irish, 1998a) while PDG2 presents higher frequencies close to figures for South Africans (Table 4.4.13).

Table 4.4.13 – Frequencies of TD for UI2 in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 1-6)

Sample	N	%	Reference
Çatalhöyük (Neolithic)	69	11.6	Pilloud, 2009
BASE (Portugal)	32	25.1	Fidalgo, 2014; Cunha et al., in prep.
Scotland	216	29.6	Adler, 2005
Çatalhöyük (Chalcolithic)	302	30.2	Pilloud, 2009
PDG1	23	34.8	Present study
BT07	66	37.8	
Europe	152	38.1	Irish, 1998a
Norway	43	54.5	Adler, 2005
North Africa	189	58.7	Irish, 1998a
South Africa	454	61.2	
PDG2	18	77.8	Present study

Canine Mesial Ridge (*Bushman* canine)

Frequencies for the trait in the Iberian Chalcolithic samples are detailed in Table 4.4.14. Although no typical 'Morris type' *Bushman* canine has been registered in this study, lower degrees of expression for the trait are present.

Table 4.4.14- Frequencies of UC mesial ridge in PDG1, PDG2 and BT07 (all ranks)

			PDG1	PDG2	BT07
Rank	**0**	**N**	35	22	56
		%	89.7	91.7	90.3
	1	**N**	2	2	3
		%	5.1	8.3	4.8
	2	**N**	2	-	3
		%	5.1	-	4.8
Total		**N**	39	24	62

The frequency of this trait in all three Chalcolithic samples is close to the ones observed in Western Europeans, North Africans and South Siberians (Table 4.4.15), slightly higher than the latter two. This pattern might be explained by a more archaic morphology for canines in those two samples probably related either to the antiquity of those series, to more significant African influence on both sites in the Chalcolithic sites in this study or due to both reasons. We have to observe that most samples composing the reference populations in Scott and Turner (1997) are several millennia more recent than the series discussed in the present work. Besides the chronological effect of simplification of tooth crown in the samples used by those authors to characterize the Western European dentition, those populations are characterized by the historical admixture with Northern and Eastern Europeans.

Table 4.4.15 – Frequencies of UC mesial ridge in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 1-3)

Sample	N	%	Reference
Northern Europe	125	0.0	Scott and Turner, 1997
Western Europe	230	4.3	
North Africa	261	6.1	Irish, 1998a
PDG2	24	8.3	Present study
South Siberia	155	8.4	Scott and Turner, 1997
BT07	62	9.6	Present study
PDG1	39	10.2	
BASE (Portugal)	32	12.5	Fidalgo, 2014; Cunha et al., in prep.
Natufians (Levant)	58	13.8	Lipschultz, 1997
South Africa	586	18.1	Irish, 1998a
West Africa	55	29.1	Scott and Turner, 1997
Khoisan	77	35.1	

Canine Distal Accessory Ridge (DAR)

Upper canines display more variability of ranks and more marked forms of expression for DAR, conforming to the trait description (as in Scott, 1977a; Turner *et al.,* 1991; Scott and Turner, 1997) (Table 4.4.16).

Table 4.4.16- Frequencies of UC DAR in PDG1, PDG2 and BT07 (all ranks)

			PDG1		**PDG2**		**BT07**	
			UC	**LC**	**UC**	**LC**	**UC**	**LC**
Rank	**0**	**N**	14	19	11	9	22	46
		%	50.0	95.0	57.9	90.0	52.4	88.5
	1	**N**	1	-	2	-	-	3
		%	3.6	-	10.5	-	-	5.8
	2	**N**	7	1	3	-	6	1
		%	25.0	5.0	15.8	-	14.3	1.9
	3	**N**	4	-	3	1	5	2
		%	14.3	-	15.8	10.0	11.9	3.8
	4	**N**	1	-	-	-	7	-
		%	3.6	-	-	-	16.7	-
	5	**N**	1	-	-	-	2	-
		%	3.	-	-	-	4.8	-
Total		**N**	28	20	19	10	42	52

Trait frequencies for DAR in the Chalcolithic Iberian samples in this study fall in between those of reference populations in North Africa and Europe, being lower than the figures of modern North Europeans and Contemporary Portuguese (Table 4.4.17).

Table 4.4.17 – Frequencies of UC DAR in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 1-5)

Sample	N	%	Reference
BASE (Portugal)	29	17.2	Fidalgo, 2014; Cunha et al., in prep.
North Africa	195	34.9	Irish, 1998a
PDG2	19	42.1	Present study
BT07	42	47.7	
PDG1	28	50.1	
Europe	89	51.7	Irish, 1998a
England	70	57.2	Turner, unpublished data
Russia	22	63.6	
Coimbra (Contemporary Portugal)	469	67.6	Marado, 2014
South Africa	483	71.8	Irish, 1998a

Upper Premolar Mesial and Distal Accessory Tubercles (UPMDAT)

This is a low frequency trait in most European populations, although late prehistoric Iberians (Table 4.4.18) display high frequencies of UPMDAT.

Table 4.4.18 – Frequencies of UP2 accessory tubercles in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU+)

Sample	N	%	Reference
BT07	48	0.0	Present study
Greece (Chalcolithic- Bronze Age)	73	0.0	Parras, 2004
Cyprus (Chalcolithic- Bronze Age)	85	0.0	
Syria (Chalcolithic- Bronze Age)	13	0.0	
Coimbra (Contemporary Portugal)	455	0.4	Marado, 2014
PDG2	22	4.5	Present study
BASE (Portugal)	29	16.0	Fidalgo, 2014; Cunha et al., in prep.
La Navilla (Bronze Age, Granada)	51	18.8	Oumaoui, 2009
PDG1	37	21.6	Present study
El Castellón Alto (Bronze Age, Granada)	34	28.6	Oumaoui, 2009

Maxillary Premolar Accessory Ridges (MxPAR)

Frequencies of MxPAR in all ranks for the three Iberian series in this study are detailed in Table 4.4.19.

Table 4.4.19- Frequencies of MxPAR in PDG1, PDG2 and BT07 (all ranks)

			PDG1		PDG2		BT07	
			UP1	**UP2**	**UP1**	**UP2**	**UP1**	**UP2**
Rank	**0/T**	**N**	26	17	11	12	39	43
		%	83.9	73.9	78.6	75.0	92.9	86.0
	1	**N**	3	2	1	1	-	-
		%	9.7	8.7	7.1	6.3	-	-
	2	**N**	1	1	1	2	1	4
		%	3.2	4.3	7.1	12.5	2.4	8.0
	3	**N**	1	2	-	1	1	2
		%	3.2	8.7	-	6.3	2.4	4.0
	4	**N**	-	1	1	-	1	1
		%	-	4.3	7.1	-	2.4	2.0
	Total	**N**	31	23	14	16	42	50

Considering the comparative samples in Table 4.4.20, BT07, PDG1 and PDG2 present the highest frequencies of MxPAR. These figures however are within the expected for Indo-European populations (Burnett *et al.*, 2010). All prehistoric samples in that comparison either do not display the trait or do it in extremely low frequencies. The same scenario is observed in the Portuguese Contemporary population studied by Marado (2014).

Table 4.4.20 – Frequencies of UP2 accessory ridges in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 1-4)

Sample	N	%	Reference
Greece (Chalcolithic- Bronze Age)	73	0.0	Parras, 2004
Cyprus (Chalcolithic- Bronze Age)	81	0.0	
Syria (Chalcolithic- Bronze Age)	13	0.0	
BASE (Portugal)	25	2.1	Fidalgo, 2014; Cunha et al., in prep.
Çatalhöyük (Chalcolithic)	49	4.1	Pilloud, 2009
Çatalhöyük (Neolithic)	65	9.2	
Coimbra (Contemporary Portugal)	469	12.8	Marado, 2014
BT07	50	14.0	Present study
PDG2	16	25.1	
PDG1	23	26.2	

Odontome

Odontomes are absent in all series in this study (Table 4.4.21), as in most samples used in the comparisons here. Feteira II seems to be an outlier once it displays a frequency of 10%. That is well beyond the highest known frequencies for odontomes in reference populations from North East Asia and Indigenous North Americans in which this trait reached the highest figures (see in Scott and Turner, 1997:322-323).

Table 4.4.21 – Frequencies of odontomes in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU +)

Sample	N	%	Reference
Northern Europe	111	0.0	Scott and Turner, 1997
West Africa	56	0.0	
Khoisan	86	0.0	
PDG1	50	0.0	Present study
PDG2	31	0.0	
BT07	74	0.0	
North Africa	441	0.2	Irish, 1998a
South Africa	756	0.4	
Coimbra (Contemporary Portugal)	487	0.4	Marado, 2014
Natufians (Levant)	161	0.6	Lipschultz, 1997.
Western Europe	246	0.8	Scott and Turner, 1997
Feteira II, Portugal	41	10.0	Horwath *et al.*, 2014

Carabelli's Trait

Carabelli's trait (Figure 4.4.3) can be expressed on all upper molars, however, this trait was registered only on the polar tooth (UM1) in this study.

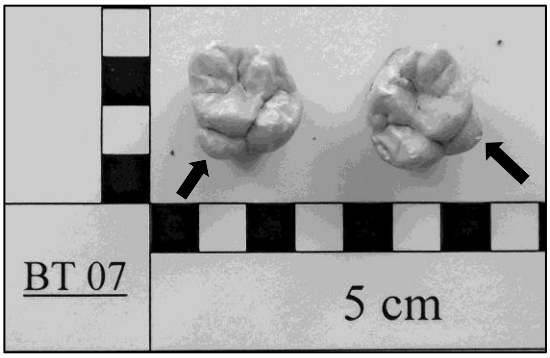


Figure 4.4.4 – Carabelli's cusp (arrows, both grade 7) on a left and on a right UM1 from BT07. Both teeth are compatible with a same non-adult individual. Inventory numbers (from left to right): BT07/809-107.3 and BT07/831-107.3. Scale in half millimeters.

Carabelli's trait is considered a distinctive trait for European populations when the most expressive ranks (5-7 in the ASUDAS scale) are considered (Scott and Turner, 1997). If lesser pronounced forms are taken into account, the geographical patterning is not particularly distinctive as most Western Eurasians will present similar frequencies (Scott and Turner, 1997). When the breakpoint employed includes grades 2-7 for trait presence, Sub-Saharans and North Africans display higher frequencies than Europeans (respectively 51.2%, 54.7% and 47.4%) (Irish, 1998a). Trait frequencies for Carabelli's tubercle in all ranks are detailed in Table 4.4.22.

Table 4.4.22- Frequencies of UM1 Carabelli's trait in PDG1, PDG2 and BT07 (all ranks)

			PDG1	**PDG2**	**BT07**
Rank	**0**	**N**	28	8	30
		%	45.9	50.0	51.7
	1	**N**	2	-	1
		%	3.3	-	1.7
	2	**N**	4	1	2
		%	6.6	6.3	3.4
	3	**N**	6	-	6
		%	9.8	-	10.3
	4	**N**	4	2	6
		%	6.6	12.5	10.3
	5	**N**	11	3	5
		%	18.0	18.8	8.6
	6	**N**	4	1	5
		%	6.6	6.3	8.6
	7	**N**	2	1	3
		%	3.3	6.3	5.2
Total		**N**	61	16	58

All Iberian Chalcolithic series from the Guadiana valley discussed here display high frequencies of Carabelli's trait close to reference populations from North and West Africa and Western Europe (Table 4.4.23). On the other hand, samples from the 4th millennium BC (Dolmen de Ansião) and from the 3rd millennium BC (Paimogo I and São Paulo II) (*in* Silva, 2002) have much lower frequencies of Carabelli's cusp. Silva's samples come from the Atlantic Portuguese façade and this discrepancy may refer to regional differences resulting from different patterns of gene flow.

Table 4.4.23 – Frequencies of UM1 Carabelli's trait in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 5-7)

Sample	N	%	Reference
Coimbra (Contemporary Portugal)	479	6.1	Marado, 2014
Paimogo I (central Portugal)	75	8	Silva, 2002
South Africa	246	11.4	Scott and Turner, 1997
Çatalhöyük (Neolithic)	95	11.6	Pilloud, 2009
Çatalhöyük (Chalcolithic)	59	11.9	
São Paulo II (south Portugal)	25	12	Silva, 2002
Dolmen de Ansião (central Portugal)	30	16.7	Silva, 2002
Khoisan	155	16.8	Scott and Turner, 1997
Northern Europe	138	18.1	
North Africa	200	20.0	
West Africa	61	21.3	
BT07	58	22.4	Present study
Western Europe	249	27.3	Scott and Turner, 1997
PDG1	61	27.9	Present study
PDG2	16	31.3	

Marginal mesial accessory tubercles (MMAT)

Although the work on this series has proven that MMAT is a high frequency trait in prehistoric Iberian samples in opposition to Contemporary populations (Table 4.4.24) and it may be more frequent than the distal accessory tubercles in many populations (Scott and Turner, 1997), its use in comparative studies may be hindered by the lack of works dealing with this trait. This absence of published data may be related to the trait's tendency to be easily obliterated even by moderate tooth wear (Kanazawa *et al.*, 1990).

Table 4.4.24 – Total frequency of UM1 MMAT in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU +)

Sample	N	%	Reference
Coimbra (Contemporary Portugal)	457	1.3	Marado, 2014
BT07	34	38.2	Present study
PDG1	35	74.3	
PDG2	7	85.7	

Enamel extensions

Enamel extensions are not frequent in Western Eurasians and Africans (Scott and Turner, 1997). This trait was not found in any UM1 of the samples here. It seems to be a rare trait in European populations (particularly in the Prehistoric Iberian ones) (Table 4.4.25). The sample from the site of Feteira II (central Portugal) however displays a relatively high frequency of those extensions.

Table 4.4.25 - Frequencies of enamel extensions on UM1 in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 2-3)

Sample	N	%	Reference
West Africa	99	0.0	Scott and Turner, 1997
Khoisan	15	0.0	
BASE (Portugal)	24	0.0	Fidalgo, 2014; Cunha et al., in prep.
PDG1	15	0.0	Present study
PDG2	5	0.0	
BT07	72	0.0	
Natufians (Levant)	156	0.0	Lipschultz, 1997
Northern Europe	229	2.2	Scott and Turner, 1997
Coimbra (Contemp.Portugal)	353	3.1	Marado, 2014
Western Europe	371	3.8	Scott and Turner, 1997
North Africa	503	6.8	
South Africa	387	8.0	
Feteira II, Portugal	35	8.6	Horwath *et al.*, 2014

***Metaconule* (distal accessory tubercle, cusp 5 or UM1 C5)**

The *metaconule* is not a high frequency trait in the Chalcolithic Iberian samples from PDG1, PDG2 and BT07. Frequencies for all ranks of UM C5 are displayed in Table 4.4.26.

Table 4.4.26 - Frequencies of UM1 *metaconule* in PDG1, PDG2 and BT07 (all ranks)

			PDG1	**PDG2**	**BT07**
Rank	**0**	**N**	43	12	41
		%	89.6	92.3	83.7
	1	**N**	1	-	2
		%	2.1	-	4.1
	2	**N**	3	1	3
		%	6.3	7.7	6.1
	3	**N**	1	-	2
		%	2.1	-	4.1
	4	**N**	-	-	1
		%	-	-	2.0
Total		**N**	48	13	49

The geographical pattern for the distribution of this trait evidences low frequencies in Western Eurasians (including Eurodonts) between 10-25%, while Sunda-Pacific and some Sub-Saharan populations display intermediate figures (30-40%). The highest frequencies (40-60%) are among Sahul-Pacific and some Sub-Saharan populations (Scott and Turner, 1997).

The lowest frequencies of UM1 C5 in Table 4.4.27 are displayed by prehistoric and historic Western Europeans and by prehistoric Natufians. BT07 and North Africans have intermediate figures. Compared with the Africans, particularly Sub-Saharans and Western Africans, Europeans are characterized by the reduction of this trait along with other simplifications of the form for molars (Irish, 1997, 1998a, 1998b; Scott and Turner, 1997).

Table 4.4.27 - Frequencies of UM1 C5 in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 1-5)

Sample	N	%	Reference
BASE (Portugal)	19	0.0	Fidalgo, 2014; Cunha et al., in prep.
Paimogo I (central Portugal)	67	6.0	Silva, 2002
Natufians (Levant)	189	7.4	Lipschultz, 1997
PDG2	13	7.7	Present study
Coimbra (Contemp. Portugal)	478	8.7	Marado, 2014
PDG1	48	10.4	Present study
Western Europe	238	11.8	Scott and Turner, 1997
São Paulo II (south Portugal)	25	12	Silva, 2002
Dolmen de Ansião (central Portugal)	24	12.5	

Table 4.4.27 - Frequencies of UM1 C5 in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 1-5) (cont.)

Sample	N	%	Reference
BT07	49	16.3	Present study
North Africa	357	18.5	Irish, 1998a
Northern Europe	140	26.4	Scott and Turner, 1997
South Africa	619	32.8	Irish, 1998a
West Africa	48	62.5	Scott and Turner, 1997.

Hypocone or Cusp 4

Frequencies for UM2 *hypocone* per rank in all three Iberian Chalcolithic samples in the present work are detailed in Table 4.4.28.

Table 4.4.28 - Frequencies of UM2 *hypocone* in PDG1, PDG2 and BT07 (all ranks)

			PDG1	**PDG2**	**BT07**
Rank	**0**	**N**	2	1	11
		%	6.5	6.7	22.0
	1	**N**	9	3	1
		%	29.0	20.0	2.0
	2	**N**	4	2	6
		%	12.9	13.3	12.0
	3	**N**	7	3	14
		%	22.6	20.0	28.0
	3.5	**N**	-	-	2
		%	-	-	4.0
	4	**N**	8	4	11
		%	25.8	26.7	22.0
	5	**N**	1	2	5
		%	3.2	13.3	10.0
	Total	**N**	31	15	50

Considering the reduction of UM2 C4, the Chalcolithic samples of BT07 and PDG2, along with the Bronze Age series from Serpa (Portugal) and Coimbra fall within the range for the expected figures for North African and European groups (Table 4.4.29). PDG1 and the coeval sample from Paimogo I display the highest rate of *hypocone* reduction in this comparison.

Table 4.4.29 - Frequencies of UM2 *hypocone* in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 0-1)

Sample	N	%	Reference
West Africa	83	3.6	Scott and Turner, 1997
Khoisan	86	6.2	
North Africa	446	10.6	
Scotts	379	17.9	Adler, 2005
Northern Europe	239	19.2	Scott and Turner, 1997
BT07	50	22.0	Present study
BASE (Portugal)	26	23.0	Fidalgo, 2014; Cunha et al., in prep.
Western Europe	308	24.7	Scott and Turner, 1997
Coimbra (Contemporary Portugal)	530	26.4	Marado, 2014
PDG2	15	26.7	Present study
Paimogo I (central Portugal)	72	33.3	Silva, 2002
PDG1	31	35.5	Present study

Parastyle

Parastyle (Figure 4.4.4) is absent in PDG2 and rare in BT07 and PDG1. Frequencies per rank for this trait are detailed in Table 4.4.30 for the three samples.

Figure 4.4.4 – *Parastyle* on a left UM 2 from PDG1. Inventory number: PDG1-880. Scale in millimeters.

Table 4.4.30 - Frequencies of UM3 *parastyle* in PDG1, PDG2 and BT07 (all ranks)

			PDG1	**PDG2**	**BT07**
Rank	**0**	**N**	62	24	55
		%	93.9	100	98.2
	1	**N**	1	-	1
		%	1.5	-	1.8
	2	**N**	1	-	-
		%	1.5	-	-
	3	**N**	1	-	-
		%	1.5	-	-
	5	**N**	1	-	-
		%	1.5	-	-
Total		**N**	66	24	56

Parastyles seem to be a fairly rare trait among human populations in general. Irish (1998a:254) attributes frequencies of 1.2% for North Africans, 1.3% for Sundadonts, 2% for Sub-Saharans, 4.5% for Europeans and 4.8% for Sinodonts. The Iberian Chalcolithic samples fall within the expected frequencies for this trait (Table 4.4.31).

Table 4.4.31 - Frequencies of UM 3 *parastyle* in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 1-5)

Sample	N	%	Reference
PDG2	24	0.0	Present study
Feteira II, Portugal	36	0.0	Horwath *et al.*, 2014
North Africa	332	1.2	Irish, 1998a
BT07	56	1.8	Present study
Ireland (Neolithic – Early Christian)	104	1.9	Weets, 2004
South Africa	550	2.0	Irish, 1998a
Coimbra (Contemporary Portugal)	296	3.3	Marado, 2014
Çatalhöyük (Neolithic)	74	4.1	Pilloud, 2009
Europe	134	4.5	Irish, 1998a
BASE (Portugal)	18	5.6	Fidalgo, 2014; Cunha et al., in prep.
PDG1	66	6.1	Present study
Italy (Chalcolithic)	335	17.6	Coppa *et al.,* 2007

Lower Canine Root Number

This trait seems to be absent or very rare in the Guadiana Valley, in the Atlantic façade of the Peninsula and even in prehistoric Basques (Table 4.4.32). Prehistoric Iberian's low frequency of the double-rooted canines might be understood as the reflex of African genetic flow into Iberia. Considering a South-North cline for the presence of the trait, North Africans and Southern Iberians (such as the population from BT07) would be on the border between the European distribution of the trait and its complete absence in African populations.

Table 4.4.32 - Frequencies of LC double rooted canines in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU +)

Sample	N	%	Reference
West Africa	33	0.0	Scott and Turner, 1997
South Africa	333	0.0	Irish, 1998a
Khoisan	14	0.0	Scott and Turner, 1997
PDG1	4	0.0	Present study
PDG2	9	0.0	
Feteira II, Portugal	32	0.0	Horwath *et al.*, 2014
Basque Country (Neolithic-Chalcolithic)	32	0.0	Rivera, 2001
North Africa	347	2.3	Irish, 1998a
BASE (Portugal)	14	2.4	Fidalgo, 2014; Cunha et al., in prep.
BT07	41	2.4	Present study
South Siberia	260	3.0	Scott and Turner, 1997
Western Europe	314	5.7	
Northern Europe	214	6.1	

Tomes' Root

Frequencies of this trait in all ranks observed in the samples here are detailed in Table 4.4.33. Most cases of Tome's roots in the Iberian Chalcolithic samples conform to the lower ranks of trait expression according to the ASUDAS scoring system.

Table 4.4.33 - Frequencies of LP1 Tomes' root in PDG1, PDG2 and BT07 (all ranks)

			PDG1	**PDG2**	**BT07**
Rank	**0**	**N**	7	12	35
		%	77.8	85.7	76.1
	1	**N**	-	2	4
		%	-	14.3	8.7
	2	**N**	1	-	4
		%	11.1	-	8.7
	3	**N**	-	-	3
		%	-	-	6.5
	5	**N**	1	-	-
		%	11.1	-	-
	Total	**N**	9	14	46

Fragmentation of the roots in the samples from PDG1 and PDG2 hindered the number of observations of Tomes' root in those collections. In that matter, BT07 presents more solid numbers and this sample is characterized by simpler roots, in which the trait is expressed only in minor grades (Table 4.4.33, above). That trait is also absent in the neighboring populations of BASE and absent or rare in Prehistoric Anatolians and Modern Europeans. North Africans display slightly higher frequencies (8.6%). On the other hand, South and Western Africans display high frequencies (23-38.7%). This pattern might suggest a simplification of the originally complex root form for LP1 in Sub-Saharans.

Table 4.4.34 - Frequencies of LP1 Tomes' roots in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 4-7)

Sample	**N**	**%**	**Reference**
PDG2	14	0.0	Present study
BT07	46	0.0	
BASE (Portugal)	26	0.0	Fidalgo, 2014; Cunha *et al.,* in prep.
Çatalhöyük (Chalcolithic)	36	0.0	Pilloud, 2009
Çatalhöyük (Neolithic)	48	2.1	
Western Europe	270	5.9	Scott and Turner, 1997
Northern Europe	168	6.6	
North Africa	372	8.6	
PDG1	9	11.1	Present study
Basque Country (Neo-Chalcolithic)	50	14.3	Rivera, 2001
South Africa	217	23.0	Scott and Turner, 1997
West Africa	49	38.7	

Multiple Lingual Cusps (LP2 Lingual Cusp Variation)

Distribution of grade frequencies for LP2 lingual cusp variation is marked by a large proportion of grade 2 (Figure 4.4.5) in the three prehistoric samples here. This noticeable pattern is also observed for other European samples such as historical English, Russian, Estonian, Karelian and Saami samples and prehistoric Danish and Ukrainians, ranging from 54-70% of presence for grade 2 specifically (in Turner's raw data, electronic communication from G. Richard Scott, February 7th, 2014), as well as in other sources of raw data (see, for instance Adler's Scottish samples *in* Adler, 2005).

Figure 4.4.5 – Fragment of a mandible from PDG1 with several teeth in situ. LP2 displays a grade 2 lingual cusp variation. Inventory number: PDG1-92.

Table 4.4.35 - Frequencies of LP2 lingual cusp variation in PDG1, PDG2 and BT07 (all ranks)

			PDG1	**PDG2**	**BT07**
Rank	**0/A**	**N**	2	-	16
		%	4.8	-	28.6
	1	**N**	1	-	-
		%	2.4	-	-
	2	**N**	27	16	25
		%	64.3	69.6	44.6
	3	**N**	8	6	6
		%	19.0	26.1	10.7
	4	**N**	0	-	2
		%	0.0	-	3.6
	5	**N**	2	-	3

Table 4.4.35 - Frequencies of LP2 lingual cusp variation in PDG1, PDG2 and BT07 (all ranks) (cont.)

			PDG1	**PDG2**	**BT07**
Rank		%	4.8	-	5.4
	6	**N**	1	-	-
		%	2.4	-	-
	7	**N**	-	-	3
		%	-	-	5.4
	8	**N**	1	-	-
		%	2.4	-	-
	9	**N**	-	1	1
		%	-	4.3	1.8
Total		**N**	42	23	56

The Chalcolithic series in this work and those in Silva (2002), along with North Africans and Chalcolithic Anatolians, display the highest frequencies of multiple cusps on LP2 (Table 4.4.36) in opposition to a latter Portuguese population (BASE). Contemporary Portuguese fall within the range of frequency for North Europeans and Chalcolithic Italians.

Table 4.4.36 - Frequencies of LP2 cusp variation in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 2-9)

Sample	N	%	Reference
BASE (Portugal)	28	50.0	Fidalgo, 2014; Cunha et al., in prep.
Europe	159	62.9	Irish, 1998a
Italy (Chalcolithic)	374	63.4	Coppa *et al.,* 2007
Coimbra (Contemporary Portugal)	502	64.3	Marado, 2014
South Africa	530	68.5	Irish, 1998a
Paimogo I (central Portugal)	45	68.9	Silva, 2002
BT07	56	71.4	Present study
North Africa	270	72.6	Irish, 1998a
Çatalhöyük (Chalcolithic)	28	78.6	Pilloud, 2009
PDG1	42	92.9	Present study
PDG2	23	100	

Cusp Number

Cusp number was registered for all three lower molars in this study (Table 4.4.37). The focal tooth for comparative population studies is usually LM2 which displays more inter-population variability, although information on LM1 also shows valid patterning of geographical distribution (Scott and Turner, 1997).

Table 4.4.37 - Frequencies of 4-cusped, 5-cusped and 6-cusped lower molars in PDG1, PDG2 and BT07

		PDG1			**PDG2**			**BT07**		
		LM1	**LM2**	**LM3**	**LM1**	**LM2**	**LM3**	**LM1**	**LM2**	**LM3**
4 cusps	**N**	6	56	28	4	13	21	7	72	27
	%	8.8	88.9	66.7	15.4	50.0	72.4	8.0	93.5	69.2
5 cusps	**N**	59	7	10	20	6	8	77	4	9
	%	86.8	11.1	23.8	76.9	23.1	27.6	87.5	5.2	23.1
6 cusps	**N**	3	-	4	2	7	-	4	1	3
	%	4.4	-	9.5	7.7	26.9	-	4.5	1.3	7.7
Total	**N**	68	63	42	26	26	29	88	77	39

Considering the simplification of LM1, the series in this study display trait frequencies between those of Western Europeans (7.8%) and North Europeans and North Africans (10%) (Table 4.4.38). Those numbers contrast against the trait in Western and Southern Africans where LM1 is characterized by having more additive morphology and always or almost always display 5-cusped first molars.

Table 5.1.38 - Frequencies of LM1 cusp reduction in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU C5=0)

Sample	N	%	Reference
West Africa	47	0.0	Scott and Turner, 1997
Khoisan	133	0.8	
South Africa	346	1.2	
Western Europe	217	7.8	
BT07	88	8.0	Present study
Coimbra (Contemp. Portugal)	424	8.0	Marado, 2014
PDG1	68	8.8	Present study
BASE (Portugal)	32	9.4	Fidalgo, 2014; Cunha *et al.,* in prep.
Northern Europe	170	10.0	Scott and Turner, 1997
North Africa	250	10.0	
PDG2	26	15.4	Present study

The same cline of the reduction of C5 is observed on LM2 (Table 4.4.39) as South and Western African populations display the lowest frequencies of 4-cusped LM2 while the North Africans and Europeans display the highest ones. Reduced LM2 are particularly frequent in Iberian prehistoric samples with frequencies over 88% (except for PDG2).

Table 4.4.39 - Frequencies of LM2 cusp reduction in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU C5=0)

Sample	N	%	Reference
Khoisan	88	6.8	Scott and Turner, 1997
West Africa	75	12.0	
South Africa	585	24.1	Irish, 1998a
North Africa	381	66.4	
Western Europe	284	71.1	Scott and Turner, 1997
PDG2	29	72.4	Present study
Coimbra (Contemporary Portugal)	491	78.6	Marado, 2014
Northern Europe	225	84.4	Scott and Turner, 1997
PDG1	63	88.9	Present study
BASE (Portugal)	37	89.2	Fidalgo, 2014; Cunha *et al.*, in prep.
Paimogo I (central Portugal)	166	89.2	Silva, 2002
BT07	77	93.5	Present study
Monte Canelas (South Portugal)	39	94.9	Silva, 2002
Cova da Moura (central Portugal)	51	96.1	
Dolmen de Ansião (central Portugal)	33	97.0	
São Paulo II (south Portugal)	43	97.7	

Anterior *Fovea*

Frequencies for all ranks of anterior *fovea* on LM1 in PDG1, PDG2 and BT07 are detailed in Table 4.4.40.

Table 4.4.40 - Frequencies of UM1 *anterior fovea* in PDG1, PDG2 and BT07 (all ranks)

			PDG1	PDG2	BT07
Rank	**0**	**N**	3	-	16
		%	8.3	-	32.0
	1	**N**	2	1	5
		%	5.6	10.0	10.0
	2	**N**	6	3	14
		%	16.7	30.0	28.0
	3	**N**	16	5	12
		%	44.4	50.0	24.0
	4	**N**	9	1	3
		%	25.0	10.0	6.0
	Total	**N**	36	10	50

The Iberian series of PGD1, PDG2 and BT07 display high frequencies of anterior *fovea* (Table 4.4.41). Intermediate figures were obtained for another Iberian Chalcolithic population (Feteira II), while Bronze Age and later Iberians present the lowest frequencies for the trait. This might be an indication of the simplification of the morphology of lower molars in more recent local populations.

Table 4.4.41 - Frequencies of LM1 *anterior fovea* in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 2-4)

Sample	N	%	Reference
BASE (Portugal)	18	5.6	Fidalgo, 2014; Cunha et al., in prep.
Coimbra (Contemporary Portugal)	417	11.3	Marado, 2014
Çatalhöyük (Chalcolithic)	36	19.4	Pilloud, 2009
Çatalhöyük (Neolithic)	55	23.6	
Feteira II, Portugal	24	33.3	Horwath *et al.*, 2014
BT07	50	58.0	Present study
PDG1	36	86.1	
PDG2	10	100	

Distal *Trigonid* Crest (DTC)

Distribution of DTC in PDG1 and BT07 is similar to that of Western European reference populations according to Scott and Turner (1997) and higher than later Portuguese populations (Table 4.4.42). PDG2 displays higher frequency of DTC, but that figure must be taken cautiously once the number of observations for this trait is low in that sample.

Table 4.4.42 - Frequencies of LM1 DTC in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU +)

Sample	N	%	Reference
West Africa	45	0.0	Scott and Turner, 1997
Natufians (Levant)	119	0.0	Lipschultz, 1997
BASE (Portugal)	18	0.0	Fidalgo, 2014; Cunha et al., in prep.
South Africa	447	1.3	Irish, 1998a
Northern Europe	200	2.4	Scott and Turner, 1997
Coimbra (Contemporary Portugal)	424	2.6	Marado, 2014
North Africa	276	3.3	Irish, 1998a
Khoisan	56	4.3	Scott and Turner, 1997

Table 4.4.42 - Frequencies of LM1 DTC in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU +) (cont.)

Sample	N	%	Reference
PDG1	41	4.9	Present study
Western Europe	219	6.4	Scott and Turner, 1997
BT07	64	7.8	Present study
PDG2	16	12.5	

Protostylid

All cases of *protostylid* in PDG1 and PDG2, and almost all cases in BT07 refer to the lowest degree of expression for this trait characterized by the presence of a pit in the buccal groove of molars (Table 5.143). Although this is the most common degree of expression for the trait (also referred to as *foramen molare caecum*), there remain some questions as to the pit-like form is actually an expression of *protostylid* or a completely different trait altogether (Scott and Turner, 1997; Scott, personal communication, September, 2011).

Table 4.4.43 - Frequencies of LM1 *protostylid* in PDG1, PDG2 and BT07 (all ranks)

			PDG1		**PDG2**		**BT07**	
			LM1	**LM3**	**LM1**	**LM3**	**LM1**	**LM3**
Rank	**0**	**N**	23	23	15	15	34	28
		%	45.1	67.6	62.5	75.0	45.3	73.7
	1	**N**	28	11	9	5	39	9
		%	54.9	32.4	37.5	25.0	52.0	23.7
	2	**N**	-	-	-	-	1	1
		%	-	-	-	-	1.3	2.6
	3	**N**	-	-	-	-	1	-
		%	-	-	-	-	1.3	-
Total		**N**	51	34	24	20	75	38

When degree one is considered within the range of presence of *protostylid*, it is a highly frequent trait in archaeological populations from Iberia, Ireland and Turkey and Modern/Contemporary populations from North Africa (Table 4.4.44). In Contemporary Portuguese, the frequency of this trait drops more than 30% in comparison to prehistoric populations in PDG1 and BT07.

Table 4.4.44 - Frequencies of LM1 *protostylid* in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 1-6)

Sample	N	%	Reference
Coimbra (Contemp. Portugal)	429	19.6	Marado, 2014
Europe	200	20.0	Irish, 1998a
South Africa	556	21.0	Irish, 1998a
Çatalhöyük (Neolithic)	100	24.0	Pilloud, 2009
North Africa	351	32.5	Irish, 1998a
Çatalhöyük (Chalcolithic)	46	37.0	Pilloud, 2009
PDG2	24	37.5	Present study
BASE (Portugal)	25	40.0	Fidalgo, 2014; Cunha et al., in prep.
Ireland (Early Christian)	81	51.9	Weets, 2004
BT07	75	54.7	Present study
PDG1	51	54.9	

***Hypoconulid* (Cusp 5 or LM1 C5)**

All grades of expression of this trait on LM1 in the series under study here are detailed in Table 4.4.45. Comparative studies employ different breakpoints for this trait given the emphasis is placed either on the absence of C5 or on its most expressive ranks.

Table 4.4.45 - Frequencies of LM1 *hypoconulid* in PDG1, PDG2 and BT07 (all ranks)

			PDG1	PDG2	BT07
Rank	**0**	N	6	2	5
		%	14.0	11.1	7.9
	2	N	1	-	-
		%	2.3	-	-
	3	N	5	4	6
		%	11.6	22.2	9.5
	4	N	16	7	31
		%	37.2	38.9	49.2
	5	N	15	5	21
		%	34.9	27.8	33.3
Total		N	43	18	63

Although Scott and Turner (1997) report higher frequencies of positive expressions of C5 for prehistoric Europeans when compared to historic ones, in Portugal frequencies for Contemporary and Prehistoric samples are very similar, as seen in Table 4.4.46. Both the populations from Perdigões and Coimbra reference collection are between 87.8% and 88.9%. The Spanish sample here (BT07) displays more complex LM1 marked by the highest expressions of C5.

Table 4.4.46 - Frequencies of LM1 C5 in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 3-5)

Sample	N	%	Reference
BASE (Portugal)	24	70.8	Fidalgo, 2014; Cunha et al., in prep.
PDG1	43	86.0	Present study
Coimbra (Contemporary Portugal)	423	87.8	Marado, 2014
Italy (Chalcolithic)	508	87.8	Coppa *et al.,* 2007
PDG2	18	88.9	Present study
BT07	63	92.1	
Basque Country (Neolithic-Chalcolithic)	36	94.4	Rivera, 2001

***Entoconulid* (*tuberculum sextum* or Cusp 6)**

Table 4.4.47 details the frequency of this trait on that tooth for all series here.

Table 4.4.47 - Frequencies of LM1 C6 in PDG1, PDG2 and BT07 (all ranks)

			PDG1	PDG2	BT07
Rank	**0**	**N**	51	21	73
		%	98.1	91.3	94.8
	1	**N**	-	-	1
		%	-	-	1.3
	2	**N**	1	2	2
		%	1.9	8.7	2.6
	5	**N**	-	-	1
		%	-	-	1.3
Total		**N**	52	23	77

The *entoconulid* is a very common trait in most human groups, except in Western Eurasians and San (Khoisan) who display frequencies between 0% and 10%. Sub-Saharan Africans (except the San), South Siberians, Altaic populations and New Guineans have intermediate numbers (10-20%). North and East Asians are characterized by frequencies between 30-50%, while Polynesians and Australians present the highest figures (>50%) (Scott and Turner, 1997).

The populations in this study fall within the expected range of trait frequency for Eurasians (Table 4.4.48). Frequencies of this trait may have decreased in Western Eurasians through time. This is suggested by the decrease of its frequency between Neolithic and Chalcolithic Çatalhöyük (Pilloud, 2011), Chalcolithic and later Iberians (Fidalgo, 2014; Cunha *et al.,* in preparation) and between the Portuguese samples from the Atlantic coast: Dolmen de

Ansião (3637-3094 BC cal. 2σ) (Silva, 2002), Monte Canelas (3380-2890 BC cal. 2σ) (Boaventura, 2009), Paimogo I (3077-3066 BC cal. 2σ), Cova da Moura (2255-2205 BC cal. 2σ) and São Paulo II (2905-1950 BC cal. 2σ) (Silva, 2002).

Table 4.4.48 - Frequencies of LM1 C6 in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 1-5)

Sample	N	%	Reference
BASE (Portugal)	26	0.0	Fidalgo, 2014; Cunha et al., in prep.
Monte Canelas (south Portugal)	35	0.0	Silva, 2002
Çatalhöyük (Chalcolithic)	50	0.8	Pilloud, 2009
Paimogo I (central Portugal)	179	1.1	Silva, 2002
Coimbra (Contemp. Portugal)	424	1.6	Marado, 2014
Cova da Moura (central Portugal)	54	1.9	Silva, 2002
PDG1	52	1.9	Present study
São Paulo II (south Portugal)	45	4.4	Silva, 2002
Khoisan	85	4.7	Scott and Turner, 1997
BT07	70	5.2	Present study
North Africa	352	7.7	Scott and Turner, 1997
Western Europe	217	8.3	
Dolmen de Ansião (central Portugal)	36	8.3	Silva, 2002
PDG2	23	8.7	Present study
Çatalhöyük (Neolithic)	96	14.0	Pilloud, 2009
Northern Europe	130	16.9	Scott and Turner, 1997
South Africa	362	18.8	
West Africa	47	44.7	

***Metaconulid* (*tuberculum intermedium* or Cusp 7)**

All degrees of expression for C7 (Figure 4.4.6) in the samples discussed here are detailed in Table 4.4.49.

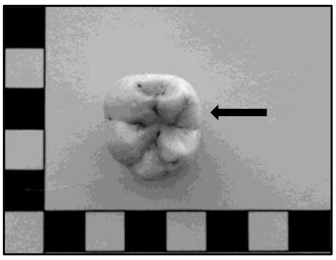


Figure 4.4.6 – C7 (arrow) on a left LM1 from BT07. Inventory number: BT07/D912-107.3. Scale in half centimeters.

Table 4.4.49 - Frequencies of LM1 C7 in PDG1, PDG2 and BT07 (all ranks)

			PDG1	**PDG2**	**BT07**
Rank	**0**	**N**	55	24	67
		%	98.2	100	87.0
	1A	**N**	1	-	9
		%	1.8	-	11.7
	2	**N**	-	-	1
		%	-	-	1.3
Total		**N**	56	24	77

The geographical patterning for the *metaconulid* is marked by frequencies of 25-40% in sub-Saharan Africa and 0-10% among populations from other parts of the world (Scott and Turner, 1997). Among the nine high frequency traits characterizing the Afridont dental complex (Bushman canines, LM1 C7, 2-rooted UP1, UM1 Carabelli's trait, 3-rooted UM2, LM2 Y-groove, LP1 Tomes' roots, 2-rooted LM2 and UM3 presence) is the second "most" African feature given its rarity outside Africa (Irish, 2013: 289).

That pattern is exemplified in Table 4.4.50. Most historic and prehistoric Eurasian populations included in this comparison fall within the 0-10% of frequency for the trait as expected, while South Africans display a frequency of 38.5%. Intermediate figures are provided by BT07 and an Italian population from the Roman Republic period. The Roman expansion to North Africa and the circulation of people from all corners of the Mediterranean into the Italic Peninsula (Alcock and Cherry, 2005) might explain the presence of this African trait in such significant frequency in the latter. As for BT07 and considering the antiquity of this population, we might be dealing with (I) the retention of an archaic trait, (II) gene flow from North Africa into the Guadiana as groups interacted via commerce (Schuhmacher *et al.,* 2009; Schuhmacher and Banerjee, 2012; García Sanjuán *et al.,* in press) or with both.

Table 4.4.50 - Frequencies of LM1 C7 in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 1-4)

Sample	N	%	Reference
PDG2	24	0.0	Present study
São Paulo II (south Portugal)	45	0.0	Silva, 2002
Ireland (Neolithic)	19	0.0	Weets, 2004
PDG1	56	1.8	Present study
Cova da Moura (central Portugal)	54	1.9	Silva, 2002
Catalonia (Neolithic)	27	3.7	Subirá *et al.*, 2014

Table 4.4.50 - Frequencies of LM1 C7 in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU 1-4) (cont.)

Sample	N	%	Reference
Ireland (Early Christian)	81	3.7	Weets, 2004
Paimogo I (central Portugal)	181	5.5	Silva, 2002
Europe	223	5.8	Irish, 1998a
Coimbra (Contemporary Portugal)	432	6.7	Marado, 2014
Sundadont	367	7.4	Irish, 1998a
Çatalhöyük (Neolithic)	93	7.5	Pilloud, 2009
BASE (Portugal)	26	7.7	Fidalgo, 2014; Cunha et al., in prep.
North Africa	414	9.4	Irish, 1998a
Çatalhöyük (Chalcolithic)	49	10.2	Pilloud, 2009
BT07	77	13.0	Present study
Italy (4th-2nd century BC)	72	14.5	Coppa *et al.*, 1998
South Africa	598	38.5	Irish, 1998a

LM1 *Radix entomolaris* (3-rooted LM1 or 3RM1)

The presence of 3-rooted lower molars is used in population studies given its marked pattern of distribution. North and East Asians and American Arctic populations are characterized by frequencies of 3RM1 over 20%. Intermediate frequencies (5-15%) are found in Sunda-Pacific populations and American Indians outside the Arctic region. Populations from other parts of the world either do not have the trait or display it in low rates up to 5% (Scott and Turner, 1997).

Based on his extensive study on Asian populations and on the chronological and geographical dispersion of this trait through Paleolithic East Asia, Turner (1990) suggests that the mutation(s) that caused occurrence of this trait is at least 30,000 years old and was dispersed by Paleolithic population movements. 3RM1 is absent in PDG1 and PDG2 and very rare in most Western Eurasian populations listed in Table 4.4.51, except for Western Africans who display a slightly higher frequency of this trait.

Table 4.4.51 - Frequencies of 3RM1 in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU +)

Sample	N	%	Reference
Northern Europe	198	0.0	Scott and Turner, 1997
Khoisan	15	0.0	
PDG1	11	0.0	Present study
PDG2	6	0.0	
Western Europe	357	0.6	Scott and Turner, 1997
North Africa	337	1.2	Irish, 1998a
South Africa	409	1.7	
BT07	41	2.4	Present study
BASE (Portugal)	32	3.1	Fidalgo, 2014; Cunha et al., in prep.
Feteira II, Portugal	20	3.3	Horwath *et al.*, 2014
Basque Country (Neolithic-Chalcolithic)	82	3.3	Rivera, 2001
West Africa	92	7.6	Scott and Turner, 1997

Groove Pattern (*Dryopithecus* pattern or Y-groove pattern)

Table 4.4.52 details the frequencies for all patterns on all molars from the Iberian samples studied here. As noted by Scott and Turner (1997) for other populations, most LM1 in all three samples display the Y-groove pattern, while for LM2 those rates are more variable.

Table 4.4.52 - Frequencies of groove pattern for LM1, LM2 and LM3 in PDG1, PDG2 and BT07.

		PDG1			**PDG2**			**BT07**		
		LM1	**LM2**	**LM3**	**LM1**	**LM2**	**LM3**	**LM1**	**LM2**	**LM3**
X	**N**	15	22	18	5	18	13	9	25	14
	%	32.6	40.7	51.4	26.3	66.7	59.1	12.9	39.7	35.9
+	**N**	1	5	2	-	5	2	16	16	16
	%	2.2	9.3	5.7	-	18.5	9.1	22.9	25.4	41.0
Y	**N**	30	27	15	14	4	7	45	22	9
	%	65.2	50	42.9	73.7	14.8	31.8	64.3	34.9	23.1
Total	**N**	46	54	35	19	27	22	70	63	39

The retention of the *Dryopithecus* pattern does not exhibit a clear pattern of geographical distribution differentiating human populations (Scott and Turner, 1997:211) except for the San who seem to be an outlier among all human populations. Western Eurasians, Sino-Americans, Sunda-Pacific populations and native Australians are characterized by low frequencies of this trait (5-20%) on LM2. East and South Africans, Melanesians and New

Guineans present intermediate frequencies (25-40%), while San have the highest ones (60-70%).

PDG2 presents frequencies of retention of the *Dryopithecus* pattern compatible with other European populations (Table 4.4.53). BT07's figures are closer to the ones displayed by North and Western Africans, while PDG1 has surprisingly high frequencies of this trait. Further study on the latter is necessary to try to identify possible causes for such high retention of Y-groove pattern, although the nearby population (BASE) also displays frequencies higher than expected, as well as the Chalcolithic sample from Cova da Moura. The difference between PDG1 and PDG2 in what concerns this trait also raises questions. Considering the numbers presented by BT07, BASE, Cova da Moura and PDG1, there is a tendency for higher frequencies of Y-groove pattern. The population from PDG2 stands as a regional outlier in that sense.

Table 4.4.53 - Frequencies of LM2 Y-groove pattern in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU Y)

Sample	N	%	Reference
PDG2	27	14.8	Present study
Coimbra (Contemporary Portugal)	480	20.2	Marado, 2014
Northern Europe	319	21.0	Scott and Turner, 1997
Western Europe	257	27.2	
Natufians (Levant)	154	30.5	Lipschultz, 1997
North Africa	402	30.6	Irish, 1998a
West Africa	67	32.8	Scott and Turner, 1997
BT07	63	34.9	Present study
Cova da Moura (central Portugal)	20	35.0	Silva, 2000b
BASE (Portugal)	29	41.4	Fidalgo, 2014; Cunha et al., in prep.
PDG1	54	50.0	Present study
South Africa	617	52.4	Irish, 1998a
Khoisan	89	71.9	Scott and Turner, 1997

Mandibular *Torus*

Frequencies of mandibular *torus* for the samples in this study are detailed in Table 4.4.54.

Table 4.4.54 - Frequencies of mandibular *torus* in PDG1, PDG2 and BT07 in comparison with other samples (BKP += ASU +)

			PDG1	**PDG2**	**BT07**
Rank	**0**	**N**	24	28	36
		%	77.4	93.3	100
	1	**N**	3	-	-
		%	9.7	-	-
	2	**N**	3	2	-
		%	9.7	6.7	-
	3	**N**	1	-	-
		%	3.2	-	-
Total		**N**	31	30	36

Although the mandibular *torus* was registered during this study, the author did not include its frequencies in any comparison here given her doubts on the use of these figures in the assessment of biological affinities. That uncertainty is based on two aspects: the dubious interpretation of this trait as an expression of genetic/phenetic proximity (Hylander, 1977; Hauser and De Stefano 1989; Halffman *et al.*, 1992; Hassett, 2006; García-García *et al.,* 2010) and the intrinsic characteristic of the samples from BT07, PDG1 and PDG2 regarding the observation of *tori*: the location of the exostosis observed on mandibular fragments and is association with tooth wear (See Chapter 5.1).

4.5. Biological affinities of the Chalcolithic samples at Perdigões and Cerro de las Baterías to worldwide samples

The objective of the following sections is to verify biological affinities among the samples in the present study, and among themselves and with reference series using Principal Components Analysis (PCA).

The PCAs presented below are divided into two levels of analysis: geographic and chronological. PCAs 1-4 address the relationship of populations on a regional level. The remaining tests follow a chronological rationale.

PCA 1 analyzes the intra-site biological affinities among the Chalcolithic Iberian samples of tomb 1 (PDG1) and tomb 2 (PDG2) at Perdigões, and the tomb of Cerro de las Baterías (BT07).

PCA 2 deals with the affinities among the Chalcolithic series (PDG1, PDG2 and BT07) and Bronze Age samples from the same region. Data collection on the dental morphology of the latter followed the same laboratorial protocol as the present work and was carried out by the author and Daniel Fidalgo (Fidalgo, 2014). Both were trained on the ASUDAS by the same advisor (Ana Maria Silva, Department of Life Sciences, University of Coimbra).

PCAs 3 and 4 used data from world-wide reference samples in order to assess biological affinities of the dentition of Chalcolithic Iberian samples to those from macro-regions of interest. Populations in these regions are characterized by displaying the major variations of the human dentition: western Eurasia (Eurodonty); sub-Saharan Africa (Afridonty); Southeast Asia and prehistoric Japan (Sundadonty), and Northeast Asia and indigenous Americans (Sinodonty).

PCAs 5 to 13 assess morphological affinities of the samples in the study against other populations within the geographical limits established for this work through time. Affinities among the samples included in this study and worldwide populations are provided by comparisons against reference series for macro-geographical regions in the literature (Scott and Turner, 1997; Irish, 1998a). Due to space and time limitations, only the most significant results are explained in detail in this chapter. For further PCA results, please refer to Appendix 2.

There is a direct relationship between the available data on the dental morphology of human populations and time. The older the period, the more scarce data are. Preservation of human remains from more ancient times and population structure in certain periods may explain that paucity of information (Pearson, 2005). Anthropic actions, including the funerary treatment will also interfere in the preservation of human remains (Silva, 1996b; 2002).

The funerary treatment of the deceased is one of the features distinguishing humans from other species. However, not all forms of disposing of the dead leave long lasting evidence. Formal inhumation was not dispensed to the majority of individuals in archaeological populations. Even in cases where inhumation was practiced, the type of treatment of the dead may not have had preservation as one of its main objectives. On the contrary, some funerary rites tend to obliterate signs of the individual after his death. Funerary rituals involving exposure to weathering and faunal action, dismemberment of the corpse, cremation of the dead and consumption of body tissues or ashes (either as part of the ritual or for nutritional purposes) help obliterate the physical evidence of the diseased body (Hurlbut, 2000; Weitzel and Mackenzie, 2000; Pearson, 2005). Even when inhumation takes place as part of the funerary treatment, the depth of the tomb may add to taphonomic risk factors: human remains in shallow graves are prone to erosion and truncation in open-air sites over time (Pearson, 2005).

The dispersal of small populations over large territories, high mobility of human groups and the lack of monumentality of funerary spaces in older prehistoric phases can make tombs invisible in the landscape. Thus the identification and recovery of human remains in the buried funeral environment is difficult. Land use after deposition of the bodies may also obliterate their presence. As a consequence of these preservation factors, data decrease as we go back in time through prehistory (Pearson, 2005).

4.5.1. Intra-site, regional and world comparisons

PCA 1

The first comparison deals with the morphological affinities among the three samples included in this study. PDG1 presents slightly older absolute dates than PDG2 but they come from the same site (Valera *et al.*, 2014). Both sepulchers probably served populations living in close proximity over time. Whereas, Cerro de las Baterías (BT07) is located on the opposite side of the Guadiana River, 70 km from Perdigões. Although there are no absolute dates available for BT07, relative dating places it in the Chalcolithic and therefore culturally contemporary to PDG1 and PDG2 (Table 4.5.1). For further information on these osteological series and the archaeological contexts of their provenances, please refer to chapters 2, 3 and 4 in this dissertation.

Table 4.5.1 - Samples used in PCA 1.

Acronym	Full Name	Region/country	Chronology
PDG1	Perdigões Tomb 1	Portugal	Chalcolithic. 2870/2580 – 2830/2470 cal. BC 2σ (Valera *et al.*, 2014).
PDG2	Perdigões Tomb 2	Portugal	Chalcolithic. 2860/2500 – 2460/2200 cal. BC 2σ (Valera *et al.*, 2014).
BT07	Cerro de las Baterías	Spain	Chalcolithic

Only frequencies of traits observed on key teeth were used in this PCA to avoid redundancy in the results. Frequencies of 35 discrete traits (Table 4.5.2) were employed in the analysis. These are distributed on both the superior (18) and inferior (17) jaws and on the anterior (11) and posterior (24) dentition.

Table 4.5.2 - Matrix of the component loadings, *eigenvalues* and variances of the PCA 1 comparing PDG1, PDG2 and BT07*.

Traits	BKP	Component	
		1	2
UI1 shoveling	+= ASU 2-6	**.575**	**.818**
UI1 labial convexity	+= ASU 2-4	**.732**	**.682**
UI1 HRUCI	+=1/0-1	**.685**	**.729**
UI1 double shoveling	+= ASU 2-6	**.953**	.302
UI2 peg	+= ASU 1-2	**.953**	.302
UI2 TD	+= ASU 2-6	**-.712**	**.702**
UI2 interruption groove	+= ASU +	**-.963**	.268

Table 4.5.2 - Matrix of the component loadings, *eigenvalues* and variances of the PCA 1 comparing PDG1, PDG2 and BT07* (cont.).

UC DAR	+= ASU 2-5	**.782**	**-.623**
UC mesial accessory ridge	+= ASU 1-3	**.891**	-.454
UP1 accessory tubercle	+= ASU +	**-.997**	-.081
UP1 accessory ridge	+= ASU +	**-.895**	.445
UM1 Carabelli's trait	+= ASU 2-7	**-.886**	-.464
UM1 C5	+= ASU 2-5	**.983**	.183
UM1 mesial *paracone* tubercle	+= ASU +	**-.997**	-.075
UM2 3-Cusped	+= ASU 0	**.950**	.313
UM2 *hypocone*	+= ASU 3-5	**.513**	**.859**
UM3 *parastyle*	+= ASU 1-5	.074	**-.997**
UM3 congenital absence	+= ASU +	**.953**	.302
LC DAR	+= ASU 2-5	**-.645**	**.764**
LC 2-rooted	+= ASU +	**.953**	.302
LP1 Tomes' root	+= ASU 3-5	.394	**-.919**
LP2 cusp variation	+= ASU 2-9	**-.998**	-.066
LPs congenital absence	+= ASU +	**-.988**	-.155
LM1 C6	+= ASU 1-5	-.318	**.948**
LM1 C7	+= ASU 1-4	**.953**	.302
LM1 3-rooted	+= ASU +	**.953**	.302
LM1 *anterior fovea*	+= ASU 2-4	**-.981**	-.194
LM1 *protostylid*	+= ASU 1-6	**.731**	**-.682**
LM1 C5	+= ASU 1-5	**.695**	**.719**
LM1 4-cusped	+= ASU 4+	**-.808**	**.589**
LM1 DTC	+= ASU +	-.428	**.904**
LM2 5-cusped	+= ASU 5+	**-.885**	.465
LM2 Y-pattern	+= ASU Y	.379	**-.925**
LM3 4-cusped	+= ASU 4+	**.814**	**-.581**
LM3 congenital absence	+= ASU +	**.953**	.302
	Eigenvalue:	23.299	11.701
	Variance (%):	66.569	33.431
	Total variance (%):	66.569	100.000

*Principal Components Analysis. 2 components extracted. Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. BKP=breakpoint.

Two components were extracted explaining 100% of the inter-sample variance. Principal Component 1 (PC1) accounts for 66.57% of that variability, while Principal Component 2 (PC2) sums to 33.43% of the variance.

PC1 is characterized by a significant number of strong loadings, both positive (>0.5) and negative (<-0.5). These loadings are balanced when considering the different divisions of the dentition once both superior and inferior dentition, as well as anterior *versus* posterior teeth play relevant roles in the matrix. In order to focus on the loadings that correlate/inversely correlate most significantly to the distribution of frequencies, the author details those >0.9 or <-0.9 below.

If we consider only the strongest positive loadings over 0.9 in PC1, the main traits influencing the results are: UI1 double shoveling, UI2 peg, UMI C5, 3-cusped UM2, UM3 congenital absence, 2-rooted LC, LM1 C7, LM1 3-rooted and LM3 congenital absence. That implies a slightly heavier loading on the superior dentition. In respect of the strongest negative loadings (<-0.9), the most important loadings are placed by the posterior dentition: UP1 accessory tubercles, UM1 *paracone* tubercle, LP2 lingual cusp variation, congenital absence and *anterior fovea*, against only one strong negative loading provided by the frequencies of UI2 interruption groove.

PC2 presents less strong loadings either positive or negative (>0.5 or <-0.5). Considering only the strongest positive loadings (>0.9), all traits contributing most to PC2 refer to traits on the postero-inferior dentition (LM1 C6 and LM1 DTC). The strongest negative loadings (<-0.5) refer to traits on the posterior dentition, two on the lower arch (LP1 Tomes' root and LM2 Y-groove pattern) and one in the upper one (UM3 *parastyle*).

Figure 4.5.1 displays the relative proximity among the three samples in this study along the two axis representing the variability within the analysis. Factor Score 1 (*x* axis) accounts for most of the variability (66.57%). Along *x* axis both samples from Perdigões share closer phenetic affinities to each other than either to BT07's sample. However in the *y* axis, the BT07 sample is closer to PDG2.

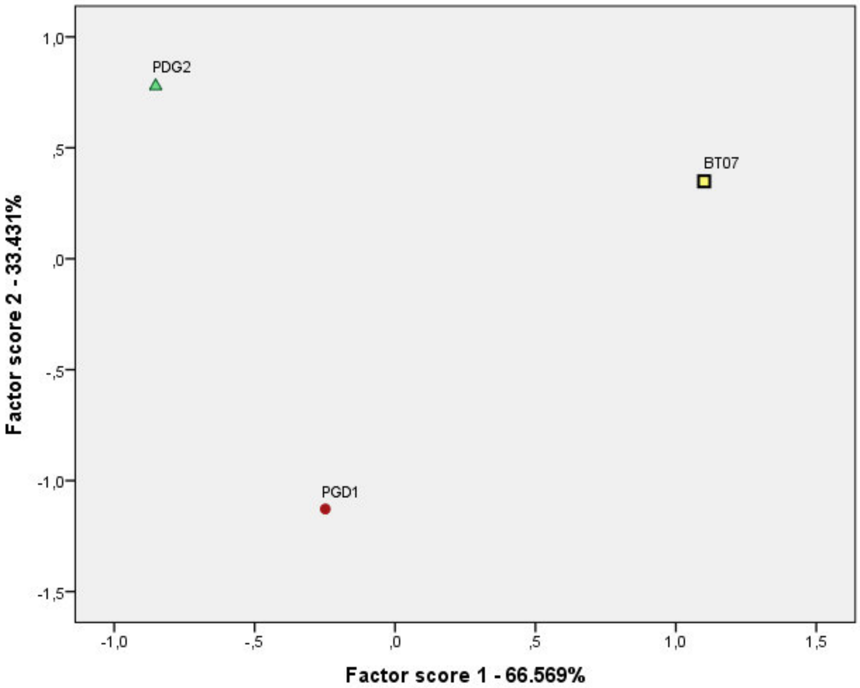


Figure 4.5.1 – Scatterplot of the two first components extracted in the comparison of the samples for PCA 1: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain.

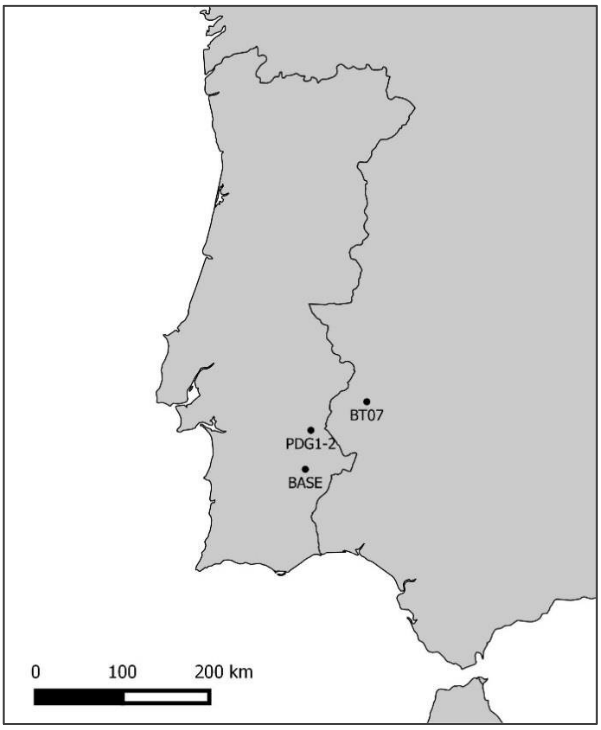
On the *x* axis (FS1 based on PC1) both samples from Perdigões are closely related. Considering that this PC explains over 66% of the inter-sample variability, this proximity suggests that morphologically these two samples share stronger affinities to each other than between either of them to BT07. That is to be expected when both samples come from the same site and, as far as we know, the only difference between these populations is chronological. In fact the time span over which tomb 2 is used as a funerary monument partially overlaps the C14 dates available for tomb 1 (Valera *et al.*, 2014). Although the site of Perdigões may have served as an aggregation center for an extended region as suggested by the archaeological evidence (Valera, 2008b; 2012a; 2012b), these two sepulchers may in fact contain osteological remains from different individuals belonging to the same population. The morphological proximity of these two samples is clear in PCA 16 (see below, PCA 13) when compared to the Coimbra sample in an analysis involving 33 non-metric traits.

It should also be noted that there is archaeological evidence that the chamber of tomb 2 was ‘emptied’ to be re-used at some point in time (Valera and Godinho, 2009), which adds to the complexity of the population profile of this monument.

On the *y* axis (FS2 based on PC2) BT07 is closer to PDG2. That proximity is explained by similar higher frequencies for some traits in both samples (in comparison to PDG1) that resulted in strong positive loadings (>0.7) on PC2. Inversely, the proximity of the samples is also influenced by strong negative loadings (<-0.7) produced by frequencies of some traits that are lower in the first two than in PDG1. The distribution of frequencies of these traits are either correlated or inversely correlated with the distribution of samples along the axes. Most communalities represented by those similar frequencies in PDG2 and BT07 refer to either mass additive traits (such as the presence of tubercles, supernumerary cusps and ridges) or more archaic ones (such as the Y pattern for LM2).

PCA 2

PCA 2 analyzes the morphological affinities among the samples included in this study and a Bronze Age sample from Serpa, Portugal (BASE) (Map 4.5.1). The BASE sample is composed of individuals exhumed from four sites: Outeiro Alto 2/Monte do Gato de Cima 3 (OA2, MNI=19), Cadavais (CAD, MNI=1) and Torre Velha 3 (TV3, MNI=28). The sites are distributed in a 7 km radius and located 45 km south of Perdigões, also on the right margin of the Guadiana River. Human occupation in this area extends at least from the Neolithic to Late Antiquity (Filipe, 2009a; 2009b; 2010; Alves *et al.,* 2010 and 2012; Tomé, 2012). However, the dental morphological studies supporting this analysis were carried out on Bronze Age contexts only.



Map 4.5.1 - Location of the sites included in PCA 2: Perdigões (PDG1-2) and BASE (Serpa) in Portugal and Cerro de las Baterías (BT07) in Spain.

BASE dental sample comes from articulated skeletons exhumed from different kinds of funerary structures (*hypogea* of diverse typology and burial pits). Although some of these tombs were collective contexts, the articulated skulls and mandibles were removed *en bloc* from their original context and subsequently excavated in laboratorial conditions. Thus the dentition from each individual was identified and individually studied. MNI for this sample is 48. The dental morphological study of the individuals from OA2 and CAD was performed by the author. Laboratorial study of and the register of dental traits on the sample from TV3 was carried out by Fidalgo (2014). Both researchers employed the same scoring protocol (including trait selection).

Radiocarbon dates on human remains (for OA2 and CAD) and on faunal remains from the funerary offerings (in TV3) produced a series of dates placing the use of these monuments in the 2nd millennium BC (1870-1410 cal. BC) (Alves, 2012; Tomé, 2012; Tomé *et al.*, 2013). The *hypogea* in TV3 displayed rich funerary goods consisting of ceramics (some of them typologically exogenous to regional production), metal objects and segments of animal paws (*Bos sp.*) understood as votive offerings to the deceased (Alves *et al.*, 2010).

The geographic conditions of these Bronze Age sites are virtually the same as Perdigões, and at least very similar to BT07: all sites are located in the plains flanking the Guadiana River. To date there is no documented archaeological evidence of significant population movement or resettlement between the Chalcolithic and the Bronze Age within this landscape. Nor is there a genetic study of the sample from Serpa. Large/important sites such as Perdigões and Outeiro Alto 2 seem to have been used for millennia (Filipe, 2010; Filipe *et al.,* 2013; Valera *et al.,* 2014). The archaeological context and the regional settlement pattern suggest continuity of occupation of the sites in Serpa (Filipe, 2009a; 2009b; 2010; Alves *et al.,* 2010; 2012; Tomé, 2012; Filipe *et al.,* 2013). Therefore, this statistical test is intended to verify possible biological affinity of BASE series to the Chalcolithic communities that occupied the same territory a millennia before them (PDG1 and PDG2) and also one series from across the Guadiana (BT07).

For PCA 2 only frequencies of traits observed on their respective key teeth were used. Frequencies of 34 discrete traits were employed in the analysis. These are distributed on both the superior (17) and inferior (17) jaws and on the anterior (11) and posterior (23) dentition (Table 4.5.3).

Table 4.5.3 - Matrix of the component loadings, *eigenvalues* and variances of the PCA 2 comparing PDG1, PDG2, BT07 and BASE*.

Traits	BKP	Component		
		1	2	3
UI1 shoveling	+= ASU 3-6	**.839**	-.212	**.502**
UI1 labial convexity	+= ASU 2-4	**.687**	**.603**	-.405
UI1 HRUCI	+=1/0-1	**.750**	**.559**	-.353
UI1 double shoveling	+= ASU 2-6	**-.928**	-.034	-.370
UI2 peg	+= ASU 1-2	**-.937**	-.253	-.239
UI2 TD	+= ASU 2-6	**.899**	-.367	-.240
UI2 interruption groove	+= ASU +	-.369	**-.927**	-.071
UC DAR	+= ASU 2-5	**.577**	**.759**	.302
UC mesial accessory ridge (*Bushman* canine)	+= ASU 1-3	**-.510**	**.850**	.132
UP2 Accessory tubercle	+= ASU +	-.425	-.276	**.862**
UP1 accessory ridge	+= ASU +	**.996**	-.041	.074
UM1 Carabelli's trait	+= ASU 5-7	**.974**	.003	.227
UM1 C5	+= ASU 1-5	**.600**	**.799**	-.036
UM2 3-cusped	+= ASU 0-1	.342	-.099	**.935**
UM2 *hypocone*	+= ASU 3-5	**.619**	.442	**-.650**
UM3 *parastyle*	+= ASU 1-5	**-.695**	.068	**.716**
UM3 peg	+= ASU 0-1	**-.912**	-.383	-.149
LC DAR	+= ASU 1-5	.062	.156	**-.986**
LC 2-rooted	+= ASU +	**-.939**	-.237	-.249
LP1 Tomes' root	+= ASU 3-5	-.148	**.638**	**.755**
LP2 odontome	+= ASU +	**-.912**	-.383	-.149
LP2 cusp variation	+= ASU 2-9	**.934**	-.148	.325
LP2 congenital absence	+= ASU +	**.753**	-.474	.456
LM1 C6	+= ASU 1-5	**.875**	-.104	-.472
LM1 C7	+= ASU 1-4	-.467	**.652**	**-.598**
LM1 3-rooted	+= ASU +	**-.814**	.275	**-.512**
LM1 *anterior fovea*	+= ASU 2-4	**.947**	.052	.316
LM1 *protostylid*	+= ASU 1-6	.084	**.897**	.434
LM1 C5	+= ASU 1-5	.220	**.544**	**-.810**
LM1 4-cusped	+= ASU 4+	**.582**	**-.764**	-.278
LM1 DTC	+= ASU +	**.950**	-.049	-.309
LM2 4-cusped	+= ASU 4+	**-.605**	**.778**	.169
LM2 Y-pattern	+= ASU Y	**-.591**	.430	**.683**
LM3 4-cusped	+= ASU 4+	**-.564**	**.783**	.263

Table 4.5.3 - Matrix of the component loadings, *eigenvalues* and variances of the PCA 2 comparing PDG1, PDG2, BT07 and BASE*.

	Component		
	1	2	3
Eigenvalue:	17.363	8.637	8.000
Variance (%):	51.068	25.402	23.530
Total variance (%):	51.068	76.470	100.000

* Principal component Analysis. 3 components extracted. Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. BKP=breakpoint.

Three components were extracted for PCA 2, explaining 100% of the total variance. PC1 accounts for 51.1% of total variance, followed by PC2 (25.4%) and PC3 (23.5%). In all three components, a number of trait frequencies produced strong positive (>0.5) or negative (<-0.5) loadings. In order to focus on the traits that correlate/inversely correlate most significantly to the distribution of frequencies, loadings >0.7 or <-0.7 are detailed below.

For PC1 traits with the strongest positive (>0.7) and strongest negative (<-0.7) loadings are distributed evenly throughout traits on both upper and lower dentition. UI1 Shoveling, UI2 TD, UP1 DAR, UM Carabelli's trait, LP2 cusp variation, LP2 congenital absence, LM1 C6, LM1 *anterior fovea* and LM1 DTC contributed to the strongest positive loadings. The negative ones were related to UI1 double shoveling, UI2 peg, UM3 peg, LC 2-rooted, LP2 odontome and LM1 3-rooted. In all cases, the most contrasting sample was BASE which presented very low frequencies of traits influencing positive loadings and very high frequencies of features contributing to the negative ones.

PC2 traits with the strongest positive loadings (>0.7) were produced by: UC DAR, *Bushman* canine, UM1 C5, LM1 *protostylid*, LM2 4-cusped and LM3 4-cusped. In all cases but the first trait, the lowest frequencies were presented by PDG2. The lowest frequency of UC DAR was displayed by BASE. The scenario is the same for strongest negative loadings (<-0.7). Strongest negative loadings were displayed by UI1 interruption groove and LM1 4-cusped. The highest scores for these traits were presented by BASE and PDG2 respectively.

Finally, PC3 only presents one strong negative loading (<-0.7) (LC DAR) whose highest frequency was produced by BT07. The significant positive loadings were displayed by UP2 accessory tubercles, UM2 3-cusped, Tomes' root and UM3 *parastyle*. The lowest frequencies of these traits were produced by BT07 (for the first two traits) and PDG2.

These samples conform to the Eurodont pattern in most of the traits listed as characterizing this dental complex by Scott and coauthors (2013). All 4 series display low frequencies of shoveling (BKP 3-6, between 3.4 and 9.1%), double shoveling (0-1.3%), LM1

C7 (0-13%), 3-rooted LM1 (0-2.4%), LM1 *protostylid* in its positive ranks of expression (BKP 2-6, 0-2.6%) and for the presence of 6 cusps LM1 (0-7.7%). The samples also display high frequencies of enamel extension (absent in all 4 samples), reduction of the *hypocone* in the UM2 resulting in 3-cusped molars (22-35.5%), multiple cusps in LP2 (50-100%) and reduction of cusp number in LM1 (8-15.4%) and LM2 (72.4-93.5%) resulting in 4-cusped molars.

Two trait frequencies do not conform to the Eurodont pattern. The presence of Y groove pattern, another typically low frequency trait in Eurodonts is high in BT07 (34.9%), BASE (41.4%) and PDG1 (50%). While PDG2 (14.8%) conforms to European numbers. On the other hand, BASE also displays very low frequency of Carabelli's trait in its cusp/tubercle form for a European series: 9.6%.

When analysis is made based on a large set of frequencies and at a micro-regional scale (only the available samples from the local Middle Guadiana Basin), PDG1 and BT07 share closer biological affinities than with either of the others (see bi-dimensional scatterplot representing 76.47% of the inter-sample variability in Figure 4.5.2). That is particularly obvious in the *x* axis, accounting for over 51% of the intra-sample variability. Considering the affinities expressed in this analysis, PDG1, PDG2 and BT07 are morphologically more similar to each other than to the Bronze Age sample, despite the close geographical distance between the sites of provenance for BT07 and PDG (1 and 2). Closer proximity between the samples from BT07 and PDG1 is also noticed on the *y* axis (25.4% of the variability).

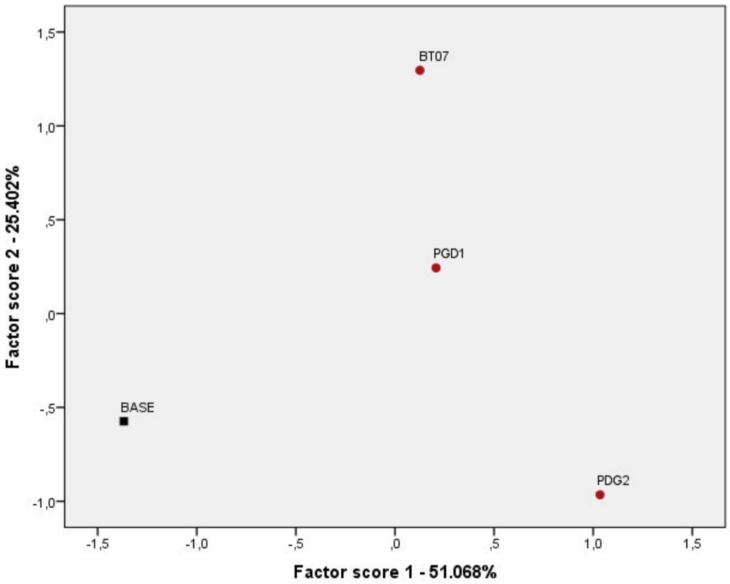


Figure 4.5.2– Scatterplot of the two first components extracted in the comparison of the samples for PCA 2: PDG1=Perdigões, tomb 1, PDG1=Perdigões, tomb 1, and BASE=Bronze Age Serpa, all three in Portugal; BT07=Cerro de las Baterías tomb, Spain.

In the 3-D scatterplot produced from the component matrix of PCA 2 (Figure 4.5.3), the proximity between PDG1 and BT07 on two of the axes is visible, although on the third axis PDG1 stands farther from the other three samples. PDG1 displays a tendency for the simplification of form and reduction of mass for three of the five traits contributing to phenetic distance in the third axis: higher frequencies of 3-cusped UM2 and lower frequencies of LC DAR and LM1 *radix entomolaris*. This morphological simplification conforms to the Eurodont pattern (Scott *et al.*, 2013).

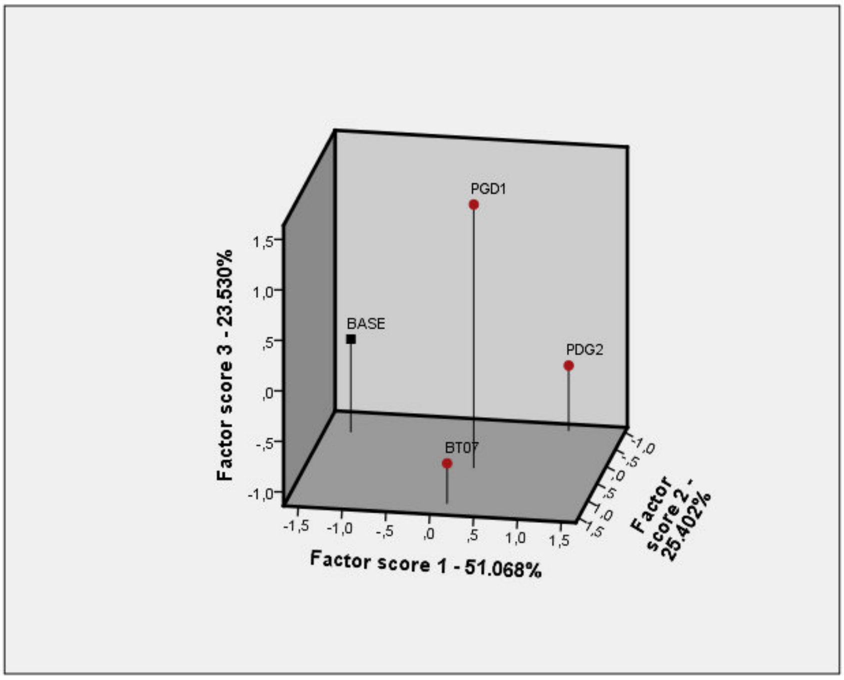


Figure 4.5.3 – Scatterplot of the two first components extracted in the comparison of the samples for PCA 2: PDG1=Perdigões, tomb 1, PDG1=Perdigões, tomb 1, and BASE=Bronze Age Serpa, all three in Portugal; BT07=Cerro de las Baterías tomb, Spain.

Although all samples are morphologically similar, this PC analysis shows that BASE shares less affinities with the Chalcolithic samples than the latter among themselves. This result is interesting considering the geographical proximity between PDG and BASE (only 45 km apart).

These affinities between the Chalcolithic populations on both sides of the Guadiana may indicate shared origins in the genetic stock. However these results may also suggest that Chalcolithic populations living on both sides of the Guadiana could have maintained close enough contacts to allow genetic exchange among people living in the settlements interconnected by that major river. The similar dental morphology expresses closer biological affinities between populations living 70 km apart and across from the river (BT07 and both series from PDG) than among those and later populations living geographically closer (BASE).

Inter-marriage among different populations could produce these similarities among the 3 Chalcolithic samples. Cultural affinities, regular social interaction and commerce among culturally similar groups may have acted as motivating factors for the interaction among populations.

Also of note, on PC1 axis, both BASE and PDG2 differ from BT07 and PDG1. The most obvious factor differentiating these samples are chrono-cultural aspects (Lago *et al.*, 1998; Filipe, 2009a, 2009b, 2010; Alves *et al.,* 2010 and 2012; Tomé, 2012; Filipe *et al.,* 2013; Valera *et al.*, 2014).

PDG2 produced Bell Beaker material and slightly more recent C14 dates than PDG1 (Valera and Godinho, 2009; Valera *et al.*, 2014). BASE is approximately 1000 years more recent than PDG1 and PDG2 (Filipe, 2009a; 2009b; 2010; Alves *et al.,* 2010; 2012; Tomé, 2012; Tomé *et al.*, 2013; Filipe *et al.,* 2013). Chronologically, PDG2 and BASE are the two most recent samples in the batch.

Continuity of Bell Beaker material culture in Early Bronze Age burials, as well as the re-visitation and continuity of use of Beakers funerary structures by later communities (Lillios, 2014) may indicate a continuity of the occupation by the same population through time. If the population from BASE descends from the previous regional gene pool (a probable scenario), its morphological distance from the other series could be explained by one or more processes: (I) genetic input from 'foreign' populations; (II) genetic drift and/or (III) endogamy in the Bronze Age stock. These last two hypotheses are favored by the general archaeological interpretation that Bronze Age Portuguese communities endured a period of inter-group conflict (Kunst, 2000; Kunst and Arnold 2011). Hence, genetic drift, probably favored by endogamic practices within the Bronze Age population of BASE, could be presented as a possible factor explaining the biological distance among that sample and the local Chalcolithic groups.

To date, there is no anthropological study addressing population movements during the Bronze Age in the region of Serpa. Most of the material culture in these burial sites is typologically local although with influences from the Argaric Bronze Age traditions from the Southeast of the Iberian Peninsula being observed (Alves *et al.*, 2010; Filipe *et al.*, 2013). Such influence is reflected in some of the funerary architecture, in the deposition of specific faunal elements (same taxa and part of the body) within the funerary pack in TV3 (Lillios, 2014), and also the typology of certain items of funerary ceramics (Alves *et al.*, 2010; Filipe *et al.*, 2013).

The beginning of the admixture of local populations with exogenous groups could also explain the slight dissimilarities between the Beaker sample of PDG2 and the slightly older Chalcolithic series of PDG1 and BT07.

PCA 3

PCA 3 addresses the biological affinity among the Chalcolithic populations of PDG1, PDG2 and BT07 and a selection of macro-regional reference samples from different regions in Scott and Turner (1997). Frequencies from that source were drawn from several thousand individuals belonging to hundreds of ethnic groups world-wide.

The majority of data result from Christy G. Turner's extensive work on the dental morphology of populations from Western Eurasia, Africa, the American Continent, Asia and Pacific Islands. Contributions have also been made by Joel D. Irish (Africa) and G. Richard Scott (Northern Europe) (Scott and Turner, 1997). Twenty traits were included in Scott and Turner's study. Due to the trait selection criteria for the present study (presented in Chapter 3) the author was able to use 19 of those traits in PCA 3.

Comparative samples used in PCA 3 (table 4.5.4) are representative of the major human dental complexes (Sinodonts, Sundadonts, Afridonts and Eurodonts) (Scott and Turner, 1997). This analysis is intended to provide a broad view of the biological affinities among PDG1, PDG2, BT07 and populations belonging to those complexes.

Table 4.5.4 - Samples from other sources used in PCA 3 (source: Scott and Turner, 1997).

Acronym	Sample	Region – Country	Chronology
WEU	Western Europe	Western Europe	Historic
NEU	Northern Europe	Northern Europe	
NAF	North Africa	North Africa	Prehistoric-Modern
WAF	West Africa	West Africa	Historic
SAF	South Africa	Sub-Saharan Africa	Prehistoric-Modern
KHOI	Khoisan	Sub-Saharan Africa	
CHM	China-Mongolia	Asia	
JOM	Jomon	Japan	Neolithic
NES	Northeast Siberia	Asia	Prehistoric-Modern
SSI	Southeast Siberia	Asia	
AAR	American Artic	North America	
NWA	Northwest North America	North America	
NSAI	North/South American Indian	Americas	
SEE	Southeast Asia	Southeast Asia	
SER	Southeast Asia Recent	Southeast Asia	Historic

The rationale behind sample selection in Scott and Turner's 1997 work was the characterization of the dental morphology of native populations from each region, preferably without the genetic admixture that resulted from increased population mobility and its inherent influence on tooth morphology after the 1500s (Scott and Turner, 1997). These parameters were crucial for the discussion on population history for different regions, human dispersal from Africa and peopling of Asia, Oceania and the Americas by the authors contributing to this data collection (*i.e.,* Turner, 1990; Scott, 1992; Scott and Alexandersen, 1992; Scott and Turner, 1997; Irish 1998a; 2013; Ullinger *et al.,* 2005; Scott *et al.,* 2013) which resulted in reference values commonly used in statistical analysis of population affinities based on dental non-metric traits (*i.e.,* García-Sívoli, 2009; Oumaoui, 2009; Marado, 2010; 2014; Rivera, 2011).

PCA 3 is based on the frequencies of 16 discrete traits distributed on both upper (9) and lower (7) dentition, and on the anterior (4) and posterior (12) dentition. Presence/absence dichotomy was made using the BKP employed by Scott and Turner (1997). Four components were extracted and the three first ones were used in a component matrix explaining 80.66% of the intra-sample variability (Table 4.5.5).

Table 4.5.5 - Matrix of the component loadings, eigenvalues and variances of the PCA 3*.

Traits	BKP	Component		
		1	2	3
UI1 shoveling	+= ASU 3-6	**.946**	.082	-.152
UI1 double shoveling	+= ASU 2-6	**.863**	.040	-.283
UI2 Interruption groove	+= ASU +	**.811**	-.262	.138
UC *Bushman* canine	+= ASU 1-3	**-.631**	**.649**	.146
Up odontome	+= ASU +	**.903**	.040	-.169
UM1 Carabelli's trait	+= ASU 5-7	**-.764**	-.266	-.344
UM1 C5	+= ASU 1-5	-.146	**.821**	-.022
UM1 Enamel Extension	+= ASU 2-3	**.951**	.026	-.110
UM2 3-cusped	+= ASU 0-1	.421	-.480	**.600**
LM1 4-cusped	+= ASU 4+	**-.618**	**-.691**	-.183
LM2 4-cusped	+= ASU 4+	**-.666**	**-.674**	-.082
LM2 Y-pattern	+= ASU Y	**-.676**	.358	.415
LM1 C6	+= ASU 1-5	**.845**	.357	-.053
LM1 C7	+= ASU 2-4	-.290	**.867**	.094
LM1 3-rooted	+= ASU +	**.817**	.104	.087
LM1 DTC	+= ASU +	.458	-.439	.485
	Eigenvalue:	8.157	3.618	1.130
	Variance (%):	50.980	22.613	7.064
	Total variance (%):	50.980	73.592	80.657

* Principal component Analysis. 3 components extracted. Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. BKP=breakpoint.

Several trait frequencies produced either strong positive (>0.5) or negative (<-0.5) loadings. In order to focus on the ones that correlate/inversely correlate most significantly to the distribution of frequencies, loadings of >0.7 or <-0.7 are presented below.

PC1 encompasses a little over 50% of the variance among samples. Traits contributing to the strongest positive loadings (>0.7) in this component are: UI1 shoveling, UI1 double shoveling, UI2 interruption groove, UP odontome, UM1 enamel extensions, LM1 C6 and LM1 3-rooted. For all these traits, the Chalcolithic Iberian samples present low or very low frequencies in the range obtained for the European and North African samples in Scott and Turner (1997). The only trait presenting markedly strong negative loading (<-0.7) in PC1 was UM1 Carabelli's trait. The samples of PDG1, PDG2 and BT07 are characterized by high frequencies of this trait (between 22.4 and 31.2%) being those very similar to the Western European (WEu) sample (27.3%).

PC2 displays only two loadings over 0.7 for UM1 C5 and LM1 C7. Both are low frequency traits in the all 3 Chalcolithic Iberian samples, but also in the WEu sample. UC *Bushman*, produced a positive loading (>0.6). Frequencies of this trait in the Iberian samples are in the range of trait presence for North African samples. The strongest negative loadings in PC2 are <-0.6 and were obtained for cusp reduction in LM1 and LM2. In both cases, PDG1, PDG2 and BT07 present high frequencies. These results are in concordance with other Eurodont samples (NEu, WEu and NAF), and in the opposite spectrum of trait frequency from the Sub-Saharan samples.

PC3 presents only one strong positive loading for UM2 3-cusped. Regarding the reduction of *hypocone* resulting in a 3-cusped UM2, PDG1 and PDG2 are clearly closer to the Sub-Saharan pattern with frequencies of 6.5 and 6.7% respectively; whilst BT07, displaying 22% of 3-cusped LM2, is characterized by more gracile 3-cusped molars conforming to the Eurodont pattern. There are no significant negative loadings on PC3.

The bi-dimensional scatter plot in Figure 4.5.4 (73.59% of the total variance) illustrates the biological affinity among the samples used in PCA 3. Four clusters of samples are visible. The first one (diamonds) comprises the Sinodont populations used in the comparison. The second one (ovals) is composed by Sundadont samples. The third cluster (crosses) contains Sub-Saharan samples. The fourth group comprises Eurodont populations among PDG1, PDG2 and BT07. This pattern of clustering confirms the affinity of the Iberian samples included in this study with major populations within the Eurodont dental complex.

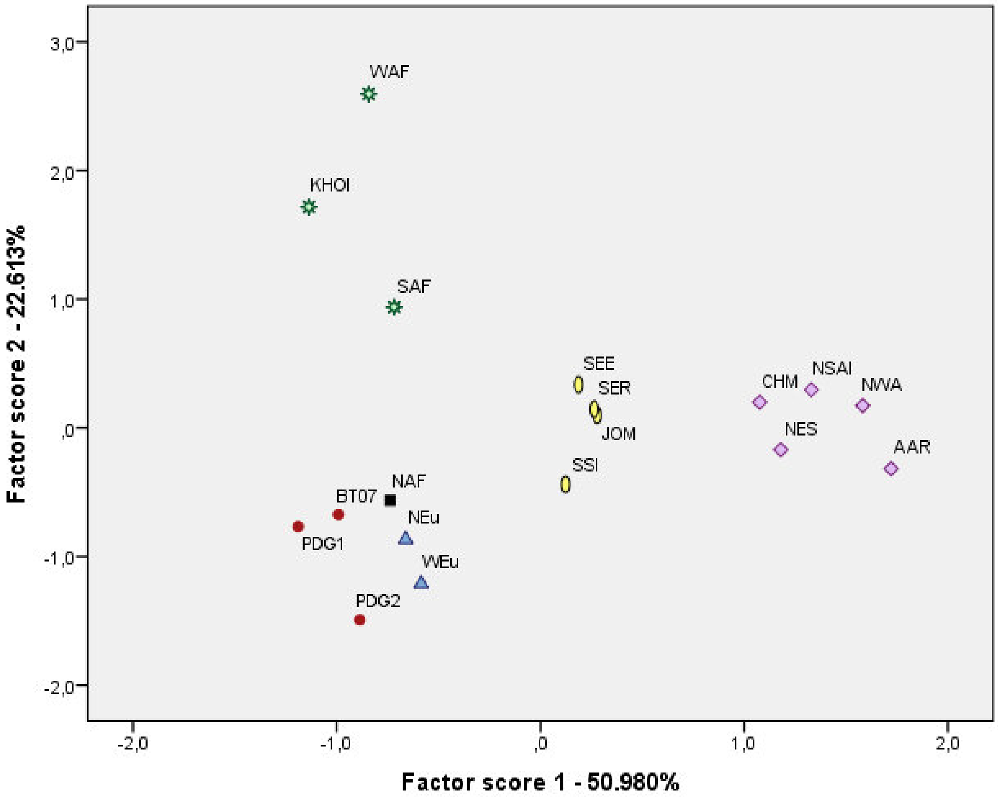


Figure 4.5.4 – Scatterplot of the first two components extracted in the comparison of the samples for PCA 3: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; WEU= Western Europe; NEU= Northern Europe; NAF= North Africa; WAF= West Africa; SAF= South Africa; KHOI= Khoisan; CHM= China-Mongolia; JOM= Jomon; NES= Northeast Siberia; SSI= Southeast Siberia; AAR= American Artic; NWA= Northwest North America; NSAI= North/South American Indian; SEE= Southeast Asia; SER= Southeast Asia Recent.

It should be noted that regarding PC1 (explaining 51% of the intra-sample variability), Afridont and Eurodont populations are closely aligned. That result falls into the expected pattern in concordance with Irish's (1997; 1998a; 2013) conclusions that Afridont individuals are morphologically closer to Eurodonts than to Sundadonts and Sinodonts.

The tridimensional scatter plot in Figure 4.5.5 (encompassing 80.7% of the total variance) reinforces the affinities among all samples in the Eurodont cluster. The traits influencing the third axis, WEu, NEu, NAF, PDG1, PGD2 and BT07 appear to be a more homogeneous batch than the Sundadont populations in this PCA. Populations are even more variable within the Sinodonts.

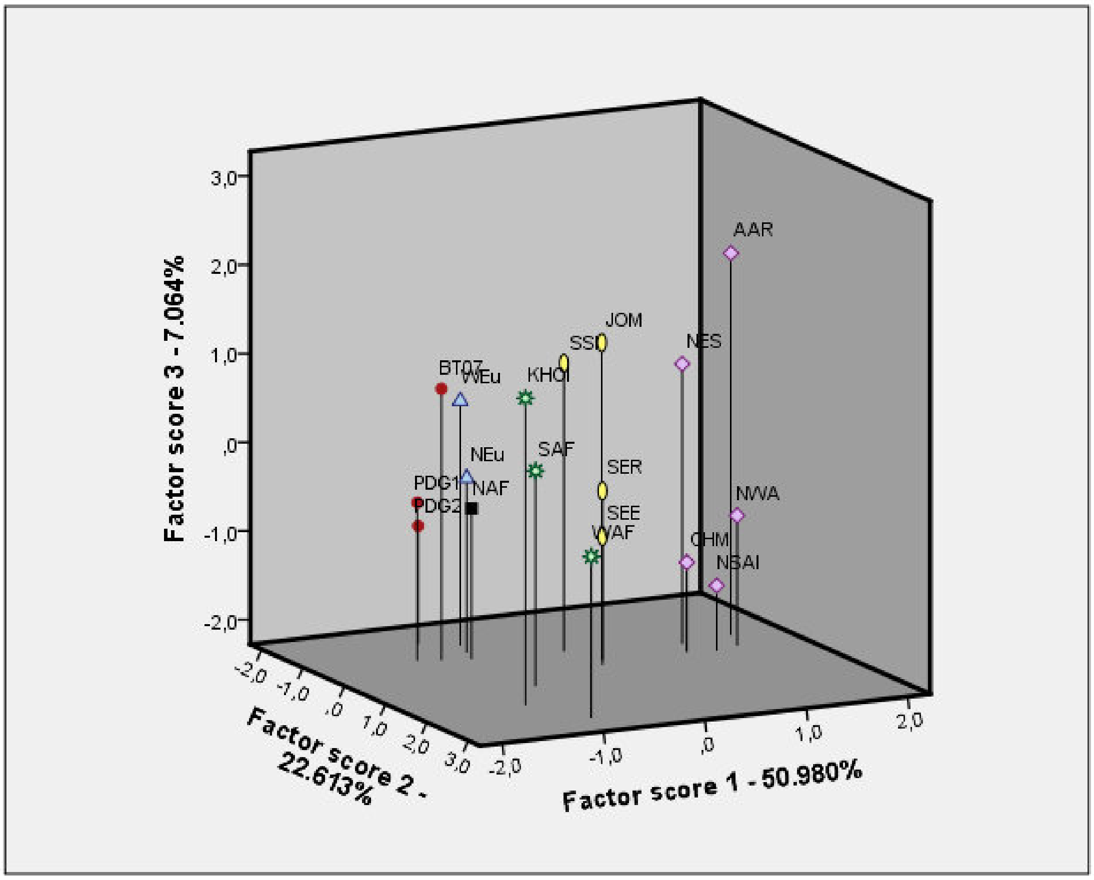


Figure 4.5.5 – Scatterplot of the first three components extracted in the comparison of the samples for PCA 3: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; WEU= Western Europe; NEU= Northern Europe; NAF= North Africa; WAF= West Africa; SAF= South Africa; KHOI= Khoisan; CHM= China-Mongolia; JOM= Jomon; NES= Northeast Siberia; SSI= Southeast Siberia; AAR= American Artic; NWA= Northwest North America; NSAI= North/South American Indian; SEE= Southeast Asia; SER= Southeast Asia Recent.

Populations living across such long distances as those in the Sinodont cluster will undergo more pressure of events promoting biological distance, *e.g.* genetic drift. Considerable distance is expected between the Chinese-Mongolian sample (CHM) and the American Arctic series (AAR), although both are included in the Sinodont pattern and share more similarities between themselves than with samples in other clusters (Turner, 1990; Scott and Turner, 1997). Whilst in the Eurodont cluster it is noted that, regarding the traits analyzed in PCA 3, PDG1 is closer to the European samples and BT07 is closer to NAF and to PDG2.

PCA 4

PCA 4 also addresses the biological affinity among the Iberian Chalcolithic samples (PDG1, PDG2 and BT07) and a batch or macro-regional samples reporting to the major dental complexes. Samples in this comparison (Table 4.5.6) published by Irish (1998a) include 976 individuals from Sub-Saharan groups (SSAH) and 667 from North African groups (NA_JDI). The remaining data on macro-regional groups (EUR, SUN and SIN) come from publications by Turner (Irish, 1998a). Although these samples compose part of the series pooled by Scott and Turner (1997) used in the previous comparison (PCA 3), the two batches differ in the number of African individual observations, breakpoints employed and in trait selection.

Irish (1998a) includes data on traits not addressed by Scott and Turner's publication (namely: UI2 TD, UC DAR, UM3 *parastyle*, UM3 pegged/absent, LP2 cusp variation and LM1 *protostylid*).

Breakpoints for some traits (UI1 shoveling, UM1 enamel extension, UM2 *hypocone*, LM1 cusp number and UM1 Carabelli's trait) are not the ones used by Scott and Turner (1997). The use of different breakpoints helps us identify slight differences in the degree of expression of some traits (*i.e.* for Carabelli's trait) and allows a better perspective on the distribution of those features in different ranks. In the Iberian samples (PDG1, PDG2 and BT07), Carabelli's trait in particular presents more similarities with African samples in its rank of expression than with the European ones.

Finally, the number of individual observations published by Irish (1998a) for the SSAH is in most cases higher than the figures provided by Scott and Turner (1997).

Table 4.5.6 - Samples from other sources used in PCA 4 (source: Irish, 1998a).

Acronym	Sample	Region – Country	Chronology
SSAH	Sub-Saharan	Sub-Saharan Africa	19th century AD.
NA_JDI	North Africa	North Africa	Prehistoric-Modern
EUR	European	Europe	
SUN	Sundadont	Southeast Asia	
SIN	Sinodont	Northeast Asia and New World	

Twenty discrete traits were used in this comparison (Table 4.5.7). Twelve are located on the upper dentition and 8 on the lower arch. Five refer to the anterior teeth and fifteen to the posterior ones. Five components were extracted and the first three used in the following component matrix covering 80.6% of the intra-sample variability.

Table 4.5.7 - Matrix of the component loadings, *eigenvalues* and variances of PCA 4 analyzing world frequencies in Irish (1998a) the Iberian samples included in this study*.

Traits	BKP	Component		
		1	2	3
UI1 shoveling	+= ASU 2-6	**.954**	-.038	-.055
UI1 double shoveling	+= ASU 2-6	**.867**	-.208	.248
UI2 TD	+= ASU 1-6	.321	.095	**-.850**
UC DAR	+= ASU 1-5	**.740**	.461	.192
UC *Bushman* canine	+= ASU 1-3	**-.687**	**.588**	.180
UP odontome	+= ASU +	**.924**	-.129	.202
UM1 Carabelli's trait	+= ASU 2-7	**-.871**	.228	-.028
UM1 C5	+= ASU 1-5	.471	**.754**	-.136
UM1 Enamel extension	+= ASU 1-3	**.942**	-.175	.106
UM2 *hypocone*	+= ASU 1-5	.034	**.552**	-.497
UM3 *parastyle*	+= ASU 1-5	.165	-.080	**.853**
UM3 pegged/absent	+= ASU +	**.744**	-.117	-.139
LP2 cusp variation	+= ASU 2-9	**-.690**	-.209	-.430
LM1 C7	+= ASU 1-4	.107	**.926**	.005
LM1 3-rooted	+= ASU +	**.946**	-.071	.053
LM1 *protostylid*	+= ASU 1-7	-.430	-.356	.341
LM1 6-cusped	+= ASU 1-6	**.969**	.055	-.067
LM1 DTC	+= ASU +	-.122	**-.815**	-.322
LM2 4-cusped	+= ASU 4+	**-.849**	-.439	.159
LM2 Y-pattern	+= ASU Y	**-.578**	**.684**	.376
Eigenvalue:		9.663	3.964	2.499
Variance (%):		48.317	19.820	12.497
Total variance (%):		48.317	68.137	80.634

* Principal component Analysis. 5 components extracted. Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. BKP=breakpoint.

Several trait frequencies produced either strong positive (>0.5) or negative (<-0.5) loadings. In order to focus on the loadings that correlate/inversely correlate with the most significant distribution of frequencies, only >0.7 or <-0.7 are detailed below.

PC1 encompasses 48.3% of the total variance among samples. Traits contributing to the strongest positive loadings (>0.7) in this component are: UI1 shoveling, UI1 double shoveling, UC DAR, UP odontome, UM1 Carabelli's trait, UM1 enamel extensions, pegged/absent UM3, LM1 3-rooted and LM1 6-cusped. Almost all these traits are characteristically low in the

Chalcolithic Iberian samples (except Carabelli's trait which presents relatively intermediate numbers). For most of these traits, PDG1, PDG2 and BT07 showed low or very low frequencies in the range of those obtained for either the European or the North African samples in Irish (1998a). The exceptions are frequencies for UI1 double shoveling and 6-cusped LM1. The lowest figures for these two traits are displayed by the Iberian samples and SSAH respectively.

The only trait presenting markedly strong negative loading (<-0.7) in PC1 was LM1 DTC. The Iberian samples (PDG1, PDG2 and BT07) are characterized by intermediate (4.9%, PDG1) and high frequencies of this trait (7.8 and 12.5% for BT07 and PDG2 respectively). The latter are very similar to the numbers for the EUR sample (8.6%).

PC2 presents only two loadings over 0.7 for UM1 C5 and LM1 C7. The first is a low frequency trait in all three Chalcolithic Iberian samples, but also in the EUR series. For the *metaconulid* cusp however, there is a noted dispersion of frequencies among the Iberian samples. While PDG1 displays a low frequency for this trait (1.8%) and PDG2 does not present the trait, similarly to EUR's figures (5.8%), BT07 displays a 13% rate, again closer to North Africans (9.4%). Other traits presenting relatively strong positive loadings are UC *Bushman* and LM2 Y-groove pattern. PDG1, PDG2 and BT07 present intermediate frequencies of the first trait, while for the LM2 Y-groove pattern only PDG1 and BT07 display the high frequencies close to the African ones.

The only strong negative loading (<-0.7) in PC2 is displayed by LM1 DTC. PDG2 and BT07 present high frequencies in concordance with the EUR, in the opposite spectrum of trait frequency from the Sub-Saharan sample.

PC3 presents one strong positive loading (>0.7) for UM3 *parastyle* and one negative loading for UI2 TD. The first trait is not uniform throughout the Iberian samples. PDG2 displays total absence of the trait, while BT07 shows an intermediate number (1.8%) and PDG1 displays the highest frequency of all the samples included in this comparison (6.1%).

The numerical and graphic results of PCA 4 (Figures 4.5.6 and 4.7.7) place PDG1, PDG2 and BT07 within the Eurodont cluster. The only grouping visible in both the scatterplots includes the samples under study here, North Africans and Europeans.

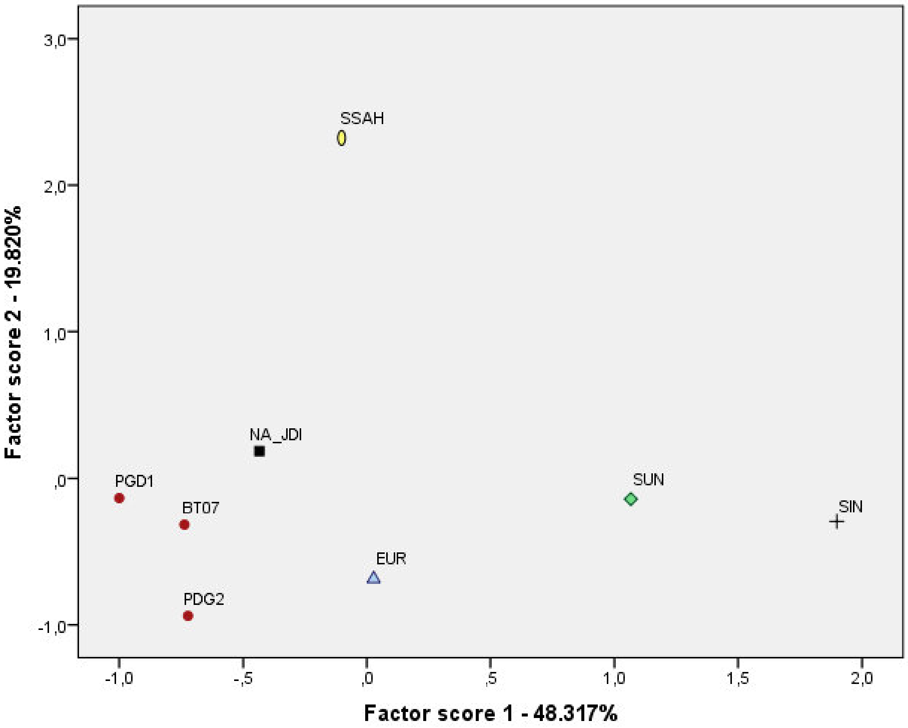


Figure 4.5.6 – Scatterplot of the two first components extracted in the comparison of the samples for PCA 4: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; SSAH= Sub-Saharan; NA_JDI= North Africa; EUR= European; SUN= Sundadont; SIN= Sinodont

Figure 4.5.6 shows the North African sample to be closer to the Chalcolithic samples than to EUR. That result implies similarities on the traits influencing the PC1 (48.31% of the variability). PDG1, PDG2, BT07 and the North African populations display the lowest figures for four traits influencing this axis with strong positive loadings (UC DAR; odontomes, enamel extensions and 6-cusped LM1). The other four traits bearing stronger positive loadings (UI1 shoveling, UI1 double shoveling, pegged/absent UM3 and 3-rooted LM1) share the lowest frequencies either with European or Sub-Saharan populations. The Chalcolithic series in this study and North Africans display intermediate or high frequencies for most traits bearing the strongest negative loadings in PC1. These are either close to Europeans or to sub-Saharans. Statistical exceptions seem to be the relative low frequency of LM2 Y-pattern in PDG1 (14.8%), and the high frequency of multiple cusps on LP2 for Sundadonts.

In respect of the PC2 axis, the typically higher frequencies of *Bushman* canines, UM1 C5, *hypocone*, LM1 C7 and LM2 Y-pattern displayed by Sub-Saharan populations, as well as their low numbers for DTC, sets them apart not only from PDG1, PDG2 and BT07, but also from all others included in this analysis.

The position of PDG1 and BT07 (the two largest Iberian series) in the 3D scatterplot (Figure 4.5.7) minimizes the distance between the Iberians and other European populations.

Low frequencies of UI2 TD and intermediate/high figures for UM3 parastyle in those series draw them closer.

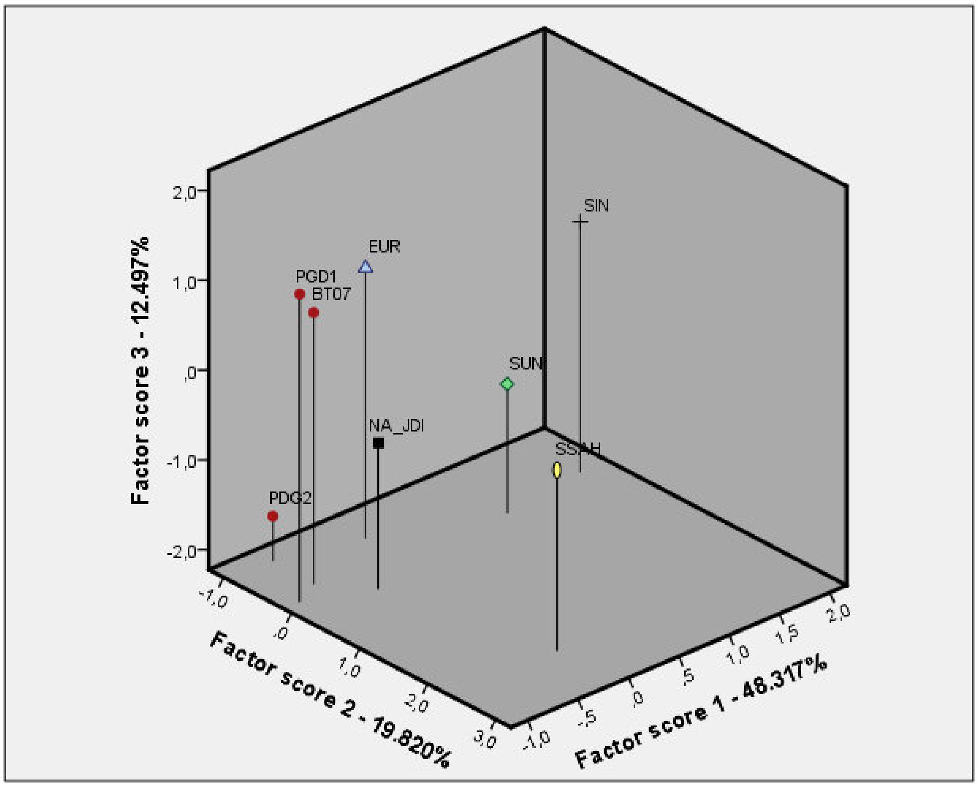


Figure 4.5.7 – Scatterplot of the first three components extracted in the comparison of the samples for PCA 4: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; SSAH= Sub-Saharan; NA_JDI= North Africa; EUR= European; SUN= Sundadont; SIN= Sinodont

Irish (1998a: 256) noticed the existence of an "expansive dental cline that extends from Sub-Saharan Africa through North Africa into Europe". Effects of that cline are visible in the PCA where the samples included in this study are consistently closely associated with populations from both North Africa and Europe (Irish, 1998a). Further similarities may be seen for specific trait frequencies representing deviations from the Eurodont pattern in the direction of the Afridont pattern. The same deviations were found by that author for North African samples.

These deviations in the samples discussed here may be the result of retention of ancestral features (sympleisiomorphy) in the Chalcolithic samples or they may reflect gene flow from South Africa into North African populations and from those into the Iberian Prehistoric stock. Considering the evidence of trade between Chalcolithic groups and North Africa (as discussed in Chapter 2) the second hypothesis has to be considered as a strong possibility.

4.5.2. Biological affinities of PDG1, PDG2 and BT07 to prehistoric and historic populations within the Afridont and Eurodont complexes: diachronic comparisons

The diachronic sample comparisons discussed below (PCAs 5-13) deal with populations in major chrono-cultural phases from the Paleolithic to the Contemporary period in order to infer biological affinities among the Chalcolithic samples of PDG1, PDG2 and BT07 and other populations, most of which from around the Mediterranean basin.

The Mediterranean is the largest inland sea in the world. Although the definition of a Mediterranean region varies according to the criteria employed. Environmental and cultural factors, not only geographical ones have been used to define the extent of the region. Environmental factors include climate, soil features and distribution of characteristic plant regimes. In this context, although not bordering this inland sea, Portugal is fundamentally Mediterranean in climate and culture (Knapp and Blake, 2005).

The Mediterranean is one of the world's two earliest theaters of maritime activity (Broodbank, 2006; Farr, 2010). Although Pleistocene movements across this sea remain debatable and Upper Paleolithic ones seem to be punctual and sporadic, the transition to the Holocene marks the beginning of Mediterranean seafaring (Broodbank, 2006).

The Mediterranean earliest routes seem to have linked the Levant and Anatolia to the Greek Islands and Cyprus (Waelkens *et al.*, 2004). Another route worked across the Italian islands and was favored or motivated by the circulation of obsidian (Farr, 2006; 2010). The consistent use of seafaring is provided by the expansion of the Neolithic innovations through the basin reaching coastal mainland and the Islands. By the 6th millennium BC the Western Mediterranean was integrated in the maritime Neolithic routes (Broodbank, 2006) and by the 5th millennium BC all islands in central Mediterranean were either colonized or being exploited for raw materials (Farr, 2010).

By the middle of the 8th millennium BP Iberian material culture found in North Africa and African industry in Iberia suggest that populations in both sides of the sea were in contact, hence the Neolithization of both areas must be understood as an integrated process (Linstädter, 2008; Linstädter *et al.*, 2012). Based on the study of industry, Cortés-Sánchez and coauthors (2012) defend that the introduction of the Neolithic features into the Iberian Peninsula may have happened via a trans-Mediterranean route from North Africa. Moreover, these authors suggest that this process was far more complex than simple migration and may have involved "transfers, integration and reinterpretation of cultural traits among the cultural mosaic of coeval groups settled in the Western Mediterranean" (Cortés-Sánchez *et al.,* 2012: 231).

There is no reason to believe that these maritime routes ceased being used in later periods. Between the Neolithic mobile groups and the Bronze Age trade routes (Linstädter *et al.*, 2012), Chalcolithic populations should have enjoyed previously existing routes. Continuity of contacts between North Africa and Iberia are evidenced in the archaeological records during Bronze Age (Lillios, 2014).

The major subdivisions of Prehistory are mainly differentiated by technological improvements on the way man interacts with the environment in his attempt to obtain resources, and on shifts in the economic models human societies employ for that purpose. Those changes will inevitably have repercussions on the social organization of human groups (Renfrew and Bahn, 2004).

In what concerns *H. sapiens*, the Paleolithic is characterized by the existence of small hunter-gather communities highly dependent on the seasonality of game and on the available resources from gathering. This dependency required Upper Paleolithic modern humans to be mobile both on a micro scale (*i.e.*, moving from camps within a territory depending on the seasonality of resources) and in a macro-scale (*i.e.*, migrating longer distances when adjusting to unfavorable environmental conditions or following migrating game). Although sites evidencing Upper Paleolithic industry are fairly common, human remains excavated from this period are scarce (when compared to later prehistoric phases), usually providing few individuals and being restricted to fragments of bone and isolated teeth (Scarre, 2005a; Pettit, 2005; Trinkaus, 2005; Barroso and Cunha, 2007/2008).

Most of the earliest archaic *sapiens* come from African sites. Sites dating from 90,000 BP are found in the Near East and only after 35,000 BP directly dated sapien remains appear in the fossil record of Europe (Trinkaus, 2005). Ecological conditions limiting habitable regions in Europe also contribute to restricted geographical distribution of Paleolithic populations to southernmost areas where temperatures were milder (Pettit, 2005).

The Mesolithic (or Epipaleolithic) is a transitional phase when technological improvements, such as composite stone tools based on microlithic industry and stone utensils used to process vegetable products, begin playing an important role in subsistence economies (Scarre, 2005a, 2005b). With the retreat of the ice caps from the Last Glacial Maximum (LGM), large game typical of cold climate migrates to northern regions and human groups adapt to smaller game and more profitable milder environments where expanding forests and riverine ecosystems provide better chances of acquiring resources. Domestication of animals and plants are important Neolithic contributions, however in different regions in the old world, it is during the Mesolithic that human groups begin exploiting the wild types that would be domesticated in the Neolithic (Raposo and Silva, 1993; Bar-Yosef, 1998; Scarre, 2005a, 2005b; Maher *et al.*, 2012).

Most Mesolithic sites seem to reflect population mobility as a strategy to exploit different resources (Raposo and Silva, 1993; Scarre, 2005a), but regional analyses have shown that the beginnings of more enduring architectures make a debut in the Levant (Maher *et al.*, 2012). Paleobotanic and zooarchaeological data support the use of some sites in different seasons of the year, suggesting longer periods of occupation (Watkins, 2005). Funerary rites will vary over the Mediterranean basin, however some common aspects are noticeable: (I) funerary architecture makes use of more enduring lithic elements; (II) primary burial is prevalent; (III) individual inhumations constitute the majority of cases, but they are grouped in the first cemeteries. MNI in those will range from one to a few individuals in some regions to over a hundred in others (Bar-Yosef, 1998; Watkins, 2005; Meiklejohn, 2009; Meiklejohn, *et al.*, 2009; Maher *et al.*, 2012; Jackes and Lubell, 2012). It is during the Mesolithic that a significant regional chronological difference begins being observed around the Mediterranean. If in the Levant the Epipaleolithic ranges from 23,000 to 11,500 ca. BP (Maher *et al.*, 2012), in the opposite side of the basin, Spanish Epipaleolithic groups would thrive between 10,500 and 6,000 BP (Meiklejohn, 2009) and in neighboring Portugal C14 dates on human bones from Mesolithic shell midden burials place their occupation in a time frame around 8,500-6,300 cal. BP (Meiklejohn, *et al.*, 2009; Jackes and Lubell, 2012).

This disparity of dates observed in the Mesolithic continue into the Neolithic. Communities characterized by food producing economies are found in the 8th-7th millennium BC in Southwest Asia, whilst in Iberia the first farming enclaves show up in the archaeological record only around 6th millennium BC (Scarre, 2005b; Watkins, 2005; Pilloud, 2009). Technological developments such as the domestication of animals and plants provided resources for larger populations and favored the emergence of social complexity in the Neolithic (Renfrew and Bahn, 2004; Scarre, 2005b). Larger numbers of individuals and differential preservation conditions of Neolithic remains provide more anthropological data on the populations from this period (Cruz and Cunha, 2007-2008).

The economic, cultural and technological changes introduced in the Neolithic have been focus of intense and so far unresolved debate for over 100 years (Trigger, 1989; Divišová, 2012). They will not be addressed in detail here once this is not the main focus of the present work. However the main approaches to the topic must be mentioned once they relate to the population history of the Mediterranean basin.

Main models for the Neolithization of Europe have postulated either: (I) an indigenous development of Neolithic features driven by changing ecological conditions and influenced by the trade of goods and ideas with Neolithic 'foreign' communities; or (II) an actual population movement and spread of Neolithic farmers through demic diffusion from the Near East into Europe (Ammerman and Cavalli-Sforza 1971; 1984; Trigger, 1989; Tringham, 2000; Scarre, 2005b). A third model considers a phased integration of small migrating Neolithic groups into hunter-gatherer Mesolithic communities (Zvelebil, 2002). Incoming ideas and goods would permeate into indigenous groups from frontier contacts at a first phase, being selectively transmitted into hunter-gather territories by pre-existing contact networks. Subsequently, in a second phase, Neolithic innovations are practiced in traditionally Mesolithic territories either by the adoption of new subsistence strategies from forager communities or by the establishment of small food producing communities. Finally, the Neolithic life style is widely distributed in former Mesolithic territories and transition evidence disappears as extensive and intensive food producing groups dominate the landscape (Zvelebil, 1986a; 1986b, 2002; Lewthwaite, 1986).

Other main models include: (I) elite dominance in which a foreign elite establishes dominance over an autochthone population; (II) infiltration of a community by specialists fulfilling a particular need in a local community; (III) “leapfrog” colonization in which pioneer foreign groups install colonies forming foreign enclaves in a given territory (Richards, 2003). Different models would produce diverse genetic signatures in the European Neolithic communities, once the main question stands at what level foreign/Near Eastern influence operated in the Neolithization process.

The first genetic works on the Neolithic expansion into Europe (Ammerman and Cavalli-Sforza 1971; 1984; Cavalli-Sforza, 1994) were based on classical genetic markers (allele frequencies for blood samples) of modern populations. Later works have broadened the range of data collection by using non recombinant mitochondrial (mtDNA) and Y chromosome DNA (Y-DNA), new laboratorial procedures, different statistical approaches, and most importantly taking ancient DNA (aDNA) as their object of study (Pinhasi *et al.*, 2012). The major breakthrough of these studies on both mtDNA and Y-DNA was the possibility of applying a chronological frame to the processes of Mesolithic-Neolithic transition by inferences on the molecular clock (Richards, 2003).

The demic diffusion model as proposed by Ammerman and Cavalli-Sforza (1971; 1984) does not exclude cultural diffusion, but it places major importance on population movements produced by a wave of advance that would displace or absorb smaller dispersed Mesolithic groups. This wave was expressed by a gradient map displaying the Near East as the mark zero of a genetic cline to Northwest Europe (Cavalli-Sforza, 1994). This map was based on the Principal Components Analysis (PCA) of the variation of 95 classical genetic markers and mirrored the available C14 dates for the spread of Neolithic sites through Europe. Works by other authors (*i.e.,* Sokal *et al.*, 1991) using different analysis supported the idea of sound Neolithic gene flow into Europe as evidence of the Neolithic wave of advance.

Although Ammerman and Cavalli-Sforza’s (1971; 1984) pioneer work stands as a landmark in the study of the genetic history of the Old World, later research based on non-recombinant genetic data challenges certain aspects of the hypothesis of a “wave of advance”. Unlike the classical genetic markers available, mtDNA and Y-DNA (I) provide separate maternal and paternal genealogical histories; (II) are not subjected to reshuffling between lineages; (III) are suitable for chronological inferences, once time of mutation in its genes can be estimated (hence they provide a timescale); and (IV) are suitable for a phylogeographic approach (Richards *et al.*, 1997; Richards and Macaulay, 2001; Richards, 2003).

Richards (2003) summarizes much of the criticism against the genetic approach, statistical treatment and interpretation of the data supporting the model of the demic diffusion of a Neolithic wave of advance through Europe. Using mtDNA and Y-DNA results, Richards (2003) proposes a more important genetic contribution from Mesolithic groups to the European later gene pool. His estimate for Neolithic Near Eastern contribution is between 12-23% (probably 13%). Although Neolithic gene flow is observable, the majority of the European gene pool is most probably the result of acculturation of indigenous populations. Differences in the frequencies of the contribution of male and female lineages is also observed.

The most important result of the study of non-recombinant DNA is that at a regional level, different results are compatible with different forms of interaction among populations (Richards, 2003; Pinhasi *et al.*, 2012) suggesting that the Neolithization of Europe was not an homogeneous process, but derived from regional dynamics resulting in a mosaic picture expressed by the varied genetic data (Tringham, 2000; Pinhasi *et al.*, 2012).

Another interesting conclusion of recent works on aDNA is that the spatial structure genetic variation in Europe was not fixed in the Neolithic and major demographic events that shaped it continued in action after that (Haak *et al.*, 2010; Pinhasi *et al.*, 2012).

During the Chalcolithic (or Copper Age), human groups develop increasingly technological improvements that will facilitate more profitable use of the natural resources, such as the use of draft animals and irrigation systems in agriculture (Mathews, 2005). In terms of social organization, in most of the old world, human groups increase in numbers and, as a result, villages become larger and socially more complex. Hierarchical elites begin the process that will lead to the formation of later Bronze and Iron Age States (Chapman, 2005; Mathews, 2005; Scarre, 2005a; 2005b).

However in some regions in the Old World, particularly across most of the African continent, there seems to have been no actual Copper Age and transition from stone based utensils to iron working happens without this transitional phase, contrary to surrounding regions such as Asia and Europe (Connah, 2005: 368). Despite this difference in technology, human groups in Iron Age Africa exhibit the development of more refined subsistence technologies and the social changes that will escalate into the first African states and empires (Connah, 2005).

When comparing dental samples from published sources to the ones included in the present study we must be aware of not only these chronological differences in the historical phases, but more importantly, of the different chronologies at which these phases happen in different regions around the Mediterranean. The advent of Neolithic and Chalcolithic periods in southwest Asia and in the Levant predate the same cultural phases in Western Europe by thousands of years (Burton and Levy, 2001; Scarre, 2005a; 2005b; Connah, 2005; Mathews, 2005), while in the Iron Age in all three regions and Maghrebian Africa present closer absolute dates (beginning in the end of the 2nd or beginnings of the 1st millennium BC) (van der Plicht *et al.*, 2009).

In terms of absolute chronology, Chalcolithic communities of the 4th-3rd millennia in the Iberian Peninsula were in fact contemporary to (1) Late Chalcolithic and Early Bronze Age communities in Southwest Asia and Levant and (2) Pre-Dynastic and Early Dynastic societies (Dynasties 0-3) in Egypt (Burton and Levy, 2001; Scarre, 2005a; 2005b; Connah, 2005; Mathews, 2005).

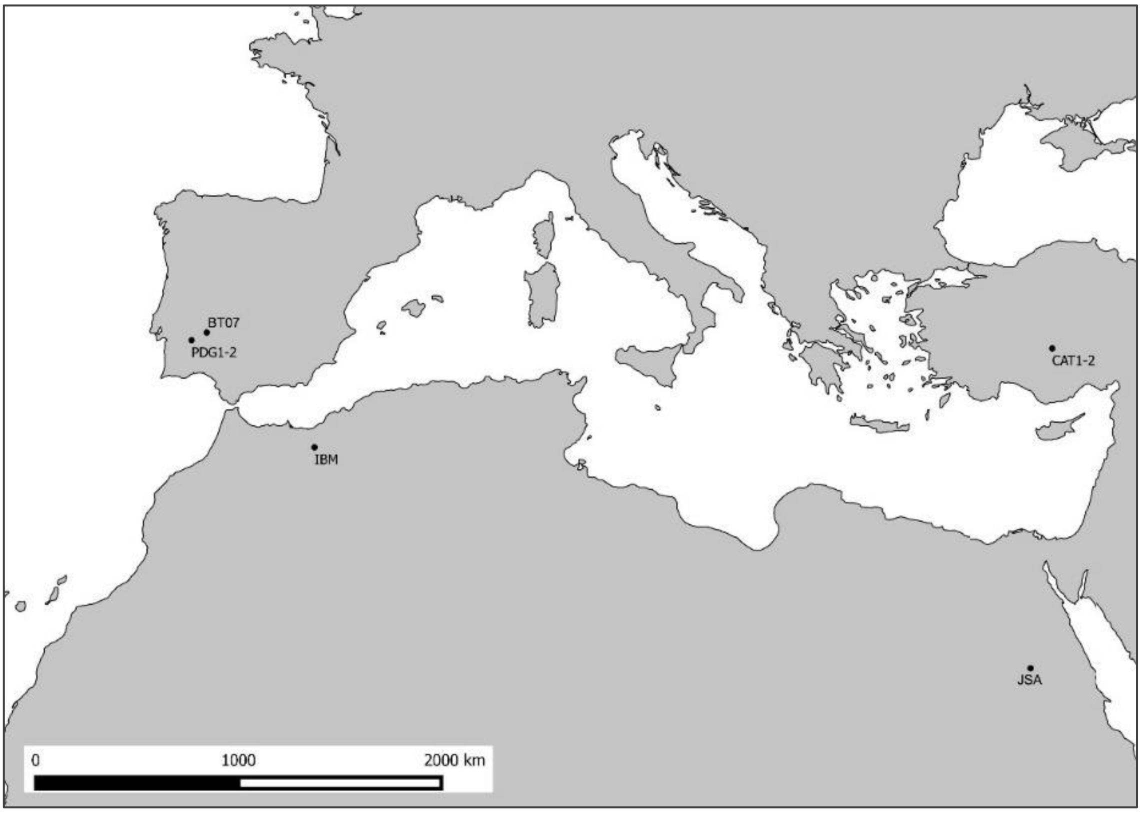
Another point that needs to be stressed is that each genetic pool from which different populations derive is never a fixed uniform snapshot of reality. As any feature in the population history, each genetic pool is dynamic and the expression of its mutability is human variability. Demographic processes working on this variability do not stop at a certain time, but continue affecting population structure though time. It should be expected that as human groups became more mobile in the course of History those dynamics were accelerated.

Having in mind the disparity in prehistoric cultural chronology within the areas of interest of the present work, the author has decided to organize sample comparisons within time frames rather than cultural phases for populations prior to the 1st century AD. The following PCAs will compare the samples addressed by this work against others in 5 periods: 5th millennium BC and older samples, 4th-3rd millennium BC, 2nd-1st millennium BC, 1st millennium-Modern Age, and Contemporary.

4.5.2.1. Comparisons of PDG1, PDG2 and BT07 to others dated to the 5th Millennium BC and older

PCA 5

PCA 5 addresses the biological affinities among the populations in the present work and four others from key locations in the Mediterranean basin (Map 4.5.2) and nearby regions: a sample from Jebel Sahaba (Irish, 2005), two series from Çatalhöyük (Pilloud, 2009), and a pooled Iberomaurusian sample (Irish, 2000) from the Maghreb (Morocco and Algeria) in North Africa.



Map 4.5.2 - Location of the sites included in PCA 5: PDG1 and 2 (Portugal), BT07 (Spain), IBM (Iberomaurusians) and JSA in North Africa and ÇAT1 and 2 (Çatalhöyük, Turkey).

JSA is a Late Paleolithic sample (Irish,1998a) excavated from 3 cemeteries near Jebel Sahaba (ancient Nubia), located on the present day Sudan-Egypt border, and dated to between 14,000-12,000 BP (Irish, 2005) (see Table 4.5.8). The morphological study carried out by Irish (2005) showed that this group diverges from later Nubian populations. While the dental morphology of JSA is more similar to Sub-Saharans, later Nubians share strong affinities with other North African populations (Irish, 2005).

Table 4.5.8 – Samples from other sources used in PCA 5.

Acronym	Sample	Region – Country	Chronology	Reference
JSA	Jebel Sahaba	Sudan	14000-12000 BP	Irish, 2005
ÇAT1	Çatalhöyük 1	Turkey	Neolithic. 7400-6100 cal. BC	Pilloud, 2009
ÇAT2	Çatalhöyük 2	Turkey	Chalcolithic, 6000-5600 cal. BC	
IBM	Iberomaurusian	Maghreb	16750-11450 BP	Irish, 2000a

Çatalhöyük is one of the largest Neolithic sites in Turkey. Research work started in the 1960's and it has contributed to the understanding of the practical, social and symbolic aspects of daily life within the first farming communities of the Middle East (Hodder, 2007b; Watkins, 2005). Çatalhöyük is one of the oldest examples of 'urban' sites in Eastern Mediterranean. Its architecture, art and the large network of procurement of raw materials and goods attest to the importance of the settlement at regional level (Watkins, 2005). The site is divided into two mounds formed by several layers of occupation. The east mound was occupied during the Neolithic (7400-6100 BC) and the west mound during the Chalcolithic (6000-5600 BC) (Hodder, 2003; 2005; 2006; 2007a; 2008; 2009; 2010; 2011; 2012; 2013; Watkins, 2005; Pilloud, 2009).

Most burials excavated in the site are primary inhumations of single individuals in shallow pits covered by plastered floors within the houses. Some tombs have been revisited for the addition of newer cadavers, resulting in disarticulations and reductions of previous individuals. There is no significant sex or age differences in the funerary treatment of the deceased, although some neonates were buried within the foundation deposits of some of the houses (Hodder; 2003; 2005; 2006; 2007a; 2008; 2009; 2010; 2011; 2012; 2013; Pilloud, 2009).

Pilloud (2009) made a thorough study of the dental morphology and population structure at Çatalhöyük (MNI=455). Çatalhöyük's individuals are divided into two samples: a Neolithic population (excavated from the eastern mound of the site) and a Chalcolithic one from the western mound occupation (Table 4.5.8, above).

Pilloud's (2009) work has shown that individuals buried within the houses were no more affiliated biologically than the rest of the population in general. Building on that Pilloud and Larsen (2011) suggest that inclusion in a house-based cemetery did not rely on biological affinity but rather on social interaction. Ian Hodder extrapolates on that and defends the existence of a fostering system in action in Çatalhöyük. Children would be raised with socially defined 'kin', rather than by their biological families (Hodder, 2013, oral presentation at the Allan Hall Memorial Lecture, British Institute of Ankara). Pilloud (2009) also found significant intra-site differences at three levels: (I) between the North and South areas; (II) between gender; and (II) among different chronologic strata. Inclusion in the North and South moieties would be biologically distinct and this distinction would play a role in the selection of burial place. Women seem to be biologically more variable, probably coming from different regions. That would fit a model of male-centered post marital residence practice. The diachronic population differences would reflect gene flow into Çatalhöyük as people migrating from other parts of Anatolia, were incorporated into the social tissue of the site.

The Iberomaurusian population (IBM) (Table 4.5.8, above) is a composite Epipaleolithic sample resulting from numbers published by Irish (2000) from two sites in the Maghreb region (North Africa): Taforalt cave and Afalou-Bou-Rhummel. Iberomaurusian's culture was defined on the basis of a techno-complex predominantly based on microlithic industries. These populations are spread through the Maghreb, being phenotypically characterized by marked skeletal robusticity unlike more gracile later North African populations

(Lubell *et al.,* 1984; Irish, 2000a). Both the origin of those groups and their relationship to later populations is a current debate (Irish, 2000a; Mariotti *et al.*, 2009).

Common aspects of the funerary treatment of Iberomaurusians include (I) multiple/collective burials; (II) complex manipulation of the human remains with the use of defleshing and dismemberment and removal of body parts (particularly of the skulls), (III) extensive use of ochre over the remains, and (IV) association of the human remains with industry and refuse of faunal remains (mouflons) (Lubell *et al.,* 1984; Harverkort and Lubell, 1999; Mariotti *et al.*, 2009). In both Afalou-Bou-Rhummel and Taforalt, human remains were found in the back spaces of the cave/shelter in areas not suitable for domestic use under low ceilings (Mariotti *et al.*, 2009).

Although the origin of Iberomaurusians and their relation to later populations is still debated (Mariotti *et al.*, 2009), some of their funerary practices seem to have influenced later Capsian populations inhabiting the same region (Harverkort and Lubell, 1999).

Irish (2000) addressed the topic of population continuity of Iberomaurusians using discrete dental traits to compare populations from Afalou-Bou-Rhummel and Taforalt to Capsians; historic Algerian Berbers; Guanches (relatively dated c. 2020-310 BP); Paleolithic Nubians; three samples from Egypt (Dynastic through Byzantine), and 4 Nubian samples (Dynastic though Christian times). Irish's (2000) results showed that Iberomaurusians (and particularly the population from Taforalt) diverge from Nubians and Egyptians. They present biological affinities to later North African populations (especially Berbers and Capsians). These results suggest population continuity in North Africa in the transition from the Paleolithic to Late Neolithic. Those relationships are explained by a less complex morphology of Iberomaurusians when compared to the Nubian dentition (Irish, 2000).

Some traits in Afalou-Bou-Rhummel draw this sample apart from the other Maghrebian populations, attesting to the heterogeneity of the morphology of Pleistocene North Africans (Irish, 2000a). In order to verify the effects of the heterogeneity within the Iberomaurusian samples when compared to the populations discussed in this work, two PCA analyses were made providing similar results: (I) PCA 5 (below) using both populations pooled into a single sample, and (II) PCA C (Appendix 2). Once results were very similar, the author has opted to discuss in more detail the analysis making use of more solid numbers provided by the pooled IBM sample.

Fifteen traits were used in PCA 5. Nine refer to the upper dentition and six to the lower one. Traits affecting both anterior (6) and posterior (9) teeth were included. Five components were extracted and the first 3 were used in the components matrix in Table 4.5.9, explaining 73.36% of the variability among the samples.

Table 4.5.9 - Matrix of the component loadings, *eigenvalues* and variances of PCA 5*.

Traits	BKP	Component		
		1	2	3
UI1 labial convexity	+= ASU 2-4	**.911**	.208	-.165
UI1 double shoveling	+= ASU 2-6	-.335	**.666**	**-.535**
UI2 peg	+= ASU 1-2	-.446	**.663**	.468
UI2 interruption groove	+= ASU +	**-.758**	-.363	.316
UC DAR	+= ASU 2-5	**.613**	**.780**	-.007
UC mesial accessory ridge	+= ASU 1-3	-.161	**.592**	**.735**
UP odontome	+= ASU +	**-.567**	-.032	**-.596**
UM3 parastyle	+= ASU 1-5	-.209	-.394	-.126
UM3 congenital absence	+= ASU +	**-.793**	-.166	.430
LP2 cusp variation	+= ASU 2-9	**.760**	.186	.402
LM1 *anterior fovea*	+= ASU 2-4	**.915**	.152	-.043
LM1 *protostylid*	+= ASU 1-6	**.702**	-.203	.295
LM1 6-cusped	+= ASU 6+	-.404	**.862**	-.020
LM1 DTC	+= ASU +	**.805**	-.406	.018
LM2 Y-pattern	+= ASU Y	-.048	.472	-.459
	Eigenvalue:	5.833	3.430	2.191
	Variance (%):	38.888	22.864	14.606
	Total Variance (%):	38.888	61.752	76.359

*Principal component Analysis. 5 components extracted (matrix of the first 3 components). Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. BKP= breakpoint.

The strongest positive loadings (>0.5) in PC1 were registered for six traits: UI1 labial convexity, UC DAR and LM1 *anterior fovea,* LP2 cusp variation, LM1 DTC and LM1 *protostylid.* In almost all cases the Chalcolithic Iberian samples present the highest or close to the highest trait frequencies. UC DAR is an exception, once the samples studied here present intermediate frequencies between the simpler canines from IBM and ÇAT and the extremely frequent UC distal ridges in JSA. All positive loadings refer to traits that characterize complex dentitions and for three of them (UI1 labial convexity, UC DAR and LM1 *anterior fovea*) frequencies of PDG1, PDG2 and BT07 are closer to the Afridont pattern exhibited by JSA than to the other populations. For two of the positive loadings (LP2 cusp variation and LM1 *protostylid*), the high frequencies presented by the Iberian samples are similar to the Chalcolithic sample of ÇAT2.

The strongest negative loadings (<-0.5) for PC1 were observed for three traits. All of them are low frequency features in the Iberian samples: UP odontome, UM3 congenital absence and UI2 interruption groove. The first trait is absent in all samples in PCA 5 except for ÇAT1 (2.4%). The second, UM3 congenital absence, is absent in JSA, PDG1 and PDG2, while BT07 and IBM present low frequencies (3.5 and 4.2% respectively), less than half of the frequencies presented by ÇAT1 and ÇAT2. For the UI2 interruption groove both ÇAT samples and the IBM one display clearly higher numbers than all the other populations.

PC2's five strongest loadings are all positive (>0.5). The Iberian samples present the lowest or second lowest frequencies for four traits (UI double shoveling, UI2 peg, UC *Bushman* canine and 6-cuped LM1), while for the 5th trait (UC DAR) those are intermediate as explained before. For all those traits, JSA displays the highest or second highest frequencies and IBM stands in the opposite end of the spectrum.

PC3 exhibits only one strong positive loading (>0.5) (for UC *Bushman* canine) and two strong negative ones (<-0.5) (UI1 double shoveling and UP odontome). For the first two mass additive traits, the morphology of the Iberian samples is much simpler than all the other populations in this comparison. UP odontome does not seem to be very useful in terms of providing contrast among the samples once in PC 1 and 3 its negative loadings are only barely significant. That is explained by the relatively low variance among the frequencies used, since most of the samples do not display the trait.

Figure 4.5.8 illustrates the biological affinities among the seven samples included in PCA 5 on a bi-dimensional scatterplot representing 61.75% of the inter-sample variability. Two clusters and one outlier are clear in the graphic representation. The first cluster is composed by the Iberian samples. A second cluster draws the Paleolithic IBM sample and the Western Asian ÇAT1 and ÇAT2. The outlier is the only Afridont sample in the batch.

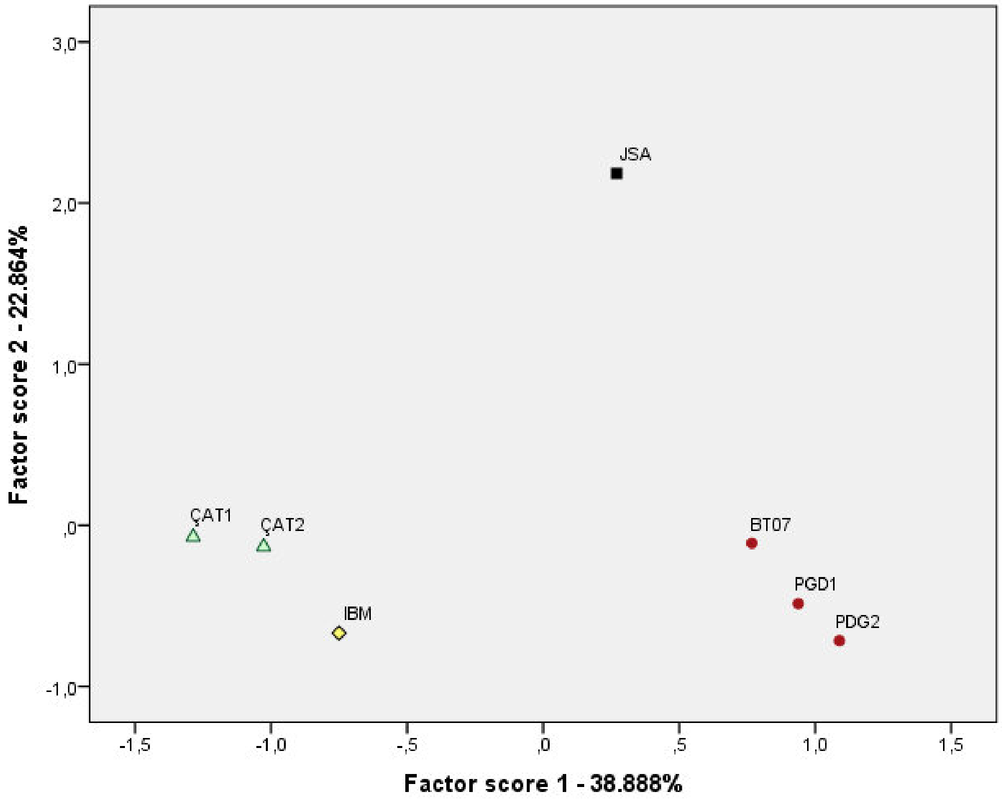


Figure 4.5.8 – Scatterplot of the two first components extracted in the comparison of the samples for PCA 5: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; JSA= Jebel Sahaba, Sudan; ÇAT1= Çatalhöyük 1 and ÇAT2= Çatalhöyük 2, Turkey; IBM= Iberomaurusian, Maghreb.

PC1 axis (explaining 38.9% of the variance) differentiates the Iberian populations and JSA from the other samples because, as explained before, strongest loadings for this axis lay on traits for which the Iberian morphology seems to retain a more archaic morphology: highly convex UI1; complex morphology for LM1 and LP2; presence of UM3, absence of odontomes and low frequencies of UI2 interruption grooves. ÇAT1, ÇAT2 and IMB are on the opposite end of trait expression.

On the other hand, PC2 axis (22.9% of the variance) draws JSA farther from all other samples in this batch once all traits contributing to the strongest loadings are highly significant for Afridont dentitions.

The 3D graphic in Figure 4.5.9 adds information provided by PC3 (14.6% of the variance). It is observable that: (I) biological affinity among the Iberian samples is emphasized in a close grouping; (II) there is a noticeable distance between ÇAT1 and ÇAT2; (III) in what concerns the third axis, the Iberian samples also seem to form a homogeneous group.

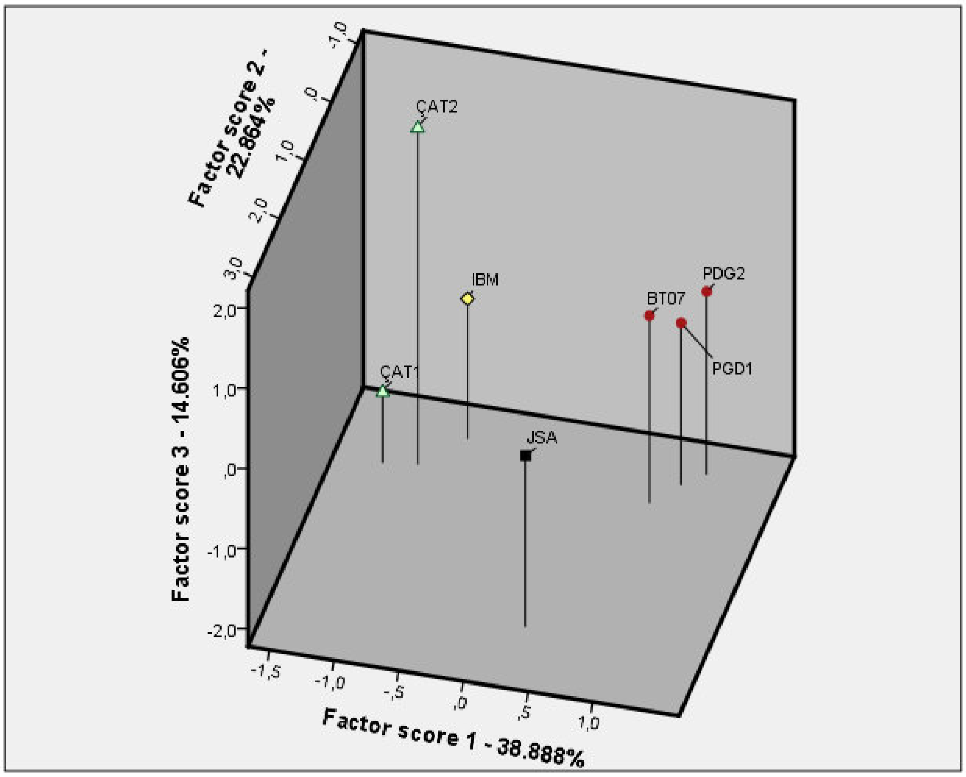


Figure 4.5.9 – Scatterplot of the first three components extracted in the comparison of the samples for PCA 5: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; JSA= Jebel Sahaba, Sudan; ÇAT1= Çatalhöyük 1 and ÇAT2= Çatalhöyük 2, Turkey; IBM= Iberomaurusian, Maghreb.

The results provided by PCA 5 are consistent with Pilloud's (2009) conclusion of a chronological difference between the Neolithic and Chalcolithic populations from Çatalhöyük. This divergence was probably caused by later gene flow into the latter population from other Anatolian groups migrating and being integrated into the flourishing Chalcolithic village (Pilloud, 2009).

Both numerical and graphic results of PCA 5 are also consistent with Irish's (2009) results of a deep difference between Paleolithic Iberomaurusians and Nubians.

The Iberian Chalcolithic samples stand as an isolated cluster apart from all series included in this comparison, demonstrating that they share more affinities among themselves than with any other population in this batch.

However, PDG1, PDG2 and BT07 share more similarities with JSA (as demonstrated by the results of PC1) than with both IBM and samples from Çatalhöyük. That is caused by a more complex morphology in the first (JSA and Iberians): higher frequencies of complex/mass-additive traits (labial convexity, UC DAR, multiple cusps in LP2, *anterior fovea, protostylid*, DTC). At the same time they are characterized the absence or low frequencies of traits that imply mass reduction such as absence of the third molar or pegged UI2.

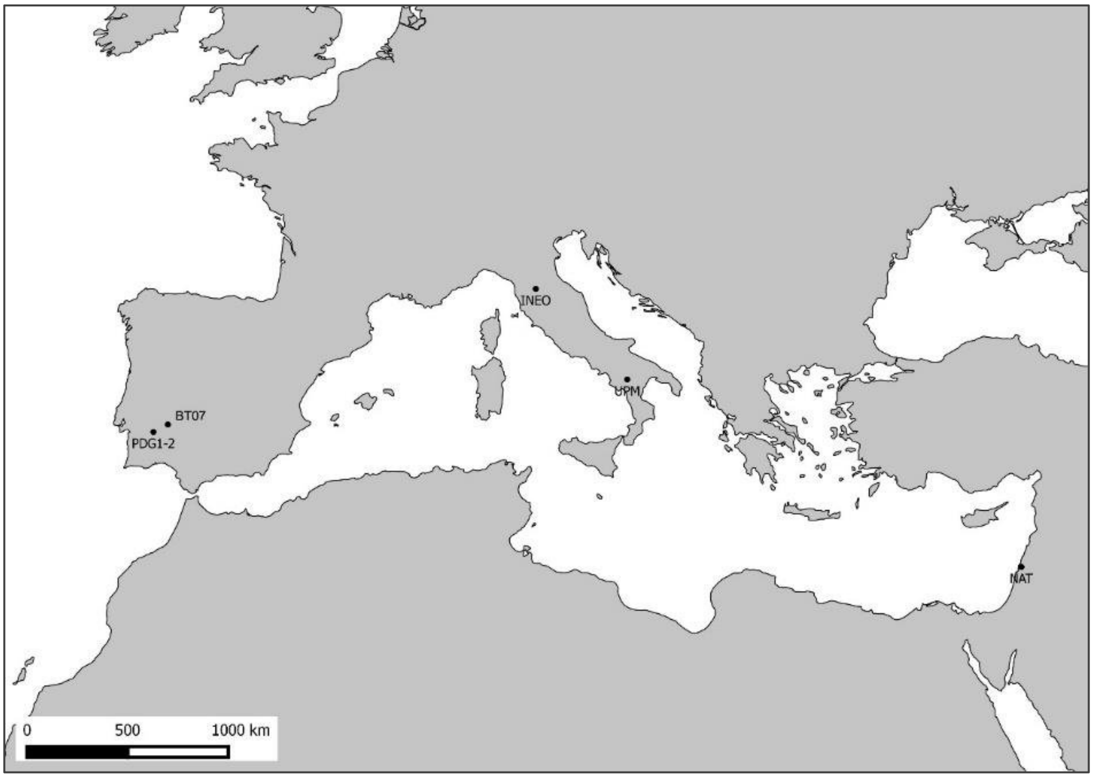
PCA 6

This comparison focus on the assessment of biological affinities among the samples of PDG1, PDG2 and BT07; two Italian series by the acronym of UPM and INEO (Paleolithic-Mesolithic and Neolithic respectively); a sample from Mesolithic-Neolithic Ukraine (UKR), and an Epipaleolithic Natufian series (NAT) (Table 4.5.10).

Table 4.5.10 - Samples from other sources used in PCA 6.

Acronym	Sample	Region – Country	Chronology	Reference
UPM	Upper Paleolithic-Mesolithic Italy	Italy	Upper Paleolithic-Mesolithic, 30000-6000 cal. BC	Coppa *et al.*, 2007
INEO	Neolithic Italy	Italy	Neolithic, 5800-3300 cal. BC	
NAT	Natufians	Levant	12800-10200 BP	Lipschultz, 1997

Geographically, those populations are mostly distributed in the East, North and Northwest of the Mediterranean Sea close to coastal areas (Map 4.5.3).



Map 4.5.3 - Location of the sites included in PCA 6: PDG1 and 2 in Portugal; BT07 in Spain; UPM and INEO in Italy, and NAT in the Levant.

The Natufian culture thrived in the Levant in the Final Epipaleolithic between 13000-10000 BP. They represent the transition of populations from mobile hunter-gatherers to sedentary herders and farmers in the Prehistoric Levant. Archaeological evidence provided by large base camps and smaller temporary occupations suggest that Natufian groups exploited rather smaller foraging areas than their Paleolithic predecessors, depending on intensive and extensive exploitation of plant material (cereal, fruit, tubers) and on locally available medium-sized and small game, besides fish and malacological fauna in coastal areas in the Mediterranean (Bar-Yosef and Belfer-Cohen, 1989; Bar-Yosef, 1998). Natufian lithic industry is abundant on grinding and pounding utensils for processing dry seeds and other plant material. Other frequent bone and lithic industries were involved in the hunting and processing of game (Bar-Yosef, 1998; Watkins, 2005).

Despite being considered a coherent population in terms of biological affinities among different sites (Lipshultz, 1997), Natufians were also involved in short and long term exchange networks ranging as far as the Red Sea and Anatolia (Bar-Yosef, 1998; Watkins, 2005).

The first organized cemeteries in the Levant were made by the Natufians in their settlements. Funerary practices were much diversified in terms of number of individuals per grave and position of the body. Primary and secondary burials occur, as well as the practice of skull removal, although the latter two are more frequent in the Late Natufian and may have been caused by disturbances of earlier graves (Bar-Yosef, 1998). Grave goods consist of frequent elements of body decoration. Only rarely are other kinds of items included. As a novelty, the first inhumations of animals (dogs) appear with the Natufians. Some graves are marked by the deposition of large worn out deep mortars or rocks with cup holes (Bar-Yosef, 1998; Watkins, 2005). Considering time of occupation and population estimates, Bar-Yosef (1998) believes that only a minority of individuals were buried in their cemeteries. However there seems to be no hierarchical selection in access to formal burial.

Lipshultz (1997) made the morphological study of the dentition from all available Natufian human remains in the mid-1990s applying the ASUDAS. He found that the population was highly coherent among the nine sites sampled. This indicates that despite coming from different settlements they displayed consistent biological affinity. When compared with Late Pleistocene Nubians they diverged.

The morphological Italian data used in this PCA comes from the work by Coppa and coauthors (2007) and was then used to test the hypothesis of continuity between the Paleolithic-Mesolithic and Neolithic populations in Italy and the relation of these with later samples also from Italy. The numbers for the composite Paleolithic-Mesolithic population include all human remains bearing permanent dentition in Italy by 2007. The Neolithic numbers refer to the majority of individuals available in the country by that time. Comparative later samples in Coppa *et al.* (2007) are distributed from Chalcolithic to Middle Age Italy.

As discussed before, the main points in comparing pre- and post-Neolithic populations are the questions of population continuity and population structure of Europeans after the Neolithization process, one of the two major events in the genetic history of this Eurasian peninsula (Pinhasi *et al.,* 2012).

In the case of the dental morphology of Italian populations, the results mimic those of genetic studies in different parts of Europe (Haak *et al.*, 2010; Pinhasi *et al.*, 2012): the comparison of Paleo-Mesolithic and Neolithic dental morphology of Italians express morphological and genetic discontinuity (Coppa *et al.*, 2007). However the scenario portrayed by those authors is not one of total population replacement. Although they have identified a specific set of dental traits for Neolithic Italy, some features characterizing the pre-Neolithic populations are also expressed in the later dental morphology of human groups from the region.

Because of differences in breakpoints and teeth observed between the sources used, only ten traits could be employed for this PCA (Table 4.5.11). Three of those are located on anterior teeth, while seven on the posterior ones. Both dental arches are contemplated in this analysis as six traits are located on maxillary teeth and four on mandibular ones.

Table 4.5.11 - Matrix of the component loadings, *eigenvalues* and variances of PCA 6.

Traits	BKP	Component		
		1	2	3
UI1 shoveling	+= ASU 3-6	**-.700**	.473	-.169
UI1 double shoveling	+= ASU 2-6	<u>**.879**</u>	.339	.284
UI2 interruption groove	+= ASU +	.007	**-.939**	-.117
UM1 Carabelli's trait	+= ASU 2-7	<u>**.966**</u>	.102	.100
UM3 parastyle	+= ASU 1-5	-.208	-.272	<u>**.594**</u>
UM3 peg	+= ASU 1-2	<u>**.944**</u>	.307	.103
LP2 cusp variation	+= ASU 2-9	-.482	<u>**.741**</u>	-.357
LM1 C7	+= ASU 1-4	-.178	.095	<u>**.822**</u>
LM2 4-cusped	+= ASU 4+	**-.820**	-.179	.448
LM2 Y-pattern	+= ASU Y	-.257	<u>**.693**</u>	.376
	Eigenvalue:	4.133	2.469	1.641
	Variance (%):	41.327	24.691	16.414
	Total Variance (%):	41.327	66.018	82.432

*Principal Components Analysis. 4 components extracted (matrix of the first 3 components). Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. BKP= breakpoint.

The first three components extracted for PCA 6 summarize 82.4% of the total inter-sample variance. PC1 accounts for 41.3% of that followed by PC2 (24.7%) and PC3 (16.4%).

PC1 presents four strong positive loadings (>0.5). For three of the traits influencing these positive numbers (UI1 double shoveling, UM1 Carabelli's trait and UM3 pegged tooth) the pattern observed in the frequencies is the same: the Iberian samples present the lowest frequencies (along with UPM) while INEO present intermediate ones and NAT display the highest numbers. It must be observed that NAT frequency of pegged UM3 seems to be an outlier. Prehistoric samples from Portugal (present study; Fidalgo 2014; Cunha *et al.*, in preparation), Greece, Syria, Cyprus (Parras, 2004), and Italy (Coppa *et al.*, 2007) display either the absence of the trait or frequencies under 8% for this trait while NAT displays values over five times that (50%). For the last strong positive value (4-cusped LM2), this pattern is somehow inverted as NAT displays the lowest frequency, PDG2 and UPM intermediate ones and BT07 and PDG1 the highest ones. Although two of these traits refer to mass additive features and the last two to the opposite, these clearly place NAT at the end of the dental spectrum explained by the first PC. PDG1 stands as the most dissimilar to NAT in PC1 axis, as observed in Figure 4.5.10.

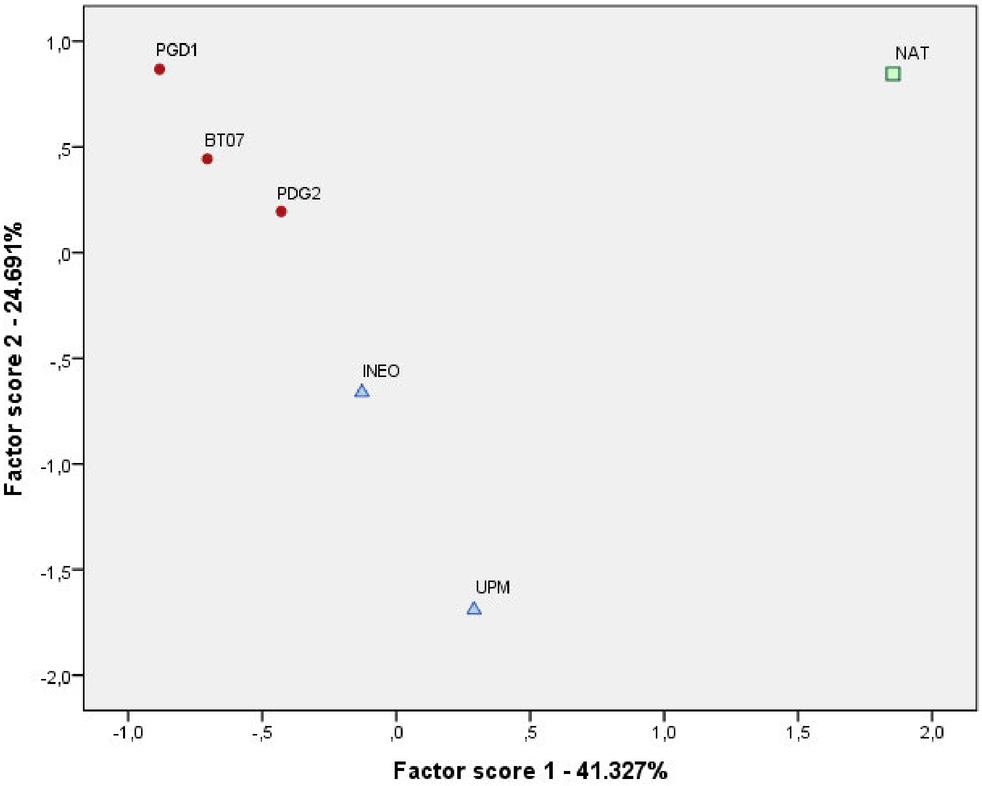


Figure 4.5.10– Scatterplot of the two first components extracted in the comparison of the samples for PCA 6 accounting for 66% of the total inter-sample variance: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; UPM= Upper Paleolithic-Mesolithic and INEO= Neolithic, Italy; NAT= Natufians, Levant.

The only strong negative loading for PC1 refers to UI1 shoveling (<-0.5). Interestingly, frequencies of that trait for the Iberian samples and INEO fall within the observed for African populations while NAT presents a number lower than half of that and UPM displays total absence of the trait.

PC2 presents two strong positive loadings (>0.5) produced by the frequency of LP2 cusp variation and LM2 Y groove pattern. For the first trait the Iberian Chalcolithic samples present the highest frequencies (between 71.4-100%) while UPM present the lowest one (28%) and INEO and NAT display intermediate numbers. For the second trait PDG2 and UPM produced the lowest numbers (14.8% and 15% respectively). INEO displayed an intermediate frequency (23.8%) and the other series the highest values: NAT (30.5%), BT07 (34.9%) and PDG1 (50%). The information the numbers summarize is that these mass additive and complex traits the Italian Mesolithic sample present a simpler morphology. However, PDG1 and BT07 display the highest frequencies which are closer to the ones observed in African populations (Irish, 1998a).

The only strong negative loading (<-0.5) in PC2 was drawn by UI2 interruption groove. In that regard BT07 and NAT display the lowest frequencies (8.8% and 13% respectively). PDG1 and PDG2 present intermediate frequencies (17.4% and 27.8%) while both Italian samples provide the highest figures characteristic of the Eurodont pattern.

Considering the Y axis produced by PC2, one can observe that NAT is relatively close to the Chalcolithic Iberian sample (Figure 4.5.10, above) and very dissimilar to UPM. For all three traits contributing significantly to PC1, UPM displays simpler and more 'European' morphology, immediately followed by INEO.

The results produced by PC1 and PC2 are graphically expressed on the bi-dimensional scatter plot in Figure 4.5.10 (above). The Chalcolithic Iberian samples form a cluster as expected. This cluster shares more similarities with the Neolithic Italian sample (INEO) than with either UPM or NAT.

PC3 accounts for 16.4% of the total variance and it presents only two strong positive loadings (>0.5) referring to UM3 *parastyle* and LMI C7. For the first trait PDG2, BT07 and NAT display the lowest frequencies (<2%). UPM and PDG1 present intermediate frequencies (2.5 and 6.1% respectively) and INEO a relatively high figure (16.9%). Frequencies for the second trait are more uniform with only two series (INEO and BT07) presenting high frequencies in the range of the ones displayed by North African populations, while all the other samples either do not or barely display the trait (NAT, 2.9%).

PC3 is graphically expressed in Figure 4.5.11. When considering the variance along the 3rd axis (PC3), PDG2 is a clear outlier. This may be due to a statistical artifact caused by the low number of traits influencing PC3. It is valid to mention that for both traits with significant loadings in this PC, PDG2 is characterized by the absence of the features.

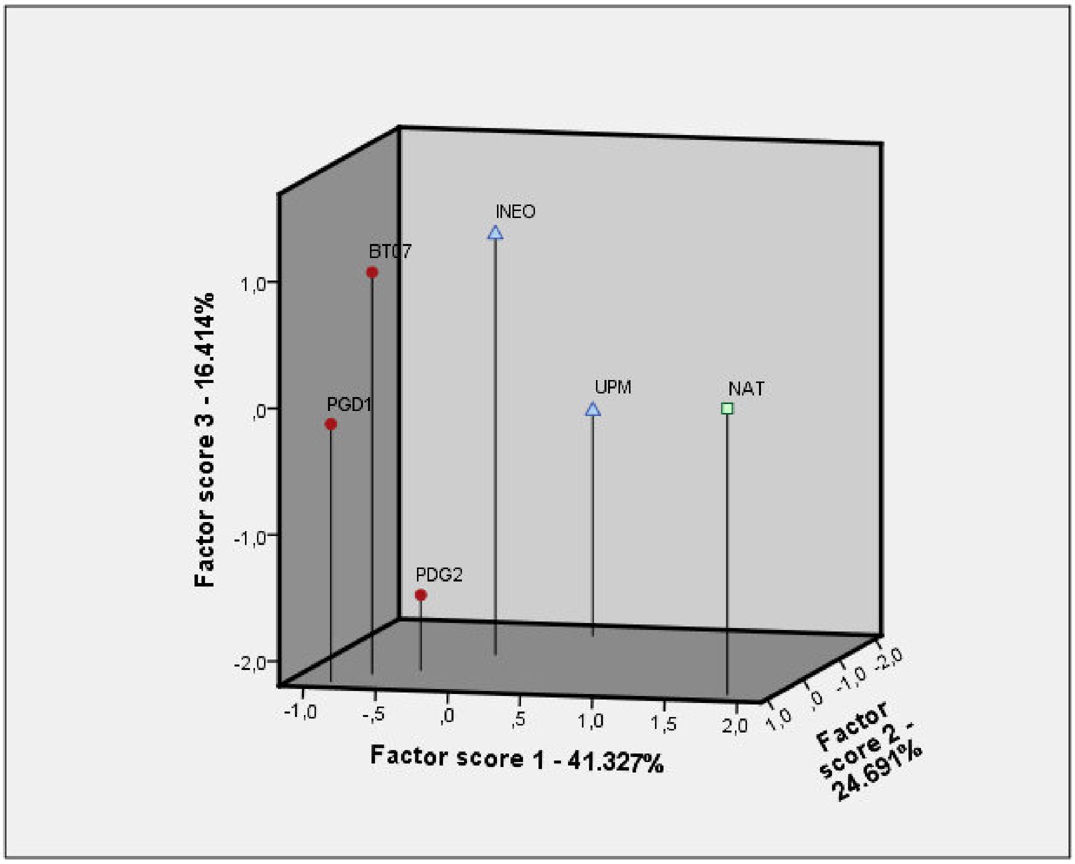


Figure 4.5.11– Scatterplot of the three first components extracted in the comparison of the samples for PCA 6: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; UPM= Upper Paleolithic-Mesolithic Italy and INEO= Neolithic, Italy; NAT= Natufians, Levant.

Although this PCA is based on few traits, it expresses biological dissimilarities between Natufians and all the other samples which may result from the effects of geographical and chronological distance between this population and the others in this batch. The biological structure and the set of morphological traits characterizing this Near Eastern population are expected to be different from the European ones.

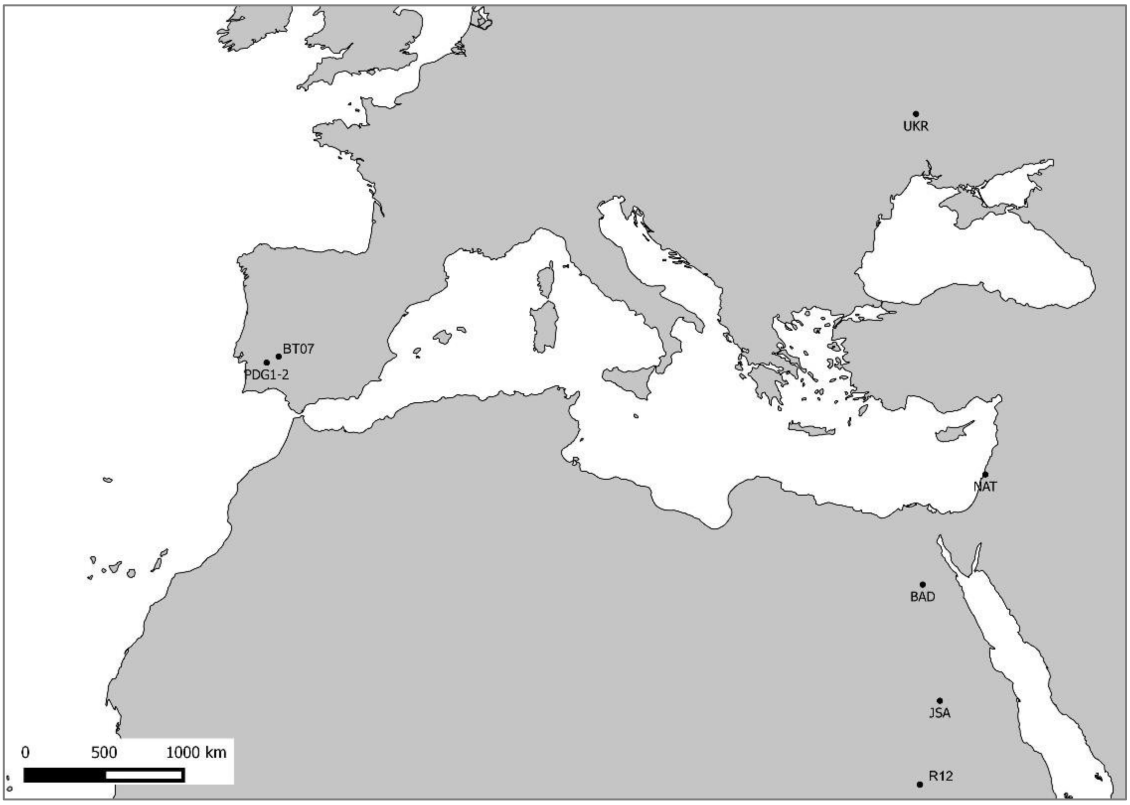
A second sample that is set apart from all others is UPM. This Paleolithic/Mesolithic series displays rather simpler dental morphology. It probably reflects the effects of the genetic drift from the original AMH populations in Africa. It also illustrates the cline towards simplification of traits and reduction of mass as human groups diverge morphologically in time and space from their African roots (Irish, 1997; 1998a; 1998b; 2013; Scott and Turner; 1997; Irish and Guatelli-Steinberg, 2003).

Similarities between the Iberian samples and INEO may be explained not only by their chronological proximity, but also by probable common population admixture produced by the Neolithic population movements in the Mediterranean basin (discussed above in this chapter).

Another hypothesis is that there may have been some direct contact among these populations favored by geographical proximity (all of them are located in Southern Europe) and by existing seafaring routes in the Mediterranean.

PCA 7

This comparison deals with biological affinities among the Iberian populations included in this work (PDG1, PDG2 and BT07) and five other samples distributed in a time frame between 14,000 and 6,000 BP. Geographically, these series come from the Levant (Natufians, NAT), Sudan (Jebel Sahaba, JSA and R12), Upper Egypt (Badarian, BAD) and Ukraine (UKR) (Map 4.5.4).



Map 4.5.4 - Location of the sites included in PCA 7: PDG1 and 2 in Portugal; BT07 in Spain; NAT in the Levant; BAD in Egypt; JSA and R12 in Sudan, and UKR in Ukraine.

Contextual information on NAT and JSA is discussed above (PCA 6).

Information on the UKR (Table 4.5.12) sample is scarce and provided only by electronic communication from G. Richard Scott (University of Nevada, Reno; February 7th, 2014). The formidable work on dental non metric traits carried out by Christy G. Turner II during over four decades has resulted in an impressive collection of morphological data currently curated by Scott. Turner's database contains the results of decades of the late researcher's work on dental non metric traits. It includes raw data per trait and rank registered for each series/population observed during Turner's fieldwork. Region, city or site of provenance are available for those samples as well as, in some cases specificities of ethnic group and/or chronology. Data from this impressive database has been used by Turner and coauthors in countless publications. After Turner's passing in 2013, some of the information on this series got temporarily unavailable once his files are still being subjected to re-organization. The only information so far available for this population is the country of provenance (Ukraine) and the cultural phase attributed to this population (Mesolithic-Neolithic).

Table 4.5.12 - Samples from other sources used in PCA 7.

Acronym	Sample	Region – Country	Chronology	Reference
NAT	Natufians	Levant	12800-10200 BP	Lipschultz, 1997
JSA	Jebel Sahaba	Sudan	14000-12000 BP	Irish, 2005
BAD	Badarian	Upper Egypt	Predynastic, 4400-4000 cal. BC.	Irish, 2006; Irish and Konigsberg, 2007
UKR	Ukraine	Ukraine	Mesolithic-Neolithic	Christy Turner's database
R12	R12 Site	Sudan	Neolithic 5910+/-50 – 5860+/-80 BP	Irish, 2008

Although the dates for Mesolithic sites in Ukraine seem to be problematic (Zaliznyak and Kozlowski, 2007), Neolithization of the Northern Black Sea region began around 7500 cal. BC (Nadezhda, 2009). Chalcolithic was fully established around 4500 cal. BC (Motuzaite-Matuzeviciute *et al.*, 2013). UKR sample is probably not more recent than the 5th millennium BC.

Badarians (BAD, Table 4.5.12, above) are Predynastic (5th millennium BC) farmers from the Nile River Valley excavated from sites in the surroundings of Badari by Brunton between 1922 and 1924 (Brunton and Thompson, 1928). Despite the fact that the cemeteries of the Badarian were subjected to looting over the millennia, the original publication of the remaining findings is very detailed on the funerary contexts of what was spared from destruction. All the undisturbed inhumations were primary and individual. Graves are shallow round/oval pits with sloping walls. There seems to have been some kind of perishable material covering the graves. The dead were deposited on mats in semi-flexed position with their heads in the higher part of the grave suggesting the position of a "comfortable sleep" (Brunton and Thompson, 1928: 18). The deceased were dressed in skin clothing and sometimes shrouded or partially covered by cloth. Preservation conditions allowed the identification of not only textiles, but some preserved human soft tissues and hair (including identifiable coiffure of the dead). The funerary package included ceramics; lithic industry; a variety of items of body adornment and cosmetic preparation; deposition of faunal elements (from ostrich eggs and feathers to an ovicaprid skeleton); zoomorphic and anthropomorphic figurines and rich industry on bone and ivory.

Differences in size and grave goods led Brunton and Thompson (1928) to propose that Badarian communities were not egalitarian and that there would be richer and poorer classes. A later statistical study of grave goods agreed with that assumption (Anderson, 1989).

Irish (2006) and Irish and Konigsberg (2007) analyzed the biological affinities among later Egyptian populations and other samples from both Sub-Saharan and North African samples based on their dental morphology. These studies have shown that Badarians share biological affinities with later Egyptian populations and differ from Sub-Saharan Africans. Badarian dentition is morphologically closer to North Africans.

R12 (Table 4.5.12, above) in the Northern Dongola Reach, Sudan (ancient Nubia), is a Late Neolithic cemetery on a natural hill at the southern end of the Seleim Basin (Salvatori and Usai 2001; 2002). In total 63 tombs were excavated between 2000 and 2002. The most frequent kind of inhumation consisted of individual burials in pit graves, although a few graves contained two individuals and, at least in one case, there was a reduction of a skeleton disturbed by the excavation of a later grave. Some bones scattered among the sediment of another tomb may result of the same kind of disturbance. Five other pits were carefully re-opened for the addition of a second individual without disturbing the first deposition. Funerary goods accompanying the dead included a variety of items: ceramics, lithics, items of body ornament, ochre, industry on ivory and bone, shells and faunal elements. Particular attention was given to the latter once most tombs contained elements such as horns, bucrania and, in two occasions, a complete skeleton of a goat. The archaeologists who excavated the site argue that cattle herding must have had a significant role in the economy of the groups using the R12 cemetery (Salvatori and Usai 2001; 2002).

Despite poor preservation of the human remains, the anthropological field work recovered important demographic and paleopathological information on the individuals exhumed from R12. All age groups and both sexes are represented in the sample. The skeletons, in particular the male individuals, were robust and presented signs of occupational stress such as marked muscular insertions. One case of violence was identified in an isolated vertebra bearing an embedded microlithic projectile. Mandibles and teeth are the best preserved elements of the skeleton. Despite gracile features of the skulls, the mandibles seem to be robust. The teeth presented evidences of non-dietary alterations compatible with their use as tools besides the expected dietary wear (Crivellaro 2001; 2002).

Irish (2008) carried out the dental morphological study of a sample from this population (n=50) and compared their dental morphology to the Nubian Neolithic sample (Gebel Ramlah, GRM) and to three later Egyptian and Nubian series. His results proved that, despite being both geographically and chronologically close, GRM and R12 were morphologically more dissimilar among themselves than between the three later samples. The morphology of the individuals excavated from R12 is characterized by the absence of typically frequent Afridont traits such as UI1 winging, UI1 double shoveling and *Bushman* canines; by relatively low frequencies of UM1 enamel extensions and LM2 Y groove pattern, and by relatively higher frequencies of double rooted UP1, LM1 C7 and Tomes' roots.

Frequencies of eighteen discrete traits were employed in this analysis (Table 4.5.13). These are distributed on both the superior (11) and inferior (7) jaws, and on the anterior (5) and posterior (13) dentition. Five components were extracted for PCA 7, explaining 73.1% of the total variance. PC1 accounts for 29.28%, whilst PC2 (26.24%) and PC3 (17.57%) reflect slightly less variation. The strongest positive loadings (>0.5) for PC1 were obtained from traits whose frequencies in the Iberian series were relatively low (in comparison to all others in this batch). The only exception was verified for LM2 Y groove pattern. In what concerns this trait, the Chalcolithic Iberian samples disagree, since PDG2 presents the lowest number of all the samples included in this comparison (14.8%), while BT07 displays an intermediate frequency (34.9%) and PDG1 the second highest one (50%). The only strong negative loading (<-0.5) was produced by the frequencies of DTC. The Iberian samples along with BAD display the highest figures for this trait.

Table 4.5.13 - Matrix of the component loadings, *eigenvalues* and variances of PCA 7*.

Traits	BKP	Component		
		1	2	3
UI1 shoveling	+= ASU 2-6	**.617**	-.461	.254
UI1 double shoveling	+= ASU 2-6	.275	**.909**	.280
UI2 TD	+= ASU 2-6	-.172	**.767**	.251
UI2 interruption groove	+= ASU +	.026	-.318	-.421
UC mesial accessory ridge	+= ASU 1-3	.393	.146	**.894**
UP odontome	+= ASU +	-.042	**.972**	.136
UM1 Carabelli's trait	+= ASU 2-7	-.042	**.824**	-.409
UM1 C5	+= ASU 2-5	**.823**	-.447	.029
UM1 enamel extension	+= ASU 1-3	**.953**	-.177	.043
UM2 *hypocone*	+= ASU 3-5	.452	**.515**	-.140
UM3 *parastyle*	+= ASU 1-5	-.387	-.216	**.605**
LP2 cusp variation	+= ASU 2-9	.137	**-.601**	.020
LM1 C7	+= ASU 2-4	.402	-.129	**-.803**
LM1 *protostylid*	+= ASU 1-6	-.291	-.375	**.776**
LM1 6-cusped	+= ASU 6+	**.872**	.338	.119

Table 4.5.13 - Matrix of the component loadings, *eigenvalues* and variances of PCA 7* (cont.)

LM1 DTC	+= ASU +	**-.642**	-.402	-.042
LM2 Y-pattern	+= ASU Y	**.941**	-.064	-.119
LM2 5-cusped	+= ASU 5+	**.603**	-.090	.362
Eigenvalue:		5.270	4.723	3.164
Variance (%):		29.277	26.236	17.575
Total variance (%):		29.277	55.514	73.089

*Principal Components Analysis. 5 components extracted (matrix of the first 3 components). Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. BKP= breakpoint.

In PC2 strongest positive loadings (>0.5) were obtained from five traits. For three of these (UI1 double shoveling, UM1 Carabelli's trait and UM3 *hypocone*), the Chalcolithic series present relatively low frequency. A fourth trait (UI2 TD) is found in intermediate frequencies in the Iberian populations and the last one (UP odontome) is hardly diagnostic once almost all samples included in this analysis are characterized by its absence, except for the 0.6% frequency for the NAT sample. The only strong negative loading (<-0.5) in PC2 is observed for the LP2 lingual cusp variation. BT07 presents the second lowest frequency for this trait (71.4%) among the samples included in this PCA while PDG1 and PDG2 display high frequencies (92.9% and 100% respectively).

Figure 4.5.12 illustrates the biological affinities among the four samples included in PCA 7 on a bi-dimensional scatterplot representing 55.51% of the inter-sample variability. In this graphic representation a grouping is formed by the Iberian Chalcolithic samples, UKR and two of the North African series (BAD and R12). The composition of this cluster is explained by the expected similarity among the European samples and the typically North African morphology of the populations excavated from R12 and the Badari cemeteries (Irish, 2006; Irish and Konigsberg, 2007; Irish, 2008). Within this cluster, the Iberian samples display closer biological affinities than the remaining populations, which is explained by their geographical and chronological proximity. The two outliers in Figure 4.5.12 are the Epipaleolithic Levantine sample (NAT) and the Afridont population of JSA. Although this last sample comes from the same region as BAD and R12, the dental morphology of JSA sample is more closely related to South African populations than to North Africans (Irish, 2005).

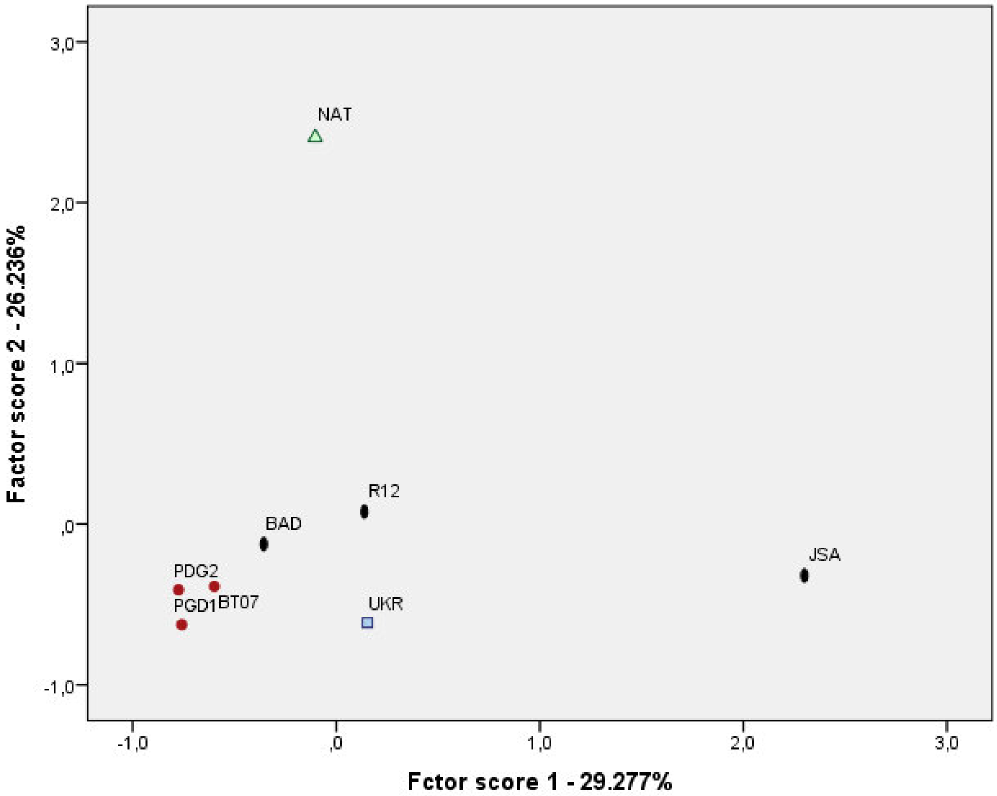


Figure 4.5.12 – Scatterplot of the two first components extracted in the comparison of the samples for PCA 7: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; NAT= Natufians; JSA= Jebel Sahaba and R12= R12 Site, Sudan; BAD= Badarian, Egypt; UKR= Ukraine.

If we consider the PC axes 1 and 2 separately however, it is observable that for the first component (29.3% of the inter-sample variability), the populations in the cluster are similar to the NAT sample and very dissimilar to JSA. That is explained by JSA's high frequencies of most traits contributing significantly to PC1 (UI1 shoveling, UM1 C5, UM1 enamel extensions, LM2 Y groove pattern and 5-cusped LM2). These traits the mass-additive morphology of JSA places it in the opposite end of the dental spectrum from all other series included in this batch. On the other hand, PC2 draws the series in the cluster closer to JSA and farther from NAT. That is mainly explained by some lower frequency traits in JSA (UI double shoveling, UI2 TD, UP odontome).

Finally, PC3 presents 3 strong positive loadings (>0.5) for three traits: *Bushman* canines, LM1 *protostylid* and UM3 *parastyle.* The Iberian samples display intermediate frequencies of LM1 *protostylid* and UM3 *parastyle*, the only exception being the absence of the latter in only one of these samples (PDG2). The only strong negative loading (<-0.5) in PC3 is observed for LM1 C7, a trait which is either absent or low frequency (at the 2-4 BKP) in the Iberian samples.

Information added by PC3 and expressed in the 3D scatterplot (Figure 4.5.13) explains 17.6% of the inter-sample variability. On this axis, the PDG1, PDG2 and BT07 samples are much closer to the outlier series (NAT and JSA) than to the remaining populations in this comparison. That is explained by relatively intermediate/high frequencies of *Bushman* canines, UM3 *parastyle* and LM1 *protostylid*, and by low frequencies of LM1 C7 in all five series.

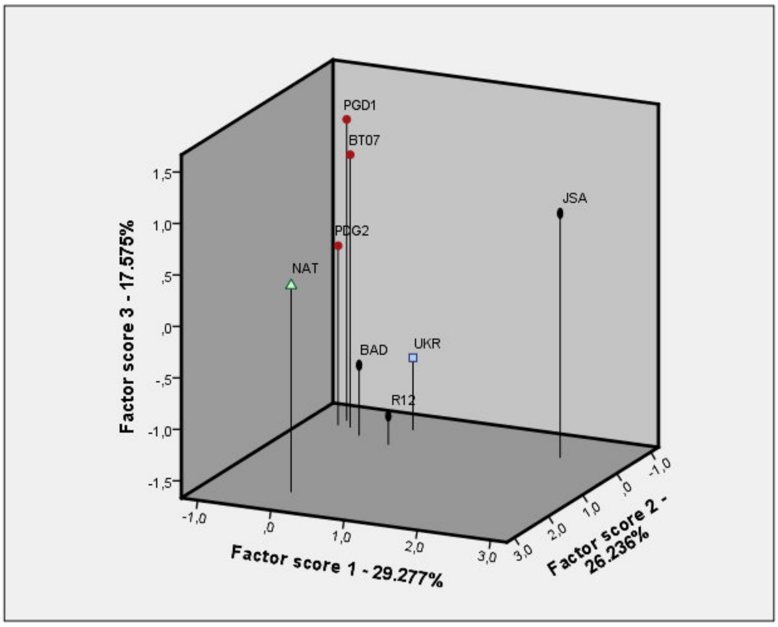


Figure 4.5.13 – Scatterplot of the three first components extracted in the comparison of the samples for PCA 7: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; NAT= Natufians; JSA= Jebel Sahaba and R12= R12 Site, Sudan; BAD= Badarian, Egypt; UKR= Ukraine.

The graphic results expressed by the 3D scatterplot were drawn from the first three components. Considering that this graphic expresses 73.1% of the inter-sample variability, the biological similarity among the Iberian samples addressed by this study is obvious. The closest population to those is the North African BAD series. At a secondary level in this cluster, we find another North African sample (R12) and the European UKR series. This cluster is expected to happen if as Irish (1998a; 2013) defends, North African populations are morphologically close to Europeans (in this case the Iberian samples and UKR) although influenced by the Sub-Saharan dental morphology. It is also in agreement with Scott's (Scott *et al.*, 2013) proposal that the North African populations along with Europeans should be included in the Eurodont dental complex.

The two samples which are clearly outliers to this group are the North African JSA and the Levantine NAT.

As demonstrated by Irish (2005), JSA´s morphology is characterized by complex mas additive morphology more similar to Sub-Saharan (Afridont) than to other Nubian populations. Given its chronology, JSA probably tends to be closer to the archaic African Plio-Pleistocene dentition than the other much later North African samples included in this batch. In summary, despite its geographical origin, this population is more in the range of the Afridont dentition than all other North Africans discussed in this PCA.

The Natufian is aligned to the Eurodont series in PC1 axis. This is probably due to the influence of North African groups in the dispersal of archaic sapiens and their African morphology though the Levant in the Paleolithic. For most traits influencing this component, NAT frequencies are closer to North Africans and Europeans and farther to Sub-Saharans, which is expected given the possible prehistoric routes of dispersion of the Modern Humans and the effect of the cline from Afridonty to Eurodonty.

4.5.2.2. Comparisons of PDG1, PDG2 and BT07 to others dated to the 4th – 3rd Millennium BC

PCA 8

PCA 8 analyzes the morphological affinities among the samples included in this study and series from two contrasting regions: Eastern Mediterranean and Northern Europe (Map 4.5.5).

Map 4.5.5 - Location of the sites included in PCA 8: PDG1 and 2 in Portugal, BT07 in Spain, SYR in Syria, CYP1 in Cyprus, GRK2 in Greece and DAN in Denmark.

Data on the Eastern Mediterranean samples used in this comparison come from a regional study (Parras, 2004) on biological affinities of Chalcolithic and Bronze Age populations in Cyprus and Greece. During the mid-3rd millennium BC, commercial, cultural, political and ideological links that transformed the cultures of the Aegean Sea into complex inter-related identities (Renfrew, 1972; Chapman, 2005).

The commerce of goods among the different regions operated in the exchange of metals (mainly copper, tin and lead); fish and other foods; ceramics; wine; pottery and exotic/prestige goods such as ivory, ostrich eggshells, cosmetics, perfume and jewelry. These sea routes connected Egypt, the Levant, Anatolia, the Aegean Islands, Mycenae, Crete and Cyprus (Waelkens *et al.*, 2004; Matthews, 2005; Alcock and Cherry, 2005).

Beyond the commerce of goods, the circulation of ideas and beliefs is suggested by the distribution of similar ideotechnic artifacts in different regions of the Eastern Mediterranean. As argued by Kristiansen (2011) in the 'world system' of Bronze Age Europe, the distribution of powerful recurring objects is informative of social interactions. One such example may be the presence of votive anthropomorphic figurines sharing the same iconography but expressed in different regional styles in Badari (Egypt) (Brunton and Thompson, 1928), Be'er Sheva (and other sites in the Negev region, Levant) (Rowan and Golden, 2009) and Naqada (Egypt) in the 5th and 4th millenniums BC, and in the Aegean Islands in the late 4th-early 3rd millenniums BC

(Hendrix, 1998; Matthews, 2005). The iconographic and formal aspects of those pieces understood as a framework culturally established aspects (Stokstad, 1995) are: the same theme; the same canonical body posture; the presence of sexual/dimorphic attributes, oversized and sometimes inlaid eyes and care in the execution of facial details, tattoos and hair. These are anthropomorphic figurines, usually executed in prestige materials (such as ivory) or adorned with expensive items (such as imported pigments or inlaid rocks). They are found in contexts related to either funerary or religious activities (Brunton and Thompson, 1928; Hendrix, 2003; Matthews, 2005; Rowan and Golden, 2009).

Three of the populations included in this PCA (CYP1, GRK2 and SYR) (Table 4.5.14) were in the range of this network of ideas and trade.

Table 4.5.14 - Samples from other sources used in PCA 8.

Acronym	Sample	Region – Country	Chronology	Reference
CYP1	Cyprus – sample 1	Cyprus	4000-2500 BC	Parras, 2004
GRK2	Greece – sample 2	Greece	2900-1050 BC	
SYR	Syria	Syria	3500-2400 BC	
DAN	Danish sample	Denmark	Neolithic	Christy Turner’s database

CYP1 individuals were drawn from populations exhumed from three sites: Kissonerga-Mosphilia (Kissonerga), Lemba-Lakkous (Lemba) and Souskiou-Vathyrkakas (Vathyrkakas). All these are located in in the Southwest coast of Cyprus and dated from the 4th to the 3rd millennium BC. The first two are only 1-2 km apart. Both are villages where the dead were buried in intramural areas. The demographic profile indicates that these series are natural populations characterized by the presence of individuals from both sexes and all age groups (Parras, 2004; 2006). Souskiou-Vathyrkakas is 20 km far from Lemba-Lakkous.

Contrary to the first two sites and to other known Neolithic and Chalcolithic burial sites in Cyprus (Parras, 2004; 2006), Vathyrkakas is an extra-mural cemetery. Its demography points to the existence of inclusion criteria in the access to burial and not all age groups are included.

Chronologically all three sites were used in the fourth and third millenniums BC, although the material culture in Kissonerga points to contacts with foreign populations. The results of biodistance studies among these populations indicate that all three series are consistent with biological continuity of the same population, despite cultural differences expressed by the choice of funerary place and the presence of ‘foreign’ goods in the latter cemetery (Parras, 2004; 2006).

GRK2 is a composite series gathering data from two Greek sites: Asine and Lerna. Asine is a settlement located nearby the modern city of Tolo (in the Argos Gulf, Greece). Individuals exhumed from this site come from different cemeteries both intra and extra-mural and from different types of tombs (cists, *pithos* urns, shafts and earth-cut graves). Lerna is located in the plain of Argos, facing the gulf and only a few kilometers across the gulf from Asine. Burials were made within or nearby houses and most tombs consisted of cists and pits. Culturally both sites are very similar, the few observed differences are attributed to the size and importance of each town in the regional context (Parras, 2004).

The Chalcolithic/Bronze Age SYR series comes from the Tell of Jerablus-Tahtani in the Carchemish region in the Northwest Syria-Turkey border. The site is located in the banks of the Euphrates River and its archaeological layers attest to human occupations since the Neolithic. The site is favored both by the fertility of the lands provided by the Euphrates, but also by its proximity to the Mediterranean (only 160 km away) and its milder climate in comparison to drier lands to the East. These conditions allowed the existence of a local network of settlements by the Chalcolithic and Bronze Age. The human remains in the SYR sample were exhumed from different kind of tombs (cists, *pithos* urns, chamber tombs, shaft and pit burials). Jerablus is a small town unlikely to have gathered rich and numerous tombs. Its proximity to the larger and more important site of Carchemish may suggest a regional use of its funerary spaces, particularly the grand corbelled Chalcolithic tomb (Tomb 302). Geographical proximity and shared ecological conditions may have favored closer contacts with Anatolian populations. Exogenous goods in the material record in the Carchemishian sites attest to their connections to larger networks operating at a regional level (Parras, 2004; Wilkinson *et al.*, 2007).

Information on the DAN sample is scarce and provided only by electronic communication by G. Richard Scott (University of Nevada, Reno; February 7th, 2014). This Neolithic sample from Denmark is part of the populations studied by Christy Turner during his extensive research on the dental morphology of populations world-wide. The Danish Neolithic extends from the end of the 4th to the middle of the 2nd millenniums BC.

Frequencies of fourteen discrete traits were used in this PCA. They include traits observed for both the upper and lower teeth (ten and four respectively). Five of those traits refer to the anterior and 10 to the posterior dentition.

Three components were extracted for PCA 8, explaining 78.9% of the total variance. PC1 accounts for 42.3% of that figure, followed by PC2 (23.8%) and PC3 (12.8%) (Table 4.5.15).

Table 4.5.15 - Matrix of the component loadings, *eigenvalues* and variances of PCA 8*

Traits	BKP	Component		
		1	2	3
UI1 shoveling	+= ASU 2-6	**-.629**	-.293	.170
UI1 double shoveling	+= ASU 2-6	.451	**-.632**	**<u>.556</u>**
UI2 TD	+= ASU 2-6	**<u>.658</u>**	-.026	**-.639**
UI2 interruption groove	+= ASU +	.253	**<u>.899</u>**	.062
UC DAR	+= ASU 2-5	**<u>.942</u>**	.024	.235
UM1 Carabelli's trait	+= ASU 2-7	**<u>.948</u>**	.183	-.095
UM1 enamel extension	+= ASU 2-3	**<u>.770</u>**	-.341	.211
UM1 C5	+= ASU 2-5	.083	**<u>.789</u>**	.490
UM2 *hypocone*	+= ASU 3-5	-.496	.467	.365
UM3 *parastyle*	+= ASU 2-5	.358	**<u>.768</u>**	.337
LP2 cusp variation	+= ASU 2-9	**<u>.828</u>**	.238	-.146
LM1 *protostylid*	+= ASU 2-6	.451	**-.632**	**<u>.556</u>**
LM1 DTC	+= ASU +	**<u>.854</u>**	.004	-.294
LM2 Y-pattern	+= ASU Y	**<u>.665</u>**	-.099	.162
	Eigenvalue:	5.918	3.339	1.789
	Variance (%):	42.272	23.850	12.778
	Total variance (%):	42.272	66.122	78.901

*Principal Components Analysis. 4 components extracted (matrix of the first 3 components). Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. BKP= breakpoint.

Seven traits produced strong positive loadings (>0.5) for PC1. Four of those (UC DAR, UM1 Carabelli's trait, LP2 cusp variation and LM1 DTC) are high frequency features in the Iberian Chalcolithic samples and also in the Danish sample while the Eastern Mediterranean series present the lowest figures. These are mass additive features and their frequencies characterize the more robust western dentition in comparison with the tendency for more gracile teeth in the East. For two other traits (UI2 TD and LM2 Y pattern), the Syrian population also displays high frequencies while GRK2 and CYP1 are characterized by markedly lower numbers. Only DAN provided positive frequency of UM1 enamel extensions, once the trait is absent from all other series used in this PCA. The only negative loading (<-0.5) for PC1 was drawn from UI1 shoveling. CYP1 and GRK2 present high frequencies of this trait (over 32%), while the other samples vary between 9.1 and 24%. The graphic representation of these numbers places the Iberian samples closer in the PC1 axis followed by DAN (Figure 4.5.14), being PDG1 and BT07 extremely close in what concerns the traits influencing this component. At the opposite end the 3 Eastern samples are closely associated, being CYP and SYR morphologically very alike, replicating the results obtained by Parras (2004).

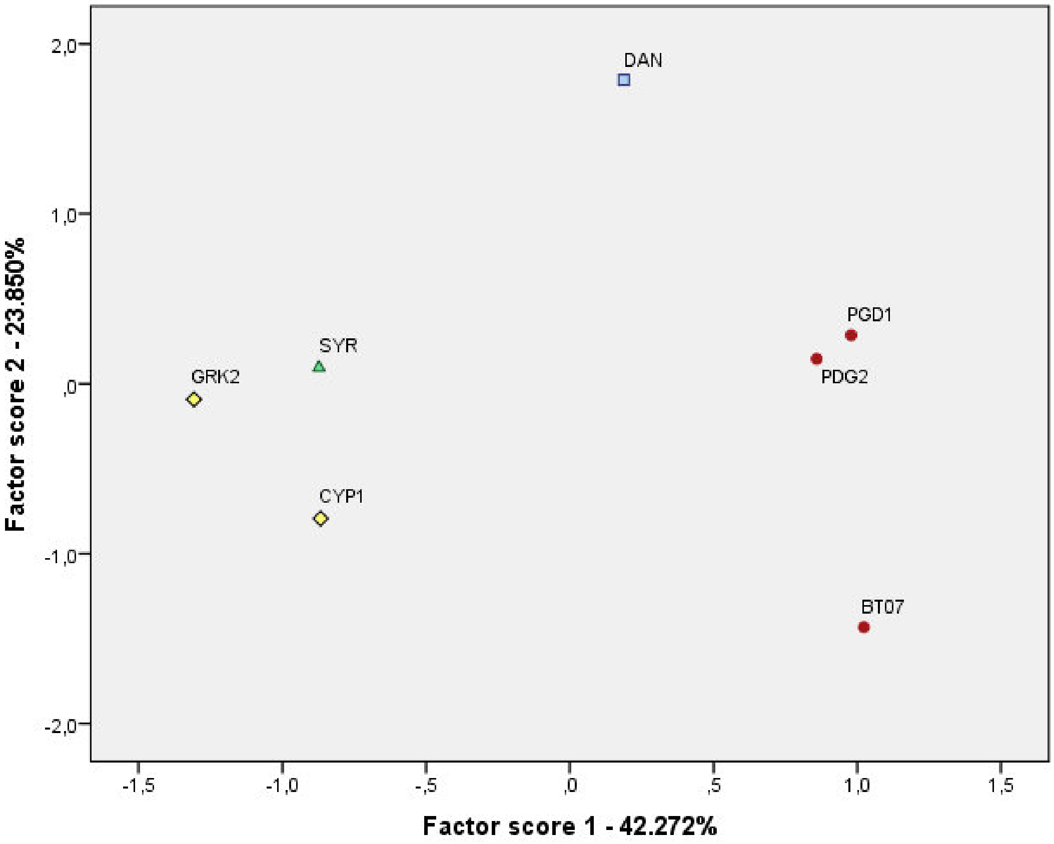


Figure 4.5.14 – Scatterplot of the two first components extracted in the comparison of the samples for PCA 8: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; CYP1= Cyprus – sample 1; GRK2= Greece – sample 2; SYR= Syria; DAN=Danish sample.

In PC2 2 traits provided strong positive loadings (>0.5): UM1 C5, UM3 *parastyle* and UI1 interruption groove. The first two are low frequency features. In both cases SYR and GRK2 display the lowest numbers while PDG1, DAN and BT07 display the highest ones. Once again, the pattern suggests a more complex and robust dentition in the western samples. As for the frequency of interruption groove, CYP1 and BT07 display low numbers (2.9 and 8.8% respectively), GRK and PDG1 present intermediate numbers below 20%, and SYR, PDG2 and DAN's scores are between 22.2% and 45.9%. Both strong negative loadings (<-0.5) in PC2 refer to low frequency traits (UI1 double shoveling and LM1 *protostylid*) for which all samples display the absence of the feature, except BT07 and in very low numbers (1.2 and 2.7% respectively). Comparing the frequency of all traits included in this batch, BT07 is characterized by higher numbers of mass additive complex discrete traits.

There is a clear cluster in the bi-dimensional scatter plot in Figure 4.5.14 (above) joining PDG1 and PDG2 and that is expected once both series come from the same site and probably were drawn from the same population presenting only diachronic differences. The closest related series to this cluster is BT07. This population comes from the same valley. Considering cultural and probable biological ties existing between these three samples, this proximity is also expected, as is the alignment of PDG1 and BT07 in the PC1 axis explaining over 42% of the variability expressed in this graphic representation. A second cluster gathers the 3 Eastern samples expressing the biological proximity of Chalcolithic/Bronze Age Syrians, Greeks and Cypriots. These affinities were probably favored by population movements westwards at least since the beginning of the Neolithic (Tringham, 2000) and by the gene flow of later population as a result of the commercial and cultural ties linking the populations around the Eastern end of the Mediterranean (Brunton and Thompson, 1928; Parras, 2004; Matthews, 2005; Broodbank, 2006; Rowan and Golden, 2009; Farr, 2010).

PC3 presents only two strong positive loadings (>0.5) for UI1 double shoveling and LM1 *protostylid*. As discussed above the one decisive sample for the loadings produced by these two traits is BT07, which is the only one having frequencies of both (although in low numbers) while the traits are absent in all other series included in this PCA. The only strong negative loading (<-0.5) was drawn from UI2 TD (also discussed above). The 2 main aspects expressed by these positive and negative loadings are the homogeneity of the Eastern samples and the discrepancy of BT07 among all other samples in what concerns the 3 traits influencing the Z axis (graphically represented in Figure 4.5.15).

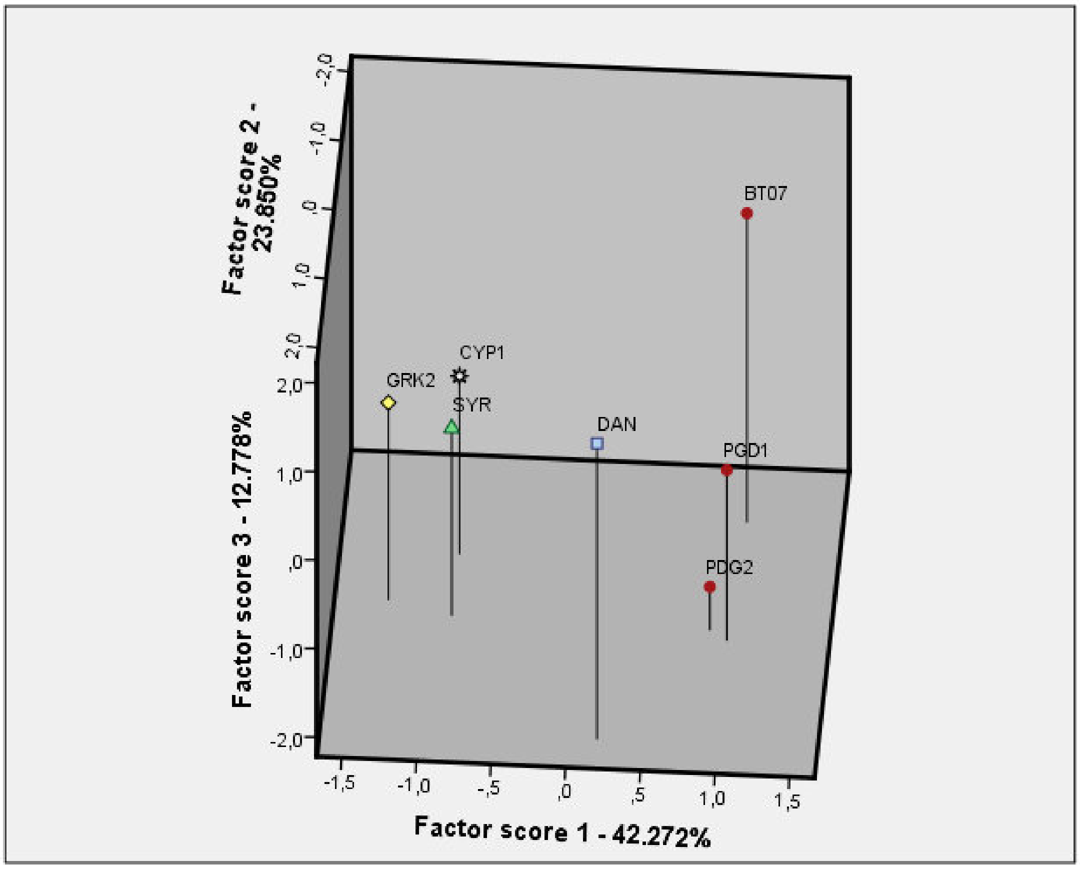
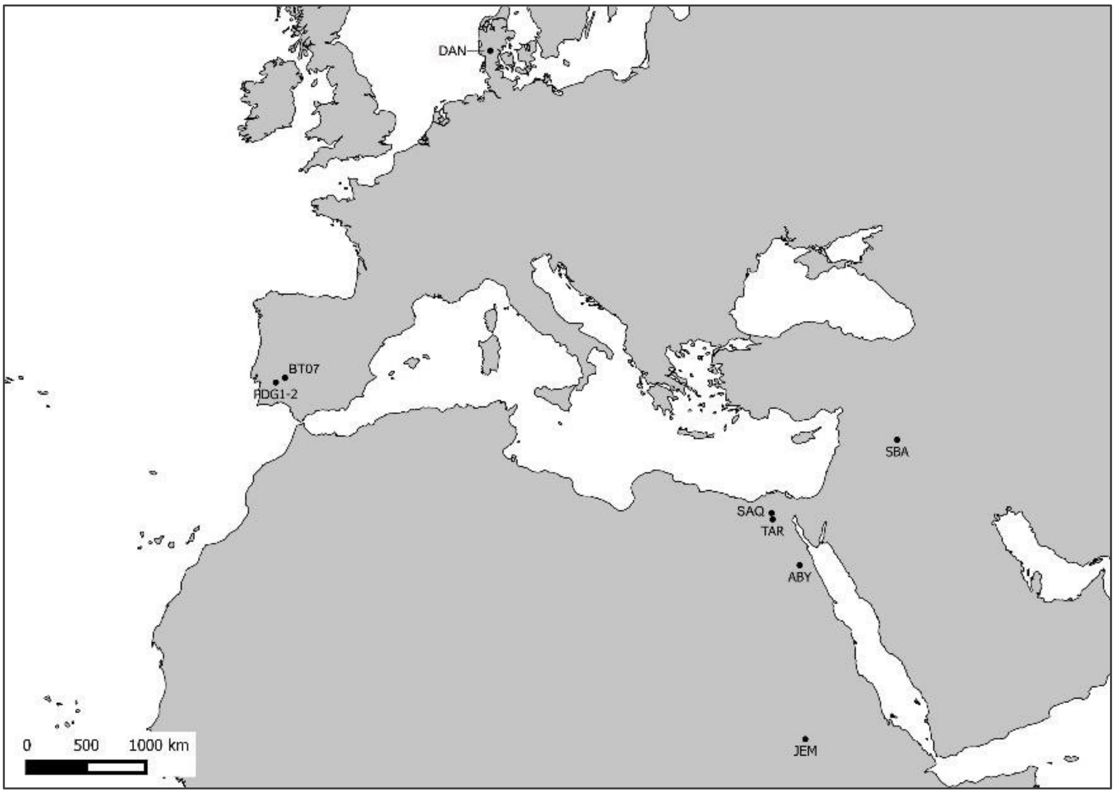


Figure 4.5.15 – Scatterplot of the three first components extracted in the comparison of the samples for PCA 8: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; CYP1= Cyprus – sample 1; GRK2= Greece – sample 2; SYR= Syria; DAN=Danish sample.

Although all samples in this comparison come from within the limits of the Eurodont complex (Scott *et al.*, 2013), the PCA above show there are regional differences between the East and West side of the Mediterranean Basin, and from those regions to Northern Europe. Population history and genetic drift may explain the observed clusters and the divergence of the DAN series from the other Western series.

PCA 9

PCA 9 deals with morphological affinities among PDG1, PDG2 and BT07 to one series from the Near East (SBA); four samples from North Africa (JEM, SAQ, TAR and ABY) and a sample from Northern Europe (DAN) (Map 4.5.6).



Map 4.5.6 - Location of the sites included in PCA 9: PDG1 and 2 in Portugal; BT07 in Spain; SAQ, TAR and ABY in Egypt; SBA in Syria; JEM in Sudan and DAN in Denmark.

The SBA series comes from the Bronze Age site of Terqa in modern day Tell Ashara in the banks of the Euphrates River, Southeast of Syria (Soltysiak and Bailon, 2013) (Table 4.5.16). In this region, the fertile floodplains of the Euphrates are a thin fringe of green land surrounded by desert on both sides of the river. The region has been subjected to human mobility since the Paleolithic, with particularly well recorded population movements related to commerce and conflict from the end of the third and into the second millennium BC. Geographically it is a cross roads between the Levant to the East and the Iraq-Iran corridors into Asia to the West. Flowing from Northwest to Southeast, the Euphrates may have worked as a pathway between the Southern Mesopotamia and Anatolia (Matthews, 2005; Tomczyk *et al.,* 2011).

Table 4.5.16 - Samples from other sources used in PCA 9.

Acronym	Sample	Region – Country	Chronology	Reference
SBA	Syrian Bronze Age	Syria	Bronze Age, c. 2700-1200	Soltysiak and Bialon, 2013
JEM	Jebel Moya	Sudan	3000-100 cal. BC	Irish and Konigsberg, 2007
SAQ	Saqqara	Lower Egypt	2613-2494 cal. BC	Horwath *et al.*, 2014.
TAR	Tarkhn	Lower Egypt	3000-2890 cal. BC	Irish, 2006
ABY	Abydos 2	Upper Egypt	Early Dynastic, 3000-2680 cal. BC	Irish and Friedman, 2010
DAN	Danish sample	Denmark	Neolithic	Christy Turner's database

Human populations in the Chalcolithic and Bronze Age in this part of the Euphrates Valley were either associated with farming activities in the wet fertile strip by the river or with animal husbandry in the steppe. Despite different lifestyles these communities seem to be closely related biologically (Soltysiak and Bailon, 2013).

Terqa's oldest levels date to the beginning of the 3rd millennium BC and much of this large city has been covered by the modern city of Al Ashara. Erosion and mainly alluvium processes have also contributed to the obliteration of part of the occupation. However, archaeological evidences show that the city worked as a provincial capital in the Early Bronze Age (Mari dynasty). Later it was the capital of the Kingdom of Khana and one of the largest urban centers in Mesopotamia in the 2nd millennium BC (Buccellati and Kelly-Buccellati, 1997).

The dental morphology of a number of series from Terqa was published by Soltysiak and Bailon in 2013. Those populations were distributed from the Early Bronze Age to the Modern Era. That work tested the continuity of local population through time. The results indicate that there has population continuity in the region between the Bronze Age and the Early Islamic Period in the 13th century AD. In the Second half of that century the region was severely depopulated due to Mongoloid raids, being occupied again only in the 17th century AD by Modern Bedouin populations. These last were morphologically diverse from the earlier groups inhabiting the region.

The JEM sample (Table 4.5.16, above) comes from the site of Jebel Moya, located in Southeast Sudan (c. 250 km South of Khartoum). It includes human remains from two of its phases of occupation ranging from 3000 BC to 100 BC (Irish and Konigsberg, 2007).

Jebel Moya was one of the largest British excavations in Africa holding both habitation and funerary context. Although only one fifth of its area was explored (Irish and Konigsberg, 2007), it is the largest funerary archaeological site in Sub-Sahara (Brass, 2014). The excavation took place between 1911 and 1914 under the supervision of Sir Henry Wellcome. However, but the first excavation report was published in 1949. A report on the human remains (including inventory, sexing and aging of the skeletons) came out in 1955 by Mukherjee and colleagues (Irish and Konigsberg, 2007). Most of the human remains were lost in the years after excavation, although recent studies have addressed both the remaining osteological material itself and the documentation produced since the end of the excavation (Irish and Konigsberg, 2007; Brass, 2009; 2014).

Individuals from JEM seem to have been culturally distinct from other nearby populations. Material culture excavated from the site indicates exogenous influences from North Sudan and from Sub-Saharan Chad in the West, probably working as an annual meeting place for an heterogeneous yet culturally coherent population (Irish and Konigsberg, 2007; Brass, 2014).

Data on the dental morphology and craniometrics of human remains recently published (Irish and Konigsberg, 2007) have addressed key information on the population from JEM. Once there is a clear division of two phases for its long funerary use, the question of continuity and correlation between both sub-samples was assessed. MMD tests applied to those have proven that there is no significant difference between the sub-samples. A second contribution of that study was the confirmation of both the heterogeneity of features within JEM population and the cohesion of it in comparison to other African series. Cranial traits of the individuals exhumed from Jebel Moya display robust South African morphology while their dentition tends to be similar to the more gracile North African populations. In summary, Irish and Konigsberg (2007) defend that the site's population were aligned to both North Africans and Sub-Saharans and constituted a distinctive "biocultural amalgam" (p. 153).

SAQ is an Egyptian sample from the Old Kingdom Period. The Saqqara funerary complex was funded c. 3000 BC and it served as a private cemetery during the 1st and 2nd Dynasties. In the 3rd Dynasty it became the choice for burials of the royal family and high ranking officials in the Pharaonic state, serving the purpose of an elite cemetery up to the 6th Dynasty, except for the period of the 4th Dynasty when the monuments of Giza were being built and used by the royal family. The Old kingdom is characterized by large investments in monumental constructions with emphasis in in the funerary architecture as a symbol of the power of the royal family. Administrative, religious and military powers were centralized in the small elite surrounding the pharaoh. This elite would be buried in the in the surroundings of the large highly visible superstructures of the royal tombs (Bárta, 2013a; 2013b; Lauer, 1999).

Anthropological information on this sample and scarce and based only on museum records (Irish, 2006). Data obtained by Irish have been used in a number of comparative works

(Irish and Konigsberg, 2007; Irish and Friedman, 2010; Horwarth *et al.*, 2014; Schrader *et al.*, 2014). The results of these studies place SAQ along with other North African series.

The TAR sample comes from the cemetery of Tarkhan located at 100 km to the South-Southwest of modern day Cairo. The site was excavated by Flinders Petrie between 1911 and 1914. The majority of the burials excavated (2176 tombs) are relatively dated to the end of the 4th and beginning of the 3rd millenniums BC – Predynastic and Early Dynastic periods. Later sporadic use of the site as cemetery extended up to the Roman Period, although Petrie used a different site name (hence, different inventory) for later tombs as a recording strategy to differentiate the samples (Petrie *et al.*, 1913; Mawdsley, 2012).

Individual inhumations compose the majority of the burials in the early cemetery, although double and multiple burials were also found. The funerary treatment of the dead and funerary goods were extremely varied. Pit burials, as well as simple and complex mudbrick constructed tombs (*mastabas*) were excavated. Inside those, bodies were placed directly on the ground, on mats, in wood or reed coffins, in ceramic urns or on wooden beds. The quality of the containers/coffins, the quality and quantity of elements in the funerary package varied. That led Petrie to imply the existence of a hierarchical organization in the site. The material culture excavated from the burials indicate that people buried in Tarkhan had at least trade relations to Southern Egypt, the Sinai region, the Eastern Desert and possibly Syria (Petrie *et al.*, 1913; Mawdsley, 2012).

The human dental sample studied by Irish (2006) is hosted at the University of Cambridge and similarly to many excavations in the early 20th century, the loss of information over the decades of storage of the osteological material is significant.

The ABY sample comes from the Predynastic and Early Dynastic cemeteries of Abydos. The site area is divided into 3 cemeteries (U, B and royal tombs). Information on the human remains from these cemeteries, as well as the first excavated materials were highly damaged by a series of processes. The largest and richer tombs have suffered looting since later dynastic periods through historical times. In the end of the 2nd millennium BC the cemetery was used as a cult center for Osiris and at least one of its largest tombs excavated in search of this god's tomb. The excavation and recording processes of the first campaigns in the 1800's and the loss of information over the more than 100 years from the first excavations added to later problems of the site. In 1895-1898 the site was explored by Émile Amélineau who admitted to excavating between 150 and 160 graves in four days. There is no detailed information on the human remains from his work and material culture from his excavations was sold and is now scattered worldwide. Later, the site was excavated by Petrie (1899-1910) and by Peet and Naville (1911-1912). Since 1973 the German Institute of Archaeology has worked on the site. New excavations and re-examination of the materials from old ones have produced new findings and important information on the funerary contexts (Dreyer, 1999).

The cemeteries were used for the burial of both elite and commoners. Individual, multiple and collective burials were excavated from Abydos. Although the larger elite burials were looted and no 'royal' individual recovered, subsidiary burial chambers within the lager tombs kept preserved burials of dozens of individuals, most of which believed to be servants to the tomb's owner. Besides the larger elite tombs, funerary structures in the site included simple pit burials, rock-cut tombs and mudbrick constructions of varied typology. Imported goods from as far as Palestine were found in the cemetery attesting to contacts with distant regions (Peet and Loat, 1913; Dreyer, 1999).

The existence of prestige imports such as Levantine wine in elite tombs in the U cemetery of Abydos may attest to contacts between the Levant and Egypt that would result in the establishment of Egyptian colonies in the latter region in the Bronze Age (Braun, 2011).

Commerce items from Egypt also circulated in the Levant, such as Nile fish exports to the Sinai and Syro-Palestinian region. This commerce seems to have begun in the Levantine Chalcolithic, although evidence of that for this period comes from only one site (Tel Katif). In the Early Bronze Age findings related to commerce/imports are still scarce, but in the Middle Bronze Age it increases leading to an abundance of the distribution of these exports in the region during the Late Bronze Age and Iron Age (Waelkens *et al.*, 2004).

At another level of influence, Braun (2011) recognizes the similarities between the ivory anthropomorphic figurines found in Egypt during the Badarian and Naqada periods and others from Late Chalcolithic Levantine sites such as Be'er Sheva'.

The circulation of ideas and iconography (and of the objects themselves) is an indication of interactions between the Predynastic Egypt and the Chalcolithic-Bronze Age Levant.

Information on the DAN sample is discussed above (PCA 8).

Eleven traits were used to obtain the matrix of component loadings used in PCA 9 (Table 4.5.17). Six of those traits are located on the superior dentition and five on the inferior one. Five refer to anterior teeth and six to posterior ones. Four components were extracted for this PCA explaining 77.1% of the inter-sample variability.

Table 4.5.17 - Matrix of the component loadings, *eigenvalues* and variances of PCA 9*

Traits	BKP	Component		
		1	2	3
UI1 shoveling	+= ASU 2-6	.182	**.850**	-.021
UI2 TD	+= ASU 2-6	**.824**	-.143	.254
UI2 interruption groove	+= ASU +	**.765**	.042	-.132
UC mesial accessory ridge	+= ASU 1-3	-.362	.281	**.794**
LC 2-rooted	+= ASU +	**.688**	-.414	.172
UM1 Carabelli's trait	+= ASU 2-7	.309	**-.770**	-.166
LP2 cusp variation	+= ASU 2-9	**.613**	.327	**.562**
LM1 C7	+= ASU 2-4	**-.915**	-.071	-.134
LM1 3-rooted	+= ASU +	-.011	**.634**	**-.699**
LM1 *protostylid*	+= ASU 1-6	.091	**.765**	.298
LM2 Y-pattern	+= ASU Y	**-.665**	-.340	**.581**
	Eigenvalue:	3.660	2.801	2.018
	Variance (%):	33.272	25.468	18.349
	Total variance (%):	33.272	58.739	77.088

* Principal Components Analysis. 3 components extracted. Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. BKP= breakpoint.

PC 1 accounts for 33.3% of the variance among samples. Most of the strongest positive loadings (>0.5) influencing this component refer to traits located on the anterior dentition (UI2 TD, UI2 interruption groove, 2-rooted LC and LP2 cusp variation). All strong positive loadings refer to complex, mass additive traits. An interesting pattern observed for this batch is that JEM presents the lowest frequencies for all 4 traits. That affects the distance between this sample and all others. In most series of this batch (JEM, SBA, PDG1, ABY, PDG2, and DAN), 2-rooted LCs are absent, while BT07 (at 2.4%) and TAR (at 4.4%) display frequencies close to North African and Western European frequencies and SAQ has higher figures (6.1%)

Both strong negative loadings (<-0.5) in PC1 were drawn from traits observed on lower posterior teeth (for LM1 C7 and LM2 Y pattern). Three series (PDG1, PDG2 and SAQ) do not present LM1 C7 and 4 samples (DAN, BAY, TAR, and SBA) present intermediate figures 2-4.2% while in BT07 and JEM this is a high frequency trait (13 and 19.6% respectively). For this specific trait, BT07 falls within the interval of frequencies for North African samples (between 0 and 18.8%) provided by Irish (1998a) and JEM's number is intermediate between North Africans and Sub-Saharans. The second trait producing strong a negative loading, LM2 Y groove pattern, is a low frequency feature in SBA, PDG2 and DAN (6.9%, 14.8% and 15.3% respectively). SAQ and ABY provided intermediate figures (22.7 and 27%). TAR and BT07 display frequencies within the range for North African series (30.6 and 34.9%) while JEM (48.9%) and PDG1 (50%) provide the highest numbers.

Iberian inter-sample variance of traits contributing most to PC 1 resulted in a more disperse distribution of those along the *x* axis of the bi-dimensional scatterplot in Figure 4.5.16, although those influencing PC2 (*y* axis) are clearly more uniform in these populations. The cluster produced by the combination of PC 1 and 2 gathers the series included in this study, the Danish one and ABY. Contrary to the other African samples in this batch (SAQ, JEM and TAR) the population from Abydos.

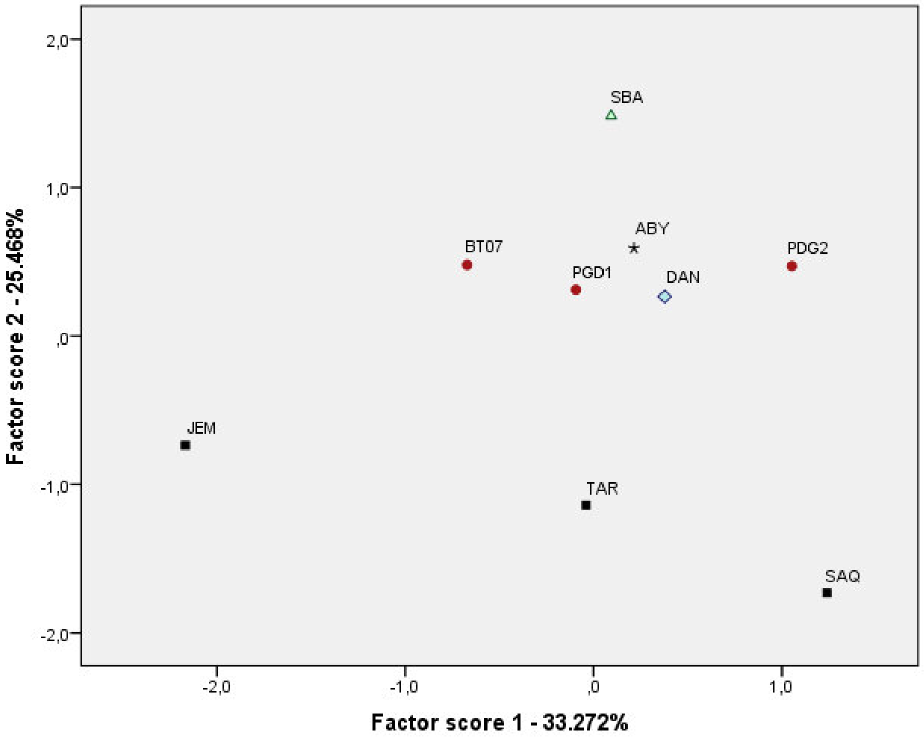


Figure 4.5.16 – Scatterplot of the two first components extracted in the comparison of the samples for PCA 9: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; SBA= Syrian Bronze Age; JEM= Jebel Moya; SAQ= Saqqara; TAR= Tarkhn; ABY= Abydos 2; DAN= Danish sample.

The strongest positive loadings (>0.5) influencing PC 2, accounting for 25.5% of the variance among samples, were drawn from 3-rooted LM1, UI1 shoveling and LM1 *protostylid* frequencies. Most series in this comparison fall within the frequency interval of 0-1.2% expected for Eurodont populations (Northern and Western Europeans and North Africans specifically) (Scott and Turner, 1997; Irish, 1998a). BT07 presents a slightly lower number (2.4%) while SBA displays high frequency for the trait (8%). The only strong negative loading (<-0.5) was obtained from the frequencies for Carabelli's trait. DAN, BT07, PDG1 and PDG2 display frequencies between 42.9 and 50.8%, close to European numbers in Irish (1998a) while

JEM and SBA present low frequency of the trait and TAR, ABY and SAQ have the highest frequencies.

PC 3, accounting for 18.3% of the variance among samples is characterized by strong positive loadings (>0.5) for LP2 cusp variation, LM2 Y pattern and *Bushman* canine. The frequencies for the first two traits are discussed above. As for the UC mesial accessory ridge, SBA and SAQ samples do not display the trait. TAR, DAN and PDG2 are characterized by intermediate frequencies between 5.4 and 8.3%, and JEM, PDG1, BT07 and ABY by the highest figures in the batch (between 10 and 17.7%). The only strong negative loading for PC 3 was drawn from LM1 3-rooted whose frequencies are discussed above. PDG1, PDG2, ABY and to a certain extent BT07's distribution of frequencies for the traits influencing PC3 are very similar, placing them close in the 3rd axis in Figure 4.5.17.

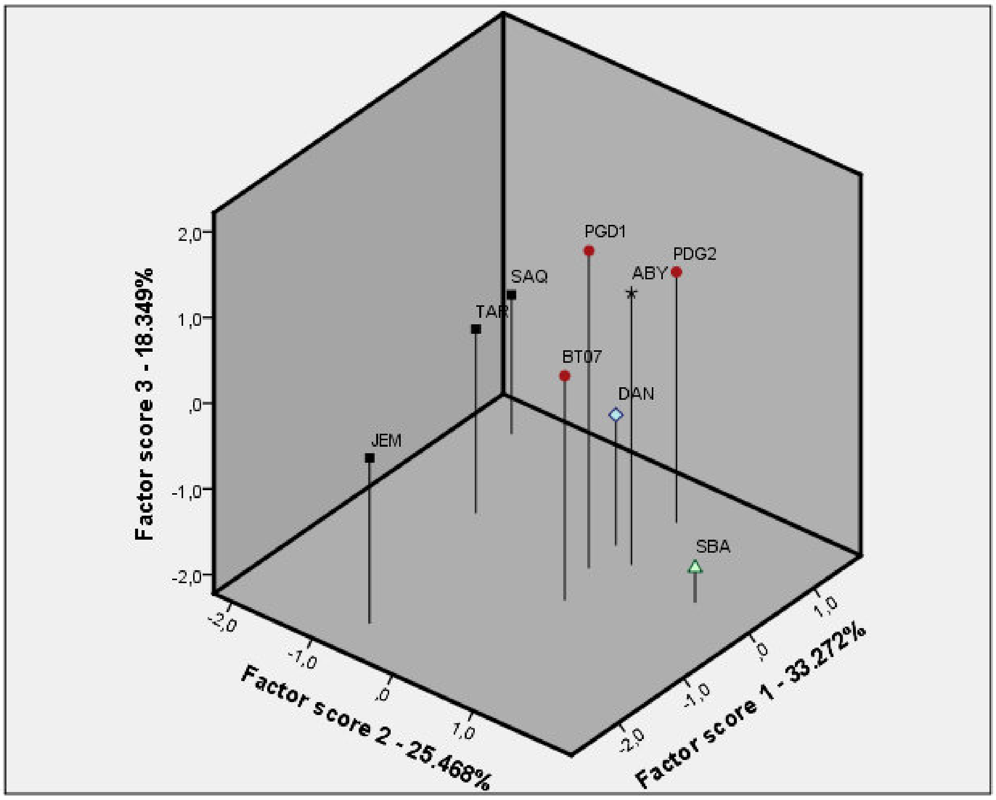


Figure 4.5.17 – Scatterplot of the three first components extracted in the comparison of the samples for PCA 9: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; SBA= Syrian Bronze Age; JEM= Jebel Moya; SAQ= Saqqara; TAR= Tarkhn; ABY= Abydos 2; DAN= Danish sample.

PCA 9 has produced a clear cluster gathering all European samples in this batch and ABY. That is explained by frequencies of traits which are within the range of Eurodont in ABY. A second cluster, somehow close to the first one is composed by the other two North African series (SAQ and TAR). Geographical and biological proximity among ABY, SAQ and TAR, and morphological similarities between the Iberians and North Africans explain the proximity of these clusters. SBA has shown to be morphologically closer to the Eurodont (European and North African) samples in this batch. That proximity may be caused by closer biological ties of both Syrian and Egyptians in the 4th and 3rd millenniums BC. Hassan (1988) defends that groups coming from both the Eastern Sahara and Levant settled in the Nile Valley at that time, helping forge the Egyptian identity. On the other hand, as Waelkens and colleagues (2004) and Braun (2011) summarize, findings of Egyptian and Egyptianized material culture from different sites in the Syro-Palestianian region demonstrate increasing contacts between populations living in both regions from the Chalcolithic through the Bronze Age.

The most isolated sample in this batch, JEM, presents stronger Afridont influence. Trait frequencies for this series are clearly among the lowest for typically high frequency Eurodont traits such as 2-rooted LC and LP2 cusp variation.

PCA 10

PCA 10 deals with biological affinities among the series included in this study, two other Iberian samples (BOL and FET, both from Portugal) and three North African populations (Table 4.5.18). In terms of geographical location it is interesting to notice that while the African samples and the series addressed by the present study are connected to areas of influence of the Mediterranean via major rivers (Nile and Guadiana), the other Portuguese samples come from sites in the Atlantic façade of the Iberian Peninsula.

Table 4.5.18 - Samples from other sources used in PCA 10.

Acronym	Sample	Region – Country	Chronology	Reference
BOL	Bolores	Portugal	Late Neolithic (Chalcolithic), 2800-2600 cal. BC	Horwath *et al.*, 2014
FET	Feteira II	Portugal	Late Neolithic (Chalcolithic), 3600-2900 cal. BC	
HRK	Hierakonpolis	Upper Egypt	Predynastic, 3500-3200 cal. BC	Irish, 2006; Irish and Friedman, 2010
ABY	Abydos 1	Upper Egypt	Predynastic, c. 4000-3200 BC	Irish, 2006; Horwath *et al.*, 2014
SAQ	Saqqara	Lower Egypt	2613-2494 BC	Horwath *et al.*, 2014

The BOL sample comes from the site of Bolores (Map 4.5.7). This burial context is a shallow natural shelter under shale slabs whose rock base was cut in order to shape the burial space (Lillios *et al.*, 2010). It is located near the modern day town of Torres Vedras, Portugal.

The shelter faces the Sizandro River, a rather small body of fresh water (only 40 km long). Nowadays the site is 10 km away from the Atlantic coast. At the time of the funerary use of Bolores (the first half of the 3rd millennium BC), a marine estuary extended inland (following the present course of the Sizandro River) and the shelter was only 2 km from the ocean. To the Southeast, the site is only 30 km from the Tagus Estuary (Lillios *et al.*, 2010).

Map 4.5.7 - Location of the sites included in PCA 10: PDG1, PGD2, BOL and FET in Portugal; BT07 in Spain; SAQ, HRK and ABY in Egypt.

Both articulated skeletons and disarticulated human remains were excavated from Bolores. The human bones from this site are highly fragmented (Lillios *et al.*, 2010). The context in Bolores is quite similar to many other Iberian collective sites where collective tombs are mostly (but not exclusively) used for primary depositions of human corpses (Tomé, 2011). Later disarticulation of the earlier skeletons and fragmentation of bones in similar Iberian contexts are probably promoted by either the addition of more recent individuals, or by manipulations required by the funerary ritual (Silva, 1996a; 2002; Tomé, 2011; Diaz-Zorita *et al.*, 2012). Some of the articulated individuals were placed on triangular limestone slabs suggesting a peculiar treatment not reported for other sites either in the Extremadura (Silva, 1996b; 2002) or in the nearby North Ribatejo (Tomé, 2011) regions. MNI in Bolores is 14 divided into 3 age groups: 6 adults, 2 adolescents (12-21 yrs. old) and 6 children (0-10 yrs. old) (Lillios *et al.*, 2010).

The other sample from central Portugal included in this batch (FET) comes from Feteira II (Table 4.5.18, above). Feteira is a cave located near the city of Lourinhã, Portugal (c. 19 km from Bolores). The site is in the banks of the Grande River, contrary to the name, a rather small river running only 25 km from the limestone massif of Estremadura to the Atlantic Ocean. The site of Feteira was discovered in 1981 (Zilhão, 1984), but only years later its Neolithic funerary necropolis (Feteira II) was discovered. It was excavated between 1995 and 1997 (Waterman *et al.*, 2014b). C14 dates on human bones from Feteira II date its use as a funerary space between 3600 and 2900 cal. BC. MNI excavated from the site is 68 (among these, 26 are non-adults) (Waterman, 2007; Horwath *et al.*, 2014; Waterman *et al.*, 2014b).

Biological studies by Waterman and colleagues (2014a; 2014b) and by Horwath and others (2014) on the population from Bolores and Feteira II deal with these series in a regional context within the Portuguese Estremadura, although Horwath and colleagues have also compared dental morphological data with populations from regions around the Mediterranean.

Strontium isotopic analyses addressing population mobility were performed on 55 individuals from collective tombs in the region between the Sizandro and Grande valleys (Waterman *et al.*, 2014a), namely: the burial natural caves of Cova da Moura, Feteira II and Lapa da Rainha II; the artificial caves/rock cut tombs of Bolores and Cabeço da Arruda I and the *tholos* tomb of Paimogo I. In most of these samples (including Bolores and Feteira II), no non-local individuals were found. In two sites (Cova da Moura and Cabeço da Arruda I) however, some individuals were migrants, probably coming from the Alentejo region (Waterman *et al.*, 2014a). Coincidentally, those two burial contexts and the Zambujal settlement have produced industry on Ivory (Thomas, 2011; Schuhmacher and Banerjee, 2012). As discussed before, ivory is a valued raw material consistently found in the large collective tombs of Alentejo and Southern Spain.

Stable isotopic analyses were also performed on samples from Bolores, Feteira II and Paimogo I (Waterman *et al.*, 2014b; Horwath *et al.*, 2014). Results of the analysis on collagen indicate that in all sites the main dietary staple was terrestrial, although some individuals from Feteira II seem to have consumed fresh or salt water fish. Intra-sample inequality of protein intake was also observed mainly in Paimogo I. Apatite values also indicate that the individuals exhumed from Feteira II were also consuming a more varied plant intake (Waterman *et al.*, 2014b).

There are at least 3 settlements by the margins of the Sizandro River dated from the Neolithic to the beginning of the Bronze Age. The largest one and the most extensively excavated is the fortified settlement of Zambujal.

Zambujal was probably the largest and most important settlement in the region. Its occupation is dated between the Chalcolithic and the Early Bronze Age (Lillios, 1997). Excavations have revealed houses, workspaces and have exposed material culture rich in ceramics, lithic industry, metals and some isolated human remains. However, the site is characterize by a series of impressive defensive walls. Their construction and frequent alterations during the Chalcolithic suggest that conflict at a regional level was a serious threat to the community living in this stronghold (Kunst, 2000; Kunst and Uerpmann, 2002; Kunst and Arnold, 2011). Because of its proximity the paleo-estuary (only 2 km away), Zambujal controlled resources coming from both coastal and inland territories. Like other large settlements in Iberian Peninsula, Zambujal seems to have had satellite smaller villages and large collective tombs within a few kilometers radio. Material culture excavated from those tombs attest to contacts with trade routes bringing exogenous items such as amphibolite or African Ivory (Thomas, 2011; Schuhmacher and Banerjee, 2012). Although not all collective tombs in the influence area of Zambujal have survived latter exploitation of the land, some that did undergo archeological excavations have produced impressive MNI, for instance the cave and *tholos* of Cabeço da Arruda (MNI=93), Cova da Moura Cave (MNI=90), and the *tholos* of Paimogo I (MNI=413) (Silva, 2012).

Zambujal and the other nearby settlement sites were served by a number of funerary sites of different typology (*tholoi*, *hypogea*, caves and at least one rockshelter), among which Bolores and Feteira II (Lillios *et al.*, 2010).

The dental morphological study of Bolores and Feteira 2 (Horwath *et al.*, 2014) demonstrates that there is no significant morphological distance between both samples. Considering that these burials are less than 20 km apart and that for about half the time of the funerary use of Bolores, Feteira II was also being used, chances are that they served biologically very close populations if not the same group.

When comparing Bolores and Feteira II to North African samples, Horwath and colleagues (2014) argue that despite the inter-sample similarity of the Portuguese populations, individuals from Bolores seem to be morphologically/phenetically closer to North Africans, particularly Capsians. However, as those authors point out, the sample from Bolores is small (Horwath *et al.*, 2014: 98).

Bolores and Feteira II present missing data. Out of the 36 traits listed, both series do not have data for 6 traits. Considering the remaining 30 traits, Bolores display n<10 for 13 characters. Actually, the three traits used to illustrate similarities between that sample and Capsians are presented in very low number of observations (<10) either in Bolores (deflecting wrinkle, n=8) or in the Capsian series (interruption groove, n=5 and UC DAR, n=7) (Horwath *et al.*, 2014: 98).

The HRK sample comes from three cemeteries of Hierakonpolis, Egypt (Irish, 2006). Hierakonpolis (originally named Nekhen) is located near the modern day village of Kom el-Gemuwia on the West bank of the Nile River. It is an impressive accumulation of successive occupations ranging from the Predynastic to the Roman period. It holds a variety of structures including domestic areas, temples, the first complex dedicated to beer brewing in Egypt and a number of cemeteries. Besides the constructions, it is also an important rock art site whose petroglyphs display the local prehistoric fauna but also scenes of the life by the great river (Adams, 1999). Excavations on the site have started on 1898 (Adams, 1999) and are still on-going (Friedman, 2003).

Although many of the tombs, including all elite burials, have suffered lootings since antiquity and its organic middens have been used for mining of organic materials by local farmers, the amount of both human remains and of material culture in its cemeteries is impressive. Despite the destructive anthropic factors, overall preservation conditions of organic materials are extremely favored by the dry sandy environment. Nekhen was equipped with distinct areas for the burial of elite and commoners since the Predynastic period (Friedman, 2003), although the morphological study proves that individuals from both classes come from the same genetic stock (Irish, 2000b). Paleopathological and paleobiological studies also show that both elite and commoners enjoyed very little environmental stress. They had access to a varied diet, although elite individuals were subjected to less musculo-skeletal stress and sex/age classes had different access in terms of proportion of some kinds of food (bread, meats and vegetables) (Irish, 2000b; Gamza and Irish, 2010).

Funerary spaces varied according to the socio-economic class of the diseased. Elite burials were made in constructed tombs, some of which displayed the first above ground funerary structures in Egypt. Individuals belonging to lower classes were buried in pit burials excavated in sand. Funerary packages were also clearly defined by classes. Rich burials, even after millennia of looting still produce varied material goods and are sometimes surrounded by subsidiary burials. Some of those were animal burials (Adams, 1999; Friedman, 2003; Dougherty and Friedman, 2007).

Lower class treatment of the dead were characterized by little or no grave goods. Single burials compose the majority of the findings, although a few double burials are also found. The corpse was deposited in flexed position on his left side facing West and hands laid near the face. A linen shroud covered the body and matting was placed beneath and over it. The mats employed present no wear damage and its extensive use and technical specificities imply that there should be industry of these items specifically for funerary purposes (Friedman, 2003; Dougherty and Friedman, 2007).

Cut marks and evisceration were observed in few individuals (less than 5%). Cut marks evidence scalping and decapitation. The multiple cut marks in each individual were executed with light blades. There does not seem to be significant socio-economic differences between lacerated and non-lacerated individuals and those were well nourished. Although these may result from *peri mortem* or *post mortem* violence archaeologists do not exclude the hypothesis that they may result from the funerary treatment. In the cases of decapitation the head was placed on the anatomical position. In one case it was wrapped in resin-soaked linen. This treatment of the head was also applied to the internal organs of the eviscerated individuals and may be associated with the preservation of the body. Finally, evisceration, dismemberment of the corpse and the return of these parts to the body were used as funerary treatment in Ancient Egypt (Friedman, 2003; Dougherty and Friedman, 2007). These may be the first efforts in artificial mummification in Egypt (Friedman, 2003).

The dental morphological comparisons performed by Irish (2006) and Irish and Friedman (2010) have placed the HRK sample within the range of trait expression of North African samples, morphologically close to Europeans.

Frequencies of 24 traits including the upper (13) and lower (11) teeth were used in PCA 10 (Table 4.5.19). Nine of those traits are located in the anterior dentition while 15 in the posterior one. Three components were extracted for PCA 10, explaining 71.4% of the total variance.

. Table 4.5.19 - Matrix of the component loadings, *eigenvalues* and variances of PCA 10

	BKP	Component		
		1	2	3
UI1 shoveling	+= ASU 2-6	.446	.215	.286
UI1 labial convexity	+= ASU 2-4	**.912**	.008	.027
UI1 double shoveling	+= ASU 2-6	-.174	.345	**.739**
UI2 peg	+= ASU +	-.449	**.875**	.025
UI2 TD	+= ASU 2-6	.009	.407	**-.779**
UI2 interruption groove	+= ASU +	**-.523**	-.130	**-.536**
UC DAR	+= ASU 2-5	.084	**-.929**	.186
UC *Bushman* canine	+= ASU 1-3	**.799**	.213	.205
UP odontome	+= ASU +	**-.581**	**-.766**	-.011
UM1 enamel extension	+= ASU 1-3	**-.568**	-.084	**.541**
UM2 *hypocone*	+= ASU 3-5	**-.825**	.479	.000
UM3 *parastyle*	+= ASU 1-6	**.736**	.078	.119
UM3 congenital absence	+= ASU +	-.421	**.860**	-.101
LC 2-rooted	+= ASU +	-.423	**.775**	.279
LP1 Tomes' root	+= ASU 2-5	.496	.338	**.577**
LP2 cusp variation	+= ASU 2-9	**.695**	-.017	-.149
LM1 C7	+= ASU 2-4	-.003	-.020	.393
LM1 3-rooted	+= ASU +	-.223	-.308	**.784**
LM1 *anterior fovea*	+= ASU 2-4	**.900**	-.241	-.251
LM1 *protostylid*	+= ASU 1-7	**.978**	.021	.045
LM1 6-cusped	+= ASU 6+	-.274	**-.751**	.344

Table 4.5.19 - Matrix of the component loadings, *eigenvalues* and variances of PCA 10 (cont.)

		Component		
		1	2	3
LM1 DTC	+= ASU +	**.696**	-.004	-.070
LM2 5-cusped	+= ASU 5+	**-.600**	-.233	.136
LM2 Y-pattern	+= ASU Y	**.602**	**.584**	.370
Eigenvalue:		8.245	5.418	3.463
Variance (%):		34.356	22.576	14.429
Total variance (%):		34.356	56.933	71.362

Principal Components Analysis. 7 components extracted (matrix of the first 3 components). Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. BKP= breakpoint.

PC1 accounts for 34.4% of that variance, followed by PC2 (22.6%) and PC3 (14.4%). PC1's strongest positive loadings (>0.5) influencing the analysis are all mass-additive complex traits (see Table 4.5.19, above). In almost all cases, except for LM1 *anterior fovea*, BOL and FET display the lowest relative frequencies. This pattern is mimicked by SAQ, except for its frequency of LM2 Y pattern. Inversely, in most cases BT07, PDG1, PDG2 and ABY tend to be present the highest numbers. HRK's frequencies for those traits vary from low (UM3 *parastyle, anterior fovea* and LM1 *protostylid*), intermediate (UI1 labial convexity, *Bushman* canine and LM1 DTC) and high (LP2 cusp variation and LM2 Y pattern). The only noticeable pattern for PC1 strongest negative loadings (<-0.5) is that in all cases these are low frequency traits in BT07 and PDG1. PDG 2 presents in most cases low frequencies for the traits influencing PC2 negatively, except for relatively intermediate frequency of UI2 interruption groove and 5-cusped LM2. However, we must consider that for five out of the thirteen traits influencing PC1 BOL has low number of observations (<10) and that may introduce errors to this analysis.

Most PC2's strongest positive loadings (>0.5) influencing the analysis refer to low frequency traits in this batch (except for LM2 Y pattern). And except for this trait, there is a clear pattern: PDG1, BOL, PDG2, FET do not display the traits; BT07 and ABY present relative intermediate frequencies and HRK and SAQ the highest ones. For LM2 Y pattern, PDG1 has the highest numbers (50%) while FET and BOL the lowest ones (0 and 9.1% respectively).

The strongest negative loadings (<-0.5) for PC2 were drawn from the frequencies of UC DAR and odontome. In both cases BOL and FET display unusually high frequencies for European samples. For the first trait FET's frequency is 84.6% while BOL is 54.5. All the other European and African series present figures between 0 and 47.6%. As for the occurrence of odontomes, most samples in this batch do not present the trait, HRK shows a frequency of

1.3%, while BOL and FET have 10 and 11.1% of frequency respectively. World frequency highest numbers for this trait are found in Arctic (6.2%) and Northwest North American (6.5%) populations (Scott and Turner, 1997) and even those frequencies are a lot lower than those from BOL and FET. All the other samples present frequencies of odontomes within the expected range for European and African dentitions.

Information on the SAQ and ABY samples is discussed above in this chapter.

The graphic representation of PCA 10 in Figure 4.5.18 expresses the numerical results of PC1 and PC2. Three clusters are observable. The first one holds the three samples included in this study. They all come from the same valley (69 km apart across from the river), from the kind of funerary monuments and from the same Chrono-cultural context. Besides that, for both Perdigões and Cerro de las Baterías, the main route for foreign contacts/influences may have been through the Guadiana Valley to the South. Proximity and the mobility provided by that great river may have worked as a unifying factor for the populations living in the region.

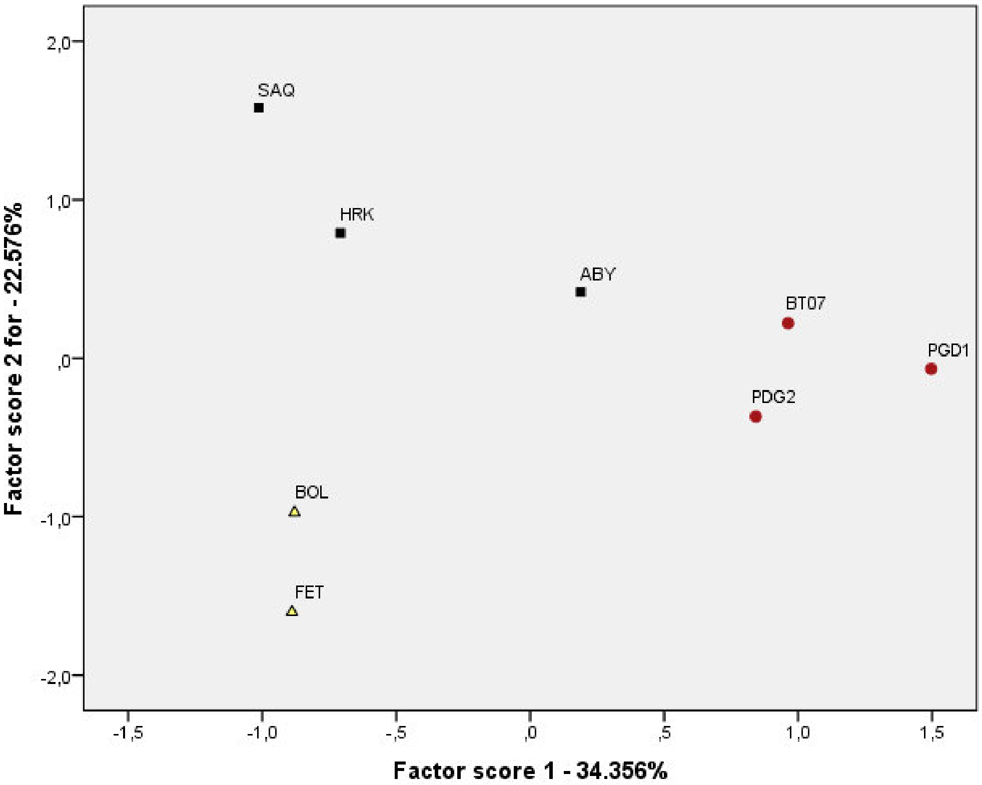


Figure 4.5.18 – Scatterplot of the two first components extracted in the comparison of the samples for PCA 10: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; BOL= Bolores; FET= Feteira II; HRK= Hierakonpolis; ABY= Abydos 1; SAQ= Saqqara.

The second cluster gathers SAQ and HRK, both North African samples from the Nile Valley whose morphology is expected to be similar to the European dentition, yet influenced by the Afridont pattern it derives from (Irish, 1998a; 2013; Irish and Guatelli-Steinberg, 2003).

Geographical location of both populations and the genetic exchanges over time reinforced the similarities between North and Sub-Saharan Africans (Irish, 1998a; 2013). It is then expected that those samples cluster. ABY is located in the middle of the cline on PC1 axis extended from the European PDG1 sample to the North African SAQ.

The third cluster is formed by BOL and FET whose close geographical and chronological relations may explain biological proximity. On the PC1 axis, those samples show more affinities to African samples than to populations living much closer in the Iberian Peninsula. However, low number of observations in BOL (>10) for traits influencing this axis (UM2 *hypocone*, UM3 *parastyle*, LP2 cusp variation, UM1 *anterior fovea*, UM1 DTC) and unexpectedly high frequencies of odontomes in BOL and FET may have introduced errors in this PCA.

Figure 4.5.19 illustrates the biological affinities among samples in this analysis with the addition of PC3 corresponding to 14.3% of the inter-sample variability. The strongest positive loadings (>0.5) for PC3 were drawn from four low frequency traits in this batch. Most samples do not display 2 of those traits (LM1 3-rooted and UI1 double shoveling). FET presents intermediate and high frequencies of 3 traits (LP1 Tomes' root, UM1 enamel extensions and LM1 3-rooted). While BT07 and HRK display the highest trait frequencies. The strongest negative loadings (<-0.5) were obtained from two traits UI2 TD and UI2 interruption groove. In both cases BOL, SAQ and PDG2 present the highest frequencies while FET, PDG1 and BT07 display the lowest figures.

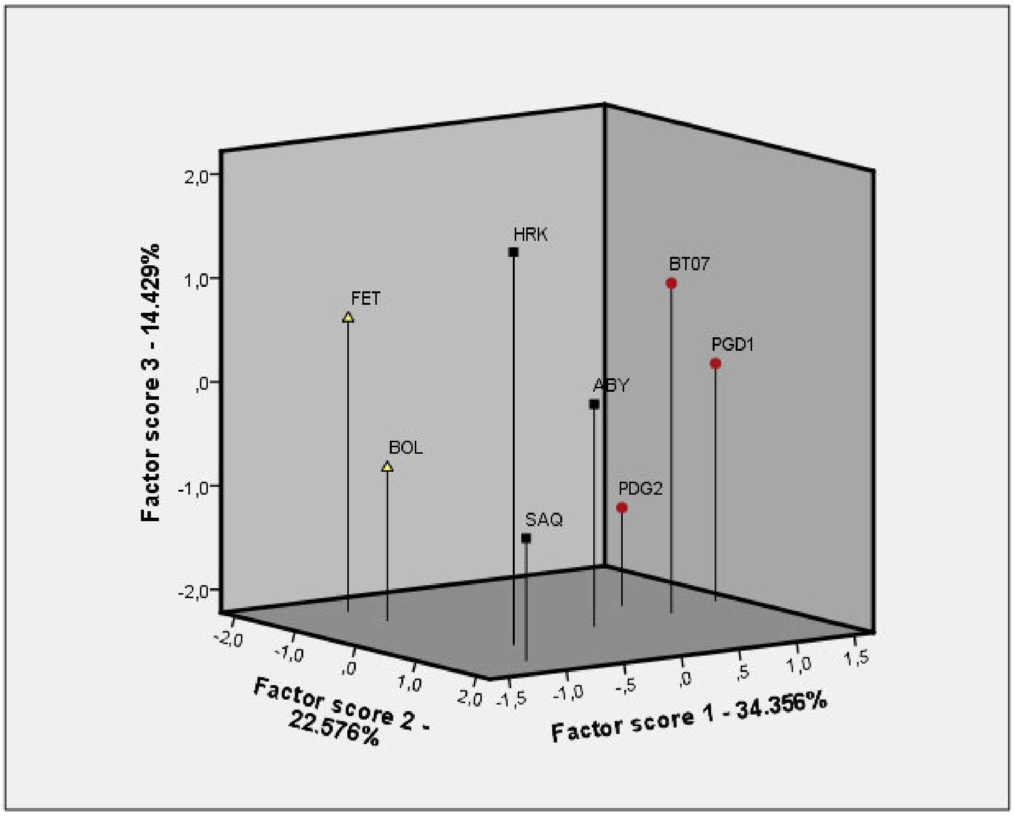


Figure 4.5.19 – Scatterplot of the three first components extracted in the comparison of the samples for PCA 10: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; BOL= Bolores; FET= Feteira II; HRK= Hierakonpolis; ABY= Abydos 1; SAQ= Saqqara.

The morphological affinities between the Iberian samples in this study and North African populations has been demonstrated in this and in previous PC analyses. These tests confirm Irish's idea (1998a: 257) that North Africans "show a strong [dental] affinity to Europeans and perhaps West Africans".

The unexpected result obtained in this analysis was the morphological dissimilarity between the Portuguese samples BOL and FET to the other Iberian samples. All five samples are contemporary and come from much closer regions than the remaining samples in this batch. A number of reasons can contribute to the weak affinity shown in this PCA.

The first possible explanation is that the genetic stock of the populations exhumed from Bolores and Feteira II cemeteries are actually very different from the groups inhabiting the South of the Iberian Peninsula. There is no published genetic study on BOL and FET specifically however, the work on ancient DAN by Chandler (2003) indicate a clear population discontinuity between the Mesolithic and Neolithic sites of the Estremadura region (where both BOL and FET are located) and Perdigões. Later works by Afonso and colleagues (2013) have gone farther and identified African contributions to the populations from Perdigões. Similar results have been obtained for Southern Spain Chalcolithic sites (Gamba *et al.*, 2008). More significant foreign (African?) contribution to the genetic pool from Perdigões and Cerro de las Baterías may be responsible for the morphological low biological affinity among BOL, FET, PDG1, PDG2 and BT07. Genetic drift, endogamy or genetic input from an unknown population into the groups living in the Grande and Sizandro basins may also be considered as possible factors distancing those populations from the southern ones.

However, some attention must be paid to the numbers provided by Horwath and colleagues (2014) and used in this PCA. For six out of the 36 traits published in the article, the number of observation in both BOL and FET is 0. The BOL series also has low number of observations (<10) for 13 of the remaining 30 traits hence, sample size in BOL may hinder its representativeness (Drenan, 1996).

Finally some of the frequencies presented for traits in BOL and FET do not fall within the usual range for regional and local populations. Besides the extremely high frequency of odontome discussed above, UI1 labial convexity, UI1 double shoveling, *Bushman* canine and LM2 Y pattern are either absent in the samples or in very low frequencies, a scenario that differs from both the literature on macro-regional scale (Scott and Turner, 1997; Irish, 1998a) and the samples under study here (for a comparison, see Chapter 4.4 in this dissertation). On the other hand, the numbers for UI2 interruption groove in BOL are almost 6 times higher than the frequency for Portuguese Contemporary populations (Marado, 2014) and at least twice higher than other Portuguese late prehistoric series (this work and Cunha *et al.*, in preparation).

4.5.2.3. Comparisons of PDG1, PDG2 and BT07 to others dated to the 2nd – 1st Millennium BC

PCA 11

PCA 11 deals with the morphological affinities of PDG1, PDG2 and BT07 to and six other populations from Spain, North Africa and the Levant, all dated to the period between the beginning of the 2nd to the end of the 1st millennium BC. Most of the series in this batch come from around the Mediterranean Basin, except for KER, the most inland of these (Map 4.5.8).

Map 4.5.8 – Location of the sites included in PCA 11: PDG 1 and 2 in Portugal; BT07, ECA and LNA in Spain; CAR in the Maghreb region of North Africa; KER in Egypt, and LCI in the Levant.

Chronologically, all samples (except for PDG1, PDG2 and BT07) come from a period when the movements of populations were favored by regular commerce routes though the Mediterranean (Knapp and Blake, 2005; Manning and Hulin, 2005) and by the expansion of some groups via the foundation of colonies overseas (Matthews, 2005). The archaeological record also points to contacts between Southern Iberia and North Africa evidenced by genetic markers in cattle, in African rock art and in shared features in burial practice in both sides of Gibraltar, although more radio-carbon dates are necessary to properly estimate some of the funerary contexts (Lillios, 2014).

ECA and LNA samples (Table 4.5.20) come from two Argaric Bronze Age sites in the Andalusia Highlands (Oumaoui, 2009). The 2nd millennium BC Argaric culture in Southeast Spain is characterized by two kinds of habitat sites. The first one consists of large settlements located in high easily defensible points in the landscape (fortified hilltop sites) with nearby access to fresh water sources and fertile lands. The second kind are small agricultural communities in the valleys, also with easy access to water and farming lands, but whose marks in the landscape are more prone to be obliterated by alluvial deposits (Contreras-Cortés, 2009-2010; Bernabeu-Aubán *et. al.,* 2012).

Table 4.5.20 – Samples from other sources used in PCA 11.

Acronym	Sample	Region – Country	Chronology	Reference
ECA	El Castellón Alto	Granada, Spain	Bronze Age, c. 1300 BC	Oumaoui, 2009
LNA	La Navilla	Granada, Spain	Bronze Age, early 2nd millennium BC	
KER	Kerma	Sudan	1750-1500 cal. BC	Irish, 2005
LCI	Lachish-Iron	Palestine	Iron Age, 1200-520 cal. BC.	Horwath *et al.*, 2014
GRK	Greece	Greece	Historic, 475-300 cal. BC	
CAR	Carthage	Tunisia, NA	751-146 BC	Irish, 1998a

The extensive use of both landscape and man-made defensive structures in Argaric hilltop settlements, the abundance of weapons among the prestige items in the funerary packs and the bioanthropological evidences of interpersonal violence in Argaric human remains suggest that those groups were subjected to competition and conflict in a local/regional scale (Contreras-Cortés, 2009-2010; Aranda-Jiménez, 2011; Bernabeu-Aubán, *et. al.,* 2012; Serrano-Ariza, 2012).

El Castellón Alto (ECA), in Galera, Granada is a typical urban Argaric settlement in what concerns its location and architecture (Contreras-Cortés, 2009-2010; Oumaoui, 2009).

In Argaric hilltop settlements, the deceased were buried either in domestic spaces in the houses or intramural funerary structures (Contreras-Cortés, 2009-2010; Aranda-Jiménez, 2011; Bernabeu-Albán, *et. al.,* 2012; Lillios, 2014). Almost all funerary structures in ECA are located inside the houses. They are excavated in the bedrock and sealed with stone slabs after the deposition of the deceased. Some more elaborate tombs will include other materials in the sealing of the space such as the use of exogenous timber and constructed walls (Oumaoui, 2009).

The funerary pack accompanying the individuals exhumed from ECA display a marked discrepancy of wealth. Some burials do not bear any item of material culture, others have but a small ceramic vase and remains of faunal offerings while the 'elite' burials display rich goods: ceramics, metal utensils, items of personal adornment and faunal offerings (Oumaoui, 2009). These features in the Argaric culture are considered as signs of social stratification and ascribed social status (Oumaoui, 2009; Bernabeu-Aubán, *et. al.,* 2012; Lillios, 2014). Differences between the material culture in male and female burials, another common feature in Argaric burials (Lillios, 2014), was also observed in ECA (Oumaoui, 2009).

The funerary treatment in ECA included individual and double burials of individuals from all age groups. Most of the double burials are composed by a male and a female individual, although only in once case the inhumation seems to have happened simultaneously.

In many tombs the first individual to be buried is reduced to an ossuary and placed along with its votive items in the periphery of the space. This opens space for the burial of the second individual. In one case, the manipulation of the human remains included the *post mortem* beheading of the deceased and the placement of his head between his hands. One of the tombs presenting a MNI of 4 seems to have been disturbed in the period of the use of site, once although the tombs content was disturbed and the bones disarticulated, the space was perfectly sealed (Oumaoui, 2009).

Conservation of organic materials in the site is optimal. Remains of timber and woodcraft, basketry, botanical and faunal remains are well preserved. In one tomb (sepulcher 121) these conditions led to the natural partial mummification of one adult individual (Molina *et al.,* 2003).

The LNA sample comes from the tomb 1 of La Navilla and this funerary monument is part of the Bermejales Megalithic Necropolis, located nearby the homonymous locality, in the autonomous region of Granada. This tomb is located 142 km to the Southwest of ECA in the fertile valley of the Cacín River. Later agricultural exploitation of the land has promoted the destruction of the upper levels of the monument.

The archaeological context in LNA is very different from ECA. While the burials in the latter were placed in the urban/domestic spaces, the human remains from LNA were found in a passage grave disassociated from domestic spaces. The monument was constructed with large orthostats and, judging for the remaining monuments in Bermejales, it may have had a tumulus and cairn, although those structures were completely destroyed in later periods (Oumaoui, 2009).

The funerary treatment of the dead was also different from ECA. Although the space seems to have been used for primary depositions of the dead (as in ECA), the MNI of 54 skeletons belonging to all age groups were excavated from communal spaces/levels within the tomb reflect a different (collective) funerary reality (Oumaoui, 2009).

Because of its location and the disassociation with a fortified hilltop village, LNA tomb probably served to one or more small agricultural occupations in the vicinities, as the pattern suggested by Bernabeu-Aubán and colleagues (2012). The fact that the human remains were found in a passage grave, a kind pf architecture associated with much earlier periods, may suggest that the space was re-used in the Bronze Age such as other Andalusian megalithic monuments. (*i.e.*, the ones in the nearby Grande River Valley) (Fernández-Ruiz, 2004) and in other regions of southern Iberia (Lillios, 2014).

The dental morphology of the samples from ECA (MNI=34) and LNA (MNI=51) were studied by Oumaoui (2009). He compared a set of Bronze Age samples from the provinces of Granada (Southeast Spain) and from La Mancha (Central Spain) to medieval populations from Granada and Burgos (Northern Spain). His results indicate that, despite the archaeological differences between ECA and LNA, both are phenetically very close, possibly representing two samples from the same population (p. 457). When comparing the prehistoric versus the historic series in his work, Oumaoui (2009) defends that the first received less gene flow and presented smaller bio-distances. In his hierarchical cluster analysis using Scott and Turner's (1997) reference frequencies for world samples, both ECA and LNA cluster along with North Africans, Western and Northern Europeans. However when discussing exogenous admixture into those Spanish populations, he argues that the prehistoric populations presented much less admixture with North Africans than the medieval populations in his work. He argues that, the morphology of the individuals in the Bronze Age series would represent the most autochthonous Spanish phenotype, while the medieval ones were under strong admixture due to the centuries of North African occupation of the Spanish territory in the Middle Ages.

KER is a Nubian series from the Kerma cemetery in the Dongola Reach (present day Sudan). Kerma was probably the center of the Kingdom of Kush. The city itself dominates a fertile flood plain whose production sustained a very large population between 2500 and 1500 BC. The large cemeteries serving the city bear over 30000 tombs (Lacovara, 1999; Irish, 2005).

The deceased were buried in primary deposition accompanied by funerary goods varying according to social status. The corpse was usually deposited on a bed and under a mound. The mounds escalate in some cases to the building of small chapels outside the funerary structure for the deposition of votive items. Some large tombs included human and animal sacrifices, besides the deposition of industry (Lacovara, 1999).

The ethnic association of KER to either Egyptian or Nubian groups has been debated although the funerary ritual and the majority of the industry points to indigenous origins (Lacovara, 1999; Sherif, 2010). Irish (2005) studied a Classical period Kerma series (1750-1500 BC) whose frequencies of non-metric traits are used in this test. That author has shown that the KER individuals were probably developed out of the A-Group Nubians, being phenetically similar to Kawa Nubians.

The LCI sample comes from the semi-independent Levantine city of Lachish (tell ed-Duweir) located in the present day State of Israel. The site was occupied since the beginning of the 4th millennium BC up to the 4th century BC, although not continuously. (Ullinger *et al.*¸ 2005). Since the early 20th century, anthropological studies on the site's large human remain series have addressed questions on population continuity in the site through its time of use. Most of those works are based on craniometrics. The questions to be answered by the anthropological studies were related to biblical versions of the local history accounting for an Israelite conquest. Using the ASUDAS approach on the dental morphology of individuals from Lachish, Ullinger and collaborators (2005) showed that there is no evidence of population discontinuity between the Late Bronze and the Iron Ages, being the population more homogeneous than previously supposed.

The GRK series whose frequencies were used from this test were obtained from Horwarth and colleagues (2014) and the site of provenance is not published in that article. The chronology of the series places it in the Classical Period (480-338 BC). That is a time when the Hellenistic tradition has integrated the fragmented Greek territory into a cultural *corpus* sharing the same language, religion and artistic expressions. Although composed by independent city-states, extra-local coalition was made and reinforced by the resistance against foreign powers (such as the barbarian incursions in the late 5th century BC). Men in that context perceived themselves as Hellenes, as well as citizens of specific cities (Alcock and Cherry, 2005).

It is also in the Classical Period that Greek expansion to other regions in the Mediterranean is at its peak with well-established Greek ‘colonies’ ranging from Present day France to the Black Sea (Alcock and Cherry, 2005). As those authors argue, the relationship between Greek ‘colonizers’ and ‘natives’ cannot be taken in the same sense as the modern acceptation of the word and interaction between those adopted more varied dynamics sometimes favoring the adoption of alien cultural traits by the newcomers, others the opposite or even a combination of traits from both. Negotiation and diplomacy were much stronger features of those relations than the use of force.

The CAR sample comes from the Punic Phoenician levels of Carthage (Irish, 1998a) located in modern day Tunisia. Phoenicians are originally a Levantine group from the coastal area of present day Lebanon. Their history was marked by the expansion to the West promoted by the largest cities of Tyre and Sidon (Alcock and Cherry, 2005). This expansion was motivated by the exploitation of seafaring and commerce and by of natural resources in new territories.

This expansion led to the establishment of westward routes in the Mediterranean and to the foundation of different sized Phoenician occupations (ports, trading posts and colonies) in both the European and African coasts of that sea, eventually into the Atlantic façade of the Iberian Peninsula (Dietler and López-Ruiz, 2009; Warmington, 2010).

The Greek and Phoenician colonial enterprises coincide in time and in some cases in its geography. Both were seeking similar resources. In some regions, such as in parts of Iberia, the interaction between both colonizing powers was mediated by diplomacy and commerce (Dietler and López-Ruiz, 2009) while in others by conflict (Alcock and Cherry, 2005). Some of the Phoenician colonies would eventually become independent cities. Carthage, probably the most influential of those colonies, seems to have received much of its historical fame for being portrayed in the words of the history written by its enemies (Greeks and Romans) (Warmington, 2010).

The city of Carthage (Kart Hadasht, ‘New City’) was probably founded with the intention to become the strong outpost of the Tyre in the 8th century BC, reaching independence in the 6th century BC. It eventually became the center of Phoenician territory with the fall of its former metropolis to the Babylonian Empire. Greek pressure on Phoenicians colonies in the modern day territory of Italy also helped this shift in the political and economic centers of the Phoenician world (Warmington, 2010).

Nineteen discrete traits were employed in this PC analysis. These are distributed on both the superior (10) and inferior (9) jaws and on the anterior (7) and posterior (12) dentition. The first three components extracted explaining 96.7% of the total inter-sample variance were used in the component matrix in Table 4.5.21. In this analysis, PC1 accounts for 29.4% of the total variance, PC 2 for 25.4% and PC3 14.9%.

Table 4.5.21 – Matrix of the component loadings, *eigenvalues* and variances of the PCA 11*.

	BKP	Component		
		1	2	3
UI1 labial convexity	+= ASU 2-4	**.747**	-.351	**.531**
UI1 shoveling	+= ASU 2-6	.235	.499	**.721**
UI1 double shoveling	+= ASU 2-6	-.297	-.358	**.713**
UI2 peg	+= ASU +	-.432	.413	-.223
UC *Bushman* canine	+= ASU 1-3	.418	**.753**	.147
UC DAR	+= ASU 2-5	**.864**	.410	-.114
UP2 odontome	+= ASU +	**-.517**	.211	-.426
UM2 *hypocone*	+= ASU 3-5	-.344	**.800**	.292
UM 2 enamel extension	+= ASU 1-3	**-.734**	.205	-.170
UM3 congenital absence	+= ASU +	**-.805**	-.412	.351
LC 2-rooted	+= ASU +	.099	**-.725**	-.250
LP2 cusp variation	+= ASU 2-9	.305	**.878**	-.107
LM1 6-cusped	+= ASU 6+	.478	-.329	**-.566**
LM1 DTC	+= ASU +	**.583**	.430	-.252
LM1 *protostylid*	+= ASU 1-7	**.955**	.091	-.101
LM1 C7	+= ASU 2-4	-.240	.284	.398
LM1 3-rooted	+= ASU +	.246	-.111	**.554**
LM2 Y-pattern	+= ASU Y	-.251	**.756**	.101
LM2 5-cusped	+= ASU 5+	**-.663**	**.513**	-.270
Eigenvalue:		5.586	4.830	2.831
Variance (%):		29.398	25.419	14.898
Total variance (%):		29.398	54.818	69.716

* Principal Components Analysis. 6 components extracted (matrix of the first 3 components). Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. BKP= breakpoint.

The strongest positive loadings (>0.5) for PC1 refer to four complex/mass additive traits: UI1 labial convexity, UC DAR, UM1 DTC and LM1 *protostylid.* In all cases, the Iberian Chalcolithic samples present the highest frequencies relatively to this batch. KER displays intermediate frequencies in most cases (except for the absence of UM1 DTC), while LCI, GRK and CAR have the lowest ones. ECA and LNA have intermediate frequencies of UC DAR and LM1 *protostylid*, absence of UM1 DTC and high frequency of UI1 labial curvature.

The strongest negative loadings (<-0.5) for PC1 were drawn from three traits. The first one, UP odontome is a low frequency trait in populations within both Afridont and Eurodont dental complexes (Scott and Turner, 1997; Irish, 1998a). In fact only LCI displays cases of this trait and in very low figures (0.5%). The other two traits (5-cusped LM1 and UM1 enamel extensions) are low frequency traits in Chalcolithic and Bronze Age Iberian samples in this batch (BT07, PDG1, PDG2, ECA and LNA) and intermediate-highly frequent in KER, GRK, CAR and LCI.

The strongest positive loadings (>0.5) for PC2 refer to four traits whose frequencies are usually high in African populations (Irish, 1998a and 2013): UC *Bushman* canine, UM2 *hypocone* (presence of the cusp) and 5-cusped LM2, and to a 5th trait which is frequent in European populations: the presence of two or more lingual cusps on LP2. The most visible trend in the batch of samples included in this analysis is that the Iberian Chalcolithic Samples (PDG1, PDG2 and BT07) and KER display intermediate and high frequencies for these features, while ECA and LNA are characterized by a simpler morphology in what concerns these mass additive traits. For almost all these features (except for the *Bushman* canine), LCI also display more complex morphology, closer to KER.

The only strong negative loading (<-0.5) in PC2 was obtained for 2-rooted LC. Four samples do not display the presence of this trait: PDG1, PDG2, LCI and CAR. Four other series (KER, BT07, GRK and LNA) have figures between 1.9 and 3.7% in the range of what has been published for North Africa (2.3%) (Irish, 1998a) and Western Europe (5.7%) (Scott and Turner, 1997). LNA's frequency of this trait (11.1%) seems far beyond the expected.

The graphic representation of morphological affinities based on PC1 and PC2 (Figure 4.5.20) displays a clear cluster containing the 3 Chalcolithic Iberian samples. They exhibit closer affinity and probably more homogeneity than the other two clusters in the scatterplot. When considering the traits influencing PC1 and PC2, frequencies in these series are much more similar amongst each other than they are between both the Spanish Bronze Age series composing the second cluster (ECA and LNA). The 3rd group is formed by LCI, GRK and CAR.

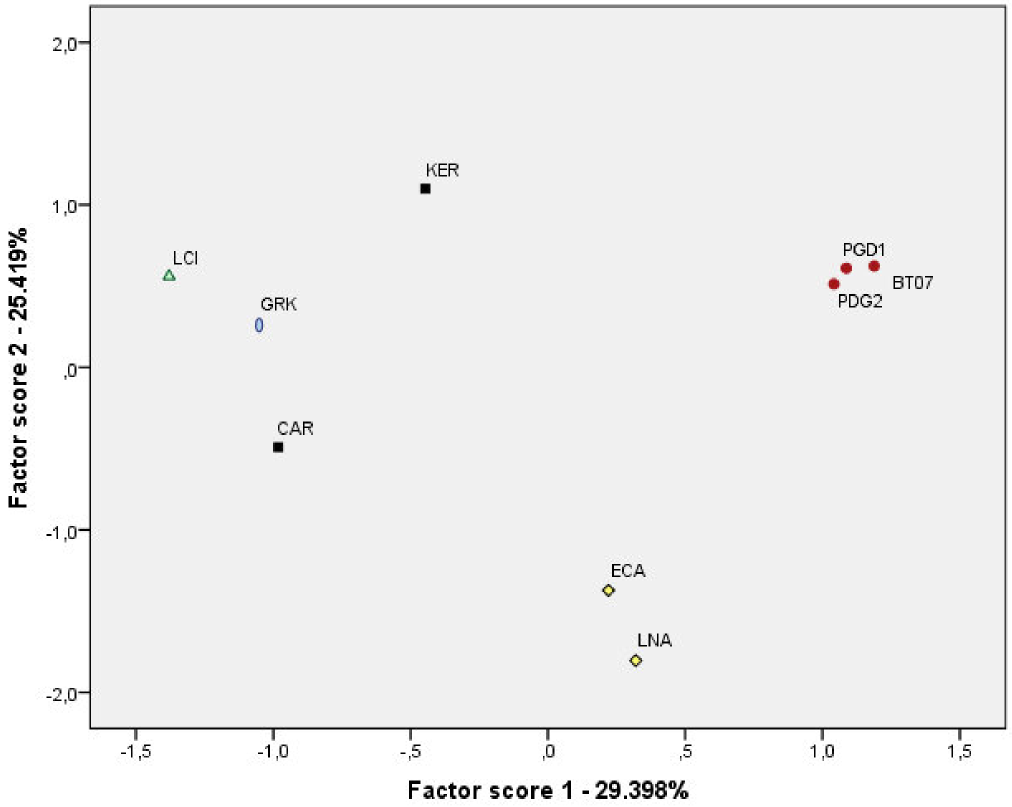


Figure 4.5.20 – Scatterplot of the two first components extracted in the comparison of the samples for PCA 11: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; ECA= El Castellón Alto; LNA= La Navilla; KER= Kerma; LCI= Lachish-Iron; GRK= Greece; CAR= Carthage.

Three groupings are formed based on the information summarized in the first two components (Figure 4.5.20, above). The first one gathers the three Iberian samples in a close cluster, expressing significant shared affinities among those three samples closely located in time. Their biological likeness probably reflects common ancestry in the Chalcolithic stock of Southwest Iberia, but also gene flow among those populations fomented by shared cultural features.

The second cluster gathers the two Argaric Spanish samples. As Oumaoui (2009) has shown, these are probably two populations coming from the same (or very close) genetic stock.

The third group gathers three populations historically know for commercial and cultural exchanges among each other. To a certain extent and in different periods in their history shared/overlapping territories may have facilitated genetic exchange among those groups. However, frequencies of traits and their effects on the graphic expression of dental affinities show that they are not as homogeneous as the first two groups.

Finally KER stands as an outlier, although close to the latter cluster in what concerns to traits influencing PC1 axis and to both the Chalcolithic Iberians and Levantines, Greek and Carthaginians on PC2 axis.

Considering PC1 axis (29% of the variance) the Iberian samples are also close to Bronze Age ECA and LNA.

The results of the PCA analysis employing the first two components reflect closer biological affinities among PDG1, PDG2 and BT07 and between those and North African populations.

Interaction and consequent gene flow among the populations living in the Guadiana Valley during the Chalcolithic may have reinforced biological affinities. These were populations living approximately 70 km apart which shared very similar cultural traits (material culture, funerary rituals and symbolic expressions). On the other hand, ECA and LNA are morphologically less homogeneous than the former populations. For a number of mass additive/complex traits (UC DAR; 2-rooted LC; LM1 6-cusped, *protostylid* and C7, and LM2 Y pattern) individuals from LNA seem to have more robust dentition, although the morphology of UI1 is more complex in ECA. Considering that Bronze Age Andalusian populations lived under the stress of intergroup conflict as evidenced in the archaeological record (Contreras-Cortés, 2009-2010; Aranda-Jiménez, 2011; Bernabeu-Aubán, *et. al.,* 2012; Serrano-Ariza, 2012), interactions and gene flow among different Argaric populations may have been hindered and endogamy could explain the differences between those two populations.

As Oumaoui (2009) has noted, the morphology in both LNA and ECA differ from the North African pattern in many aspects. On the other hand, the morphology of the Chalcolithic PDG1, PDG2 and BT07 present higher frequencies of UM2 *hypocone*, LM2 Y pattern and 5-cusped LM2, and lower frequencies of UI1 double shoveling and UM3 congenital absence closer to the North African figures. These traits are particularly significant in drawing the Iberian Chalcolithic samples closer to KER and farther from LNA and ECA in the PC2 axis.

The strongest positive loadings (>0.5) for PC3 were drawn from four traits: 3-rooted LM1 and 3 other traits located on the same tooth (UI1 labial convexity, shoveling and double shoveling). GRK and LCI either do no display those traits or do it in low frequencies. PDG1 and PDG2 present low or intermediate frequencies of those features. BT07 on the other hand present the some of the highest frequencies along with ECA, CAR and KER. These differences draw BT07, ECA, CAR and KER closer on the 5rd axis in Figure 4.5.21.

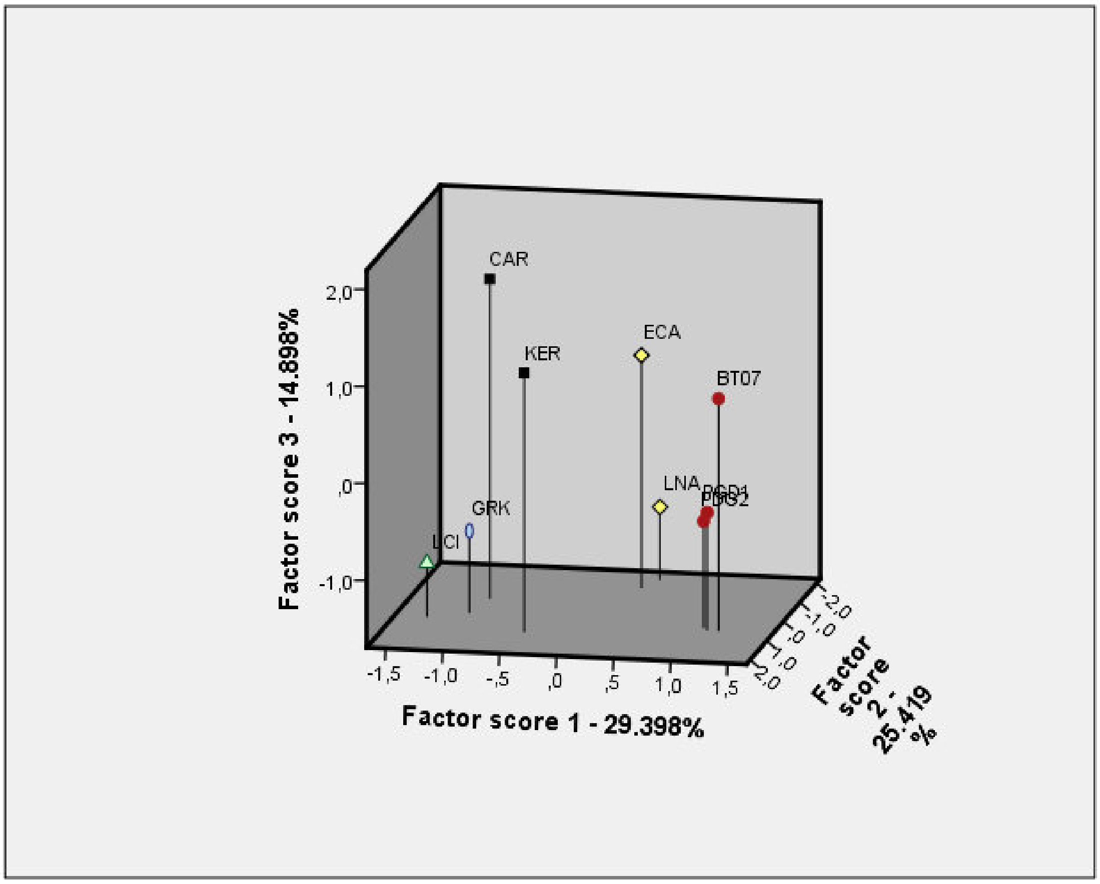


Figure 4.5.21 – Scatterplot of the three first components extracted in the comparison of the samples for PCA 11: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; ECA= El Castellón Alto; LNA= La Navilla; KER= Kerma; LCI= Lachish-Iron; GRK= Greece; CAR= Carthage.

The results of PCA 11 are coherent with the population history and archaeological evidences of relationships among the populations included in this batch.

If morphological trait expression (phenetics) mirrors genetic relatedness (Scott *et al.*, 1983; Scott and Turner, 1997), the Chalcolithic BT07, PDG1 and PDG2 are shown to share closer affinities as a cluster than all the other samples within the other groupings. That is probably an effect of more frequent biological interaction within these communities united by a common cultural background and physically by the great Guadiana River.

The Argaric populations of LNA and ECA constitute another cluster probably sharing common ancestry and cultural ties. Internal differences and genetic drift fomented by isolation and social conflict may have resulted in morphological differentiation over the generations between these two series.

LCI and GRK (and to a certain extent CAR) are originally Eastern Mediterranean populations sharing a long history of contact amongst each other (Alcock and Cherry, 2005; Matthews, 2005; Ullinger *et al.*¸ 2005; Warmington, 2010). Despite that, biological differences are significant and reflect different ancestry and interactions with other groups throughout each population's History.

KER is the most isolated series in this batch. Geographically it is also the farthest population. Although as many groups living the Nile River, KER had contacts with Mediterranean groups (mainly the Egyptian ones) (Lacovara, 1999; Irish, 2005; Sherif, 2010), their morphology in many aspects tend to express closer affinities to the Afridont pattern than all the other samples included in this batch. Among these we may highlight high frequencies of LM2 Y pattern, 4-cusped UM2 and 5-cusped LM2 and intermediate ones for *Bushman* canines.

4.5.2.4. Comparisons of PDG1, PDG2 and BT07 to others dated to the 1st Millennium AD to the Modern Ages

PCA 12

PCA 12 deals with the morphological affinities among the samples in this study and a batch of Medieval-Modern northern European samples (SAM, RUS, ESTO, NETH and SCO) and a Napatan Nubian series (KUS) (Map 4.5.9).

Map 4.5.9 - Location of the sites included in PCA 12: the Iberian Chalcolithic samples (PDG 1, PDG 2 and BT07), northern European Medieval-Modern populations (SAM, RUS, ESTO, NETH and SCO) and the Nubian Kushite series (KUS).

Information on the SAM sample (Table 4.5.22) is scarce and provided only by electronic communication by G. Richard Scott (University of Nevada, Reno; February 7th, 2014). The information available for this population relates to its ethnicity (Saami) and to the fact that data on this population was collected by Christy Turner II as part of his monumental world-wide work on dental morphology. Contrary to the Danish and Ukrainian samples discussed above in this chapter, there is no mention in Turner's files to the chronology of this series.

The Saami are Uralic (Finnic) Caucasoid peoples traditionally and legally considered indigenous to the Artic. Their native lands include parts of modern Finland, Sweden, Norway and the Kola Peninsula in Russia. Although the geographical origin of this northern population is disputed, Finns and Saami seem to share common ancestry, diverging c. 23,000 BP. These groups would meet and interact again in Fennoscandia c. 8500 BP (Niskanen, 2002). Archaeological and historic accounts attest to long interactions between the Saami and other northern populations (Finns, Swedish and Norwegians). The length and borders of Saami's territories have varied chronologically through time, mainly due to pressure from other more complex groups (Broadbent, 2006; Zachrissom, 2008).

Table 4.5.22 - Samples from other sources used in PCA 12.

Acronym	Sample	Region – Country	Chronology	Reference
SAM	Saami (Lapp)	Arctic Europe	Historic (?)	Christy Turner's database
RUS	Russian	Russia	Historic (?)	
ESTO	Estonia	Northern Europe	Historic (?)	
NETH	Netherlands	Northern Europe	Historic (?)	
KUS	Kushite	Sudan (Ancient Nubia)	600 BC – AD 550	Irish, 2005
SCO	Scotland	Scotland	Medieval	Adler, 2005

Most of what is known on the historic Saami comes from chronicles written by outsiders to this populations. There is no history of warfare between the Saami and neighboring populations. Oral traditions depict them as nomadic hunter gathers (latter reindeer shepherds) who had a symbiotic relationship with regional food producing groups. Genetic ties through the exchange of marriage partners seem to have happened among the Saami and the latter as indicated by exogenous burials in cemeteries belonging to either (Zachrissom, 2008).

Archaeological data however has challenged their nomadism probably caused by the pressure of the expansion of agrarian communities; the expansion of the Church, state taxation and trade control, and the economic competition with foreigners for fishing zones around AD

1300. The spread of the Black Death in the mid-14th century AD must also have contributed to the retrieval of Saami groups from trade zones where the disease afflicted larger numbers (Broadbent, 2006).

The information on the RUS, ESTO and NETH samples is even scarcer. Data from Christy Turner's files was kindly provided by electronic communication by G. Richard Scott (University of Nevada, Reno; February 7th, 2014). They consist of native populations from Russia, Estonia and the Netherlands respectively.

The SCO sample published by Adler (2005) is a composite of Scottish series. Ethnic groups contributing to this sample include Northumbrians, Picts, Gaels, Britons and Scandinavians (Adler, 2002; 2005). Scandinavian components in the Scottish population are historically and genetically documented. They result from the Viking expansions beginning in the late 8th century AD, but also from earlier small scale immigration of Norse groups settling in Northern and Western Scotland (Downham, 2008; Barrett, 2008). As a result, both male and female Scottish genetic inheritance is highly influenced by Scandinavian contribution (Barret, 2008).

The largest population included in Adler's 2005 study comes from Whithorn Priory in Wigtownshire (southwest Scotland) (MNI=463). Most of the individuals are dated between 1250 and 1600 AD. Other series include individuals from three Carmelite friaries in Aberdeen (MNI=90), Linlithgow (MNI=87) and Perth (MNI=26) in the eastern Scottish coast. Most of the burials in these Carmelite cemeteries are dated from the late 13th to 14th centuries and belonged to lay population. The last component of the Scottish sample comes from St. Andrews (MNI= 86) (also in the east coast). These are Early Medieval individuals with a minor contribution from a probable earlier Pre-Christian Pictish cemetery (Hallowhill, MNI= 34).

The KUS sample is a North African (Nubian) series culturally affiliated to the Merotic/Post-Merotic Kushite kingdom (Irish, 2005). The Kushite reign as an independent nation begins about 2300-1560 BC in a territory reaching as far north as beyond the second cataract of the Nile (Kas). Its early history is inferred only by archaeological evidence due to the lack of written records of the period (Leclant, 1999). Historically, the relationship between the Kushite kingdom and Egypt is marked by the alteration of power over the Nile Valley between these two nations, with either side losing sovereignty in different periods (Leclant, 1999; 2010).

The sample studies by Irish (2005) dates mostly to the 25th Dynasty (c. 750-591 BC), a period in which the Kushites ruled over Egypt and their homeland Kas region. Canonical and political imagery depict the Kushites with typical African features (broad nose, thick lips, and strong cheekbones) (Leclant, 1999; 2010).

Kushite burials were primary. Typically the deceased would be inhumated on a bed fitting a rectangular grave excavated on the soil, accompanied by grave goods (although burials in pits and shafts are also found). Individual burials are the most frequent formula, but double and multiple burials were excavated from Kushite cemeteries (Williams, 1990; Leclant, 1999; 2010). At Qustul site burials bearing more than one individual includes a female individual and a newborn (probably mother and infant) and at least 3 multiple graves (sometimes on the same bed) but no signs of sacrifice were found in any of the individuals (Williams, 1990).

The dental morphological analysis of the upper Nubia KUS sample has shown biological affinities among this series and both earlier (C-Group and Kerma Classique) and later Nubian populations (lower Nubian Merotics, X-Group and Christian), hence proving continuity of a local phenetic heritage in Ancient Nubia (Irish, 2005).

A component matrix was produced including the three first components extracted for PCA 12 (see Table 4.5.23). The first three components account for 74.1% of the total variance. Twenty traits were used in this comparison eleven refer to the superior dentition and nine to the inferior one. Six are located on the anterior teeth and fourteen on the posterior ones.

PC1, accounting for 37.1% of the inter-sample variance, displayed strong positive loadings (>0.5) for six traits: UI2, UM1 C5, UM1 enamel extension, UM3 congenital absence, 2-rooted LC and Tomes' root. In all cases, the PDG1, PDG2 and BT07 present comparatively low frequencies. This pattern is closely followed by KUS, displaying low or intermediate figures for the same features. NETH, ESTO, RUS and SCO follow an inverted trend, presenting intermediate or high frequencies of the same features. SAM is somehow more variable as it shows relatively low frequencies for 2-rooted LC and Tomes' root, intermediate ones for UM1 C5 and UM3 congenital absence, and high ones for UI2 interruption groove and UM1 enamel extension. Most of these traits, except for UM3 absence, are mass-additive or complex. Lower frequencies of LM1 enamel extension, 2-rooted LC and UM3 congenital absence in the Iberian series may result from North African genetic influences in the Iberian stock.

Table 4.5.23 - Matrix of the component loadings, *eigenvalues* and variances of PCA 12

		Component		
		1	2	3
UI1 shoveling	+= ASU 2-6	.351	**.781**	.473
UI1 double shoveling	+= ASU 2-6	.441	**.853**	.021
UI2 TD	+= ASU 2-6	**-.698**	.120	.143
UI2 interruption groove	+= ASU +	**.765**	**.540**	.003
UC *Bushman* canine	+= ASU 1-3	**-.887**	.241	.110
UM1 Carabelli's trait	+= ASU 2-7	-.321	**.764**	.207
UM1 C5	+= ASU 2-5	**.736**	**-.522**	.244
UM1 enamel extension	+= ASU 1-3	**.779**	.367	.059
UM2 *hypocone*	+= ASU 3-5	.001	-.026	**.931**
UM3 *parastyle*	+= ASU 1-6	.164	.432	**-.514**
UM3 congenital absence	+= ASU +	**.821**	-.435	.059
LC 2-rooted	+= ASU +	**.849**	.161	.183
LP1 Tomes' root	+= ASU 3-5	**.705**	-.433	-.029
LP2 cusp variation	+= ASU 2-9	**-.787**	-.060	-.415
LM1 C7	+= ASU 2-4	-.326	-.080	**.854**
LM1 3-rooted	+= ASU 1-3	-.320	-.049	**.773**
LM1 *protostylid*	+= ASU 1-6	**-.825**	.331	-.271
LM1 6-cusped	+= ASU 6+	.433	**.769**	-.190
LM2 5-cusped	+= ASU 5+	-.326	.115	.473
LM2 Y pattern	+= ASU Y	**-.524**	.151	.050
	Eigenvalue:	7.420	4.033	3.366
	Variance (%):	37.101	20.164	16.832
	Total variance (%):	37.101	57.265	74.097

*Principal Components Analysis. 5 components extracted (matrix of the first 3 components). Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. BKP= breakpoint.

All strong negative loadings (<-0.5) in PC1 were produced by the frequencies of mass-additive traits: UI1 TD, UC *Bushman* canine, LP2 cusp variation, LM1 *protostylid* and LM2 Y-pattern. For the first four traits, both KUS and the Iberian Chalcolithic samples display intermediate/high frequencies. PDG2 does not follow this trend in what concerns its low number of LM2 Y-pattern. SCO and SAM display relative intermediate frequency of all traits while ESTO consistently is among the lowest. The RUS and NETH samples are characterized by the low/intermediate frequencies for all those traits.

PC2 displays strong positive loadings (>0.5) for five mass-additive/complex traits: UI1 shoveling, UI1 double shoveling, UI1 interruption groove, UM1 Carabelli's trait and 6-cusped

LM1. The most noticeable trend in this selection of traits is that for almost all of them (except for Carabelli's) SAM and SCO display the highest frequencies, while all other series fall within intermediate and lower numbers.

The only strong negative load (<-0.5) for PC2 was produced by UM1 C5. Frequencies of this trait in the Iberian samples are relatively low (between 7.7 and 12.2%). SCO, SAM and KUS display intermediate numbers (16.8-28.6%), while NETH, RUS and ESTO have the highest ones (46.1-63%).

Figure 4.5.22 illustrates the biological affinities among the samples included in this batch considering the first 2 components discussed above. The Chalcolithic Iberian samples form a close cluster indicating that variance of trait frequencies among the 3 series is much lower than among other clusters represented in the graphic. These series are morphologically more closely affiliated and more homogeneous than all others. On a wider grouping we can consider that these along with KUS form a cluster apart from all other series in this batch. This grouping is caused by similar frequencies of a number of traits (UI1 interruption groove, UM1 enamel extensions, 2-rooted LC, UC *Bushman* canines, LP2 cusp variation and UM1 Carabelli's trait) for both the Iberians and North African populations analyzed in this PCA. Population history discussed above explains these similarities between South European populations and North African ones. Time wise, we must consider that the Iberian samples, being over 2000 years older than the KUS series, represent a somehow more archaic tooth morphology closer to the African ontogenetic pattern. These factors may help differentiate PDG1, PDG2 and BT07 from all other European samples in this batch.

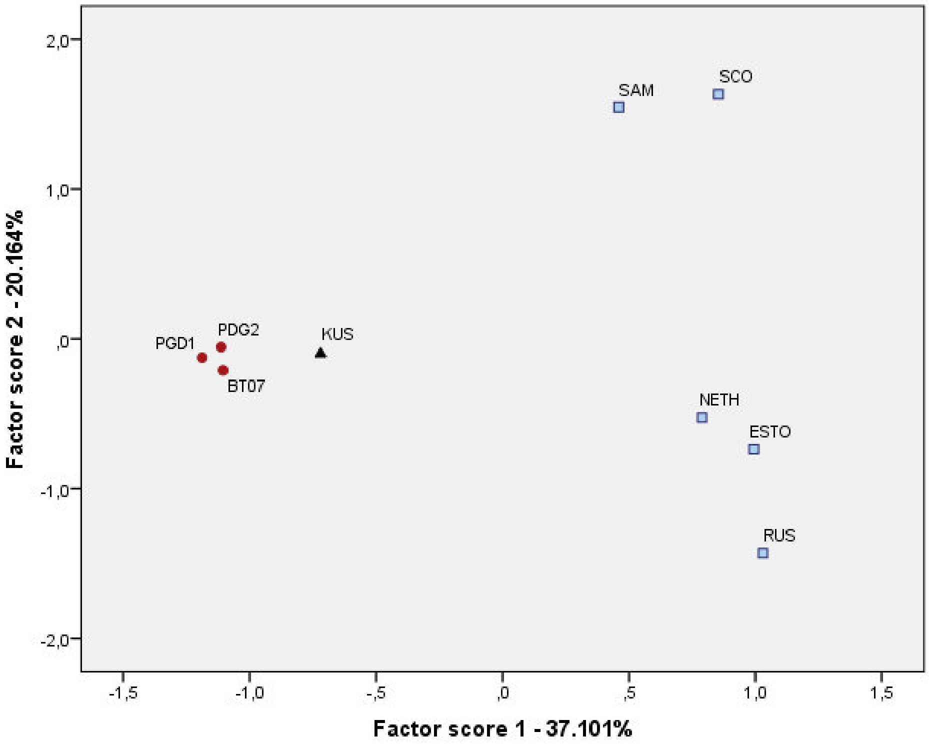


Figure 4.5.22 – Scatterplot of the two first components extracted in the comparison of the samples for PCA 12: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; SAM= Saami (Lapp); RUS= Russian; ESTO= Estonia; NETH= Netherlands; KUS= Kushite; SCO= Scotland.

A second cluster joins SAM and SCO (Figure 4.5.22, above). Similar frequencies of UI1 shoveling, UI1 double shoveling, UI2 interruption groove, UM1 C5, UI2 TD, UC *Bushman* canine, LP2 cusp variation, LM1 *protostylid*, 6-cusped LM1 and UM1 C5 influence this proximity. In terms of population history, Saami groups (here represented by the SAM sample) are Scandinavian populations (Niskanen, 2002; Broadbent, 2006; Zachrissom, 2008). Gene flow from Northern populations into the Scottish stock is postulated by Adler (2002; 2005). Gene flow was favored by both migration in small numbers motivated by commerce around the 9th century AD and larger later expansionist movements of Scandinavian groups into Scotland in the High Middle Ages (Downham, 2008; Barrett, 2008).

The last grouping is composed by NETH, ESTO and RUS. Although the provenance of the Russian sample is not known, being so morphologically closer to ESTO may be an indication that it probably comes from western Russia and that genetic exchanges between those and Estonian populations may have rendered the morphological affinities between these samples. However the closest related series in this cluster are NETH and ESTO, sharing similar or identical frequencies for seven traits (UI1 interruption groove, UM1 C5, UM3 congenital absence, 2-rooted LC, UC *Bushman* canine, LP2 variation cusp and LM1 *protostylid*).

PC3 display strong positive loadings (>0.5) for three traits: UM2 *hypocone*, LM1 C7 and 3-rooted LM1. The only obvious pattern is that KUS present the highest or the second highest frequency for all traits. All other samples are characterized either by very similar high numbers (for the UM2 *hypocone*) or very similar low ones (for both remaining features).

The only strong negative loading (<-0.5) in PC3 refers to UM3 *parastyle*. There is no clear divide among the samples in their frequencies for this trait. In all of them numbers are very low. Three series (PDG2, NETH and KUS) do not display the feature. All others have numbers between 1.8 and 6.1%.

When the information on PC3 is added to the graphic representation of morphological affinities among the samples (Figure 4.5.23), similarities between PDG1 and PDG2, as well as between NETH and ESTO become more evident. KUS on the other hand stands farther from the European samples in this batch.

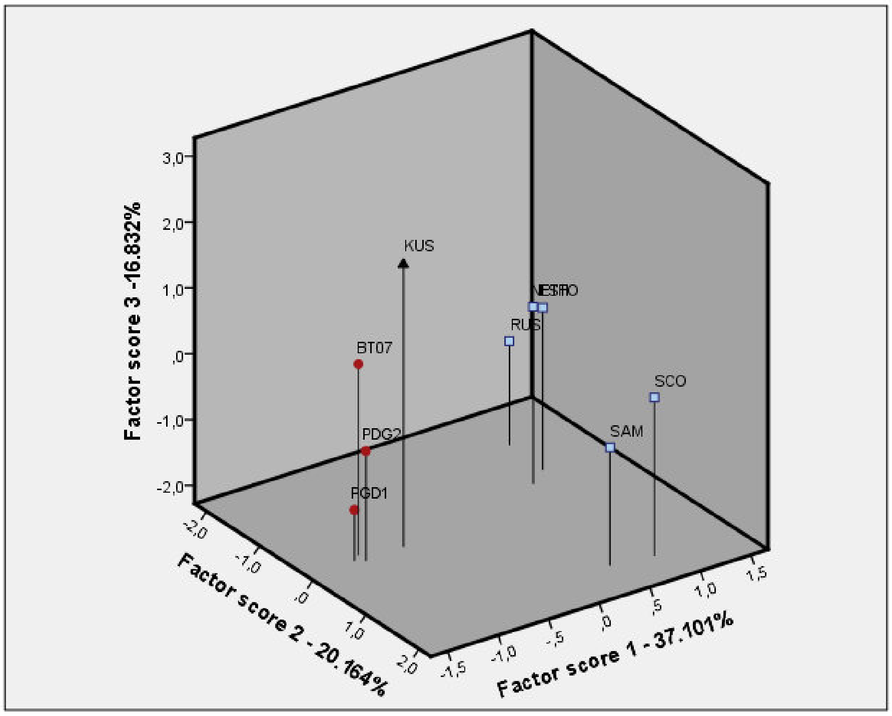


Figure 4.5.23 – Scatterplot of the three first components extracted in the comparison of the samples for PCA 12: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; SAM= Saami (Lapp); RUS= Russian; ESTO= Estonia; NETH= Netherlands; KUS= Kushite; SCO= Scotland.

PCA 12 reinforces previous results indicating that the Iberian Chalcolithic samples tend to share morphological affinities with African populations, particularly when compared to North European groups. That may result from the retention of more archaic features in the prehistoric series, particularly when considering that all the other series in this batch are more recent. However, genetic exchanges with North African populations operating since at least the

Neolithic may have contributed to closer affinities towards the populations living in Southern Iberia.

4.5.2.5. Comparisons of PDG1, PDG2 and BT07 to the Modern/Contemporary Portuguese

PCA 13

PCA 13 deals with the biological affinities among the Iberian Chalcolithic series included in this study and a Contemporary Portuguese sample (COI), mostly composed of individuals born in the district of Coimbra in central Portugal (Marado, 2014).

COI is not a natural population. The 600 individuals whose morphology was recently studied by Marado (2014) were selected from two of the osteological identified collections housed in the Department of Life Sciences, Faculty of Sciences and Technology at the University of Coimbra. The first selection criteria for this sample was related to the number of teeth available for morphological study: individuals which presented at least 5 teeth in each dental arch were selected from two collections holding a total of 1660 specimens. A second criteria used was the balance between both sexes. Hence within the available sample, Marado (2014) selected 300 males and an equal number of females. Age at death distribution within this series goes from 7-97 yrs. old at death, although most individuals (N=386, 64%) were between 20 and 49 yrs. old at death. Most of the individuals in this sample (300 males and 269 females) come from the International Trades Collection (N=1075). Despite its name, this sample comes from the Conchada cemetery in Coimbra and it is in its vast majority composed by individuals born in Portugal. These individuals died between 1915 and 1938 (Wasterlain, 2006; Santos, 2012; Marado, 2014).

The 31 remaining subjects in Marado's (2014) study (all females) come from the Medical Schools osteological collection (N=585). This series gathers osteological remains from different districts in Portugal. These individuals died between 1895 and 1903 (Wasterlain, 2006; Santos, 2012; Marado, 2014).

Individuals in COI come from different districts and regions in Portugal. Foreigners in Marado's (2014) sample make up 1.5% (N=9). These come from Africa (N=1), Brazil (N=2), Spain (N=5) and France (N=1). The origin of 5 individuals (0.8%) is not known.

Frequencies of 33 dental traits were used in this comparison (Table 4.5.24). Eighteen are located on upper teeth and the remaining 15 on lower ones. Six refer to anterior teeth and 27 to posterior ones. Three components were extracted for PCA 13 explaining 100% of the total variance.

Table 4.5.24 - Matrix of the component loadings, eigenvalues and variances of PCA 13

Traits	BKP	Component		
		1	2	3
UI1 shoveling	+= ASU 3-6	**.999**	.047	.001
UI1 double shoveling	+= ASU 2-6	**-.744**	**.668**	-.009
UI2 peg	+= ASU 1-2	**-.819**	**.574**	-.008
UI2 interruption groove	+= ASU +	**.732**	-.460	.502
UC DAR	+= ASU 2-5	**-.895**	-.181	-.408
UP1 odontome	+= ASU +	**-.878**	-.479	.004
UP2 odontome	+= ASU +	**-.878**	-.479	.004
UP1 Accessory tubercle	+= ASU +	**.992**	-.037	.119
UP2 accessory tubercle	+= ASU +	**.561**	-.422	**-.712**
UP1 accessory ridge	+= ASU +	**.939**	.150	.311
UP2 accessory ridge	+= ASU +	**.542**	**-.839**	-.041
UM1 Carabelli's trait	+= ASU 2-7	**.935**	.353	-.027
UM1 C5	+= ASU 2-5	.475	**.877**	-.076
UM1 enamel extension	+= ASU 1-3	**-.878**	-.479	.004
UM1 mesial accessory tubercles	+= ASU +	**.991**	-.045	.124
UM2 3-cusped	+= ASU 0-1	**-.542**	**.840**	.001
UM2 *hypocone*	+= ASU 3-5	-.348	**.670**	**.656**
UM3 *parastyle*	+= ASU 1-5	-.002	-.273	**-.962**
LC distal accessory ridge	+= ASU 2-5	**-.892**	-.044	.449
LP2 cusp variation	+= ASU 2-9	**.946**	-.272	.175
LM1 C6	+= ASU 1-5	.489	.261	**.832**
LM1 C7	+= ASU 2-4	**-.519**	**.855**	-.010
LM1 *anterior fovea*	+= ASU 2-4	**.994**	.098	.045
LM1 protostylid	+= ASU 1-6	**.654**	.623	-.428
LM1 *hypoconulid* (C5)	+= ASU 1-5	**-.751**	**.505**	.425
LM1 Y-pattern	+= ASU Y	**-.784**	**-.536**	.314
LM1 6-cusped	+= ASU 6+	**.827**	.119	**.549**
LM1 DTC	+= ASU +	**.643**	.246	**.725**
LM2 5-cusped	+= ASU 5+	.084	**-.717**	**.692**
LM2 Y-pattern	+= ASU Y	.328	.253	**-.910**
LM3 4-cusped	+= ASU 4+	.455	**.703**	**-.546**
LM3 *protostylid*	+= ASU 2-6	**-1.000**	-.030	-.001
LM3 Y-pattern	+= ASU Y	**.861**	-.270	-.430
Eigenvalue:		18.797	7.779	6.424
Variance (%):		56.961	23.573	19.467
Total variance (%):		56.961	80.533	100.000

*Principal Components Analysis. 3 components extracted. Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. BKP= breakpoint.

Several trait frequencies produced either strong positive (>0.5) or negative (<-0.5) loadings. In order to focus on the ones that correlate/inversely correlate most significantly to the distribution of frequencies, the author details those >0.7 or <-0.7 below.

More than half of the total variance (57%) is explained by PC1. The strongest positive loadings (>0.7) refer to 9 traits, all of them complex mass-additive features. Among those, eight traits (UI1 shoveling, UP1 accessory tubercle, UP1 DAR, UM1 Carabelli's trait, UM1 MAT, LP2 cusp variation, LM1 *anterior fovea* and LM3 Y-pattern) display the same pattern of frequency: COI has the lowest numbers, BT07 shows intermediate relative frequencies and PDG1 and PDG2 the highest ones. Frequencies for the 9th trait accounting for a very strong loading (UI2 interruption groove) is quite similar with only one difference: BT07's frequency is lower than COI's. The graphic expression of these values places both PDG samples and COI in opposite ends of the *x* axis (Figure 4.5.24). For most traits COI dentitions seem to be simpler that those of the prehistoric populations included in this study, displaying lower frequencies of mass-additive traits on the premolars and molars.

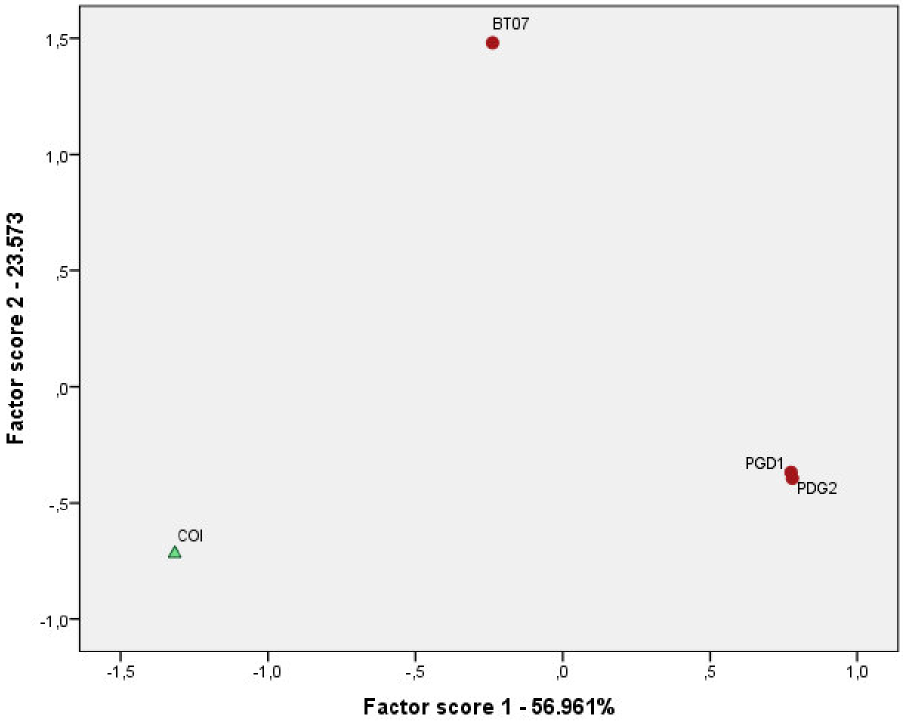


Figure 4.5.24 – Scatterplot of the two first components extracted in the comparison of the samples for PCA 13: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; COI=Coimbra reference collection.

In what concerns the strongest negative loadings (<-0.7) in PC1, the pattern is inverted for all traits. COI either presents the highest frequency of the trait (for UC DAR; UP1 and UP2 odontome; LC DAR; LM1 Y-pattern; LM1 enamel extension; LM3 *protostylid*) or the second highest (for UI1 double shoveling, UI2 peg, LM1 C5). At the opposite extreme, both samples from Perdigões present the lowest numbers. However it is valid to mention that five of those traits are low frequency traits in Eurodont populations in general (Scott and Turner, 1997; Scott *et al.*, 2013), in Iberian samples particularly (García-Sívoli, 2009; Oumaoui, 2009; Rivera, 2011; Scott *et al.*, 2013; Fidalgo, 2014; Marado, 2014; Subirá *et al.*, 2014; Cunha *et al.*, in preparation) and absent in both samples from Perdigões. Those are odontomes, UM1 *protostylid* (above degree 1 in the ASUDAS scoring system), enamel extensions, double shoveling, LM1 C7 (BKP 2-7). COI is morphologically more similar to the populations in PDG than either of them to BT07 in PC2 axis.

Most traits bearing strong positive loadings (>0.7) in PC2 (UM2 3-cusped, UM1 C5 and LM3 4-cusped) are more frequent in BT07 than in the other samples included in this batch. Frequencies of UP2 DAR and 5-cusped LM2 were responsible for the strongest negative loadings (<-0.7) in PC2. In both cases, BT07 display the lowest numbers.

When both PC1 and PC2 are considered (Figure 4.5.24, above) the dental affinities between PDG1 and PDG2 are evident, demonstrating that both samples probably refer to a single population. Minor differences are expected when a couple of centuries separate at least part of the content in both tombs.

PC3 presents 2 strong positive loadings (>0.7) drawn from LM1 C6 and LM1 DTC. In both cases, COI displays the lowest frequencies of the traits while PDG2 the highest ones. (<-0.7). Strong negative loadings (<-0.7) were produced by UP2 accessory tubercle and UM3 *parastyle* (discussed above) and LM2 Y-pattern. This last trait is expressed within the expected range by European samples (Scott and Turner, 1997) in PDG2 and COI (14.8 and 20.2% respectively), while BT07 and PDG2 display numbers close to African populations (Irish, 1998a): 34.9 and 50% respectively. Traits influencing PC3, and consequently its graphic representation (Figure 4.5.25) draw COI close to BT07.

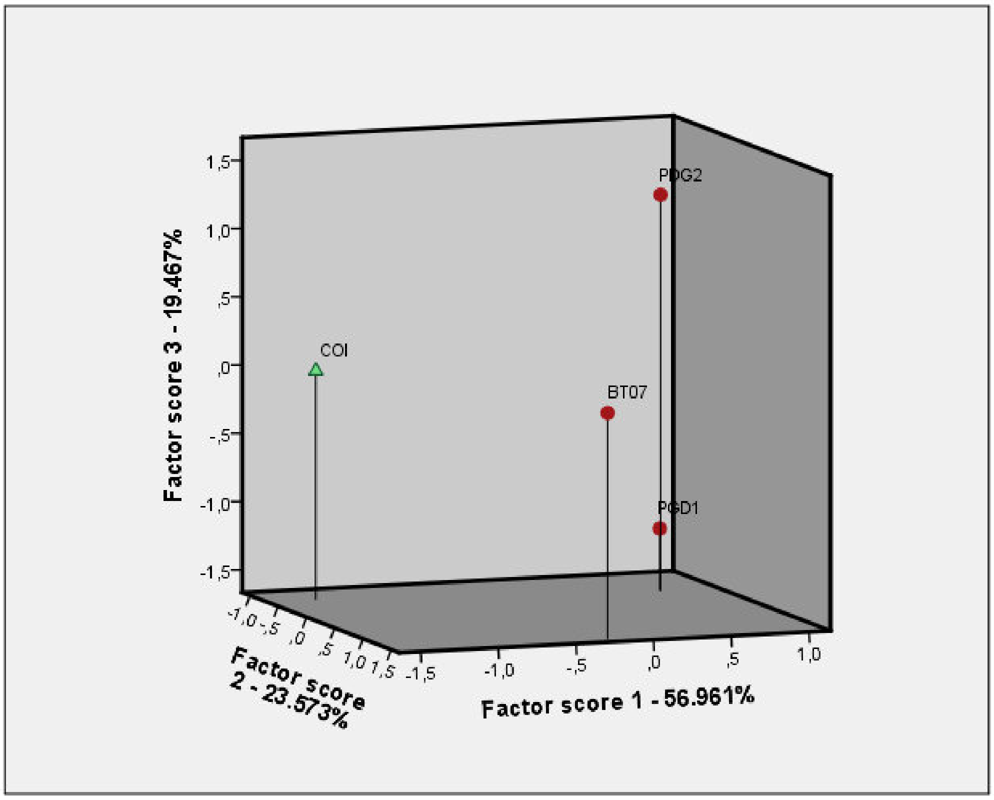


Figure 4.5.25 – Scatterplot of the three first components extracted in the comparison of the samples for PCA 13: PDG1=Perdigões, tomb 1 and PDG1=Perdigões, tomb 1, Portugal; BT07=Cerro de las Baterías tomb, Spain; COI=Coimbra reference collection.

Summarizing trait frequencies, the most striking inter-sample dissimilarities oppose COI and both PDG samples. COI is characterized by having the lowest frequencies of 15 out of the 33 used in this comparison. The morphology of upper premolars seem to be simpler with fewer tubercles and ridges. The same can be said about the 1st upper molars in what concerns Carabelli's trait, MAT and C5 and the 1st lower molar for a series of traits: C6, DTC, *anterior fovea* and *protostylid*. On the other hand, UC and LC DAR are more frequent in COI. LM3 are also more robust, displaying higher cusp numbers and more frequent *protostylids*.

Considering all three components used in this analysis, BT07 generally presents relative intermediate frequencies for most traits, although the number of cusps in UM2 and LM1 indicated individuals in BT07 had more robust molars.

5. Discussion

5. Discussion

5.1. Mandibular, Palatine and Maxillary *Tori* – a Matter of Stress?

As described in Chapter 3 (Materials and Methods), mandibular and palatine *tori* are bone exostoses that are developed during adulthood. They are congenital benign bony protuberances. There seems to be a hereditary component to their development, although that does not explain all cases (Hauser and De Stefano, 1989; Turner *et al*., 1991; García-García *et al*., 2010; Loukas *et al*., 2013).

Their etiology is not resolved and although some kinds of *tori* undergo strong genetic control (particularly palatine *tori*), most occurrences seem to be related to or triggered by environmental factors such as injuries related to chewing stress (Hylander, 1977; García-García *et al*., 2010). Other minor factors associated with the development of these exostoses in living individuals might include vitamin deficiency, the use of calcium supplements or diets rich in vitamin D and Ω3 unsaturated fatty acids. The use of phenytoin may also be related to the increase in size of *tori* (García-García *et al*., 2010).

Palatine *tori* are believed to have an autosomal dominant mode of inheritance (García-García *et al*., 2010; Loukas *et al*., 2013). The normative *locus* for the observation of palatine *tori* is the longitudinal ridge of the half palatine or on the union of the palatine *apophysis* of the maxilla (García-García *et al*., 2010). This is a poorly preserved part of the skull under the taphonomical conditions registered for the Iberian Chalcolithic samples. The lack of observation of palatine *tori* in PDG1, PDG2 and BT07 is directly related to preservation issues. No maxillary fragment in these collections had the palatal structure sufficiently preserved. In most cases the palatal roof was absent and in five cases it was deformed by pressure and/or involved in adhered salts and sediments.

On the other hand, the presence of maxillary *tori* in fragments of alveolar bone at the premolar and molar areas has been registered (Figure 5.1). Maxillary *tori* are hyperostosis of cortical and medular bone located on the buccal and/or palatal aspects of the alveolar process. It is frequently found as multiple bilateral nodules. There are probably genetic factors involved in its development but bite-force stress has been postulated as one of its causes (Loukas *et al*., 2013).

Figure 5.1 – Maxillary bone exostosis on a fragment from PDG2. Inventory number: PDG2-456. Scale in millimeters.

In both PDG1 and PDG2, the cases of maxillary *tori* found were associated with other evidences of masticatory or bite-force traumas to the teeth (Molnar, 1971; 1972; Minozzi *et al.,* 2003; Hasset, 2006; García-García *et al*., 2010; Molnar, 2011; Consolaro *et al.*, 2012). These included significant tooth wear (see Figure 5.1 above), chipping of the enamel and hypercementosis (Figure 5.2). Notched wear and atypical wear facets and angles are also observed on those specimens.

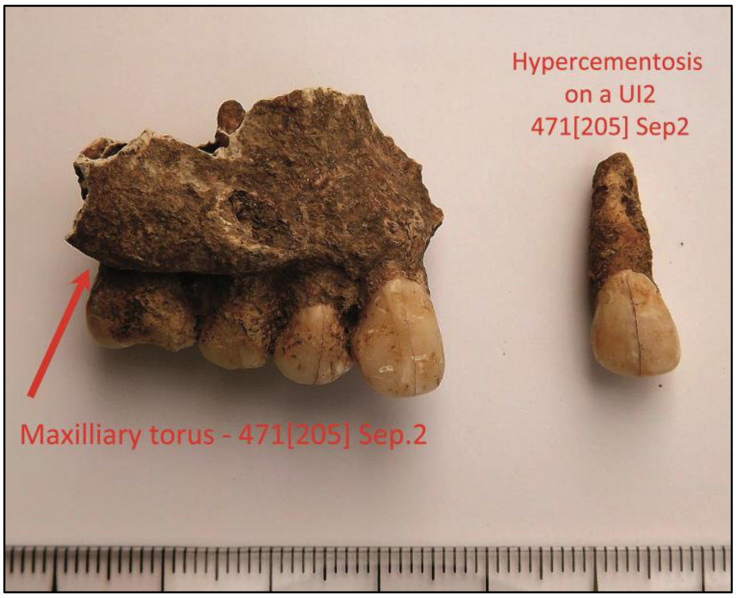


Figure 5.2 – Buccal maxillary *torus* on a bone fragment from PDG2 (left) associated with a right UI2 from the same individual displaying hypercementosis and resorption of root apex (center). Inventory number PDG2-471. Scale in millimeters.

Mandibular *tori* are absent in BT07. This absence might be associated with the proportion of non-adult individuals and juveniles (NMI=99, 58.2% of the sample) in this sample, since the development of this trait is suggested to be associated with age (Hauser and De Stefano 1989; García-García *et al.*, 2010; Loukas *et al.*, 2013) and should be scored only on adult individuals (Turner *et al.*, 1991).

Mandibular *tori* observed in PDG1 and PDG2, on the other hand, raise questions on the etiology of those exostoses in these particular series. All cases observed in both collections were registered for fragments containing *in situ* teeth characterized by tooth wear ≥3 in the scale proposed by Smith (1984, adapted by Silva, 1996).

The *loci* of those exostosis generally did not fit the epigenetic trait as described in the ASUDAS procedure. In most cases of observed *tori* in PDG1 (6/7) and in all cases in PDG2, the trait was located on or extended to the molar field (Figure 5.3). Those exostoses occurred on both lingual and buccal aspects of the mandibular bone.

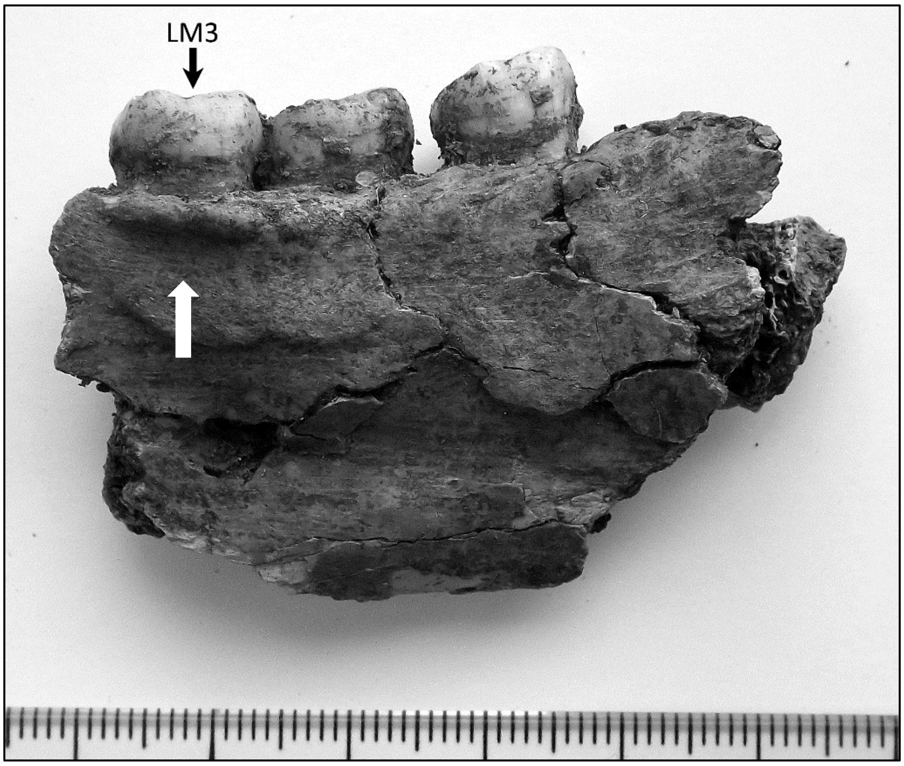


Figure 5.3 – Mandibular exostoses on the alveolar bone (arrow, lingual aspect) at the base of LM3 in a fragment from PDG1. Inventory number: PDG1-1320. Scale in millimeters.

Due to the coincidence of *tori* to moderate/severe tooth wear in the Perdigões samples and the location of the exostosis, the author cannot exclude functional stress as the probable cause for the development of these alterations. If, as suggested by Hassett (2006) and other authors (Hylander, 1977; Hauser and De Stefano, 1989; Halffman *et al.*, 1992; García-García *et al.,* 2010), the formation of mandibular *tori* is triggered by environmental factors, the frequencies of this trait obtained for PDG1 and PDG2 might be considered as reflecting functional alterations to the bone and thus not solely epigenetic in nature.

Due to the probable functional etiology of at least part of the *tori* registered in the samples, this trait was not used in the comparisons of biological affinities here.

5.2. The proposal of a new discrete trait for the human dentition.

The occurrence of abnormally short roots on several UI1 was observed during the laboratory study of the Iberian Chalcolithic samples of PDG1, PDG2 and BT07. As a result of the study a new discrete trait for the human dentition was proposed: the Hypotrophic Roots of the Upper Central Incisors (HRUCI) (Cunha *et al*., 2012). The research leading to this description was made under the supervision of Ana Maria Silva and Joel Irish, two leading researchers in the field of dental morphology. G. Richard Scott, co-author of the ASUDAS method (Turner *et al.*, 1991) also contributed with his vast knowledge and experience in proposing this new trait.

Upper central incisors are characterized by having roots longer than the cervicoincisal length of crowns (Nelson and Ash, 2012). Lind (1972) calculated that the ratio between root length and crown height (R/C value) for fully developed UI1 is 1.63 for male individuals and 1.55 for females, although the dimorphic difference was not significant. When both sexes are pooled together the R/C value is 1.6.

Abnormally short roots have been addressed by clinical literature once in extreme cases it may lead to tooth loss (Apajalahti, 2004). In archaeological literature, at least two individual cases of bi-lateral UI1 roots have been reported. The first one was reported by Anderson (1993) for a female individual excavated from and Anglo-Saxon Cemetery in Sarre, Kent (United Kingdom). The second case was reported by Šikanjić and Mešestroić (2006) for a medieval female individual from Istria (Croatia).

Shortening of roots in UI1, as a deviation of the normative anatomy of the tooth, has complex etiology and may in fact refer to the final aspect of two different biological processes: the shortening of fully developed roots by resorption and the disturbance of root development (Hölta *et al*., 2004). Clinical literature deals with this phenomenon as an anomaly and a pathological condition of the root (Lind, 1972; Thongudomporn and Freer, 1998; Apajalahti, *et al.,* 1999; Brezniak, 2002; Apajalahti, 2004), although evidence of genetic control in the occurrence of short roots in UI1 and other teeth has been suggested (Lind, 1972; Jakobsson and Lind, 1973; Apajalahti *et al*., 1999; Apajalahti, 2004; Edgcomb *et al*., 2011).

Fully developed roots displaying normal length may be shortened through resorption (Hylander, 1977). This process is triggered by one or more environmental factors: (I) trauma from orthodontic treatment, surgery or occlusal pressure; (II) anticancer therapy with chemotherapeutic drugs and/or radiation; and (III) exposure to industrialized toxins such as dioxins (Ando *et al.*, 1967; Hylander, 1977; Brezniak and Wasser-Stein, 2002; Apajalahti, 2004; Marques *et al.*, 2010). Most of these risk factors (except for occlusal trauma) may be excluded as causes for the presence of short roots in prehistoric populations.

Population (Ando *et al.*, 1967; Jakobsson and Lind, 1973; Thongudomporn and Freer, 1998), family (Lind, 1972; Apajalahti *et al.*, 1999) and longitudinal studies (Ando *et al.*, 1967; Hölta *et al.*, 2004) suggest that short roots in UI1 are a genetically controlled feature. It is also more frequent in females than males at a ratio of 2.7:1 (Jakobsson and Lind, 1973; Thongudomporn and Freer, 1998).

Considering its genetic control, Cunha and co-authors (2012) proposed that this morphological feature be considered a new discrete trait for the human dentition.

HRUCI is described as the occurrence of bilateral substantially shorter roots for UI1 that are either equal to, or shorter than the incisor maximum length of the crown (Figure 5.4). Crowns are morphologically normal sized and roots do not display alterations related to trauma (hypercementosis and evidence of fracture). In order to avoid root shortening caused by occlusal bite force, teeth displaying intensive tooth wear and its consequent loss of mass should not be scored for HRUCI (Cunha *et al.*, 2012).

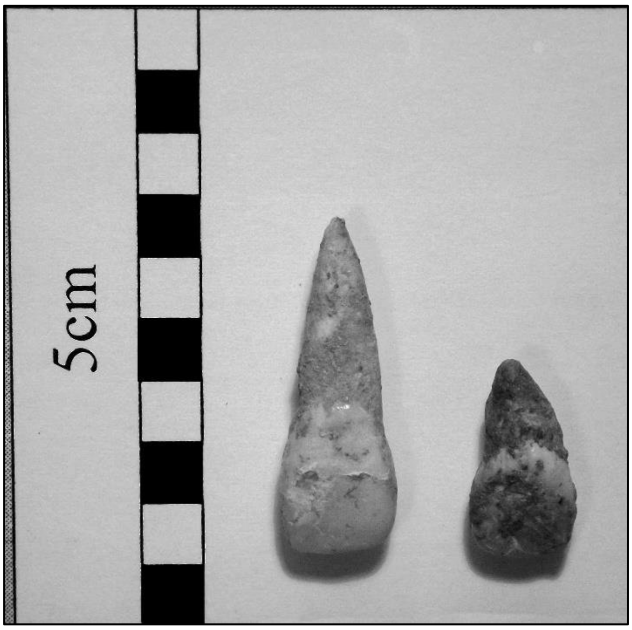


Figure 5.4 – Normal-sized root on a left UI1 (left) and HRUCI on a right UI1 (right). Both teeth were recovered from BT07. Inventory numbers: BT07/D37-107.3 and BT07/D01-107.3.

There are differences in frequencies of HRUCI among archaeological (Cunha *et al.*, 2012) and *in vivo* populations (Edgcomb *et al.*, 2011), and it may have an autosomal dominant pattern of transmission (Apajalahti *et al.*, 1999). In cases where resorption is not considered the cause, shortened roots are bilaterally expressed (Jakobsson and Lind, 1973; Marques *et al.*, 2010).

Although the trait has only recently been described, data on Portuguese archaeological populations have already been published (Cunha *et al.*, 2012) or studied (Fidalgo, 2014; Pereira, 2014) and are used in the analysis of population affinities here and in an article in preparation (Cunha *et al.*, in preparation). Data from populations from other regions are necessary in order to infer its usefulness at a larger scale.

The ASUDAS method is continually ‘under construction’ (Scott, 2008) once new traits have been described for the human dentition since the first publication of its scoring procedures (Turner *et al.*, 1991) and newly described features have been integrated into the method (see Wu and Turner, 1993; Burnett *et al.,* 2010). HRUCI has already begun being used as one part of the dental morphological protocol for data collection by workers in Portugal (this work; Pereira, 2014; Fidalgo, 2014; Cunha *et al.*, in preparation) and it is our hope that this new trait may be included in the ASUDAS method once its applicability in studies of biological affinity is broadened by the collection of data from other populations in different regions.

5.3. The dental morphology of Chalcolithic populations from Perdigões and Cerro de las Baterías

The Iberian Chalcolithic samples of PDG1, PDG2 and BT07 come from Western Eurasian populations. They are expected to exhibit the Eurodont dentition as described by Scott and co-authors (Scott and Dorio, 2010; Scott *et al.*, 2013). When compared to other Eurodont populations, as seen in the previous chapter, Chalcolithic Iberians in general display the expected Western Eurasian/Eurodont frequency of most traits, namely: UI1 shoveling, UI1 double shoveling, UI2 TD (except for the smaller sample of PDG2), UC DAR, odontomes, UM1 enamel extensions, UM1 Carabelli’s trait, UM1 C5, UM2 hypocone reduction/absence, UM3 parastyle, LP1 Tomes’s roots, 4-cusped LM1 (except for PDG2) and LM2, LM1 DTC, absence of LM1 C5, LM1 C6 and 3-rooted LM1.

All three Iberian samples have lower frequencies of double rooted canines and LM1 C7 when compared to other Europeans. They also have higher frequencies of UI1 labial convexity, *Bushman* canine, LP2 cusp variation and LM1 *protostylid.* In all cases their frequencies are closer to North Africans and/or South Africans.

PDG1, PDG2 and BT07 are characterized by very convex central upper incisors. This tendency is also observed in other prehistoric Iberians. Results of the present study and other sources (Turner, unpublished data; Irish, 1998a; Pilloud, 2009; Oumaoui, 2009; Fidalgo, 2014; Cunha *et al.,* in preparation) suggest that expression of this trait reflects the cline in complexity of dental morphology from an African archaic (complex) dentition in Sub-Saharans to simpler Northern European features as proposed by Scott and Turner (1997) and by Irish (1998a).

Sample size for UM1 DTC in PDG2 is small mainly due to tooth wear and taphonomic damages. Its high frequency of UM1 DTC must be taken cautiously.

Considering the cline of shoveling from the prehistoric Iberians (present study; Fidalgo, 2014; Cunha *et al.,* in preparation) to later preindustrial Northern and Western Europeans (Scott and Turner, 1997) and Contemporary Portuguese (Marado, 2014), there is a possibility that the trait might have been affected by the simplification of the dentition through time as defended by Scott and Turner (1997) and Irish (1998a; 1998b; Irish and Guatelli-Steinberg, 2003).

Scott and Lee (2011) have used the more marked distribution of double rooted canines in Western Asia than in the innermost and eastern regions of that continent as an indication of European dispersion into Asia. That argument may probably be reversely applied to prehistoric Iberians. This trait seems to be absent or very rare in the Guadiana Valley both in the Chalcolithic (present study) and in the Bronze Age (Fidalgo, 2014; Cunha *et al.,* in preparation), in the Atlantic façade of the Peninsula (Horwath *et al.*, 2014) and even in prehistoric Basques (Rivera, 2001). The same pattern is observable in North and South Africa. Prehistoric Iberian's low frequency of the double rooted canines might be understood as the reflex of African gene flow into the Peninsula. Considering a South-North cline for the presence of the trait, North Africans and Southern Iberians (such as the population from BT07) would be on the border between the European distribution of the trait and its complete absence in African populations.

For most of the morphological information presented in this study, trait frequencies provided by the archaeological samples of PDG1, PDG2 and BT07 fall amongst or very close to the figures expected for Europeans/Western Europeans and North Africans. The divergence from this pattern happens for few traits:

(I) The Iberian samples discussed in this work either do not display UI1 double shoveling (PDG1 and PDG2) or do it in much lower rates (BT07, 1.3%) than those expected for Western Europeans (3.8%) and North Africans (8.6%). These absent/low frequencies draw them closer to Afridonts. Considering that Afridonty stands as the closest morphological representative to the dentition exhibited by the first anatomically modern humans (Irish, 1998b; 2013), the simplification of the buccal aspect in upper central incisors in the samples discussed here may result from the retention of an archaic form, which is still observable in the Portuguese Contemporary population (Marado, 2014).

(II) Contrary to the other two Chalcolithic samples, BT07 exhibits a very low frequency of UI2 interruption groove and LP1 Tomes' root. This might point to simpler root morphology of the individuals in this sample drawing them closer to the expected European pattern. The tendency towards simplification, reduction and fusion of roots of different teeth (except LC) is a characteristic of the Eurodont dental pattern as it diverged from the Afridont dentition (Irish, 1997; 1998a; Scott and Turner, 1997; Scott, 2013).

(III) PDG1 presents a high frequency of LM2 Y-pattern (50%) comparable to those displayed by South Africans (52%), however it is not an outlier if one considers this trait's frequency for the neighboring sample of BASE (41.4%).

Regarding trait frequencies detailed here, the Iberian Chalcolithic samples fit within the Eurodont pattern. They stand in an intermediate position of the dental cline between modern Western Europeans and North Africans. For many of the traits discussed here (*i.e.*, UI1 shoveling, UP accessory ridges, Carabelli's trait, UM1 MMAT, LP2 lingual cusp number, LM1 C6, LM1 anterior *fovea* and LM1 *protostylid*) they display a tendency to have more complex, mass-additive morphology than does the Portuguese Contemporary population (see in Marado, 2014). This is in agreement with Scott and Turner's (1997) and Irish's (1997; 1998b; 2013) conclusions that for most traits the dental morphology tends towards simplification though time.

Assuming that dental phenetic expression approximates or might be used to estimate genetic variance and biological affinity (Turner, 1990; Irish, 1997; Scott and Turner, 1997), the Iberian archaeological samples of PDG1, PDG2 and BT07 have to be analyzed in comparison to other samples within the geographical limits of the Eurodont complex.

However, two important aspects must be considered when trying to understand the dental morphology of the populations from the Guadiana originating these three samples. The first one is its geographical and cultural ties to North Africa as discussed in chapter 2. The Afridont dental morphology has strong influence on North African peoples (Irish, 1997; 1998a; 2013), although the latter are Eurodonts (Scott *et al.,* 2013: 306). The reflex of this influence might have been brought into the prehistoric Iberian populations by gene flow attested by genetic studies on ancient and recent DNA, and on classical markers (Martínez-Laso *et al.,* 2000; Moral *et al.,* 2000; Gamba *et al.,* 2008; Cerezo *et al.,* 2012).

The second aspect is how the Chalcolithic populations relate to the later morphology of populations in the Iberian Peninsula and the effect of European gene flow into this region favored by population movements in historic times.

5.4. Biological Affinities of the Populations from Perdigões and Cerro de las Baterías

5.4.1. Mobility and Genetic Studies

Genetic studies on DNA support the existence of considerable North African gene flow into southern Europe, influencing the genetic diversity of this region and the Iberian Peninsula within it (Botigué *et al.*, 2013). Much of the modern day contribution from North Africa may be attributed to recent gene flow motivated by the historical Muslim occupation of the Iberian Peninsula or by the African slave trade after the 15th century (Pereira *et al.,* 2000). However ancient gene (prehistoric) flow from North Africa (Gamba *et al.,* 2008; Cerezo *et al.,* 2012) and in the opposite direction (Achilli *et al.*, 2005; Cherni *et al.*, 2009; Ennafaa *et al.*, 2009; Ottoni *et al.*, 2010) was demonstrated by recent works. Similarly to the scenario in all of Southern Europe, Holocene genetic exchanges in Iberia are neither exclusively bilateral nor homogeneous, but derive from multiple contributing regions/populations and events (Sampietro *et al.*, 2007; Pinhasi *et al.*, 2012; Gamba *et al.,* 2012), although contributions from the Middle East seem to have been overestimated through time (Botigué *et al.*, 2013). Moreover, genetic variation cannot be fixed at a specific time, but continues to be reshaped through time by demographic processes (Pinhasi *et al.*, 2012).

So far, the sample of BT07 has not been subject to any genetic study. On the other hand, the mobility and genetic background of the populations buried in PDG have been addressed by isotopic (Hillier *et al.*, 2008; 2010) and DNA studies (Chandler, 2003; Chandler *et al.*, 2005; Afonso *et al.*, 2013). The numbers of individuals sampled in these studies were very limited considering the various archaeological contexts intervened in the Perdigões enclosure.

Data on the mobility of individuals are available only for some samples from PDG1 (Hillier *et al.*, 2010). Faunal remains of mammals excavated from PDG1 were used to determine the bioavailable strontium range for the site. These values were also compared to samples of both faunal and human samples from coastal zones in Portugal which differ in isotopic levels due to the contribution of marine resources to their diet. Eight individuals from PDG1 were sampled and their 87Sr/86Sr values compared to coastal populations. Two individuals presented values compatible with locals. Six of them presented values much lower than expected and one fell in the isotopic range for coastal populations. Hillier and contributors (2010) inferred that most of the individuals sampled were not likely native to the region. Currently more osteological samples from both humans and fauna are being processed and should increase our knowledge on the mobility in Perdigões (Ana Maria Silva, personal communication, January, 2014).

Anthropological data concerning genetic relationships among the populations buried in PDG1 and PDG2 and other populations is restricted to the works conducted by Chandler and contributors (Chandler, 2003; Chandler *et al.*, 2005) and to the ongoing research by Afonso and contributors (Afonso, 2012; Afonso *et al.*, 2013). Hence data (Table 5.1) is limited and/or preliminary.

Table 5.1 – Results for DNA analysis of funerary contexts in PDG. ND indicates that information is not available in the referenced publications.

Inv. #	SU	Structure	Context	Sex	Haplogroup	Reference
206	429	Tomb 2	Chamber	F	ND	Afonso *et al.*, 2013
207	429	Tomb 2	Chamber	ND	L1b	
233	429	Tomb 2	Chamber	M	ND	
251	ND	Tomb 2	ND	ND	H1	
M1	76	Pit 11	Pit burial	M	U5	
M2	77	Pit 11	Pit burial	M	H	
M3	78	Pit 11	Pit burial	M	U4	
ND	ND	Tomb 1	ND	ND	U or H	Chandler, 2003
ND	ND	Tomb 1	ND	ND	H	
ND	ND	Tomb 1	ND	ND	H	
ND	ND	Tomb 1	ND	ND	H	
ND	ND	Tomb 1	ND	ND	U5a1a	
ND	ND	Tomb 1	ND	ND	U5a1a	
ND	ND	Tomb 1	ND	ND	H	
ND	ND	Tomb 1	ND	ND	H	

Contextualization of the material sampled by Chandler and contributors is hindered once it is not specified in their publications (Chandler, 2003; Chandler *et al.*, 2005). As such, the origin of the samples is doubtful regarding the tomb of provenance. There is neither mention of the inventory number of the samples nor the indication of which stratigraphic unit they came from. Data on the sex of the individuals sampled are not available since the osteological remains did not provide consistent amplification from the X and Y chromosomes and their sexing could not be carried out (Chandler, 2003: 133), however haplogroups were identifiable for most of the samples.

Chandler (2003) and Afonso and contributors (2013) identified individuals belonging to haplogroup (hg) U (U4, U5 and sub-clade U5a1a, and a possible U). Hg U5 is considered the most ancient European mtDNA group, being present in Europe since the Paleolithic and common in both Mesolithic and Neolithic European populations. Sub-clade U5a is believed to have evolved in South-central Europe during the Last Glacial Maximum (LGM) (≈16-20 *BC*) (Malyarchuk *et al.*, 2010).

Chandler (2003) and Afonso and contributors (2013) also identified individuals belonging to hg H. This haplogroup originated in the Near East and it is present in Paleolithic Europe (Chandler, 2003). It is prevalent in prehistoric Iberian populations since the Mesolithic (Gamba *et al.*, 2008; 2012; Hervella *et al.*, 2012), representing 44% of the mtDNA variation of modern Iberia (Ennafaa *et al.*, 2009). Most sub-clades of hg H evolved in Europe and account for over one third of the modern population. Date of coalescence for hg H1, a sub-hg found in Perdigões, is ≈22.6 *BC* (Roostalu *et al.*, 2007). Haplogroup H is also frequent in North Africa and probably entered that region from Iberia in the Early Holocene. Dates for the most frequent H sub-hgs in North Africa, H1 (42%) and H3 (13%) indicate a Late Paleolithic settlement of these lineages. Less variability in the H1 and H3 African lineages when compared to Iberians suggest that Iberia was the radiating center for its dispersal into North Africa (Roostalu *et al.*, 2007; Cherni *et al.*, 2009; Ennafaa *et al.*, 2009; Ottoni *et al.*, 2010).

Both hg U and H seem to have been favored by the optimal ecological conditions and consequent population growth in Southern Europe since the Upper Paleolithic (Malyarchuk *et al.*, 2010; Hervella *et al.*, 2012) and finding both in PDG's gene pool is expected.

The finding of hg L1b (Afonso *et al.*, 2013) however seems to be less expectable. Hg L is an African mega-haplogroup subdivided into many sub-clades, most of them found in Africa. L1b probably evolved in West Sub-Saharan Africa being spread to North Africa by demographic movements. The existence of sub-clades of L1b in specific North African and South Europe populations suggests the L1 moved into these regions long enough to have developed local sub-clades. L1b1a for instance probably evolved in Europe and L1b1a8 is present only in Iberia (Portugal and Catalonia) (Cerezo *et al.*, 2012). These L-European sub-clades attest to sporadic genetic contributions from Africa in the Late Prehistory. In fact, recent genetic studies on archaeological samples have found hg L in Chalcolithic samples in the Spanish Levant (Gamba *et al.*, 2008).

Genetic data is not available for BT07 and for PDG it is still scarce considering the magnitude of the site and the impressive amount of human remains (belonging to hundreds of individuals) already excavated from its funerary spaces. However, and even considering the small number of sampled individuals, the presence of genetic material of African descent is found in PDG (Afonso *et al.*, 2013), as is the evidence of high mobility of the individuals exhumed from its funerary contexts (Hillier *et al.*, 2010).

The scenario portrayed by the archaeological record of the territory served by the necropolises of PDG and BT07 is a highly dynamic one. Aggregation processes would bind communities living in a large area through strong cultural ties (Hurtado, 1986; 1999; 2006; 2008; 2010; Valera, 2008b; 2012b). There are evidences of exchange networks working at regional (Odriozola, 2008; Odriozola *et al.*, 2008; Dias *et al.,* 2008; Odriozola *et al.*, 2010) and interregional range (Schuhmacher *et al.,* 2009; Schuhmacher and Banerjee, 2012). At an interregional level, these relationships indicate some form of contact existed with North Africa.

More genetic data are needed to help resolve chronological issues related to hg L and its Iberian sub-haplogroups. Is the ‘African’ genetic contribution in the local genetic stock part of the first hg-L bearing stock entering the Peninsula in the Late Pleistocene-Early Holocene (Cerezo *et al.,* 2012)?

So far the little information available for PDG deals with the female inheritance system only. Genetic research regarding Y-chromosome heritage is needed to investigate if males bearing African genetic contribution reached this region of the Guadiana.

5.4.2. Biological affinities expressed by the tooth morphology

5.4.2.1. Inter-sample affinities

Comparative studies on dental morphology assume that the samples employed in the comparisons are representative of the populations they derive from and that the phenetic conformity they display provides an estimate of their genetic relatedness (Scott *et al*., 1983; Scott and Turner, 1997; Irish, 1998a).

Principal components analysis (PCA) is a data reduction technique that focuses on gathering the most information on a given set of samples in order to differentiate them. Differences are drawn from the variance and co-variance of a given set of variables. The more variables are provided in the calculation, the more precisely hypothetical differences will be assessed (Leech *et al.,* 2005; Marôco, 2011). Comparing biologically very similar samples provides detailed information of the weight of individual features in the calculation of each component, but without a contrasting ‘foreign’ sample, the graphic representation of the data will produce a somewhat equidistant diagram.

PCA 1 (see Chapter 4.7) analyzes the biological affinities among the three samples of PDG1, PDG2 and BT07 based on frequencies of 35 dental non-metric traits. The matrix of component loadings produced in this test accounts for 100% of inter-sample variance and produced two principal components by strong *eigenvalues* (23.3 for PC1 and 11.7 for PC2). The first PC explains two thirds of that variance (66.6%).

Regarding the PC1, accounting for most of the inter-sample variance in that test, biological affinities between the PDG1 and PDG2 are stronger between each other than between either of them and BT07. This is the first indication that both samples might, in fact, derive from biologically continuous populations. Minor differences between them may be explained by the effect of probable interactions and genetic exchanges with other groups or the influence of incoming individuals (*i.e.*, gene flow) into the genetic pool of the population living in the

Perdigões area. Isotopic evidence (Hillier *et al.*, 2008) suggests that the presence of 'newcomers' or 'foreigners' was not unusual in the population history of Perdigões.

The relatedness between PDG1 and PDG2 is better perceived in PCA 13, in which the Chalcolithic series are contrasted against a Portuguese Contemporary sample (Marado, 2014) (Chapter 4.7). This test was based on a large number of traits (33) and produced three components accounting for 100% of the total inter-sample variance. Given the population history of the Portuguese and frequent admixture that characterizes the modern genetic stock (Pereira and Ribeiro, 2009), Marado's (2014) sample is expected to be more biologically heterogeneous than the relatively less admixed Chalcolithic samples, hence providing contrast to the analysis.

Results provided by PCA 13 endorse the hypothesis of both PDG1 and PDG2 being representative of a same population. Moreover, when these affinities are graphically expressed, it is possible to observe that on the axis representing PC1 (accounting for 57% of the intra-sample variance) all three Chalcolithic samples share closer affinity among themselves than any on them to Contemporary Portuguese.

The major difference between the Chalcolithic and Modern Iberian dentition represented in this analysis by the Portuguese series studied by Marado (2014) seems to be the tendency for simplification of tooth morphology in the more recent population. Most diverging trait frequencies point to simpler crowns characterized by less frequent supernumerary cusps (such as UM1 C5, Carabelli's cusp and LM1 C6) and tubercles (MMAT, UP accessory tubercles). Contrary to this tendency, lower third molars are more mass-additive in the Modern population and upper and lower canines exhibit more pronounced distal accessory ridges (Marado, 2014).

However one cannot rule out the possible effect of the influence of small sample numbers for a few traits in PDG2 as the cause of this slight divergence between two series.

PCA1 demonstrates that the all three samples from the Guadiana Valley are biologically closely related. Besides the geographic proximity of the populations that made use of these funerary spaces, their cultural ties are observable in the archaeological record (see Chapter 2). The dental morphology suggests that at the biological level, these groups also shared significant affinity. There are three possible explanations for this relatedness: (1) both populations derive from a single genetic stock/founding group and the existing divergences between PDG and BT07 are a reflex of minor genetic drift through time; (2) each population derives from different genetic stocks, but through mating favored by frequent social interactions and the samples of PDG1, PDG2 and BT07 are the result of local admixture; and (3) a combination of common ancestry of the genetic stock and intra-regional social interactions and exchanges would be responsible for the affinities, while genetic drift and/or incoming gene flow from outer communities would account for the minor differences between the populations from Perdigões and Cerro de las Baterías.

5.4.2.2. Population continuity and biological affinities in the surroundings of Perdigões in the 2nd millennium BC

PCA 2 analyzed the biological affinities between the Chalcolithic (3rd millennium BC) series of PDG1, PDG2 and BT07 and a later (2nd millennium BC) Bronze Age sample (BASE) from a cluster of archaeological sites in Serpa (c. 45 km south of Perdigões) (Cunha *et al.*, in preparation). Frequencies of 34 dental discrete traits were used to produce a components matrix explaining 100% of intra-sample variance. All three components in this analysis were characterized by strong *eigenvalues* (PC1= 17.4; PC2=8.6; PC3=8).

All four samples are proven to be morphologically very similar, although trait frequencies having the most influence on the variance (represented by PC1) draw the Bronze Age population represented by BASE away from the earlier local groups. These frequencies also evidence closer similarities between PDG1 and BT07.

Phenetic affinities are reinforced among these four samples from the middle Guadiana which are all characterized by the absence or low frequency of some complex/mass-additive traits, such as UI1 shoveling, UI1 double shoveling, LM1 C7, 3-rooted LM1, LM1 protostylid (BKP 2-6) and 6-cusped LM1. Despite being Eurodont samples, three of them (PDG1, BT07 and BASE) share high frequencies of LM2 Y-groove pattern, a feature usually more frequent in African than in European populations (Scott and Turner, 1997).

These biological affinities indicate that there was no significant population replacement in the area between the 3rd and the 2nd millennia BC. The individuals from BASE probably descend from or are closely related to the regional stock already settled in the 3rd millennium BC. The differences between that series and the older local populations are expressions of diachronic changes in the social tissue that might have been introduced either by later gene flow, as the reach of more mobile Bronze Age communities stretched through long range interactions (Lillios, 2014), or as a result of endogamic mating and less admixture leading to genetic drift, as suggested for Bronze Age populations in southeast Spain (Oumaoui, 2009).

5.4.2.3. Biological affinities to macro-regional populations

The affinities of the Chalcolithic samples from the Guadiana Valley were compared to worldwide samples in two tests (PCA 3 and PCA 4). The first test was based on frequencies of 16 discrete traits provided by Scott and Turner (1997), while the second one was based on figures for 20 non-metric features drawn from populations in different continents by Irish

(1998a). The first three components in each test were characterized by strong *eigenvalues* and explained over 80% of the inter-sample variance.

The Iberian Chalcolithic samples cluster with other Eurodont populations in the scatterplots resulting from these tests, as expected when considering their place of origin. However, their positions in these clusters are not as close to European populations as expected in the initial hypotheses of this work.

Considering the geographic range of the Afridont (Irish, 1998a; 2013) and Eurodont (Scott *et al.*, 2013) complexes, North African populations are in between two massive barriers: the Sahara desert in the south and the Mediterranean Sea in the north. However, the genetic history of modern human expansion has shown that the conditions for successfully migrating through the Sahara varied depending on ecological conditions through time (Wells, 2002). The dental morphology also attests to the Sub-Saharan region as being the origin for the evolution of modern humans (Irish, 1998b; 2013). Despite the physical difficulties imposed by the desert, North Africa was the first step in the dispersal of modern human dentition throughout all continents (Scott and Turner, 1997; Irish, 1998b). As a result North Africans share the closest biological affinity to Sub-Saharans than to any native human populations from other regions. North Africans are at the borders of Afridonty.

The exact extent to which the Mediterranean acted as a barrier has been questioned over the years and the emerging view of this inland sea is that human populations not only enjoyed the mild ecological conditions of its borders (Knapp and Blake, 2005), but ventured through it since the Paleolithic (Broodbank, 2006). Although the Neolithization process is far from resolved and multiple theories provide different explanations for its beginning in Europe (Ammerman and Cavalli-Sforza 1971; 1984; Zvelebil, 1986a; 1986b; Trigger, 1989; Tringham, 2000; 2002; Richards, 2003; Scarre, 2005b), the hypothesis of Neolithic contacts between North Africa and Southern Iberia is documented in the archaeological record (Cortés-Sánchez *et al.*, 2012; Lindstäder *et al.*, 2012). Those contacts would continue through Late Prehistory as evidenced by foreign material culture and exotic items in both sides of the sea, common industry techniques and use of common/genetically related domesticates (Schuhmacher *et al.*, 2009; 2012; Cortés-Sánchez *et al.*, 2012; Lillios, 2014).

Genetic evidence (Achilli *et al.*, 2005; Gamba *et al.,* 2008; Cerezo *et al.,* 2012; Cherni *et al.*, 2009; Ennafaa *et al.*, 2009; Ottoni *et al.*, 2010) also support that the Mediterranean was not an impassable barrier for gene exchange between North Africa and South Europe in prehistoric times.

The dental morphology of the populations living in the Middle Guadiana Valley was affected by these contacts as shown in PCA 3, PCA 4 and several other tests here. The Iberian Chalcolithic samples (particularly BT07) cluster along with North Africans in the affinity diagrams provided by PCA 3 and PCA 4, and all four samples, along with European samples, compose a Eurodont clustering.

Regarding these results we must notice that population history of the samples from Scott and Turner (1997) and Irish (1998a) introduce heterogeneity to this analysis. While the Iberian samples are chronologically and morphologically closer to the founding Eurodont populations in Southern Europe, the vast majority of samples employed by those authors to characterize the macro-regional tooth morphology come from historic populations. The genetic and consequently phenetic profile of the individuals composing them underwent millennia of increasing admixture favored by countless population movements, migrations and interactions promoted by social contacts of diverse nature within Europe and between Europe and Africa.

Populations represented by the samples from Perdigões and Cerro de las Baterías belong to the Eurodont complex. Within that dental complex, they suffered strong influence by the Eurodont sub-pattern exhibited by North Africans. That influence may be explained by at least two factors: (I) a close chronological proximity to a hypothetically more ‘Africanized’/archaic dental morphology brought into Iberia by the founding modern populations and (II) occasional North African gene flow into Iberia resulting from sporadic contacts as individuals or small groups from both sides of the Mediterranean interacted via trade or ventured into Iberian territory seeking resources and farmland.

5.4.2.4. Biological affinities to populations from the 5th millennium BC and older

A series of PCA tests were carried out to infer possible biological affinities among the Iberian samples of PDG1, PDG2, BT07 and older populations. The most useful results are detailed in PCA 5, PCA 6 and PCA 7 (Chapter 4.7).

All tests produced statistically significant results and their matrices of component loadings were based on *eigenvalues* >1 (most of them >2), explaining between 73.1% and 82% of the inter-sample variance. The number of traits used in each test varied according to the different BKP employed in the sources. Frequencies dichotomized at discordant BKP in the published sources were a limiting factor in the amount of useful data.

Comparative samples were drawn from Neolithic and Chalcolithic populations from the Near East (Çatalhöyük, Turkey; Natufians, Levant) (Lipschultz, 1997; Pilloud, 2009); Paleolithic and Neolithic Italians (Coppa *et al.*, 2007); Paleolithic, Neolithic and Predynastic North Africans (Iberomaurusians, Badarians and Sudanese samples) (Irish, 2000; 2008); and a Mesolithic-Neolithic sample from Ukraine (Christy Turner’s database).

All three tests resulted in closer clustering of the Chalcolithic Iberians from PDG1, PDG2 and BT07 pointing to phenetic homogeneity of the populations they stand for in comparison with foreign samples. Populations from the Middle East proved to be consistently dissimilar to the Iberians regarding dental morphology. These results suggest that genetic contribution from the Near East did not play an important role in the original populations from which the peoples of the Guadiana derive.

Two North African samples do not share close biological affinities to Chalcolithic Iberians. The Sudanese sample from Jebel Sahaba (Irish, 2005), displays archaic Afridont traits and its divergence from the phenetic features exhibited in Iberia conform to the expected biological distance between Eurodonts and Afridonts (Irish, 2013). Iberomaurusians also seem to share little biological relatedness with Iberians, although their dental morphology has influenced later North Africans (Irish, 2000). The divergence among those and the Iberian Chalcolithic samples reflects the results obtained by Irish (2000) when comparing Iberomaurusians to other Eurodonts (including North Africans). These divergences might have been influenced by the heterogeneity of the Iberomaurusian sample (Irish, 2000).

On the other hand, populations from Italy, particularly the Neolithic sample provided by Coppa and co-authors (2007) share biological affinities with the Chalcolithic Iberians. Given the geographic and chronological proximity between those populations, contacts and genetic exchanges between the first and the latter is the most probable explanation for the phenetic similarities.

Close biological affinities were demonstrated among the PDG1, PDG2, BT07 and the North African samples from Badari (Egypt) and R12 (Sudan) even when compared to another Sudanese sample (JSA, PCA 7). The latter is characterized by complex mass-additive Afridont morphology, while the first two share more gracile tooth morphology compatible with the Eurodont pattern.

The population from Ukraine shares closer biological affinities with the Iberians and other Eurodonts when contrasted against morphologically more ‘distant’ Afridonts and Levantines.

The biological affinities explored in PCA 5 to PCA 7 indicate that populations living in the Guadiana Valley in the 4th-3rd millennium BC derive from a European stock closely related to previous groups inhabiting Southern Europe and North Africa. Results also point to no noticeable influence from the dental morphology of older populations from the Eastern Mediterranean.

5.4.2.5. Biological affinities to populations from the 4th-3rd millennium BC

PCAs 8 to 10 dealt with the biological affinities of the present Iberian samples to contemporary series from Europe, Africa and the Near East. All these tests resulted in component matrices characterized by strong *eigenvalues* (almost all of them >2).

As for the previous period, the pattern of biological relatedness among these regions maintains during the 4th and 3rd millennia BC.

Iberians display little biological affinities with populations in the Eastern Mediterranean. This pattern is repeated even when populations from Southern Europe such as Parras' (2004) samples from Greece and Cyprus are compared to Iberians. Regarding PCA 8, the Northern European sample available from Christy Turner's database is morphologically more related to Iberians than either the Greeks or Cypriots of the period.

When Syrians, Danish and Africans are compared to the Iberians (PCA 9), the latter groups including the Northern Europeans and North Africans form a cluster that diverges the Afridont pattern, but includes a North Africa sample from Abydos. The morphological affinities expressed by that test evidences proximity between some populations in North Africa to the Eurodont pattern.

A comparison between Africans and Iberians was made in PCA 10, using frequencies for 24 traits. The first three components employed in its matrix provided *eigenvalues* between 3.5 and 8.2 and accounted for 71.4% of the total inter-sample variance. Although all samples here are derived from Eurodont populations, homogeneity of the samples from the Guadiana is demonstrated by the clustering of PDG1, BT07 and PDG2 in the diagrams produced by this test. PDG1, PDG2 and BT07 are characterized by close proximity regarding the PC1 axis explaining the most variance. Likewise, the two samples from the Atlantic shores of central Portugal (Bolores and Feteira) (Horwath *et al.*, 2014) form a grouping, also displaying morphological homogeneity, particularly when considering the traits influencing the first principal component. The distance between those two clusters however was larger than expected.

Different processes might be involved in this dissimilarity. The first hypothesis is that populations from the Atlantic coast of Portugal and those from the Guadiana Valley derive from different genetic stocks.

The second hypothesis is that, although the founding groups occupying both regions might have been related, genetic exchanges operated differently, as the southernmost populations would be more prone to contacts with groups bearing a more 'North-African' version of Eurodonty while populations from Bolores and Feteira received genetic contributions from either inland central and north Iberia or from unknown populations coming via the Atlantic coast.

Results provided by a recent study on both mtDNA and Y-chromosome pools in the Atlantic façade of the Iberian Peninsula (Pardiñas *et al.*, 2014) suggests that at least in protohistory there might have been significant differences between the genetic stock of the populations living in central and south Portugal. The matrilineal and patrilineal data produced similar results, leading those authors to suggest that geographic barriers of the Iberian territory may have enhanced genetic drift processes on local populations (Pardiñas *et al.*, 2014: 624).

However, we must notice that sample size may be a problem in Bolores (Horwath *et al.*, 2014:98). Bolores's and Feteira's series are characterized by extremely high frequencies of traits which are almost always absent or rare in Eurodonts (such as odontomes) and by lower frequencies than expected of a number of highly frequent Eurodont traits as reported in different sources (Scott and Turner, 1997; Irish, 1998a; Silva, 2002; Marado, 2014; Fidalgo, 2014).

The testing of biological relatedness among other 4th-3rd millennium BC Iberian samples was attempted but faced problems related to the published data. These problems are discussed in Chapter 1.4.3 and are concerned mainly with incompatibility of BKPs, frequencies provided for non-polar teeth only and incongruences in tooth or trait nomenclature.

Two tests were carried out on other Iberian Late-Neolithic/Chalcolithic series (PCA F and PCA G, Appendix 2) but BKP incompatibilities in the available sources resulted in a reduced number of useful frequencies (7 for PCA F and 8 for PCA G). The samples in those tests were drawn from series from central and south Portugal (Silva, 2002), Basque Country (Rivera, 2011) and southeast Portugal (Fernandes, 2013). Although some tendencies are noticed in both tests, such as the closer affinity among the Portuguese samples when compared to the Basques, the samples are biologically too similar to offer contrast when the test is made based on such few traits.

5.4.2.6. Biological affinities to Argaric populations from the 2nd-1st millennium BC

Argaric groups from southeast Iberia are culturally different from their coeval southwest neighbors. PCA 11 analyzes the biological affinities between the Iberian Chalcolithic (3rd millennium BC) series of PDG1, PDG2 and BT07 and later (2nd millennium BC) series: El Castellón Alto and La Navila from Granada, Spain (Oumaoui, 2009). Contrasting series were employed in this test in order to obtain more detail regarding inter-sample variance: Kerma from Sudan (Irish, 2005); Lachish from Palestine (Horwath *et al.,* 2014); Greece (Horwath *et al.*, 2014) and Carthage (Irish, 1998a). Frequencies of 16 dental discrete traits were used to produce a components matrix explaining 69.7% of intra-sample variance. All three components in this analysis were characterized by strong *eigenvalues* (PC1= 5.6; PC2=4.8; PC3=2.8).

Computation of phenetic affinities among these 9 series was effective in estimating synchronic and regional biological affinities. Results support the existence of three groupings of morphologically similar populations.

The first grouping is composed by the Chalcolithic samples of PDG1, PDG2 and BT07. Their phenetic proximity is the result of shared genetic heritage and probably genetic exchange among very culturally similar groups exploiting neighboring territories.

The second cluster is formed by the two Spanish Bronze Age series. Despite the fact that they share enough biological affinities to stand out as a separate group from the other Iberians, they are not as closely related as the Chalcolithic series among themselves. The most probable scenario here is that these communities may have originated from a common genetic stock, but as noted by Oumaoui (2009), the Bronze Age Argaric communities were less prone to gene flow than later groups in the same territory. The pattern of settlement of Argaric communities and the extensive use of defensive structures in their largest occupation sites (hilltop sites) (Contreras-Cortés, 2009-2010; Serrano-Ariza, 2012) might indicate some degree of isolation of communities or among certain territories motivated by conflict. Isolation and genetic drift may account for minor phenetic distance between the series in this grouping.

The third and less cohesive cluster is formed by Greeks, Phoenicians and Levantine. Although coming from different regions, in the 2nd and 1st millennia BC these groups were involved in extensive interregional trade in the Mediterranean. By the 1st millennium BC Greeks and Phoenicians had established colonies in neighboring and sometimes overlapping territories (Alcock *et al.*, 2005; Manning and Hulin, 2005). Although in some regions (such as in Sicily) conflict and isolation marked the relationship between the colonizer groups, in others (such as in Iberia), those communities enjoyed a more peaceful coexistence (Dietler and López-Ruiz, 2009). The limited and yet noticeably phenetic similarities among the series composing this cluster might have been fostered by moderate genetic exchange throughout Late Prehistory and historical times, besides geographic proximity.

The only outlier in PCA 11 is a Sudanese sample (Kerma). Although all series in that test are Eurodont, the dentition of individuals from Kerma shares closer affinity to Afridonts than any of the others.

Assuming that the samples employed in this test are representative of the populations they derive from, there seems to be some affinity between the Iberian populations represented by the traits contributing most to the first principal component in this test. However, they do not seem to be closely related enough to represent direct relatedness. There is no indication of continuity between these groupings.

5.4.2.7. Biological affinities to historic populations in North Europe and North Africa

Consistently, through different tests, the Iberian populations from PDG1, PDG2 and BT07 have proved to share more phenetic affinities with other Iberians, western and southern Europeans, and North Africans from different chronologies. A test (PCA 12) was carried out to infer their affinities to historic Northern European groups. That analysis was based on the frequency of twenty discrete traits. It accounted for 74.1% of the inter-sample variance and produced *eigenvalues* >3.

Northern European populations were represented by samples drawn from Scandinavia (Saami), Russia, Netherlands and Estonia (Christy Turner's database), and from Scotland

(Adler, 2005). The North African dentition control sample is represented by a Sudanese (Kushite) sample (Irish, 2005).

The results obtained from that test reinforce the evidence of homogeneity among the Chalcolithic Iberians who are shown to be more closely related than any other group of samples in that analysis. On a larger scale, the North African sample cluster along with Iberians, although at different levels.

The second cluster resulting from this analysis gathers geographically close series (Estonians and Russians). Genetic exchange might have been favored by between the groups deriving these samples by geographic proximity and historical processes. Genetic history of the Netherlanders (Dutch) is marked by recent population discontinuity (Lao *et al.,* 2013) and the present Dutch population might not correspond to the archaeological collections sampled by Christy Turner and used here. The last group was formed by Saami and Scottish. Scandinavian contribution to Scottish genetic stock (Adler, 2002; 2005; Barret, 2008) accounts for their genetic and consequent phenetic proximity.

Biological affinities between Chalcolithic Iberians and historic North Africans is explained by the North African gene flow into the prehistoric Iberian stock demonstrated in the previous tests and at some extent to the retention of archaic/Afridont traits in the dentition of both historic Kushites and prehistoric Iberians.

6. Conclusions

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6.1. Limitations of dental comparative analysis

The staple work of dental anthropologists when addressing dental morphology is the comparison of their target populations against others. That work is facilitated when all samples involved in the comparison were studied by the same author. Methodological issues such as key teeth, specific traits and breakpoints (BKP) employed can be designed prior to the analysis itself, saving time and exploiting the most data possible. Impressive analyses have been carried out on extensive geographic areas based on that strategy, such as Irish's prolific work on African samples over the last decades (see for instance: Irish, 1997; 1998a; 1998b; 2000a; 2000b; Irish and Guatelli-Steinberg, 2003; Irish, 2005; 2006; Irish and Konigsberg, 2007; Irish, 2008; Irish and Friedman, 2010); Scott's study on North American and European populations (Scott *et al.*, 1983; 1984; 1988; Scott, 1992; Scott and Alexandersen, 1992; Scott and Turner, 1997; 2006; 2007; 2008b; O´Rourke and Scott, 2010) and Turner's extensive work on samples distributed worldwide (Turner, 1990; Scott and Turner, 1997; 2006; 2007; 2008b, among many); all are good examples of maximized efficiency based on the use of a predefined research strategy employed on a vast geographical scale.

That kind of approach is not always feasible for a number of reasons, the main ones being time, financial constraints of the work and large geographic extensions involved in attempts to cover a target region. Turner's account of the morphology of human teeth summarized in Scott and Turner (1997) was only possible as a result of decades of his own work and the contributions of his former students (such as Irish and Scott) (Scott and Turner, 1997; Turner, 2013).

Other problems in assessing the dental morphology of a given population might include access to the series themselves. Collections housed in conflict or war zones may be temporarily or permanently inaccessible. Curatorial problems involving collections excavated long time ago may hinder the analysis. Loss of the osteological materials and/or its associated information is common in such series (Silva and Ferreira, 2007; Irish and Konigsberg, 2007; Brass, 2009; 2014).

Once the information on a target population is gathered, the next step consists on comparing that to other series in order to find biological affinities or differences among groups. The access to comparable data was the first problem faced when carrying out the comparative tests in this work. Although the ASUDAS scoring system (Turner *et al.*, 1991) represented a great advance in the systematization of the study on dental morphology, the absence of standardized BKPs makes it difficult to use data collected from different published sources. Although some recent works present all ranks of observed traits (such as Parras, 2004; Adler, 2005; García-Sívoli, 2009; Rivera, 2011; Lukacs and Pal, 2013; Scott *et al.*, 2013; Marado, 2014, among others), many other published works only provide frequencies at a specific BKP per trait. Frequencies of dichotomized results reflecting different BKPs are not comparable and that might prevent the comparison among data from different authors in a regional and/or chronological comparison.

In the comparisons of populations used here, the author gathered information on 168 series from the literature (see Appendix 1). However, limitations caused by unusual BKPs and lack of ranked information led to the exclusion of many samples from the comparisons. One constructive criticism that might be made on the ASUDAS is that, although data collection is systematized by the scoring procedure, optimal breakpoints have never been established. That constraint might be overcome if either practice or convention led authors to publish all ranked data and not only frequencies at specific BKPs.

The second problem was the number of observations reported for the published frequencies. Archaeological samples, particularly the prehistoric ones, face the obvious limitations imposed by the available number of individuals exhumed from a given cemetery or funerary monument. Taphonomic post-depositional conditions of the site, funerary treatment dispensed to the deceased and lack of formal burial in certain cultures and/or chronologies might limit the number of individuals whose remains last the passing of time (Pearson, 2005). Errors might be introduced in the analysis by sampling limitations (Drenan, 1996).

A third problem faced when resorting to published data is inconsistency in the choice of target teeth per trait. Although the polar tooth per trait has been defined by the ASUDAS's scoring procedure (Turner *at al.*, 1991) and later literature (Wu and Turner, 1993; Scott and Turner, 1997; Burnett *et al.*, 2010), many times comparisons cannot be made among different publications because certain traits are not reported for the polar tooth but for others (*i.e.*, in Ruiz *et al.*, 2012; Subirá *et al.*, 2014) or frequencies result of the presence of the trait in all teeth, polar or not (*i.e.*, in Laforest *et al.*, 2012). In some cases sample restrictions, *i.e.*, *post mortem* loss of teeth affecting single-rooted teeth (Silva, 2002), might account for these limitations, since anterior teeth are absent or rare in the samples.

6.2. Geographic and chronological limits of the work

The geographic limits of analysis in the comparisons here are based on an archaeographic *rationale*: meaningful comparisons were thought to be found within the limits imposed by population derivation and movements, and by contacts that were feasible given the chronology of the samples submitted to the study.

Scott and collaborators (Scott and Turner, 1997; Scott *et al.*, 2013) propose that the Eurodont dental complex represents the tooth morphology of Western Eurasian groups. These are distributed in a vast region that includes Europe, North Africa, Middle East and parts of India. Since the samples included in the present study come from sites within the Eurodont range, series from these regions were employed in the analysis. On the other hand, Irish (1997; 2013) demonstrated that North African dental morphology is highly influenced by the sub-Saharan Afridont dental complex. In fact, a South-North cline in influence is proposed by that author, being the sub-Saharan region the birthplace of the modern human dentition (Irish and Gautelli-Steinberg, 2003).

Although no direct contact between human populations in Chalcolithic Iberian and coeval sub-Saharan groups can be made, there are archaeological (Hurtado, 1999; Schuhmacher *et al*., 2009; Cortés-Sanches *et al.*, 2012; Schuhmacher and Banerjee, 2012; García-Sanjuán *et al.*, 2013) and genetic (Martínez-Laso *et al.*, 2000; Gamba *et al.*, 2007; Afonso *et al.,* 2013; Cerezo *et al.*, 2013) indications of contacts between Southern Iberia and North Africa during the Neolithic and Chalcolithic. North African dental morphology is influenced to some extent by the Afridont pattern (Irish, 1998a) because of its ontogeny and because of prehistoric/historic genetic exchange. Understanding the genetic influence of the Afridont pattern in the southern limits of the Eurodont dental complex in North Africa and its consequences to prehistoric Iberian groups might be of interest.

Data from individual samples from the Americas, Eastern Asia and Oceania were not included in the analysis because of the chronogeographic context of the samples under study. Limitations of population movement and biological relations of these specific groups with others too distant in time and space make this kind of comparison pointless.

When characterizing the human dentition for macro-geographical regions, Scott and Turner (1997) focused their analysis in a time span ranging from Prehistory to the 1500's. The logics behind this limitation was the choice of data that best conforms to the native dental morphology living in each region. After the Age of the Discoveries, the movement of populations increased the pace of admixture while in many regions "indigenous populations were replaced, peripheralized and/or assimilated by disparate populations" (Scott and Turner, 1997: 170).

The author has set the chronological limits of comparisons used in the present work to samples from the Paleolithic to the Middle Ages. Exceptions to these limits were made for two Modern/Contemporary samples from Portugal (Marado 2010; 2014) and a living Spanish sample (Scott *et al.*, 2013). So far, Marado's (2010; 2014) work is the most complete and comprehensive assessment of the Contemporary Portuguese dental morphology using most of the traits described in the ASUDAS. The analysis of the morphological affinities between the Chalcolithic and the Contemporary dentition of Portugal and Spain is of interest for the present work.

6.3. Contributions and constraints of studying teeth from prehistoric collective burial contexts

In 2003 Silva wrote that over 1000 graves from the Neolithic and Chalcolithic times had been discovered and explored in Portugal alone. That number is by far outdated thanks to recent works on Management Archaeology in the last years (Boaventura *et al.*, 2014). Difficulties in the laboratory recovery of data from highly fragmented human remains are most times augmented by the lack of field anthropological work at their exhumation, particularly in long excavated sites (Silva 2002; 2003). These problems have discouraged the study of human remains from such contexts (Silva, 2003), many times regarded as little informative.

After dealing with the series here, the author has realized that, although these limitations do exist, the amount and quality of the data recovered in the process justifies the effort. Some aspects of the oral discrete traits were hindered or impossible to be addressed due to fragmentation of the remains and/or lack of field information. Among those, probably the first one that comes to mind is the lack of individualization of dentitions and of association of bones to specific individuals. Questions regarding symmetry, sexual dimorphism and inter-trait association in the collections cannot be answered unless we have actual individuals to study. Discrete traits, such as supernumerary *foramina mentale, tori* and other kinds of exostoses that are expressed in bones composing the oral cavity are poorly preserved in fragmented commingled human remains from prehistoric contexts. Other non-metric features such as UI1 winging that depend on the placement of teeth in their sockets will be hindered in collections bearing more *ex situ* than *in situ* dental elements. Despite all those problems, the wide variety of discrete traits in the human dentition and the massive number of teeth from some of those collective funerary contexts cannot be underestimated as a source of valid data.

6.3.1. A matter of size

The first contribution of the present work to the study of human dental discrete traits resulted from one of its limitations. Most anterior single-rooted teeth in the present study were loose from their sockets, which can be an impediment for observation of some traits mentioned above. Very rarely though it can be an advantage. Most features expressed on the radicular structure of teeth can only be visible via medical imaging techniques (not frequently available) or if they are *ex situ*.

The first tooth from BT07 to be inventoried (BT07/D01-107.3) had an unusually short root (Figure 5.4, previous Chapter). Repetition of short-rooted UI1 in that collection and others addressed here and elsewhere (Cunha *et al.*, 2012) triggered a question not included in the objective of this work: could this be a dental discrete trait?

Short roots may occur as a result of failure in their development or due to resorption of fully developed radicular structures (Hölta *et al.*, 2004). Shortening of roots can affect a single tooth, a group of teeth (Alt and Türp, 1998), and/or most or all teeth in a single dentition (Apajalahti, *et al.,* 1999).

Extensive root shortening affecting multiple teeth is considered an anomaly or a pathological condition. It is usually associated with various syndromes and systemic conditions or with environmental factors (occlusal trauma, radioactive or chemical poisoning) (Lind, 1972; Thongudomporn and Freer, 1998; Apajalahti, *et al.,* 1999; Brezniak, 2002; Apajalahti, 2004).

The specificity of the samples, namely their chronology, absence of other types of short-rooted teeth and lack of evidence of trauma in UI1 displaying short roots excluded most triggering agents of the phenomenon in the prehistoric Iberian samples. On the other hand, family (Lind, 1972; Apajalahti *et al.*, 1999; Apajalahti, 2004) and population (Edgcomb *et al.*, 2011) studies addressing the pathological condition point to a genetic etiology for the occurrence of short roots. Adding to the possible epigenetic nature of the trait, it was observed to affect both antimeres in individuals from BT07 and in individual inhumations from other archaeological contexts (Anderson, 1993; Šikanjić and Mešestroić, 2006; Cunha *et al.*, 2012).

Based on evidence that the bilateral shortening of roots is genetically controlled, it was proposed as a new discrete trait for the human dentition (Cunha *et al.*, 2012). This claim is supported by experts in the field who co-authored that article (Ana Maria Silva, Joel Irish and G. Richard Scott). Although it has only begun being used as a discriminatory feature (Cunha *et al.*, 2012; Fidalgo, 2014; Pereira, 2014), the progressive data collection on the trait will prove its usefulness in population studies.

Although the number of archaeological collections submitted to the assessment of HRUCI is limited geographically, data have been collected from eight archaeological samples distributed in coastal Portugal and the basins of the Tagus and Guadiana River (Cunha *et al.*, 2012; Fidalgo, 2014; Pereira, 2014; Cunha *et al.*, in preparation). There seem to be differences in the geographic and chronological patterning of distribution of this trait. Chronologically it is more frequent in Neolithic and Chalcolithic samples than later Bronze Age ones. Within the Neolithic-Chalcolithic time frame, HRUCI is a highly frequent trait in inland sites in the Guadiana and Tagus Valleys while its frequency is intermediate in coastal sites in Portugal. Higher endogamy and genetic drift in the Neolithic-Chalcolithic inland populations might have influenced its higher figures.

6.3.2. Non-dietary tooth use

Use of the dentition in non-dietary chores can alter the morphology of the muscles, teeth and maxillary/mandibular bones (Hylander, 1977). Those alterations may obliterate non-metric features, once teeth might lose mass at trait *loci* due to wear, fragmentation (chipping) and/or to loss of the tooth itself. Stress caused by severe occlusal forces can alter the morphology of bones by triggering the occurrence of bone exostosis (*tori*) on the mandible or maxilla (Hylander, 1977; Hauser and De Stefano, 1989; Turner *et al*., 1991; García-García *et al*., 2010; Loukas *et al*., 2013). *Tori* associated with other indications of bite force might be considered biological response to injury.

In archaeological and ethnographic populations the use of teeth for non-dietary purposes has been identified in different geographic, cultural and chronological contexts (Molnar, 1971; 1972; Hylander, 1977; Molleson, 1994; Bonfiglioli *et al*., 2004; Hasset, 2006; Scott and Jolie, 2008; Molnar, 2008; 2011, among others). In those populations, the alterations introduced to the form of teeth and bones by non-dietary use of the dentition include: formation of bone exostoses at different *loci*, fragmentation/chipping of crowns; asymmetrical, grooved and/or notched tooth wear; atypical location for tooth wear (*i.e.*, on the labial aspect of upper incisors); and root resorption and hypercementosis.

Mandibular and palatal maxillary *tori* are bone exostoses whose etiology has been claimed to be epigenetic, environmentally induced or both (Hauser and De Stefano, 1989; Turner *et al*., 1991; García-García *et al*., 2010; Loukas *et al*., 2013). During laboratory work on the collections, the absence of *tori* in BT07 was noticed and regarded as probably resulting from the high number of juvenile individuals in the sample. On the other hand, they were present in both samples from Perdigões, but the intriguing *loci* and alterations associated with such exostosis raised the question on the nature of the phenomenon in PDG1 and PDG2.

Mandible and maxilla fragments from Perdigões displaying *tori* also exhibited other alterations that may be related to non-masticatory bite force trauma including: chipping, atypical and severe tooth wear, hypercementosis and root resorption. The *loci* of all maxillary *tori* were not the normative position for the epigenetic occurrence of the feature, while the *loci* of mandibular ones extended posteriorly to the molars and buccally to the outer surface of the mandibular bone.

Although some of the mandibular exostoses in the samples from Perdigões affect the normative *loci* of the epigenetic *tori* (the lingual aspect of the alveolar bone at the premolar region), they extended beyond that region to the buccal aspect of the mandible. The association of those with evidence of bite force trauma indicate that a functional etiology for most of them cannot be rejected.

For the reasons explained above, the occurrence of mandibular and palatal *tori* were not included in the population comparisons in this work. On the positive side, the hypothesis of non-masticatory use of teeth in prehistoric Iberia was raised by the present study and is part of current research being developed by the author and others (Marado *et al*., 2014) on different archaeological samples.

6.3.3. The dental morphology of the populations from the Middle Guadiana Valley.

The present work is the first thorough study on the dental morphology of Chalcolithic populations from the Guadiana Valley in the sense that the samples studied are phenetically (and by proxy genetically) representative of the populations they derive from (Scott *et al.*, 1983). It includes all dental elements exhumed from three collective tombs corresponding to a MNI of 152 individuals from the Neolithic-Chalcolithic enclosure of Perdigões (Reguengos de Monsaraz, Portugal) and 170 individuals from the tomb of Cerro de las Baterías (La Albuera, Spain). It is also the first work on prehistoric samples of that kind to include the study of such a large number of traits: the majority of discrete features in the ASUDAS and a newly proposed one (HRUCI).

Despite the difficulties and limitations of working on highly fragmented human remains, it was possible to obtain informative data and infer a morphological profile for those populations to place them within the Eurodont Complex (Scott *et al.*, 2013). In the few cases that trait frequencies diverge from the Eurodont pattern, these phenetic expressions draw the samples closer to the North African variant of that complex, as reported in extensive work by Irish (1997; 1998a; 2000a; 2000b; 2005; 2006; 2008; 2013).

In relation to other western Eurasian populations, morphology of the populations represented by the collections here are characterized by a set of trait frequencies:

I – Relatively high frequencies of fifteen traits: UI1 shoveling, labial convexity, UI1 HRUCI, UPM accessory tubercles (except for PDG1), UP accessory ridges, Carabelli's trait (cusp form), UM1 MMAT, UM2 hypocone reduction, multiple cusps on LP2, LM1/LM2 cusp reduction, LM1 anterior *fovea*, LM1 DTC, LM1 protostylid (including pit expression), LM1 C5 and LM2 Y-groove pattern (except PDG2);

II – Relatively intermediate frequencies of six traits: UI2 interruption groove, UI2 TD (except for PDG2), UC canine mesial ridge, UC DAR, UM1 C5 and LM1 C6;

III – Relatively low frequencies of two traits: UI1 double shoveling and double rooted LC;

III – Absence or near absence of seven traits: premolar odontomes, UI1, enamel extensions, UI2/UM3 peg, UM3 parastyle, LP1 Tomes' roots, LM1 C7 (except BT07) and 3-rooted LM1.

Considering the tendency for close biological affinities of the samples from Perdigões and Cerro de las Baterías to North Africans, we must take into account the chronological, biological, cultural and geographic frames in which the Chalcolithic populations from the Guadiana lived. Chronologically, the samples from Perdigões are dated to the 3rd millennium

BC and, although absolute dates for BT07 are not available, material culture indicates its probable contemporaneity to the first. When compared to more recent Portuguese (Marado, 2014), the Chalcolithic dentition displays a more mass-additive and complex nature than their Modern counterparts. Admixture with other European populations in the modern dentition or retention of more archaic/Africanized traits in the prehistoric one might account for those differences. In general, these differences are expressed in more elaborate topography on the lingual aspect of upper incisors, upper premolars and UM1; higher frequencies of the most expressive ranks of Carabelli's trait; more complex occlusal surfaces on UM1 marked by DTC and anterior *foveae*, and more frequent Y-groove pattern on LM2.

In terms of biological admixture, the dental morphology suggests that the populations in the Guadiana Valley might have been subjected to prehistoric genetic exchanges between North Africa and southern Iberia as proposed by studies on recent and ancient DNA (Achilli *et al.*, 2005; Roostalu *et al.*, 2007; Gamba *et al.,* 2008; Cherni *et al.*, 2009; Ennafaa *et al.*, 2009; Cerezo *et al.,* 2012; Botigué *et al.*, 2013; Afonso *et al.*, 2013). Commerce of exotic/prestige goods with North Africa (Schuhmacher *et al.,* 2009; Schuhmacher and Banerjee, 2012) might have favored gene flow into the Guadiana, although the extent and the process under which this input happened is so far unknown.

The position of Iberian Chalcolithic samples of PDG1, PDG2 and BT07 in the Afridont-Eurodont cline reflects the moderate permeability of the local dentition to contributions from populations archeographically known to have interacted with south Iberians in Prehistoric times (Lindstäder, 2008; Schuhmacher *et al.,* 2009; Cortés-Sanches *et al.*, 2012; Schuhmacher and Banerjee, 2012; Lindstäder *et al.*, 2012; Lillios, 2014).

Regional populations in an extended territory on both sides of the river were connected by trade (Odriozola, 2008; Odriozola *et al.*, 2008; Dias *et al.,* 2008; Odriozola *et al.*, 2010) and cultural ties (Hurtado, 1986; 2006; 2008; Valera, 2008b; 2012a; 2012b). Social interaction and a shared cultural background probably facilitated the circulation of people and consequently, the genetic exchange within the Guadiana Valley. Several PCA tests produced during the course of this work have shown that PDG1, PDG2 and BT07 share close biological affinities. That homogeneity is expressed in both synchronic and diachronic comparisons. Regarding intra-site homogeneity, the results of Kendall's *tau*-b test and of different PCA tests indicate that trait frequencies between PDG1 and PDG2 are more correlated to each other than between either of them and BT07. Despite minor differences, both samples seem to have been drawn from the same population.

6.4. Future research

This is the first study on the dental morphology of remains of integral collections exhumed from collective burials of large collective tombs in the Guadiana Valley. However, this is just the beginning. Much more research needs to be done. Questions on the continuity of the human occupation in the valley can only be answered if data on earlier series are collected and compared to information here. The numbers of studies on Bronze Age samples for comparative studies should also be increased and include collections from the present day Spanish Extremadura.

Nowadays the ASUDAS is well known and it has been used on the study of prehistoric Iberian samples (see for instance, Silva, 2000b; 2002; García-Sívoli, 2009; Oumaoui, 2009; Rivera, 2011; Scott *et al.*, 2013; Horwath *et al.,* 2014; Subirá *et al.*, 2014; Fidalgo, 2014; Pereira, 2014). However, comparative data can only be useful if collected on a statically valid number of non-metric traits and published at various breakpoints, as ranked data or after standardization of breakpoints. Methodological questions such as those should be discussed at the academic level via publications and symposia.

During the course of this study a new discrete trait was proposed for the human dentition. The morphology of prehistoric Iberians and Europeans seems to be much more interesting than previously assumed. The author has the belief that more non-metric traits can be identified if addressed in specific works. Premolar supernumerary cusps and groove patterns should be more carefully addressed in future works. Alterations to the morphology of teeth and bones of the oral cavity can help improve our knowledge about cultural aspects of past populations. The non-dietary use of teeth should be more properly detailed. This is a well explored research line in other prehistoric populations, but that debate in Portugal has just began.

The lack of funding for large scientific projects in the field of anthropology and consequently in its sub-field of dental morphology is a problem to be faced in future research, despite efforts of institutions like the University of Coimbra. It is my hope that this study motivates fellow researchers and future students to question, challenge and confirm or deny the data provided here by the research on other Chalcolithic collections from Portugal and Spain.

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Appendices

Appendix 1 – List of samples used in the PCA analyses:

Acronym	Full Name	Region/country	Chronology	Reference
WEU	Western Europe	Western Europe	Historic	Scott and Turner, 1997
NEU	Northern Europe	Northern Europe		
NAF	North Africa	North Africa	Prehistoric, Ancient, Native (?)	
WAF	West Africa	West Africa	Historic	
SAF	South Africa	Sub-Saharan Africa	Prehistoric, Ancient, Native (?)	
KHOI	Khoisan	Sub-Saharan Africa		
CHM	China-Mongolia	Asia		
JOM	Jomon	Japan		
RJAP	Recent Japan	Japan		
NES	Northeast Siberia	Asia		
SSI	Southeast Siberia	Asia		
AAR	American Artic	North America		
NWA	Northwest North America	North America		
NSAI	North/South American Indian	Americas		
SEE	Southeast Asia	Southeast Asia		
SER	Southeast Asia Recent	Southeast Asia	Historic	
POLY	Polynesia	Polynesia	Prehistoric, Ancient, Native (?)	
MICR	Micronesia	Micronesia		
AUST	Australia	Australia		
NWG	New Guinea	New Guinea		
MELA	Melanesia	Melanesia		
SPA	Spanish	Basque Country, Spain	Contemporary Spanish	Scott *et al.*, 2013
SPB	Spanish-Basque	Basque Country, Spain	Contemporary Spanish-Basque	
BAS	Basque	Basque Country, Spain	Contemporary Basque	
CSM	Catedral de Santa Maria	Basque Country, Spain	11th-19th centuries.	
CPF	Cueva de Pantà de Foix	Catalonia, Spain	Chalcolithic, 3420-2640 cal. BC	Subirá *et al.*, 2014
COI	Coimbra	Portugal	19th-20th centuries.	Marado, 2014
ÇAT1	Çatalhöyük 1	Konya plain, Turkey	Neolithic. 7400-6100 cal. BC	Pilloud, 2009
ÇAT2	Çatalhöyük 2		Chalcolithic, 6000-5600 cal. BC	

Appendix 1 – List of samples used in the PCA analyses (cont.):

Acronym	Full Name	Region/country	Chronology	Reference
DAN	Danish sample	Denmark	Neolithic	Christy Turner's data base
UKR	Ukraine	Ukraine	Mesolithic-Neolithic	
RUS	Russian	Russia	Medieval-Modern (?)	
POU	Poundbury	England		
ESTO	Estonia	Northern Europe		
SAM	Saami (formerly Lapp)	Arctic Europe		
NETH	Netherlands	Northern Europe		
KAR	Karelian			
EUR	European	Europe	Prehistoric, Ancient, Native (?)	Irish, 1998a
SUN	Sundadont	Southeast Asia		
CHA	Chad	Chad, Sub-Saharan Africa (SSA)	19th – 20th century AD	
SSAH	Sub-Saharan	Sub-Saharan Africa	19th century AD	
NA_JDI	North Africa	North Africa	Prehistoric, Ancient, Native (?)	
CON	Congo	Congo, SSA	19th century AD	
GAB	Gabon	Gabon, SSA	19th-20th century AD	
GHA	Ghana	Ghana, SSA	19th century AD	
KEN	Kenya, Tanzania	Kenya, Tanzania, SSA	19th-20th century AD	
KHO	Khosian	South Africa, SSA	19th century AD	
NGU	Nguni	South Africa, SSA		
NIC	Nigeria, Cameron	Nigeria, Cameron, SSA		
PYG	Pygmy	Congo, Gabon, SSA	19th – 20th century AD	
SAN	San	Botswana, South Africa, SSA	20th century AD	
SEN	Senegambia	Senegambia, SSA	19th – 20th century AD	
TAN	Tanzania, Zanzibar	Tanzania, Zanzibar, SSA		
TOB	Togo, Benin	Togo, Benin, SSA	19th century AD	
TUK	Tukolor	Senegambia, SSA	19th – 20th century AD	
ALG	Algeria	Algeria, North Africa, (NA)	19th century AD	
CAN	Canary Islands (Guanche)	Canary Islands, NA	400-900 AD (?)	
CAP	Capsian	Algeria, Tunisia, NA	Neolithic, 10500-7000BC	Irish, 1998a
CAR	Carthage	Tunisia, NA	751-146 BC	

Appendix 1 – List of samples used in the PCA analyses (cont.):

Acronym	Full Name	Region/country	Chronology	Reference
BED	Bedouin	Morocco, Tunisia, Libya, NA	19th – 20th century AD	Irish, 1998a; Horwath et al., 2014
CHR	Christian	Egypt-Sudan Border (Ancient) Nubia, NA	Christian Period Nubians, AD 550-1350	Irish, 1998a and 2005; Irish and Friedman, 2010
HES	El Hesa	Egypt, NA	Roman/Byzantine Egyptians, AD 200-400	Irish, 1998a; Irish and Friedman, 2010
KAB	Kabyle	Algeria, NA	19th – 20th century AD	Irish, 1998a
KHA	Kharga	Egypt, NA	Byzantine Egyptians, AD 500-600.	Irish, 1998a; Irish and Friedman, 2010
LIS	Lisht		12th Dynasty Egyptians, 1985-1773 BC	Irish, 1998a; Irish and Friedman, 2010
MER	Meroitic	Egypt-Sudan Border (Ancient) Nubia, NA	Meroitic Period Nubians, 100 BC-350 AD	Irish, 1998a and 2005; Irish and Konigsberg, 2007; Irish and Friedman, 2010
IBM	Iberomaurusian	Morocco and Algeria	16750-11450 BP	Irish, 2000a.
PHA	Pharonic	Egypt-Sudan Border (Ancient) Nubia, NA	New Kingdom Period Nubians, 1575-1380 BC	Irish, 1998a; Irish 2005
XGR	X-Group	Egypt-Sudan Border (Ancient) Nubia, NA	X-Group Nubians, 350-550 AD	Irish, 1998a and 2005; Irish and Konigsberg, 2007; Irish and Friedman, 2010
SAD	S'Aigua Dolça	Majorca, Spain	1750-1600 cal. BC	García-Sívoli, 2009
SRE	Son Real		6th 2nd centuries BC	
IDP	S'Ilot des Porros			
CRE	Can Reinés		5th-7th centuries AD	
VMA	Vila d'Madrid	Catalonia, Spain	1st-3rd centuries AD (Roman)	
SPE	Sant Pere		5th-12th centuries AD	
PVE	Plaça Vella		16th-17th centuries AD	
ECA	El Castellón Alto	Granada, Spain	Bronze Age, c. 1300 BC	Oumaoui, 2009
LNA	La Navilla		Bronze Age, early 2nd millennium BC	
MOA	Motilla del Azuer	Castilla la Macha, Spain	Bronze Age, 2200-1350 B.C.	

Appendix 1 – List of samples used in the PCA analyses (cont.):

Acronym	Full Name	Region/country	Chronology	Reference
CDN	Cuesta del Negro	Granada, Spain	Bronze Age, 1645+/-35 BC	Oumaoui, 2009
TOR	La Torrecilla		Medieval (Islamic)	
SBM	Sahl ben Malik			
SOP	Villanueva de Soportilla	Burgos, Spain	Medieval.	
CAS	Necropolis del Castillo		Medieval.	
GRM	Gebel Ramlah	Egypt (Upper Egypt)	Late Neolithic, 5500-5700 BP (Irish, 2006); 4650-4400 cal. BC (Irish, 2006); 4690-4340 ca. BC (Irish and Friedman, 2010)	Irish, 2005; 2006; Irish and Friedman, 2010
BAD	Badarian		Predynastic, 4400-4000 cal. BC	Irish, 2006; Irish and Konigsberg, 2007; Irish and Friedman, 2010
NAQ	Naqada		Predynastic, 4000-3200 cal. BC	Irish, 2006; Irish and Konigsberg, 2007; Irish and Friedman, 2010
HRK	Hierakonpolis		Predynastic, 3500-3200 cal. BC	Irish, 2006; Irish and Friedman, 2010
ABY	Abydos 1		Predynastic, c. 4000-3200 BC	Irish, 2006; Horwath et al., 2014
ABY2	Abydos 2		Early Dynastic, 3000-2680 cal. BC	Irish and Friedman, 2010
TAR	Tarkhn	Egypt (Lower Egypt)	3000-2890 BC	Irish, 2006.
LON	Longar	Basque Country, Spain	Neolithic-Chalcolithic 2495+/-70 – 2630+/-90 cal. BC	Rivera, 2011
NCI	North-Central Italy	Italy	Chalcolithic, 3000-2300 BC	Vargiu *et al.*, 2009
LAT	Laterza			
SAR	Sardinia			
UPM	Upper Paleolithic-Mesolithic Italy		Upper Paleolithic-Mesolithic, 30000-6000 BC	Coppa *et al.*, 2007
INEO	Neolithic Italy		Neolithic, 5800-3300 BC	

Appendix 1 – List of samples used in the PCA analyses (cont.):

Acronym	Full Name	Region/country	Chronology	Reference
ICAG	Copper Age Italy	Italy	Chalcolithic, 3200-2300 BC	Coppa *et al.*, 2007
IMBA	Middle Bronze Age Italy		Bronze Age, 1600-1300 BC	
IMIA	Middle Iron Age Italy		Iron Age, 800-600 BC	
REM	Roman Empire		Roman Empire, AD 100-400.	
IMAA	Middle Age Italy		Middle Age, AD 800-1500.	
BOL	Bolores	Portugal	Neolithic, 2800-2600 cal. BC	Horwath et al., 2014
FET	Feteira II		Neolithic, 3600-2900 cal. BC	
LCI	Lachish-Iron	Palestine	Iron Age, 1200-520 cal. BC	
GRK	Greece	Greece	Historic, 475-300 cal. BC	
SBA	Syrian Bronze Age	Syria	Bronze Age, c. 2700-1200 BC	Soltysiak and Bialon, 2013
BRI	Brinches Bronze Age	Portugal	1870-1500 BC	Cunha *et al.*, in preparation.
SEI	Syrian Early Islamic Period	Syria	Islamic Period, c. AD 600-1200	Soltysiak and Bialon, 2013
SBED	Modern Bedouin Syria		19th-20th centuries	
MIN	Mesolithic India	India	Mesolithic, 8865-8640 cal. BC	Lukacs and Pal, 2013
R12	R12 Site	Northern Dongola Reach, Sudan	Neolithic 5910+/-50 – 5860+/-80 BP (Irish, 2008); 4810-4720 BC (Irish and Friedman, 2010)	Irish, 2008; Irish and Friedman, 2010
AGR	A-Group	Egypt-Sudan border (ancient Nubia)	3000 BC	Irish, 2005; Irish and Konigsberg, 2007
CGR	C-Group	Egypt-Sudan border (ancient Nubia)	2000-1350 BC	
HAW	Hawara	Upper Egypt	Roman Period, AD 50-120	Irish, 2006; Irish and Friedman, 2010
JEM	Jebel Moya	Sudan	3000-100 BC	Irish and Konigsberg, 2007
THE	Thebes	Egypt	Middle Kingdom, 2055-1773 BC	Irish and Friedman, 2010
KAW	Kawa	Sudan (Ancient Nubia)	Ancient-Middle Kerma Period, 2500-1750 BC	

Appendix 1 – List of samples used in the PCA analyses (cont.):

Acronym	Full Name	Region/country	Chronology	Reference
SAQ	Saqqara	Egypt (Lower Egypt)	2613-2494 BC	Horwath et al., 2014
KER	Kerma		1750-1500 BC	Irish, 2005
LAC	Recent Latini	Italy	4th–2nd century BC	Coppa *et al.,* 1998.
ETB	Ancient Etruscans		Middle 7th-5th century BC	
ETC	Recent Etruscans		4th–2nd century BC	
PCB	Ancient Piceni		Middle 7th-5th century BC	
PCC	Recent Picenni		4th–2nd century BC	
SANT	Santini		Middle 7th-5th century BC	
SOL	Soleb	Sudan (Ancient Nubia)	1550-1380 BC	Irish, 2005
SMBA	Syrian Middle Bronze Age	Syria	Bronze Age, c. 2000-1200 BC	Soltysiak and Bialon, 2013
SCLA	Syrian Classical and Late Antiquity		300 BC-AD600	
KUS	Kushite	Sudan (Ancient Nubia)	600 BC – AD 550	Irish, 2005
SAI	South African Iron Age	South Africa, Zimbabwe and Botswana	250-1350 AD	Warren, 2013
NAT	Natufians	Levant	12800-10200 BP	Lipschultz, 1997
JSA	Jebel Sahaba	Sudan (Ancient Nubia)	14000-12000 BP	Irish, 2005
LEV_BI	Iron/Bronze Age Levant	Palestine-Israel	1400-1100 BC	Ullinger, *et al.*, 2005
STS	St. Stephen's Monastery	Israel	AD 438 – AD 611	
WHI	Whithorn	Whithorn, Scotland.	Medieval	Adler, 2005
ABE	Aberdeen	Aberdeen, Scotland.		
STA	St. Andrew	St. Andrew, Scotland.		
LIN	Linlithgow	Linlithgow, Scotland.		
DEN	Denmark	Denmark		
ENG	England	England		
HOL	Holland	Holland		
GRE	Greenland	Greenland		
NOR	Norway	Norway		
IRE	Ireland	Ireland		
SCO	Scotland	Scotland		
CYP1	Cyprus – sample 1	Cyprus	4000-2500 BC	Parras, 2004

Appendix 1 – List of samples used in the PCA analyses (cont.):

Acronym	Full Name	Region/country	Chronology	Reference
CYP2	Cyprus – sample 2	Cyprus	1725-1200 BC	Parras, 2004
GRK2	Greece – sample 2	Greece	2900-1050 BC	
SYR	Syria	Syria	3500-2400 BC	
SIN	Sinodont	Northeast Asia and New World	Prehistoric, Ancient, Native (?)	Irish, 1998a
YAY	Yayoi	Honsu, Japan	Aeneolithic 100 BC – 300 AD	Manabe *et al.*, 2011
POR	Porto	Porto, North of Portugal	Modern - Contemporary	Marado, 2010
OKI	Okinawa	Okinawa, Japan	1867 - Present	Manabe *et al.*, 2011
AFA	Afalou-Bou-Rhummel	Algeria	16750 – 11450 BP	Irish, 2000a.
TAF	Taforalt Cave Rock Shelter	Morocco	12500 – 10500 BP	Irish, 2000a.
JOM2	Jomon	Japan	3000-300 BC	Manabe *et al.*, 2011
CM	Cova da Moura	Estremadura, Portugal.	3636-2205 cal. BC	Silva, 2002
DEA	Dolmen of Estrada de Ancião	Estremadura, Portugal.	3637-3094 cal. BC	
PM	Paimogo I *Tholos*	Almada, Estremadura, Portugal.	3077-2475 cal. BC	
SP	São Paulo II	Lourinhã, Setubal, Portugal	2553-1950 cal. BC	
MC1	Monte Canela I	Algarve, Portugal	3379-2900 cal. BC	Silva, 1996a; Silva, 2002
BASE	Bronze Age Serpa	Serpa, Alentejo, Portugal	1870-1410 cal. BC	Fidalgo, 2014; Cunha *et al.,* in preparation.
OA2	Outeiro Alto 2	Serpa, Alentejo, Portugal	2480-2297 cal. BC	Fernandes, 2013

Biological affinities of the Chalcolithic samples of PDG1, PDG2 and BT07 to Worldwide Samples

Comparisons of PDG1, PDG2 and BT07 to other samples dated to the 5th Millennium BC and older

PCA A

Table A1.3 – Samples from other sources used in PCA A:

Acronym	Sample	Region – Country	Chronology	Reference
GRM	Gebel Ramlah	Upper Egypt	4650-4400 cal. BC.	Irish, 2005; 2006
R12	R12 Site	Sudan	Neolithic 4810-4720 BC	Irish, 2008; Irish and Friedman, 2010
BAD	Badarian	Upper Egypt	4400-4000 cal. BC.	
NUB	Jebel Sahaba	Nubia, NA	Mesolithic, 14000-12000 BP.	Irish, 1998a; Irish 2005
ÇAT1	Çatalhöyük 1	Turkey	Neolithic. 7400-6100 cal. BC.	Pilloud, 2009
ÇAT2	Çatalhöyük 2		6000-5600 cal. BC.	

Table A1.4 – Matrix of the component loadings, eigenvalues and variances of PCA A

Traits	BKP	Component		
		1	2	3
UI1 double shoveling	+= ASU 2-6	.473	**.654**	-.473
UI2 Peg	+= ASU 1-2	.479	-.364	-.425
UI2 interruption groove	+= ASU +	**.516**	.053	**.783**
UC distal accessory ridge	+= ASU 2-5	**-.626**	**.690**	-.144
UC mesial accessory ridge	+= ASU 1-3	.118	**.647**	**.600**
UP1 odontome	+= ASU +	**.561**	.150	-.148
UP2 odontome	+= ASU +	.444	-.033	**.827**
UM3 congenial absence	+= ASU +	**.880**	-.104	.040
LP2 cusp variation	+= ASU 2-9	**-.811**	-.093	.273
LM1 anterior fovea	+= ASU 2-4	**-.876**	.299	.141
LM1 protostylid	+= ASU 1-6	-.437	.263	.392
LM1 6-cusped	+= ASU 6+	.129	**.785**	.155
LM1 distal *trigonid* crest	+= ASU +	**-.588**	**-.725**	-.049
LM2 Y-pattern	+= ASU Y	-.017	**.628**	**-.637**
	Eigenvalue:	4.391	3.195	2.786
	Variance (%):	31.365	22.822	19.898
	Total Variance (%):	31.365	54.187	74.085

Principal Components Analysis. 4 components extracted. Highlighted figures represent strong positive (> 0.5; boldface and underline) and strong negative (< -0.5; boldface only) loadings within each component. Matrix of 3 out of 5 components extracted.

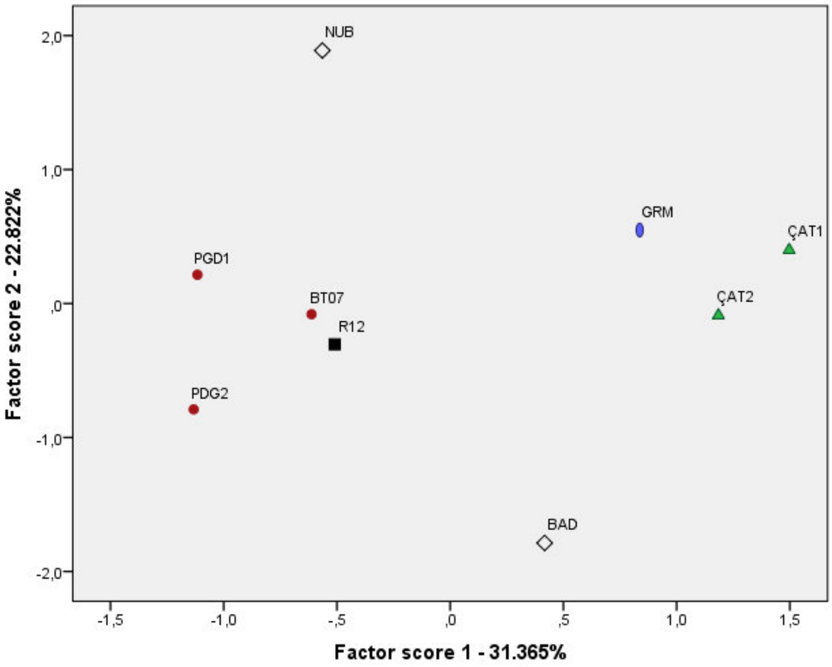

Figure A1.3 – Scatterplot of the two first components extracted in the comparison of the samples for PCA 5.

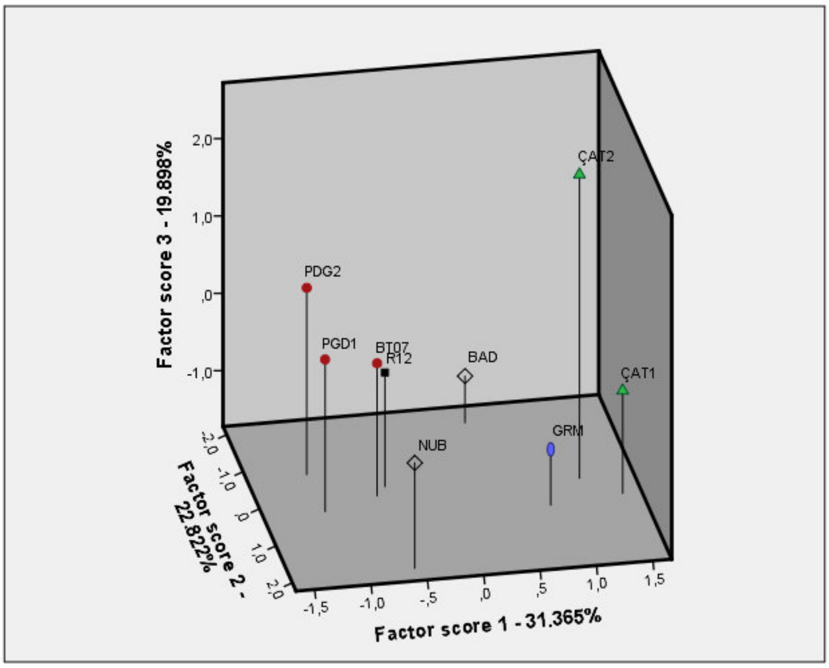

Figure A1.4 – Scatterplot of the first three components extracted in the comparison of the samples for PCA 5.

PCA B

Table A1.5 – Samples from other sources used in PCA B:

Acronym	Sample	Region – Country	Chronology	Reference
ÇAT1	Çatalhöyük 1	Turkey	7400-6100 cal. BC	Pilloud, 2009
ÇAT2	Çatalhöyük 2		6000-5600 cal. BC.	
AFA	Afalou-Bou-Rhummel	Algeria	16750 – 11450 BP	Irish, 2000
TAF	Taforalt Cave Rock Shelter	Morocco	12500 – 10500 BP	
JSA	Jebel Sahaba	Sudan	14000-12000 BP	Irish, 2005

Table A1.6 – Matrix of the component loadings, eigenvalues and variances of PCA B.

Traits	BKP	Component		
		1	2	3
UI1 Labial Convexity	+= ASU 2-4	**.971**	.040	-.058
UI2 Peg	+= ASU 1-2	-.113	**.769**	**-.578**
UI2 interruption groove	+= ASU +	**-.841**	-.267	-.180
UC distal accessory ridge	+= ASU 2-5	**.721**	**.572**	-.048
UC mesial accessory ridge	+= ASU 1-3	-.001	**.769**	.053
UP odontome	+= ASU +	**-.531**	.010	**.790**
UM3 parastyle	+= ASU 1-6	-.108	-.097	.212
UM3 congenial absence	+= ASU +	**-.636**	.034	**-.628**
LP2 cusp variation	+= ASU 2-9	**.524**	.351	.472
LM1 anterior fovea	+= ASU 2-4	**.959**	.066	.011
LM1 protostylid	+= ASU 1-6	**.753**	-.218	-.297
LM1 6-cusped	+= ASU 6+	-.262	**.811**	-.171
LM1 distal trigonid crest	+= ASU +	**.785**	-.447	.021
LM2 Y-pattern	+= ASU Y	-.220	.418	**.804**
Eigenvalue:		5.376	2.800	2.425
Variance (%):		38.399	19.998	17.323
Total Variance (%):		38.399	58.397	75.719

Principal Components Analysis. 4 components extracted. Highlighted figures represent strong positive (> 0.5; boldface and underline) and strong negative (< -0.5; boldface only) loadings within each component. Matrix of 3 out of 4 components extracted.

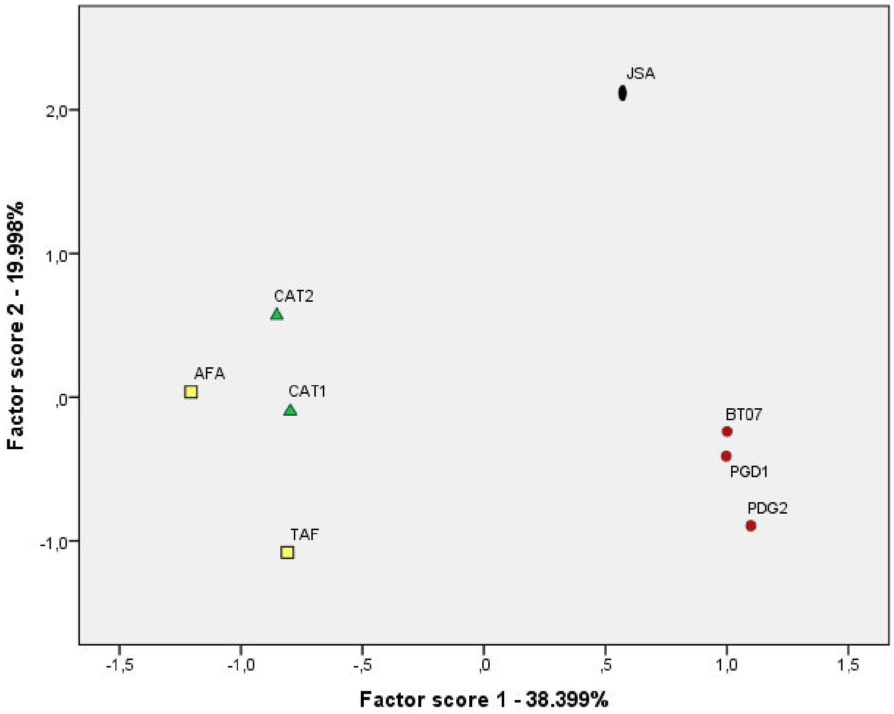

Figure A1. 5 – Scatterplot of the two first components extracted in the comparison of the samples for PCA B.

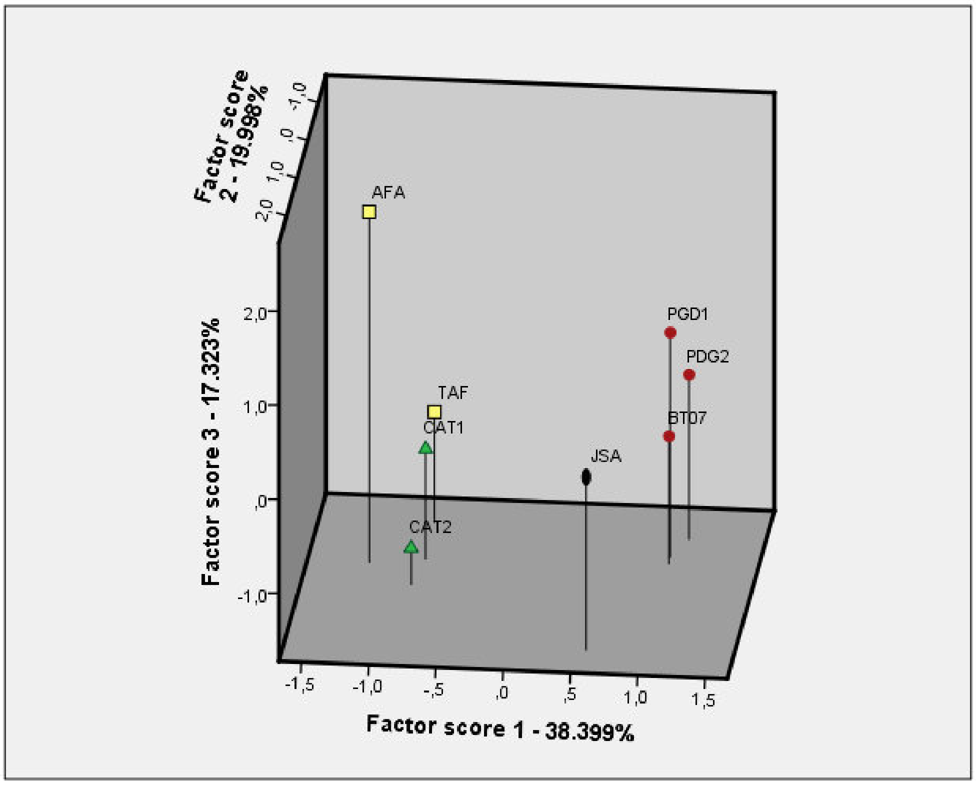

Figure A1.6 – Scatterplot of the first three components extracted in the comparison of the samples for PCA B.

PCA C

Table A1.7 – Samples from other sources used in PCA C:

Acronym	Sample	Region – Country	Chronology	Reference
UPM	Upper Paleolithic-Mesolithic Italy	Italy	30000-6000 BC	Coppa et al., 2007
INEO	Neolithic Italy		5800-3300 BC	
MIN	Mesolithic India	India	8865-8640 cal. BC	Lukacs and Pal, 2013

Table A1.8 – Matrix of the component loadings, eigenvalues and variances of PCA C

Traits	BKP	Component		
		1	2	3
UI1 Shoveling	+= ASU 3-6	.262	**.777**	.103
UI1 double shoveling	+= ASU 2-6	**-.948**	.190	.224
UI2 shoveling	+= ASU 3-6	-.252	**.601**	**.660**
UM1 Carabelli's trait	+= ASU 2-7	**.854**	-.312	.362
UM3 Peg	+= ASU 1-2	-.008	**-.525**	**.769**
LM1 *metaconulid* (C7)	+= ASU 1-4	**-.917**	.163	.350
LM1 *hypoconulid* (C5)	+= ASU 3-5	**.911**	-.390	.088
LM1 Y-pattern	+= ASU Y	**-.827**	**-.506**	-.109
LM2 4-cusped	+= ASU 4+	**.517**	.157	**.669**
LM2 Y-pattern	+= ASU Y	-.023	**.828**	-.103
LM3 3-cusped	+= ASU 4+	**.851**	.321	-.022
LM3 Y-pattern	+= ASU Y	.445	.320	-.292
Eigenvalue:		5.304	2.725	1.905
Variance (%):		44.196	22.709	15.871
Total variance (%):		44.196	66.905	82.777

Principal Components Analysis. 4 components extracted. Highlighted figures represent strong positive (> 0.5; boldface and underline) and strong negative (< -0.5; boldface only) loadings within each component. Matrix of 3 out of 4 components extracted.

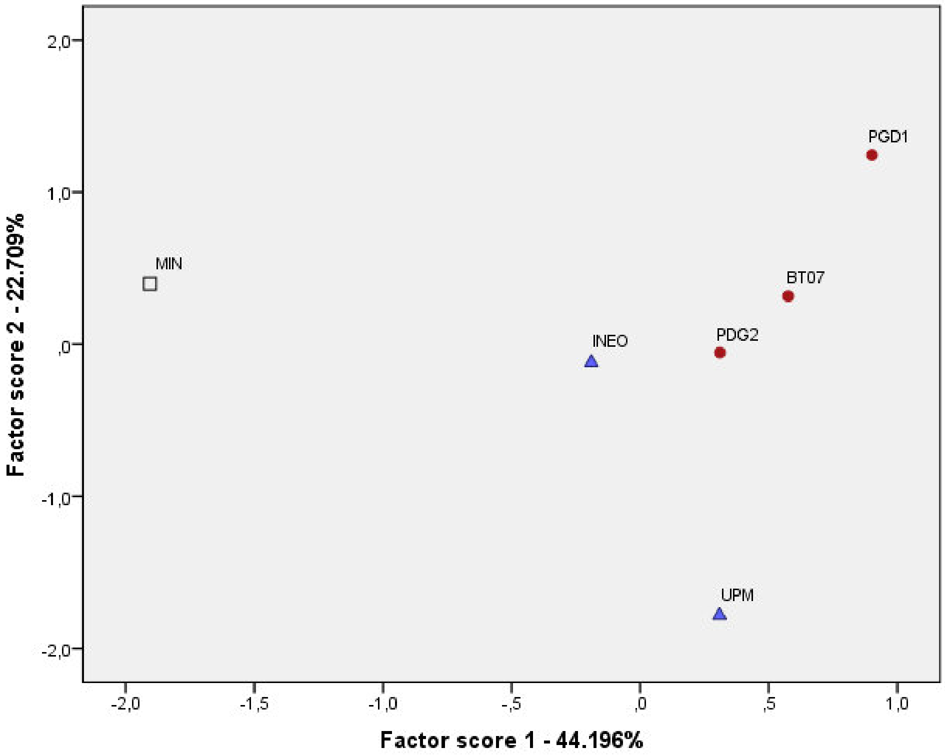

Figure A1.7 – Scatterplot of the two first components extracted in the comparison of the samples for PCA C.

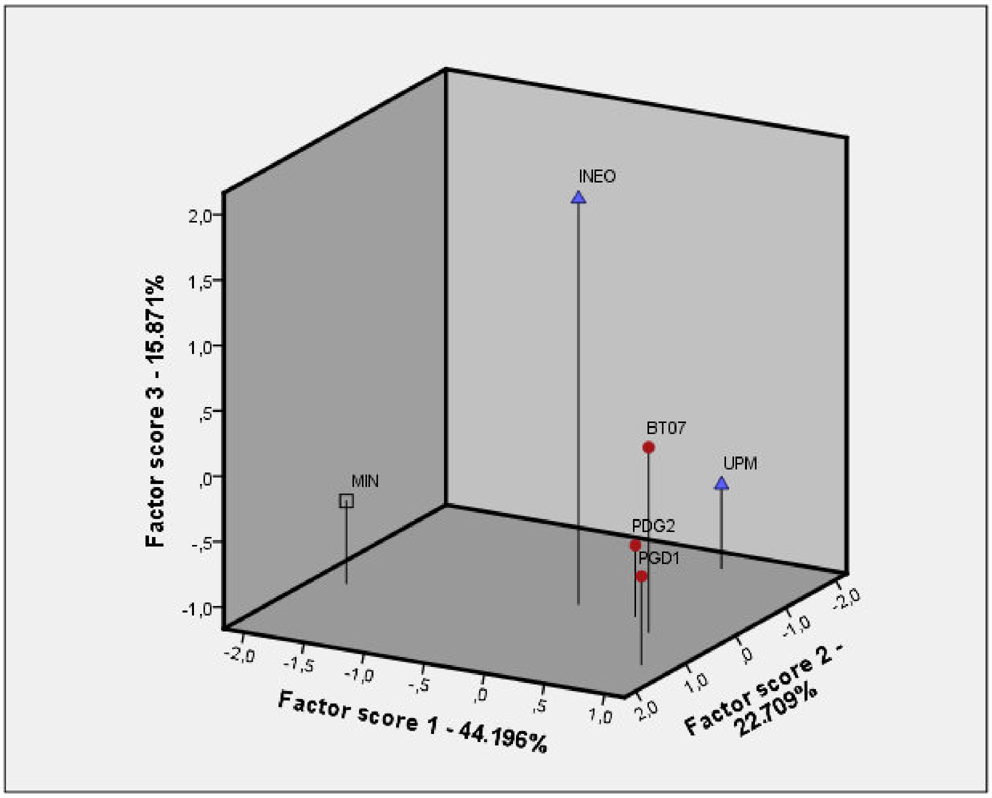

Figure A1.8 – PCA C – Scatterplot of the three first components extracted in the comparison of the samples for PCA C.

Comparisons of PDG1, PDG2 and BT07 to other samples dated to the 4th – 3rd Millennium BC

PCA D

Table A1.9 – Samples from other sources used in PCA E:

Acronym	Sample	Region – Country	Chronology	Reference
HRK	Hierakonpolis	Upper Egypt	3500-3200 cal. BC.	Irish, 2006; Irish and Friedman, 2010
NAQ	Naqada		4000-3200 cal. BC.	
TAR	Tarkhn	Lower Egypt	3000-2890 cal. BC.	Irish, 2006
SAQ	Saqqara		2613-2494 cal. BC.	
AGR	A-Group	Sudan	c. 3000 BC.	Irish, 2005
KAW	Kawa		2500-1750 cal. BC.	Irish and Friedman, 2010
SBA	Syrian Bronze Age	Syria	c. 2700-1200	Soltysiak and Bialon, 2013
DAN	Danish sample	Denmark	Neolithic	Christy Turner's database

Table A1.10 – Matrix of the component loadings, eigenvalues and variances of PCA D.

Traits	BKP	Component		
		1	2	3
UI1 shoveling	+= ASU 2-6	-.272	-.106	**.842**
UI1 *tuberculum dentale*	+= ASU 2-6	**.894**	-.266	.148
UI2 interruption groove	+= ASU +	.206	**-.739**	.057
UC mesial accessory ridge	+= ASU 1-3	**-.654**	-.042	**-.535**
UM1 Carabelli's trait	+= ASU 2-7	**.915**	.239	-.206
LC 2-rooted	+= ASU +	**.574**	**.512**	-.306
LP2 cusp variation	+= ASU 2-9	**-.537**	.297	-.455
LM1 *metaconulid* (C7)	+= ASU 2-4	.106	**.869**	.389
LM1 3-rooted	+= ASU +	-.279	**.639**	**.556**
LM2 Y-pattern	+= ASU Y	.103	**.655**	-.312
Eigenvalue:		2.898	2.630	1.922
Variance (%):		28.982	26.303	19.221
Total variance (%):		28.982	55.285	74.506

Principal Components Analysis. 4 components extracted. Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. Matrix of 3 out of 4 components extracted.

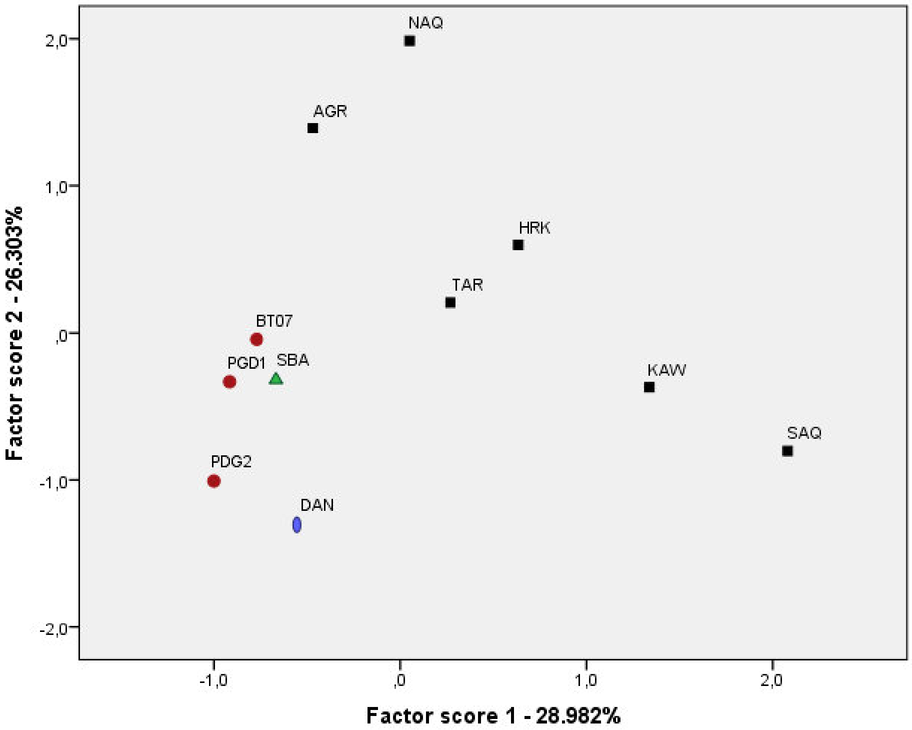

Figure A1.9 – Scatterplot of the two first components extracted in the comparison of the samples for PCA D.

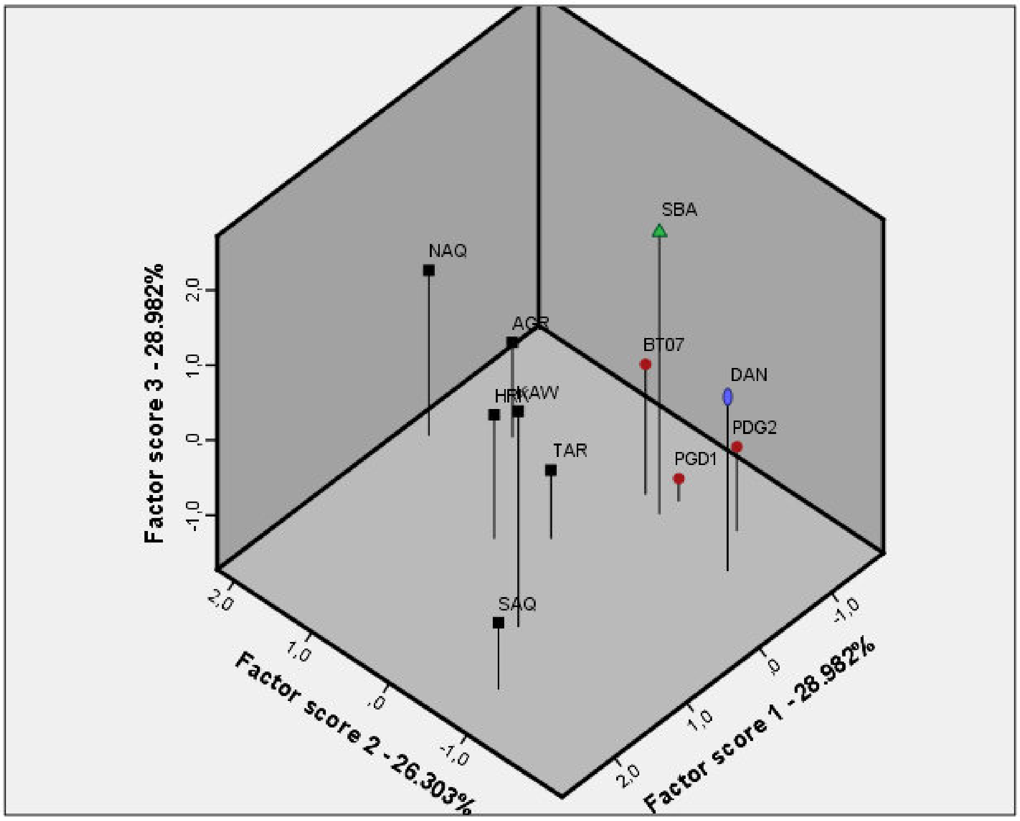

Figure A1.10 – Scatterplot of the three first components extracted in the comparison of the samples for PCA D.

PCA E

Table A1.11 – Samples from other sources used in PCA F:

Acronym	**Sample**	**Region – Country**	**Chronology**	**Reference**
CM	Cova da Moura	Estremadura, Portugal.	3636-2205 cal. BC	Silva, 2002.
DEA	Dolmen of Estrada de Anciāo		3637-3094 cal. BC	
PM	Tholos of Pai Mogo I		3077-2475 cal. BC	
SP	São Paulo II	Setubal, Portugal	2553-1950 cal. BC	
MC1	Monte Canela I	Algarve, Portugal	3379-2900 cal. BC	
SAD	S'Aigua Dolça	Majorca, Spain	3380+/-40 cal. BP.	García-Sívoli, 2009.

Table A1.12 – Matrix of the component loadings, eigenvalues and variances of PCA E

Traits	BKP	Component		
		1	2	3
UM1 C5	+= ASU 1-5	.393	**.784**	.051
UM2 3-cusped	+= ASU 0-1	.446	-.015	**-.847**
LP2 cusp variation	+= ASU 2-9	**-.784**	.243	.277
LM1 C6	+= ASU 1-5	-.348	**.654**	-.210
LM1 C7	+= ASU 1-4	**.516**	**.722**	.313
LM1 5-cusp	+= ASU 5+	**.949**	.046	.017
LM2 4-cusped	+= ASU 4+	**.682**	-.441	.476
Eigenvalue:		2.722	1.819	1.166
Variance (%):		38.890	25.990	64.880
Total variance (%):		38.890	16.652	81.532

Principal Components Analysis. 3 components extracted. Highlighted figures represent strong positive (> 0.5; boldface and underline) and strong negative (< -0.5; boldface only) loadings within each component.

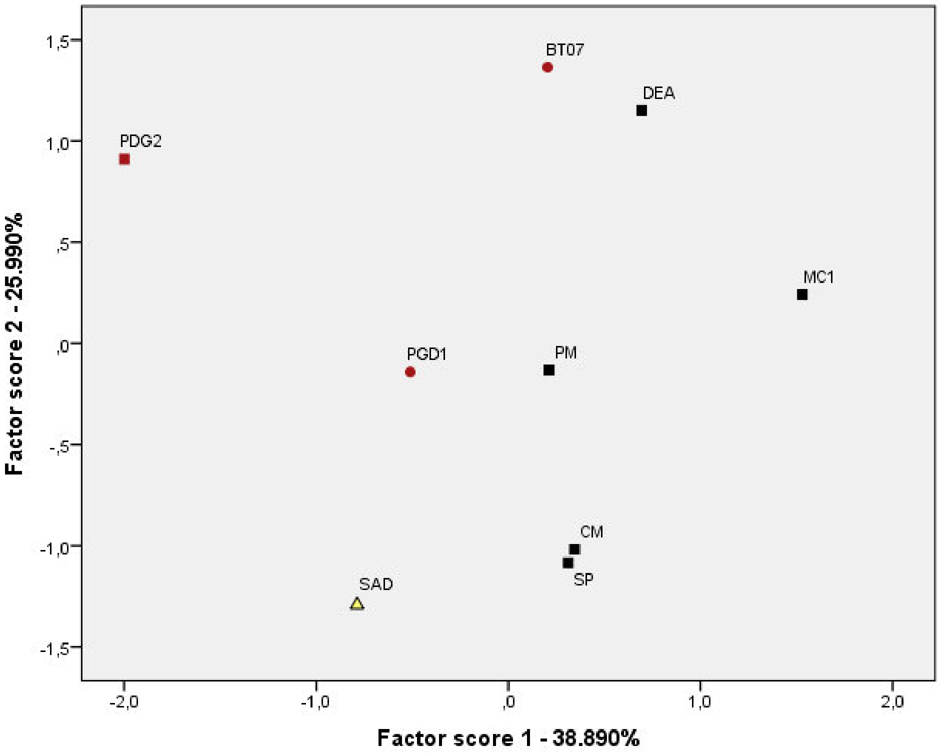

Figure A1.11 – Scatterplot of the three first components extracted in the comparison of the samples for PCA E.

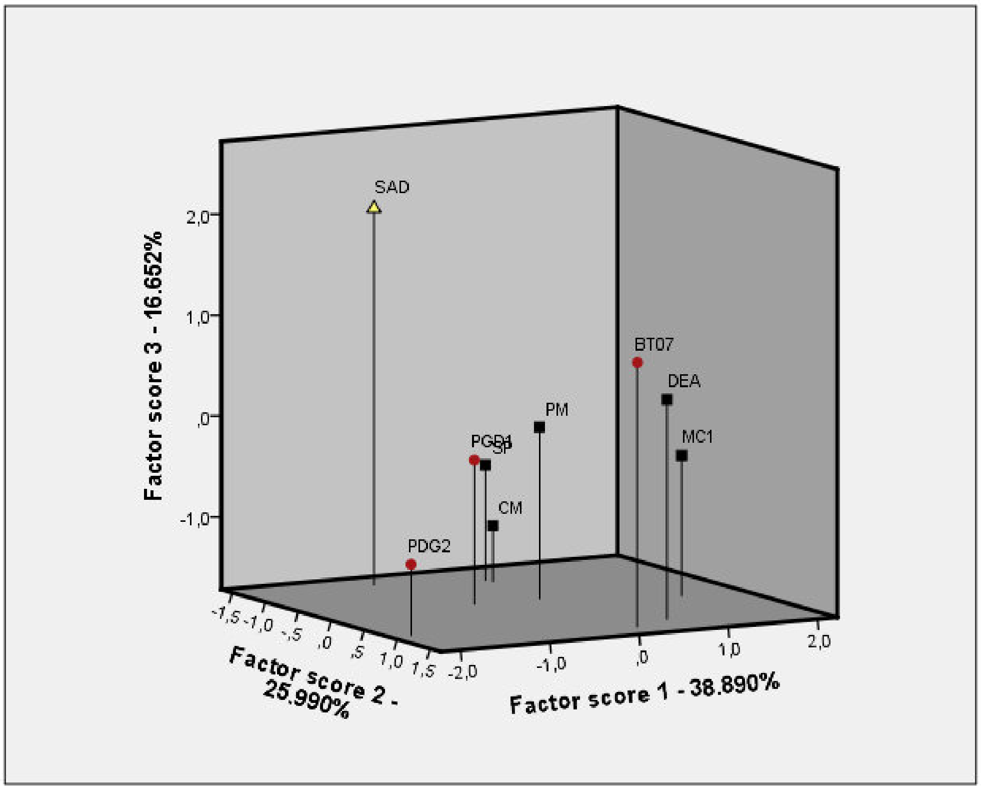

Figure A1.12 – Scatterplot of the three first components extracted in the comparison of the samples for PCA E.

PCA F

Table A1.13 – Samples from other sources used in PCA G:

Acronym	Sample	Region – Country	Chronology	Reference
PM	Paimogo I *Tholos*	Almada, Estremadura, Portugal.	3077-2475 cal. BC	Silva, 2002.
SP	São Paulo II	Lourinhã, Setubal, Portugal	2553-1950 cal. BC	
OA2	Outeiro Alto 2	Serpa, Alentejo, Portugal	2480-2297 cal. BC	Fernandes, 2013
LON	Longar	Basque Country, Spain	2495+/-70 – 2630+/-90 cal. BC	Rivera, 2011

Table A1.14 – Matrix of the component loadings, eigenvalues and variances of PCA F.

		Component		
		1	2	3
UM1 Carabelli's trait	+= ASU 5-7	<u>**.756**</u>	.464	.007
LP2 cusp variation	+= ASU 2-9	<u>**.705**</u>	.370	.258
LM1 C6	+= ASU 1-5	<u>**.716**</u>	**-.616**	-.097
LM1 C7	+= ASU 1-4	-.010	-.270	<u>**.958**</u>
LM1 C5	+= ASU 1-5	**-.693**	-.382	.012
LM1 4-cusped	+= ASU 4+	<u>**.775**</u>	.340	.114
LM2 4-cusped	+= ASU 4+	**-.752**	.341	.339
LM2 Y pattern	+= ASU Y	**-.769**	<u>**.579**</u>	-.086
Eigenvalue:		3.818	1.517	1.129
Variance (%):		47.724	18.960	14.115
Total variance (%):		47.724	66.684	80.798

Principal Components Analysis. 3 components extracted. Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. Matrix of 3 out of 4 components extracted.

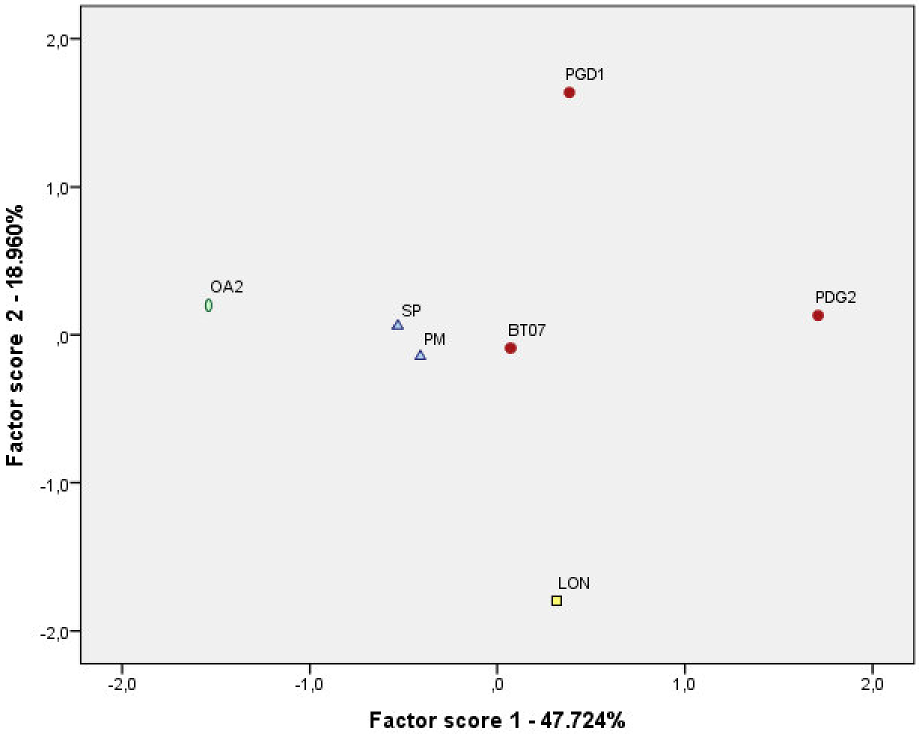

Figure A1.13 – Scatterplot of the two first components extracted in the comparison of the samples for PCA F.

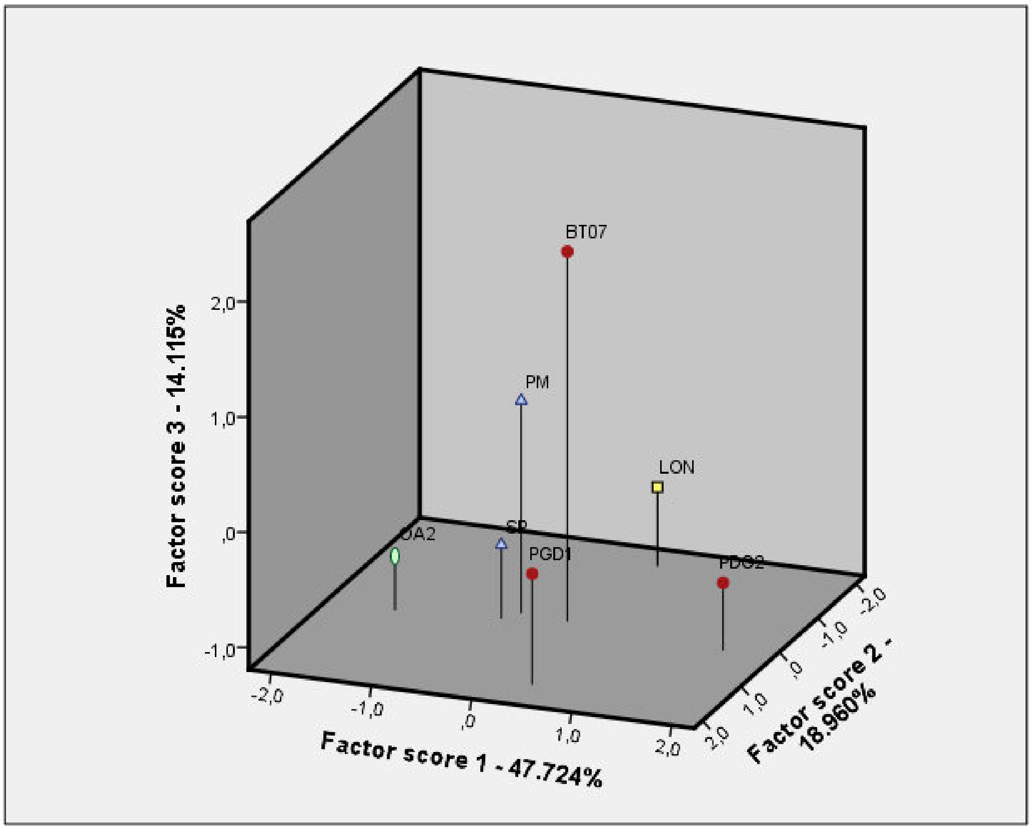

Figure A1.14 – Scatterplot of the three first components extracted in the comparison of the samples for PCA F.

PCA G

Table A1.15 – Samples from other sources used in PCA G:

Acronym	Sample	Region – Country	Chronology	Reference
HRK	Hierakonpolis	Upper Egypt	3500-3200 cal. BC.	Irish, 2006; Irish and Friedman, 2010
NAQ	Naqada		4000-3200 cal. BC.	
TAR	Tarkhn	Lower Egypt	3000-2890 BC.	Irish, 2006
SAQ	Saqqara		2613-2494 BC.	
AGR	A-Group	Sudan	3000 BC.	Irish, 2005.
KAW	Kawa		2500-1750 BC.	Irish and Friedman, 2010
SBA	Syrian Bronze Age	Syria	c. 2700-1200 BC	Soltysiak and Bialon, 2013
DAN	Danish sample	Denmark	Neolithic	Christy Turner's database

Table A1.16 – Matrix of the component loadings, eigenvalues and variances of PCA G.

Traits	BKP	Component		
		1	2	3
UI1 shoveling	+= ASU 2-6	-.272	-.106	**.842**
UI1 *tuberculum dentale*	+= ASU 2-6	**.894**	-.266	.148
UI2 interruption groove	+= ASU +	.206	**-.739**	.057
UC mesial accessory ridge	+= ASU 1-3	**-.654**	-.042	**-.535**
UM1 Carabelli's trait	+= ASU 2-7	**.915**	.239	-.206
LC 2-rooted	+= ASU +	**.574**	**.512**	-.306
LP2 cusp variation	+= ASU 2-9	**-.537**	.297	-.455
LM1 *metaconulid* (C7)	+= ASU 2-4	.106	**.869**	.389
LM1 3-rooted	+= ASU +	-.279	**.639**	**.556**
LM2 Y-pattern	+= ASU Y	.103	**.655**	-.312
Eigenvalue:		2.898	2.630	1.922
Variance (%):		28.982	26.303	19.221
Total variance (%):		28.982	55.285	74.506

Principal Components Analysis. 4 components extracted. Highlighted figures represent strong positive (> 0.5; boldface and underline) and strong negative (< -0.5; boldface only) loadings within each component. Matrix of 3 out of 4 components extracted.

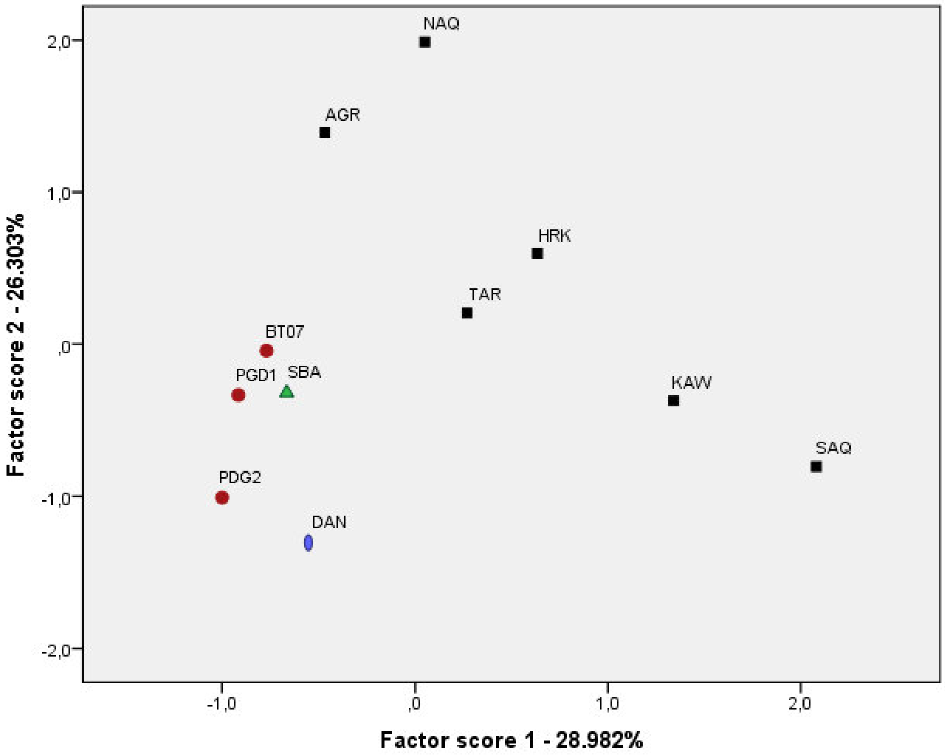

Figure A1.15 – Scatterplot of the two first components extracted in the comparison of the samples for PCA G.

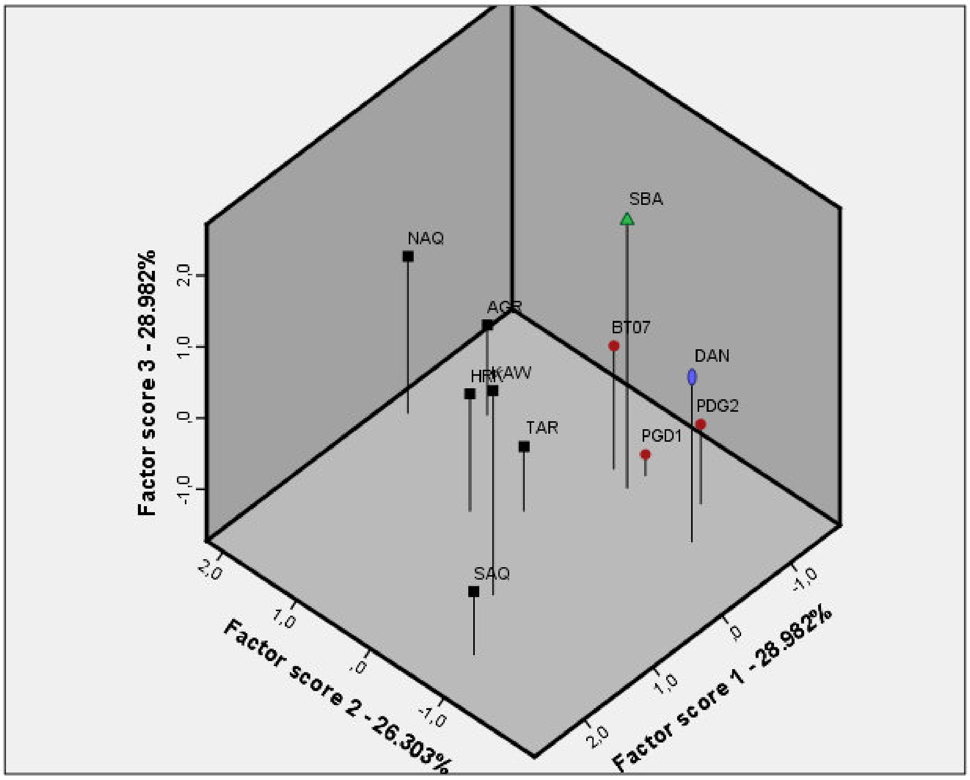

Figure A1.16 – Scatterplot of the three first components extracted in the comparison of the samples for PCA G.

Comparisons of PDG1, PDG2 and BT07 to other samples dated to the 2nd – 1st Millennium BC

PCA H

Table A1.17 – Samples from other sources used in PCA H

Acronym	Sample	Region – Country	Chronology	Reference
SRE	Son Real	Majorca, Spain	6th 2nd centuries cal. BC.	García-Sívoli, 2009.
IDP	S'Ilot des Porros		6th 2nd centuries cal. BC.	
GRK2	Greece 2	Greece	III-II Millennium cal. BC.	Parras, 2004.
LNA	La Navilla	Granada, Spain	early 2nd millennium BC.	Oumaoui, 2009.
CDN	Cuesta del Negro		1645+/-35 cal. BC.	
MOA	Motilla del Azuer	Castilla la Macha, Spain	2200-1350 cal. B.C.	

Table A1.18 – Matrix of the component loadings, eigenvalues and variances of PCA H.

Traits	BKP	Component		
		1	2	3
UI1 Shoveling	+= ASU 2-6	-.467	**.790**	-.230
UI1 Labial Convexity	+= ASU 2-4	**-.626**	.279	.219
UI1 double shoveling	+= ASU 2-6	**.628**	.328	.303
UI2 interruption groove	+= ASU +	-.084	**.641**	-.140
UC distal accessory ridge	+= ASU 2-5	**.594**	**.644**	.365
UP1 Accessory tubercle	+= ASU +	**.929**	.226	.170
UM2 hypocone	+= ASU 3-5	**-.915**	.059	-.031
UM3 parastyle	+= ASU 2-5	**-.518**	**.567**	.083
LC distal accessory ridge	+= ASU 2-5	**.800**	.420	.256
LP2 cusp variation	+= ASU 2-9	-.107	.278	**.893**
LM1 Y-pattern	+= ASU Y	**.748**	-.445	-.151
LM1 distal trigonid crest	+= ASU +	-.329	-.447	**.719**
LM2 Y-pattern	+= ASU Y	**.875**	-.203	-.108
LM3 Y-pattern	+= ASU Y	-.349	**-.582**	**.569**
	Eigenvalue:	5.540	3.043	2.120
	Variance (%):	39.569	21.738	15.145
	Total variance (%):	39.569	61.307	76.452

Principal Components Analysis. 4 components extracted. Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. Matrix of 3 out of 4 components extracted.

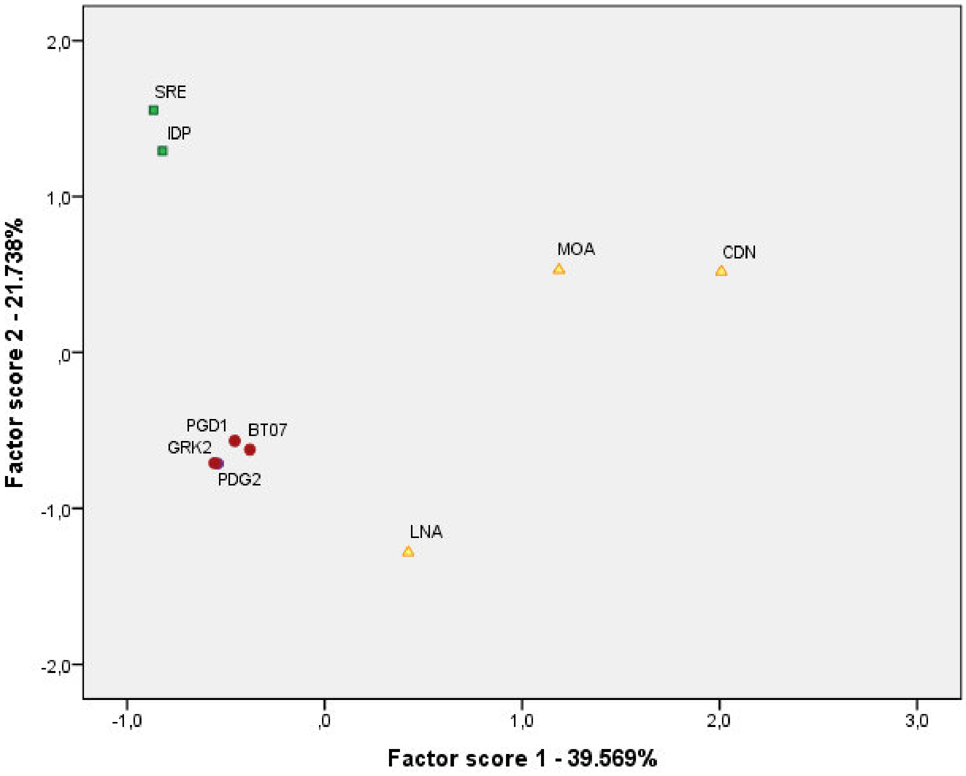

Figure A1.17 – Scatterplot of the two first components extracted in the comparison of the samples for PCA H.

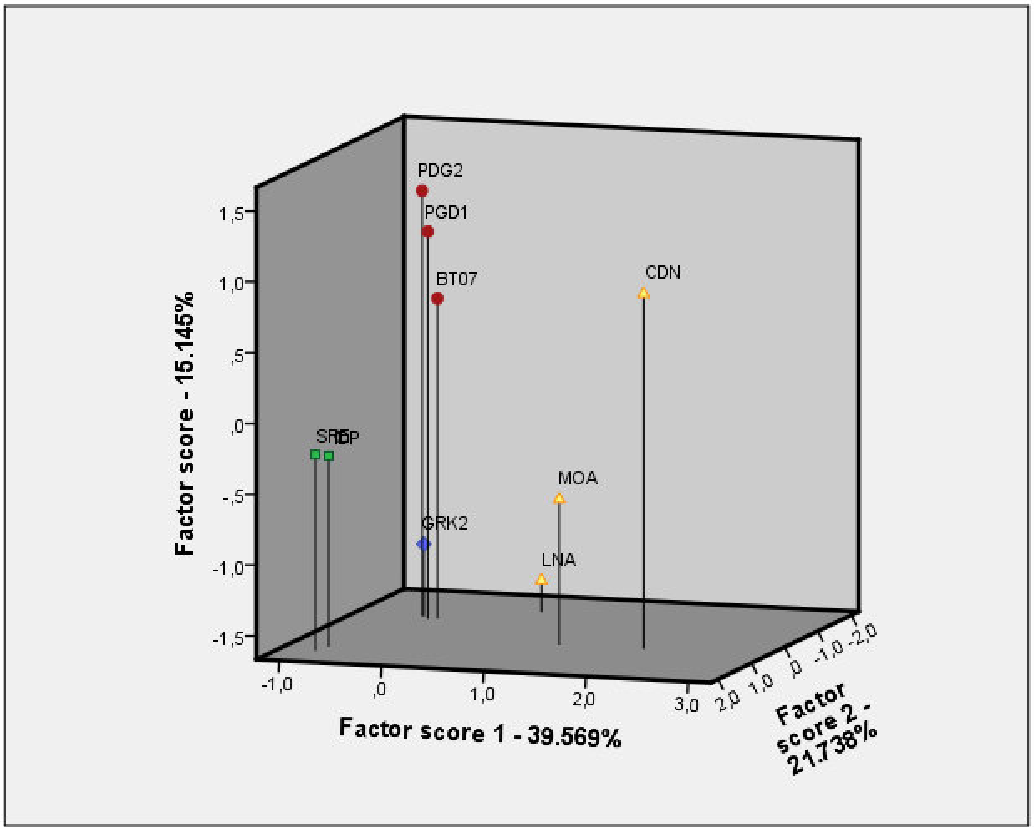

Figure A1. 18 – Scatterplot of the three first components extracted in the comparison of the samples for PCA H.

PCA J

Table A1.19 – Samples from other sources used in PCA I:

Acronym	**Sample**	**Region – Country**	**Chronology**	**Reference**
LAC	Recent Latini	Italy	4th–2nd century cal. BC.	Coppa et al., 1998.
ETB	Ancient Etruscans		Middle 7th-5th century BC.	
ETC	Recent Etruscans		4th–2nd century cal. BC.	
PCB	Ancient Piceni		Middle 7th-5th century	
PCC	Recent Picenni		4th–2nd century cal. BC.	
SANT	Santini		Middle 7th-5th century	
SRE	Son Real	Majorca, Spain	6th 2nd centuries cal. BC.	García-Sívoli, 2009.
IDP	S'Ilot des Porros			
SMBA	Syrian Middle Bronze Age	Syria	Bronze Age, c. 2000-1200	Soltysiak and Bialon, 2013

Table A1.20 – Matrix of the component loadings, eigenvalues and variances of PCA I.

Traits	BKP	Component		
		1	2	3
UI1 *tuberculum dentale*	+= ASU 2-6	**.650**	**.615**	-.328
UI2 *tuberculum dentale*	+= ASU 2-6	**.535**	.153	-.067
UI2 shoveling	+= ASU 3-6	-.430	**.818**	.263
UI2 interruption groove	+= ASU +	.341	.497	**.714**
UC *tuberculum dentale*	+= ASU 2-6	.449	**.823**	.039
UM1 Carabelli's trait	+= ASU 2-7	**.912**	-.195	-.270
UM1 metaconule (C5)	+= ASU 1-5	**.806**	.001	.277
LC distal accessory ridge	+= ASU 2-5	**.627**	**.530**	-.454
LP2 cusp variation	+= ASU 2-9	**-.741**	-.319	-.354
LM1 protostylid	+= ASU 1-6	**.647**	**-.553**	-.163
LM1 Y-pattern	+= ASU Y	**.905**	-.270	.078
LM3 protostylid	+= ASU 2-6	**.908**	.106	-.065
LM3 Y-pattern	+= ASU Y	.489	**-.659**	.319
LM2 Y-pattern	+= ASU Y	.341	**-.679**	.248
Eigenvalue:		6.053	3.701	1.374
Variance (%):		43.236	26.434	9.815
Total variance (%):		43.236	69.669	79.485

Principal Components Analysis. 4 components extracted. Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. Matrix of 3 out of 4 components extracted.

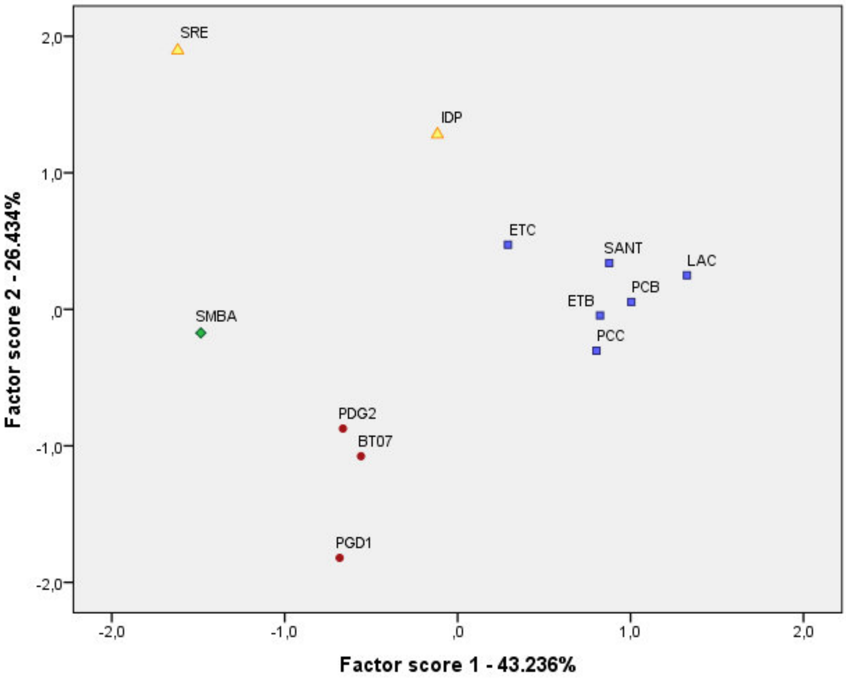

Figure A1.19 – Scatterplot of the two first components extracted in the comparison of the samples for PCA I.

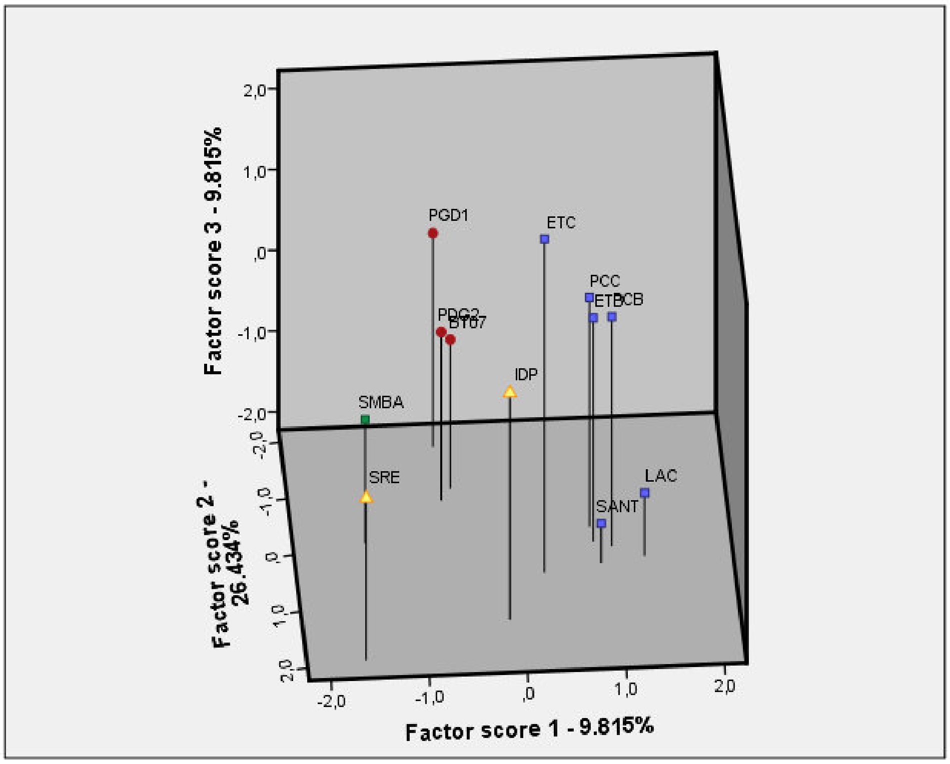

Figure A1.20 – Scatterplot of the three first components extracted in the comparison of the samples for PCA I.

Comparisons of PDG1, PDG2 and BT07 to other samples dated to the 1st Millennium AD to the Modern Ages

PCA J

Table A1.21 – Samples from other sources used in PCA J:

Acronym	Sample	Region – Country	Chronology	Reference
SAM	Saami (Lapp)	Arctic Europe	Medieval-Modern (?).	Christy Turner's database
KAR	Karelian	Northern Europe		
NETH	Netherlands			
ESTO	Estonia			
POU	Poundbury	England		
SAI	South African Iron Age	South Africa	250-1350 AD	Warren, 2013
TOR	La Torrecilla	Granada, Spain	Medieval (Islamic).	Oumaoui, 2009
SBM	Sahl ben Malik			
SOP	Villanueva de Soportilla	Burgos, Spain	Medieval.	

Table A1.22 – Matrix of the component loadings, eigenvalues and variances of PCA J.

Traits	BKP	Component		
		1	2	3
UI1 double shoveling	+= ASU 2-6	-.386	.029	**.664**
UI2 interruption groove	+= ASU +	**-.645**	**.621**	.014
UC mesial accessory ridge	+= ASU 1-3	**.856**	.395	-.078
UM2 hypocone	+= ASU 3-5	.215	**.693**	**-.565**
UM3 parastyle	+= ASU 2-6	**.636**	**.674**	.146
UM3 Peg	+= ASU 1-2	-.198	.260	**.794**
UM3 congenial absence	+= ASU +	**-.755**	.272	.099
LC 2-rooted	+= ASU +	**-.858**	.185	-.133
LP1 Tomes's root	+= ASU 3-5	-.419	**.635**	-.460
LP2 cusp variation	+= ASU 2-9	.498	**-.667**	-.041
LM1 6-cusped	+= ASU 6+	.474	**.658**	**.508**
LM2 4-cusped	+= ASU 4+	.486	-.206	.019
LM2 Y-pattern	+= ASU Y	**.892**	.334	.063
Eigenvalue:		4.775	3.087	1.921
Variance (%):		36.731	23.743	14.777
Total variance (%):		36.731	60.474	75.250

Principal Components Analysis. 4 components extracted. Highlighted figures represent strong positive (> 0.5; boldface and underline) and strong negative (< -0.5; boldface only) loadings within each component. Matrix of 3 out of 4 components extracted.

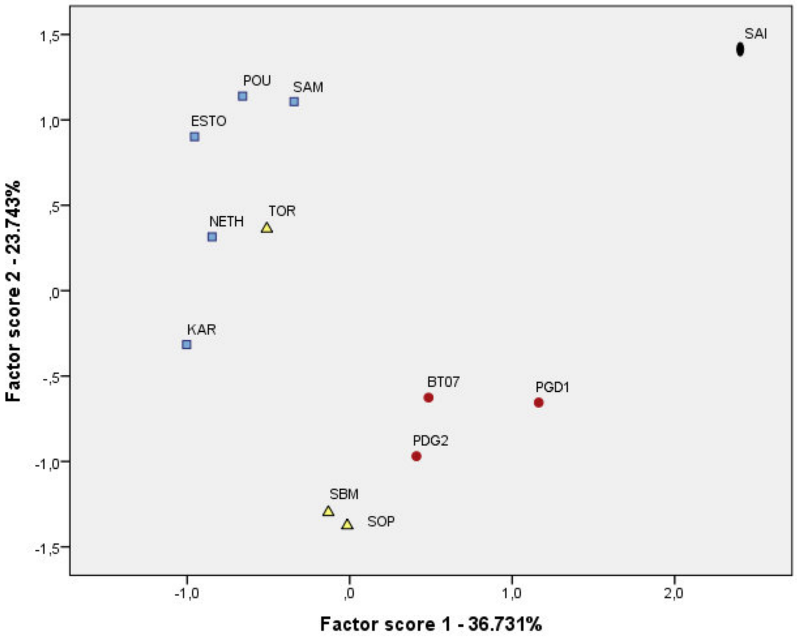

Figure A1.21 – Scatterplot of the two first components extracted in the comparison of the samples for PCA J.

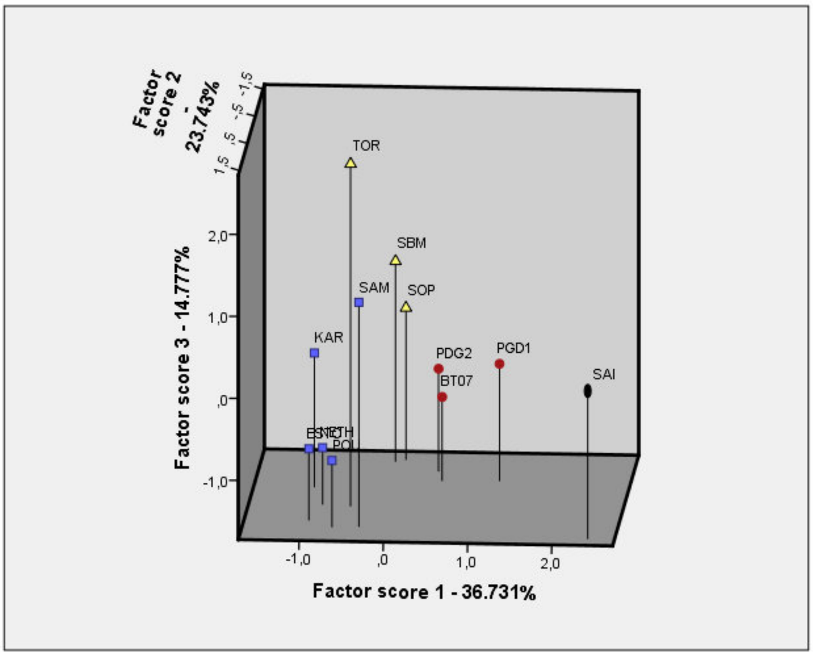

Figure A1. 22 – Scatterplot of the two first components extracted in the comparison of the samples for PCA J.

PCA K

Table A1.23 – Samples from other sources used in PCA K:

Acronym	Sample	Region – Country	Chronology	Reference
WHI	Whithorn	Whithorn, Scotland.	Medieval	Adler, 2005
ABE	Aberdeen	Aberdeen, Scotland.		
STA	St. Andrew	St. Andrew, Scotland.		
LIN	Linlithgow	Linlithgow, Scotland.		
SEI	Syrian Early Islamic Period	Syria	Islamic Period, c. AD 600-1200	Soltysiak and Bialon, 2013
SCLA	Syrian Classical and Late Antiquity	Syria	300 BC-AD600	

Table A1.24 – Matrix of the component loadings, eigenvalues and variances of PCA K.

Traits	BKP	Component		
		1	2	3
UI1 Shoveling	+= ASU 2-6	**.848**	-.073	-.399
UI2 *tuberculum dentale*	+= ASU 2-6	**-.714**	-.091	.491
UI2 interruption groove	+= ASU +	**.770**	**.586**	.097
UC mesial accessory ridge	+= ASU 1-3	-.309	**.655**	**-.602**
UM1 Carabelli’s trait	+= ASU 2-7	.261	**.911**	-.130
UM1 metaconule (C5)	+= ASU 1-5	**.916**	.133	.235
LC 2-rooted	+= ASU +	**.578**	-.001	**.729**
LP2 cusp variation	+= ASU 2-9	**-.748**	.403	.485
LM1 *metaconulid* (C7)	+= ASU 2-4	**.509**	**-.705**	-.270
LM1 protostylid	+= ASU 1-6	-.167	**-.550**	-.315
LM1 6-cusped	+= ASU 6+	**.705**	.443	.271
LM2 Y-pattern	+= ASU Y	-.254	**.575**	-.091
LM1 3-rooted	+= ASU +	.259	**-.804**	.231
Eigenvalue:		4.633	3.770	1.917
Variance (%):		35.640	28.999	14.748
Total variance (%):		35.640	64.638	79.386

Principal Components Analysis. 4 components extracted. Highlighted figures represent strong positive (> 0.5; boldface and underline) and strong negative (< -0.5; boldface only) loadings within each component. Matrix of 3 out of 4 components extracted.

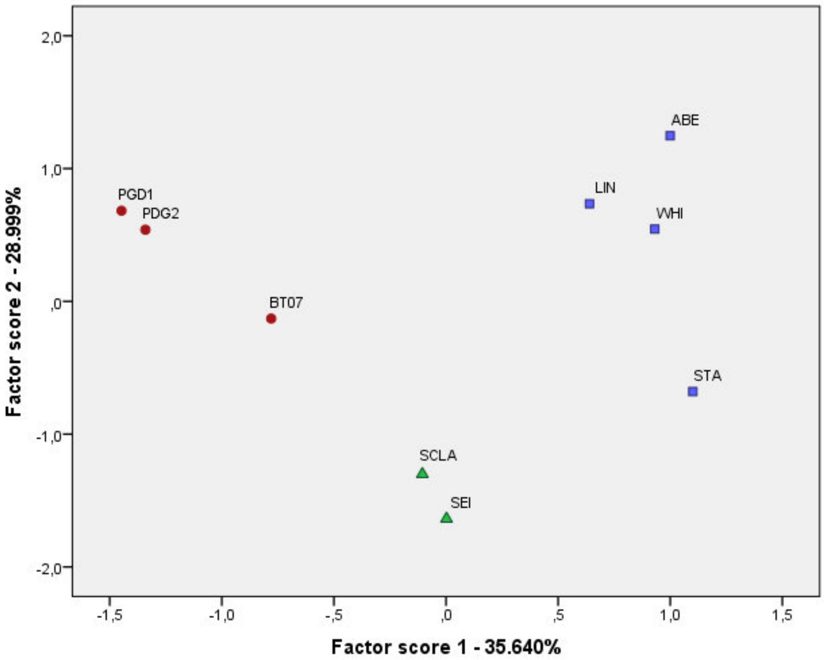

Figure A1.23 – Scatterplot of the two first components extracted in the comparison of the samples for PCA K.

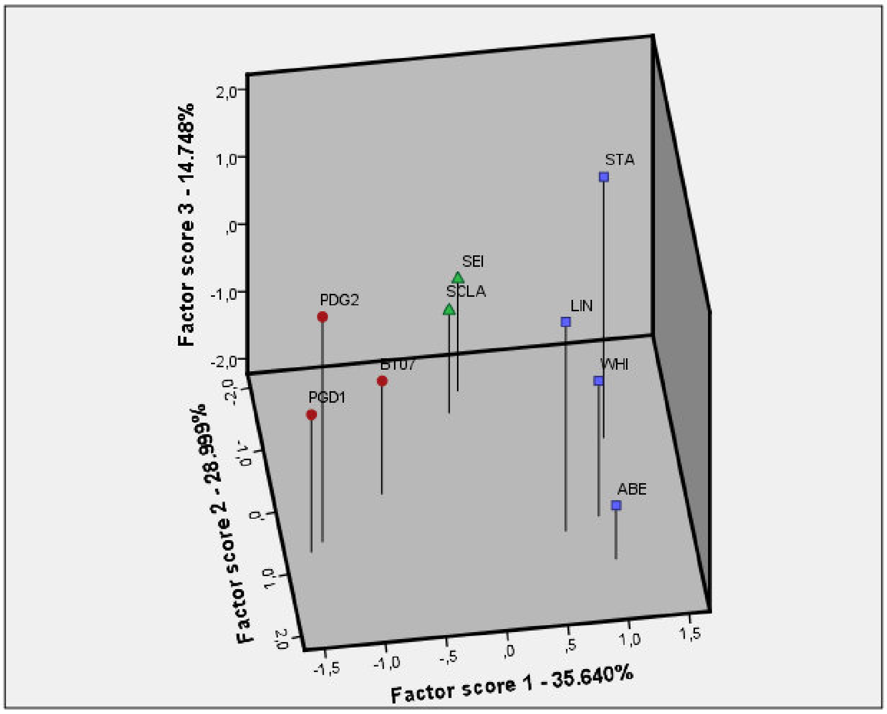

Figure A1.24 – Scatterplot of the three first components extracted in the comparison of the samples for PCA K.

PCA L

Table A1.25 – Samples from other sources used in PCA L:

Acronym	Sample	Region – Country	Chronology	Reference
TOR	La Torrecilla	Granada, Spain	Medieval (Islamic).	Oumaoui, 2009.
SBM	Sahl ben Malik			
SOP	Villanueva de Soportilla	Burgos, Spain	Medieval.	
CAS	Necropolis del Castillo			
RUS	Russian	Russia	Medieval-Modern (?)	Christy Turner's database
POU	Poundbury	England		
NETH	Netherlands	North Europe		
MER	Meroitic	Sudan	100 cal. BC - 350 AD	Irish, 1998a and 2005

Table A1.26 – Matrix of the component loadings, eigenvalues and variances of PCA L

		Component		
		1	2	3
UI1 shoveling	+= ASU 2-6	-.075	**.862**	.175
UI1 double shoveling	+= ASU 2-6	-.137	**-.718**	**.502**
UI2 interruption groove	+= ASU +	**.602**	**.500**	.463
UC *Bushmen* canine	+= ASU 1-3	**-.551**	**.723**	-.026
UP1 Odontome	+= ASU +	-.323	**.540**	**.599**
UM2 hypocone	+= ASU 3-5	.418	**.596**	**-.543**
UM1 enamel extension	+= ASU 1-3	**.867**	.326	-.073
UM3 congenial absence	+= ASU +	**.787**	-.191	.096
LC 2-rooted	+= ASU +	**.843**	-.027	.098
LP1 Tomes's root	+= ASU 3-5	**.736**	.258	-.250
LP2 cusp variation	+= ASU 2-9	**-.729**	.077	-.211
LM1 C7	+= ASU 2-4	-.094	**-.576**	.211
LM1 3-rooted	+= ASU 1-3	-.110	**-.773**	.192
LM1 *protostylid*	+= ASU 1-6	**-.865**	.199	-.062
LM1 6-cusped	+= ASU 6+	.319	-.165	**.540**
LM2 5-cusped	+= ASU 5+	-.315	**.631**	**.539**
LM2 Y pattern	+= ASU Y	-.159	-.186	**-.821**
	Eigenvalue:	5.118	4.321	2.623
	Variance (%):	30.107	25.420	15.429
	Total variance (%):	30.107	55.527	70.956

Principal Components Analysis. 4 components extracted. Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. Matrix of 3 out of 4 components extracted.

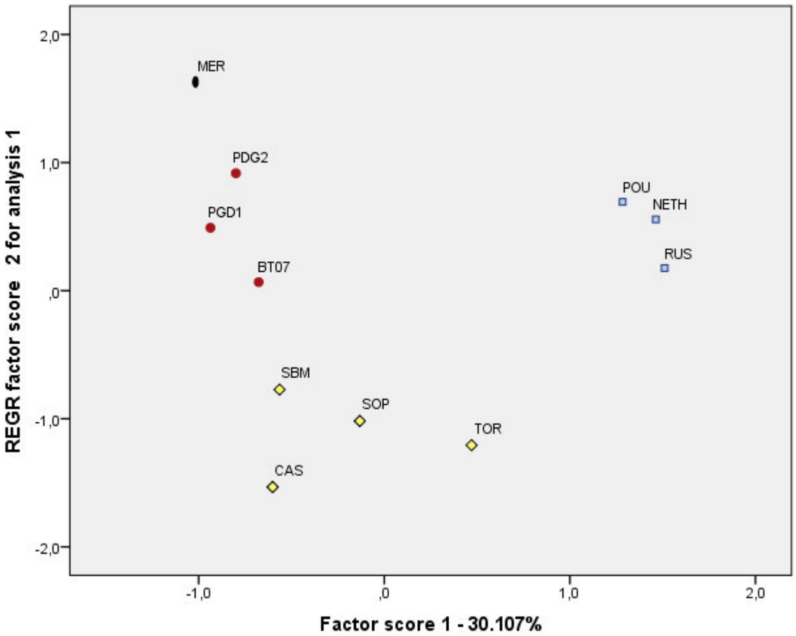

Figure A1.25 – Scatterplot of the two first components extracted in the comparison of the samples for PCA L.

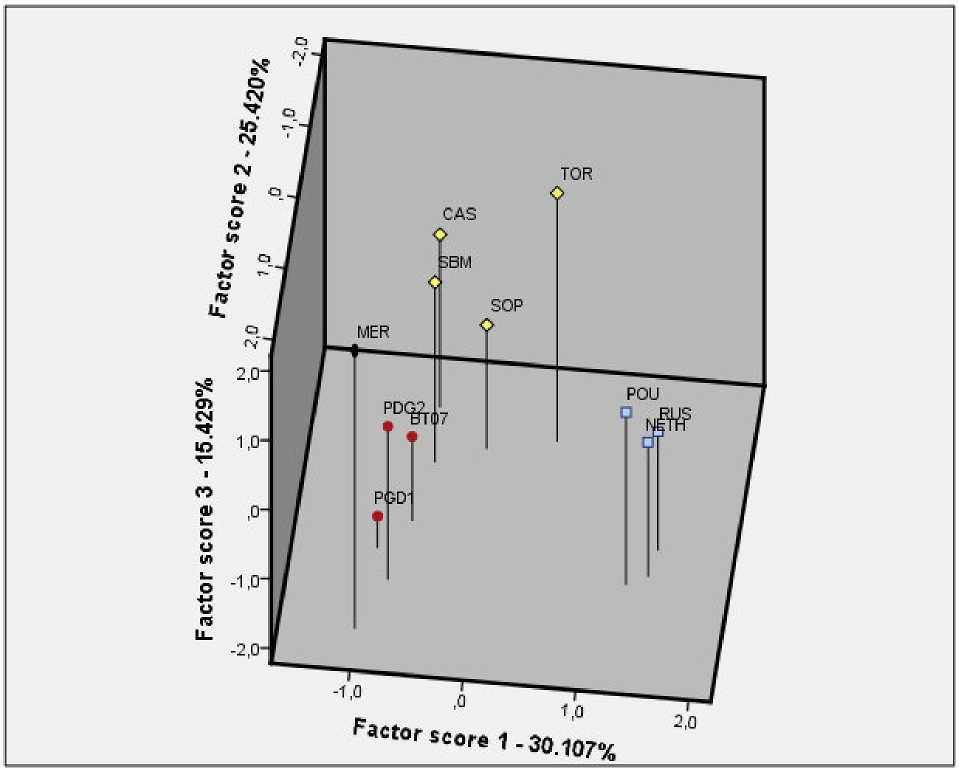

Figure A1.26 – Scatterplot of the three first components extracted in the comparison of the samples for PCA L.

PCA M

Table A1.27 – Samples from other sources used in PCA M:

Acronym	Sample	Region – Country	Chronology	Reference
SAM	Saami (Lapp)	Arctic Europe	Medieval-Modern (?).	Christy Turner's database
WHI	Whithorn	Scotland.	Medieval	Adler, 2005.
ABE	Aberdeen			
STA	St. Andrew			
CSM	Catedral de Santa Maria	Basque Country, Spain	11th-19th centuries.	Scott et al., 2013

Table A1.28 – Matrix of the component loadings, eigenvalues and variances of PCA M.

		Component		
		1	2	3
UI1 shoveling	+= ASU 3-6	-.364	**.874**	-,015
UI1 double shoveling	+= ASU 2-6	**.656**	**.627**	,166
UI2_TD2_6	+= ASU 2-6	**-.793**	.029	-,357
UI2_IntGr	+= ASU +	**.777**	.458	,152
UC Bushmen canine	+= ASU 1-3	-.090	-.386	**,667**
UM1 Carabelli's trait	+= ASU 2-7	-.032	-.020	**,549**
UM1 C5	+= ASU 1-5	**.935**	-.084	-,313
UM1 enamel extension	+= ASU 2-3	.302	**.867**	-,180
UM2 3-cusped	+= ASU 0-1	**-.855**	-.136	,136
UM3 congenial absence	+= ASU +	**.567**	.236	**,703**
LC 2-rooted	+= ASU +	**.513**	.079	**-,810**
LP1 Tomes's root	+= ASU 4-5	.141	-.092	,188
LP2 cusp variation	+= ASU 2-9	**-.762**	-.093	-,226
LM1 C7	+= ASU 2-4	.381	**-.656**	,018
LM1 3-rooted	+= ASU 1-3	.400	-.228	**-,754**
LM1 4-cusped	+= ASU 4+	**-.540**	**.730**	,221
LM2 4-cusped	+= ASU 2-4	.136	**-.952**	,107
LM2 Y pattern	+= ASU Y	-.189	-.014	,130
LM1 *protostylid*	+= ASU 2-6	**.785**	-.168	,340
Eigenvalue:		5,953	4.323	3.071
Variance (%):		31.333	22.751	16.165
Total variance (%):		31.333	54.084	70.248

Principal Components Analysis. 5 components extracted. Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. Matrix of 3 out of 5 components extracted.

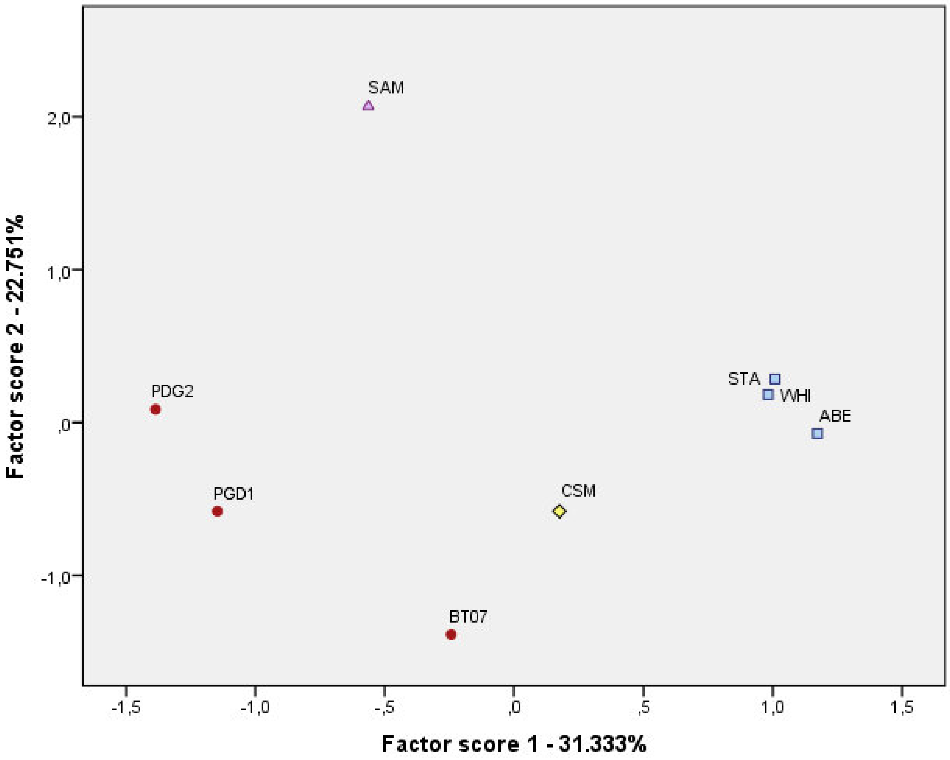

Figure A1.27 – Scatterplot of the two first components extracted in the comparison of the samples for PCA M.

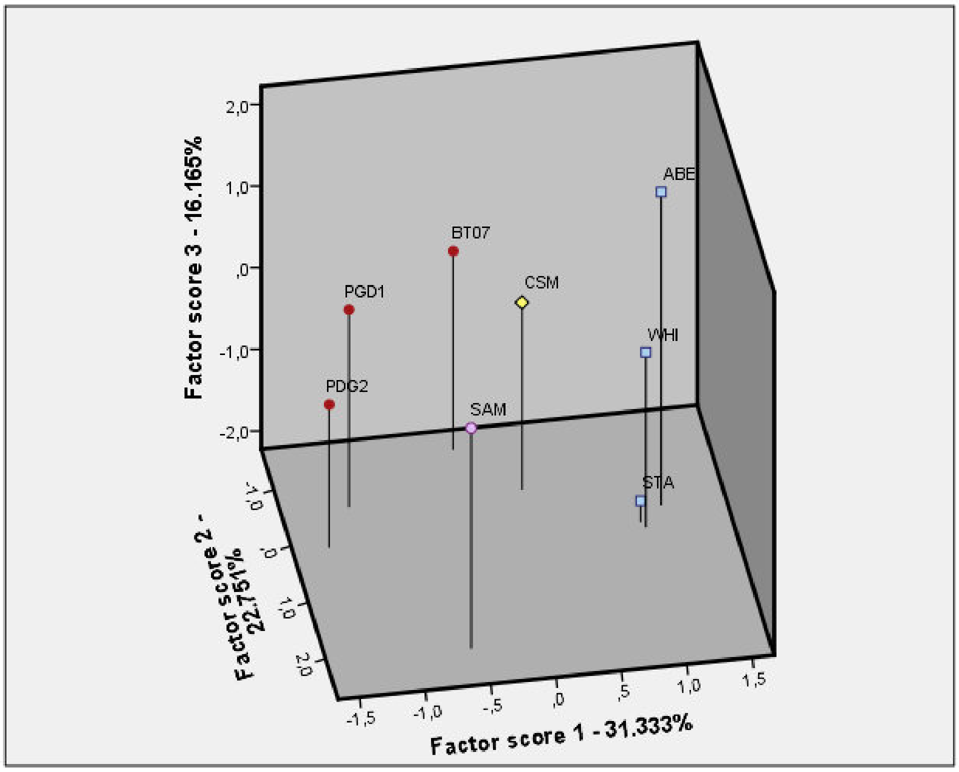

Figure A1.28 – Scatterplot of the three first components extracted in the comparison of the samples for PCA M.

Modern-Contemporary Samples

PCA N

Table A1.29 – Samples from other sources used in PCA N:

Acronym	Sample	Region – Country	Chronology	Reference
COI	Coimbra	Portugal	19th-20th centuries.	Marado, 2014
KEN	Kenya, Tanzania	Kenya, Tanzania, SSA	19th-20th century AD.	Irish, 1998a
POU	Poundbury	England	Medieval-Modern (?)	Christy Turner's database
RUS	Russian	Russia		
KAB	Kabyle	Algeria	19th-20th century AD.	Irish, 1998a

Table A1.30 – Matrix of the component loadings, eigenvalues and variances of PCA N.

Traits	BKP	Component		
		1	2	3
UI1 Shoveling	+= ASU 2-6	**-.558**	-.254	.161
UI1 double shoveling	+= ASU 2-6	**.723**	.497	.367
UI2 interruption groove	+= ASU +	-.262	**.847**	.051
UC distal accessory ridge	+= ASU 2-5	-.313	-.197	**-.883**
UP odontome	+= ASU +	**.835**	-.363	-.205
UM1 enamel extension	+= ASU 1-3	-.144	**.768**	-.358
UM2 hypocone	+= ASU 3-5	**.827**	-.039	.076
LP2 cusp variation	+= ASU 2-9	**-.832**	-.191	.351
LM1 *metaconulid* (C7)	+= ASU 2-4	**.976**	.030	-.158
LM1 protostylid	+= ASU 1-6	-.107	**-.688**	**.629**
LM1 6-cusped	+= ASU 6+	.317	**.545**	**.586**
LM1 distal trigonid crest	+= ASU +	**-.629**	-.006	.369
LM2 5-cusped	+= ASU 5+	**.843**	.040	.246
LM2 Y-pattern	+= ASU Y	**.684**	**-.537**	-.042
Eigenvalue:		5.733	2.890	2.203
Variance (%):		40.948	20.641	15.738
Total variance (%):		40.948	61.589	77.328

Principal Components Analysis. 4 components extracted. Highlighted figures represent strong positive (> 0.5; boldface and underline) and strong negative (< -0.5; boldface only) loadings within each component. Matrix of the first 3 components extracted.

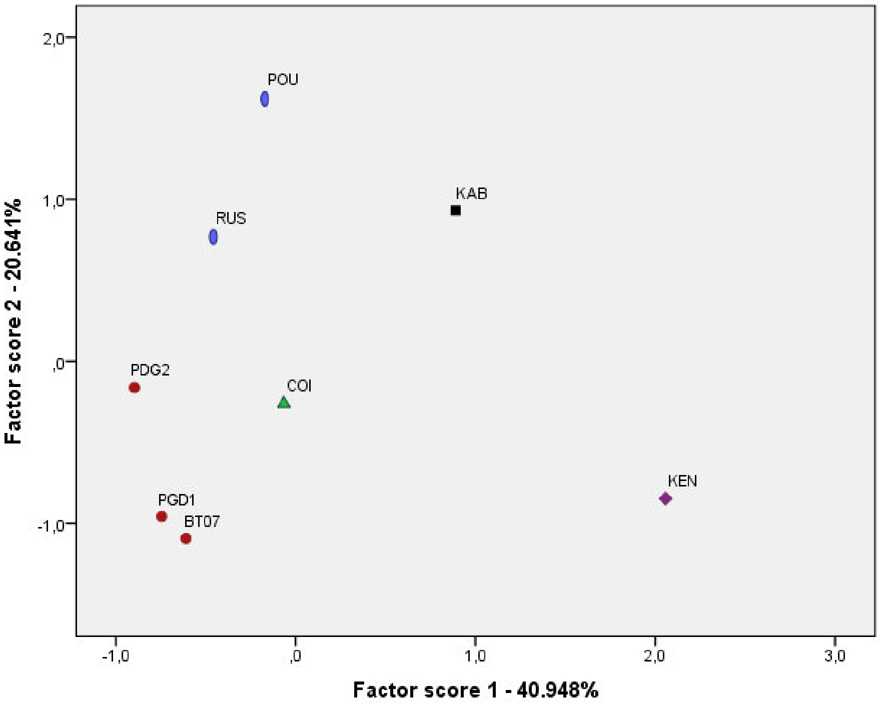

Figure A1.29 – Scatterplot of the two first components extracted in the comparison of the samples for PCA N.

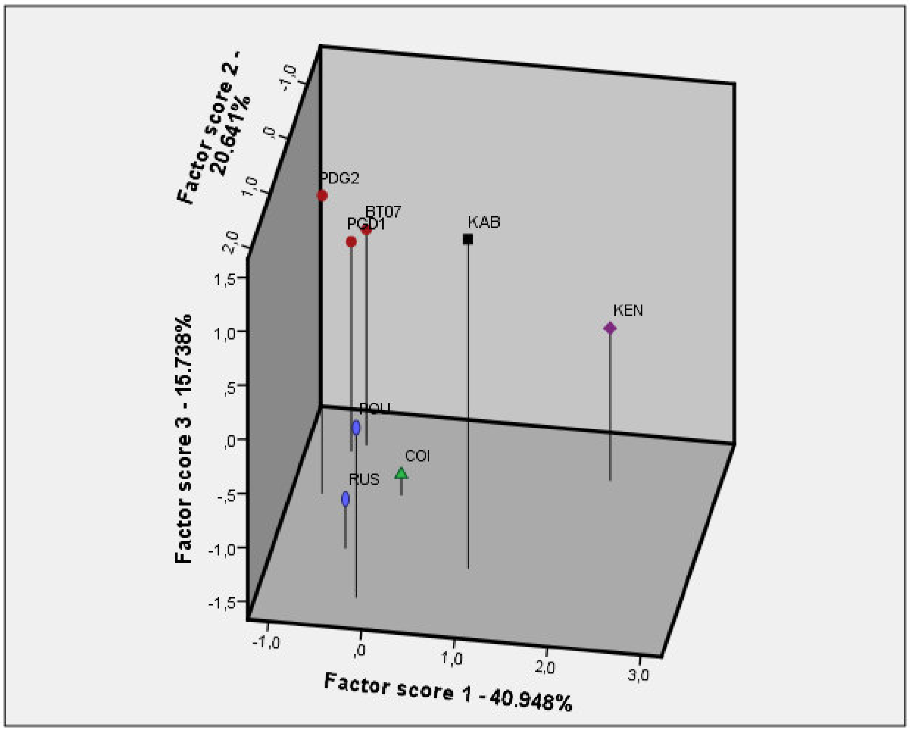

Figure A1.30 – Scatterplot of the three first components extracted in the comparison of the samples for PCA N.

PCAOP

Table A1.31 – Samples from other sources used in PCA P:

Acronym	Sample	Region – Country	Chronology	Reference
COI	Coimbra	Portugal	19th-20th centuries.	Marado, 2014
POR	Porto	Porto, North of Portugal	Modern - Contemporary	

Table A1.32 – Matrix of the component loadings, eigenvalues and variances of PCA O.

Traits	BKP	Component		
		1	2	3
Odontome	+=ASU +	**-.600**	**.637**	-.484
LC distal accessory ridge	+= ASU 2-5	**-.963**	.171	.135
LP2 cusp variation	+= ASU 2-9	**.939**	.274	-.104
LM1 *entoconulid* (C6)	+= ASU 1-5	**.647**	.391	**.571**
LM1 *metaconulid* (C7)	+= ASU 1-4	**-.981**	.028	.120
LM1 *anterior fovea*	+= ASU 1-4	**.856**	-.311	.366
LM1 protostylid	+= ASU 1-6	**.677**	**-.669**	-.135
LM1 *hypoconulid* (C5)	+= ASU 1-5	**-.772**	-.188	**.540**
LM1 Y-pattern	+= ASU Y	.319	**.701**	**-.582**
LM1 4-cusped	+= ASU 4+	**.750**	**.641**	.159
LM1 distal trigonid crest	+= ASU +	**.826**	.416	.220
LM2 5-cusped	+= ASU 5+	.341	**.906**	.042
LM2 Y-pattern	+= ASU Y	.361	**-.664**	**-.654**
LM3 5-Cusped	+= ASU 5+	.388	-.119	**.862**
LM3 *protostylid*	+= ASU 1-6	**.932**	-.358	-.034
LM3 Y-pattern	+= ASU Y	**.841**	-.118	-.375
Eigenvalue:		8.659	3.737	2.773
Variance (%):		54.120	23.353	17.334
Total variance (%):		54.120	77.473	94.807

Principal Components Analysis. 3 components extracted. Highlighted figures represent strong positive (> 0.5; boldface and underline) and strong negative (< -0.5; boldface only) loadings within each component.

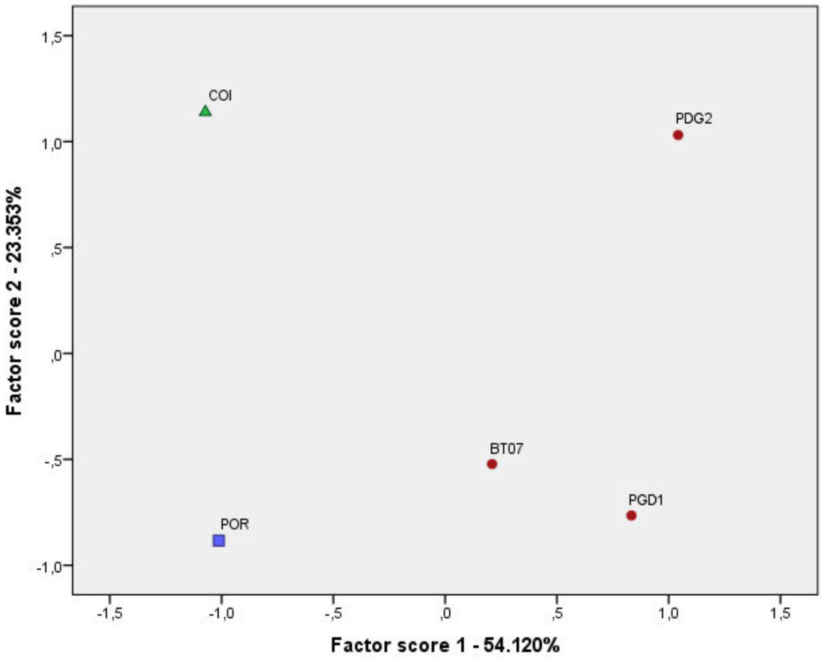

Figure A1.31 – Scatterplot of the two first components extracted in the comparison of the samples for PCA O.

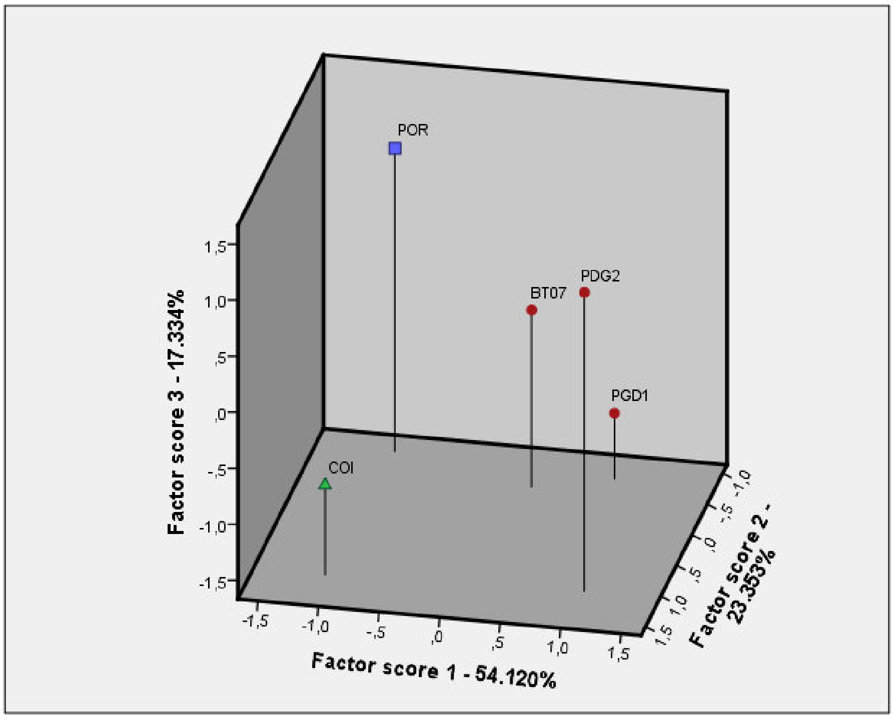

Figure A1.32 – Scatterplot of the three first components extracted in the comparison of the samples for PCA O.

PCA P

Table A1.33 – Samples from other sources used in PCA Q:

Acronym	Sample	Region – Country	Chronology	Reference
COI	Coimbra	Portugal	19th-20th centuries.	Marado, 2014
SPA	Spanish	Basque Country. Spain	Contemporary Spanish.	Scott et al., 2013
SPB	Spanish-Basque		Contemporary Spanish-Basque.	
BAS	Basque		Contemporary Basque.	
GHA	Ghana	Ghana. SSA	19th century AD.	Irish. 1998a

Table A1.34 – Matrix of the component loadings, eigenvalues and variances of PCA P.

Traits	BKP	Component		
		1	2	3
UI1 Shoveling	+= ASU 2-6	**.897**	-.067	.184
UI1 double shoveling	+= ASU 2-6	-.050	**-.575**	**-.769**
UI2 interruption groove	+= ASU +	-.393	-.140	**.839**
UM1 Carabelli's trait	+= ASU 2-7	.488	-.386	.091
UM1 metaconule (C5)	+= ASU 2-5	**.852**	.448	.025
UM2 hypocone	+= ASU 3-5	**.824**	-.394	.053
LP2 cusp variation	+= ASU 2-9	.137	**.779**	.197
LM1 *metaconulid* (C7)	+= ASU 2-4	**.934**	-.019	.031
LM1 protostylid	+= ASU 1-6	-.197	**.906**	-.157
LM1 6-cusped	+= ASU 6+	**.979**	.021	.032
LM2 Y-pattern	+= ASU Y	.253	**.696**	-.401
Eigenvalue:		4.558	2.774	1.566
Variance (%):		41.435	25.218	14.241
Total variance (%):		41.435	66.653	80.894

Principal Components Analysis. 3 components extracted. Highlighted figures represent strong positive (> 0.5; boldface and underline) and strong negative (< -0.5; boldface only) loadings within each component.

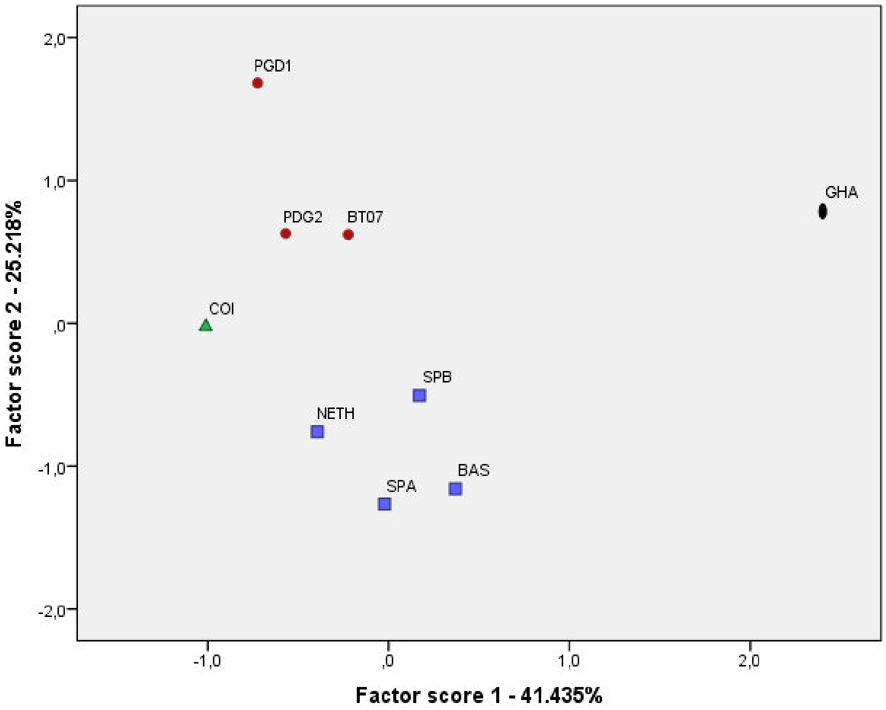

Figure A1.33 – Scatterplot of the two first components extracted in the comparison of the samples for PCA P.

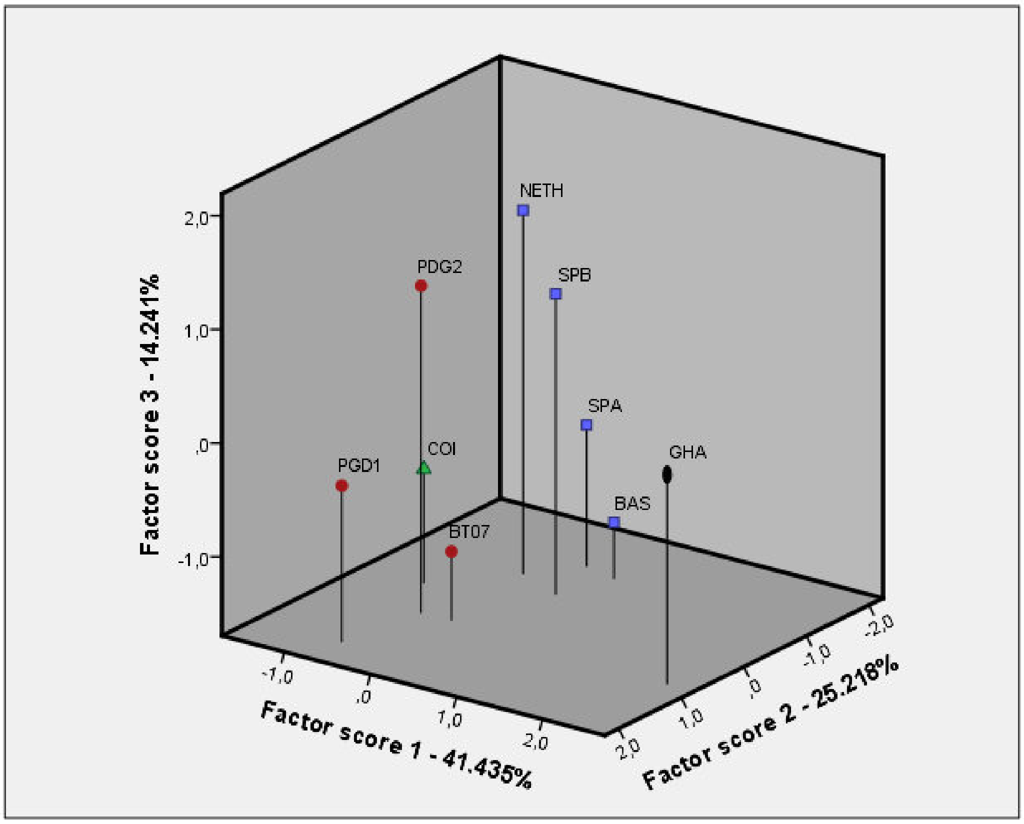

Figure A1.34 – Scatterplot of the three first components extracted in the comparison of the samples for PCA P.

PCA Q

Table A1.35 – Samples from other sources used in PCA:

Acronym	Sample	Region – Country	Chronology	Reference
COI	Coimbra	Portugal	19th-20th century AD.	Marado, 2014
KEN	Kenya, Tanzania	Kenya, Tanzania, SSA		Irish, 1998a
POU	Poundbury	England	Medieval-Modern (?)	Christy Turner's database
RUS	Russian	Russia		
KAB	Kabyle	Algeria, NA	19th-20th century AD.	Irish, 1998a

Table A1.36 – Matrix of the component loadings, eigenvalues and variances of PCA Q.

Traits	BKP	Component		
		1	2	3
UI1 Shoveling	+= ASU 2-6	**-.558**	-.254	.161
UI1 double shoveling	+= ASU 2-6	**.723**	.497	.367
UI2 interruption groove	+= ASU +	-.262	**.847**	.051
UC distal accessory ridge	+= ASU 2-5	-.313	-.197	**-.883**
UP odontome	+= ASU +	**.835**	-.363	-.205
UM1 enamel extension	+= ASU 1-3	-.144	**.768**	-.358
UM2 hypocone	+= ASU 3-5	**.827**	-.039	.076
LP2 cusp variation	+= ASU 2-9	**-.832**	-.191	.351
LM1 *metaconulid* (C7)	+= ASU 2-4	**.976**	.030	-.158
LM1 protostylid	+= ASU 1-6	-.107	**-.688**	**.629**
LM1 6-cusped	+= ASU 6+	.317	**.545**	**.586**
LM1 distal trigonid crest	+= ASU +	**-.629**	-.006	.369
LM2 5-cusped	+= ASU 5+	**.843**	.040	.246
LM2 Y-pattern	+= ASU Y	**.684**	**-.537**	-.042
	Eigenvalue:	5.733	2.890	2.203
	Variance (%):	40.948	20.641	15.738
	Total variance (%):	40.948	61.589	77.328

Principal Components Analysis. 4 components extracted. Highlighted figures represent strong positive (>0.5; boldface and underline) and strong negative (<-0.5; boldface only) loadings within each component. Matrix of the first 3 components extracted.

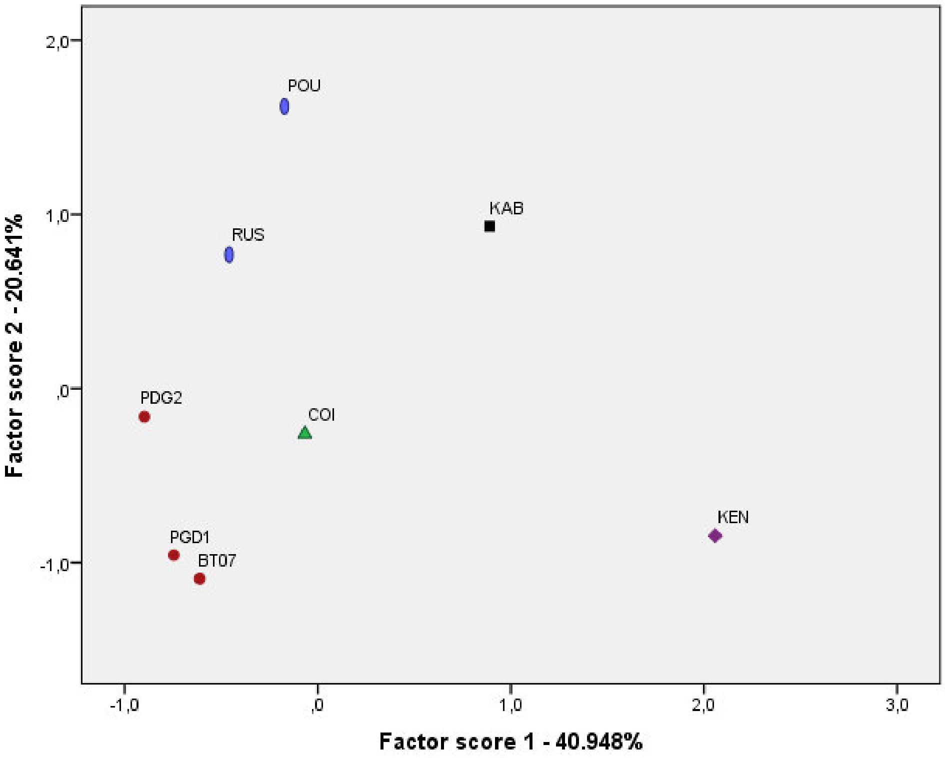

Figure A1.35 – Scatterplot of the two first components extracted in the comparison of the samples for PCA Q.

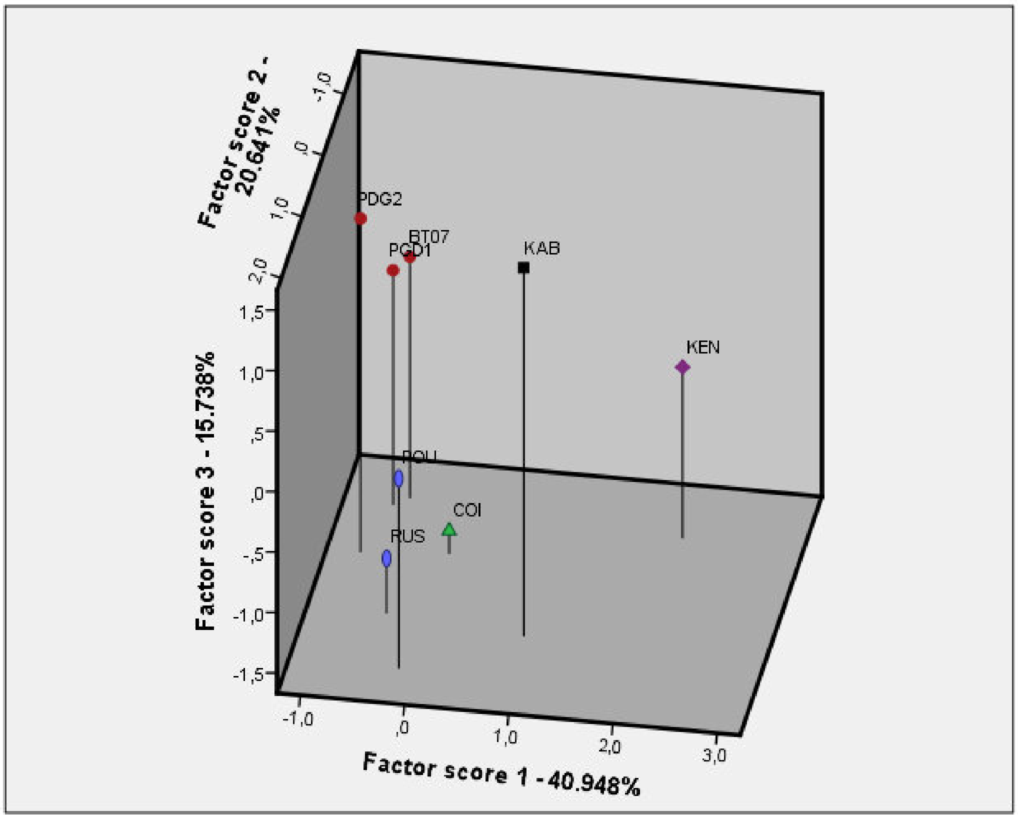

Figure A1.36 – Scatterplot of the three first components extracted in the comparison of the samples for PCA Q.