

DATING PREHISPANIC AND COLONIAL SITES ON THE ISLAND OF GRAN CANARIA: A PROPOSAL FOR A RADIOCARBON HYGIENE PROTOCOL

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ABSTRACT

Radiocarbon dating can give rise to problems associated with the nature of the dated sample, with the method used itself and with the stratigraphic reliability of the dated site. Consequently, the principal objective of this paper is to carry out a systematic exploration of each of these aspects. To this end, a critical review was conducted of the radiocarbon dates of materials from archaeological sites on the island of Gran Canaria. On the basis of this analysis, a system of categories of radiometric reliability was developed and, simultaneously, objective analytical criteria were used in an attempt to establish the reliability of radiometric dates obtained for archaeological sites in the Canary Islands and, in particular, the island of Gran Canaria.

KEYWORDS: Radiocarbon, Gran Canaria, Radiocarbon hygiene, prehispanic, Colonial.

DATAACIONES DE CONTEXTOS ABORÍGENES Y COLONIALES
DE LA ISLA DE GRAN CANARIA: UNA PROPUESTA DE
PROTOCOLO DE HIGIENE RADIOCARBÓNICA

RESUMEN

El radiocarbono puede presentar problemas relacionados con la naturaleza de la muestra fechada, los propios del método y la fiabilidad estratigráfica del contexto fechado. Por ello, el principal objetivo de este trabajo consiste en efectuar una exploración sistemática de cada uno de ellos. Para ello ha sido realizada una revisión crítica de las fechas radiocarbónicas efectuadas en materiales procedentes de contextos arqueológicos de la isla de Gran Canaria. Este análisis ha permitido elaborar un sistema de rangos de fiabilidad radiométrica al tiempo que ha pretendido establecer, sobre la base de criterios objetivos de análisis, la fiabilidad de las fechas radiométricas obtenidas en contextos arqueológicos del archipiélago canario y, en particular, de la isla de Gran Canaria.

PALABRAS CLAVE: radiocarbono, Gran Canaria, higiene radiométrica, aborigen, colonial.



1. INTRODUCTION

The interest of the Canary Islands' archaeology in carbon fourteen (^{14}C) was first shown in 1957, when the Museo Canario spent 16,200 pesetas (Delgado-Darias, 2014) on dating some mummies and a selection of wooden remains from sites on the island of Gran Canaria (de Vries and Waterbolk, 1958). This date should be considered a milestone not only for the archaeology of the islands but for Spanish archaeology as a whole, as the dates coincided with those radiometric dates made on the Iberian peninsula, such as the Muge shell middens (Roche, 1957) and the necropolis of Los Millares (Almagro, 1959). From this date onwards, archaeological research in the Canary Islands, whether into the pre-Hispanic period (the majority of studies) or the Colonial era, has used radiometric methods to date different kinds of historical processes more accurately. Thus, a considerable body of research, principally into the early settlement of the islands by groups of humans from North Africa has made recurrent use of ^{14}C dating (Navarro, 1997; Maca-Meyer *et al.*, 2004; Fregel *et al.*, 2019; 2020). This has all led to intense debate concerning the chronology of the early human settlement of the Canary Islands, as the uncritical use of radiocarbon information has clouded the complex chronology of this process in a way that, in our opinion, has made it harder to analyse the process with the caution and precision required.

The objective of this paper is to examine these radiometric dates and subsequently to categorise them according to reliability, thereby using a system based on criteria of radiocarbon hygiene. The chosen geographical framework is the island of Gran Canaria and the timeframe for the definition of radiocarbon reliability covers the entire expanse of the Canarian-Amazigh settlement and the Colonial transition (1st-16th Centuries CE).

2. RADIOCARBON DATING PROBLEMS IN THE CANARY ISLANDS

The settlement of the Canary Islands, and in particular of Gran Canaria (Martín de Guzmán, 1984), has traditionally been explained with reference to the dichotomy between Africa and the Mediterranean (Martín de Guzmán, 1984). According to this interpretation, which was based fundamentally on diffusionist paradigms and the use of formal analogies between indigenous material culture

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and the distinct cultural contexts of both regions, it was posited that the settlement process began *c.* 2500 BCE with the arrival of Neolithic Cro-Magnon groups associated with “Cave Culture”. Similarly, Mediterranean-type peoples –possibly accompanied by incursions of Atlantic Bronze Age navigators– were believed to be the driving force behind a second wave of settlement. Although this explanation collapsed with the introduction of the radiometric method (Navarro, 1997: 462)¹, its inclusion in historical discourse did not yield accurate answers capable of resolving existing doubts concerning the settlement chronology of the archipelago. In particular, this was because the method provided confusing results in archaeological excavations in that radiocarbon analysis provided different dates for cotermporal events (Navarro, 1997: 454 and 456).

On many occasions, faith in radiocarbon dating as an absolute measure of time, whose universal truth obviates the need to check results against the archaeological record or consider the problems intrinsic to the dating method, has caused more harm than good. Several studies (Bernabeu *et al.*, 1999; Bernabeu 2006; Jover and López Padilla, 2011; Zilhão, 2011, Pardo-Gordó, 2020) have illustrated a series of problems associated with radiometric dating that affect the reading of the archaeological record. These have to do with problems of taxonomy, sample selection and methodology. The following sections examine these problems in general terms, emphasising those that affect the pursuit of archaeology in the Canary Islands and, specifically, on Gran Canaria, the focus of the study.

2.1. TAXONOMIC PROBLEMS

One of the aspects that has been poorly considered in earlier research is the taxonomic identification of samples. Every sample that is sent to the laboratory should always be accompanied by a minimum of information regarding the context and characteristics of the place in which each was found. This is not a trivial issue and adds a high degree of uncertainty to the already uncertain radiocarbon method. It is true that current practice tends to reduce radiometric inaccuracies by applying Bayesian modelling techniques (Barceló and Morell, 2020), which provide probabilistic margins that are more in line with archaeological reality (Alberto Barroso *et al.*, 2019).

This section does not discuss the problems of ambiguity associated with taxonomic origins, whether foreign or local, as these are beyond the scope of this paper and do not affect the context analysed. However, we believe it to be important to dwell on the problems involved in applying the radiometric method to previously unidentified carbonic samples and to organic sediments. Several examples exist in

¹ See A. Gilman (2003) for a similar example. The use of radiocarbon made us rethink the historical process of the peninsular Recent Prehistory due to the inconsistencies between radiometric dates and the orientalist explanation.



Canarian archaeology, especially those dating from the first decades in which the radiometric method was used.

Firstly, there is no doubt that the absence of taxonomic identification of samples necessarily implies that the results of radiocarbon dating should be accepted with caution. Without this, there is no way to know whether the species in question was short- or long-lived. Sending unidentified anthracological samples to radiometric dating laboratories means that valuable information regarding the history of the plants in question is lost, along with the ability to trace the geographical distribution of woody taxa along with the possible detection of refugia of thermophilic vegetation in the regions under study (Moskal-del Hoyo *et al.*, 2018). In addition, carbonaceous samples that might potentially be dated should have been subjected to previous systematic anthracological studies. Given the floristic spectrum obtained for each stratigraphic unit, these should have collected the most suitable materials possible in order to exclude those that might constitute stratigraphic intrusions (Badal *et al.*, 2016; Moskal-del Hoyo *et al.*, 2018).

Nor does the use of organic sediments to date archaeological sites seem to be the most appropriate method, since most consist of complex mixtures with very little organic material that, as a rule, also come from numerous sources. In this regard, three principal problems associated with this kind of sample have been identified (Fowler *et al.*, 1986). In more recent sediments, one concerned the presence of fossilized carbon in the form of graphite or lignite. A second relates to the incorporation of older 'reworked' sedimentary material as the use of old sediments for conditioning soils, etc. Finally, a third problem concerns the possibility that autochthonous materials will be dated that have metabolised carbon from dissolved carbonates produced during the breakdown of other materials.

Against this background, Fowler *et al.* (1986) carried out systematic research with the aim of dating different components of sedimentary samples. The disparities they found in their research led them to conclude that the degree of variation of the radiometric data responds to the samples and the environment in which they were found. Consequently, while that decision should be guided by the evidence, it is the users who accept or reject the result (Fowler *et al.*, 1986: 448). Assuming that the conclusions of this study may be trusted, it does not seem appropriate to date archaeological levels with reference to the organic sediments found in their proximity. We illustrate this problem with reference to the dating of structure II (P93, Z7-VII) in the La Puntilla/Lomo de los Gatos settlement in Mogán, Gran Canaria (del Arco Aguilar, 2011), where the dating of sediments suggests they originated in the 14th Century CE (GX-23827), while following application of the reservoir effect ($R = 0 \pm 35$), the dating of limpet shells (*Candei crenata* / *ulyssiponensis aspera*) found at the site suggests that they were from the 3rd to 6th Centuries CE (GX-23828), a difference of around a thousand years.



2.2 SAMPLE PROBLEMS

Although the previous discussion would have fitted perfectly into this current section, we have considered it appropriate to differentiate taxonomic problems from questions concerning the nature of the samples. Below, we list the different problems that may be directly related to this question.

2.2.1. *The reservoir effect*

It is widely known that samples of marine origin (malacofauna, ichthyofauna, or the remains of humans who are known to have consumed marine resources) must be corrected during the calibration process in order to mitigate the reservoir effect, though this process is not itself unproblematic. This phenomenon has been explored in several methodological studies, which have noted that the effect is characterised by spatial and temporal fluctuations (Soares and Dias, 2006). Although these fluctuations can be demonstrated, it has been observed that the problem persists even in adjoining areas because of the effects of marine currents, prevailing winds or upwelling (Ascough *et al.*, 2005; Soares and Dias, 2006). In the specific case of the Canary Islands, this issue has been examined briefly for eight sites in Fuerteventura and Tenerife (Matos Martins *et al.*, 2012). The team behind this study concluded that in the eastern islands (Lanzarote and Fuerteventura) a correction factor of $\Delta R = 185 \pm 30$ should be applied, while for the rest of the islands the appropriate factor was $\Delta R = 0 \pm 35$. However, as the sample used was small and of markedly little geographical variety, caution should be exercised before applying the reservoir effect. This conclusion seems to be consistent with the findings of discrete pieces of research into shell middens in Tenerife, La Gomera and La Palma, which not only applied a different reservoir effect to that proposed by Matos Martins *et al.* ($\Delta R = 135 \pm 103$), but also observed the existence of other phenomena such as time-averaging (Parker *et al.*, 2018, 2019). The upwelling effect has been explored using live limpet shells collected in Puerto Rico (Fuerteventura). The dating obtained (Gif-9065: 740 ± 40 BP) using conventional methods, demonstrated the influence exerted by the Mauritanian Upwelling on the dating of materials in marine contexts².

In addition to these problems, the so-called island effect should also be taken into account. This effect is based on the premise that, in island contexts, an exchange of carbon between the water mass and the atmosphere might occur and that this would reduce the $^{14}\text{C}:^{12}\text{C}$ ratio, affecting radiometric results. Other research, based on the comparison of high-resolution calibration curves from Seattle and Belfast, has, however, argued that the island effect does not appear to exist

² Unpublished dates obtained as part of a research programme carried out under the auspices of the International Union of Geological Sciences (IUGS/UNESCO) *Past and Future Evolution of Deserts and Climates of the Past* (Onrubia *et al.*, 1997).



(Bowman 1987). By contrast, another study, conducted in Japan, which compared the growth ring patterns of standard samples of Japanese cypress (*Chamaecyparis obtusa*) with radiocarbon dates obtained from the same rings, reported a systematic pattern whereby earlier dates were reported using the latter method (Imamura *et al.*, 2007), an effect that could be associated with the island effect (Wiener, 2013: 137). In any case, the island effect for the archipelago of the Canary Islands has not been explored per se, and should therefore be explored in the future.

Thus, factors associated with the reservoir effect are capable of influencing the dating of archaeological strata when malacofaunal remains (or samples affected by them) are used. Although examples of this factor have been found across the Canary Islands, in the case of Gran Canaria, most are associated with contexts that have been dated purely from malacofauna and carbons, without additional taxonomic identifications. The settlement of Palm-Mar (Arona, Tenerife) lends itself to an exploration of this problem (Matos *et al.*, 2012). For the surface level of this site one dating exists from fauna (Sac-2259) and two exist from *Patella* sp. (Sac-2253, Sac-2254) dating, placing the site between the 14th and 17th Centuries CE. It should be noted, however, that the degree of chronological resolution differs, since the bone fragment indicated a date range between the 14th and 15th Centuries, while those for the malacofauna indicated a chronological range between the 14th and 17th Centuries.

Given the above, it does not seem appropriate to use malacofaunal dates to obtain precise chronologies for archaeological strata and the numerous problems outlined above should at least be taken into consideration when it comes to interpreting the calibration of dates.

2.2.2. *The effects of thermal alteration on bone samples*

In recent years, another new problem has come to light that affects the dating of bones showing signs of thermal alteration. Several studies (Van Strydonck *et al.*, 2009; Olsen *et al.*, 2013) have pointed out that samples with evidence of thermal alteration can produce significantly divergent results depending on the degree of fire damage to which they have been subjected (burnt or charred samples). The argument is that the degree of thermal alteration can lead laboratories to date the inorganic (e.g. mineral) fraction of the bones, leading as a rule to older results than those achieved when the organic fraction (e.g. collagen) is dated. In addition, it is important to take into account the carbon exchange that occurs between bone apatites and the combustion atmosphere (Rose *et al.*, 2020). Thus, despite the fact that laboratories are able to date thermally altered bone, it is suggested that the radiocarbon results they produce should be interpreted with caution. The recommendation, therefore, is to use non-thermally affected bone. In the case of Gran Canaria, there is no evidence of thermally altered human bones. However, on other islands such as La Palma, cremation has been documented (Hernández, 1972; Álvarez 2011), so it is important to take this aspect into account.



2.2.3. *The effects of standard deviation*

Any analysis of prehistoric or historical processes using radiocarbon information must establish the maximum limit on standard deviation (SD). Accordingly, it is important to stress that using dates without an SD threshold implies increased calibration margins and, by extension, increases the risk of inaccuracy in the dating of the event. There is a current consensus that an SD of ≤ 100 is most appropriate for dating samples. This random criterion does not resolve the difficulty of the reliability of the SD chosen, which must be analysed on an individual basis. A reliability index has recently been proposed for analysing the SD in relation to the BP date (Martínez-Grau *et al.*, 2020), while other studies have proposed using radiocarbon dates with an SD of less than 40 (Jover and López Padilla, 2011), since the lower the SD, the greater the reliability of the probability limits. This issue is of paramount importance in the Canarian context, as a date with an SD of low reliability might introduce unnecessary background noise. This factor increases the closer we get to the period of the European conquest and colonisation of the archipelago in which historical events occurred. During a period of barely a century and a half, during which the islands were visited, conquered and then repopulated by new inhabitants, a wide range of historical events occurred in rapid succession. In such contexts, chronological precision is indispensable if the historical account constructed is to be accurate.

2.2.4. *The old wood effect*

This phenomenon refers to the fact that if dating of a short-lived element (including seeds or charcoal from a short-lived woody species) is compared to that of charcoal from a long-lived species found in the same archaeological context, the latter tends to return an earlier date (Schiffer, 1986). The existence of this effect has been questioned by other researchers who have suggested that the problem applies exclusively to the region for which the effect was originally identified (Cook and Comstock, 2014). We cannot agree with Cook and Comstock though, as the effect is not directly related to the geographical region but to the nature of the sample itself. To illustrate this point we refer to the example of a coffin found in the tumular necropolis located on a lava flow in the port of Las Nieves (Agaete, Gran Canaria). The human remains (Beta-510714) found inside the coffin provide a chronology, to one sigma of probability, of between 979 and 1019 CE, while dates returned for the coffin, made of Canary Island pine, *Pinus canariensis* (Beta-510715), establish a chronology that would date the burial to be between 777 and 878 CE, to one sigma of probability: a full century earlier (Alberto Barroso *et al.*, 2019).

Another example associated with the old wood effect may be found at the site of La Cerera in Arucas, Gran Canaria (Quintero *et al.*, 2009, Morales *et al.*, 2017), and more specifically in its phase III (UE 42) for which an unidentified carbon fragment (Beta-195948) yields a chronology of between 260 and 536 CE,



while the date obtained from a barley seed (*Hordeum vulgare*) (Beta-302329) was dated to the 6th century (590-665 CE).

These findings confirm that the old wood effect requires caution to be exercised when dating charcoal from long-lived species.

The expertise of anthracology specialists should be tapped to counter the consequences of the old wood effect. In the case of a long-lived woody species like the Canary Island pine, if the sample permits testing of the last growth ring closest to the bark of the tree, the result will ensure that the most recent date possible is obtained. This corresponds to the point closest to the death of the tree, when it ceased growing. This means that any date obtained from the last growth ring of a long-lived taxon, even if taken from small diameter twigs, should be considered just as reliable for dating as seeds, bones or any other short-lived sample.

However, the difficulty in determining the location of charcoal in the anatomy of the original plant (closer to or further away from the last growth ring) means that most radiocarbon dating fails to take this aspect into account. Finally, it should be borne in mind that even if the precautions detailed above are taken, the carbon or wood in question may not belong to the time of human occupation that is being dated, as the wood might have been reused or the artefact discarded, etc.).

2.2.5. Dating of insects

Recent research has attempted to date insects associated with anthropic activities involving food preservation sites, such as Gran Canaria's well-known pre-Hispanic granaries. In principle, such dating should not present major problems as it involves short-lived aggregate samples used to date human activities. However, comparisons of insects and cereal dating found at the same level have displayed certain discrepancies, as at silo 3 (level 2) of the Risco Pintado site (Aguimes, Gran Canaria), which has been dated both through insect and cereal samples (Henríquez *et al.*, 2019 and Hagenbland *et al.*, 2017 respectively). The dating of barley (*Hordeum vulgare*) (Beta-362111) suggested that level 2 of the silo had been used between the 11th and 13th Centuries CE, while dates derived from insects (*Orizaephilus surinamensis* and *Sitophilus granarius*) (Beta-469049 and Beta-469050) take the dates to between the end of the 9th and the early 11th Centuries and between the 11th and 12th Centuries. The same is the case for the samples taken from silo 2^a (unit 1) of the granary of La Fortaleza (Santa Lucía de Tirajana, Gran Canaria) (Beta-477349 and Beta-477344), where insects (*Sitophilus granarius*) were dated to between the 8th and 10th Centuries, while a barley seed (*Hordeum vulgare*) returned a 13th-14th Century date (Henríquez *et al.*, 2020). These discrepancies pose a difficult problem when it comes to assessing the contemporaneity of cereals and insects. In the absence of a detailed approach to the problem, a possible hypothesis is that the granary was not exhaustively cleaned prior to its reuse, thus leaving the remains of previous activities behind.



2.2.6. *The influence of special objects*

This problem refers to specific pieces of evidence, including reused objects (e.g. wood and/or bone), that are passed down from one generation to another and that help create collective identity (Hodder, 1977). It is not gratuitous to warn that the dating of such objects can induce errors and may generate inconsistencies with respect to the context being dated. Although this is a matter that has not been examined explicitly in the Canary Islands, it may be approached indirectly using a recently published synthesis of available radiocarbon dates for the archipelago (Velasco-Vázquez *et al.*, 2020; see also Alberto Barroso *et al.*, 2019). This compendium provides dates for two mummies (n.º 8 from Arguineguín [Beta-391059] and n.º 12 from Guadayeque [IA-1066]) and two human bones defined as *possible relics* (Relic 8 from Arguineguín [Beta-468989] and Relic 12 from Guadayeque [Beta-468991]), with the former being dated as roughly a century more recent and the latter a century older than the mummy samples. There is no doubt that so-called special objects can increase radiometric uncertainty (age or rejuvenation) with the result that certain archaeological questions should be set aside. Thus, it is important to bear in mind that the deposit of these “relics”, which in some cases were undoubtedly introduced later on, may actually coincide with the moment the remains were recovered or to the musealisation process. An illustrative example of ancient practices that combined the anatomical elements of different individuals to create a particular museographic discourse is provided by “Vitrina 2” in the Sánchez Araña collection, Santa Lucía de Tirajana (Alberto Barroso *et al.*, 2018). This display case exhibits a supposed “family burial” in which the central individual is a woman whose skeleton is incomplete, and which has been completed using anatomical elements from other individuals.

2.2.7. *Volcanic emissions*

Employment of the radiometric method in volcanic contexts requires the question of volcanic emissions to be taken into account, and there is an extensive literature on their influence on radiocarbon dating. For example, Bruns *et al.* (1980) indicate that the mixture of volcanic and atmospheric carbon may be as high as 16% depending on distance from the source.

This problem can be ignored for Gran Canaria, as there is no geological evidence of eruptions after the island was settled (Onrubia, 2003: 102), although a dating of unidentified charcoal aggregates found on the Bandama volcano does place its last eruption during the transitional period (Alberto and Hansen, 2003: 23). However, volcanic eruptions that occurred on other islands should be taken into consideration. For example, on the island of Tenerife, several charcoal dated volcanic episodes that happened during the island’s period of habitation should have also been included. This inclusion should be in addition to volcanic activity that occurred in pre-conquest times, such as that of the Orotava Valley (1430) or Boca Cangrejo (1492). These should also include the last eruption of Teide (660 to 944



CE) and the eruption at Montaña Reventada between the 9th and 13th Centuries (Carracedo *et al.*, 2006).

Consequently, it seems both appropriate and necessary to analyse the radiometric results of inhabited islands that have experienced volcanic events. In this vein, in recent research (Holdaway *et al.*, 2018), it has been suggested that $\delta^{13}\text{C}$ can serve as an excellent indicator for evaluating the degree of contamination of radiocarbon samples due to volcanic emissions.

2.3. METHODOLOGICAL PROBLEMS

The increase in power, access and employment of different calibration software, plus the proliferation of laboratories capable of performing radiometric analysis (123, according to the latest update of the journal *Radiocarbon*) not only entails the reappearance of old problems, but also of new methodological challenges.

2.3.1. *Inherited dates*

This section deals with dating that was carried out prior to the standardisation of laboratory protocols covering sample preparation, measurement and reporting (Wright, 2017: 307). Here, it is particularly important to highlight two fundamental issues associated with radiocarbon measurements: the laboratory and the quantitative method.

The first of these issues refers to the application of low-quality protocols by laboratories³. The most important example of this is provided by the Gakushuin (GaK) laboratory, whose dates have been discarded because of the poor quality of the laboratory's protocols (Blackeslee, 1994). Similarly, the dates obtained by the Groningen laboratory (GRO) must be corrected using the guidelines provided by the laboratory itself (Vogel and Waterbolk, 1963), as their radiocarbon measurements were conducted without taking the Suess effect into account. This requirement to discard and/or correct data clearly affects the radiometric information that has been used in Canarian archaeology, since a not inconsiderable portion of the initial carbon dating of sites on the islands was carried out in these laboratories. Without going into any further detail, a total of 40 dates were obtained in the Gak laboratory and, while fewer (4) came from the Groningen laboratory, they were the first ever reported for the island of Gran Canaria.

In terms of method and quantity, it should be noted that the use of aggregates (mixtures of archaeological remains) for dating rather than single elements may pose similar problems to those observed in organic sediment samples (section 2.1).

³ See the discussion of the dating conducted by the Kiel International Institute (KIA) between 2010 and 2012 (Lull *et al.*, 2015; Meadows *et al.*, 2015).



This issue is directly related to the measurement technique used (conventional vs. Accelerator Mass Spectrometry-AMS) since the conventional procedure requires larger samples (c. 1 gram of pure carbon) to obtain reliable results within the estimated error of -0.5 to 1 % (Hedges, 1987: 58). Therefore, and whenever possible, dates obtained using AMS should be prioritised over those resulting from the use of the conventional method.

2.3.2. *Sample pre-treatment / ultrafiltration: a new problem?*

The use of archaeological samples without the prior removal of potential contaminants can lead to erroneous radiometric results. For this reason, all laboratories nowadays carry out pre-treatment methods, which may or may not involve the use of chemicals to clean the sample. However, which method is the most suitable remains a matter of debate, though some methodological trials that have compared the main pre-treatment techniques (Acid Oxidation [ABOX] and Acid-Alkaline-Acid or Acid-Base-Acid [AAA or ABA]) have concluded that the former produces superior results to the latter (Haesaerts *et al.*, 2013; Maroto *et al.*, 2012). This finding has been corroborated by a recent study (Norris *et al.*, 2020) which analyses the different varieties of AAA pre-treatment in detail, and concluded that they should involve more than the simple application of acid to the sample.

Accordingly, it is worth remembering that most Canary Island dating has been carried out in the Beta commercial laboratory, which uses the AAA method. Since it is neither convenient nor reasonable to discard all the dating carried out hitherto in this laboratory, it may be advisable to consider using other laboratories in the future when a radiometric date raises reasonable doubts that suggest a sample and/or context should be re-dated. As has recently been suggested (Bayliss and Marshall, 2019), this practice allows for the correction of potential errors in the radiometric results, while re-dating any events can reduce the number of inaccuracies.

2.3.3. *Human bones and the carbon-to-nitrogen ratio (C:N)*

In the final quarter of the 20th Century, researchers established that the C:N ratio was a factor that should be taken into account when seeking to reconstruct past human diets, as it could lead to anomalous values (De Niro, 1985; Van Klinken, 1999). This concern was confirmed experimentally (Harbeck and Grupe, 2009). Radiocarbon and C:N ratio results obtained from several Neolithic sites in the Iberian Peninsula (García Borja *et al.*, 2018) have shown that anomalous C:N ratios influence radiometric results. Moreover, dates obtained for human remains that are (generally speaking) earlier than the expected chronology are correlated with C:N values that lie beyond the range established by the different reference works (De Niro, 1985; Van Klinken, 1999). This problem might explain the extreme age assigned to some human remains exhumed in the necropolis of Las Candelarias (Agaete, Gran Canaria). During the dig, two contiguous individuals were dated using the AMS



technique (Barroso and Marrero, 2011). The date obtained for “Burial 1” (Beta-315247) indicated a chronology between 1541 and 1634 CE, which is entirely coherent both with the rest of the dates of the necropolis (13th-16th Centuries) and with the cist/pit burials found at the same site (Alberto *et al.*, 2019). By contrast, “Burial 2” (Beta-315248) was dated to be between 377 and 177 BCE (4th-2nd Centuries BCE), representing by extension the first human evidence dated using ¹⁴C on the island of Gran Canaria. In the absence of a process to re-date Individual 2, which might confirm the values produced by the initial radiocarbon date, a potential explanation of the discrepancy between the Beta-315247 and Beta-315248 dates could be associated with the C:N ratio, namely, that in the dating of Burial 2 the ratio fell outside the established reliability ranges. Other examples of this phenomenon have been found at other sites, such as the double burial at the Cova de la Sarsa (Bocairent, Valencia). There, the discrepancies between dates from one of the skeletons, when the discordant individual was dated in another laboratory (García Borja *et al.*, 2018) were associated with the existence of C:N values outside the established range.

Similarly, the question of the C:N ratio should be extrapolated to soft-tissue dating, since the decomposition process can destabilise some of the contents or the presence of added elements that age the radiocarbon dating. This has also been shown in experimental work carried out on a group of Egyptian mummies (Quiles *et al.*, 2014). The C:N problem might also apply to wooden remains, which are composed of carbon and nitrogen, and whose decomposition could, over time, affect dating. In other words, radiometric dating of woody plant remains may not only be susceptible to the problem of old wood, but also to taphonomic issues associated with the preservation of the material that could affect the dating itself. However, this is an issue that should be explored in more detail in the future.

2.3.4. *Other intrinsic problems: plateaux in the calibration curve*

This paper does not discuss the problem of radiocarbon decay rates or whether calibrated dates should be normalised or not; for this we refer to specific studies on both issues (Santamaría and de la Rasilla Vives, 2013; Weninger *et al.*, 2015). However, we do broach the problem of plateaux in the calibration curve, the best-known of which is the Hallstatt plateau (Jacobsson *et al.*, 2018). These plateaux have a direct influence on radiometric results, yielding calibrations that span several centuries, a factor that should be borne in mind when discussing dates that are affected by the issue. Broadly speaking, in chronologies from the 1st to the 15th Centuries CE, a number of radiometric calibrations may be identified. There are three major plateaux: a) c. 150 / 200 CE; b) c. 800 / 875 CE; and c) c. 1050 / 1075 CE. If dates fall within these chronological ranges, any interpretation derived from them must be made with caution and take into consideration other aspects to help minimise the effects of the uncertainty they cause. It is true that the plateaux in the calibration curve are not extensive (c. 50 years on average) but they must be taken into consideration in historical processes, such as that of the Canary Islands, where the degree of temporal resolution is perforce very narrow.



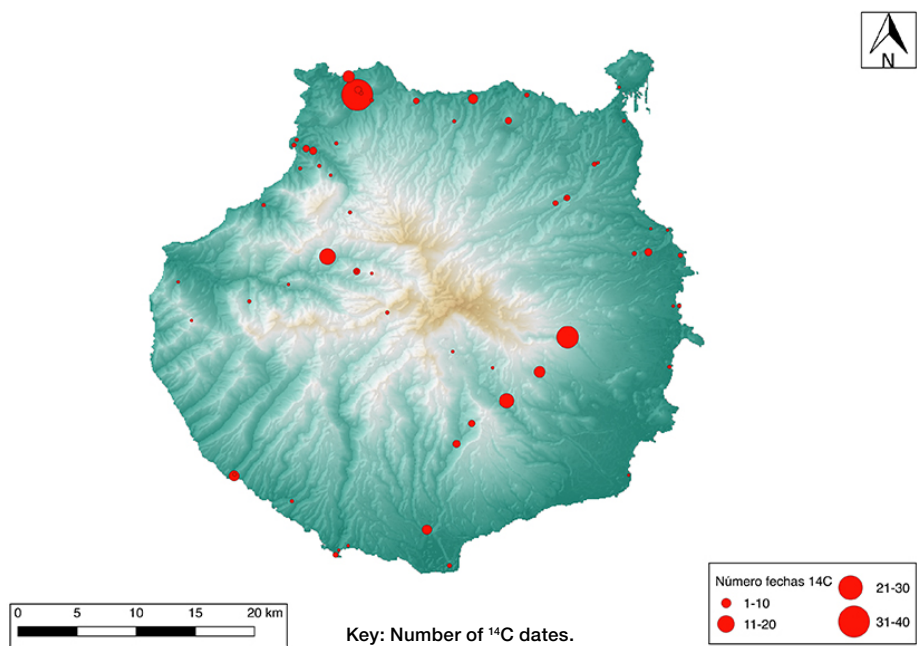


Figure 1. Archaeological sites on the island of Gran Canaria for which radiometric information is available. The size of the circle indicates the absolute number of radiocarbon dates for each site.

The question of calibration ranges should also be added to this discussion. In this connection, a useful point of reference is Individual 2 from the Acarreaderos necropolis (Agaete, Gran Canaria), which is discussed in a co-written piece by several of the authors of this paper. Calibration placed it in the 16th-17th Centuries with a probability of 99.9%, while the suggested historical context –supported by the material evidence of the burial rite– suggested a late 15th Century date, for which the radiometric probability distribution is less than 0.1% (Santana *et al.*, 2016: 773).⁴

⁴ Despite the most accurate calibration, which places the time of death towards the end of the 16th century, is consistent with the possibility, also demonstrated from written sources and previously noted by other authors (Ronquillo and Viña, 2008: 203-212), that the indigenous people and their descendants continued to bury their dead in accordance with ancient rituals. This possibility, which is quite plausible, was mentioned in the aforementioned article, although perhaps not forcefully enough. Whether or not the discrepancy may be resolved by dating the same individual in a laboratory using ABOX and through the C:N ratio, we would like to state that this scenario is perfectly possible and that, if a later date appears likely, this would be most intriguing and suggestive, as it would require a re-examination of the entire historical narrative associated with the site.



3. RADIOCARBON DATA FROM THE ISLAND OF GRAN CANARIA

In total, 297 ¹⁴C dates were assessed during the preparation of this radiometric hygiene study. The dates analysed in the methodological test are available both in the archive of the Cabildo de Gran Canaria⁵ and in the different syntheses of radiometric studies published in recent years (Morales *et al.*, 2017; Alberto *et al.*, 2019; Velasco *et al.*, 2020), for which reason we do not consider it necessary to repeat the information here.

The density of dates on the island of Gran Canaria is 0.19 ¹⁴C per km² and the mean SD of the sample analysed is ΔSD. = 40.9. However, note that the majority of the dates (n=255) have an SD ≤ 50. Geographically, the dated sites are found across the entire island. Of the 60 archaeological sites for which absolute dates exist, a few have a large number of published dates, such as Cueva Pintada (n=40) or Barranco de Guadayeque (n=27).

Similarly, as may be observed in table 1, different research projects are currently being carried out on Gran Canaria, where the criteria used to select the archaeological samples to be dated are based on a short life-cycle samples (bones, cereals, charcoal from bush species, insects).

TABLE 1. DESCRIPTION OF THE RADIOCARBON DATING ASSOCIATED WITH THE 60 SITES FOR WHICH RADIOCARBON DATA EXISTS. SOME SITES HAVE DATES FOR BOTH DOMESTIC AND FUNERARY CONTEXTS, SO THE SUM OF THE TWO IS GREATER THAN THE TOTAL NUMBER OF SITES DATED

	FUNERARY CONTEXT	DOMESTIC/ GRANARIES CONTEXT	GRAN CANARIA, TOTAL
Site*	38	30	60
Conventional	14	64	78
AMS	138	78	216
Not determined	0	3	3
Quantity (n = 296)			
Aggregate	4	23	20
Single	139	75	221
Not determined	9	47	56
Long-lived (n = 82)			
Carbon	2	53	55
Wood	9	15	24
Sediment	0	3	3
Short-lived (n = 214)			

⁵ <http://dataciones.grancanariapatrimonio.com/> [accessed 23/11/2020]



Insect	0	7	7
Seed/fruit	3	43	46
Malacofauna	0	7	7
Bone (fauna)	4	15	19
Bone (human)	114	0	114
Skin	12	0	12
Vegetable/tissue	8	2	10

(*) Results based on previous study (Alberto *et al.*, 2019).

4. A PROPOSAL FOR A RADIOMETRIC HYGIENE PROTOCOL

As is apparent from Section 2, there are numerous problems (some as yet unresolved) that affect radiocarbon information. Consequently, unnecessary debates concerning historical processes are likely to ensue if databases are used uncritically. For this reason, our aim is to present a proposal for a radiometric hygiene protocol based on a classification of available dates for the island of Gran Canaria, which is categorised according to reliability, as follows:

Category 1: corresponds to dating of short-lived samples from singular events marked by the different quality indices described in the previous section. Radiometric dates for the following items should be included in this group: fruit, seeds, insects associated with anthropogenic activities, plant fibres, charcoal from short-lived species (including shrubs, small branches with bark remains and charcoal fragments for which the last growth ring can be identified) and dates for human bones or faunal remains, including soft tissues, which have different quality indices, such as the C:N ratio. Of the 297 dating processes (including those from the Gak laboratory) examined during the preparation of this methodological test, only 51 (17.17%) were categorised in Category 1.

Category 2: includes singular dates obtained for human bone, fauna and soft tissue whose quality indices are unknown to us. In this range we have conservatively considered all the dates obtained for bone and soft tissue (140 radiocarbon dates, or 47.13% of the overall radiometric sample). This decision was taken because of the lack of available quality indices, and in particular the C:N ratio.

Category 3: includes dates for short-lived aggregate samples; that is, samples that correspond to the radiometric dates defined in categories 1 and 2. On the island of Gran Canaria, there are only 17 category 3 dates (5.72%). It has been decided to include dates in this group for which there is no available published information on the amount of material that has been dated, such that the question of whether they correspond to a single or an aggregate sample remains open. Examples include the dating of reeds from Roque Bentayga (Tejeda, Gran Canaria) and plant material from the Arteara



necropolis (A/79). Similarly, dates for insects and for mummy bundles and shrouds have been included in category 3. It is true that the available dates (Mummy no. 5 from Acusa and Mummy no. 12 from Barranco de Guadayeque) have been carried out on a single sample. However, the characteristics of manufacture –leather fragments in the case of the shrouds or winding sheets and the remains of reeds for the bundles– suggest the “aggregated” nature of the sample. Classification as an *aggregate sample* may occur due to the fact that remnants made in previous generations may be used at a later date.

Category 4: includes dates for long-lived single items that have been identified taxonomically, that is, dating performed on a charcoal or wood fragment for which the plant species is known, and the last growth ring is not available. The taxonomic identification helps to understand the radiometric result itself, allowing a much more detailed evaluation of the radiocarbonic information. The number of radiometric dates within this category amounts to six (2.02%), including the dating of the coffin from the Necropolis of Las Nieves (Agaete, Gran Canaria), which was made using wood from the Canary Island pine (Vidal-Matutano *et al.* 2021).

Category 5: corresponds to dates for charcoal aggregates of long-lived species for which there is a known taxonomic identification. At present, only the dating of structure I of El Burrero (Ingenio, Gran Canaria) (Beta-157276) has been included in this category, as it includes pine and willow charcoal aggregate remains. (Olmo *et al.*, 2005).

Category 6: includes single/aggregate dates obtained for both malacofauna and terrestrial gastropods. Also considered within this range are dates for bones for which there is evidence of a marine diet. In this group we have included one date from the site of Cueva Pintada (Galdar, Gran Canaria) (Gif-9899), all the dated samples from Aguadulce/Restinga (Telde, Gran Canaria) (Beta-131030, GaK-8056) and Tufía (Telde, Gran Canaria) (Beta-365841) and three from the site of Lomo de los Gatos (Mogán, Gran Canaria) (GX-23824, GX-23826 and GX-23828). The total number of samples amounts to six, which corresponds to 2.02% of overall samples.

Category 7: includes long-lived samples, either of a single or an aggregate sample for which taxonomic identification is not available. This group also contains dates obtained from organic sediments. In Gran Canaria, a total of 74 dates meet this criteria (24.91%), of which 52 correspond to carbonic samples, 19 to wood and three to sediments.

Having established these categories of dates according to their radiometric reliability, we now turn to highlighting other aspects that should be taken into account in the construction of the radiometric hygiene protocol:

- a) Firstly, it should be noted that this is an exclusionary protocol, meaning that any date defined at a *lower level can never contradict* a radiometric date from a *higher category*. This is to avoid introducing unnecessary uncertainty.



Similarly, it should be remembered that when discrepancies exist between two dates classified within the same range, not only will the one determined using the AMS method prevail over its conventional counterpart, but the SD of the date will also be taken into account and the sample with the lower SD value used.

- b) Many radiometric dates produced in recent years come from samples taken from archaeological materials and collections held in museum storage rooms. *A priori*, this would not be a problem, except in cases where the archaeological context is unknown and/or doubtful. For this reason, we consider it appropriate to point out that when radiometric dates come from unknown contexts they should be interpreted with caution. This is especially true when they contradict another radiometric date from the same region, obtained from material whose archaeological context has been reliably established. In short, and although it may seem obvious, if there is a contradiction between dates, the one that comes from materials excavated from a stratigraphic context will prevail. When there is a conflict between the stratigraphy and the radiometric information, the former will be used to determine the chronology, as long as a good chronostratigraphic study exists that permits the potential radiometric uncertainties to be mitigated. An example is provided by the dating of Burial 2 at Las Candelarias (Agaete, Gran Canaria). Despite this meeting all the standards and notwithstanding the possible difficulties associated with the C:N ratio mentioned above, this does not match the chronological context of the rest of the available evidence. Therefore, stratigraphic criteria should prevail over their radiometric counterparts. Another similar example comes from the village of Guinea (Frontera, El Hierro) where the dating of a bone (Beta-96135) from the upper levels of cut 2 (3860 ± 50 BP) returns a much older result than the other dates found for the same cut that were, in addition, located in its lower levels (Jiménez and Jiménez, 2007-2008). For this reason, as Jiménez and Jiménez (2007-2008) rightly point out, this dating must be rejected because of its stratigraphic-radiometric incongruence.
- c) As indicated in Section 2, some laboratories pose particular problems. This is the case of the dates obtained by the GaK, which should always be discarded (except in the case of studies focused on methodological issues). For their part, if it is decided to use results from the Groningen laboratory they should be corrected. The decision about what to do should be left to each research team. Similarly, any dismissal of a radiometric date based on SD should be supported by an individual analysis of this figure in relation to the BP date, and by extension, its reliability should be indicated in any subsequent discussion of the archaeological-historical process.
- d) In addition, the dating of marine samples merits explicit mention. As Section 2.2.1 made clear, the spatio-temporal fluctuations that characterise these samples should be corrected and they should therefore only be used in cases for which the reservoir effect has been calculated. Similarly, certain human remains may reflect a diet with a certain degree of marine input. In the case of Gran



Comparación de fechas de carbono-14 en el archipiélago según el protocolo de higiene radiocarbónica

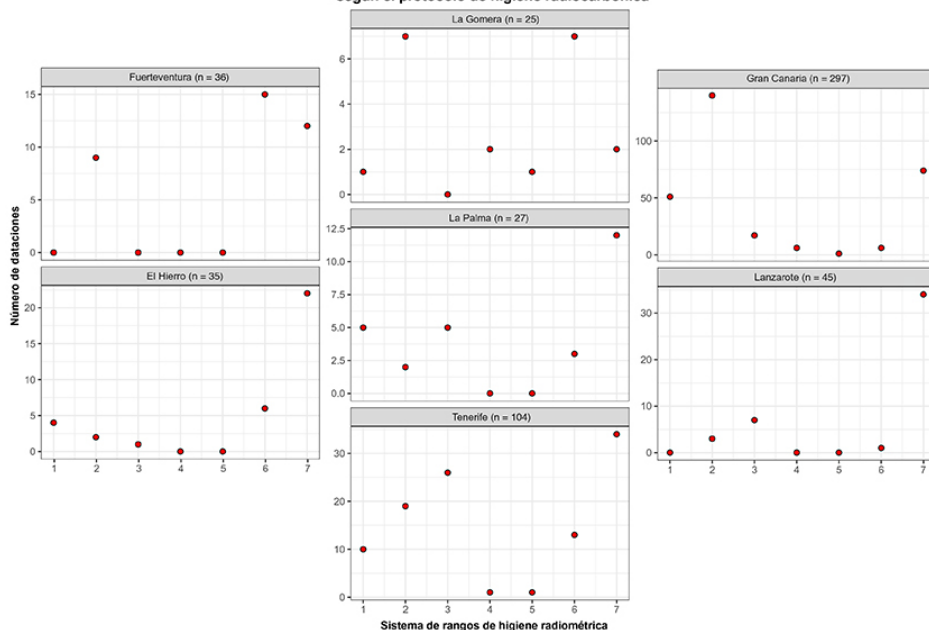


Figure 2. Comparison of the available radiocarbon dates for the archipelago of the Canary Islands categorised according to their range of reliability.

Prepared using information from Velasco *et al.*, 2020.

Canaria this question has been explored using isotopic analysis (González Reimers and Arnay de la Rosa, 1992) and physical anthropological studies (Velasco-Vázquez *et al.*, 2001). For samples displaying evidence of a marine diet, both the diet correction and the reservoir effect should be applied prior to calibration. In this regard, a recent study on stable isotopes for the island of La Gomera has identified a human dietary evolution whose first stage principal contribution was marine (Sánchez-Cañadillas *et al.*, 2021).

5. CONCLUSION

Given this presentation of the different problems associated with the radiocarbonic methodology, it does not seem inappropriate to insist on the application of a radiometric hygiene protocol. This ensures a more reliable timeline is obtained for at least two of the settlement processes involved in the occupation of the archipelago of the Canary Islands. Our proposal has focused on the island of Gran Canaria, but as may be seen in figure 2, the system of categories established in this paper may be extrapolated to the rest of the islands.



However, as has been indicated throughout this paper, some problems require further analysis. Among the most important of these are the discrepancies between dates derived on the one hand from cereals and on the other from entomological samples. If both dates are contemporary (in terms of the archaeological level they are found at), how can these insect/cereal differences be explained? Does the aggregate character of the insect sample influence the chronological discrepancy? Are different archaeological events being dated as though they were one? Although the latter seems the most plausible explanation (see Morales *et al.*, 2018; Henríquez *et al.*, 2019 for a discussion of the insect-cereal dichotomy), there is no doubt that only a study of the taphonomic and post-depositional processes of the granaries will provide a clearer elucidation of the discrepancies outlined above.

In short, this paper has attempted to present a radiometric hygiene protocol focused on establishing the reliability of each individual dating process, taking into account both the intrinsic physical-chemical and archaeological problems of each dated sample. Thus, it should be seen as a preliminary exercise which is available for use in explorations of the settlement process of the Canary Islands. Furthermore, the results should be compared with different sets of dates.

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