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Time uncertainty, site formation processes, and human behaviours: New insights on old issues in High-Resolution Archaeology

1. Introduction

Time is a widely applied concept in archaeology. Going further, we can assert that it is a foundational concept of this discipline. The main aim of archaeology is to study the behaviours of past populations and changes over time. 'Before' and 'after' are terms continuously used to describe, infer, and interpret archaeological contexts, past human behaviours, and cultural processes. The growing emphasis on radiocarbon dating, thanks to new methods and better quality control on samples (Wood, 2015), and the improvements in archaeological computing are leading to crucial advances in studying changes between regions across large block of time. These include, but are not limited to, the origin and spread of agriculture (Fuller et al., 2014), the transformation of social networks affected by long-distance migrations (Mills et al., 2013), and the relation between demographic processes and cultural changes (Riede, 2009; French, 2016).

However, in archaeology, we do miss a critical consideration of how time is registered in the archaeological layers and in the culture material that is stored in them. Studies traditionally have assumed that the materials found in a single archaeological layer were the result of a single occupation at the site. This means that the archaeological record is viewed – and studied – as the result of contemporaneous activities carried out by the same human group, without considering depositional processes and post-depositional disturbances. The limitation of this approach is that different items that are related to different and not necessarily connected import, export, production, foraging, and discard events are mixed together (Vaquero, 2008; Rivals et al., 2015a, 2015b; Romagnoli and Vaquero, 2016). Furthermore, it is currently impossible to obtain absolute the dating of each episode due to the short temporal gap between them that is not measured by absolute dating. Consequently, the analytical units that are traditionally used in archaeology ('layer', 'horizon', 'phase', and 'culture') underestimate the variability of human behaviour at short temporal scales and homogenise our vision of past lifestyles in an inaccurate way. Indeed, the most visible behaviour in an archaeological horizon was not necessary the most common, and we can lose the real rate of change in the archaeological record on which is based our definition of a cultural time period (Perreault, 2018).

Part of the problem is the huge amount of new discoveries and the advances in computational modelling that have led to the creation and processing of 'big data'. The use of these giant datasets is often the purview of specialists that have little understanding of specific archaeological problems such as taphonomy and low-scale temporal resolution because they relate to very different disciplines (e.g., computer sciences or physics), or because they are more comfortable with the empirical approach as opposed to 'getting the hands dirty' which is necessary when dealing with archaeological material.

None of that means, however, that the classical analytical units are not useful or informative (Nishiaki et al., 2017). Their most relevant contributions are, in our opinion, the creation of comparable categories that are advantageous for solving specific research questions on a large scale (as in the cases cited above), for obtaining large samples to be processed statistically, and for assigning a specific archaeological context to a cultural period.

The study of past cultures starting with the appearance of hominins on the planet has always been the focus of Archaeology and has allowed researchers to approach studying the behavioural evolution of humanity. What we are proposing is the need to reduce the scale of analysis of the archaeological record in order to enlarge our understanding of adaptive, flexible, and variable behaviours in past human groups and thus contribute to richer and more all-inclusive interpretations of the past. Furthermore, this approach could contribute to overcoming some concepts and models according to a renewed view over the archaeological record. We can define this as a new field of research: High-Resolution Archaeology. In this paper, we listed some of the contributions of current high-resolution research that is shedding new light on the contents of archaeology, also presenting the implication of these works to the categorization and interpretation of past human behaviours. Before we enumerate them, we examine some of the critical concepts and methods that constitute the basis of high-resolution archaeology and we address some of the misunderstandings that are still present when referring to time in archaeology.

2. Time resolution of archaeological contexts: concepts, problems, and implications

Time is the raison d'être of archaeology, but also one of its main problems. Through archaeology, we can access our most remote past and work with temporal scales to which very few disciplines can hope to achieve. Time is the essence of archaeology, but also that of the material entities with which archaeologists work: archaeological remains and assemblages of remains. Each of the material items that we find in a site is the result of a sequence of events developed over a more or less prolonged period, including those related to its manufacture or modification by humans, but also those that took place from its abandonment until its recovery by archaeologists. Each of these events has

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left its imprint on the material remains, whose interpretation depends on the extent to which we are able to unravel this sequence. In the same way, the archaeological assemblages that have constituted our fundamental unit of analysis are the result of a sequence of formation and deformation events. The use of the term palimpsest to characterise both remains and assemblages, regardless of whether this term is appropriate in a strict sense, expresses this temporal nature of archaeological realities (Bailey, 2007).

Currently, it is common to recognise that the vast majority of archaeological sites are palimpsests. However, research has lived for a long time with its back to that temporal nature. This is related to the geological criteria traditionally used to define archaeological assemblages. The stratigraphic unit has been the fundamental reference in the construction of these assemblages. Although stratigraphy incorporates a temporal component, as a sequence of strata, it contribute to the creation of an illusion of contemporaneity within each unit. Implicitly or explicitly, it has been assumed that remains found in the same stratum constitute a unit from the cultural or functional point of view. The characterisation of these stratigraphic units has been the basis for the construction of the archaeological discourse and the interpretation of the record in historical, evolutionary or behavioural terms. Often, this characterisation has been the ultimate goal of research and it is common to find in numerous works conclusions such as "level X of site Y is Middle Magdalenian" or "corresponds to long-term occupations" or "it is a place specialised for hunting".

However, that illusion of contemporaneity and consistency referred to stratigraphically-defined assemblages cannot be maintained at present. Once the temporal nature of the archaeological sites has been assumed, the possibility arises that events of very different characteristics, even apparently contradictory, may have taken part in its formation. From this point of view, the dissection of these palimpsests is a necessity in the archaeological interpretation. The identification of units of higher resolution than the stratigraphic level can reveal the variability of formation contexts, without which the assemblage-as-a-whole can express a temporal mean that simplifies and distorts the complexity of human culture and behaviour (Lyman, 2003; Monahan, 1998). It is important to emphasise that the problems derived from time averaging do not only affect the palaeoetnographic approaches to the archaeological record, but also the very definition of the chronocultural entities or techno-complexes that have been the traditional object of study from a cultural-historical perspective.

The temporal dimension of archaeological assemblages forces us to reflect on two aspects. The first is that of the different temporal scales that can be distinguished in the archaeological reality and their consequences from the point of view of the issues that can be addressed in each of them (Holdaway and Wandsnider, 2008). Using the Braudelian terms, this allows us to combine, on the one hand, the great temporal trends and continuities of the *longue durée* and, on the other hand, the variability of the responses to the specific conditions that take place in the short term. The former can be recognised in the low temporal resolution of stratigraphic units or sequences, the latter in the individual events identified in contexts of high temporal resolution (Beck et al., 2007; Brooks, 1982). Integrating these two temporal scales in the same discourse is one of the challenges that archaeology poses at this time (Harding, 2005). Another challenge is the identification of intermediate temporal scales, which approximate the ethnographic time to which a good part of the models used in archaeological interpretation correspond.

The second aspect that emerges from the temporal nature of archaeological reality is the need to contemplate a reading of assemblages in historical terms. When we speak about the historicity of assemblages, we refer to a very specific principle: the events that occur in a certain place depend on those that took place previously. The past is not irrelevant to understand the activities that were carried out in a site. The history of use of a space influences its subsequent use (Bailey and Galadinou, 2009), which reminds us on the other hand of the dynamic nature of the archaeological entities, which are subject to a continuous process of transformation. One of the best examples of this dynamism is the reuse and recycling of abandoned archaeological remains, a behaviour that can substantially modify the characteristics of an assemblage (Julien et al., 1992).

The development of high-resolution archaeology is essential to address the challenges we face when temporalizing the archaeological reality. In this objective, all areas of research are involved, although some play a fundamental role, such as archaeostratigraphy, taphonomy, and spatial analysis or refitting. However, it is necessary to continue working on the extension of the temporal agenda to the whole of archaeological research. Some of the papers published in this volume are good examples of this line of research. Another pending task is to broaden the spectrum of archaeological contexts analysed from a temporal perspective. Up to now, high-resolution perspectives have been applied mainly in contexts in which the formation processes themselves had generated poorly-developed palimpsests. That is, the high temporal resolution was the result of the formation dynamics of the stratigraphic deposit. However, if we want the temporal dimension to be of general interest to the archaeologists as a whole, it is necessary to advance in terms of applying high-resolution perspectives in low-resolution stratigraphic contexts. The dissection of large palimpsests is still a pending task, for which it will be necessary to develop specific procedures.

3. Teeth as time capsules: high-resolution from stable isotopes and dental wear

Among a variety of archaeological records, faunal assemblages can provide a unique type of information about the temporal resolution in archaeological sites through approaches that were developed in the past decades. Among the fossil record, teeth have always been of interest as they are at the interface between the organisms and their environment. Teeth act as temporal capsules that record the diet of organisms. This record occurs during formation of the teeth (period of growth) as well at the time of death (Davis and Pineda Munoz, 2016). Various techniques allow access to paleodietary information at these different moments in the life of an individual. The technique most commonly employed include stable isotopes and tooth micro- and mesowear. Palaeodiet in fossil mammals is a powerful proxy for reconstructing habitats and potential shifts related to temporal or spatial changes (such as seasonal changes, migrations, and transhumance).

High-resolution analysis of tooth enamel through serial sampling along the tooth crown permits researchers to study intra-tooth variability in stable isotopes and to detect seasonal-scale dietary shifts. Serial sampling of isotopes allows tracking changes in diet and temperatures during the formation of the tooth. In Pleistocene archaeological sites, besides the reconstruction of palaeodiets, such techniques are employed to establish animal migrations and hominin hunting strategies, or to test the contemporaneity of death in animal assemblages (e.g., Britton et al., 2011; Julien et al., 2015). In the Holocene, stable isotopes are used to analyse diet, mobility and seasonal reproductive patterns in domestic animals (e.g., Makarewicz and Sealy, 2015; Tornero et al., 2016).

Dental wear analyses refer to two techniques used to reconstruct dietary traits in mammals: microwear that records the diet at the time of death, and mesowear that reflects the diet in the last weeks or months before death. Due to their temporal resolution, these two techniques used in tandem track seasonality in the formation of archaeological or natural assemblages (Sánchez-Hernández et al., 2016; Mihlbachler et al., in press). Tooth microwear is also a proxy for estimating the duration of formation of these assemblages (Rivals et al., 2015a, 2015b).

The integration of these two dietary proxies, dental wear and stable isotopes, is particularly powerful for providing high-resolution data about dietary traits in fossil species. It provides access to significant information about the diet and its variability at different timeframes