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Cover image. Various pendants from Grotte du Renne and Bacho Kiro (adapted from Hublin et al., 2020, p. 301, Figure 3; Zilhão, 2012, p. 38, Figure 4.3).

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1 Introduction

Throughout time, humankind has always been on the move, spreading across the globe and settling into new territories. This constant movement has shaped and impacted the course of human history in significant ways. Exactly because of this human tendency to move and settle in new areas, migration has been a highly studied topic within archaeology, with each society or group taking their diverse cultures and technologies with them (Frachetti, 2010, p. 196; McSparron et al., 2020, p. 219-220).

The Middle Palaeolithic (MP) to Upper Palaeolithic (UP) transition (approximately 45-35 ka cal B.P.) is known as a key topic of debate in archaeological research. It is characterised by a demographic shift caused by the emergence of anatomically modern humans (AMH) on the European continent and their involvement with Neanderthals, who were eventually replaced by the AMH (Morales et al., 2019, p. 1-2; Rendu et al., 2019, p. 1). This transition is characterised by the transitional assemblages, such as the Neronian, Bachokirian and Châtelperronian assemblages (Morales et al., 2019, p. 1-2). It is widely accepted that Neanderthal populations are primarily linked to the MP, while AMH groups are predominantly connected to the Aurignacian culture (Morales et al., 2019, p. 2). Nevertheless, significant debate remains regarding the specific group responsible for the transitional industries (Morales et al., 2019, pp. 1–2).

In a recent study, Slimak (2023) examined the migration movements from the AMH groups into western Eurasia. In this study, it was argued that the migration of the early modern humans into Western Eurasia into Neanderthal territory challenges the established concepts regarding the initial migrations of Homo sapiens and the fundamental characteristics of the UP in western Eurasia (Slimak, 2023, p. 1). It was proposed that there are three migratory waves of Homo sapiens emerging from the Eastern Mediterranean into Europe between 55-42 ka (Slimak, 2023, p. 1-2). Slimak (2023) refers to this as the ‘three waves hypothesis’. The argument is based on the (lithic) technological and chronological similarities between the archaeological sequences from the East Mediterranean region and Europe (Slimak, 2023, p. 1-5). This hypothesis is important because it revises the current migration timelines. The study provides evidence that AMH groups reached Europe sooner than previously thought,

pushing back the timeline of their migration by about 10,000 years to around 54,000 years ago (Slimak, 2023, p. 1). In addition, it also challenges existing theories about the interaction between AMH groups and Neanderthals and the timing of their coexistence. By analysing lithic technologies from different phases of the UP, the study offers new insights into the technological advancements and cultural practices of early modern humans (Slimak, 2023, p. 12-16). The detailed stratigraphic and comparative analyses highlight the sophistication and diversity of modern human tool-making and usage.

Out of the three waves hypothesis of Slimak (2023), the second wave is particularly important as it marks a significant period of technological innovation, with the development and spread of new lithic technologies and tools (Farizy, 1991, p. 317; Roussel et al., 2016, p. 29). This wave also indicates a period of demographic expansion for AMH groups in Europe as Slimak argues that the Châtelperronians were not Neanderthals, but modern humans that came with wave II migration into Europe (Choi, 2023; Slimak, 2023, p. 1, 12-13). The expansion of the Châtelperronian and Early Upper Palaeolithic (EUP) cultures across a wide geographic area suggests increasing population sizes and movements of modern humans into new territories previously occupied by Neanderthals (Slimak, 2023, p. 15).

There are several technological and chronological similarities found of the proposed wave II cultures specifically between the Bachokirian and Châtelperronian cultures (Slimak, 2023, p. 13). Therefore, it is expected that personal ornaments from these cultures would also share similar characteristics. Personal ornamentation, which has been central to debates about human evolution, is considered a key indicator of the emergence of modern human behaviour (Abadía & Nowell, 2015 p. 962; White, 1982, p. 170). Personal ornaments are seen as evidence of one of the recognized forms of symbolic expression (Bar-Yosef Mayer & Bosch, 2019, p. 19). The production of such ornaments allows us to study the production processes, while still ascertaining the identity of the objects as being ornamental (Bar-Yosef Mayer & Bosch, 2019, p. 20).

To study the problem surrounding the MP to UP transition and the three waves hypothesis of Slimak (2023), personal ornaments from the sites of Bacho Kiro (modern-day Bulgaria) and Arcy-sur-Cure (modern-day France) will be studied based on production technique,

material, and type. This could either support or challenge our current understanding of modern human migration into Europe during the transition from the MP to UP in Europe.

1.1 Aim and research questions

The aim of this study is to conduct a comprehensive comparative analysis of the personal ornaments found in two proposed wave II sites. Specifically, this research focuses on the Châtelperronian site of Arcy-sur-Cure and the Early Upper Palaeolithic site of Bacho Kiro. To achieve this, the following research question is formulated: What similarities and differences exist between the personal ornaments found at the sites Arcy-sur-Cure and Bacho Kiro during the Middle to Upper Palaeolithic transition in Europe?

By examining and comparing these artefacts, this study will determine whether the ornamental practices observed at these sites are consistent with Slimak's (2023) second wave from the three waves hypothesis of Homo sapiens expansion. Analysing the personal ornaments from these two sites will help assess whether their stylistic and technological attributes reflect the second chronological and cultural wave, as outlined in the hypothesis. Thereby providing insights into the connections between these early human migrations and their material culture. To achieve this research objective, the following three questions will be addressed for the sites of Arcy-sur-Cure and Bacho Kiro:

1. What different types of ornaments have been discovered, and what are their characteristics?
2. What kinds of materials have been used to create these ornaments?
3. Which techniques have been applied to produce these ornaments?

By addressing these questions for each site, it is possible to compare the different findings. This would allow us to shed light on the cultural and technological exchanges that occurred throughout the critical MP to UP transition in Europe. The findings could validate or challenge Slimak's hypothesis and offer deeper insights into the complexities of prehistoric human migrations and their impact on cultural developments. Ultimately, this study will

contribute to a more comprehensive narrative of human history during one of its most transformative periods.

1.2 Thesis outline

Chapter two provides a deeper explanation of the three waves hypothesis of Slimak (2023). Moreover, a detailed description of both archaeological sites (i.e., Arcy-sur-Cure and Bacho Kiro), from which the wave II ornaments will be studied, is provided. It includes information on the geographical locations, excavation history, and significance of each site.

The third chapter outlines the specific criteria used to compare the ornaments. This includes detailed descriptions of the techniques employed to assess the production of ornament types and raw material usage.

In the fourth chapter, the findings of the comparative analysis are presented. Data is systematically organised and displayed, highlighting any patterns or discrepancies observed in the materials, type, and technology of the wave II ornaments. This chapter focuses on the outcome of the analyses, providing a clear and objective presentation of the results.

Chapter five will cover the discussion, the results are interpreted and discussed in depth. First, the patterns identified in the results are examined. Then, these findings are compared with existing literature, such as studies on ornaments from various other sites among which Ksar Akil. The implications of these comparisons are considered, addressing what the results mean for the understanding of the MP to UP transition and the three waves hypothesis of Slimak (2023). This chapter also reflects on the broader implications of the research, suggesting avenues for future research.

The final chapter concludes the main findings of this thesis and underscores their significance. It revisits the primary research question and sub-questions, providing clear answers based on the results and discussion. This chapter also highlights how the findings contribute to the field of Palaeolithic archaeology.

2 Background

The archaeological record in Eurasia indicates a significant transition from the MP to UP, between 50,000-39,000 thousand years ago in Eurasia. This is attested by major changes in technological and cultural aspects, discernible through lithic assemblages that show a preference for volumetric blade extraction and the increased prevalence of tools from osseous technologies (Gicqueau et al., 2023, p. 1; Martisius et al., 2022, p. 2; Mellars, 2005, p. 12; Tsanova, 2023, p. 156). This transition is also characterised by the emergence of various new technologies, such as blade technology (Kadowaki et al., 2024, p. 2). Some of these technologies are argued to have possibly been created by Neanderthals (Martisius et al., 2022, p. 2; Welker et al., 2016, p. 11162).

The first appearance of Homo sapiens in Europe has been characterised by the Initial Upper Palaeolithic (IUP) industries (Tsanova, 2023, p. 156). Kuhn and Zwyns (2014) argue that this term refers to 'the set of early Upper Palaeolithic assemblages, from Eurasia, with features of Levallois technology in blank production and essentially Upper Palaeolithic retouched tool inventories' (p. 31). A variety of technological features have been assigned to the IUP and EUP, and it has been argued that these represent multiple dispersal events of Homo sapiens (Hublin, 2015, p. 194-206; Martisius et al., 2022, p. 2-3).

Among these new industries, the emergence of personal ornaments is linked to what is termed 'modern human behaviour'. The earliest possible personal ornaments are perforated shells, associated with the AMH groups in the both the Levant and parts of Africa, dating to around 75,000–90,000 B.P. (d'Errico et al., 2009, p. 16051; Higham et al., 2010, p. 20234; Martisius, et al., 2022, p. 5). In Europe, the IUP assemblages show personal ornaments such as pendants and beads crafted from numerous materials. These materials consisted of animal teeth, bone, and ivory (Higham et al., 2010, p. 20234; Hublin et al., 2012, p. 18743; Martisius et al., 2022, p. 4-5). It has been argued that both the emergence and use of personal ornaments are likely connected to AMH cultures (Bednarik, 1997, p. 32; Borić & Cristiani, 2018, p. 209; Botha, 2020, p. 35; Higham et al., 2010, p. 20234; Hublin et al., 2012, p. 18743). However, it should be noted that research in this area that is focussing on the IUP record is still in its very early stages (Martisius et al., 2022, p. 3).

To enhance our understanding of the transition from the MP to the UP, as well as the concomitant technological advancements and migratory movements, studying materials from well-preserved sites like Arcy-sur-Cure and Bacho Kiro is invaluable. Studying personal ornamentation is pivotal in discussions about human evolution, serving as a crucial sign of the development of modern human behaviour (Abadía & Nowell, 2015, p. 962; White, 1982, p. 170). They especially provide an excellent means to study production methods (Abadía & Nowell, 2015, p. 964-965). Beneficially, similar techniques for lithic technology can be employed to study personal ornaments (Abadía & Nowell, 2015, p. 964). The chaîne opératoire approach is particularly useful for examining these ornaments, as it explores the process from the original material to the end product. This approach considers the raw materials and technologies used to modify them, revealing both the difficulty and complexity involved in creating these ornaments (Abadía & Nowell, 2015, p. 964-965). Moreover, a personal ornament, such as a pendant, requires some sort of cord for either attaching or hanging the ornament. This cord can be made of various materials, but most importantly, this indicates that creating a personal ornament not only requires the skill and knowledge to create such an object, but also requires another complex technology to be able to make use of the ornament (Marshack, 1990, p. 466). The differences in material choice and the types of ornaments could reflect cultural preferences and symbolic meanings attached to the ornaments (Abadía & Nowell, 2015., p. 962; Bar-Yosef Mayer & Bosch, 2019, p. 19-20; Botha, 2020, p. 63-65). Additionally, ornaments can also reflect both the influence of the environment and climate in the availability and choice of certain materials for this particular function (Kuhn & Clark, 2014, p. 10; Martisius et al., 2022, p. 3; Tolmie, 2013, p. 196-197). Therefore, studying personal ornaments provides a very unique angle of the respective cultures that are being studied which cannot be provided by only studying the lithic technologies (Marshack, 1990, p. 466).

2.1 The three waves hypothesis

Slimak's (2023) three waves hypothesis offers an in-depth examination of the earliest human migrations into Europe. His study delineates three separate migration waves of Homo sapiens from the Eastern Mediterranean to Europe, each linked to distinct lithic

technologies and chronological periods (Choi, 2023; Slimak, 2023, p. 1-20). Based on Slimak (2023, p. 12-13), the three waves could be summarised as follows:

- First Wave (around 60,000-50,000 years ago): This phase is characterised by the Neronian, Bohunician and Kremenician lithic traditions, linked to IUP. It marks an early migration of modern humans into Europe, notably evidenced in the Middle Rhône Valley to Ukraine.
- Second Wave (around 45,000 years ago): This phase corresponds to the cultures of the Châtelperronian, Bachokirian associated with the EUP, exhibiting bipolar blades and backed points.
- Third Wave (around 42,000 years ago): Represented by the Proto-Aurignacian and Southern Early Ahmarian, this phase shows evidence of long rectilinear bladelets. It is known for its recognisable industries all over Europe, marking the first instance of a unified cultural presence throughout Western Eurasia.

This conclusion is drawn from direct comparisons with archaeological sites such as Grotte Mandrin and Ksar Akil in the Eastern Mediterranean (Slimak, 2023, p. 1). These sites indicate that the EUP phases in Western Europe have counterparts in terms of chronology and technology. This is supported by evidence of trans-Mediterranean technological connections (Slimak, 2023, p. 1, 15). This research underscores the importance of recognizing how the origins, evolution, and development of the EUP across the European continent mirrors similar archaeological developments observed within the Eastern Mediterranean.

2.2 Description of the sites

This study will focus on the archaeological sites of Arcy-sur-Cure (i.e., Grotte du Renne) and Bacho Kiro, as both correspond to wave II. These sites are notable for their extensive research and the considerable quantity of personal ornaments they yield.

2.2.1 Bacho Kiro

The Bacho Kiro cave (45,990-43,000 cal B.P.), is situated in Bulgaria (see Figure 1), and provides a critical window into human prehistory (Fewlass et al., 2020, p. 794; Hublin et al.,

2020, p. 299; Martisius et al., 2022 p. 7; Smith et al., 2021, p. 3). Its rich stratigraphy encompasses a prolonged period from the MP to the UP, confirmed through radiocarbon dating (Fewlass et al., 2020, p. 794). The site was excavated twice in the past, first in 1938 by D. Garrod and R. Popov, and later from 1971 to 1975 by B. Ginter and J. Kozłowski (Fewlass et al., 2020, p. 794; Hublin et al., 2020, p. 299; Smith et al., 2021, p. 3). During these excavations, numerous artefacts were found, including pendants of animal teeth, lithic assemblages, different tools made of bone, human remains, and ornaments like beads (Fewlass et al., 2020, p. 794; Hublin et al., 2020, p. 299; Martisius et al., 2022, p. 12-13; Smith et al., 2021, p. 3). Initially labelled as 'Bachokirian' and considered transitional dividing the MP and the UP, this lithic assemblage is now identified as EUP (Fewlass et al., 2020, p. 794-796; Slimak, 2023, p. 1-15; Smith et al., 2021, p. 3-4). The importance of this site is clear as Smith et al. (2021) argue that the site is ‘the earliest occurrence of Late Pleistocene Homo sapiens in Europe’ (p. 3). More recently, in 2015, the site was re-examined, which included new excavations by the Max Planck institute and the national archaeological institute at Sofia to further study the chronology (Hublin et al., 2020, p. 299). Notably, the osseous artefacts from the deposits at Bacho Kiro represent some of the earliest known examples of UP technology, offering invaluable insights into early human innovation and dispersal (Martisius et al., 2022, p. 5).

Figure 1. Location of Bacho Kiro. The map shows the location of Bacho Kiro in Bulgaria in Europe (Fewlass et al., 2020, p. 795, Figure 1).

2.2.2 Arcy-sur-Cure

A well-known site for its special position and containing levels of the transitional period, thus playing a crucial part in the debate around the MP to UP transition, is Arcy-sur-Cure (d'Errico et al., 2003, p. 247; Farizy, 1991, p. 303). The site is situated in Burgundy along the Cure river in modern day France as shown in Figure 2 (Farizy, 1991, p. 303). The site is well known for its prominent position in discussions regarding the possible interaction between AMH groups and Neanderthals during this transitional period (Higham et al., 2010, p. 20234). It was first excavated in the 1950s by A. Leroi-Gourhan (Farizy, 1991, p. 303). The site consists of multiple caves: the Grand des Fées, Grotte du Bison, Grotte de Cheval, Grotte de Trilobite, Grotte d'Ours, Grotte du Loup, Grotte de Lion, Grotte du Renne, Grand Grotte, the Grottes de Lagopède and Grotte de l'Hyène (Farizy, 1991, p. 303; Tolmie, 2013, p. 98). Arcy-sur-Cure, specifically the Grotte du Renne (45,000-28,000 B.P.), is crucial for studying the MP to UP transition and the three waves hypothesis proposed by Slimak (2023). This site has excellent preserved MP and UP artefacts, including numerous personal ornaments from the Châtelperronian industry (Farizy, 1991, p. 317; Higham et al., 2010, p. 20234-20235; Tolmie, 2013, p. 109). These ornaments are essential for understanding technological and cultural developments during this period (Farizy, 1991, p. 317; Higham et al., 2010, p. 20234-20235; Tolmie, 2013, p. 109). Among these personal ornaments are

grooved and perforated animal teeth, a fossil shell and small perforated beads (Botha, 2020, p. 35).

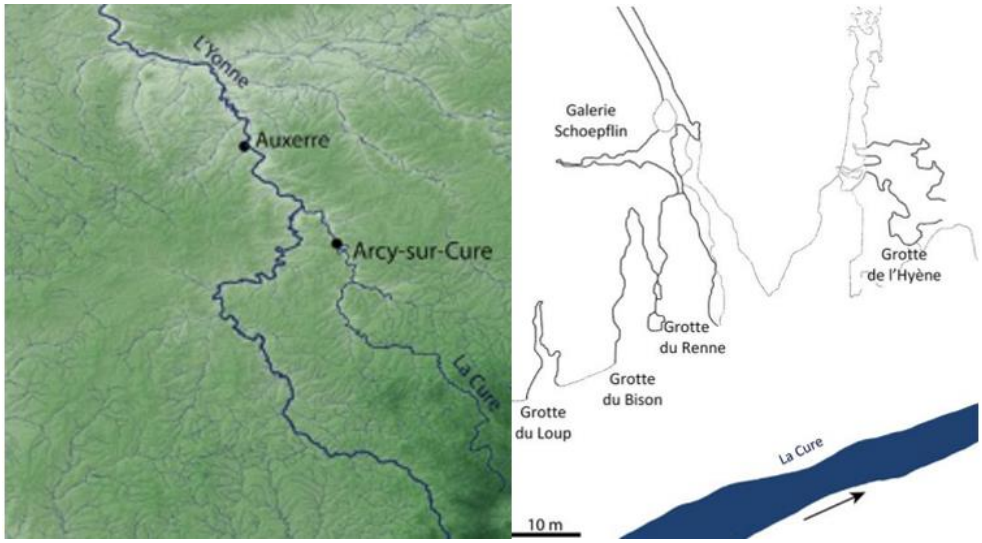

Figure 2. Location Grotte du Renne. The map displays the location of Arcy-sur-Cure on the left, while on the right, it provides a more detailed view of the caves, including Grotte du Renne in France (Adapted from Gicqueau et al., 2023, p. 2, Figure 1).

3 Methods

This study will conduct a comparative analysis of ancient ornament production. As both sites have been excavated in the past by others, the artefacts cannot be directly studied, at least not within the scope of this thesis. Therefore, this research relies on the available raw data of the ornaments found at both sites, published analyses mentioning the sites and ornaments, and general archaeological literature related to these sites. The explanation of the concept of personal ornaments focuses on artefacts identified by archaeologists within this category. As Abadía and Nowell (2015) note, these include: 'beads, perforated teeth, pendants, rings, bracelets, carved bones objects, colourants and any other object suspected to have been used as a form of bodily decoration' (p. 953). To compare the sites of Bacho Kiro and Arcy-sur-Cure in terms of personal ornament production, the analysis focuses on three key aspects. These aspects involve the material they were created from, the types of ornament made, and which production techniques were used to create them. Each of the aspects has different assessment criteria and are explained in more detail below.

3.1 Material

One of the analyses involves the categorisation of the materials used in the ornaments. During the UP in Europe, there was widespread use of relatively standardised forms of ornaments, such as pendants and beads (Arrighi et al., 2020, p. 171; Kuhn et al., 2001, p. 7641; Lbova, 2021, p. 5-6; Vanhaeren & d'Errico, 2006, p. 1113; White, 1993, p. 334). Additionally, the materials used to create these ornaments were also quite consistent (Kuhn et al., 2001, p. 7641; Marshack, 1990, p. 461; White, 1993, p. 33). Considering the period and site locations, four common types of materials for personal ornaments are expected. These include: shells, stone, bone, and teeth. Possible other materials found will be reported too, so the full scope of materials used will be analysed. Consequently, the archaeological record primarily focuses on these materials, especially teeth, which was the most commonly used material to craft ornaments from during this period (Arrighi et al., 2020, p. 182; Kuhn et al., 2001, p. 7641).

Additionally, looking at the sites of this study, an additional subclassification will be made. The identification of the animal species to which the material belongs is important because the differences in material choice could reflect varying cultural preferences (Abadía & Nowell, 2015., p. 962; Bar-Yosef Mayer & Bosch, 2019, p. 19-20; Botha, 2020, p. 63-65). Besides the reflection of cultural preference, it could also provide us with information about the use of local resources in their environment. The choice of materials could reflect the availability of resources and the palaeoenvironment (Kuman, 2014, p. 13; Tsanova, 2023, p. 168, 187). This means for the material analysis, for the osseous materials (i.e., bone and teeth) specifically, the species of animal will be used to further classify the materials used in the ornament production.

In this creation of a comprehensive and systematic overview of prehistoric ornamentation, it is also essential to differentiate between the various types of teeth used, which happens while recovering and analysing teeth from archaeological contexts (Bendrey, 2014, p. 258, 264; Messenger, 2014, p. 2471). The types of teeth used will be categorised into: molars, premolars, canines, and incisors. When classification between premolars, canines, or incisors is unclear, the classification of single rooted teeth will be used instead. This process of type of teeth determination relies on the understanding that dental morphology is closely linked to diet and varies significantly among mammals, allowing for relatively straightforward species identification (Hillson, 1986, p. 145).

While alterations or modifications of certain materials are rarely questioned as being ornamental, other materials can be more difficult to place in the category of personal ornaments (Bar-Yosef Mayer & Bosch, 2019, p. 20). Among these, shells are a difficult material, because they often have natural perforations, which indicates that these shells do not necessarily had to be modified before they could be used as ornament (Bar-Yosef Mayer, 2015, p. 1; Bar-Yosef Mayer & Bosch, 2019, p. 20; Baysal, 2019, p. 83). The earliest evidence of shells used as ornaments has been found at MP sites from approximately 100,000-70,000 years ago (Bar-Yosef Mayer, 2015, p. 1; d'Errico et al., 2009, p. 16051). Among the criteria used to establish if a shell has been used as personal ornament, are the identification of intentional perforations, the archaeological context and a selectiveness of certain species (Bar-Yosef et al., 2009, p. 310-311; Bar-Yosef Mayer & Bosch, 2019, p. 20).

3.2 Type of ornament

Artefacts, such as personal ornaments, represent key evidence in archaeology that points towards advanced cognitive capacities (Botha, 2020, p. 13). They include beads, pendants, rings, bracelets, and carved objects that were likely used as bodily decoration (Abadia & Nowell, 2015, p. 953). As part of this research, the different types of personal ornaments found at the sites will be studied. The ornament types will be classified according to the categories used in site-specific literature.

3.3 Production techniques

To study production techniques of ornaments, archaeologists can use similar methods for studying stone tools (Abadía & Nowell, 2015, p. 966). These methods can include electron microscopy, experimental techniques, microwear analysis, standardisation of measurements and design in ornament production, geologic provenience analysis, the choice of raw materials for ornaments, and methods to recognize artificially made modifications (Abadía & Nowell, 2015, p. 966; White, 2007, p. 289). That said, not all of these methods were available during the excavation and analyses or classifications when the sites of this study were first excavated, but could have been applied in follow up studies.

Production techniques and use-wear are crucial for interpreting the manufacturing and use of personal ornaments, specifically on pendants from various animal teeth (Osipowicz et al., 2020, p. 1; Shunkov et al., 2020, p. 3). Technological production methods can be analysed and often exist of drilling, scraping, a combination of both scraping and drilling, and grooving (Osipowicz et al., 2020, p. 3; Shunkov et al., 2020, p. 4-11; White & Normand, 2015, p. 144). These are included, because they are common techniques used and analysed from sites during the EUP and UP (White & Normand, 2015, p. 144). In addition, there will also be a focus on the use wear analysis which exist of abrasion, polishing, striations, depressions, crushing and smoothing (Martisius et al., 2022, Table 5; Shea, 2013, p. 20; Shunkov et al., 2020, p. 13).

Table 1. Overview of different modification techniques. Clarification of different possible techniques used in the manufacture of personal ornaments (Adapted from Conte et al., 2014, p. 59-60; Martisius et al., 2022, Table 5; Osipowicz et al., 2020, p. 3-5; Shea, 2013, p. 20; White, 1989, p. 379; White & Normand, 2015, p. 144).

Technique	Clarification
Drilling	Technique used to create a hole, often applied on both sides of the material
Scraping	Technique that in this case is used either to create a perforation or it is used at the last stage in creating a perforation
Combination scraping and drilling	The surface where the perforation was intended was smoothed by scraping, thus removing extra material, resulting in a flat or hollow surface that made the subsequent drilling process easier
Grooving	Technique used to create grooves for suspension
Gouging	Technique used to thin an object for perforation
Abrasion	Mechanical wearing down of a particular surface, often due to a certain amount of friction
Polishing	Technique to smoothen a surface
Striations	Marks/ scratches on a surface caused by either friction or abrasion
Depressions	Hollow indentations on surfaces, caused by use or occur during the production process
Crushing	Break or fracture of a material
Smoothing	Technique used to worn down a surface to a finer texture

3.4 Site-specific focus

Both sites involve a multitude of periods that are found during the excavations and reflect on the complexity of their stratigraphic layers (Fewlass et al., 2020, p. 794–796; Gicqueau et al., 2023, p. 3). Therefore, it is essential that only the findings from the relevant layers about the transitioning from the MP to UP are included in this study. This targeted approach helps to avoid conflating data from unrelated periods, maintaining the integrity of the analysis.

For the Bacho Kiro site, only the layers H, I, and J are used, as they correspond to the IUP (Figure 3). Layers 10/9c to 11a are dated between 46,940 and 43,650 years B.P. (Fewlass et al., 2020, p. 799). This is based on several carefully dated bone fragments (Fewlass et al., 2020, p. 794-796; Hublin et al., 2020, p. 300; Martisius et al., 2022, p. 7). The excavations at this site uncovered a 5-meter deep stratigraphic sequence, revealing distinct MP and UP layers. The MP portion at the base included three Mousterian layers (14, 13, and 12), characterised by local stone use and the Levallois technology for stone tool production (Tsanova et al., 2024, p. 3, 5). Above the Mousterian layers, the UP sequence began with early UP artifacts in layers 10/9c (layer H), 11 (layer I) and 11a (layer J), followed by Aurignacian and Epigravettian layers. Layer 11, the richest in findings, provided early UP evidence and yielded a radiocarbon date suggesting an age greater than 43,000 years B.P., predating the Aurignacian period (Tsanova et al., 2024, p. 3, 5). A substantial dataset of high-precision radiocarbon dates was established through accelerator mass spectrometry (AMS) of bone material (Fewlass et al., 2020, p. 796). Collagen extraction was successful in 139 out of 147 samples. Overall, 95 samples underwent AMS radiocarbon dating, six of which were identified as Homo sapiens (Fewlass et al., 2020, p. 796).

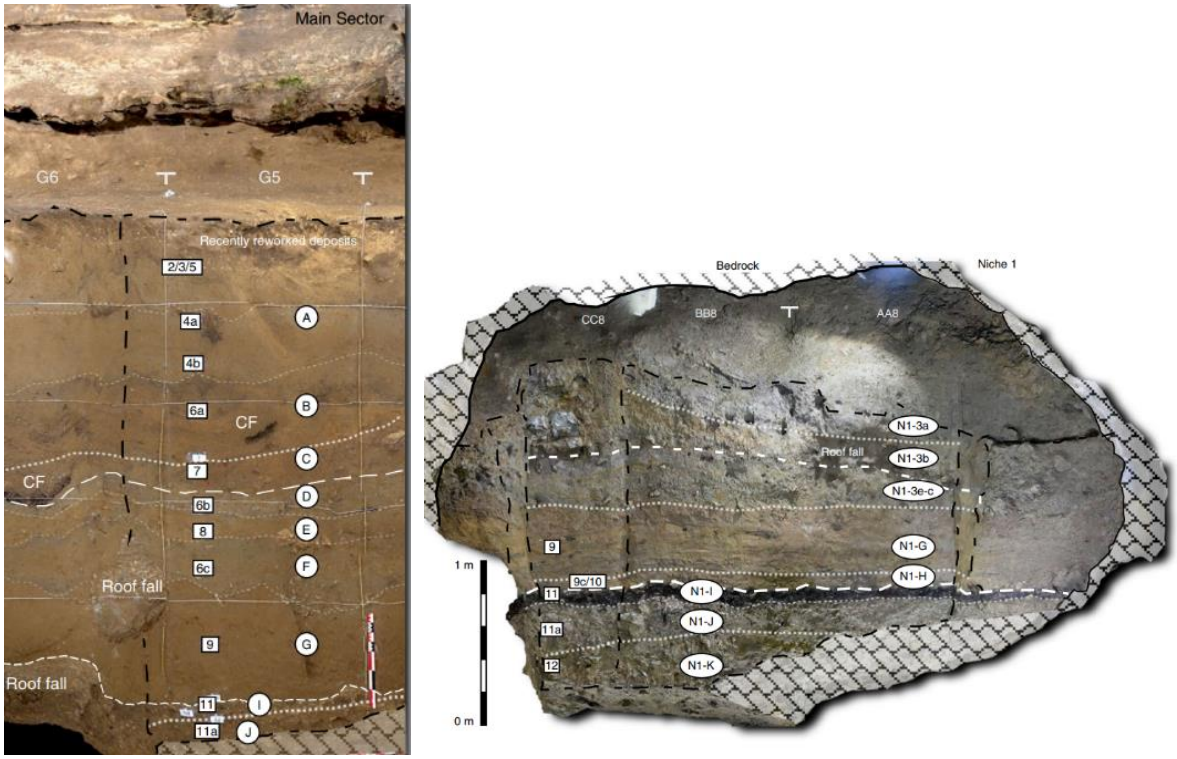

Figure 3. Stratigraphy at Bacho Kiro. The stratigraphy shows the layers in the excavated sectors (Adapted from Fewlass et al., 2020, p. 795, Figure 1).

For the Arcy-sur-Cure site, the focus will be on the Châtelperronian Layers X through VIII at the Grotte du Renne as shown in Figure 4. These layers date between 44,500 and 41,000 years B.P. (Hublin et al., 2012, p. 18746). This site has 14 stratigraphic layers of which the dating is based on the AMS of multiple bone collagen fragments (Hublin et al., 2012, p. 18747; Zilhão, 2007, p. 16, 27). Layer XI represents the highest stratigraphic level associated with the Mousterian (Hublin et al., 2012, p. 18744). The majority of Châtelperronian artefacts at the site were uncovered in layers X and IX (Hublin et al., 2012, p. 18744). Layer VIII contains fewer artefacts and features many predator bones, pointing to sporadic human presence. Layer VII contains a Proto-Aurignacian assemblage (Hublin et al., 2012, p. 18744). The radiocarbon dates obtained in this study are consistent with the stratigraphic divisions (Hublin et al., 2012, p. 18744). The layers X through VIII are crucial for understanding the Châtelperronian cultural phase and provide significant data for comparative analysis.

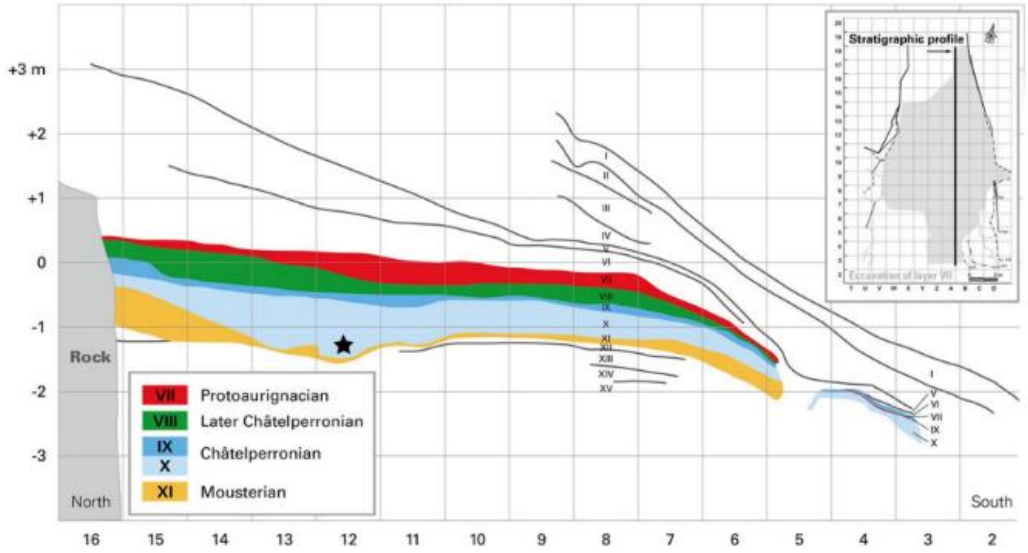

Figure 4. Stratigraphy at Grotte du Renne. It features layers X, IX and VIII as Châtelperronian (Gicqueau et al., 2023, p. 3, Figure 2).

4 Results

A total of 68 personal ornaments are found at both sites during the EUP. Based on the analysis, it is clear that the ornament type pendant is predominantly (n=59) represented in the dataset as shown in Table 2. Other types of personal ornaments were also present at both sites, but in small numbers.

Table 2. Ornaments found at Bacho Kiro and Grotte du Renne. Types of ornaments and the materials from which they are made, discovered at both Bacho Kiro and Grotte du Renne sites (Adapted from d'Errico et al., 1998, p. S5, Table 2; Martisius et al., 2022, Table 4, 5; Zilhão, 2007, p. 27, Table 3).

Type of ornaments	Material	Amount Bacho Kiro	Amount Grotte du Renne	Total amount
Pendants	Animal teeth	27	23	50
	Fossil mollusk	-	4	4
	Bone	-	5	5
Beads	Sandstone	1	-	1
	Ivory	1	3	4
	Bone	1	-	1
Rings	Ivory	-	3	3

The analysis shows that at Bacho Kiro, a total of 30 ornaments are found, of which 27 pendants (or fragments of pendants) and three beads (Hublin et al., 2020, p. 300; Martisius et al., 2022, p. 24-26; Talamo et al., 2021, p. 1). All pendants are crafted from animal teeth, primarily those of carnivores (n=16), although several herbivore teeth (n= 9) are also found (Martisius et al., 2022, p. 1; Tsanova, 2023, p. 162, 193; Fewlass et al., 2020, p. 794; Talamo et al., 2021, p. 1). Two pendants could not be assigned to a specific species (Martisius et al., 2022, Table 5). Based on the morphological characteristics of the root and crown of the teeth, 15 carnivore pendants are attributes to the cave bear (Martisius et al., 2022, p. 26;

Talamo et al., 2021, p. 1; Tsanova, 2023, p. 162, 193). Out of these, the incisors (n=9) are the most used teeth type to craft pendants. All single rooted teeth could not be classified into distinctive tooth types, but are confirmed to be from herbivores. Eight teeth have not been determined to be a specific species, but based on basic features, it has been argued that six of these are herbivore teeth (Martisius et al., 2022, p. 26). The other ornament found are three disk-shaped beads, each from a different type of material (Martisius et al., 2022, p. 24-25).

Besides ornament type and material of use, the production method is also analysed. At Bacho Kiro, 16 of the pendants are pierced biconically, two pendants are only grooved, one pendant is pierced by the method of gouging, three pendants show traces of scraping to create a shelf-like structure, and one is partially pierced (Martisius et al., 2022, p. 27). Some of the pendants are shown in Figure 5.

Figure 5. Animal teeth pendants at Bacho Kiro. Perforated and grooved pendants made of cave bear teeth (Adapted from Hublin et al., 2020, p. 301, Figure 3).

The remaining four teeth show evidence of scraping used for perforation, but are fragments (Martisius et al., 2022, p. 27). Analysis of the herbivore tooth crowns suggests frequent alteration by abrasion, a feature not observed on the carnivore teeth (Martisius et al., 2022, p. 26). When looking at evidence from the roots, the incisors and molars' roots show scraping traces over the widest faces and the molars often miss minimally one root (Martisius et al., 2022, p. 27). This and other details are presented in Table 3. Examining the data on the other personal ornaments, the ivory bead exhibits no traces of manufacture,

but it was likely drilled as it has a regular round perforation (Martisius et al., 2022, p. 24). The bead of sandstone shows traces of drilling and is biconically perforated. The bead of bone has been ground, exemplified by grinding traces (Martisius et al., 2022, p. 24-25, 44).

Table 3. Summary of the modification of pendants of animal teeth. More detailed summary of the Bacho Kiro pendants (Adapted from Hublin et al., 2020, p. 300; Martisius et al., 2022, Table 5).

Animal	Tooth type	Technique of Perforation	Type	Use Traces
Unknown	Single rooted tooth	Scraped, Drilled	Biconically drilled	Smoothed, Striations
Unknown	Single rooted tooth	Scraped, Ground, Drilled, Grooved	Biconically drilled	Polished
Cave bear	Incisor	Scraped, Drilled	Biconically drilled	Smoothed
Cave bear	Molar	Scraped, Ground, Drilled	Biconically Drilled	Smoothed
Unknown	Single rooted tooth	Scraped	Scraped to form shelf like feature	Striations, Crushed
Unknown	Single rooted tooth	Scraped, Drilled	Biconically drilled	Polished, Smoothed, Striations
Bos/bison	Single rooted tooth	Scraped, Drilled	Biconically drilled	Polished

Bos/bison	Single rooted tooth	Scraped, Drilled	Biconically drilled	Smoothed, Polished, Depressions
Cervidae	Single rooted tooth	Scraped, Drilled	Biconically drilled	Smoothed, Striations
Unknown	Single rooted tooth	Scraped, Drilled, Grooved	Biconically drilled	Smoothed, Polished
Unknown	Single rooted tooth	Scraped, Drilled	Biconically drilled	Striations
Cave bear	Molar	Scraped	Scraped to form shelf like feature	Polished, Striations, Depression Crushed
Cave bear	Molar	Scraped, Drilled	Biconically drilled	Smoothed, Polished, Striations
Cave bear	Incisor	Scraped, Drilled	Biconically drilled	Smoothed, Polished, Striations, Depressions
Cave bear	Incisor	Scraped, Drilled	Biconically drilled	Smoothed, Polished, Striations
Cave bear	Incisor	Scraped, Drilled	Biconically drilled	Smoothed, Polished, Depressions

Wolf	Incisor	Scraped, Drilled	Biconically drilled	Smoothed, Polished, Striations
Cave bear	Premolar	Grooved	Grooved	Smoothed, Polished, Striations
Cave bear	Incisor	Grooved	Grooved	Smoothed, Striations
Cave bear	Incisor	Scraped, Gouged	Gouged	Striations
Cave bear	Incisor	Scraped, Ground	Unknown	Smoothed
Unknown	Unknown	Scraped, Grooved	Unknown	Unknown
Cave bear	Premolar	Scraped,	Unknown	Polished, Smoothed
Cave bear	Molar	Scraped	Unknown	Polished
Cave bear	Incisor	Scraped	Scraped to form a shelf like feature	Smoothed, Crushed
Unknown	Single rooted tooth	Scraped, Ground, Drilled	Biconically drilled	Smoothed, Striations
Cave bear	Incisor	Unknown	Partially pierced	Polished, Striations

At Arcy-sur-Cure, and more specifically the Grotte du Renne site, the analyses of different studies showed inconsistent in the amount of ornaments found (Botha, 2020, p. 35; Caron

et al., 2011, p. 3; d'Errico et al., 1998, p. S4; d'Errico et al., 2003, p. 247; Zilhão, 2007, p. 27). For the purpose of this study a total of all unique reported findings are considered. This resulted in a total of 38 personal ornaments of which 32 are classified as pendants. These are made from 11 carnivore teeth, 12 herbivore teeth, four herbivore phalanges, one herbivore metacarpal and four shells and fossils from three different species (d'Errico et al., 1998, p. S4; Movius, 1969, p. 120; Zilhão, 2007, p. 27). Of the 24 teeth that have been discovered, the majority belong to the fox species (n=8), with a total of ten different species identified (d'Errico et al., 1998, p. S5; Movius, 1969, p. 120; Zilhão, 2007, p. 27). The other pendants are either made of bone, fossil or shell (d'Errico et al., 1998, p. S4; Movius, 1969, p. 120; Zilhão, 2007, p. 27). Besides the pendants, rings and beads were also found. The findings comprise an angled ring, two fragments of an angled ring, and three flat ivory beads (d'Errico et al., 1998, p. S5; Marshack, 1990, p. 461; White, 2001, p. 257; Zilhão, 2007, p. 26).

At Grotte du Renne the production techniques found contain less details than the analyses done for the ornaments from Bacho Kiro. The only analysis on production technique that is available identifies the different modifications, which distinguishes two groups: perforation and grooving (Zilhão, 2007, p. 27). The data shows that there was a preference for grooved pendants (n=21) over perforated pendants (n=11). Some of the pendants are shown in Figure 6. The fossil and two shells are perforated, but this could be a natural perforation, as this is the case in many shells (Bahn, 2016, p. 30; Baysal, 2019, p. 83; d'Errico et al., 1998, p. S4). The Rhynchonella is grooved (d'Errico et al., 1998, p. S5; Zilhão, 2007, p. 27). The overview of findings with the type of modification are also shown in Table 4. The perforations on the fox canines were located at the end of the roots, whereas the other teeth had mostly grooves (d'Errico et al. 1998, p. S12; Movius, 1969, p. 120; White, 2001, p. 262). The perforations were made by the following technique described by Zilhão (2007) 'first abrading the root, then piercing the thinned surface with a puncture blow or a series of pressure removals, and finally smoothing and enlarging the hole' (p. 26). Most of the worked teeth show another technique, which exists of incising a parallel groove for suspension (Marshack, 1990, p. 461; Movius, 1969, p. 120). The manufacturing techniques employed for creating these beads involved grooving and drilling (d'Errico et al., 1998, p. S15; Marshack, 1990, p. 461). At least two of the rings exhibit manufacturing traces such as striations, while one of them shows evidence of grooving (Botha, 2020, p. 51; d'Errico et al.,

1998, p. S8-S9). Notably, all of the beads found at the site are perforated (d'Errico et al., 1998, p. S5).

Figure 6. Various pendants at Grotte du Renne. Image of several pendants that were created from different materials like animal teeth, bone, and fossil (Adapted from Zilhão, 2012, p. 38, Figure 4.3).

Table 4. Overview of findings for the pendants at Grotte du Renne. Analysis of the species, type of material and modification of the material at Grotte du Renne of the pendants found (Adapted from d'Errico et al., 1998, p. S5, Table 2; Zilhão, 2007, p. 27, Table 3).

Species (amount)	Type (amount)	Modification (amount)
Fox (8)	Canine (8)	Perforated (4)
		Grooved (4)
Horse (1)	Incisor (1)	Grooved (1)
Hyena (1)	Incisor (1)	Grooved (1)
Bear (1)	Incisor (1)	Grooved (1)
Bayania lactea (2)	Fossil shell (2)	Perforated (2)
Belemnite (1)	Fossil (1)	Perforated (1)
Wolf (1)	Canine (1)	Grooved (1)
Rhynchonella (1)	Fossil (1)	Grooved (1)
Rhinoceros (1)	Molar fragment (1)	Grooved (1)
Bovid (4)	Incisor (4)	Grooved (4)
Marmot (2)	Incisor (2)	Grooved (2)
Reindeer (8)	Incisor (3)	Grooved (3)
	Phalange (4)	Grooved (2)
		Perforated (2)
	Metacarpal (1)	Grooved (1)
Red deer (1)	Canine (1)	Perforated (1)

The results of the material analysis for the pendants and other ornament types of each site are presented in Table 5 and Table 6 respectively. These tables indicate that at both sites, they preferred working with single rooted teeth rather than with molars. At Bacho Kiro, carnivores appear to have been more commonly used for ornament creation, whereas herbivores were more frequently found at Grotte du Renne, see also Figure 7. Likewise, the

diversity of osseous material used for the creation of personal ornaments is also higher at Grotte du Renne. The amount of ornaments created from bears at Bacho Kiro seems to indicate a strong preference for this specific species. At Grotte du Renne the variety of species is higher and less specific to a particular species, as is clearly demonstrated in Figure 8. For the other types of ornaments, there is a clear difference notable in the absence of shells at Bacho Kiro and also the fact that no rings have been found. At Arcy-sur-Cure there also seems to be more frequent use of ivory.

Table 5. Overview of the pendants at Bacho Kiro. Analysis of the pendants divided in type of animal, the animal species and the sub classification of material used (Adapted from Martisius et al., 2022, Table 5).

Type of animal (amount)	Species (amount)	Sub classification material used (amount)
Carnivore (16)	Bear (15)	Molars (4)
		Premolars (2)
		Incisors (9)
	Wolf (1)	Incisors (1)
Herbivore (9)	Cervidae (1)	Single rooted teeth (1)
	Bos/Bison (2)	Single rooted teeth (2)
	Unknown middle to large herbivores (6)	Single rooted teeth (6)
Unknown animal type (2)	Unknown species (2)	Single rooted teeth (2)

Table 6. Overview of the pendants at Grotte du Renne. Analysis of the pendants divided in type of animal, the animal species and the sub classification of material used (Adapted from d'Errico et al., 1998, p. S5, Table 2; Zilhão, 2007, p. 27, Table 3).

Type of animal (amount)	Species (amount)	Sub classification material used (amount)
Carnivore (11)	Fox (8)	Canine (8)
	Hyaena (1)	Incisor (1)
	Bear (1)	Incisor (1)
	Wolf (1)	Canine (1)
Herbivore (17)	Horse (1)	Incisor (1)
	Reindeer (8)	Phalange (4)
		Incisor (3)
		Metacarpal left (1)
	Red deer (1)	Canine (1)
	Bovid (4)	Incisor (4)
	Marmot (2)	Incisor (2)
	Rhinoceros (1)	Molar fragment (1)
Fossil mollusk (4)	Bayania lactea (2)	Fossil shell (2)
	Belemnite (1)	Fossil (1)
	Rhynchonella (1)	Fossil (1)

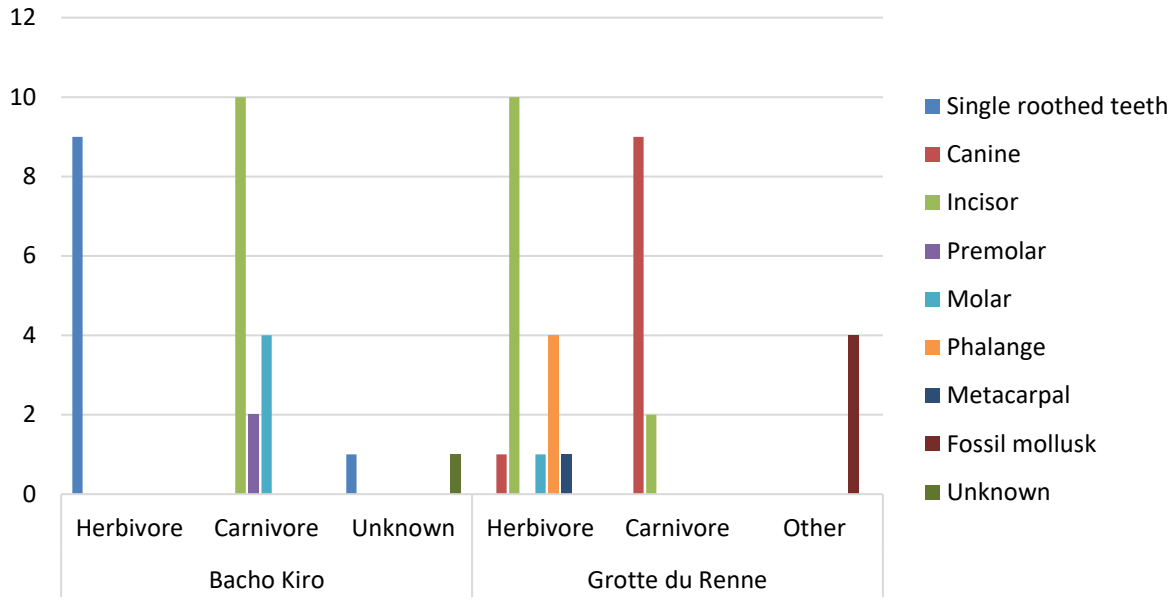

Figure 7. Distribution of osseous material for pendants. The graph highlights the different selection of osseous materials for pendant creation at both sites (Adapted from d'Errico et al., 1998, p. S5, Table 2; Martisius et al., 2022, Table 4, 5; Zilhão, 2007, p. 27, Table 3).

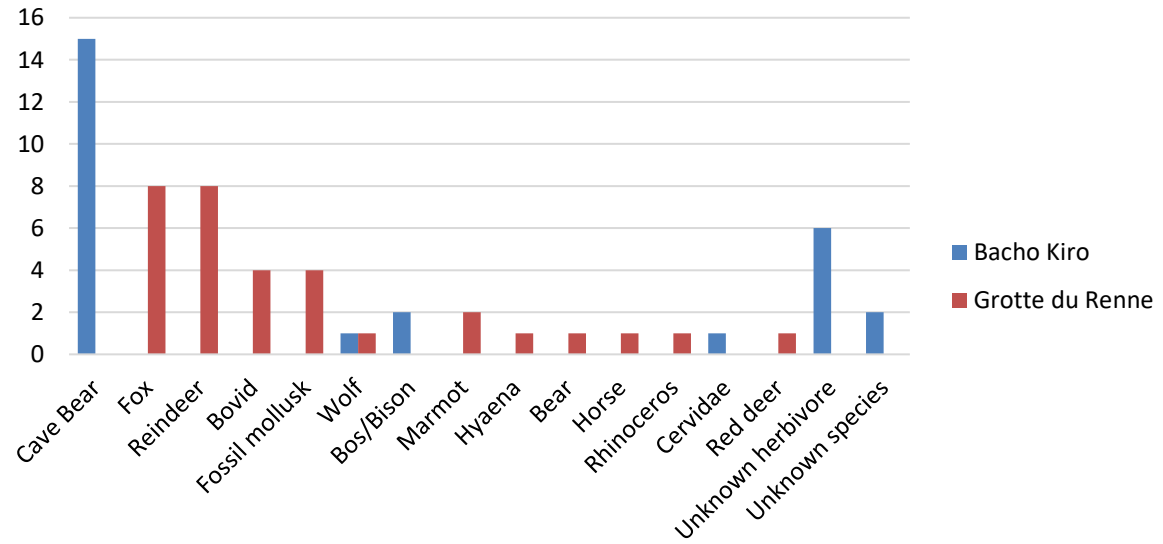

Figure 8. Distribution of species type for pendant production. The graph shows the distribution of the animal types used for pendants at both sites (Adapted from d'Errico et al., 1998, p. S5, Table 2; Martisius et al., 2022, Table 4, 5; Zilhão, 2007, p. 27, Table 3).

Comparing the two sites, there is a clear difference in the techniques used for pendant creation. At Bacho Kiro, perforation was the most common technique, while at Grotte du Renne, grooving was predominant, as shown in Figure 9. Moreover, this figure also shows that there is a great diversity in production techniques between the sites as Bacho Kiro shows five different techniques and Grotte du Renne two different techniques. However, both sites show no preference for a specific production technique linked to animal type as indicated in Table 7.

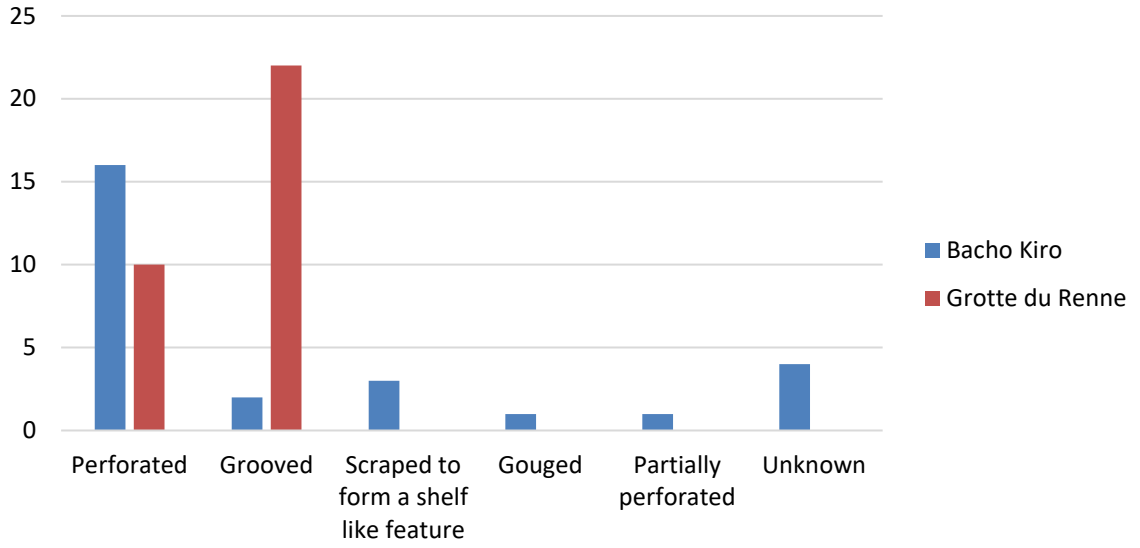

Figure 9. Production types at Bacho Kiro and Grotte du Renne for pendants. The graph displays the different production methods used at the sites to create the pendants (Adapted from Martisius et al., 2022, Table 4, 5; Zilhão, 2007, p. 27, Table 3).

Table 7. Animal type and production techniques of the pendants of both sites. Exploring links between the used production techniques and carnivores, herbivores, and other species (Adapted from d'Errico et al., 1998, p. S5, Table 2; Martisius et al., 2022, Table 4, 5; Zilhão, 2007, p. 27, Table 3).

Production technique	Carnivore	Herbivore	Fossil Mollusk	Unknown
	Bacho Kiro			
Perforated	7	9		
Scraped to form a shelf like feature	2	1		
Grooved	2			
Gouged	1			
Partially pierced	1			
Unknown	3			1
	Grotte du Renne			
Perforated	4	3	3	
Scraped to form a shelf like feature				
Grooved	7	14	1	
Gouged				
Partially pierced				
Unknown				

We can see in Figure 10 that at Grotte du Renne the link between the types of material used for pendants and the production technique shows that all incisors are grooved and Bacho Kiro a wide variety has been used for this type of tooth. At Grotte du Renne a large group of material types are the canines, these have not been found at Bacho Kiro. Furthermore, we see no clear or trends associated with the material type and the production technique, as

illustrated in Figure 10. In addition, there appear to be no special trends with regard to material type and production method as shown in Figure 11.

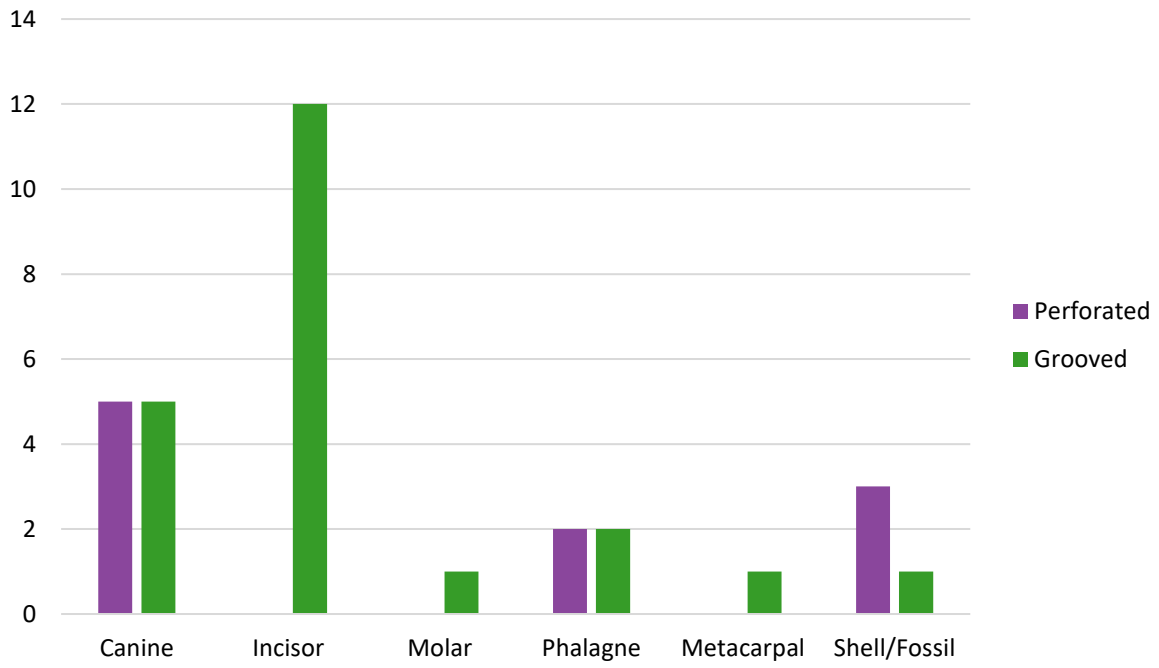

Figure 10. Overview material type and production methods at Grotte du Renne. An overview to study a potential correlation between the material type and the production technique to craft the pendants (Adapted from d'Errico et al., 1998, p. S5, Table 2; Zilhão, 2007, p. 27, Table 3).

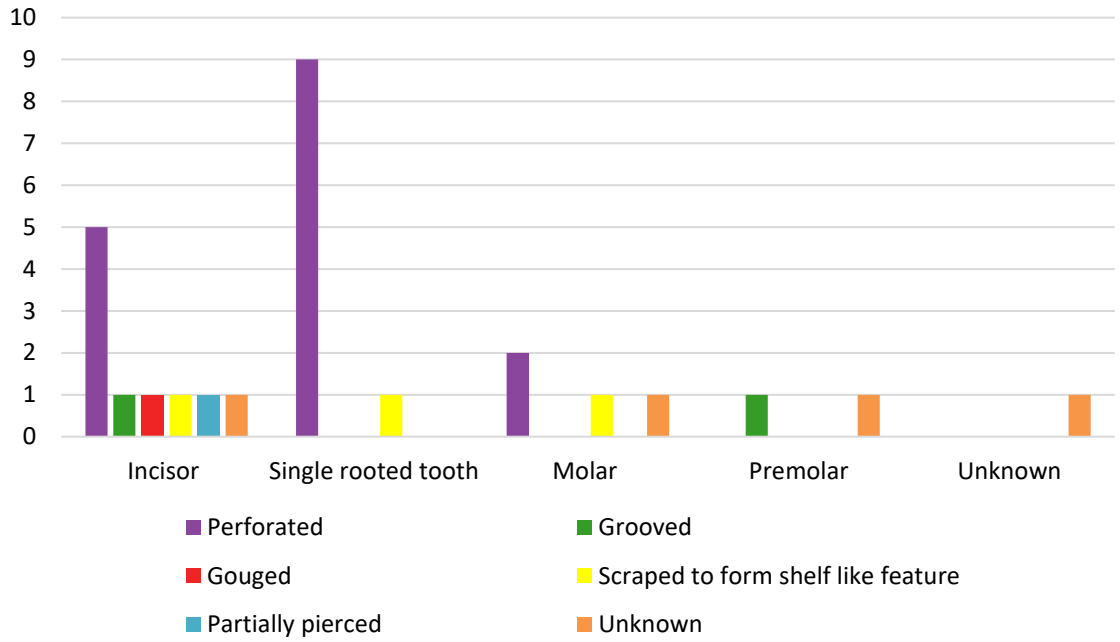

Figure 11. Overview material type and production methods at Bacho Kiro. An overview to study a potential correlation between the material type and the production technique to craft the pendants (Adapted from Hublin et al., 2020, p. 300; Martisius et al., 2022, Table 5).

5. Discussion

The goal of this thesis is to determine what similarities and differences exist between the personal ornaments found at the sites Arcy-sur-Cure (i.e., Grotte du Renne) and Bacho Kiro during the MP to UP transition in Europe. Key differences were observed. Grotte du Renne utilised a greater variety of species, favoring teeth and bones, particularly from foxes and reindeer, whereas Bacho Kiro predominantly relied on carnivore teeth, especially cave bear. In terms of manufacturing techniques, at Bacho Kiro multiple techniques were attested, with perforation being most common, while Grotte du Renne predominantly used grooving and only two different techniques have been reported. Ivory rings, present at Grotte du Renne, were absent at Bacho Kiro, and the materials used for beads also differed. Ivory was exclusively found at Grotte du Renne versus three different types of material at Bacho Kiro. Despite these differences, both sites showed a shared preference for animal teeth, both carnivore and herbivore, as the primary material for ornaments, mostly commonly the pendant. Grooving and perforation were utilised at both locations to create ornaments, and beads were recovered from each site.

Both sites are proposed to be part of the second wave out of the three waves hypothesis of Slimak (2023). These waves are characterised by similarities in the lithic technologies across space in a particular time period. In this second migration wave, it would be expected that Bacho Kiro is slightly older than Arcy-sur-Cure as Slimak (2023) proposes that the migratory waves originate from the Eastern Mediterranean. Since Bacho Kiro appears to be older than Arcy-sur-Cure, this further supports Slimak's (2023) hypothesis. The reliability of this assumption is, however, limited by uncertainties in the dating of both sites (Higham et al., 2010, p. 20239; Hublin et al., 2020, p. 301; Mellars, 2010, p. 20147). Moreover, the results of the comparative analysis of this study already challenge the hypothesis that both sites belong to the same migration wave. The clear differences in ornament production between the two sites, particularly the differing preferences for techniques and choice of materials, are inconsistent with a singular migration wave. In the following, several scenarios and alternative interpretations of this pattern are discussed.

First, recent studies by Tsanova et al. (2024, p. 2, 33) and Hublin et al. (2020, p. 301) suggest that Bacho Kiro aligns more with the IUP, which Slimak (2023) identifies as the first wave,

than with the EUP, which is considered the second wave. The IUP is regarded as a technology between the MP and preceding the EUP (Tsanova et al., 2024, p. 2). Multiple studies support these findings on the basis that the IUP is based on blade manufacturing that incorporates aspects from Levallois techniques (Fewlass et al., 2020, p. 794; Smith et al., 2021, p. 2; Tsanova et al., 2024, p 33). It should be noted that the term IUP is very broad, as it could generally refer to industries between 50 ka and 35 ka that show certain features of the Levallois technique (Kuhn & Zwyns, 2014, p. 30). For the second wave, it was proposed to be characterised by the appearance of certain stone tools as backed points alongside bipolar blades (Slimak, 2023, p. 13). In Slimak's study (2023, p. 13), it is mentioned that the lithic tradition of the Bachokirian contrasts in some aspects with the second-wave lithic technologies, as it lacks features such as Levallois and backed points and exhibits only mildly bipolar blade technology. This could suggest that it may predate the Châtelperronian. As the interpretation of the lithic technology at Bacho Kiro is called into question, the differences found in the personal ornaments further questions the attribution of Bacho Kiro to the second wave of migration.

Second, Arcy-sur-Cure, more specifically the Châtelperronian layers at Grotte du Renne, is also highly debated. This debate arises from the traditional attribution of the Châtelperronian culture to Neanderthals (Botha, 2020, p. 36-37; Caron et al., 2011, p. 7-8; Zilhão, 2012, p. 37-38). According to the three wave hypothesis of Slimak (2023), however, Grotte du Renne and its Châtelperronian are attributed to AMH arriving with the second migration wave (Slimak, 2023, p. 13). Other studies supported the assumption that the Châtelperronian is attributed to Neanderthals, such as Bailey and Hublin (2006, p. 506-507), Soressi and Roussel (2014, p. 2680), Soressi and d'Errico (2007, p. 307). Mellars (2010, p. 20148) has succinctly outlined this debate. The first view posits that European Neanderthals may have developed aspects of the AMH culture, such as personal ornaments, on their own. The second view, known as the acculturation model, suggests that aspects of modern human culture were adopted through cultural contact and exchange between Neanderthals and AMH groups during their migration across the continent.

On the one hand, numerous studies argue in relation to the personal ornaments found at Grotte du Renne, suggesting they could have been independently produced by Neanderthal

populations (Caron et al., 2011, p. 7-8; Soressi & d'Errico, 2007, p. 307; Zilhão, 2012, p. 37-38). Caron et al. (2011, p. 2), for example, argue that the association between the personal ornaments, Châtelperronian stone artefacts, and Neanderthal bones from Châtelperronian levels VIII–X is definitive proof. They center this argument on the stratigraphic consistency and spatial distribution of artefacts. Diagnostic tools and symbolic items are overwhelmingly found in their expected stratigraphic levels. Thus, they argue that this association between the ornaments, artefacts and Neanderthal bones is not related to the displacement of these objects.

On the other hand, several studies argue against the notion that Neanderthals created personal ornaments, suggesting instead that their capacity to create such items might not match that of AMH groups (Bar-Yosef & Bordes, 2010, p. 592; White, 2007, p. 291). The occurring personal ornaments within Châtelperronian stratigraphic levels could therefore indicate trade between Châtelperronian Neanderthals and Aurignacian groups, suggesting that the Châtelperronian culture resulted from acculturation between Neanderthals and migrating AMH groups (d'Errico et al., 2003, p. 248; White, 1993, p. 351, 2001, p. 266). This is also supported by Hublin (2017, p. 10521), who mentioned that these contacts might explain some of the cultural advancements seen among the final Neanderthal populations. These hypotheses are supported by the argument that personal ornaments were not often found in Neanderthal contexts, focusing on sporadic evidence of modification and cut marks on talons, wing bones, and an occasional pigment stained shell (Botha, 2020, p. 51-52). It remains debated whether the Châtelperronian population produced the pendants at all, as there has only been one other instance of animal teeth pendants, at the site of Quinçay, France, among 40 Châtelperronian sites, making these finds virtually unique (Bar-Yosef & Bordes, 2010, p. 592; Mellars, 2010, p. 20147).

Furthermore, the stratigraphy of the Grotte du Renne and associated archaeological finds is highly contested, with many suggesting they may have intruded from the upper layers (Bar-Yosef & Bordes, 2010, p. 589-590; Higham et al., 2010, p. 20239; Mellars, 2010, p. 20147). This is also argued for the ivory objects, as the techniques used to produce these are very similar to Aurignacian techniques and are therefore likely originating from the overlying Aurignacian layer (White, 2001, p. 266; Zilhão, 2007, p. 26). A further argument that

questions the integrity of the stratigraphy is based on radiocarbon dating of various objects from the site. Higham et al. (2010, p. 20239) found a significant number of outliers, dates that were inconsistent with their position in the stratigraphy. They suggest that mixing of layers was more substantial than previously thought.

All things considered, this study contributes to this debate by demonstrating the use of both perforation and grooving techniques in pendant production at Grotte du Renne, along with the use of various animals. Both results show similar patterns with those of the Aurignacian. As Aurignacian pendants found in assemblages from 98 sites in both the Near East and Europe existed of all teeth types from various animals and were made into ornaments by perforating into the root or making a horizontal groove around the root (Vanhaeren & d'Errico, 2006, p. 1108). Moreover, relatively many fox canines were used, also reflecting an early Aurignacian pattern where carnivore remains, predominantly foxes, were used as personal ornaments (White, 1989, p. 377, 2001, p. 266).

In addition to personal ornaments suggesting Aurignacian similarities, human remains could also provide evidence. Specifically, Gicqueau et al. (2023, p. 2) recently reported the discovery of a modern human pelvic bone within the Châtelperronian layers of the Grotte du Renne. They propose that this bone most likely belongs to a AMH, although comparative remains are scarce. Contrary to this interpretation, Botha (2020, p. 40) argues that the Châtelperronian layers of the Grotte du Renne contain multiple human remains, all attributed to Neanderthals. This finding reopens the debate concerning the creators of the Châtelperronian culture. Were its makers exclusively AMH, with the Neanderthal remains at the site being intrusive? Or could both AMH and Neanderthals have contributed, suggesting that there is no straightforward one-to-one relationship between archaeological cultures and human species? Similarly, the association of Neanderthal remains with the Châtelperronian culture has been contested at the site of Saint-Césaire. Gravina et al. (2018, p. 10) argue that the site's mixed archaeological context prevents the Neanderthal bones from being definitively attributed to the Châtelperronian layer. Thus, it remains difficult to rely solely on human remains to securely contribute to the debate, highlighting the necessity of incorporating other forms of evidence.

A third point of discussion is that several other sites further complicate the homogeneity of Slimak's (2023) second wave of migration. One of these sites is Kozarnika, modern day Bulgaria, a site that has been dated stratigraphically to the IUP (Tsanova, 2023, p. 157; Tsanova et al., 2021, p. 3). At this site, multiple tools and personal ornaments dating to both the IUP and EUP have been found (Martisius et al., 2022, p. 4). At layer six and seven of this site, which correspond to the IUP, two fox canine pendants have been found (Tsanova, 2023, p. 193). Comparing personal ornaments of Bacho Kiro with Kozarnika, both dated to the same period and the same geographical area, significant differences between ornaments can be attested. The predominant taxon of Bacho Kiro are perforated cave bear molars and incisors, whereas the personal ornaments at Kozarnika are grooved fox teeth canine pendants (Martisius et al., 2022, p. 44; Tsanova, 2023, p. 193). Interestingly, the two pendants found show much more similarities with Grotte du Renne than Bacho Kiro in terms of both the production technique of grooving and the choice of fox canine (Martisius et al., 2022, p. 44). This is beyond what would be expected.

Another critical site to consider is Quinçay. As mentioned before, there has only been one other instance of animal teeth pendants found among 40 Châtelperronian sites (Bar-Yosef & Bordes, 2010, p. 592; Mellars, 2010, p. 20147). The only other site that has personal ornaments in the form of animal teeth pendants dating securely to the Châtelperronian is the site of Quinçay (Roussel et al., 2016, p. 14). In the Châtelperronian layers of this site, six perforated canine pendants have been found, among which three fox teeth, a wolf tooth, and two red deer teeth (Álvarez-Fernández & Jöris, 2007, p. 33; Granger & Lévêque, 1997, p. 539-540). Comparing this to Grotte du Renne, it seems that the preference for fox canines is apparent, but the production technique differs. The preference for perforation seems to have more similarity with the pendants found at Bacho Kiro, but the choice of species and teeth type reflects more closely with Grotte du Renne. Two perforated teeth have been found at Grotte des Fees, but the stratigraphy of this site has been debated and it has been argued that the teeth belong to the Aurignacian (Álvarez-Fernández & Jöris, 2007, p. 33).

The last site that will be discussed, which is challenging the homogeneity, is the site of Ksar Akil in Lebanon. This Eastern Mediterranean site spans a period roughly from the MP to the Epi-Palaeolithic (Kuhn et al., 2001, p. 7641). Slimak (2023, p. 2-4, 6) suggests that the site

parallels the EUP phases in Europe in both chronology and technology, with the technological changes in the Ksar Akil sequence mirroring developments observed in Europe. This development can be separated into three successive technological stages, with the second stage potentially contributing to the understanding of AMH migration patterns (Choi, 2023; Slimak, 2023, p. 12). Specifically, the wave II parallel shows a correlation between Ksar Akil and the Bachokirian and Châtelperronian cultures (Slimak, 2023, p. 13). The ornaments found at Ksar Akil mostly represent perforated mollusc shells (Kuhn et al., 2001, p. 7641). Two species in particular were used for most of the ornaments, *Nassarius gibbosula* and *Columbella rustica* (Bosch et al., 2015, p. 7684; Kuhn et al., 2001, p. 7641). Moreover, the gastropods that were utilised are similar in both their size and shape (Kuhn et al., 2001, p. 7644). Of these two species, 194 beads were found (Zilhão, 2007, p. 11). The technique of creating these personal ornaments was based on scraping, scratching, or punching a hole near the edge of the shell with a sharp or pointed tool (Bar-Yosef Mayer & Bosch, 2019, p. 20; Kuhn et al., 2001, p. 7644).

When comparing these findings from Ksar Akil with those of this study, a number of aspects stand out. At Ksar Akil, there is a primary use of perforated shells from two specific mollusc species for most of their ornaments (Kuhn et al., 2001, p. 7641). Although some sea fossils and shells have been found at Grotte du Renne, the choice of material definitely differentiates with the European sites that preferred animal teeth. In the techniques used to create personal ornaments, there is similarity in the use of perforation and scraping (Kuhn et al., 2001, p. 7644). There is no sign of grooving found, but this is to be expected as grooving is not a suitable technique to modify shells (Baysal, 2019, p. 82; Stiner et al., 2013, p. 384-385, 389-391).

When considering all discussed sites on their homogeneity, no clear pattern emerges in the selection of materials for ornament creation. Even geographically proximate sites do not exhibit consistent similarities in this regard. Similarly, production techniques do not display a uniform approach across sites within the same region. However, an interesting find is that there always seems to be a consistent preference in having one or a few specific species for personal ornament creation. Building on this finding, two additional considerations arise, which are the faunal assemblage and cultural implication.

Considering the preference for particular species, the faunal assemblages offer valuable context for understanding broader patterns in material selection. Even without the apparent preference, the difference in material selection could still be attributed to the environment and available resources. Smith et al. (2021) investigated the subsistence strategies during the IUP at Bacho Kiro Cave. Their analysis suggests that it was improbable that the cave's inhabitants actively hunted large carnivores (Smith et al., 2021, p. 25-26). Their findings indicate that, at this site, there was a consistent food preference for herbivores (Smith et al., 2021, p. 1, 30, Tsanova et al., 2024, p. 34). These herbivores represented diverse habitats surrounding the site (Smith et al., 2021, p. 1, 30; Tsanova et al., 2024, p. 34). Smith et al. (2021) highlight that 'the large faunal dataset from Layer I allowed for the identification of the selective transport of large herbivore body parts, especially limb bones, into the site' (p. 30). In contrast, the carnivore remains, particularly those of cave bears, suggest either opportunistic or occasional hunting, or more likely, exploiting natural deaths in the cave (Smith et al., 2021, p. 25-26, 30; Tsanova et al., 2024, p. 34). Both the layers I and J exemplify an enormous amount of faunal data, thus showing that even though many animal species were readily available, there was still a preference for certain taxa (Tsanova, 2023, p. 169-170).

In Grotte du Renne a similar pattern can be observed. The zooarchaeological research of layer X (Xc) by Tolmie (2013, p. 122) indicates that varying kinds of species have been found at the site. Similarly as Bacho Kiro, the occupants of the cave brought parts and pieces of their prey with them to the caves (Tolmie, 2013, p. 152). The presence of bovid and reindeer pendants at Grotte du Renne is not surprising, as they were a common prey (Tolmie, 2013, p. 122; d'Errico et al., 1998, p. S10). This reflects the influence of the local environment, where the abundance of reindeer in subsistence practices is linked to dry and temperate climatic conditions (Tolmie, 2013, p. 196-197). An interesting finding is that no bones or teeth of the fox have been found at Grotte du Renne in this layer, which make up one of the largest groups of species used for creating the personal ornaments (Tolmie, 2013, p. 122). A possible explanation can be that the fox remains are part of the other layers. Although this would be unexpected, since the majority of fox pendants are found in the oldest

Châtelperronian layer X (d'Errico et al., 1998, p. S8; Zilhão, 2007, p. 26). As it is attested that even large carnivores and herbivores were hunted and brought back to the site, the absence of fox bones and teeth remains notable (d'Errico et al., 1998, p. S10; Tolmie, 2013, p. 197). A possible limitation in this could be the lack of published faunal remains of the other layers at the site. It would also be interesting to explore the possibility that these fox teeth pendants might indicate exchange between sites. Even though it is hard to explain this preference for foxes, we could argue that foxes had a special relationship with humans. Especially, because this is attested from the Aurignacian onwards (Venditti et al., 2023, p. 4). During the IUP and prior to this, foxes functioned in relatively specialised niches such as commensals (Venditti et al., 2023, p. 4). However, it has been argued that after this period, another new dominant fox niche emerged as commensals to humans, taking advantage of human food waste, which in turn facilitated the easy capture of foxes for use as resources (Baumann et al., 2020, p. 2; Venditti et al., 2023, p. 4). Moreover, during the EUP, incisors from other animal species, including horses and reindeer, were scarcely utilised (Álvarez-Fernández & Jöris, 2007, p. 38–39; d'Errico et al., 1998, p. S12). However, at Grotte du Renne, this group remains relatively well-represented, suggesting a notable divergence in material usage of this site and other EUP sites.

The effects of the local environment is to some extent similar between Grotte du Renne and Bacho Kiro, where herbivore teeth were used as pendants and likely made up a large part of the local faunal resources (Smith et al., 2021, p. 1, 30; Tolmie, 2013, p. 197). This is also likely the case for Kozarnika and Quinçay as both of these sites are situated in similar environments as respectively Bacho Kiro and Grotte du Renne. Remarkable is that no bones were used to craft pendants at Bacho Kiro, while those resources were abundantly available. Moreover, this also forms a stark contrast with Ksar Akil, where the shells seem to have been gathered and brought to the site specifically, without consuming them necessarily (Smith et al., 2021, p. 28-29). This seems to indicate that the molluscs used for personal ornamentation at Ksar Akil were actively used for ornamentation only and that there seems to have been a deliberate choice to use certain molluscs instead of more opportunistic exploitation of mammals as found at Bacho Kiro. For the fossils found at Grotte du Renne, Marshack (1990, p. 463) has proposed that the use of these fossils for ornamentation likely

resulted from the exploitation of local rocks containing fossils in their territory. However, it is equally plausible, according to Marshack (1990, p. 463), that these fossils could also have been exchanged between different groups of people. This could also support the explanation for the fox teeth pendants being acquired by exchange. This exchange could be explained by the acculturation involving AMH.

As the faunal assemblage seems not to have affected the preference for particular species, despite the variety of choice of material across the sites, the cultural aspect might provide an explanation for this pattern. Cultural differences are, however, not expected as Bacho Kiro and Grotte du Renne supposedly belong to the same migration wave of AMH. Differences in material choice and the production technique could be explained by varying cultural preferences and possibly symbolic meanings attached to these materials (Abadía & Nowell, 2015, p. 962; Bar-Yosef Mayer & Bosch, 2019, p. 19-20; Botha, 2020, p. 63-65). For instance, animal teeth might have had specific symbolic or social significance in Bacho Kiro and Arcy-sur-Cure, while mollusc shells held similar importance in Ksar Akil. In more detail, it is possible that cave bear teeth held a special meaning for the occupants of Bacho Kiro whereas different animals and materials hold multiple special meanings for Grotte du Renne, Kozarnika, and Quinçay with an emphasis on their most important herbivore prey and, especially, for foxes. These findings make it clear that the choice of materials or species is strongly linked to cultural preferences rather than resource availability.

The non-pendants may also provide valuable insights into cultural preferences, despite their relative rarity. One of the beads at Bacho Kiro is a bone bead, this type of ornament is virtually unknown in South-eastern Europe during a long period, spanning from the MP to the Aurignacian (Borić & Cristiani, 2018, p. 214). Shells were the preferred material for beads in South-eastern Europe (Borić & Cristiani, 2018, p. 231). The stone bead should also be regarded as an anomaly, as Boric and Cristiani (2018, p. 214-221) have shown that in the Bacho Kiro area no other perforated stone beads are attested. Furthermore, they also argue that stone and bone beads are also virtually unknown in other sites during the MP and IUP and only becoming more common during the Gravettian of South-eastern Europe. Like the two other beads, the ivory bead also is unexpected. Ivory beads have not even been mentioned in the study of Borić and Cristiani (2018, p. 214-221). Starting in the UP in

Eurasia, beads became increasingly prevalent and were often made from challenging materials, particularly ivory (Bednarik, 2015, p. 55). It could be possible that since this is the only bead from Layer H at the site, which is the youngest IUP layer, it might have intruded from a younger overlying layer, however, Layers G–D yielded no evidence of lithic artefacts and barely any animal bones (Fewlass et al., 2020, p. 795, 797).

At Grotte du Renne, three rings and three beads of ivory have been found. The beads and a ring fragment at Grotte du Renne belong to the youngest Châtelperronian layer VIII and it has been convincingly argued that these objects originate from the overlying Aurignacian layer as the techniques used to produce these are extremely similar to the beads found in the Aurignacian layer (d'Errico et al., 1998, p. S15; White, 2001, p. 266). This is supported by the fact that in southwestern Europe, ivory was used primarily for crafting personal ornaments, especially beads, during the Early Aurignacian (Wolf & Heckel, 2018, p. 2). The two ivory rings from layer X remain an anomaly in the dataset of Grotte du Renne. They are virtually unknown in Châtelperronian sites and they are also scarce in Aurignacian sites (White, 2001, p. 258-260). Only a few ivory rings have been attested at some Aurignacian sites among which Spy and Trou Magrite in Belgium (White, 2001, p. 258-260). The non-pendants are relatively rare but appear too numerous to be dismissed merely as anomalies. These artefacts are, therefore, more plausibly interpreted as evidence of exchange or acculturation.

Contrary to the subject of material preference, it is argued that during the EUP, there are different techniques used for perforation and shaping of objects (Álvarez-Fernández & Jöris, 2007, p. 40). Many techniques have been clearly demonstrated at Bacho Kiro, but differ strongly from Grotte du Renne, most importantly the preference for perforation. Possibly, the reason for this is the lack of data on more detailed analysis of the production techniques for the findings from Grotte du Renne. Despite the lack of analysis, it would still fail to explain the observed preference for grooving. Interestingly, it has been observed that in the Châtelperronian layers, grooving appears a practice not seen in the Aurignacian levels of Grotte du Renne (d'Errico et al., 1998, p. S5, S12; White, 2001, p. 257). Meaning that there is a clear difference in technique used, despite the lack of a more detailed technique analysis, compared to the (Proto-)Aurignacian at Grotte du Renne that is associated with the third

wave (Slimak, 2023, p. 13). The only exception in this are the ivory beads, which seem to be produced with Aurignacian techniques (d'Errico et al., 1998, p. S15; White, 2001, p. 266) Cultural preference could thus explain this difference, in which the Châtelperronian culture evolved to the (Proto-)Aurignacian during the MP to UP transition. Ksar Akil should be regarded as an exception, as perforation was probably the only main viable technique to craft shells.

Regarding the research question of this thesis, it has been established that both similarities and differences exist between the personal ornaments from Grotte du Renne and Bacho Kiro. If both sites are indeed associated with the same migration wave, it is plausible that cultural preferences evolved during the migration as environmental changes introduced new resources. However, this is not directly supported by the findings of this research. Therefore, there must have been cultural preferences that would exhibit greater similarities if they originated from the same migration wave, as Slimak (2023) proposes. Likewise, it would be expected that the material types, preferences, and techniques would align more closely than what can be observed in the findings of this study. An alternative explanation is offered by Greenbaum et al. (2019), who suggest that the transition from the MP to the UP was shaped by increasing interpopulation connectivity between AMH and Neanderthals. This connectivity may have led to the development of regionally distinct transitional toolkits, a hypothesis that could explain the observed differences in personal ornaments between Grotte du Renne and Bacho Kiro. Furthermore, this perspective aligns with some of the observed similarities between Aurignacian ornaments and those found at Grotte du Renne, potentially reflecting shared cultural influences.

5.1 Limitations and future research

Despite the valuable insights gained, there are important limitations that should be considered. First of all, there is a significant group of ornaments at Bacho Kiro that could not be assigned to species or animal groups. Potentially the group of animals or preference for certain teeth could affect the interpretations of this study. The effect is likely minimal and it is proposed by Martisius et al. (2022, p. 26) that most unknown animals belong to the

Bos/Bison species which does not broaden the number of animals used. Secondly, it was a challenge to accurately report the findings from Grotte du Renne, as Zilhão (2007, p. 27), White (2001, p. 257), and d'Errico et al. (1998, p. S5) present conflicting data on the same personal ornaments dataset. These discrepancies highlight the challenges in forming a cohesive understanding of archaeological records. When data from key studies contradict each other, it complicates the establishment of a clear overview. As a result, these conflicts often spur further research to re-examine findings. Thirdly, to my knowledge a detailed analysis of manufacture and microwear has not been published yet for the pendants of Grotte du Renne. The sporadic information that could be found on this could not be traced back to the exact personal ornaments as no find numbers have been established in other literature. Lastly, to be able to validate the three wave hypothesis of Slimak (2023), more research is needed about personal ornaments from multiple sites relating to at least one of the different proposed waves. This in combination with more studies relating to lithic technology and other technological systems such as bone tools, would provide the context needed that is currently lacking. Expanding comparative studies to include additional sites from the IUP and EUP periods would provide a more comprehensive view of ornament production, helping clarify regional and temporal patterns across Europe.

6 Conclusion

This study aimed to examine the similarities and differences between the personal ornaments found at the sites Arcy-sur-Cure and Bacho Kiro during the MP to UP transition in Europe. The key findings reveal that the sites show significant differences in their ornaments, particularly in the animal species selected and techniques utilised to create the personal ornaments. At Bacho Kiro, there was a strong preference for cave bears, with perforation being the preferred technique used, though a variety of other techniques were attested. In contrast, at Grotte du Renne, reindeer and fox remains were favored, more animal species were included in the creation of personal ornaments, non-animal, namely fossil mollusk, were utilised for the creation of pendants, and grooving was the preferred technique. Although only two techniques were reported in the archaeological records for Grotte du Renne.

Despite these differences, some notable similarities are also found. Both sites showed a preference for the pendant as personal ornaments and mainly used animal teeth as preferred material. At both sites, beats were reported in relatively low numbers. Additionally, the two main techniques, grooving and perforation, were attested at both sites. The non-pendant ornaments are more rare, but found too numerous to be dismissed as anomalies and should be interpreted as evidence of exchange or acculturation. Comparing these sites with other sites during this transitional phase, there seems to be a specific consistent preference for specific animal species across all sites. This preference is unlikely driven by resource availability as animals used for other purposes are not overrepresented in the material selection for personal ornaments. It is highly probable that this is driven by cultural preference instead.

In addition, an important secondary objective of this study was to evaluate the three-waves hypothesis of Slimak (2023) and assess whether both sites indeed belong to the second migration wave of AMH. A slight difference between the sites was to be expected as the second migration wave originates from the Eastern Mediterranean, meaning that Bacho Kiro should have been affected earlier. However, the results of the comparative analysis challenge this assumption. The large variations in ornament production, particularly in the

techniques utilised and the selection of materials, suggest that these sites are unlikely to have originated from a single migratory wave.

Alternative explanations are given to explain the differences found. First it is suggested that Bacho Kiro likely represents an earlier migration wave. Second, Grotte du Renne displayed characteristics associated with the (Proto-) Aurignacian culture from the third wave. However, some key differences were also observed, pointing to the possibility that the Châtelperronian culture was either part of the second migration wave or influenced by acculturation from that wave. Third, the homogeneity with other geographically proximate sites from the same period and region still do not exhibit consistent similarities. While Bacho Kiro and Arcy-sur-Cure are thus unlikely to be orginiting from a similar wave, this study does not rule out the possibility of three distinct AMH migration waves. Another alternative explanation is that the transition from the MP to the UP was shaped by an increasing interpopulation connectivity between AMH and Neanderthals. This connectivity could have led to regionally distinct developments, which could also explain the differences in personal ornaments found between the sites.

Further research should focus on more detailed analysis of personal ornaments dating to the IUP and EUP periods in order to gain more insight into technological aspects, cultural preferences, parallels between AMH sites, and a better understanding of late Neanderthal groups. The comparative analysis of Bacho Kiro and Arcy-sur-Cure has refined our understanding of cultural dynamics during the MP to UP transition and challenges the new narrative of hominin migration into Europe. Personal ornaments hold distinct and additional valuable information and should be considered to a greater extent in Palaeolithic site analyses. By uncovering the nuances of ornament production and material choices, this research contributed to our understanding of the complex archaeological landscape of Europe in this transitional phase.

Abstract

The Middle Palaeolithic (MP) to Upper Palaeolithic (UP) transition represents one of most debated archaeological periods, marked by the appearance of anatomically modern humans (AMH) in Europe and their encounters or interbreeding with Neanderthals, who were eventually replaced. This demographic and cultural shift involves complex questions around migration patterns, cultural exchange, and technological developments. Different lithic technological and chronological similarities have been observed between several sites and cultures, pointing to potential connections with migration waves of AMH into Europe. However, as much of the focus has been on lithic industries, this study shifts attention to personal ornaments to study this transformative period. In this study, personal ornaments from two key sites from this period have been analysed: Bacho Kiro and Arcy-sur-Cure (Grotte du Renne). The primary objective of this study is to assess the cultural and technological diversity within personal ornaments at these sites, focusing on material and species selection, type of ornaments, and production methods. The comparative analyses showed clear differences between the two sites, mainly on preference for particular species for material selection and production technique used. This could reflects cultural preferences. When placed in the broader context of the MP to UP transition, Bacho Kiro appears to align more closely with the Initial Upper Palaeolithic (IUP) in terms of difference in personal ornaments with Grotte du Renne. In contrast, Grotte du Renne exhibits greater similarities with the Aurignacian culture, particularly in its preference for the fox species and similarities in production techniques used for the different materials selected. Studying the personal ornaments provided a significant insight into the migration waves of AMH into Europe at this transitional juncture, reinforcing the significance of personal ornaments as markers of intergroup interactions and cultural preferences.

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