The Role of Lithic Innovation in the Demise of Neanderthals: Evidence from Les Cottés (France) during the Initial Upper Paleolithic

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Rendu, W., Renou, S., Soulier, M., Rigaud, S., Roussel, M., & Soressi, M. (2019). Subsistence strategy changes during the Middle to Upper Paleolithic transition reveals specific adaptations of Human Populations to their environment [supplementary information]. *Scientific Reports*, *9*(1). https://doi.org/10.1038/s41598-019-50647-6

The Role of Lithic Innovation in the Demise of Neanderthals: Evidence from Les Cottés (France) during the Initial Upper Paleolithic

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Thesis BA3 - 1083VBTHEY_2425_HS

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Leiden, 15-06-2025

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Table of contents

List of figures and tables

List of figures

List of tables

Chapter 1: Introduction

1.1 Background

Technological innovations are still prevalent to this day. Most societies or communities try to improve their way of living and technological innovations are the main factor for this. This concept is not very different from the past, only a different scale. The Anatomically Modern Humans (AMH) arrived in Europe in the interval between 50 and 39 Ka BP. The Neanderthals went extinct around 41 to 39 Ka BP (Picin et al., 2022, pp. 321-336). This overlap in time cannot be a coincidence and has something to do with each other. The period is called the initial upper palaeolithic. The extinction of the Neanderthals can have multiple explanations, but the changes are high that the AMH has something to do with it. There are a lot of different hypotheses proposed over the last 20 years. The right answer is probably a mix of these hypotheses. To get the whole picture you probably need to combine all these hypotheses, which is not an easy task, and it consumes a lot of work. Some explanations for the demise of the Neanderthals are abrupt climate change, competition with *Homo Sapiens*, interbreeding with *Homo Sapiens*, and technological innovations (Timmerman, 2020, pp. 2-3). Because we cannot discuss all explanations, we shift our focus to one, namely the technological innovations of the *Homo Sapiens* compared to the Neanderthals. We focus specifically on stone tools, even though bone and wooden tools are also often preserved. This is because stone tools have the most robust and comparable dataset for analyzing technological differences between Neanderthals and AMH. Wooden and bone tools certainly played a big part in Neanderthal and AMH technologies, but they are not preserved on the scale of the stone tools and are less often associated with clear stratigraphic layers or production sequences. Stone tools are more likely to survive over tens of thousands of years, whereas organic materials like wood and bone are susceptible to decomposition and are rarely preserved. Stone tools are more preserved and systematically studied in the archaeological record (Tryon et al., 2010, p. 378).

1.2 Stone tools

In this thesis, I will talk a lot about two stone tool technologies: the proto-Aurignacian and the Châtelperronian. This will be a talking point because these two technologies are found at the same site in France, namely les Cottés. These technologies can perhaps explain the demise of the Neanderthals and say something about the interaction of AMH and Neanderthals. The proto-Aurignacian is mostly attributed to the AMH (Benazzi et al., 2015, pp. 793-796), while the Châtelperronian is mostly attributed to the Neanderthals (Soressi & Roussel, 2014, pp. 2679-2693). This is an important detail that is essential for understanding the arguments presented in the remainder of this thesis. Stone tools were a crucial aspect of their everyday life, and life would be more difficult without them. Stone tools were used for hunting, processing food, woodworking, and crafting composite tools (Hoffecker, 2018). According to Hoffecker (2018), Neanderthals had quite a sophisticated stone tool technology, involving multiple production steps and different tool types. The stone tool technology of the Neanderthals was highly developed and showed great cognitive skills and planning. While the stone tools of Neanderthals looked highly developed and diverse, the stone tools of AMH are also highly developed and maybe even more developed than the Neanderthal technologies. In this thesis, I will investigate the differences and similarities of the stone tool technologies (the Proto-Aurignacian and Châtelperronian).

1.3 Research questions

This research aims to investigate the difference in stone tool technologies between the Neanderthals and the AMH, and could this difference be an explanation for the demise of the Neanderthals? To answer this, I am focusing on a case study, namely the Les Cottés site in France. At Les Cottés, archaeologists found different stone tool technologies that are mostly attributed to the AMH and the Neanderthals. Les Cottés is known as a transitional site where archaeologists found Proto-Aurignacian and Châtelperronian tool technologies. I intend to understand the differences in these technologies and understand why the Neanderthals went extinct. I want to better understand why the Neanderthals suddenly disappeared and the sole survival of our species, the *Homo Sapiens*. According to my hypothesis, the difference in technologies has something to do with the demise of the Neanderthals. One example of an earlier study that gave me the idea for this hypothesis is the study of Kadowaki et al. (2024). Kadowaki et al. (2024) researched that a significant increase in stone tool cutting-edge productivity did not coincide with the Initial Upper Paleolithic, which introduced blade technology, but occurred later, with the emergence of bladelet technology in the Early Upper Paleolithic. This finding suggests that changes in lithic technology were not immediate or uniform, but part of a gradual, regionally diverse evolutionary process. Such results support a more nuanced view of cultural and technological shifts, motivating my hypothesis that differences in tool production efficiency and technological strategies, rather than the mere presence of new tool types, played a key role in shaping the behavioral divergence and eventual replacement of Neanderthal populations by *Homo sapiens* (Kadowaki et al., 2024). I articulated this hypothesis because several factors had something to do with the demise of the Neanderthals, but I cannot see the differences in stone tool technologies and the disappearance of the Neanderthals as separate from each other. The studies of Nowell (2023) concluded that the Neanderthals had effective tools but may have lacked innovations. An example of this can be seen in hunting efficiency. Neanderthals were primarily ambush hunters who used thrusting spears to kill prey at close range. This is a high-risk method requiring strength and coordination but limited flexibility. In comparison, the AMH used mechanically delivered projectile points such as bow and arrow as new innovations. These tools allowed safer, long-distance hunting, improving efficiency and reducing injury risk. This technological gap highlights a significant difference in innovation and adaptability between the two species (Nowell, 2023, p. 160). This could make the Neanderthals less competitive in rapidly changing environments or under demographic pressure. The study of Oxilia et al. (2022) also explored and discussed the stone tool technologies of Neanderthals and AMH a bit. This research does not suggest that stone tools themselves caused Neanderthal extinction, but the transition in stone tool type is marked as the arrival and spread of the AMH. It reinforces the idea that demographic, cultural, and possibly competitive factors (like AMH bringing new technologies) played a role in the demise of the Neanderthals. I will use the theory of Banks et al. (2008), which supports the idea that competition, rather than climate change, is the primary factor in their extinction. For competition, stone tools are a significant factor in being competitive. With better stone tools, it is easier for the hunt and butchery of animals. It is simply a case of competitive exclusion. And in my research, I will investigate if the stone tools made a difference.

To address these issues, the following research questions were formulated:

Aim of the research: Can the difference in tool technology between Neanderthals and Anatomically Modern Humans (AMH) contribute to an explanation for the demise of the Neanderthals?

Research question 1: What are the differences between the Châtelperronian and proto-Aurignacian tool technologies found at les Cottés?

Research question 2: Is there evidence that the Neanderthals also used the (proto) Aurignacian technology or is it only found with AMH?

Research question 3: Do the differences in tool production suggest different cognitive or adaptive strategies between Neanderthals and AMH?

Research question 4: How does the lithic assemblage at Les Cottés compare with other key transitional sites?

Research question 5: Can these technological differences be interpreted as one contributing factor to Neanderthal extinction?

1.4 Research outline

In this thesis, I will investigate the demise of the Neanderthals and specifically go into the difference in stone tool technologies around the time the AMH dispersed into Europe, where the Neanderthals were already present in the initial upper Palaeolithic (50,000-40,000 BP). I will analyze the data from Les Cottés in detail and compare it with other key transitional sites (e.g., Grotte du Renne). I also review the Gravettian culture around 20-25 Ka to get a better understanding of the context. This is necessary to understand the Proto-Aurignacian better after the Neanderthals had already disappeared. The Gravettian culture gives us insights into how the proto-Aurignacian developed further after the Proto-Aurignacian tool technologies. This tool technology is around 10 thousand years later, but it gives us information about what the AMH was capable of. If the innovation is quick between those 10 thousand years, it becomes more plausible that the modern humans outcompeted the Neanderthals because of their quick innovation. The Aurignacian is between the Proto-Aurignacian and the Gravettian, but we need to look at a bigger timeperiod to get a better overview of their innovation after the Neanderthals disappeared. This may give us information about the mindset of the AMH and how significant their tools were in their lives. Using previous studies, I can describe the difference in the chaîne opératoire of the tool technologies to understand more about how flexible their behaviour can be. Finally, I am trying to conclude whether differences in stone tools can be one of the reasons for the demise of the Neanderthals.

Chapter 1 provides an overview of the research and gives some background information. Chapter 2 provides the methodology about the research. Chapter 3 describes the stone tools of the Châtelperronian and Proto-Aurignacian separate from each other and gives some additional background information about the stone tools and their use. In chapter 4, I will talk about the case study of les Cottés in detail and analyze the results. In Chapter 5, I will compare the results of the case study with other key transitional sites to see if les Cottés is an exception or if it matches other sites. This will lead to a discussion about the results. In chapter 6, I will draw a conclusion and give recommendations for further research on this subject.

Chapter 2: Methodology

2.1 Introduction

In this chapter, I will talk about how this research is conducted and followed the research design that was established. I will give a detailed description of the steps that were taken in this study.

The purpose of the study is to research the stone tools of Neanderthals and AMH and explain the differences between these techno-complexes. This study aims to examine and describe these differences, suggesting that the differences in stone tools may have contributed to the demise of the Neanderthals.

2.2 Research design

To conduct this research, I combine qualitative and quantitative research to get the best answers to my questions. First, I started with a literature review to get some background information about the Proto-Aurignacian and the Châtelperronian. Also, the Gravettian has been explored in the background information, because it ensures us that the AMH keep developing their stone tools after the Neanderthals disappeared. This can ensure that we know that the AMH are smart enough to make better and better tools, which possibly can be a reason for the demise of the Neanderthals. This is a significant step in the research, because it is always necessary to have some information already before you start the research. Next, a case study will be conducted in France at the site of Les Cottés. This will be a descriptive analysis of the material found at Les Cottés and specifically focusing on the stone tools of the Proto-Aurignacian and Châtelperronian. These datasets are already existing and can be found at the Data Repository for the University of Minnesota (DRUM). This data is created by Samantha T. Porter, Morgan Roussel, and Marie Soressi as part of a study comparing core technologies between the two technocomplexes (Porter et al., 2018). After this descriptive analysis, we will explore the differences between the two technocomplexes and how this could have been an influence in the disappearance of the Neanderthals. The study of Banks et al. (2008) adopts the framework of competitive exclusion, which posits that Neanderthals were outcompeted by AMHs occupying similar eco-cultural niches. This approach can help to interpret shifts in material culture and their technological innovations between the Neanderthals and AMH as consequences of interspecies competition. This case study will be a significant part in exploring that one question: Why did the Neanderthals disappear, and did the AMH not? What is the reason that our species thrived, and other species did not? To ensure that our data at Les Cottés is not an exception to the rule but the norm, we need to compare our findings with other transitional sites of the Proto-Aurignacian and the Châtelperronian (e.g., Grotte du Renne). This will probably lead to a discussion, which we can substantiate with arguments from our earlier findings. Last, we try to draw conclusions based on our findings and case study.

2.3 Case study

All the materials of the case study at Les Cottés are already present. To have this kind of information is available at the Data repository for the university of Minnesota. I made this small sub-chapter because it is important to know how I deal with all the data of the case study. I will compare the purpose of the different tools with each other to see if the purpose is completely different and if this ensured that the AMH got an advantage over the Neanderthals, because of the difference in tool sophistication. Beforehand, it is important to know that one assumption is that the AMH tools were more sophisticated than the Neanderthals' tools. We will be looking at this case study of Les Cottés to see if this really was the case, or if the Neanderthals' tools were also very sophisticated and were not inferior to the AMH.

Chapter 3: Background

3.1 Introduction

In this chapter, I will explain the background of the stone tools found at Les Cottés in France. I will give background information about the stone tools of the Proto-Aurignacian and Châtelperronian, but also about the Gravettian culture. The Gravettian culture contributed completely to the AMH because the Neanderthals were already extinct at that point. Maybe you will ask why it is important to know about the Gravettian culture then. This has a simple answer: the Gravettian culture has already developed its tools further in comparison with the earlier stone tools of the Châtelperronian and the Proto-Aurignacian. Maier et al. (2023) found that especially the evolution in projectile points reflects an adaptation for better hunting efficiency. Also, the appearance of shouldered points, which may integrate both lateral and frontal hafting functions into a single tool, is a further development in tool technology. By looking at the Gravettian culture, we can see if the difference in stone tools affected the disappearance of the Neanderthals because it is an AMH stone toolkit that further developed from the Proto-Aurignacian. With the Gravettian stone tools included, it is possible to understand the context of the Neanderthals and AMH and how the AMH developed their toolkits while the Neanderthals disappeared.

3.2 Proto-Aurignacian

The Proto-Aurignacian contributed to the Anatomically Modern Humans. Banks et al. (2013) said that via his age model, the Proto-Aurignacian stone tools date to 41,5-39,9 Ka cal BP. Higham et al. (2013) have criticisms of these dates because he is convinced that Banks only used outdated data, inappropriate assumptions (Banks was convinced that the Proto-Aurignacian always preceded the Aurignacian), and modelling bias (the structure of the model may have artificially constrained results to match his hypothesis). With the calculations of Higham, the Proto-Aurignacian is dated to 42,640–41,900 cal BP. A few thousand years older than Banks said. Although this means that we do not know the exact date of the Proto-Aurignacian, it is clear that both the dated periods are in the transitional period of the AMH in Europe and the disappearance of the Neanderthals. Benazzi et al. (2015) researched whether the Proto-Aurignacian was really of the AMH. Benazzi studied two deciduous teeth that were found in combination with the Proto-Aurignacian stone tools in Italy. They investigated the teeth of the sites of Riparo Bombrini and Grotta di Fumane.

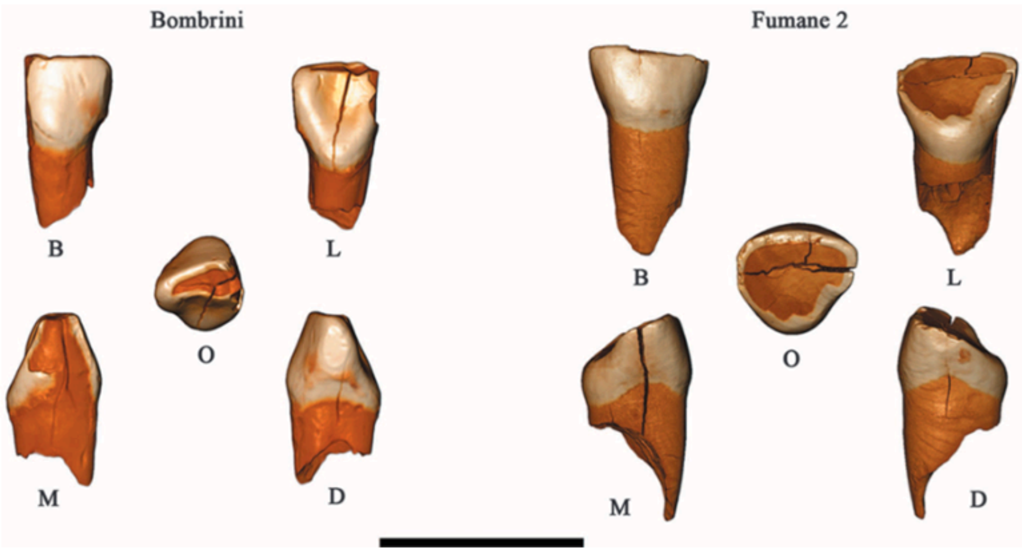


Fig. 3.1. "Three-dimensional digital models of the Protoaurignacian human remains." (Benazzi et al., 2015, p. 793).

They analysed the Bombrini theeth and through the study of enamel thickness found that the teeth were more in the range of modern humans than in the range of Neanderthals (Benazzi et al., 2015, pp. 793-794).

Table 3.1: "3D enamel thickness. Bombrini (Ldi2) is standardized to Z scores (for RET index) of theNeandertal and recent modern human (RMH) di2 sample in different wear stages. Standard deviations areindicated in parentheses. AET, average enamel thickness index; RET, relative enamel thickness index." (Benazzi et al., 2015, p. 794).

Taxon	Wear stage*	*n*	AET (mm)		RET (scale free)		*Z* scores for RET index
			Mean	Range	Mean	Range	
Bombrini	4		0.29		9.22		
Neandertals	1/2	3	0.29 (0.01)	0.28–0.30	7.88 (0.33)	7.54–8.20	4.06
Neandertals	3	2	0.26 (0.007)	0.26–0.27	6.95 (0.55)	6.56–7.34	4.13
RMH	2	3	0.35 (0.006)	0.35–0.36	11.41 (0.41)	10.97–11.77	−5.34
RMH	3	11	0.31 (0.04)	0.24–0.35	9.98 (1.17)	8.01–11.85	−0.65
RMH	4	4	0.26 (0.04)	0.22–0.32	8.67 (1.4)	6.98–10.40	0.39

The other site of Grotta di Fumane is more analysed through DNA analysis. Benazzi et al. (2015) extracted and sequenced mitochondrial DNA. The results were clear: Unambiguously modern human mtDNA. The conclusion is reliable because of the low contamination rate (Benazzi et al., 2015, pp. 793-794).

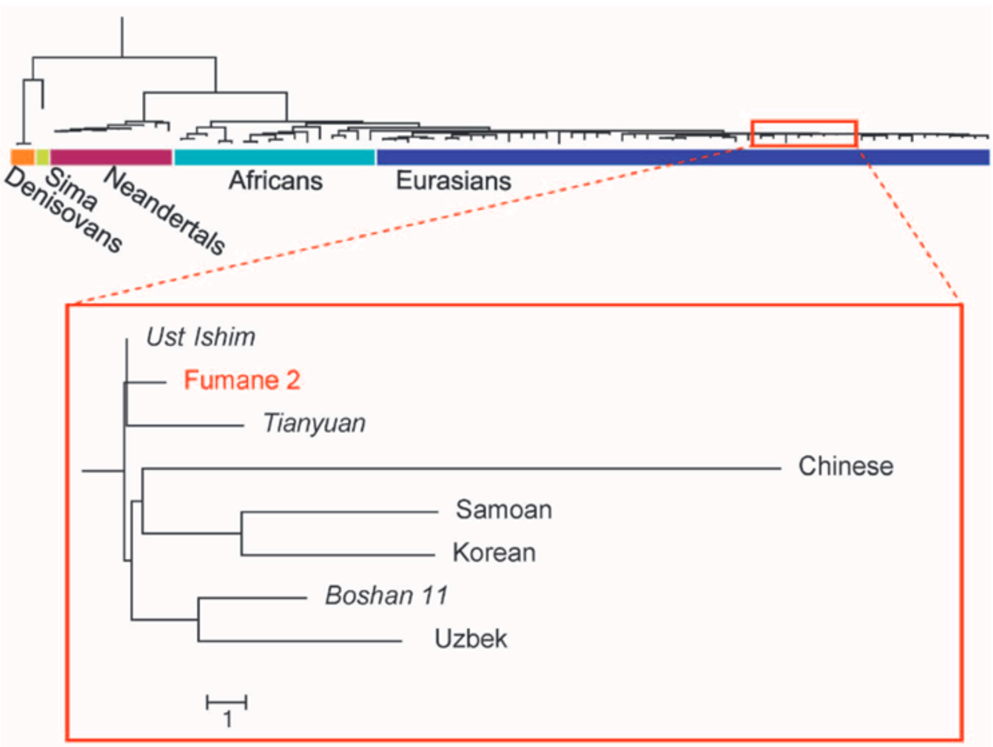


Fig. 3.2. "Phylogenetic analysis of the Fumane 2 mtDNA genome, inferred using the neighbor-joining method. The Fumane 2 mitochondrial genome falls within the variation of modern humans and outside the variation of Neandertals, Denisovans, and a hominin from Sima de los Huesos. The insert shows the branches closest to Fumane 2. Other ancient modern humans are noted in italics. Branch lengths represent the evolutionary distance between individuals, reflected by the number of inferred substitutions per sequence." (Benazzi et al., 2015, p. 794).

Now we know about the people that made the Proto-Aurignacian from these two sites, but how did the stone tools look like? First, the Proto-Aurignacian marks a shift from flakes-based industries to bladelet-dominated industries (Falcucci & Peresani, 2022, p. 1). Bladelets and blades were the dominant product of lithics production in the Proto-Aurignacian technology. Bladelets often had triangular or trapezoidal cross-sections. Curved or slightly curved profiles dominate the blade and bladelets samples, with some bladelets being straight or even twisted. Many bladelets were narrow , with pointed distal ends, which suggests intentional shaping for specific functions. Both blades and bladelets were made using unidirectional reduction strategies. Bladelets often show scar patterns, a sign of intentional shaping to create sharp, narrow tips (Falcucci et al., 2017, pp. 12-17).

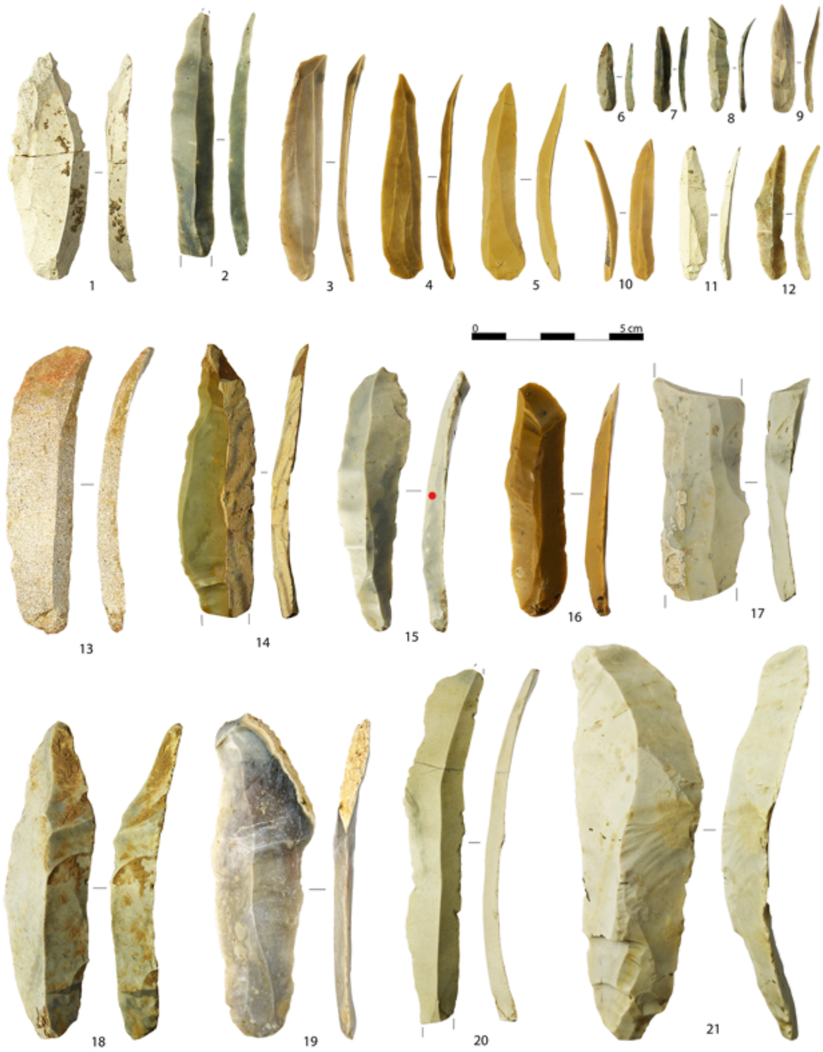


Fig. 3.3. "A sample of blades (1,13-21) and bladelets (2-12) of different sizes with unidirectional scar patterns." (Falcucci et al., 2017, pp. 14-15).

How did the AMH make this type of blade and bladelets? Multiple core types are discovered that they used to make blades and bladelets, which indicates a variety of reduction techniques.

Table 3.2: Core types and their purpose. (Adapted from Falcucci et al., 2017, pp. 10-12).

Core Type	**Purpose**
Narrow-sided	Bladelets

Semi-circumferential	Blades and bladelets
Wide-faced flat	Blades and bladelets
Transverse carinated	Bladelets
Multi-platform	Mixed use (Reduction and re-use)

As you can see in table 2 above, bladelet-specific cores like narrow-sided and transverse carinated suggest intentional bladelet manufacturing and not just a by-product (Falcucci et al., 2017, pp. 10-12).

Fig. 3.4. **Cores of Proto-Aurignacian.** "Semi-circumferential blade core (1, 8, 10), wide-faced flat blade core (2, 7), transverse carinated cores (3, 6), narrow-sided cores (4, 12), multi-platform core, and its schematic drawing (arrows indicate direction of the removals and numbers indicate the order of the removals), exploited for blade (phase 1) and bladelet productions (phases 3 and 5) (5, 9), and parallel core (11)." (Falcucci et al., 2017, p. 11).

All these types of cores, blades, and bladelets are from a site in Italy, namely Fumane. The tools were finely made and varied in shape and size, and they indicate complex planning in tool production.

3.3 Châtelperronian

The Châtelperronian is typically associated with the Neanderthals but exhibits upper Palaeolithic traits (e.g., blades, ornaments, and bone tools). It is a transitional technology between Neanderthals and Anatomically Modern Humans. The general range that the Châtelperronian was made is estimated between 44,000 to 40,000 years ago, exactly between the technologies of the Mousterian and Proto-Aurignacian. This is exactly the period that AMH arrived in Europe and Neanderthals disappeared (Djakovic et al., 2024, p. 3). The first link with Neanderthals was the discovery of a near-complete Neanderthal skeleton in 1979 associated with Châtelperronian artifacts at the site of Saint-Césaire (Lévêque & Vandermeersch, 1981). Also, in Grotte du Renne are human remains found at a Châtelperronian site. After subsequent studies, Researchers confirmed that the associated remains are anatomically Neanderthal (Bailey & Hublin, 2006, pp. 506-507). However, Djakovic et al. (2024) takes a critical stance on the assumption that the Châtelperronian is made by the Neanderthals. They raise doubts about whether the Neanderthal remains are truly from the same archaeological layer. They suggest a possible mixing of Middle and Upper Palaeolithic levels. There is also a pelvic fragment found of an immature *Homo sapiens* at the same layer as Neanderthal remains at Grotte du Renne. The Châtelperronian may not have been made solely by Neandertals. It could reflect a *Homo sapiens*-driven expansion, Cultural or biological mixing between *Homo sapiens* and Neandertals, or a shared, hybrid context we don't yet fully understand (Djakovic et al., 2024).

Another group of researchers have analysed stone tools of the three Châtelperronian layers from the Quinçay cave in France to determine whether Neanderthals made the Châtelperronian. The Quinçay cave is extraordinary because it is the only Châtelperronian site where there are no intrusive Upper Palaeolithic layers above the Châtelperronian deposits, removing the possibility that the material was mixed with later AMH layers (Roussel et al., 2016, p. 14). Now we know who made the Châtelperronian (this is not 100% certain, see Djakovic et al. (2024)), there are more questions. How did they make the Châtelperronian? And how did it look like? To answer these questions, we will continue with the same research of the Quinçay cave.

To make the Châtelperronian blades, the Neanderthals had a specialized core preparation, where they prepared a flat striking platform over a narrow flaking surface. Then, a one-sided crested blade was created to establish the first removal surface, which created the “starting ridge” for production. Once the core was prepped, they systematically removed blades. They did this with unidirectional removals. There are two flaking surfaces exploited, one narrow and one wide. After a few blades were removed, asymmetrical blades were extracted at the junction of surfaces, which resulted in cores with triangular or rectangular cross-sections, a unique trait of the Châtelperronian (Roussel et al., 2016, pp. 19-21).

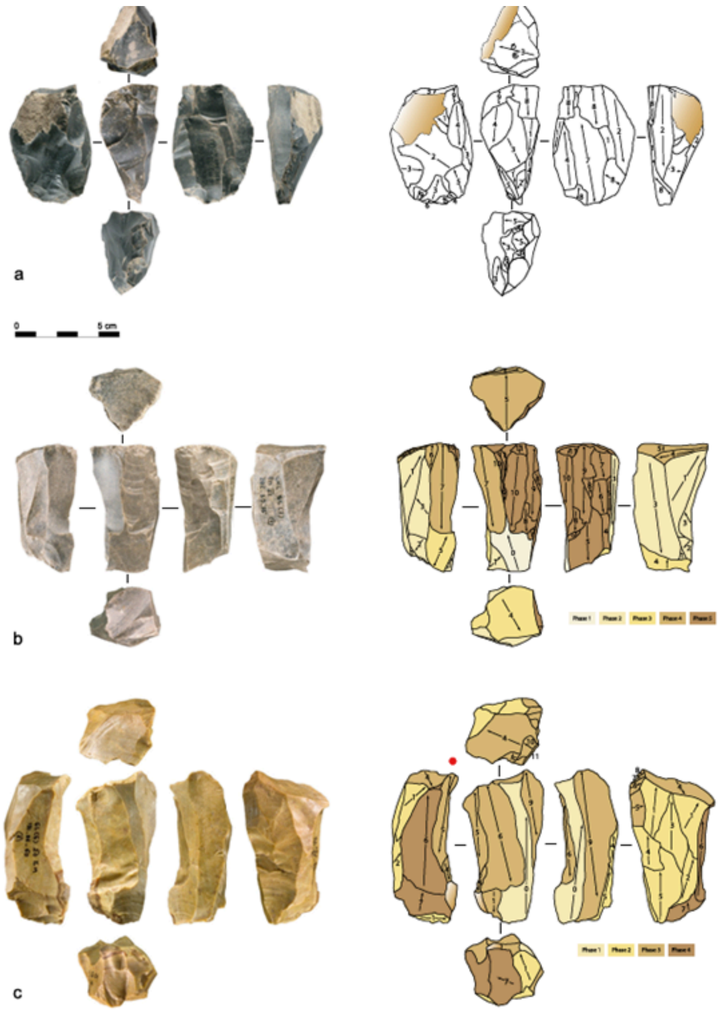


Fig. 3.5. “Blade cores of Châtelperronian exploited on 2 or 3 surfaces. On a and b, note the triangular cross-sections. On c, note the shifted second striking platform from which a last blade has been produced. Arrows indicate direction of the removals and numbers indicate the order of the removals.” (Roussel et al., 2016, p. 21).

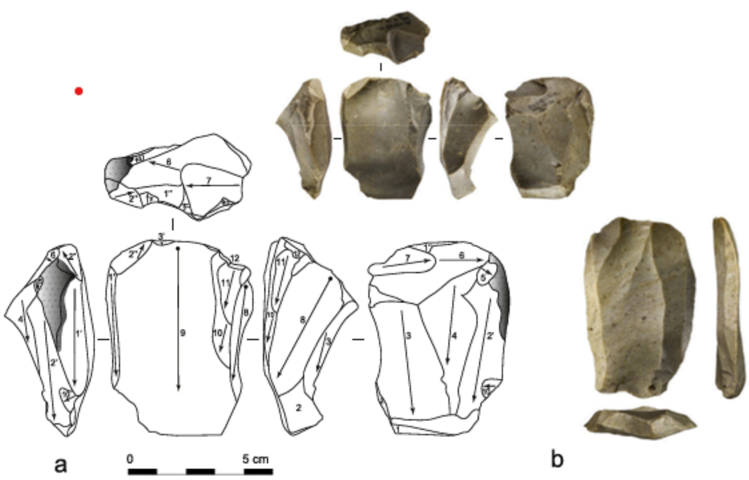


Fig. 3.6. "a: Blade core, and its schematic lithic drawing, with the scar of a laminar rejuvenation flake removed from the wide surface. b: Un-retouched laminar rejuvenation flake. Arrows indicate direction of the removals and numbers indicate the order of the removals." (Roussel et al., 2016, p. 22).

The Châtelperronian did not only have blades but also bladelets. Bladelet cores are typically prismatic in shape and are often made on flakes or small blocks, not being reduced from larger blade cores. Bladelet cores also have a unidirectional reduction, like blade cores. Also similar is the asymmetrical cross-section that bladelets often have. Bladelets are mostly slightly curved or straight and are produced in organized series, not opportunistically (Roussel et al., 2016, pp. 22-25).

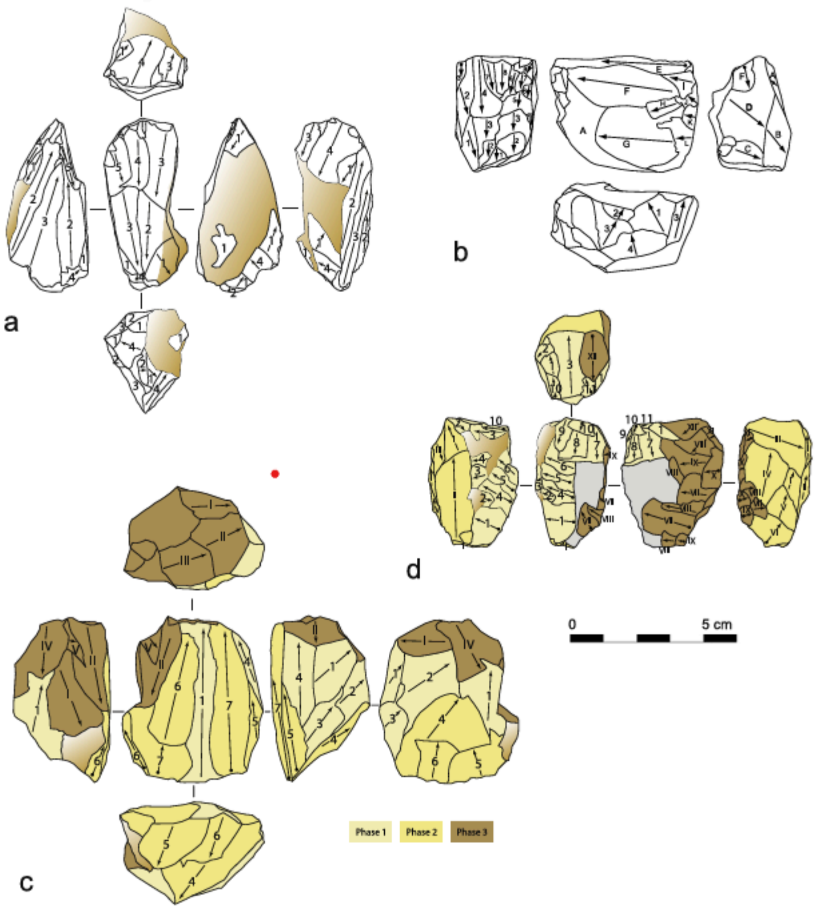


Fig. 3.7. "Schematic lithic drawings of bladelet cores from Quinçay. a, c and d: Reoriented bladelet cores with two independent flaking surfaces. b: Bladelet core on which the blank is a re-used blade core; flaking surfaces are chronologically disconnected. d: Rough-out bladelet core with failure in the extraction of the one side crested bladelet." (Roussel et al., 2016, p. 24).

The Châtelperronian also consisted also out of retouched tools. A few examples are Châtelperronian points, end-scrapers, and retouched bladelets.

First, the Châtelperronian points are always made on blade blanks and not flakes. They often used blades with natural asymmetry, retouched only on one side. The Châtelperronian points are standardized in size and form across all layers in the Quinçay cave (Roussel et al., 2016, p. 17).

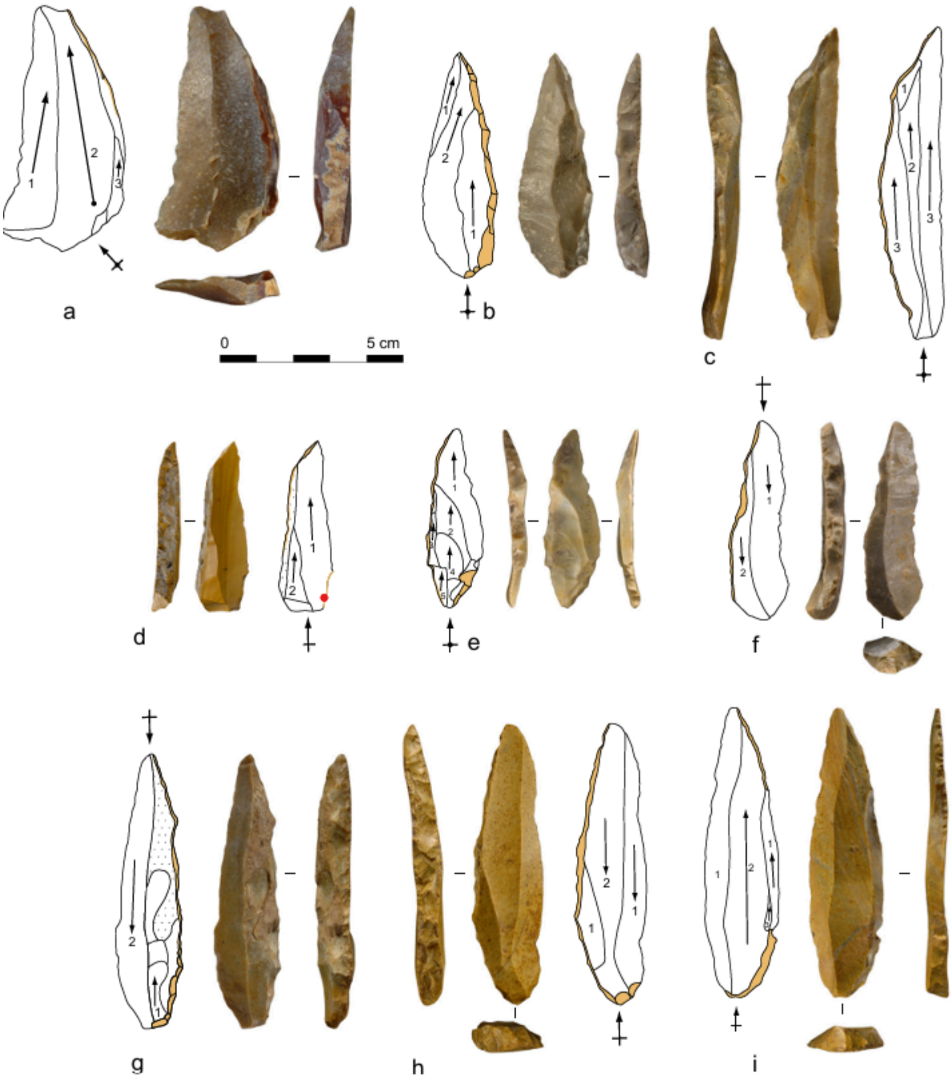


Fig. 3.8. "Backed pieces in Quinçay. a: Audi knife. b to i: Châtelperronian points. On a, d and i, note the asymmetrical blank cross-sections. Arrows indicate direction of the removals and numbers indicate the order of the removals." (Roussel et al., 2016, p. 18).

Secondly, the end-scrapers were made on rejuvenation flakes (special flakes removed from a stone core that are not being used as tools themselves, but to restore or improve the core's geometry so more usable flakes or blades can be removed afterwards) and not regular blades. There are two different types of end-scrapers: Thick scrapers and thin scrapers. Thick scrapers are less refined than Aurignacian versions (Roussel et al., 2016, p. 17).

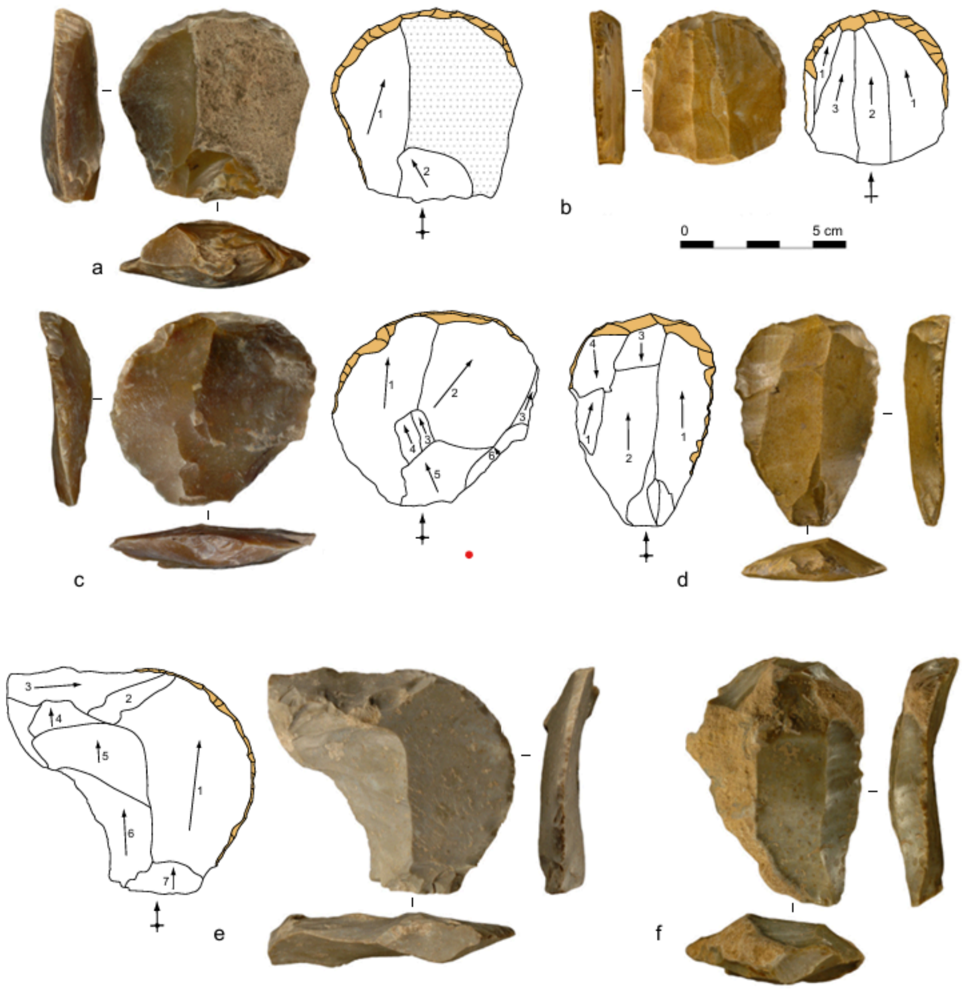


Fig. 3.9. “End-scrapers in Quinçay. a to e: With semi-circular fronts. f: Single end-scraper. On b, d and f, note the blanks which are “laminar rejuvenation flakes”. Arrows indicate direction of the removals and numbers indicate the order of the removals.” (Roussel et al., 2016, p. 19).

Lastly, the retouched bladelets often have an inverse retouch on the right side, suggesting a functional choice. They are small in number but intentionally produced, not accidental by-products (Roussel et al., 2016, pp. 20-21).

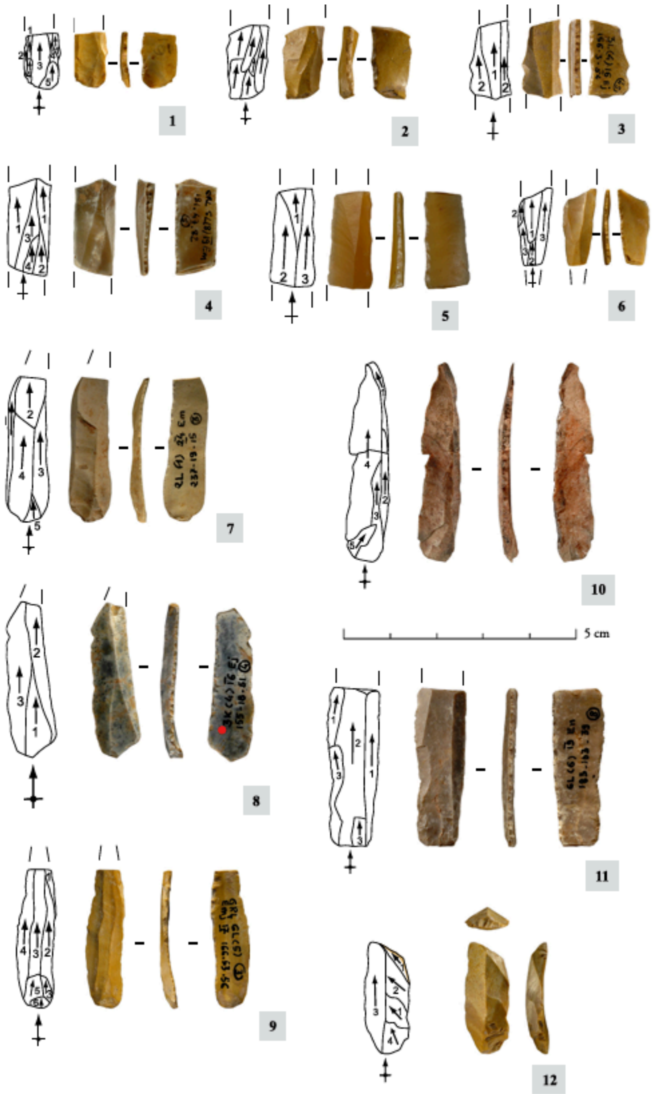


Fig. 3.10. “Retouched bladelets from the three Châtelperronian layers in Quinçay. 1 to 11: Inverse retouched bladelets on the right side; 10 is complete.12: Truncated bladelet. Arrows indicate direction of the removals and numbers indicate the order of the removals.” (Roussel et al., 2016, p. 23).

The Châtelperronian concludes that some tool forms resemble those of the Proto-Aurignacian industry. It is possible that Neanderthals adopted certain tool designs from AMH but used different techniques to make them.

3.4 Gravettian culture

The Gravettian culture and its techno-complex represents the first Upper Paeolithic culture to spread all across Europe. Using radiocarbon dating, Bicho et al. (2017) determined that the oldest sites of the Gravettian culture were dated to 37,5 and 30 Ka cal. BP. The Gravettian culture succeeded the Aurignacian tradition, and in some marginal places, it displaced some remaining Neanderthal populations or entered regions previously uninhabited. According to Bich et al. (2017), full occupation of ice-free Europe by AMH occurred only with the Gravettian, which signals the dominance and replacement of older traditions like the Aurignacian. But unlike the Aurignacian, it did not extend beyond Europe (Kozlowski, 2017, pp. 3-4).

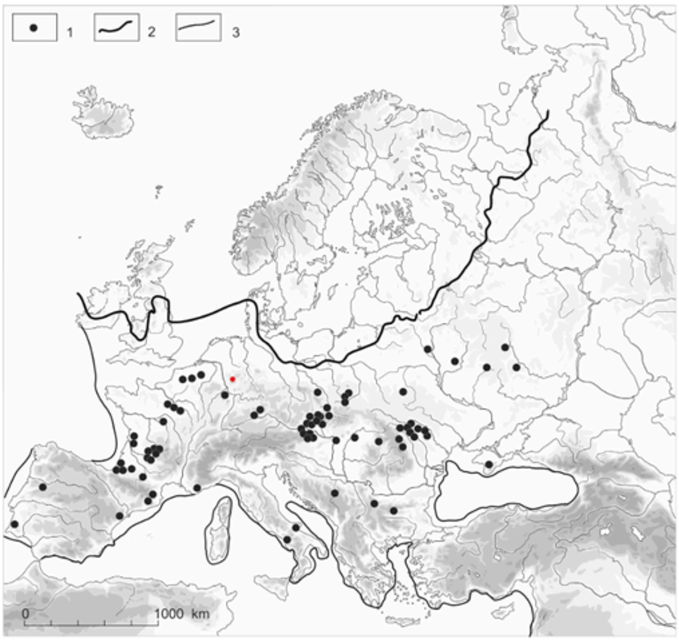


Fig. 3.11. "Map of the Gravettian distribution in Europe: 1 - most important sites, 2 - LGM ice-sheet, 3 - coastline." (Kozlowski, 2015, p. 4).

The Gravettian culture has also lithic technology. They made blade production from double-platform volumetric cores. Common tool types are backed bladelets, burins, end-scrapers, Fléchettes, Parageometric microliths (e.g. trapezes, segments), and pavlovian points with convergent retouch. The Gravettian also already developed a symbolic use and a form of art (decorated antler tools and personal ornaments). The Gravettian made their techno-complex with local and imported flint, antler, bone, and ivory. The techniques used for their techno-complex are volumetric core reduction and microlith production. The stone tools played also an important role in big-game hunting. The Gravettian were specialized big-game hunters (mammoth, horse), while the Aurignacian was opportunistically big-game hunters (reindeer, horse). The Aurigncaian was more blade-based and had a large tool industry. The Gravettian was more blade/bladelet based with microliths and layed the emphasis on composite tools. So, the Gravettian developed more standardized, microlithic tools for projectile weaponry (Kozlowski, 2017, pp. 4-7).

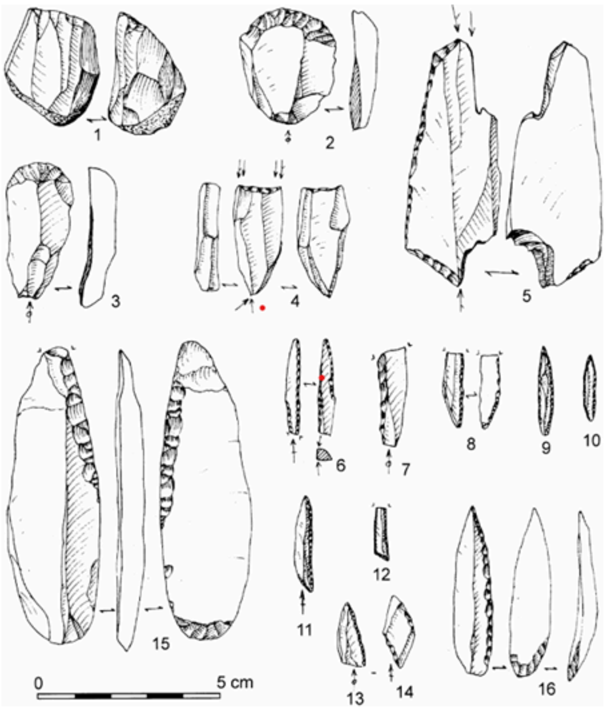


Fig. 3.12. "Early Gravettian from Willendorf II, AH 5: 1- core, 2, 3 - end-scrapers, 4, 5 - burins, 6-12 - backed bladelets, 13, 14 - parageometric microliths, 15-16 - Pavlov points." (Otte ,1981).

Like I said before, the Gravettian developed more art, specifically portable art. One example of this are the Venus figurines. These figures represent their symbolic thinking and show us how much Humans have evolved. Although there is some evidence that the Neanderthals made art, it is still debated and never went to the level of the AMH like the Venus figurines (Dixson & Dixson, 2011, pp. 1-2).

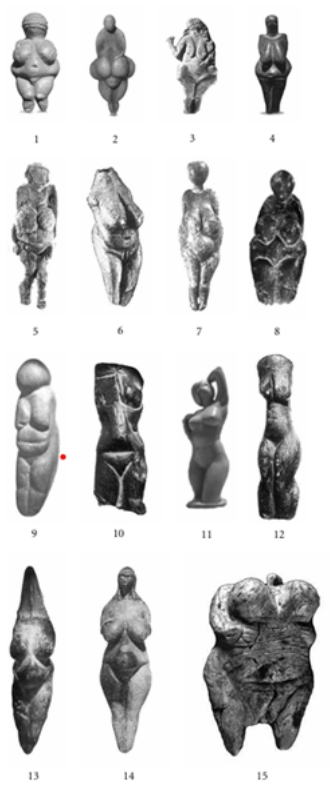


Fig. 3.13. Venus Figurines. (Dixson & Dixson, 2011, p. 3).

This example gives us evidence that the AMH could think more about their art; maybe they also could think more about their techno-complexes and invent better tools for their purposes. This reasoning of better toolmaking could have outcompeted the Neanderthals and eventually led to their demise.

3.5 Conclusion

There are a lot of reasons and hypotheses about why the Neanderthals went extinct. We cannot discuss all those hypotheses, so we focus only on one: the differences in their techno-complex.

The Proto-Aurignacian, Châtelperronian, and Gravettian are all three extraordinary techno-complexes. The Châtelperronian is made by the Neanderthals according to Roussel et al. (2016). The Proto-Aurignacian and Gravettian, however, are made by the Anatomically Modern Human. The Châtelperronian and Proto-Aurignacian looked a bit similar to each other, probably because of little interactions between the two species. Eventually is it the AMH that continued further, while the Neanderthals went extinct.

The Gravettian is a culture that probably succeeded the Aurignacian after the Neanderthals went extinct far earlier. So, the Gravettian started well after the Neanderthals already went extinct. The Gravettian is a good benchmark for what the AMH were capable of (especially art and symbolic use stood out). We can use the Gravettian to see how the AMH evolved further and why the Neanderthals were outcompeted by the AMH. The Technocomplex of the Gravettian was more standardized and developed microlith tools for better projectile weaponry. Perhaps it is possible that the differences in hunting weapons and tools gave the AMH an advantage that the Neanderthals were never able to regain.

Chapter 4: Case study

4.1 Introduction

The case study of Les Cottés is the focus of this thesis. In this chapter, I will talk about all the aspects of this site that contribute to the debate of the interaction between Neanderthals and AMH, specifically focusing on the two stone tools: the Châtelperronian and the Proto-Aurignacian. To understand this, I will be using a lot of literature already present and the database, which can be found in the Data Repository for the University of Minnesota.

The Middle to Upper Palaeolithic transition is the key period for understanding the interactions between the Neanderthals and the modern humans in Europe. Les Cottés in France is one of the rare sites with a complete and well-defined sequence about the period from the Mousterian to the Early Aurignacian. It has several layers that are significant: it has Mousterian, Châtelperronian, Proto-Aurignacian, and Early Aurignacian layers. (Talamo et al., 2012, p. 175).

4.2 Background and site description of Les Cottés

Les Cottés is a small limestone cave site located at the southwestern edge of the Paris Basin in France, near the Aquitaine Basin. It is dated from 45,000 to 35,000 years ago. It lies at the northern limit of the Châtelperronian distribution in France.

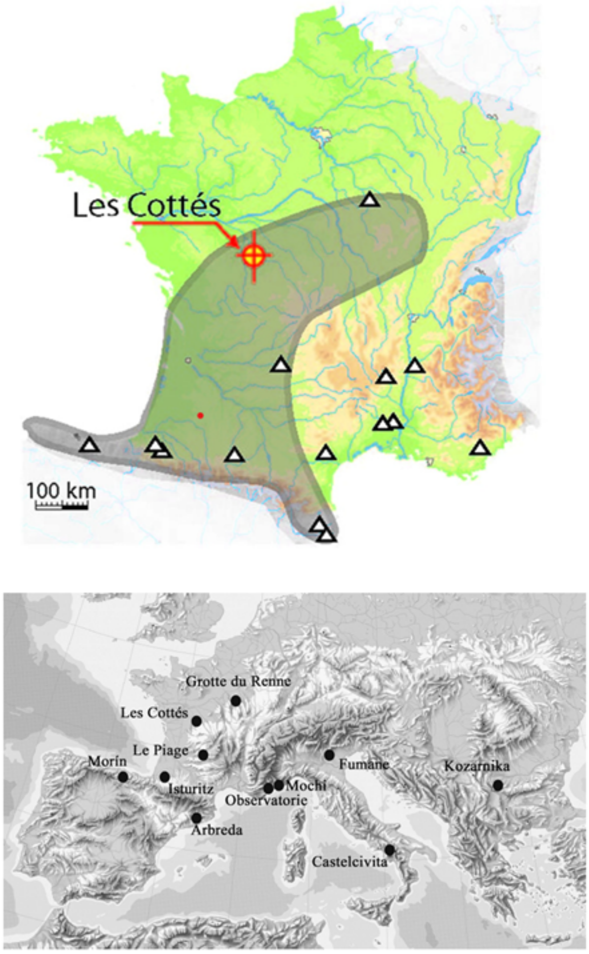


Fig. 4.1. (above) “Map of Les Cottés and of Châtelperronian as well as Protoaurignacian sites in France and north of Spain (map drawn by Soressi and Roussel).” (Talamo et al., 2012, p. 176). (Bottom) “Map showing the localization of Les Cottés and other Protoaurignacian sites.” (Falcucci et al., 2018, p. 542).

Rochebrune (1881a, b) discovered the site in the late nineteenth century. The first excavations were led by Rochebrune, and during this first excavation, anatomically modern human remains were found at the entrance of the cave. This was the Aurignacian layer of the cave. Later, Pradel (1961) established a stratigraphic sequence, which included the Mousterian, Châtelperronian, Early Aurignacian, and Gravettian industries. Les Cottés became particularly notable for its Aurignacian industry, including split-based points and a type of artifact known as the Les Cottés points from an evolved Châtelperronian assemblage (Pradel, 1963).

The sequence has identified five major units, each attributed to different industries.

Table 4.1: All layers with their respective industry at Les Cottés (adapted from Talamo et al., 2012, pp. 176-177).

Unit	**Industry**
Unit 08	Mousterian
Unit 06	Châtelperronian
Unit 04 lower	Proto-Aurignacian
Unit 04 upper	Early Aurignacian
Unit 02	Final Early Aurignacian

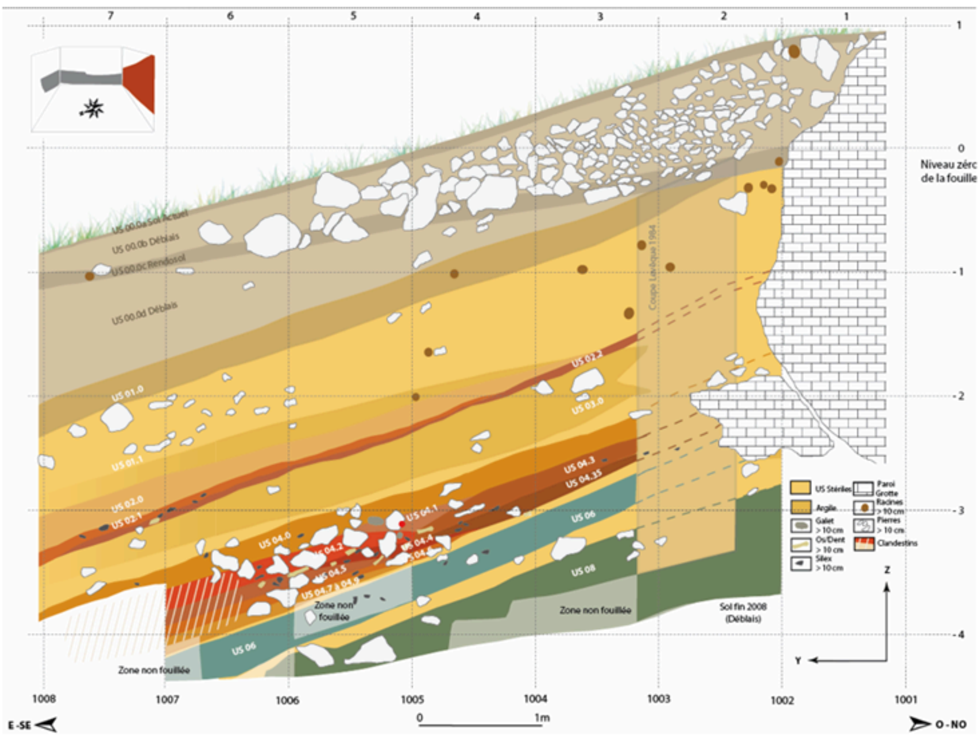


Fig. 4.2. "Stratigraphy of Les Cottés South profiles. US 04upper is constituted by US04.0, US04.1 and US 04.2. US 04lower is constituted by the other US04 subdivisions." (Soressi et al., 2010).

All the layers in table 4.1 are separated by sterile sediments, which reinforces their integrity as temporally discrete phases and not a continuous habitation.

The lithic industries at Les Cottés reflect evolution across the Middle to Upper Palaeolithic transition. The Mousterian layer (Unit 08) is poor represented, but is possibly Quina-type, with some ambiguity because of the low sample size. The next layer is the Châtelperronian (Unit 06), which is rich in backed stone tools such as Châtelperronian points and Les Cottés points. The production is especially focused on rectilinear blades using unipolar core reduction strategies. Next, the Proto-Aurignacian layer (Unit 04 lower) is oriented toward independent bladelet production, primarily of Dufour-type bladelets. Especially the bladelet cores are dominant and indicate a non-reductional sequence (not from blade cores). In contrast to the Proto-Aurignacian, the Early Aurignacian (Unit 04 upper) includes more robust and wider blades, with more tools such as end-scrapers, and Aurignacian retouched blades. Bladelets are less commonly retouched than the retouch in the Proto-Aurignacian. Lastly, the final Early Aurignacian layer (Unit 02) features small, curved bladelets without retouch and a higher number of end-scrapers (Talamo et al., 2012, pp. 176-178).

We focus in this thesis especially on the Châtelperronian and Proto-Aurignacian layers, because those tools are normally attributed to the Neanderthals (Châtelperronian) and anatomically modern humans (Proto-Aurignacian). There are also faunal remains found in the different units. In the Châtelperronian layer, stable carnivore is present, with reindeer dominating. In the Proto-Aurignacian layer did the carnivore activity almost disappeared, and the human presence dominated. So, Les Cottés is a rare site documenting the shift between Neanderthal associated industries to AMH-associated industries (Talamo et al., 2012, pp. 177-178).

Talamo et al. (2012) concluded after radiocarbon dating that there is a 1000-year age gap between the Châtelperronian and the Proto-Aurignacian, in which they established that the anatomically modern human was present around 39,500 Cal BP (Talamo et al., 2012, pp. 180-181).

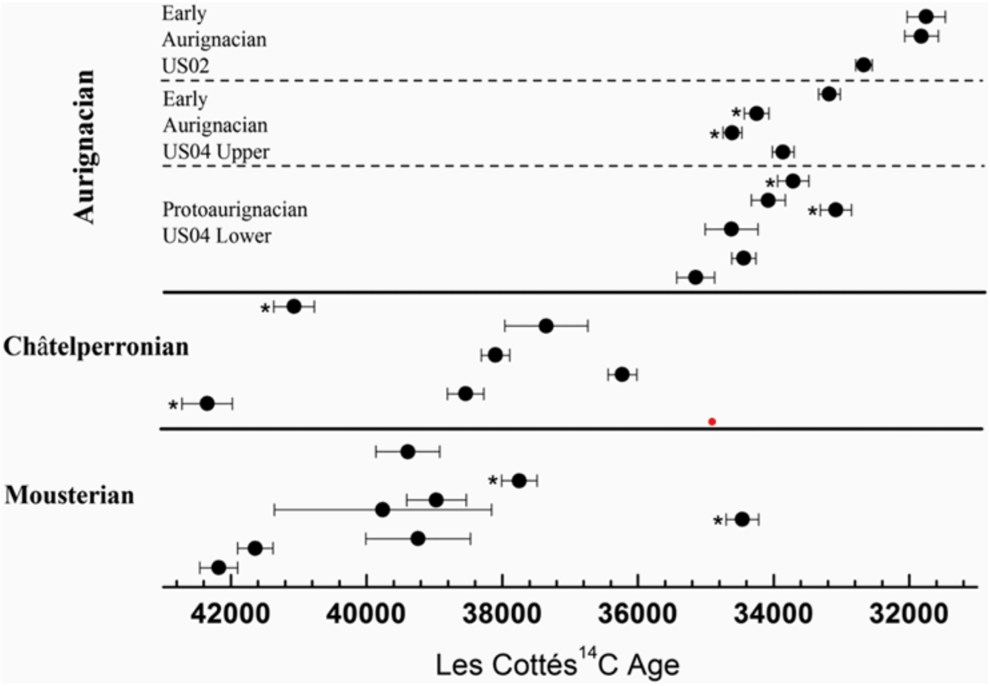


Fig. 4.3. "Radiocarbon ages of the weighted means of Les Cottés. The dates are arranged according to the archaeological layer; within each layer they are sorted by depth. The asterisks indicate the outliers for the Bayesian analyses." (Talamo et al., 2012, p. 180).

4.3 Techno-complex of the Proto-Aurignacian at Les Cottés

As stated in table 4.1 above, the Proto-Aurignacian layer is unit 04 lower. It is separated by a sterile layer, suggesting a clear chronological break between the Proto-Aurignacian and Early Aurignacian layers (Roussel & Soressi, 2013, p. 291). The Proto-Aurignacian layer is dated to 39-40 Ka cal. BP, indistinguishably from the Early Aurignacian above it (Falcucci et al., 2016, p. 542). Bladelets are the defining feature of Proto-Aurignacian lithic production, and the intensification of bladelet production is a key hallmark of their techno-complex. Bladelets were produced as independent tool types and not just a by-product of core reduction. These bladelets were probably hafted in wooden shafts for projectile use. So, there is a huge emphasis on bladelets. The Proto-Aurignacian technology used carinated cores, which are semi-conical cores designed for the production of small, regular bladelets. This reflects a more standardized bladelets production system, which is in contrast from the Mousterian and Châtelperronian industries that relied more on flake-based strategy (Châtelperronian will be more talked about in chapter 4.4).

Proto-Aurignacian assemblages typically include retouched bladelets, end-scrapers (for working antler or hide), and Burins (used for engraving or working bone). The tools were mostly modular, combining different tool functions. The toolkits suggest multi-functional use, which supports the idea that les Cottés was a residential base with diverse activities, including wood, hide, and bone working (Rendu et al., 2019, pp. 1-2, 8).

As already said, the main focus was bladelet production. The collection that was analysed includes 150 retouched bladelets from the Proto-Aurignacian layer. Bladelets were mostly made on unidirectional blanks and show standardized morphology. The cores that were used were of pyramidal and prismatic shapes. The most dominant tool type in the Proto-Aurignacian at Les Cottés are the retouched bladelets with 54%.

Table 4.2: "List of the analyzed retouched bladelets at Les Cottés of the Proto-Aurignacian sub-grouped according to their degree of breakage." (Adapted from Falcucci et al., 2016, p. 543).

Degree of breakage	**Frequency at Les Cottés (n = 150)**
Complete	2 (1.3%)
Almost complete	2 (1.3%)
Proximal	46 (30.7%)
Mesial	87 (58%)
Distal	13 (8.7%)

The retouch is mostly inverse. 93.3% of retouched bladelets have inverse retouch, and only 1.3% alternate and 5.3% direct. Bladelets are predominantly lateral retouched. Unlike with other Proto-Aurignacian sites, at Les Cottés there are no bladelets with convergent retouch found. Bladelets with a pointed apex, which is common in other sites like Fumane and Isturitz did not play a major role in the toolkits at Les Cottés. So, at Les Cottés are not a lot of projectile candidates.

As stated in table 4.2, only a few bladelets were complete or almost complete, which means that there is high fragmentation. This posed a big problem for determining the exact use of the tools, but it can also be an indication of intensive tool use or discard after breakage. Most Bladelets' shape is sub-parallel with 60%, followed by convergent (19%) and convex (15%) (Falcucci et al., 2016, pp. 542-546). These statistics about the retouch and shape can be seen in the table 4.3 and table 4.4 below.

Table 4.3: "Retouch position on the entirety of the analyzed retouched bladelets of the Proto-Aurignacian." (Adapted from Falcucci et al., 2016, p. 544).

Retouch position	Frequency at Les Cottés (n = 150)
Alternate	2 (1.3%)
Inverse	140 (93.3%)
Direct	8 (5.3%)

Table 4.4: "Blank morphology of retouched bladelets of the Proto-Aurignacian considering the whole samples(a) and only the complete and almost complete specimens(b)." (Adapted from Falcucci et al., 2016, p. 543).

Blank morphology of retouched bladelets	Frequency at Les Cottés (n = 150)	Frequency at Les Cottés (n = 4)
	a	**b**

Sub-parallel	91 (60.7%)	0
Convergent	29 (19.3%)	2
Convex	23 (15.3%)	2
Irregular	8 (5.3%)	0

Based on the use-wear study of Pasquini et al. (2013) did have two functional size categories.

Firstly, Narrower, thinner bladelets that were more likely used for projectile inserts. Les Cottés did only have very few of these narrow, thin bladelets.

Secondly, larger bladelets: these showed wear associated with butchery, scraping, and general cutting of soft and hard materials.

The sample of Les Cottés fell mostly into the larger bladelets category, which suggests that these tools were used for domestic or processing activities, rather than for hunting. This suggest a production-oriented or a residential function for Les Cottés (Pasquini et al., 2013).

Fig. 4.4. "Dorsal, ventral, and profile views of a sample of bladelets with lateral retouch (1-13) from Les Cottés. On ventral view, dashed lines indicate the localization of the inverse retouch." (Falcucci et al., 2016, p. 550).

There is already said that the Proto-Aurignacian is dominated by bladelets, but especially Dufour-type bladelets, with inverse, continuous retouch that is mostly on the right edge. The presence of scrapers is moderate (11%), and they vary in form: more than the overlying Aurignacian layer. Burins are scarce but still present (Roussel & Soressi, 2013, pp. 289-291).

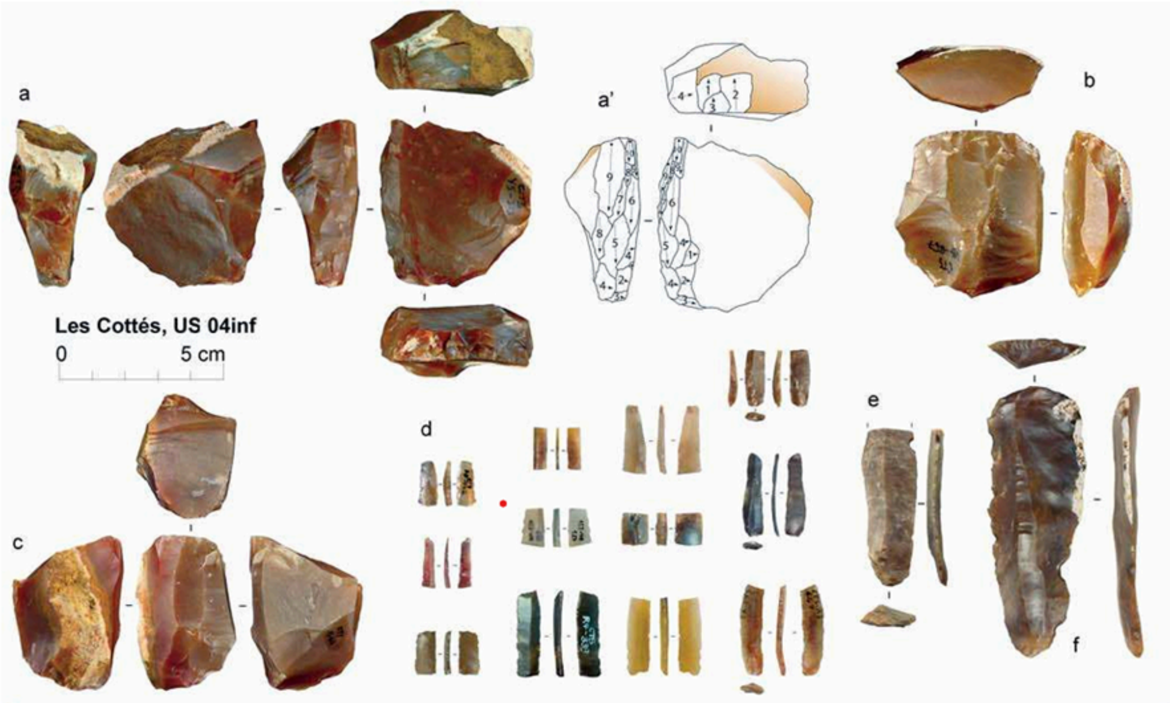


Fig. 4.5. "Les Cottés, lithic industry from US 04 lower (2006-2009 excavations). a and c. Large rectilinear bladelet core; b. Blade-baldelet core; d. Dufour bladelets sub-type Dufour; e. Blades with marginal direct retouch; f. End-scrapers." (Roussel & Soressi, 2013, p. 290).

The Proto-Aurignacian tools at Les Cottés are typically consistent with Proto-Aurignacian standards of other sites. Some subtle differences in retouch style and frequency support the idea of distinct regional traditions within a shared technological framework.

Les Cottés provides strong evidence for a robust Proto-Aurignacian presence in northern France. Its assemblage reinforces the characterization of Proto-Aurignacian as a bladelet-focused technocomplex with diverse yet systematic reduction strategies. The presence of a technologically mature Proto-Aurignacian assemblage supports the view that modern human occupation in northern Europe was both early and culturally diverse (Falcucci, 2018, p. 106).

4.4 techno-complex of the Châtelperronian at Les Cottés

The Châtelperronian layer is found in stratigraphic unit 06 at Les Cottés. Just like the Proto-Aurignacian layer is this layer also protected from overlying layers by sterile sediments, preventing stratigraphic mixing (Porter et al., 2019, p. 43). This layer provides a critical data point in the ongoing debate about the behavioural and cultural capabilities of Neanderthals, as the Châtelperronian is frequently associated with them (Roussel & Soressi, 2013, p. 295) But this is not the goal of our research here. In this research lies the focus on the stone tools themselves and if the tools the Neanderthals used made their life more difficult in comparison with the anatomically modern humans, because the tools of the Neanderthals were less developed. Culture and behaviour are part of that, but then the research will be too big. So, we focus on a subgroup and look if they could produce the tools for a better and easier life. This layer is dated by AMS radiocarbon dating (Talamo et al., 2012), single-grain quartz OSL, and feldspar MET-pIRIR (Jacobos et al., 2015). These methods concluded that the Châtelperronian layer is dated to 43 Ka cal. BP. In the Châtelperronian layer were 6000 lithics, larger than 15 mm pieces plotted. The raw material that was used for these lithics was predominantly local and collected within a few kilometres of Les Cottés. Exogenous material is rare and mostly linked to retouched tools that are found at Les Cottés.

The Châtelperronian, which are contributed to the Neanderthals, are more focused on a highly structured blade production. The core reduction strategy begins with the reduction of one-sided crests (a ridge created by removing flakes down one edge) on blocks, slabs, or large flakes. A key goal in the production process is to find blocks, slabs, or large flakes with broad, flat surfaces. They needed this to have blanks that allowed for controlled and predictable flake removal. Cores are asymmetrically reduced, sometimes with opposing platforms, and are used sequentially. Next, the core was reduced through unidirectional or bidirectional flaking. There are a few percussion techniques that were used. One is the soft-stone hammer, which was used for most removals and resulted in a thin striking platform. Secondly, the hard-hammer percussion, which was used during early initialization, platform rejuvenation, and core maintenance phases (Marciani et al., 2025, pp. 10-13).

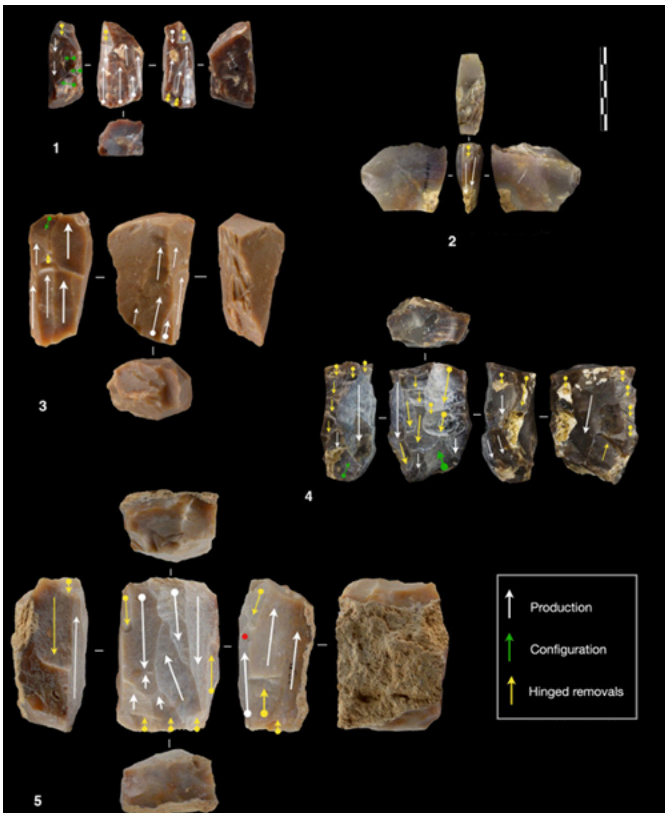
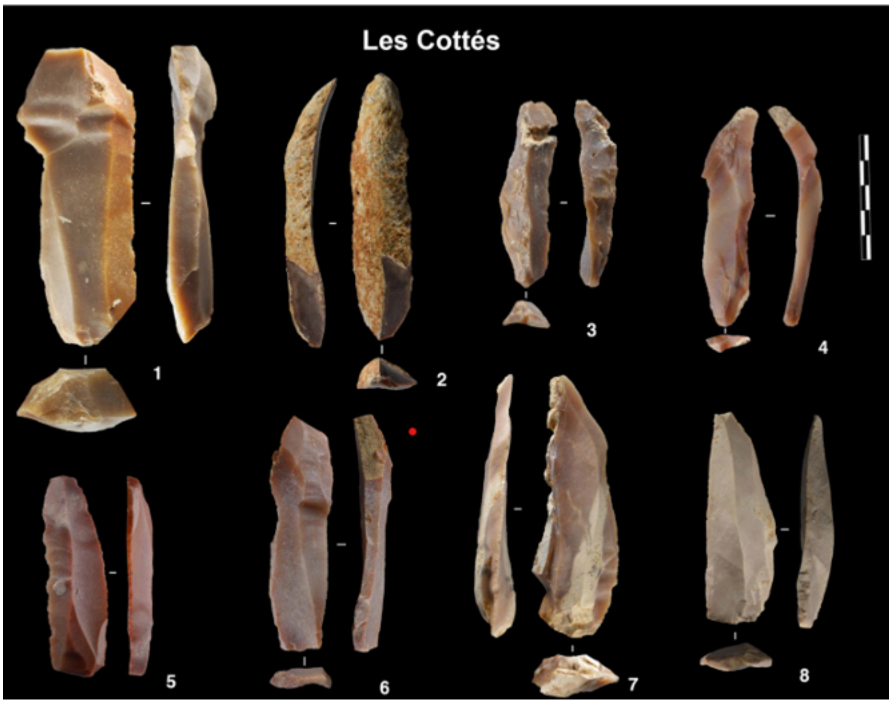


Fig. 4.6. “Cores from the Châtelperronian of Les Cottés (US6).” (Marciani et al., 2025, p. 13).

There are a few significant blade characteristics that you need to know to keep the blades and bladelets apart. First, the blades: They have parallel/semi-parallel dorsal scar patterns, clean ventral surfaces, and often retain crests or marginal cortex from earlier stages. Secondly, the bladelets: in comparison with the Proto-Aurignacian are the bladelets from the Châtelperronian not the product that they wanted to make beforehand. The bladelets were often made with minimal preparation and using small cores or residual pieces from the blade production.



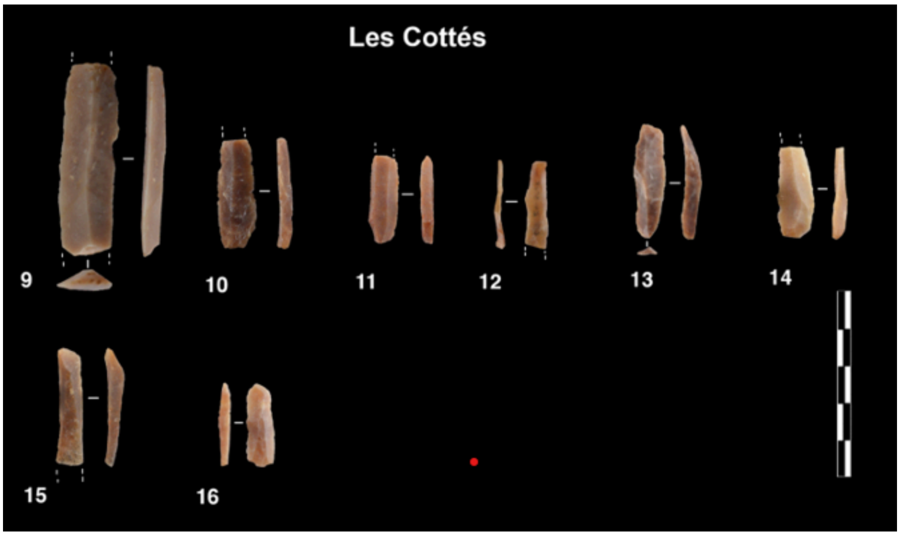


Fig. 4.7. Blade (above) and bladelet (bottom) debitage from the Châtelperronian of Les Cottés (US6).” (Marciani et al., 2025, pp. 15-16).

Most striking platforms are plain and show soft abrasion (indicating soft-hammer percussion) and maintained platform angles between 75 and 90 degrees. The tool production consisted of Châtelperronian points, which are made from carefully selected blades and are retouched with an abrupt, steep retouch along one edge to form a backed blade. The Châtelperronian points are likely used as projectile tips or cutting implements.

Another tool that was in the Châtelperronian toolkit is the end-scraper, which is often made on rejuvenation blades or large flakes and is retouched with convex working edges. These tools were not just by-products, but deliberately planned outcomes of their core reduction strategy (Marciani et al., 2025, pp. 9-13).

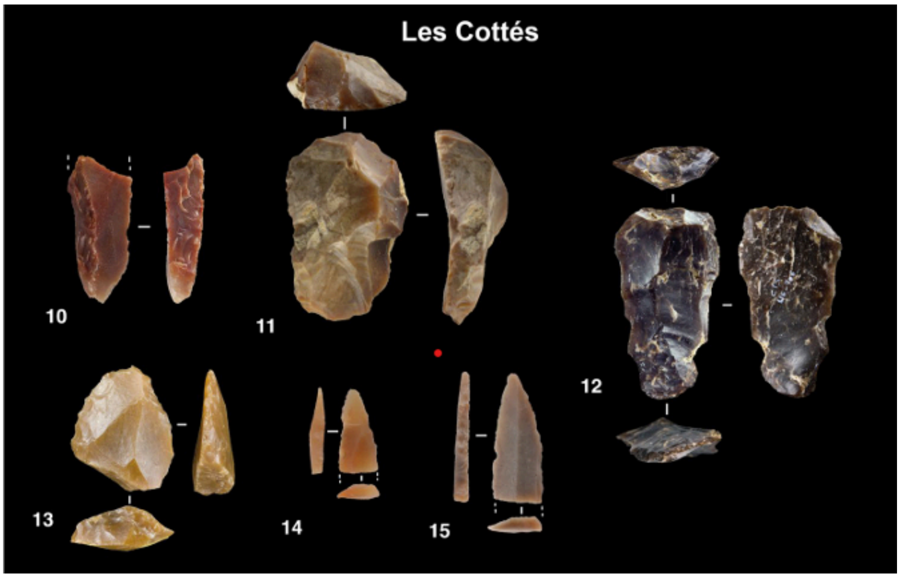


Fig. 4.8. “Retouched tools from the Châtelperronian of Les Cottés (US6). (11, 12) Wide-fronted end scrapers produced on ‘laminar rejuvenation flakes’ and wide blades. (14, 15) Châtelperronian backed points. (10) Neo crested blade. (13) Convergent side-scraper. Note the variation in size of the pieces.” (Marciani et al., 2025, p. 19).

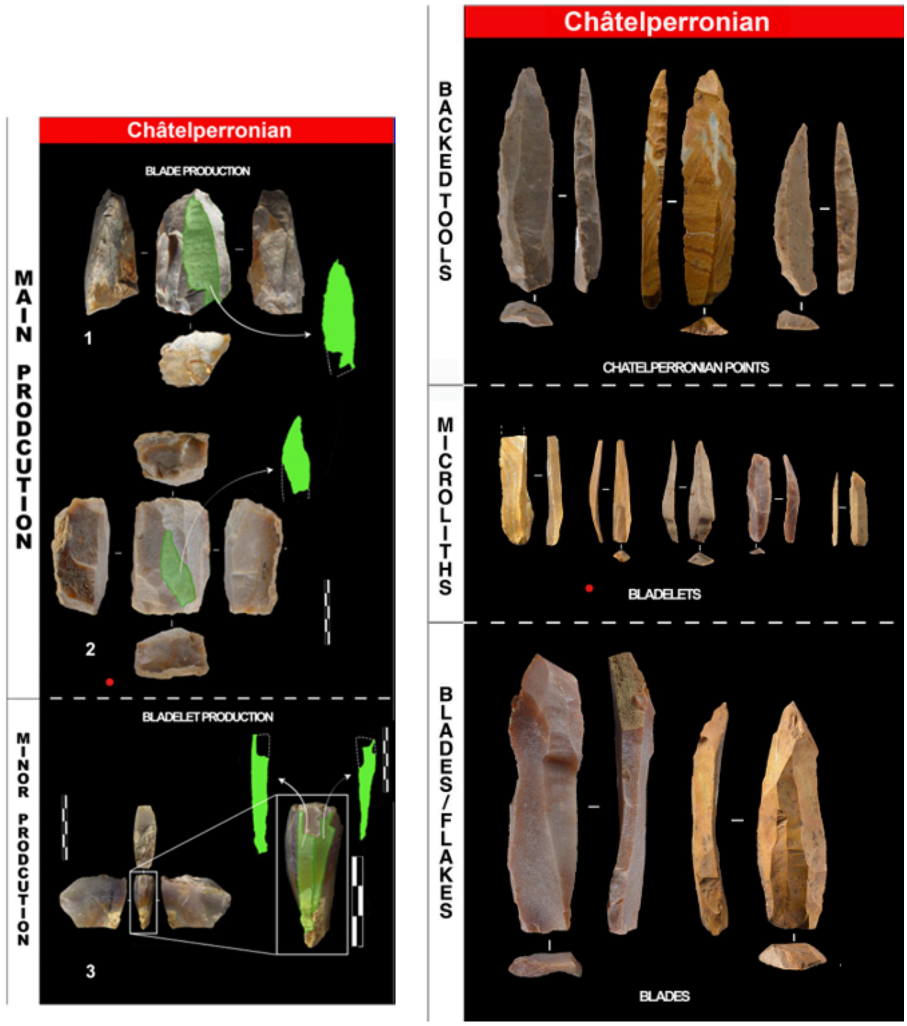


Fig. 4.9. (Left) Main and minor production modes of the Châtelperronian. (1, 2) Châtelperronian blade cores. (3) Châtelperronian bladelet core. (Right) Backed tools, microliths and blades/flakes of the Châtelperronian. (Marciani et al., 2025, pp. 22-23).

The Châtelperronian layer is a blade-dominated layer. This conclusion is also made by Roussel & Soressi (2013), who found the layer consisted of retouched tools such as the Châtelperronian points, scrapers, and backed bladelets. Blades show unidirectional, often semi-prismatic production methods, and some reduction sequences indicate well-controlled core preparation and maintenance. The combination of typical Châtelperronian point types and the associated blade technology supports the cultural attribution of US 06 as firmly Châtelperronian (Roussel & Soressi, 2013, pp. 291-295).

4.5 Comparison between the Proto-Aurignacian and the Châtelperronian at Les Cottés

Les Cottés provides a well-stratified and preserved sample of both the Proto-Aurignacian and the Châtelperronian. This allowed for a direct comparison without the concern of contamination, because all the layers are separated from each other with overlying sterile sediments. First, the raw material of the Châtelperronian is mainly local flint. The Proto-Aurignacian used the same regional flint (Roussel & Soressi, 2013, pp 287-288).

Secondly, we look at differences in the cores between the Proto-Aurignacian and the Châtelperronian. Porter et al. (2019) researched this already and confirmed that the Châtelperronian core had larger platform angles than the Proto-Aurignacian. This supports the idea that Châtelperronian reduction was less continuous and perhaps more opportunistic.

Next, the cross-section shape of blade cores, which is often thought to reflect technological intentions and knapping strategies. Châtelperronian cores are expected to be more asymmetrical and angular. This reflects a strategy of working two distinct flaking surfaces (bifacial or multi-platform reduction), often creating triangular or wedge-like profiles. This is expected because the Châtelperronian is normally more flake-based than the Proto-Aurignacian, which is more bladelet-based. These asymmetrical and angular cores are also linked to the production of Châtelperronian points and knives, which may require asymmetrical blanks. In contrast with the Châtelperronian, the Proto-Aurignacian cores are more likely to be symmetrical and rounded because they often show evidence of a semi-turning technique, which is a continuous flaking process around a single convex surface resulting in rounded or oval cross-sections. The blanks produced are bladelets, which are typically more standardized and regular in shape. These expectations are found in previous studies by scholars like Roussel (2013) and Pelegrin (1995). But unlike those studies, at Les Cottés there was no significant difference between the Châtelperronian and the

Proto-Aurignacian. The Châtelperronian and Proto-Aurignacian cross-sections overlapped heavily, despite initial predictions. Artifact size did also not explain the pattern because there was variation across all size quartiles. It is possible that it did not differ from each other very much, because they may not have followed a standardized template. Because cores are often by-products of tools production, it is less likely to be strictly standardized (Porter et al., 2019, pp. 47-48).

A last study Porter et al (2019) has done about the cores of Les Cottés is about the angle between core axes (symmetry vs. reduction axis). The Proto-Aurignacian cores should show that the angles are closer to 0 degrees, while the Châtelperronian should have larger angular divergence and be closer to 45 degrees due to multiple surfaces being worked. After the results, it is indeed the Proto-Aurignacian that lies closer to 0 degrees, but two potential outliers muddied the interpretation. This means that the results are suggestive but not yet definitive. To get a better view, we need a bigger sample size (Porter et al., 2019, pp. 48-51).

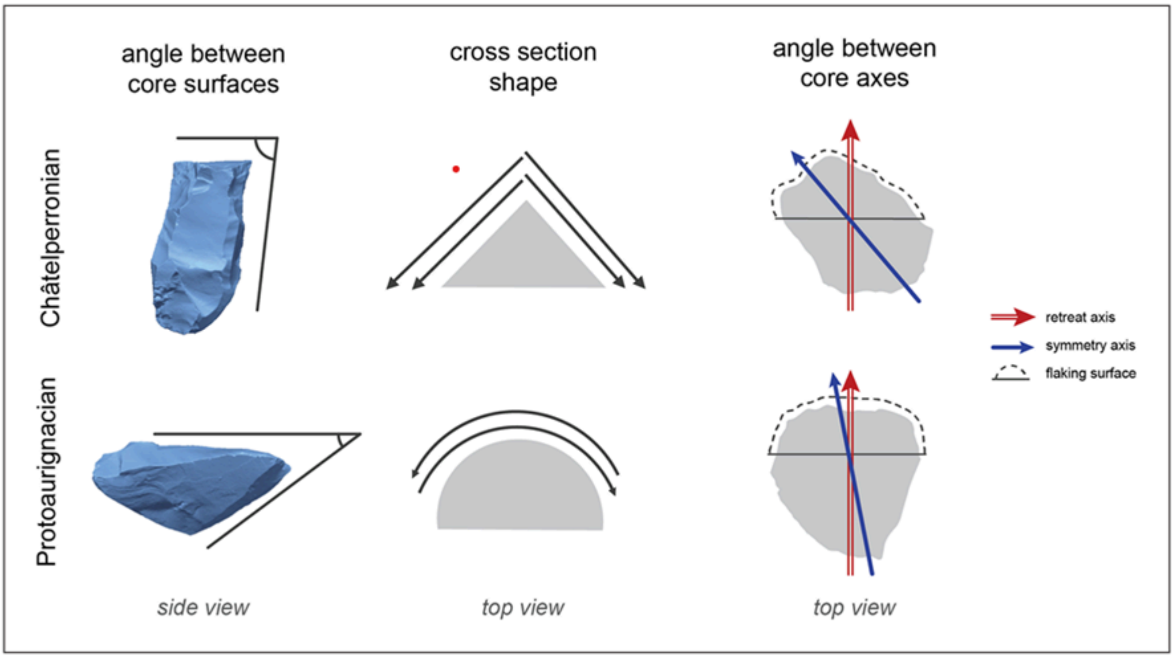


Fig. 4.10. Schematic Illustration of the three core attributes described above. (Porter et al., 2019, p. 43).

Fig. 4.11. 3D images of (Above) Châtelperronian core: angular, irregular. (Bottom) Proto-Aurignacian core: regular, rounded. (Porter et al., 2016, p. 8).

The cores that were used by the Châtelperronian are mostly for blades with unipolar reduction, while the Proto-Aurignacian have more bladelet cores than blade cores. The bladelet cores are more focused on long, straight bladelets. The lithic production consisted mostly of medium to small blades, which are rectilinear at the Châtelperronian. The robusticity is lower than the Aurignacian. At the Proto-Aurignacian, the lithic production consisted of an equal amount of blades and bladelets, but there is an emphasis on producing large, straight bladelets.

The Châtelperronian did use crested blades for core preparation and they had very few large blades. The Proto-Aurignacian especially used Dufour-type bladelets with consistent retouch, which means that there are only a few scrapers and burins.

Lastly, 38% of the pieces in the Chatelperronian are backed stone tools, 29% retouched blades, and 12% are still Mousterian-like tools. The Proto-Aurignacian did have more retouched 52% of retouched bladelets (mostly Dufour-type tools with inverse retouch) and had a low retouched blade presence (Roussel & Soressi, 2013, pp. 288-292).

4.6 Conclusion

This chapter was about the case study of Les Cottés in France. Here are multiple layers separated from each other because of overlying sterile sediments. This ensured that the contamination rate was low and that the results of new research are trustworthy. We focused on the two layers of the Châtelperronian and the Proto-Aurignacian. These layers are associated with the Neanderthals (Châtelperronian) and the anatomically modern humans (Proto-Aurignacian). There are a few differences in these layers that you should know about. There is a technological distinction between the two layers. The Châtelperronian industry at Les Cottés is characterized by blade production with a significant presence of backed tools, possibly including Les Cottés points, which is indicative of an evolved phase. In contrast, the Proto-Aurignacian is focusing on producing rectilinear bladelets with standardized Dufour-type retouch, suggesting different toolkits and intentions. While Châtelperronian retains some Middle Palaeolithic tool types (scrapers, notches), the Proto-Aurignacian exhibits a clear break in typology with almost no Mousterian traits and greater emphasis on fine bladelets, aligning it more with early modern human behaviour. These differences can be a possible scenario for how the Neanderthals disappeared. The shift from broader, more generalist tools in the Châtelperronian to narrower, task-specific bladelets in the Proto-Aurignacian suggests a different approach to problem-solving and resource use. Furthermore, the greater standardization and multifunctionality of AMH toolkits may have provided a behavioural and technological advantage in adapting to new environments or securing resources more efficiently. Although the core-cross sections at Les Cottés did not yield definitive distinctions, other factors such as reduction strategies, retouch type, and bladelet emphasis provide evidence for different technological traditions. The results from Les Cottés not only reinforce the idea that modern humans employed a more flexible and perhaps more innovative technological repertoire but also highlight that Neanderthals were capable of complex tool production themselves. Nevertheless, when viewed in the broader archaeological and temporal context, the

Proto-Aurignacian techno-complex may have allowed AMH to thrive where Neanderthals could not. The differences in lithic technology seen at Les Cottés offer a compelling window into the dynamics that may have shaped the eventual disappearance of the Neanderthals.

Chapter 5: Discussion

5.1 Introduction

In this chapter, I will discuss the findings of other key sites to compare Les Cottés' results with those of other Châtelperronian and Proto-Aurignacian sites. This will eventually lead to a discussion about the findings at Les Cottés. Is Les Cottés just an exception, or did this also happen at other key sites? This discussion will be about the implications of all findings combined. Did my research agree or conflict with other sites? Eventually, this will spark the discussion if the two stone tools of the Chatelperronian and Proto-Aurignacian led to the extinction of the Neanderthals.

5.2 Grotte du Renne

Grotte du Renne is also a site in France that has a Châtelperronian and a Proto-Aurignacian layer. All the layers are dated via radiocarbon dating. The Châtelperronian layers are dated to 41,000 and 35,500 BP. The Proto-Aurignacian layers are dated to 34,810-29,930 BP (Hublin et al., 2012, pp. 18745-18746). At Grotte du Renne, the assemblage of the Chatelperronian included a blade-based lithic technology, just like Les Cottés. Tools were produced using blade and bladelet techniques. There was even evidence of core preparation technology, indicating an advanced method of producing blanks. Another tool type that was found at Grotte du Renne was the Châtelperronian points, which is a characteristic tool type of the Châtelperronian. The presence of awls (pointed bone implements) in the Châtelperronian layer is significant because bone tool production is often associated with modern human behaviours. The difference with Les Cottés is that there are no sterile sediments that separate the different layers. So, it is possible that these tools are not solely from the Châtelperronian layer. The chronostratigraphic confusion at the site due to vertical mixing and post-depositional disturbance casts doubts on whether these tools are truly Châtelperronian or intrusive from the Aurignacian layers above. Just above this Châtelperronian layer is a Proto-Aurignacian layer, which is typical of the AMH. This layer includes tool types such as bladelets, split-based bone points, and personal ornaments like those of the Châtelperronian layer. This technological overlap adds to the difficulty of securely assigning artifacts to one group or another (Higham et al., 2010, pp. 20234-20238).

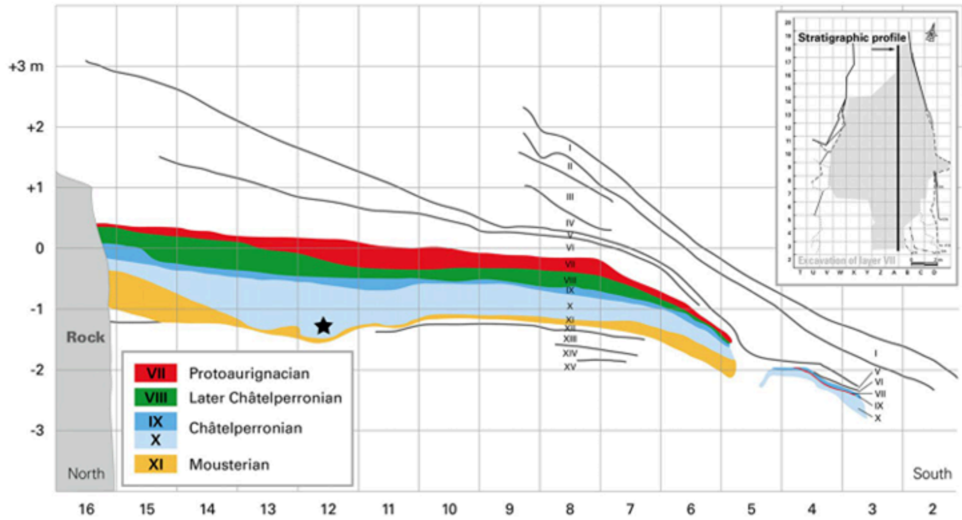


Fig. 5.1. The stratigraphic sections at Grotte du Renne. (Gicqueau et al., 2023, p. 3).

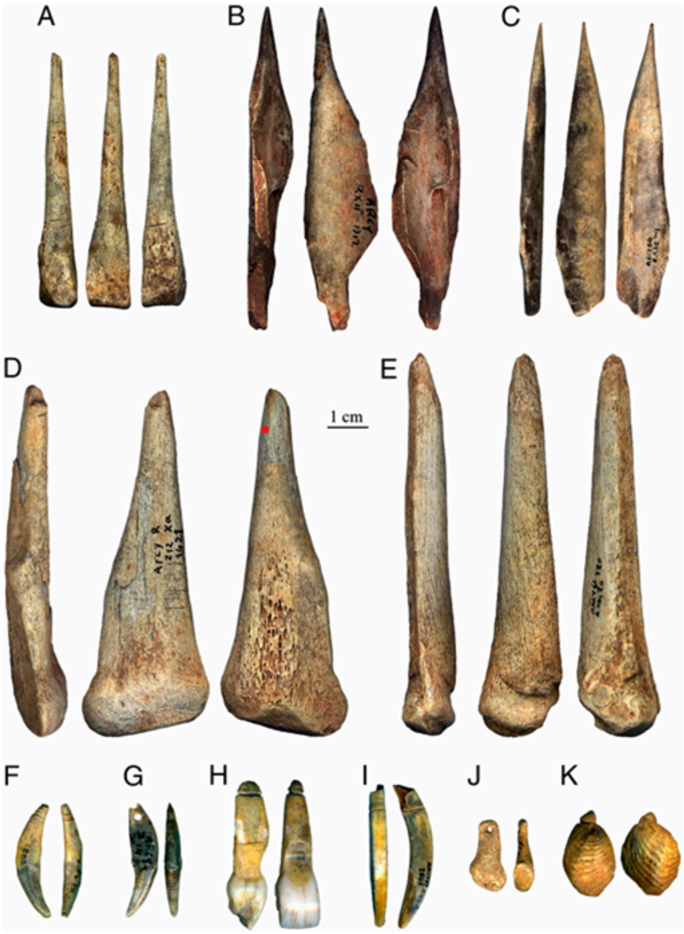


Fig. 5.2. "The remains of some of the personal ornaments, awls, pierced animal teeth, and ivory pendants that have been excavated from the Châtelperronian levels at Grotte du Renne." (Higham et al., 2010, p. 20235).

Grotte du Renne has a few differences from Les Cottés. At Grotte du Renne, Neanderthal remains are found (teeth, skull fragments) in Châtelperronian layers, and there is one AMH perinatal ilium (pelvic bone) recently identified. This AMH piece can be in the Châtelperronian layer because of the vertical mixing or post-depositional disturbance, but the real reason we do not know yet. maybe it is possible that the AMH also made the Châtelperronian, and the interaction between the two species ensured that both species contributed to the Châtelperronian (Gicqueau et al., 2023, pp. 4-10).

The similarities of the sites of Grotte du Renne and Les Cottés are the blade and bladelets techniques and the core preparation technology of the Châtelperronian. All those were also found at Les Cottés in the Châtelperronian layer. For example, the Châtelperronian points were found at both sites. Also, the fact that the Proto-Aurignacian mostly contributed to bladelet production was found at both sites.

This is a big difference from Les Cottés, which is primarily used for its well-stratified cultural sequence. At Grotte du Renne, there are ornaments, awls, and bone tools found in the Châtelperronian layers, while at Les Cottés, no ornaments are associated with the Châtelperronian, but only with the Proto-Aurignacian and Early Aurignacian. The techno-complexes of Les Cottés are better secured because of the sterile sediments that separate the different layers and prevent stratigraphic mixing, something that is not the case at Grotte du Renne. Les Cottés proposes clear transitions between different technological industries, while Grotte du Renne's integrity of associations between tools, ornaments, and Neanderthals is highly debated (Talamo et al., 2012, pp. 175-178; Higham et al., 2010, pp. 20234-20238; Gicqueau et al., 2023, pp. 4-10).

5.3 Broader implications and other sites

The Comparison of Les Cottés with other key transitional sites, such as Grotte du Renne, highlights both its uniqueness and its broader relevance in addressing the Middle to Upper Palaeolithic transition.

The findings of Les Cottés, when compared with other sites such as Grotte du Renne, suggest that the technological differences between the Châtelperronian and the Proto-Aurignacian are not site-specific but part of a broader pattern. The stratigraphy of Grotte du Renne is less secure due to vertical mixing than the stratigraphy of Les Cottés. Even though this is not ideal, the presence of similar tools such as bladelets, awls, ornaments, and core preparation methods supports a regional consistency in tool use during the Middle to Upper Palaeolithic transition (Higham et al., 2010, p 20235; Hublin et al., 2012, p. 18746).

The presence of symbolic items at the Châtelperronian layer of Grotte du Renne, such as personal items and bone tools, has sparked debates about Neanderthal capabilities. However, the possible vertical mixing or post-depositional disturbance means these artifacts could be intrusive (Higham et al., 2010, pp. 20234-20236). In contrast, Les Cottés has sterile sediment that separates the different layers, which allows for more confident attribution of tool types to specific hominin groups (Talamo et al., 2012, pp. 176-178).

Other key transitional sites like Quincay, Roc-de-Combe, and Fumane offer additional support. At Roc-de-Combe, studies by Pelegrin (1995) highlight consistent core reduction strategies in the Châtelperronian. These strategies emphasize blade production rather than bladelet production (Often seen in the Proto-Aurignacian). These differences underline a technological distinction between AMH and Neanderthals.

At Quincay, which is mostly a Châtelperronian site, reflects similar blade and bladelet production with structured reduction strategies (Roussel et al., 2016, pp. 19-21). Fumane, which represents the Proto-Aurignacian, emphasizes standardized bladelet production with carinated cores, which closely matches the findings at Les Cottés (Falcucci et al., 2017, pp. 10-15).

5.4 Interpretations

The proto-Aurignacian technology, associated with AMH, is more focused on standardized, multifunctional bladelets, while the Chatelperronian technology associated with Neanderthals is more centered on blade production with some evidence of innovation, but less emphasis on standardization or multifunctionality.

These patterns may reflect different cultural capacities. The bladelet-dominated Proto-Aurignacian assemblages may have given the AMH an advantage in hunting efficiency and mobility (Falcucci et al., 2017, p 14; Pasquini, 2013). This gives them an advantage in environmental and demographic pressures, because the ability to rapidly produce standardized tools that could be easily replaced or adjusted may have supported adaptive responses, which can give them an advantage in changing environments or demographic pressures.

In contrast, the production of the Neanderthals' tools, while technically sophisticated, lacked this flexibility. Their emphasis on blades and reuse of cores suggests a different, possibly more conservative, technical approach (Roussel et al., 2016, pp. 17-22). This may have limited the Neanderthal resilience during periods of rapid change or increased competition with AMH.

5.5 Conclusion

The comparison of Les Cottés with other transitional sites suggests that the observed differences in lithic technology are part of a broader trend and not unique anomalies. The Proto-Aurignacian, with its emphasis on bladelets and modular toolkits, reflects more adaptive and dynamic strategies that may have contributed to the competitive edge of the AMH. The more modular and task-specialized toolkit of the AMH allowed them to hunt and process resources more efficiently. In contrast, the Châtelperronian's generalized blade technology, though sophisticated, lacked such optimization. These distinctions likely reflect differences in adaptive strategies under demographic and environmental pressure. This could be a reason that the AMH got a competitive edge over the Neanderthals. The Châtelperronian, which is innovative in its way, may represent its technological ceiling of the Neanderthals. When these differences are combined with demographic and environmental stressors, they may offer a compelling explanation for the eventual disappearance of Neanderthals.

Chapter 6: Conclusion

6.1 Conclusion

This thesis is set out to explore the differences in tool technologies between the anatomically modern humans and Neanderthals, focusing on the Châtelperronian and Proto-Aurignacian industries found at Les Cottés. This will help with the broader question that is asked: whether these technological differences contribute to the demise of the Neanderthals. Through a detailed case study, analysis of the lithic production methods, and the comparison with other key transitional sites, it becomes apparent that stone tools played a significant, although not solitary, role in the competitive dynamics between Neanderthals and AMH.

The Châtelperronian industry at Les Cottés showed that Neanderthals had a high degree of technical ability. Their blade and bladelet production strategies show careful preparation, unidirectional flaking techniques, and standardized tool types such as end-scrapers and Châtelperronian points. These techniques indicate that Neanderthals were not just copying AMH innovations but were developing sophisticated tool-making methods themselves, which they suited to their needs. However, the Châtelperronian industry reflects a continuity of earlier Mousterian traditions, without the major technological and organizational leaps that are evident in the Proto-Aurignacian.

In contrast, the Proto-Aurignacian showed a radical shift towards independent bladelet production with carinated and prismatic cores. Bladelets were produced in a standardized manner, with a plan. This suggests not only advanced technical skills but also a fundamentally different way of organizing production and tool use. The Proto-Aurignacian assemblage at Les Cottés indicates a shift towards modular, multifunctional tools, likely used for a wide variety of tasks, including complex projectile weaponry. Although Les Cottés itself shows relatively few projectile points compared to other Proto-Aurignacian sites, the technological flexibility and emphasis on bladelet production hint at more adaptive cognitive and subsistence strategies.

The comparison of these two technologies at Les Cottés shows that both the Neanderthals and AMH are capable toolmakers. The AMH technology only offered a broader range of functionality and adaptability. The Proto-Aurignacian reflects not only the difference in tool shape or production methods, it showed a deeper cognitive and cultural shift. The rapid innovation, creating modular toolkits, and specializing in new hunting techniques would have provided a significant survival advantage under changing climatic and demographic pressures.

Furthermore, evidence from the Gravettian culture showed that AMH continued to develop and standardize their toolkits and technology over time, having a lot of highly specialized weapons and symbolic artifacts such as the Venus figurines. This long-term trajectory of innovation is very different from the technological traditions of the Neanderthals. Many researchers and archaeologists have discussion about whether the Neanderthals also had a very highly developed toolkit. To this day, there is not one consensus that everyone agrees on.

While climate change, interbreeding, and demographic shifts certainly played a significant role in the demise of the Neanderthals, technological differences cannot be overlooked. Better tools meant better hunting efficiency, more reliable resource acquisition, and perhaps better social organization. In the competitive context of the Upper Palaeolithic, small advantages can lead to major demographic shifts over millennia. Thus, it is reasonable to conclude that the superior flexibility and innovation in AMH stone tool technology were one of the key factors contributing to the Neanderthals' disappearance.

6.2 Further research

This thesis focused on the technological differences between AMH and Neanderthals at Les Cottés. But future research is needed to deepen our understanding of how the differences in tool technologies impacted survival and competition. Future studies should expand by incorporating more extensive functional analysis, such as use-wear analysis and residue studies, to better understand how stone tools were used in hunting, processing, and other daily activities. Expanding the sample size by including more transitional sites across Europe, especially those with well-preserved stratigraphic sequences, would also help determine whether the patterns observed at Les Cottés are representative or unique to this region. Additionally, integrating faunal and environmental data could help clarify how technological flexibility may have been tied to changing climates and resource availability. Finally, genetic studies alongside lithic analyses could offer a fuller picture of population interactions and cultural transmission during the Middle-to-Upper Paleolithic transition. A multi-disciplinary approach will be essential to untangle the complex factors that led to Neanderthal extinction. Furthermore, interdisciplinary research incorporating genetics, archaeology, and anthropology could shed more light on the extent of cultural exchanges, hybridization, and competition between Neanderthals and AMH. It remains crucial to investigate whether technological innovations were purely a result of independent invention, cultural diffusion, or a combination of both. Future work should also explore how symbolic behavior, demographic pressures, and social organization interact with technological changes to influence the ultimate survival of AMH over Neanderthals. We can only fully appreciate the complex dynamics that shaped this pivotal moment in human history through a multi-faceted research approach.

Abstract

This thesis investigates the role of technological differences between anatomically modern humans and Neanderthals during the initial Upper Palaeolithic, focusing on the case study of Les Cottés in France. The central research question asked whether the differences in tool technologies contributed to the demise of the Neanderthals. The focus lies on the Châtelperronian, which is normally associated with the Neanderthals, and the Proto-Aurignacian, which is normally associated with the anatomically modern humans. Through a detailed analysis of lithic assemblages from Les Cottés, this study highlights key technological contrasts. The Châtelperronian shows a high degree of technical skill, which includes blade and bladelet production and specialized tool types such as Chatelperronian points. However, these techniques largely represent an elaboration of existing Middle Paleolithic methods rather than a significant technological revolution. In contrast, the Proto-Aurignacian shows a great cognitive flexibility and an increased capacity for adaptation among AMH populations. The Proto-Aurignacian technology signifies a major shift, characterized by systematic bladelet production, standardized carinated cores, and the development of modular, multifunctional toolkits. Comparison with other key transitional sites (e.g. Grotte du Renne) reinforces the idea that Proto-Aurignacian strategies were more flexible and better suited to varied environmental challenges. Furthermore, the Gravettian culture, which developed after the disappearance of the Neanderthals, provides evidence that AMH continued to refine and expand their technological and symbolic capacities. The extinction of the Neanderthals was undoubtedly influenced by multiple factors, such as climate change and demographic pressures, but this research shows that technological differences also played a role in the demise of the Neanderthals. The superior adaptability, specialization, and cognitive organization reflected in AMH stone tool industries likely provided a critical competitive advantage. This thesis concludes that technological differences and particularly the standardization and innovation, which is seen in the Proto-Aurignacian, should be considered a major factor in the survival of the anatomically modern human and the extinction of the Neanderthals. Further interdisciplinary research combining lithic assemblages, genetic data, and environmental studies is recommended to develop a more complete understanding of this significant period in human evolution.

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Appendix A: Database

You can find all the cross-sections and 3D models of Chatelperronian and Proto-Aurignacian cores from the site of Les Cottés at the Data Repository for the University of Minnesota (DRUM).

Table A.1. Table of the dataset of Les Cottés (Porter et al., 2018).

Artifact ID	Industry	Level	Cross-section available	Core volume (cm³)	Inter-axis angle	Platform to debitage angle
CTS_CP_R4-860	Chatelperronian	US 6.3BJ	Yes	23.97	18.0	76
CTS_CP_R5-1485	Chatelperronian	US 6.2BJ	Yes	110.57	35.0	92
CTS_CP_R5-1697	Chatelperronian	US 6.3BJ	Yes	35.59	21.0	Null
CTS_CP_R6-624	Chatelperronian	US 5.0BJ	Yes	86.11	19.0	60
CTS_CP_S5-65	Chatelperronian	US 6.2BJ	Yes	31.67	40.0	73
CTS_CP_U6-282	Chatelperronian	US 6.1002	Yes	26.8	16.0	81
CTS_CP_U6-358	Chatelperronian	US 6.1002	Yes	22.54	21.0	86
CTS_CP_U6-421	Chatelperronian	US 6.1002	Yes	48.85	8.0	71
CTS_CP_U6-461	Chatelperronian	US 6.1002	Yes	87.96	8.0	70
CTS_CP_U6-467	Chatelperronian	US 6.1002	Yes	15.07	26.0	68

CTS_CP_U6-661	Chatelperronian	US 6.1003	Yes	11.93	25.0	72
CTS_CP_W6-123	Chatelperronian	US 6.1002	Yes	20.37	10.0	60
CTS_CP_W6-161	Chatelperronian	US 6.1002	Yes	18.17	40.0	74
CTS_CP_W7-614	Chatelperronian	US 6.1003	Yes	26.44	31.0	84
CTS_CP_X6-106_Y4-313	Chatelperronian	US 6.RC/6.04	Yes	129.69	0.0	90
CTS_CP_X6-643	Chatelperronian	US 6.1003	Yes	91.16	9.0	78
CTS_CP_Y4-140	Chatelperronian	US 6.RC	Yes	11.187	30.0	Null
CTS_CP_Y4-854	Chatelperronian	US 6.1	Yes	78.74	16.0	76
CTS_CP_Y4-866	Chatelperronian	US 6.1	Yes	7.1	20.0	47
CTS_CP_Y5-1635	Chatelperronian	US 6.02	Yes	20.55	16.0	77
CTS_CP_Y6-1258	Chatelperronian	US 6.03	Yes	15.23	26.0	63
CTS_CP_Y6-1574	Chatelperronian	US 6.RC	Yes	58.99	34.0	89
CTS_CP_Y6-2021	Chatelperronian	US 6.1	Yes	133.82	6.0	83
CTS_CP_Y6-2258	Chatelperronian	US 6.1est	Yes	18.52	6.0	86
CTS_CP_Z4-1201	Chatelperronian	US 6.RC	Yes	15.29	33.0	88

CTS_CP_S6-1137	Chatelperronian	US 6.2003	No	nan	nan	nan
CTS_CP_T6-851	Chatelperronian	US 6.1002	No	nan	nan	nan
CTS_CP_T6-880	Chatelperronian	US 6.1003	No	nan	nan	nan
CTS_CP_U6-460	Chatelperronian	US 6.1002	No	nan	nan	nan
CTS_CP_U6-803	Chatelperronian	US 6.1002	No	nan	nan	nan
CTS_CP_W6-165	Chatelperronian	US 6.1003	No	nan	nan	nan
CTS_CP_W6-209	Chatelperronian	US 6.1003	No	nan	nan	nan
CTS_CP_W6-250	Chatelperronian	US 6.1001	No	nan	nan	nan
CTS_CP_W6-65	Chatelperronian	US 6.1003	No	nan	nan	nan
CTS_CP_X7-638	Chatelperronian	US 6.1003	No	nan	nan	nan
CTS_CP_Y4-294	Chatelperronian	US 6	No	nan	nan	nan
CTS_CP_Y4-390	Chatelperronian	US 6.RC	No	nan	nan	nan
CTS_CP_Y5-2500	Chatelperronian	US 6	No	nan	nan	nan
CTS_CP_Y5-2612	Chatelperronian	US 6.1	No	nan	nan	nan
CTS_CP_Y5-2740	Chatelperronian	US 6.1	No	nan	nan	nan

CTS_CP_Y5-2865	Chatelperronian	US 6	No	nan	nan	nan
CTS_PA_A3-616	Protoaurignacian	US 4.3	Yes	23.86	23.0	64
CTS_PA_A3-620	Protoaurignacian	US 4.3	Yes	4.981	11.0	56
CTS_PA_R4-632	Protoaurignacian	US 4.42BF	Yes	6.83	8.0	70
CTS_PA_R5-1497	Protoaurignacian	US 4.42BF	Yes	38.35	21.0	69
CTS_PA_R5-675	Protoaurignacian	US 4.42BF	Yes	8.54	42.0	41
CTS_PA_R5-794	Protoaurignacian	US 4.42BF	Yes	56.66	19.0	79
CTS_PA_R6-430	Protoaurignacian	US 4.42BF	Yes	6.95	24.0	62
CTS_PA_S6-993	Protoaurignacian	US 4.4BF	Yes	33.44	16.0	78
CTS_PA_U7-126	Protoaurignacian	US 4.3RCE	Yes	20.31	9.0	Null
CTS_PA_W7-382	Protoaurignacian	US 4.4	Yes	53.83	44.0	71
CTS_PA_Y4-118	Protoaurignacian	US 4.45	Yes	32.64	22.0	62
CTS_PA_Y5-1856	Protoaurignacian	US 4.7	Yes	25.15	6.0	66
CTS_PA_Y5-313	Protoaurignacian	US 4.2	Yes	28.47	13.0	Null
CTS_PA_Y5-324	Protoaurignacian	US 4.2	Yes	89.49	2.0	64

CTS_PA_Y5-637	Protoaurignacian	US 4.3	Yes	16.87	5.0	67
CTS_PA_Y6-1584	Protoaurignacian	US 4.8	Yes	22.04	6.0	65
CTS_PA_Y6-582	Protoaurignacian	US 4.2	Yes	12.73	9.0	71
CTS_PA_Y6-764	Protoaurignacian	US 4.2	Yes	33.41	23.0	60
CTS_PA_Y6-857	Protoaurignacian	US 4.5	Yes	22.07	18.0	57
CTS_PA_Z4-1529	Protoaurignacian	US 4.35	Yes	64.4	12.0	78
CTS_PA_Z4-1663	Protoaurignacian	US 4.35	Yes	37.21	5.0	85
CTS_PA_Z4-1696	Protoaurignacian	US 4.35	Yes	6.98	2.0	70
CTS_PA_Z4-3315	Protoaurignacian	US 4.35	Yes	23.05	6.0	69
CTS_PA_Z4-3389	Protoaurignacian	US 4.35	Yes	30.53	27.0	81
CTS_PA_Z4-3595	Protoaurignacian	US 4.55	Yes	23.37	22.0	62
CTS_PA_A3-306	Protoaurignacian	US 4.3	No	nan	nan	nan
CTS_PA_A3-401	Protoaurignacian	US 4.3	No	nan	nan	nan
CTS_PA_A3-746	Protoaurignacian	US 4.3	No	nan	nan	nan
CTS_PA_R5-782	Protoaurignacian	US 4.42BF	No	nan	nan	nan

CTS_PA_S6-296	Protoaurignacian	US 4.4BF	No	nan	nan	nan
CTS_PA_S6-939	Protoaurignacian	US 4.4BF	No	nan	nan	nan
CTS_PA_X7-408	Protoaurignacian	US 4.904	No	nan	nan	nan
CTS_PA_Y5-10047	Protoaurignacian	US 4.4	No	nan	nan	nan
CTS_PA_Y5-1829	Protoaurignacian	US 4.07	No	nan	nan	nan
CTS_PA_Y5-1830	Protoaurignacian	US 4.7	No	nan	nan	nan
CTS_PA_Y5-2007	Protoaurignacian	US 4.8	No	nan	nan	nan
CTS_PA_Y5-923	Protoaurignacian	US 4.4	No	nan	nan	nan
CTS_PA_Y6-2190	Protoaurignacian	US 4.904	No	nan	nan	nan
CTS_PA_Y6-420	Protoaurignacian	US 4.2	No	nan	nan	nan
CTS_PA_Y6-826	Protoaurignacian	US 4.5	No	nan	nan	nan
CTS_PA_Z3-774	Protoaurignacian	US 4.35	No	nan	nan	nan
CTS_PA_Z3-842	Protoaurignacian	US 4.35	No	nan	nan	nan
CTS_PA_Z4-1716	Protoaurignacian	US 4.35	No	nan	nan	nan
CTS_PA_Z4-1824	Protoaurignacian	US 4.35	No	nan	nan	nan

CTS_PA_Z4-1849	Protoaurignacian	US 4.35	No	nan	nan	nan
CTS_PA_Z4-2336	Protoaurignacian	US 4.45	No	nan	nan	nan
CTS_PA_Z4-2558	Protoaurignacian	US 4.3	No	nan	nan	nan
CTS_PA_Z4-3091	Protoaurignacian	US 4.35	No	nan	nan	nan
CTS_PA_Z4-3178	Protoaurignacian	US 4.35	No	nan	nan	nan

Table A.2. Core-reduction comparison between the Châtelperronian and the Proto-Aurignacian at Les Cottés (Porter et al., 2019; Falcucci et al., 2016; Roussel & Soressi, 2013).

Attribute	**Châtelperronian**	**Proto-Aurignacian**	**Remarks**
Platform angle (average)	Larger angles	Smaller angles	Châtelperronian reduction less continuous
Core symmetry (reduction axis)	More asymmetrical / angular	More rounded / symmetrical	No statistically significant difference
Core reduction strategy	Unipolar flaking on broad surfaces	Circumferential reduction using carinated cores	Proto-Aurignacian focused on bladelet production
Dominant product	Blades	Bladelets	Bladelets more standardized in Proto-Aurignacian
Tool retouch type	Abrupt, single-edge retouch	Inverse, fine lateral retouch	Dufour bladelets (Proto-Aurignacian)

			vs. Châtelperronian points
Typical core shapes	Asymmetrical, wedge-shaped	Pyramidal, prismatic	Reflects their respective reduction strategies