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CRO-MAGNON PERSONAL ORNAMENTS REVISITED

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ABSTRACT

The Cro-Magnon rock-shelter hosted the first discovered and certainly one of the most important Gravettian burial sites in Europe. However, the copious ornament collection found among the human skeletons was not analysed with modern techniques. After proposing a synthesis of the complex curatorial history of the Cro-Magnon material, we submitted a large proportion of the personal ornaments found at the site, hosted in five conservation institutions, to a taxonomic study as well as to taphonomic, morphometric and microscopic analyses. The studied assemblage encompasses shell beads belonging to six species (*L. littorea*, *N. lapillus*, *Turritella* sp., *L. obtusata*, *L. lurida*, *C. jeffreysianus*), two perforated teeth - a Red Deer canine and a bovid incisor - and three shaped pendants, two made of ivory and one displaying no diagnostic features allowing a clear identification of the raw material. Shell ornaments were compared to modern reference collections to identify selection criteria. The Cro-Magnon people used marine shells coming from both the Atlantic and possibly the Mediterranean coasts as ornaments. The distance to these coasts indicates that shells may have been acquired via exchange or during seasonal migration. Very few may have originated from closer fossil outcrops. Conversely, ivory and teeth were available locally. No size preference is observed in the *L. littorea*, the most represented shell species used as beads. The vast majority of shell beads were perforated by puncturing them through the aperture. All ornaments bear diagnostic traces indicating that they were worn during the individuals' lives, and suggesting they belong to beadwork buried with the deceased. The three shaped pendants feature differences in technology, shape, size and decoration suggesting different agency for each. Re-examination of the single radiocarbon age obtained from one of the *L. littorea* leads us to propose, in the light of more up-to-date calibration curves and the nature of the sample, that additional radiocarbon dating should be performed in order to refine the chronological attribution of the Cro-Magnon burials.

RÉSUMÉ

Les ornements personnels de Cro-Magnon revus

L'abri-sous-roche de Cro-Magnon est l'un des premiers sites archéologiques à avoir livré des restes humains aux côtés de vestiges de faunes disparues depuis le Pléistocène supérieur. Ce site a ainsi contribué à démontrer sans équivoque que les hommes du Paléolithique supérieur enterraient leurs morts et suscité l'intérêt du public et des universitaires. Alors que le site a livré sans doute l'une des plus importantes sépultures gravettiennes d'Europe, en raison de la nature pionnière de la fouille et de l'importance de la découverte de Cro-Magnon et dans la hâte de partager les résultats, la disposition spatiale du matériel archéologique a été peu documentée. Depuis leur mise au jour, des analyses de plus en plus exhaustives et informatives ont été réalisées sur les restes humains, ce qui a permis de fournir des données anthropologiques inédites sur la biologie des défunts, leur état de santé et leur comportement. Malgré le rôle clef du site, les nombreux objets de parure trouvés parmi les restes humains n'ont jamais été analysés avec les techniques modernes. Après avoir proposé une synthèse de l'histoire complexe du matériel de Cro-Magnon après sa découverte, nous avons soumis une majeure partie des ornements corporels, conservés dans cinq institutions différentes, à des analyses taphonomiques, morphométriques et microscopiques. Sur les quelque trois cents parures de coquillages mentionnées par Lartet (1868), nous avons pu en localiser deux cent deux (cent quatre-vingt-quatre L. *littorea*, une *L. obtusata*, quatre *Turritella* sp., six *Nucella lapillus*, une *Luria lurida*, un fragment de nacre et un *Colus jeffreysianus*). Deux dents perforées (une canine de cerf et une incisive de bovidé) et trois pendentifs façonnés, deux en ivoire et un ne présentant pas de caractéristiques claires pour identifier la matière première sont également présents dans la collection. L'ensemble du matériel est dispersé dans de nombreux musées et, nous avons pu étudier cent quarante-trois objets de parure. Les ornements en coquillages ont été comparés à des collections de référence modernes afin d'identifier les critères de sélection et d'évaluer la provenance des coquillages. Les hommes de Cro-Magnon ont sélectionné des coquillages provenant à la fois des côtes atlantique et peut-être méditerranéenne. La distance qui sépare ces côtes du site indique que les coquillages ont pu être acquis par échange. Quelques spécimens proviennent d'affleurements fossiles plus proches. À l'inverse, l'ivoire et les dents étaient disponibles localement. L'analyse microscopique a permis d'identifier des traces laissées par des prédateurs et des spongiaires, indiquant que les coquilles ont été ramassées après leur mort, apparemment dans le seul but d'être transformées en ornements, et non pour être consommées. Aucune sélection en fonction de la taille des coquilles n'est observée pour l'espèce de coquillage la plus représentée (*i.e.*, *L. littorea*). Diverses méthodes ont été employées pour perforer les coquilles, la pression à travers l'ouverture à l'aide d'une petite pointe étant la technique privilégiée. La propension à utiliser cette méthode peut être liée à la morphologie de la coquille des *L. littorea*, afin de minimiser les risques de fracture des coquilles lors de la perforation. Tous les ornements portent des traces diagnostiques indiquant qu'ils ont été portés, suggérant que les perles trouvées à Cro-Magnon appartenaient aux défunts. La présence de différents degrés d'usure sur les *L. littorea* pourrait résulter du fait que l'assemblage comprend des coquillages qui étaient à l'origine intégrés dans différentes parures, utilisées pendant des périodes différentes, et que ces parures ont été recyclées, réparées ou réassemblées au cours du temps. Alternativement, l'intensité de l'usure variable pourrait aussi dépendre du type de suspension, des colliers, par exemple, produisant un degré de mouvement plus élevé que les coquillages cousus sur les vêtements. Les données contextuelles de terrain manquent pour avancer dans cette discussion. L'ocre observé à l'intérieur et à l'extérieur des coquilles indique sa présence à la fois sur le fil et sur le matériau avec lequel les coquilles étaient en contact (vêtements, peau humaine). La présence d'ocre est aussi attestée sur les pendeloques en ivoire et sur les restes humains, ce qui indique que soit l'ocre était présent sur les parures et les hommes de Cro-Magnon de leur vivant, soit il était apposé sur une couverture qui protégeait les corps dans le dépôt funéraire, soit il a été dispersé lors de l'inhumation, aucune de ces hypothèses n'étant mutuellement exclusive ou facile à vérifier à partir des données de terrain disponibles. Quoi qu'il en soit, il convient de noter que la présence d'ocre est une caractéristique commune des sépultures gravettiennes à travers l'Europe. Les trois pendentifs en os présentent des différences en termes de technologie, de forme, de taille et de décoration, indiquant différents modes de production et d'utilisation. Bien que l'utilisation de l'ivoire pour les ornements personnels ait été très répandue au Gravettien, les pendentifs de Cro-Magnon sont particuliers de par leur forme et leur aménagement. Une explication de ces idiosyncrasies peut être que la sépulture de Cro-Magnon recrutait des individus ayant un statut social exceptionnel associé à des types de pendentifs en ivoire particuliers. Cette différence est également observée dans la proportion des parures à Cro-Magnon par rapport au site voisin de l'Abri Pataud. Cro-Magnon présente une

MOTS-CLÉS Paléolithique supérieur, Gravettien, coquillage, perle, analyse microscopique, ivoire.

abondance de *L. littorea* et une relative rareté de pendentifs en ivoire, alors que le niveau 5 contemporain de l'Abri Pataud présente l'inverse. Cette différence peut être due aux fonctions des sites, c'est-à-dire une habitation par rapport à une inhumation. Une hypothèse alternative est que malgré leur proximité et leur pénécontemporanéité, Cro-Magnon et l'Abri Pataud étaient fréquentés par des groupes gravettiens différents portant les mêmes parures mais dans des proportions différentes. Lartet (1868) mentionne aussi qu'un des pendentifs en ivoire a été retrouvé légèrement éloigné des restes humains à Cro-Magnon. Il est possible que les pendentifs en ivoire n'aient pas été portés sur le corps des individus mais plutôt utilisés pour décorer des objets tels que des sacs, des couvertures et des objets en bois, ce qui aurait entraîné leur sous-représentation dans les contextes funéraires. Cette hypothèse est toutefois partiellement contredite par la découverte de pendentifs en ivoire similaires dans des sépultures gravettiennes d'Europe de l'Est. La comparaison typologique des ornements corporels de Cro-Magnon avec le matériel documenté sur d'autres sites montre que le matériel de Cro-Magnon s'intègre à la diversité stylistique connue pour le Gravettien. Bien que présentant des similitudes avec ceux des autres groupes, les ornements de Cro-Magnon affichent néanmoins un certain degré de spécificité, soulignant le désir de cette communauté de montrer sa propre identité dans un cadre symbolique plus large. Le réexamen de l'unique âge radiocarbone obtenu sur l'une des *L. littorea* nous amène à proposer, à la lumière de courbes de calibration les plus récentes et de la nature de l'échantillon, que des datations radiocarbones supplémentaires sont nécessaires afin d'affiner l'attribution chronologique des sépultures de Cro-Magnon.

Human mortuary practices have varied dramatically throughout prehistory (*e.g.*, Boyd *et al*. 2016; d'Errico and Stringer 2011; Dillehay 2012; Harrold 1980; Pettitt 2013; Riel-Salvatore *et al*. 2001), but it is not until the Upper Palaeolithic Gravettian technocomplex (*circa* 34 – 24 ka cal. BP (Kozłowski 2015; Wilczyński *et al*. 2020)) that buried individuals associated with elaborate and archaeologically visible ornaments, and grave goods, begin to represent a widespread cultural phenomenon (*e.g.*, Dobrovolskaya *et al*. 2012; Kacki *et al*. 2020; Mussi *et al*. 2000). When compared to preceding Eurasian and African cultural adaptations, the Gravettian testifies to a veritable revolution in not only the number of primary burials (*e.g.*, d'Errico and Vanhaeren 2015; Henry-Gambier 2008; Nowell 2020), but also the diversity of personal ornaments accompanying the deceased (*e.g.*, Giacobini 2007; Pettitt 2013; Taborin 1993). Considering the recurrent use of personal ornaments in the burials of modern traditional societies (*e.g.*, Petru 2018; Rossano 2010), the presence of varied ornamental grave goods within Upper Palaeolithic burials adds a degree of complexity to burial practices and makes them somehow closer to known historical instances (Baray *et al*. 2007; Henry-Gambier 2008).

Among Gravettian burial sites, the Cro-Magnon rock-shelter stands out clearly for its impact on the then burgeoning disciplines of palaeoanthropology and prehistory (Bougard 2014; Lartet 1868; Puech and Puech 2012). Being one of the first archaeological sites to yield human remains alongside extinct animals, it was instrumental in unequivocally demonstrating the antiquity of humans, suggesting they were burying their dead (Bougard 2014; Henry-Gambier 2002; Hurel 2018), and thus kindled both public and academic interest in these issues (Hurel 2018; Lartet 1868). Because of the pioneering stage of the discipline and the importance of the Cro-Magnon discovery, in the haste to share the findings, the spatial arrangement of the archaeological material was poorly documented (Bougard 2014; Bougard and Delluc 2014; Henry-Gambier *et al*. 2013). Since their unearthing, increasingly exhaustive and informative analyses have been performed on the human remains, which has provided novel anthropological data on the deceased's biology (Broca 1869; Henry-Gambier 1986; Partiot *et al*. 2020; Thibeault and Villotte 2018; Vallois and Billy 1965), health status and behaviour (Charlier *et al*. 2018; Trinkaus *et al*. 2021). However, the numerous personal ornaments found in association with the human remains have not been submitted to in-depth analyses (Henry-Gambier *et al*. 2013).

In this study, we located the numerous conservation institutions in which personal ornaments reported to have been found close to the buried Cro-Magnon individuals are housed and examined almost half of the hundreds of personal ornaments kept in these institutions. By applying an integrated approach that combines available historical information, taphonomic, technological, and functional analyses of the ornaments, the study of reference collections, and comparison with ornaments found at other Gravettian sites, we provide a reassessment of the Cro-Magnon bead collection within the context of the South Western France Gravettian.

1 | HISTORY OF RESEARCH

The Cro-Magnon rock-shelter (Bougard and Delluc 2014; Bourlon 1907; Breuil 1907; Delluc and Delluc 2013; Giraux 1907; Henry-Gambier 2002; Henry-Gambier *et al.* 2013; Hurel 2018; Lartet 1868; Lartet *et al.* 1875; Massénat 1869, 1877; Peyrony 1907; Rivière 1894, 1897) is located on the left bank of the Vézère River, close to the village of Les Eyzies (Dordogne, France) (**fig. 1a**). The site consists of a roughly 10 m deep shelter, which opens to the south within the Upper Cretaceous limestone cliffs of the Vézère valley.

The rock-shelter was discovered in the March of 1868 and was first described by Louis Lartet in the same year (Lartet 1868). Though generally believed to have been unearthed during the construction of a railway, it was in fact found during the creation of the road running adjacent to it (Bougard, Delluc 2014). In his first excavation, Lartet (1868) described eleven archaeological layers (**fig. 1b, c**). He grouped, from the bottom to the top, the first eight of these layers (A-H) into a lower unit and the latter three into an upper unit (I-K). Within the lower unit, layers A, C and E were archaeologically sterile whereas layers B, D, F, G and H yielded archaeological material. Within the upper unit, layers J and K were almost sterile, whilst the area just above layer I yielded the remains of several human skeletons (**fig. 1d, e**) and several hundred personal ornaments.

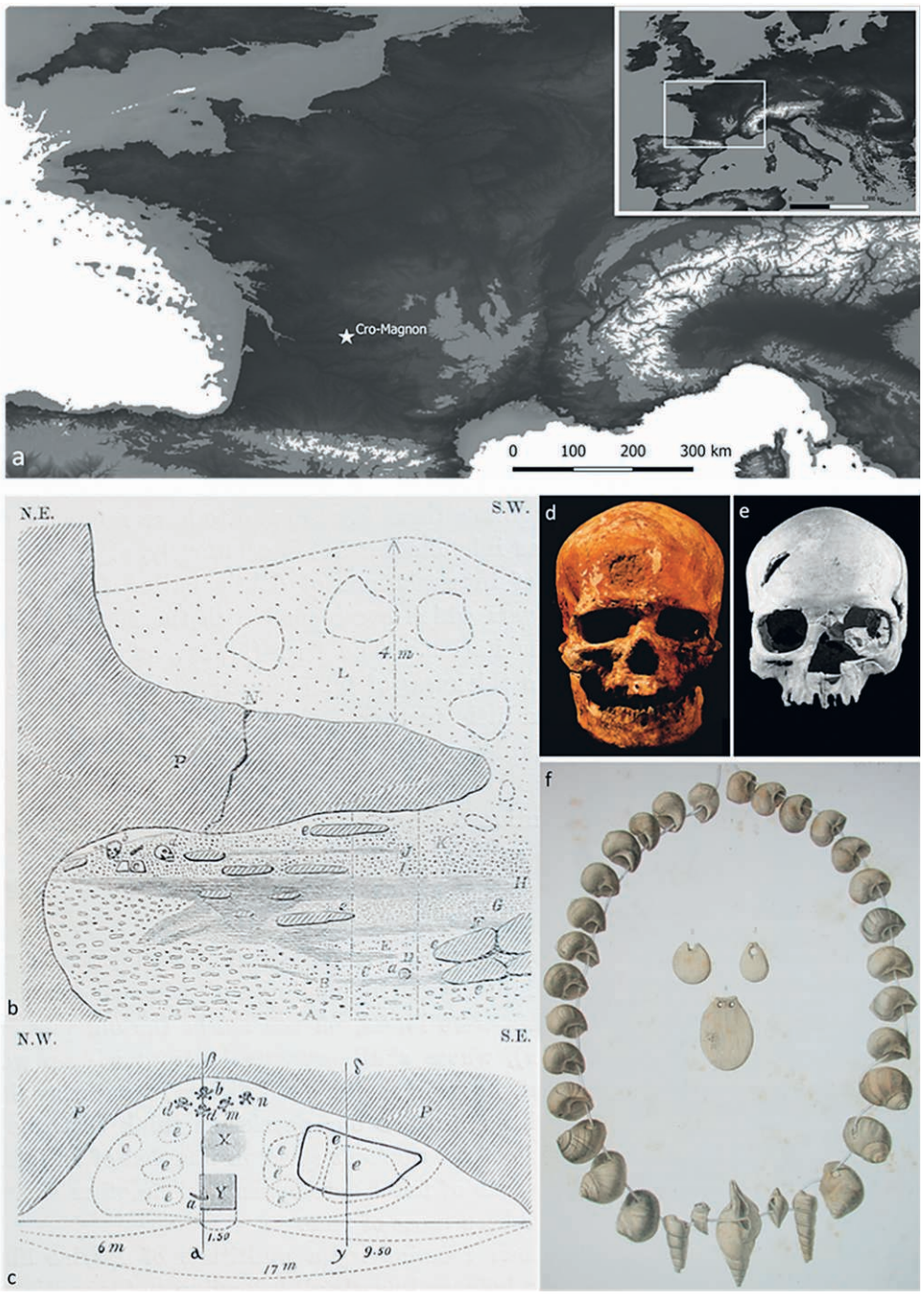


FIGURE 1

a) Map showing the location of Cro-Magnon rock-shelter. Created on QGIS using ETOPO1 Global Relief Model data with a modern and Gravettian coastline at -100 m (Lambeck and Chappell 2001). b) Stratigraphy of Cro-Magnon rock-shelter as established by Lartet in 1868. A)- Limestone Debris. B) Ash deposit. C) Limestone debris. D) Second Ash deposit. E) Limestone debris coloured red by fire. F) Third Ash deposit. G) Red earth with bones. H) Thick layer of Ash with bones (main hearth). I) Yellow earth with bones. J) Thin bed of washed Gravel. K) Limestone Scree. L) Removed Talus. N) Crack in ceiling of Rock-shelter. P) Cretaceous Limestone. a) Elephant Tusk. b) 'Le Vieillard' Skeleton. c) Gneiss block. d) Human remains. e) Collapsed Limestone blocks. c) plan of Cro-Magnon. P) Limestone.) central portion of layer H. Y) base of pillar built to support roof. a) tusk of elephant. b) skull of 'Le Vieillard'. d) human remains. e) Slabs fallen from roof. m) woman remains. n)– Human remains (Images from Lartet 1868). d) Skull of 'Le Vieillard' (image adapted from Henry-Gambier *et al.* 2013). e) Skull of Cro-Magnon 2 (image adapted from Wolpoff *et al.* 2006). f) Personal ornaments found in association with the human remains (image from Lartet *et al.* 1875).

a) Localisation de l'abri-sous-roche de Cro-Magnon. Carte créée avec QGIS en utilisant les données du modèle de relief global ETOPO1 avec une ligne de côte moderne et une ligne de côte correspondant au niveau marin durant le Gravettien 100 m plus bas que l'actuel (Lambeck et Chappell 2001) b) Stratigraphie de l'abri-sous-roche de Cro-Magnon telle qu'établie par Lartet en 1868. A) Débris calcaires. B) Dépôt de cendres. C) Débris calcaires. D) Deuxième dépôt de cendres. E) Débris calcaires rubéfiés. F) Troisième dépôt de cendres. G) Sédiment rouge avec ossements. H) Épaisse couche de cendres avec ossements (foyer principal). I) Sédiment jaune avec ossements. J) Mince couche de gravier. K) Éboulis calcaires. L) Talus. N) Fissure dans le plafond de l'abri sous roche. P) Calcaire du Crétacé. a) Défense d'éléphant. b) Squelette du Vieillard. c) Bloc de gneiss. d) Restes humains. e) Blocs de calcaire effondrés. c) Plan de l'abri Cro-Magnon. P) Calcaire. X) Partie centrale de la couche H. Y) Base d'un pilier construit pour soutenir le plafond. a) défense d'éléphant. b crâne du Vieillard. d) restes humains. e) dalles tombées du plafond. m) restes d'un individu de sexe féminin. n) restes humains (images de Lartet 1868). d) Crâne du Vieillard (image adaptée de Henry-Gambier et al 2013). e) Crâne de Cro-Magnon 2 (image adaptée de Wolpoff et al. *2006). f) Objets de parure trouvés en association avec les restes humains (image de Lartet* et al. *1875).*

Lartet interpreted the lower layers as reflecting a short-term occupation hunting site, the middle layers as witnessing a habitation, and layer I as containing a cemetery (Hurel 2018; Lartet 1868).

During the following half century, a total of nine archaeologists excavated the site and the cultural attribution of the human remains changed alongside the refinement of our knowledge of European Upper Palaeolithic chronology and cultural succession (**tabl. 1**). Lartet (1868) refers to the rock-shelter as a cemetery of 'Périgordian' troglodytes. Élie Massénat completed two excavations of the site in 1869 and 1873 (Massénat 1869, 1877) and concluded that there was no 'Périgordian', just a 'Solutrean' level below a level with Aurignac points, a diagnostic artefact of the Ancient Aurignacian (Kitagawa and Conard 2020; Liolios 2006). Subsequently, Émile Rivière undertook two excavations (Rivière 1894, 1897), the first of which was conducted where the skeletons had been discovered by Lartet. The lithic material found led him to think that there was a 'Magdalenian' layer below the skeletons and, as a consequence, that the human remains post-dated that culture. Henri Breuil, who later conducted two excavations in 1897-1898 and 1905-1906 (Henry-Gambier *et al*. 2013), disagreed with the previous attributions to the 'Magdalenian' and the 'Solutrean'. In 1905 he proposed the term 'Aurignacian' (Breuil 1907) for an industry stratigraphically positioned between the 'Mousterian' and the 'Solutrean', and suggested that this was the culture to which the Cro-Magnon human remains and associated archaeological material, including the ornaments, should be attributed.

Following excavations were undertaken by Denis Peyrony in 1905 (Peyrony 1908), Pestourie and Berthoumeyrou in 1906 (Peyrony 1908), Paul Girod in 1906 (Delluc and Delluc 2013), by L. Giraux in 1907 (Giraux 1907) and by the proprietor of the site, M. Pagès, probably before 1907 (Bourlon 1907). With the exception of the site owner, all of these excavators concluded that the remains were 'Aurignacian'. He instead proposed a 'Pre-Solutrean' attribution for the human remains.

The discovery in 1960 of an engraved bone featuring a bison in the Cro-Magnon material kept at the Musée du Laténium, Neuchâtel, Switzerland, (Bougard 2014; Pittard 1962) led some researchers to question the 'Aurignacian' attribution of the human remains and rather proposed a Gravettian affiliation (Bouchud 1966; Vallois 1968). This cultural reattribution was based on stylistic similarities to engravings found in Level 3 of Trilobite cave (Breuil 1907; Henry-Gambier *et al*. 2013) which itself yielded Gravette points. Another similarly styled engraved bone, featuring an anthropomorph, housed with the Cro-Magnon material in the Musée d'Art et d'Archéologie du Périgord (MAAP) (Rivière 1894), lent further support to a Gravettian attribution (cf. Movius 1969).

However, the persistent consensus until the 1970s, was that the human remains were Aurignacian (Sonneville-Bordes 1960; Movius 1969). Further evidence for an Early Gravettian attribution came from the identification of a Bayac flechette, a diagnostic lithic tool of the Early Gravettian (Douka *et al*. 2020; Pesesse 2008a, 2008b), within the Cro-Magnon material kept at the Muséum d'Histoire Naturelle in Toulouse (Bougard, Delluc 2014; Pesesse 2008a).

A major contribution to the debate on the age and cultural attribution of the human remains and associated archaeological material was provided by the ^{14}C AMS dating of a perforated *L. littorea,* identified by Lartet as a personal ornament found close to the human remains (Henry-Gambier 2002). The shell yielded an age of 27,680 ± 270 (Beta-157439), *i.e.*, a calibrated age of 31,324 – 32,666 cal. BP (Reimer *et al*. 2009) bringing the burial event within the bounds of the Early Gravettian. Henry-Gambier *et al*. (2013) also noted the stark similarities in style between the Cro-Magnon ivory pendants and those from Abri Pataud Level 5. This level has yielded five radiocarbon ages between 26,780 – 28,250 (30,895 – 33,264 cal. BP) (Douka *et al*. 2020; Higham *et al*. 2011; Reimer *et al*. 2009), similar to that of the *L. littorea* from Cro-Magnon. It is now widely agreed that the human remains and the personal ornaments belong to the Early Gravettian technocomplex (Chiotti *et al*. 2015; Vercoutère and Wolf 2018; Villotte *et al*. 2019).

2 | HISTORY OF THE COLLECTION

Since their discovery, the Cro-Magnon human remains were transferred and curated at the Musée de l'Homme (MdH), which belongs to the Muséum National d'Histoire Naturelle, Paris (Henry-Gambier 2002). A detailed account of the associated artefacts spatial provenance is unfortunately lacking. Concerning the personal ornaments,

Excavator	Excavation year	Cultural attribution of human remains	Reference/s
Louis Lartet	1868, 1869	Perigordian	Lartet 1868
Élie Massénat	1868, 1873	…	Massénat 1869, 1877
Émile Rivière	1893, 1897	…	Rivière 1894, 1887, 1905
Henri Breuil	1897, 1905, 1907	Aurignacian	Breuil 1907, 1909
Denis Peyrony	1905	Aurignacian	Peyrony 1908
Pestourie & G. Berthoumeyrou	1905	Aurignacian	Peyrony 1908
P. Girod	1905	Aurignacian	Delluc and Delluc 2013
L. Giraux	Before 1907	Aurignacian	Giraux 1907
M. Pagès	Before 1907	Pre-Solutrean	Bourlon

— TABLEAU 1 —

Summary of the excavations conducted at the Cro-Magnon rock-shelter and the proposed cultural attributions of the human remains and associated archaeological material.

Liste des fouilles menées à l'abri sous roche de Cro-Magnon et attributions culturelles proposées pour les restes humains et le matériel archéologique associé.

we do not know to which individual they were associated with, although in the original report Lartet explicitly states that they were found amongst and near the human remains (Lartet 1868 p. 346-347). This association is vouched for by the presence of ochre on both the ornaments and the human bones (Henry-Gambier 2002). Following a practice common at the time, and under the instruction of the then French Minister of Education Victor Duruy, the archaeological material from Cro-Magnon was quickly disseminated to various museums and private collections in France, Europe and the United States (pers. com. V. Mistrot 2021; Sarradet 1975 p. 24). Only sparse documentation providing an account of these events exists and available information can in some cases be misleading.

The information present in the literature on the personal ornaments number and types (**tabl. 2**) are contradictory (Henry-Gambier *et al*. 2013; Lartet 1868; Lartet *et al*. 1875; Movius 1969; Taborin 1993). This unreliability likely stemmed from different standards of reporting and identification since their discovery (**tabl. 2**).

3 | HUMAN REMAINS

Due to methodological improvements since their early analysis, the conjectured number of individuals found in the rock-shelter and their sex and age attribution has fluctuated substantially.

According to Lartet, when he first arrived at the site, the workers declared that they had found as many as fifteen skeletons (Vallois, Billy 1965). However, the three publications analysing the skeletal material in the year following the discovery significantly reduced this estimation (Broca 1868; Lartet 1868; Pruner-Bey 1868).

While Lartet identified four adult skeletons, one of which he attributed to a female, and one to an infant, Broca proposed that there were three and potentially four or five adults. In regards to the infant (CM5), Broca mentioned only the presence of infant skull fragments but makes no reference to post-cranial material. It was Broca who coined in his 1868 publication the term 'Le Vieillard' for the elderly male skeleton, and introduced the practice of referring to the remains of the other individuals as CM1 – CM5. The pioneer phase in the description of the remains ended with Pruner-Bey's study, who identified three male and one female adult skeletons. Unlike Lartet and Broca, Pruner-Bey attributed the non-adult bones to a foetus – and identified foetal long bones.

The minimum number of individuals (MNI) and recruitment changed little over the intervening century. In 1965, Vallois and Billy agreed with the previous estimation in their comprehensive osteological analysis. They concluded that the remains comprised three males (of which one was elderly), one female adult and a perinatal infant. The adult sex estimation relied heavily on the cranial remains but the assignment of the female (CM2) and one of the males (CM3) was not corroborated in a recent anthropological study (Guyomarc'h *et al*. 2017).

It was not until Henry-Gambier (1986) conducted an osteometric analysis of the infant remains that the long established MNI was contested. Her study revealed the presence of likely three and possibly four non-adults of which two (or three) were neonatal and one was approximately one year of age (**tabl. 3**). Although this study dramatically changed both the MNI and the recruitment, its conclusions were not mentioned in her more recent work in which she refers to the infant remains as a single individual (*e.g.*, Henry-Gambier *et al*. 2006, 2013).

In 2006, Henry-Gambier *et al*. reassessed the age and sex of the Cro-Magnon adult remains by applying a novel methodology (Bruzek 2002; Bruzek *et al*. 1999; Schmitt 2001, 2002). According to this study, two of the pelves are attributed to males, one to a female. The fourth individual remained unsexed. The three sexed individuals were assigned an age in excess of 50 years, with the female being at least over fifty and possibly sixty years of age.

More recent studies (Thibeault and Villotte 2018; Trinkaus *et al*. 2021; Villotte *et al*. 2020) used a combination of classical and modern morphometric methods on the adult human remains. The first of these (Thibeault and Villotte 2018), focusing on the lower limbs and the pelvic girdle, identified only three adults of which two would be male and one would be female. They concluded that the likelihood that a fourth adult is present is rather low. The second study (Villotte *et al*. 2020) focusing on the upper limbs and the pectoral girdle remains, identified four adults, of which one is likely a female due to its gracility. The other three individuals were not attributed a sex or an age. Trinkaus *et al*. (2021) identified, based on dental data, four adults. One of these was likely a young adult whereas the others were more elderly (**tabl. 3**).

A more recent morphometric assessment of the non-adult remains (Partiot *et al*. 2020) corroborated the first of Henry-Gambier's (1986) findings, *i.e.*, a plurality of infants and their respective ages, and identified a minimum of

Ornament Type	Lartet	Lartet & Christy	Movius	Taborin	Henry Gambier et al.
Tritia reticulata				1	Some
Littorina littorea	~300	~300	~300	300	Some
Nucella lapillus	Some	Some	Some	5	Some
Colus jeffreysianus			Some▪	1	Some
Trivia monacha				1	Some
Turritella sp.	Some		Some	Some	Some
Chlamys sp.					Some
Ostrea					Some
Shaped pendants	3	4	3		Some
Bovid incisor	Some*	Y	1≤		
Red deer canine	Some*				

TABLEAU 2

Ornament types found at Cro-Magnon mentioned in the literature (Henry-Gambier *et al.* 2013; Lartet 1868; Lartet *et al.* 1875; Movius 1969; Taborin 1993). * Refers to other teeth, * referred to as Fusus Islandicus.

Types d'ornements trouvés dans l'abri Cro-Magnon mentionnés dans la littérature (Henry-Gambier et al. *2013 ; Lartet 1868 ; Lartet* et al. *1875 ; Movius 1969 ; Taborin 1993). * Se réfère aux autres dents, * désignées sous le nom de Fusus Islandicus.*

Designation	Sex	Age (Years)	Pathology
CM1	M	40-50	Likely Neurofibromatosis Type 1
CM2	F	>50	
CM3	M	20-30	Likely Osteochondritis Dissecans
CM4	M	20-30	
CM5-1	.	End of first year	
CM5-2	.	Neonatal	
CM5-3	.	Neonatal	
CM5-4	.	Neonatal	

TABLEAU 3

Summary of data on sex and age attribution of the Cro-Magnon human remains. M) Male, F) Female (data from Charlier *et al.* 2018; Henry-Gambier *et al.* 2006; Partiot *et al.* 2020; Ruggieri *et al.* 2018; Trinkaus *et al.* 2021; Villotte *et al.* 2011).

Résumé des données sur l'attribution du sexe et de l'âge des restes humains de Cro-Magnon. M) Homme, F) Femme (données de Charlier et al. 2018 ; Henry-Gambier et al. 2006 ; Partiot et al. 2020 ; Ruggieri et al. 2018 ; Trinkaus et al. 2021 ; Villotte et al. 2011).

four infants (CM5-1 to CM5-4, **tabl. 3**). In summary, the current MNI for the Cro-Magnon rock-shelter stands at eight individuals, almost double the original published estimates.

4 | MATERIALS

We studied one hundred forty-two ornaments from Cro-Magnon (**tabl. 4**). The largest collection is kept at the MdH and includes twenty-seven *Littorina littorea* (Linnaeus 1758), four *Turritella* sp., two *Nucella lapillus*, one *Littorina obtusata*, one *Colus jeffreysianus* and two drop-shaped ivory pendants (**fig. 2, fig. 3a, b**). Three drop-shaped ivory pendants are illustrated in original publications (**fig. 1f**) but one has since been lost (Henry-Gambier *et al.* 2013). Eighteen *L. littorea* (**fig. 4**), an elongated shaped pendant (**fig. 3c**), a bovid incisor (**fig. 3d**) and a Red Deer canine (**fig. 3e**) were studied at the Musée d'Archéologie Nationale (MAN). Twenty-one *L. littorea* and a *N. lapillus* from the Musée d'Aquitaine (MAQ) (**fig. 5**), thirty *L. littorea* from the MAAP (**fig. 6**) and twenty-eight *L. littorea* (twenty-seven of which are perforated), three *N. lapillus* (two of which are perforated) and an unperforated *Luria lurida* from the Musée National de Préhistoire (MNP) (**fig. 7**) were also analysed. A single lion canine from the British Museum (pers. com. J. Cook) was also analysed (**fig. 8a, b**).

Ornament Type	Number
Littorina littorea	124
Littorina obtusata	1
Nucella lapillus	6
Colus jeffreysianus	1
Turritella sp.	4
Luria lurida	1
Red deer canine	1
Bovid incisor	1
Bi-perforate ivory pendant	1
Mono-perforated ivory pendant	1
Elongated shaped pendant	1
Total	**142**

TABLEAU 4

Ornaments from Cro-Magnon included in this study.

Objets de parure provenant de l'abri Cro-Magnon inclus dans cette étude.

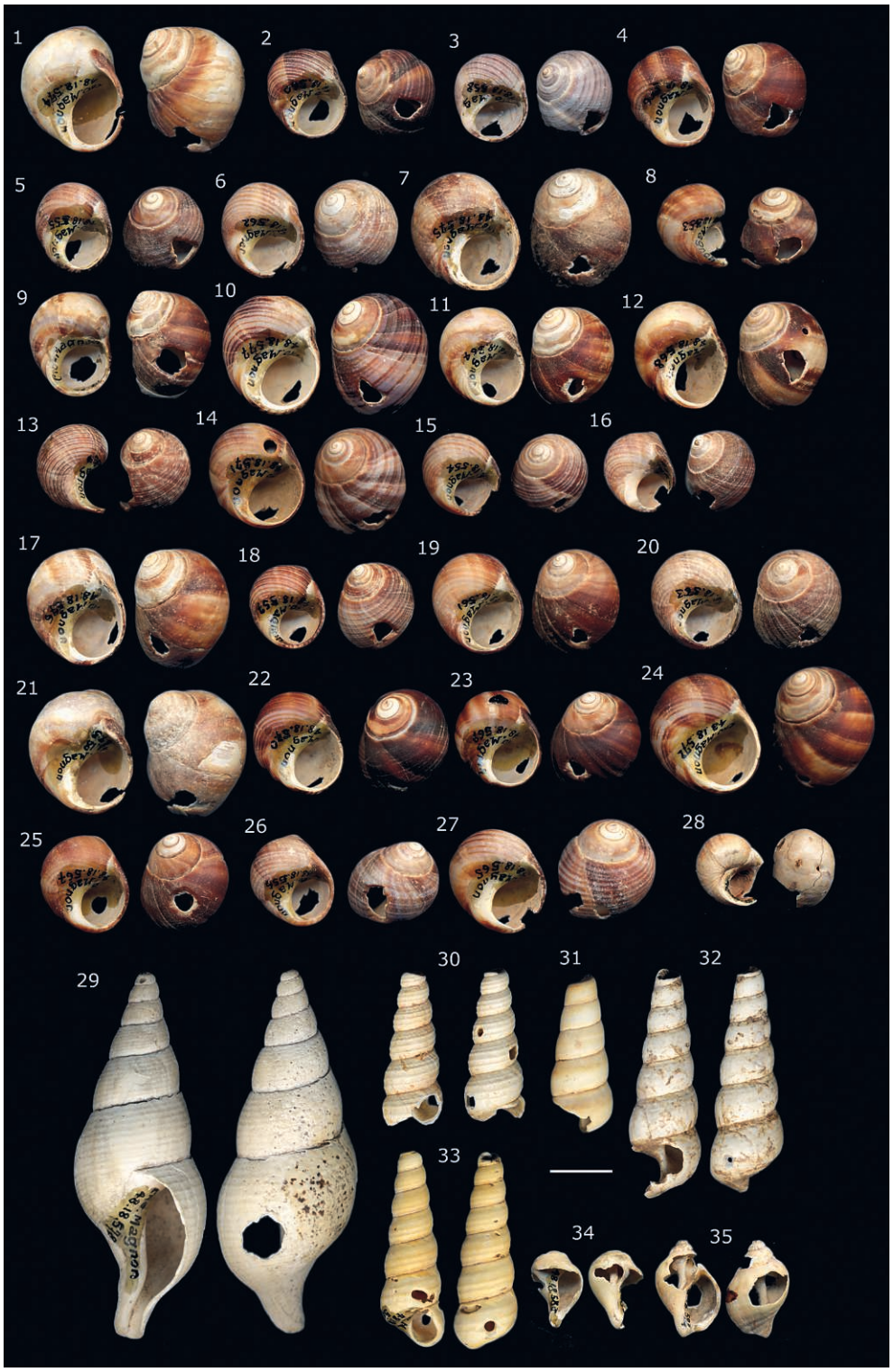


FIGURE 2

Cro-Magnon shell ornaments curated at the Musée de l'Homme. 1-27 *Littorina littorea*, 28 *Littorina obtusata*, 29 Colus jeffreysianus, 30-33 Turritella sp., 34-35 Nucella lapillus. (Scale bar = 10 mm).

Parures en coquillages de Cro-Magnon conservées au Musée de l'Homme. 1-27 Littorina littorea, *28* Littorina obtusata, *29* Colus jeffreysianus, *30-33* Turritella *sp., 34-35* Nucella lapillus *(échelle = 10 mm).*

FIGURE 3

Osseous ornaments from Cro-Magnon: a) bi-perforated ivory pendant, b) mono-perforated ivory pendant, c) elongated shaped pendant, d) perforated Bovid incisor, e) perforated Red deer canine. (Scale bar = 10 mm).

Objets de parure en os de l'abri Cro-Magnon : a) pendentif en ivoire bi-perforé, b) pendentif en ivoire mono-perforé, c) pendentif de forme allongée, d) incisive de bovidé perforée, e) canine de cerf perforée. (Échelle = 10 mm).

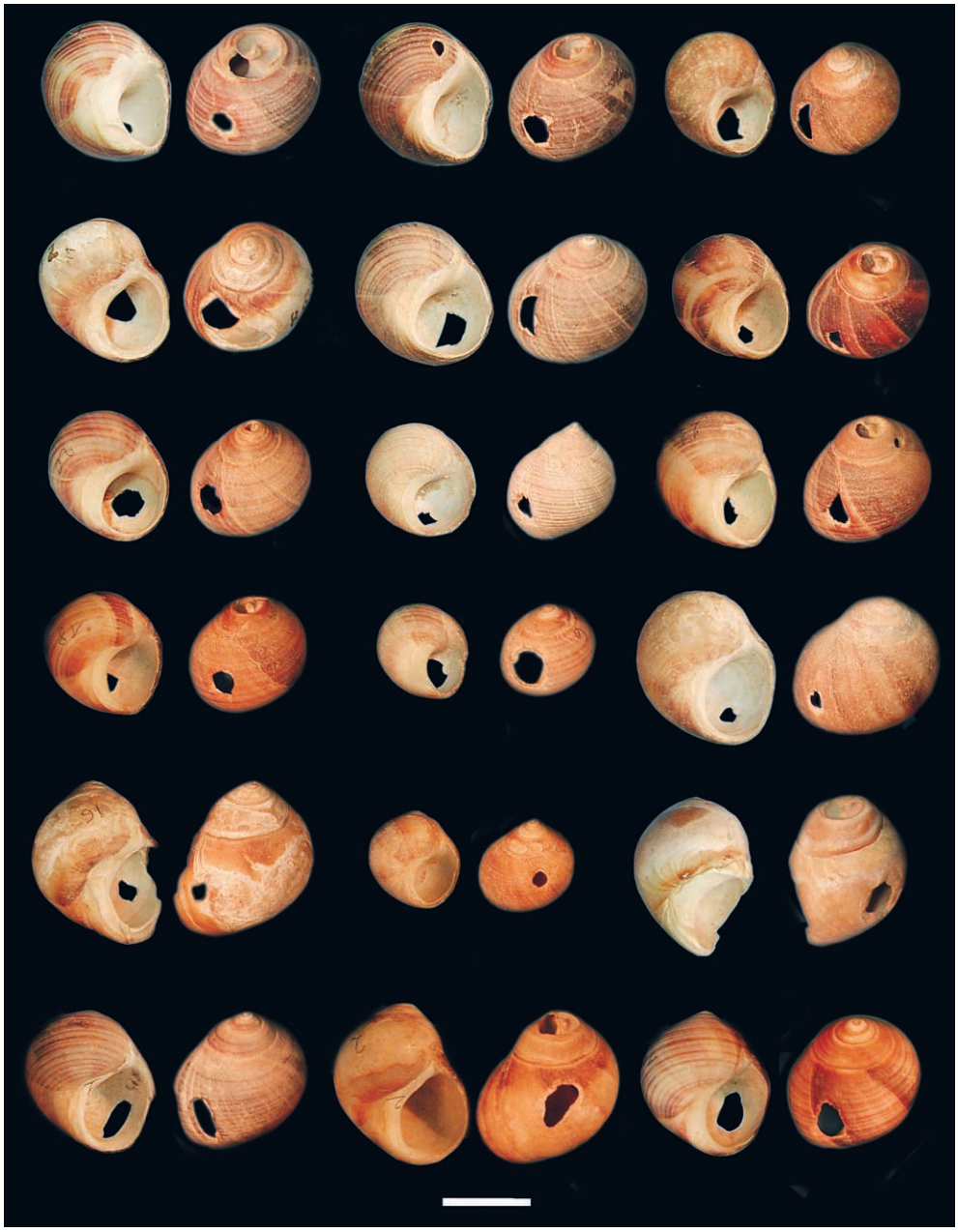


FIGURE 4

Cro-Magnon perforated *L. littorea* curated at the Musée d'Archéologie Nationale. (Scale bar = 10 mm).

Objets de parure réalisés sur des L. littorea *provenant de Cro-Magnon et conservés au Musée d'Archéologie Nationale. (Échelle = 10 mm).*

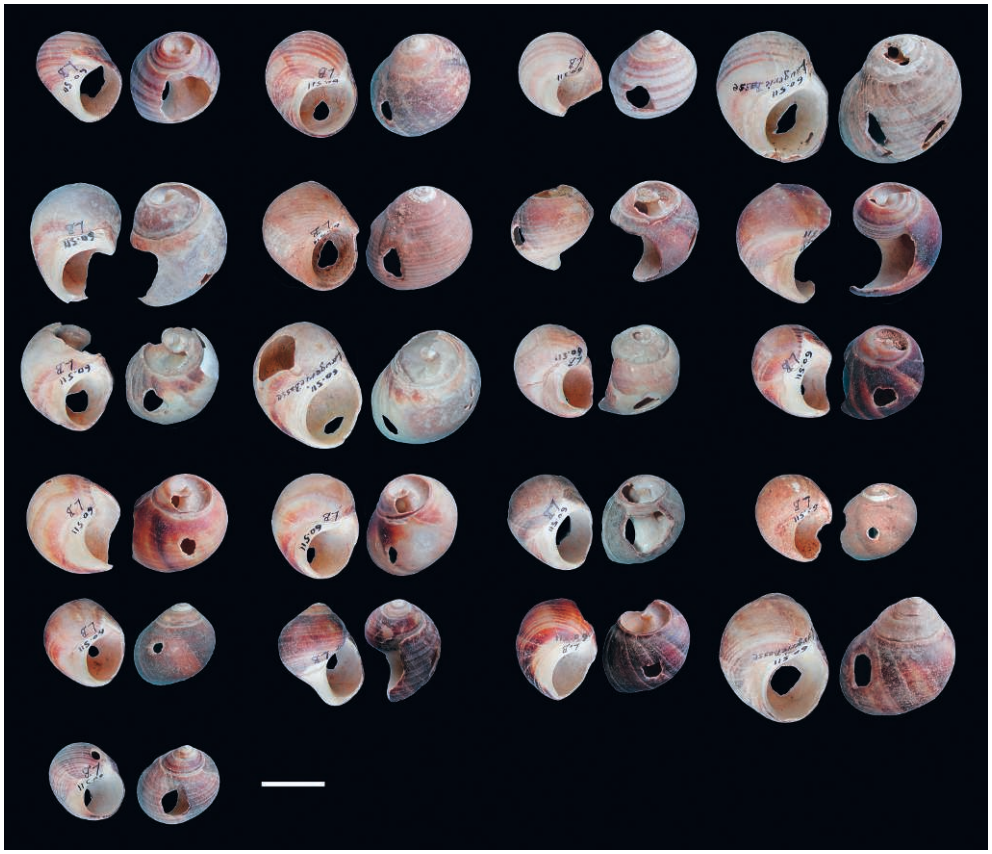


FIGURE 5

Cro-Magnon perforated *L. littorea* curated at the Musée d'Aquitaine, erroneously labelled as from Laugerie-Basse (pers. com. V. Mistrot 2021) (Scale bar = 10 mm).

Parures de Cro-Magnon L. littorea *conservées au Musée d'Aquitaine. Erreur d'étiquetage attribuant faussement les objets à Laugerie-Basse (com. pers. V. Mistrot 2021) (échelle = 10 mm).*

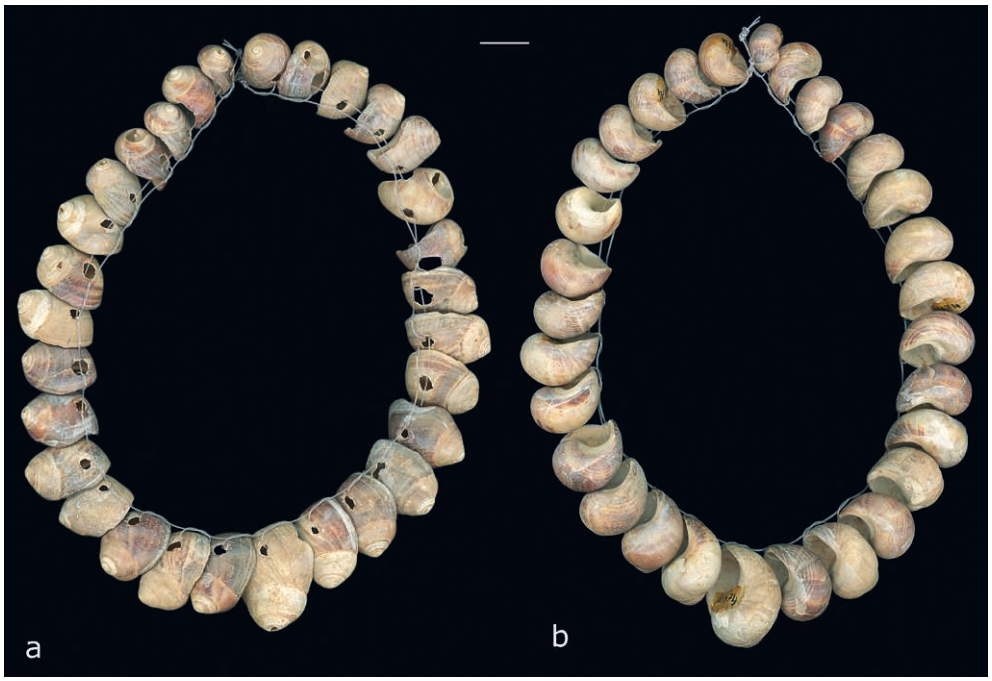


FIGURE 6

Cro-Magnon perforated *L. littorea* curated at the Musée d'Art et d'Archéologie du Périgord: a) dorsal aspect, b) ventral aspect. (Scale bar = 10 mm).

Ornements de Cro-Magnon L. littorea conservés au Musée d'Art et d'Archéologie du Périgord : a) face dorsale, b) face ventrale. (Échelle = 10 mm).

FIGURE 7

Cro-Magnon perforated shells curated at the Museum d'Histoire Naturelle de Toulouse, housed at the Musée National de Préhistoire. 1-28 *Littorina littorea*, 29-31 *Nucella lapillus* (two of which are perforated) and 32 *Luria lurida* (unperforated) (Scale bar = 10 mm).

Parures en coquillages de Cro-Magnon conservées au Muséum d'Histoire Naturelle de Toulouse, hébergées par le Musée National de Préhistoire. 1-28 Littorina littorea, *29-31* Nucella lapillus *(deux sont perforées) et 32* Luria lurida *(non perforées) (échelle = 10 mm).*

FIGURE 8

Cro-Magnon lion canine curated at the British museum: a) buccal aspect, b) lingual aspect (Scale bar = 10 mm).

Canine de lion de Cro-Magnon conservée au British Museum : a) vue labiale, b) vue linguale (échelle = 10 mm).

5 | METHODS

All of the personal ornaments, except those from the MAAP, were observed and photographed with a Wild M3C microscope equipped with a Nikon Coolpix 995. Those from the MAAP were observed and photographed with a Motic SMZ-168 microscope equipped with a digital camera Cannon 700 D. Scans of the ornaments were created with an Epson Perfection v600 photo scanner at 600 dpi resolution. Measurements were taken with a digital calliper (Mitutoyo 500-463).

5.1 | Marine shells

5.1.1 | Taxonomic identification

Taxonomic identification of the shells involved two steps: the characterization of general shape for class determination (*e.g.,* Scaphopoda, Gasteropoda, Bivalvia), followed by examination of the shape and ornamentation of scaphopods and bivalves (Poppe and Goto 1991), along with examination of the number of whorls, the form of the aperture, lip, ventral and dorsal sides, and ornamentation of gastropods to determine genus or species (Harasewych and Moretzsohn 2014; Poppe, Goto 1991). The nomenclature was taken from the World Register of Marine Species (WoRMS) (https://www.marinespecies.org, search performed on 12/06/2021).

5.1.2 | Morphometric analysis

Differences in size between natural populations and archaeological assemblages can identify which shell sizes were preferred by prehistoric people. Morphometric variables (shell length and width, width of the spire and aperture) were recorded on well preserved archaeological specimens and reference collections. Two modern reference samples of *L. littorea* were hand-collected on the 7th of May 2021 at Moëze (n=40) and Fouras (n=248), Charente Maritime, France by one of us (SR). All shells visible to the naked eye (n=288) were collected and measured with a digital calliper.

5.1.3 | Microscopic analysis

Shell surfaces show microscopic modifications testifying to events occurring either during the life of the mollusc or after death. In the case of shells collected and modified by prehistoric groups, microscopic analyses provide information concerning subsequent anthropogenic and taphonomic modifications (d'Errico *et al*. 2005; Kelley 2008; Manca 2018; Taborin 1993; Vanhaeren *et al*. 2013; Zuschin and Stanton Jr 2001). Anthropogenic modifications such as perforations, ochre staining and use-wear were systematically recorded as well as the minimum and maximum perforation diameter and the bridge width (*i.e.*, the distance between the labre and perforation). The production method of the perforations was assessed following criteria established in the literature (Avezuela *et al*. 2011; d'Errico *et al*. 2005; Peschaux *et al*. 2022). The presence of use-wear at specific locations (i.e., perforation, apex, aperture) was recorded as is common in shell bead studies (*e.g.*, Manca 2016; Rigaud *et al*. 2022).

5.1.4 | Statistical analysis

The statistical analyses of the shell features were performed in R v4.2.0 (R Core Team 2019).

5.2 | Osseous ornaments

5.2.1 | Taxonomic Identification

The osseous personal ornaments were visually inspected, compared to paleontological reference collections (collection PACEA) and subsequently assigned to a species and an anatomical element when possible.

5.2.2 | Red Deer canine

The sex identification of the Red Deer canine was performed using the method proposed by d'Errico and Vanhaeren (2002). The determination of the Red Deer age was based on the collection of four qualitative morphological variables (d'Errico, Vanhaeren 2002): stage of root development (3 stages), stage of occlusal wear (5 stages), degree of pulp cavity fermature and the removal by wear of the disto-lingual-cervical-lobe (DLCL), a prominence found on the posterior edge of the lingual aspect of the crown (Greer, Yeager 1967).

5.2.3 | Shaped pendants

The shaped pendants were analysed with an optical microscope. Anthropogenic and taphonomic modifications were recorded and photographed. High resolution digital photographs of the two ivory pendants were imported into Adobe Illustrator to produce a detailed tracing of these objects.

5.3 | Geographic diversity

In order to compare the personal ornaments found at Cro-Magnon with those discovered at other Gravettian sites, we have considered for the shells the synthesis published by Taborin (1993) in addition to other available sources (**tabl. 5**). The maps were created on QGIS using ETOPO1 Global Relief Model data with a modern and Gravettian coastline at -100 m (Lambeck, Chappell 2001). One needs to be aware, however, that the accuracy of the attribution to the Gravettian or to a specific phase of this technocomplex is variable and dependent on the accuracy with which sites were excavated and ornaments recovered.

Site	Reference/s
Gargas	San Juan-Foucher and Foucher 2008; San Juan-Foucher et al. 2012; Taborin 1993
Laussel	Lalanne and Bouyssonie 1946; Taborin 1993
Isturitz	Taborin 1993
La Gravette	Taborin 1993
Abri Pataud	Taborin 1993; Vercoutère 2004
Paviland	Aldhouse-Green and Pettitt 1998; Henry-Gambier 2002; Taborin 1993
Pair-non-Pair	Taborin 1993
Le Flageolot	Taborin 1993
El Cuco	Gutiérrez-Zugasti et al. 2013
Garma A	Alvarez-Fernandez 2007
Le Sire	d'Errico and Rigaud 2011
Lagar Velho	Zilhao and Trinkaus 2002
Lapa do Picareiro	Haws et al. 2020
Les Cendres	Villaverde and Roman 2004; Villaverde et al. 2019
Abreda	Soler et al. 2013
Mollet	Soler et al. 2013
Figuier	Moncel et al. 2012
Riparo Mochi	Stiner 1999
Barma Grande	Pettitt 2013
Arene Candide	Pettitt 2013
Paglicci	Fabbri and Giacobini 2021; Pettitt 2013
Ostuni	Coppola and Vacca 1995; Giacobini 2006; Pettitt 2013
Duruiroarea Veche	Cârciumaru et al. 2019
Cosauti	Cârciumaru et al. 2019
Poiana Ciresului-Piatra Neamt	Cârciumaru et al. 2019
Kostenki	Sinitsyn 2010; Pettitt 2013
Brillenhohle	Conard and Moreau 2004
Geissenklosterle	Conard and Moreau 2004
Hohle Fels	Conard and Moreau 2004
Mainz-Linzenberg	Alverez-Fernandez 2003
Weinberghohlen	Klima 1968
Obere Klause	Lázničková-Galetová 2015, 2019
Dolni Vestonice	Pettitt 2013
Kranawetberg	Antl and Bosch 2015
Brinzeni	Cârciumaru et al. 2019
Molodova	Cârciumaru et al. 2019
Pushkari	Wygal et al. 2022
Buran Kaya	Prat et al. 2011

TABLEAU 5

Sites yielding similar ornaments to Cro-Magnon (Lalanne and Bouyssonie 1946; San Juan-Foucher and Foucher 2008; Taborin 1993); Vercoutère 2004).

Sites présentant un ou plusieurs types d'objets de parure similaires à ceux de Cro-Magnon (Lalanne and Bouyssonie 1946 ; San Juan-Foucher and Foucher 2008 ; Taborin 1993) ; Vercoutère 2004).

6 | RESULTS

6.1 | Conservation institutions housing Cro-Magnon ornaments

Literature mining and the consultation of historical documents provided a potential list of museums, conservation institutions and private collections which could have potentially housed Cro-Magnon ornaments. Concerning the osseous ornaments, we located a total of five: two ivory pendants in the MdH, a bovid incisor, a Red Deer canine and an elongated shaped pendant at the MAN. The twelfth plate in Lartet *et al.* (1875) (**fig. 9a** and **9b**) shows a close up of the elongated shaped pendant.

Of the *circa* three hundred shell ornaments mentioned in Lartet (1868), we were able to localise two hundred one (one hundred eighty-six *L. littorea*, one *L. obtusata*, four *Turritella* sp., seven *Nucella lapillus*, one *Luria lurida*, one nacre fragment and one *Colus jeffreysianus*) (**tabl. 6**).

We analysed one hundred twenty-five *L. littorea* housed in different institutions (**tabl. 6**). Ten additional *L. littorea*, on display at the MAN, could not be analysed. This was also the case for the *L. littorea* from the MAN used by Henry-Gambier (2002) for a radiocarbon date which was destroyed (**tabl. 6**).

The *L. littorea* from the MAQ are labelled (**fig. 5**) as originating from Laugerie-Basse but are currently displayed at the museum as coming from Cro-Magnon. It is likely that this labelling is erroneous, and this is for four reasons. Firstly, the original museum ledger at the time of donation reads, « 23 littorines percées pour collier » (23 Littorines perforated for a necklace) from Les Eyzies. In this catalogue Laugerie-Basse is listed under a separate subsection and the listed items do not include Littorines. Secondly, the Paul de Vibraye collection housed at the Muséum national d'Histoire naturelle (MNHN), which comprises material from Laugerie-Basse does not contain Littorines either, only *Cardium*, *Dentalium* and *Glycymeris* species (pers. com. P. Paillet 2021). Thirdly, all of the *L. littorea* clearly coming from Cro-Magnon present the peculiarity of being extremely well preserved and keep the natural shell colour in contrast to those found at other Upper Palaeolithic sites which are all whitish pale in colour. This is a peculiarity shared by the L littorea kept at the MAQ and wrongly labelled as coming from Laugerie-Basse. Fourthly, the labelling itself, likely dating from the 1960s or 1970s, was done during a time when collections within the MAQ were moved around multiple times and the museum did not have a curator (pers. com. V. Mistrot 2021), which may have contributed to an erroneous labelling. Considering the above reasons, we have included these shells in our analysis.

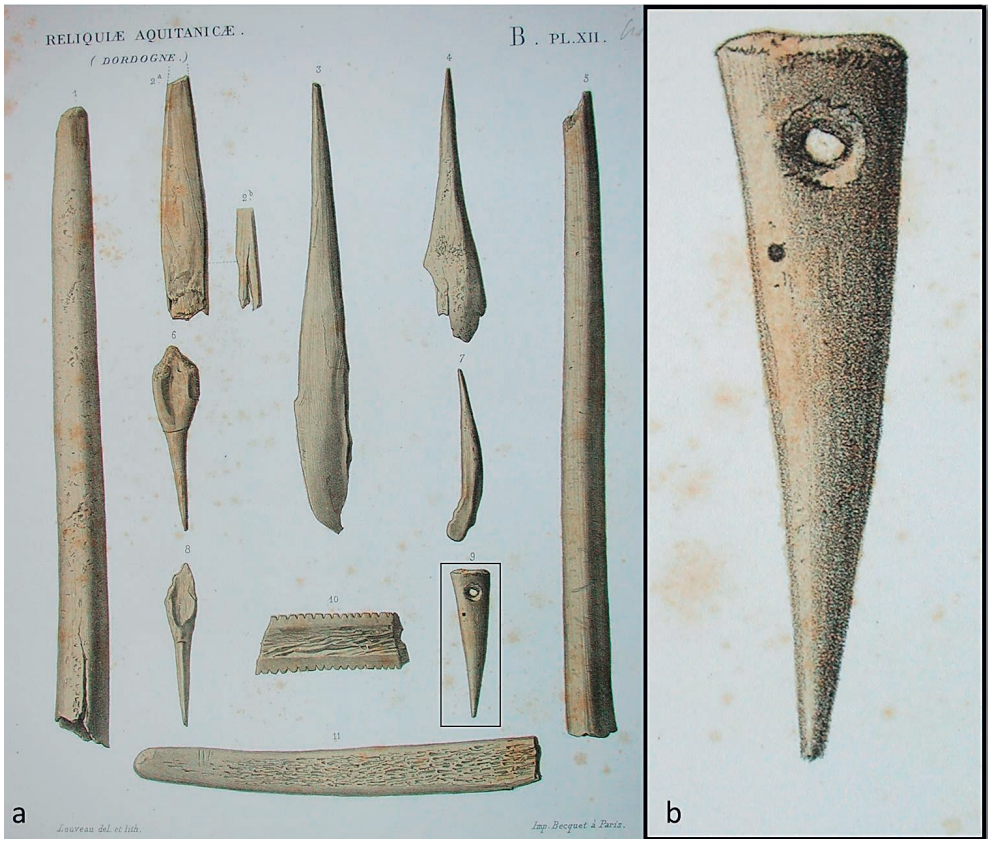


FIGURE 9

a) Osseous artefacts and perforated shaped point (illustrated by Lartet *et al.* 1875), b) close up of the elongated shaped pendant.

a) Objets en os et pointe perforée (illustrée par Lartet et al. *1875), b) gros plan du pendentif de forme allongée.*

Museum	Collection	Type	Number	Catalogue No.	Reference
Muséum national d'Histoire naturelle (MdH)	Lartet	*L. littorea*	27	101-128	Henry-Gambier 2002
(Département d'Anthropologie Humaine)		*L. obtusata* †	1		
		Colus jeffreysianus	1	129	
		Turritella sp.	4	130-131	
		Ivory pendant	2	132-133	
		Nucella lapillus	2	134-135	
Muséum national d'Histoire naturelle		*L. littorea*	39		
(Département de Paléontologie)		*Nucella lapillus*	1		
Musée Archeologie Nationale (MAN)	Lartet	*L. littorea*	28		
		Nacre/Ostrea	1		pers. com. E. Bougard
		Red deer canine	1		
		Bovid incisor	1		
		Elongated shaped pendant	1		
Musée National de Préhistoire (MNP)*	Lartet	*L. littorea*	29		
		Nucella lapillus	3		
		Luria lurida †	1		
Institut de Paléontologie Humaine (IPH)	Bourlon	*L. littorea*	2		
Musée d'Art et d'Archéologie du Perigord (MAAP)		*L. littorea*	30		pers. com. V. Merlin-Anglade
Musée d'Aquitaine**		*L. littorea*	21		
		Nucella lapillus	1		
Smithsonian Institute		*L. littorea*	10		
British Museum***	Christy	Lion canine†	1		pers. com. J. Cook

— TABLEAU 6 —

Modern locations of Cro-Magnon personal ornaments (* on loan from Muséum d'histoire naturelle de Toulouse, ** erroneously labelled as coming from Laugerie-Basse, *** the lion canine shows cut marks, Æ added to modern literature).

Lieux de conservation des objets de parure de l'abri Cro-Magnon (* en prêt du *Muséum d'histoire naturelle de Toulouse, ** étiqueté par erreur comme provenant de Laugerie-Basse, *** le canine de lion montrant marques de coupe, Æ ajouté à la littérature moderne).*

Taborin (1993) mentions the presence of a *Hinia reticulata* (now called *T. reticulata*) amongst the Cro-Magnon ornaments but we were unable to locate this specimen.

The labelling of a *L. lurida* shell kept at the MNP (**fig. 7**) as coming from Cro-Magnon is surprising since this specimen is not mentioned in the original literature. This could result from a mislabelling of a shell possibly coming from Laugerie Basse, a site that yielded several *L. lurida* specimens (Massénat *et al.* 1872; Rivière 1904; Taborin 1993). We have included this specimen in the analysis and will discuss later on the uncertainty linked to its association with the Cro-Magnon material.

6.2 | Marine shells

6.2.1 | Taxonomic identification

In this study, one hundred thirty-eight shells interpreted as personal ornaments were identified. These belong to six species: one hundred twenty-five *L. littorea*, six *N. lapillus*, four *Turritella* sp., one *L. obtusata*, one *C. jeffreysianus* and one *L. lurida*.

6.2.2 | Preservation and taphonomy

The shell ornaments show different degrees of surface preservation. Most of them are well preserved, few have partially lost their original colour (n=12), and some display a flaking off of the surface (n=18) (**fig. 2, fig. 4, fig. 5, fig. 6, fig. 7**). Differences in colour may reflect the origin of the shell, the whiter probably being those coming from fossil outcrops (**fig. 5**).

There are multiple indications that many shells were collected after the mollusc's death. As many as twenty-seven *L. littorea* and the *Colus jeffreysianus* shell **(fig. 10a, b, c, d)** show signs that they were attacked by bioeroders (Stefaniak *et al*. 2005; Walker 1998), nine *L. littorea* feature diagnostic holes caused by a predatory mollusc's radula (Dietl, Kelley 2006; Gorzelak *et al*. 2013; Rojas *et al*. 2015) (**fig. 10e, f**), one *L. littorea* displays an aborted predation attempt (**fig. 6**). Finally, five *L. littorea* show a characteristic lunar-shaped hole on their apex caused by mechanical abrasion caused by wave action (**fig. 10g, h**).

6.2.3 | Technological analysis

At least three distinct techniques were used to perforate the *L. littorea*. The most common perforation technique (88.68%) consisted in exerting a pressure through the aperture with a pointed tool. This produced microflake scars on the outer surface of the perforation (**fig. 11f, g**). Five shells feature evidence of sawing (**fig. 11a, b**), or scraping (**fig. 11c, d, e**), the outer surface of the body of the last spire whorl followed by puncturing to enlarge the hole (4.71 %) (Peschaux 2013; Rigaud *et al*. 2022). Three shells were perforated by exerting a pressure on the outer surface of the body of the last spire whorl, which produced microflake scars on the internal surface of the shell around the perforation (**fig. 11h, i**). The perforations created with this technique are unusually large compared to those made using the other two techniques (**fig. 12a**). Three *L. littorea* are too fragmentary and another too heavily covered with glue to identify the perforation technique applied.

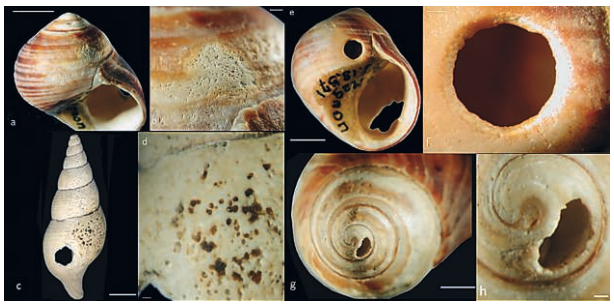


FIGURE 10

Taphonomic modification of the shell ornaments: a & b) *L. littorea* showing characteristic bioerosion by endobiotic sponges (Scale bar a = 10 mm, b = 5 mm), c & d) Colus jeffreysianus showing characteristic bioerosion by endobiotic sponges (Scale bar c = 10 mm, d = 1 mm), e & f) *L. littorea* with a hole caused by the radula of a predatory gastropod (Scale bar e = 5 mm, f = 0.5 mm), g & h) *L. littorea* showing mechanical abrasion caused by wave action (Scale bar g = 1 mm, h = 0.1 mm).

Modifications d'origine naturelle documentées sur les objets de parure en coquillages : a & b - L. littorea montrant une bioérosion caractéristique de l'action d'un spongiaire (échelle a = 10 mm, b = 5 mm), c & d - Colus jeffreysianus montrant une bioérosion caractéristique de l'action d'un spongiaire (échelle c = 10 mm, d = 1 mm), e & f - L. littorea avec une perforation causée par la radula d'un gastéropode prédateur (échelle e = 5 mm, f - 0.5 mm), g & h - L. littorea montrant une abrasion mécanique résultant de l'action des vagues sur le sable ('échelle g = 1 mm, h - 0.1 mm)

FIGURE 11

Perforation methods of shell ornaments: a, b) *L. littorea* with perforation created by sawing and puncturing (Scale bar a = 5 mm, b = 1 mm) c, d & e) *L. littorea* with perforation created by scraping and puncturing (Scale bar a = 5 mm, d & e = 1 mm) f & g) *L. littorea* with a perforation created by pressure through the aperture (Scale bar f = 5mm, g = 1mm) h & i) *L. littorea* with perforation probably created by external pressure and rotation (Scale bar h = 5 mm, i = 1 mm).

Méthodes de perforation des ornements de coquillages : a, b) L. littorea *avec une perforation créée par sciage et pression (échelle a = 5 mm, b = 1 mm) c, d & e)* L. littorea *avec une perforation créée par raclage (échelle a = 5 mm, d & e = 1 mm) f & g)* L. littorea *avec une perforation créée par pression à travers l'ouverture (échelle f = 5 mm, g = 1 mm) h & i)* L. littorea *avec une perforation probablement créée par pression externe et rotation (échelle h = 5 mm, i = 1 mm).*

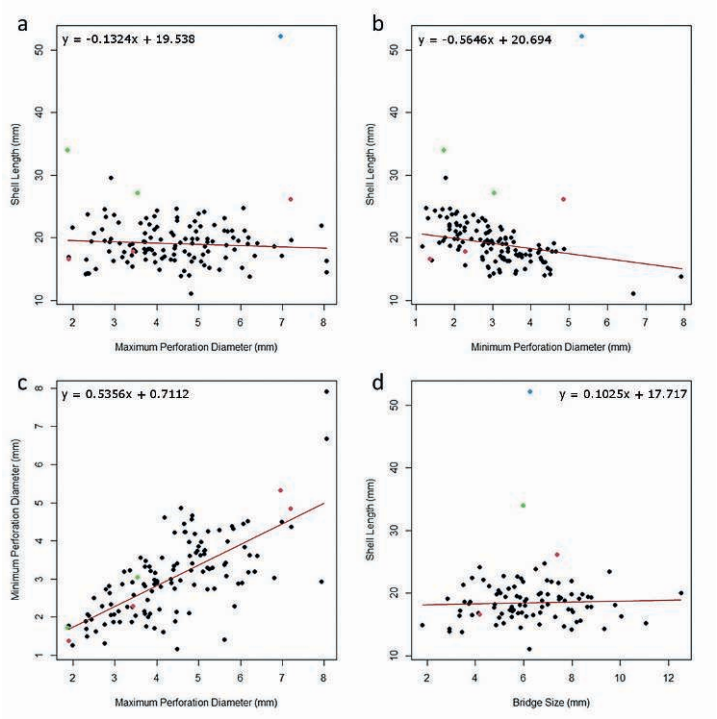


FIGURE 12

Morphometric analysis of archaeological shells: a) biplot of shell length and perforation maximum diameter, b) biplot of shell length and perforation minimum diameter, c) biplot of minimum and maximum perforation diameters, d) biplot of the distance between the perforation and aperture edges (bridge) compared to the lengths of the shells. (Black = *L. littorea*, Red = *Nucella lapillus*, Green = *Turritella*, Blue = *Colus jeffreysianus*).

Analyse morphométrique des coquilles archéologiques : a) biplot de la longueur de la coquille et du diamètre maximal de la perforation, b) biplot de la longueur de la coquille et du diamètre minimal de la perforation, c) biplot des diamètres minimal et maximal de la perforation, d) biplot de la distance entre les bords de la perforation et de l'aperture (pont) par rapport aux longueurs des coquilles. (Noir = L. littorea, *Rouge* = Nucella lapillus, *Vert* = Turritella, *Bleu* = Colus jeffreysianus*).*

The perforations of the *L. littorea* are highly varied in their dimensions, their distance from the labre (bridge width) and the production technique used. The maximum perforation diameter ranges from 8.05mm to 1.89mm. There appears to be no correlation between the shell length and the maximum perforation diameter (**fig. 12a**) but a negative correlation between shell length and minimum perforation diameter (**fig. 12b**). A clear positive correlation is observed between the maximum and minimum diameters of the perforations (**fig. 12c**). There is no correlation between the size of the shell and the bridge width (*i.e.*, the distance between the labre and perforation) (**fig. 12d**).

The *N. lapillus* feature perforations created by exerting either a pressure on the internal or the external shell surface, as evidenced by the presence of microflaking around the perforation, on its external and internal surface, respectively (**fig. 13a, b**). The *Turritella sp.* shells were perforated by first sawing and scraping the outer surface of the shell and then enlarging the hole by rotation with a lithic point (**fig. 13c**). The *C. jeffreysianus* (**fig. 13d**) was probably perforated by internal pressure although this is difficult to state with certainty due to surface alterations.

6.2.4 | Use-wear

A bright sheen around the perforation or aperture lip, interpreted as resulting from use-wear, was recorded on all of the shells (**fig. 14a et b**). Two thirds of the shells (64.8 %) only display a low degree of development of the sheen (**fig. 15a**), less than one third an intermediate degree (25.9 %) (**fig. 15b**) and a small proportion (9.3 %) a high degree.

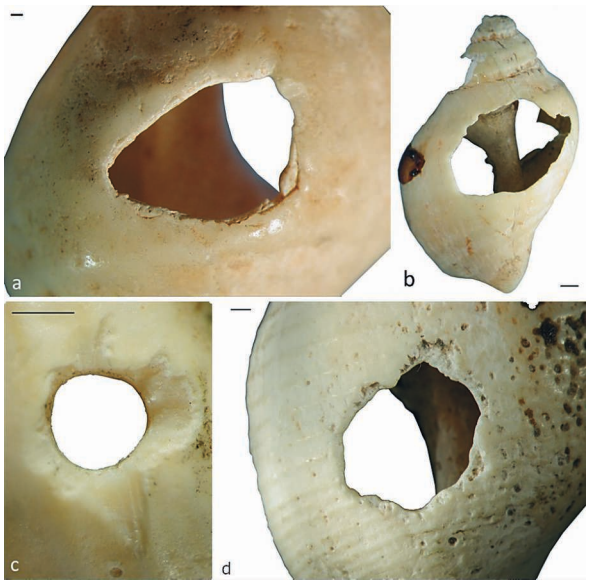


FIGURE 13

Perforation methods of shell ornaments: a) *N. lapillus* with perforation created by pressure through the aperture, b) *N. lapillus* with perforation created by external pressure, c) *Turritella* sp. shell with perforation created by sawing, scraping and rotation, d) *C. jeffreysianus* with perforation created by internal pressure (Scale bar = 1 mm).

Méthodes de perforation des ornements de coquilles : a) N. lapillus *avec perforation créée par pression à travers l'aperture, b)* N. lapillus *avec perforation créée par pression externe, c)* Coquille Turritella *sp. Avec perforation créée par sciage, raclage et rotation, d)* C. jeffreysianus *avec perforation créée par pression interne (Échelle = 1 mm).*

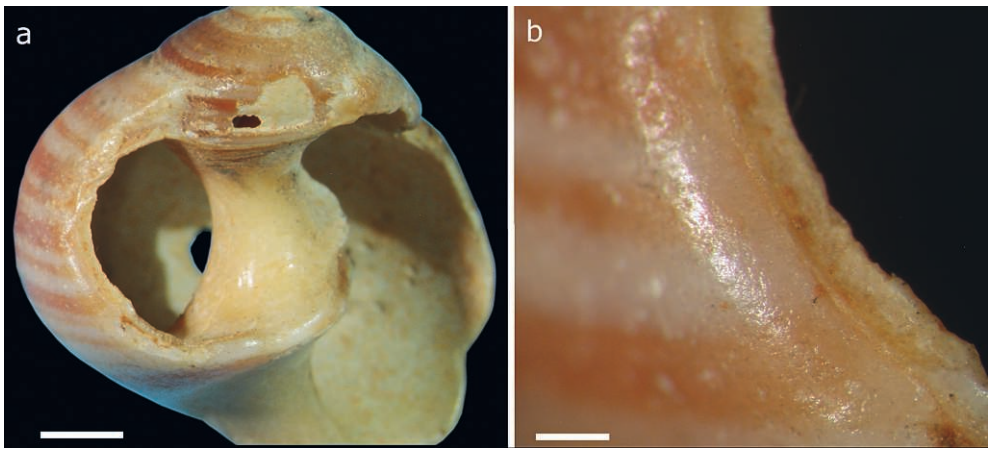


FIGURE 14

Example of use-wear on a *L. littorea* ornament from Cro-Magnon: a) wide view of shell (Scale bar = 10 mm), b) close up of the use-wear (Scale bar = 1 mm).

Exemple d'usure sur un ornement de L. littorea *de Cro-Magnon : a) macrophoto de la coquille (échelle = 10 mm), b) traces d'usure (échelle = 1 mm).*

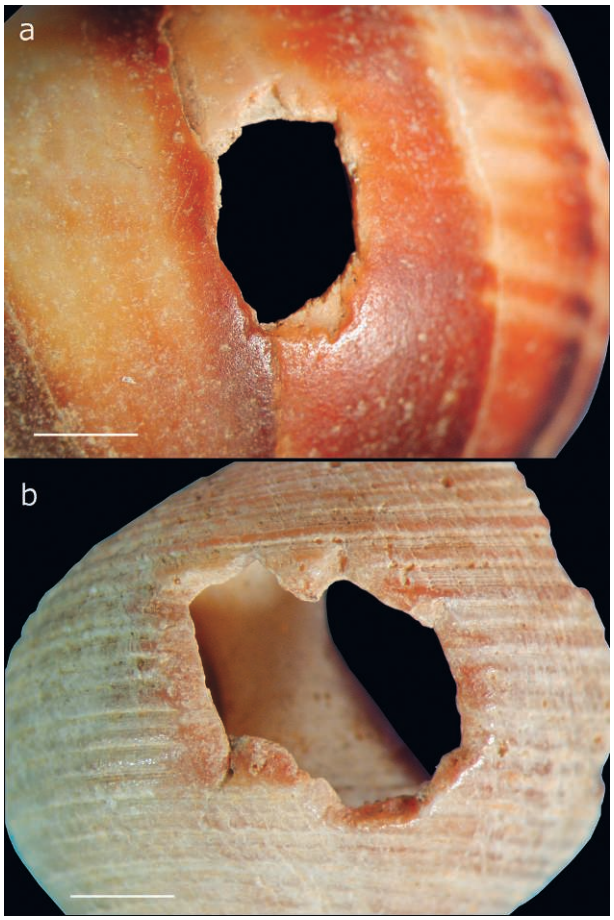


FIGURE 15

Slight and intermediate use-wear on *L. littorea* from Cro-Magnon: a) slight, b) intermediate. (Scale bar = 5 mm).

Usure légère et intermédiaire sur les L. littorea *de Cro-Magnon : a) légère, b) intermédiaire. (Échelle = 5 mm).*

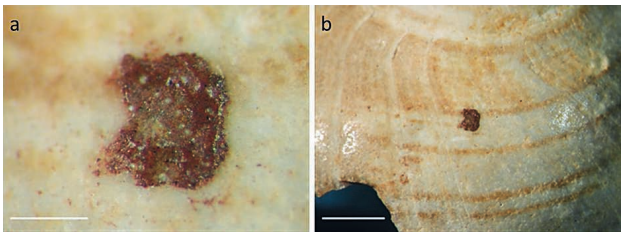


FIGURE 16

Bright red residue found on one *L. littorea* (a & b) (Scale bar: a = 5 mm, b = 1 mm).

Résidu rouge vif trouvé sur un L. littorea *(a & b) (échelle : a = 5 mm, b = 1 mm).*

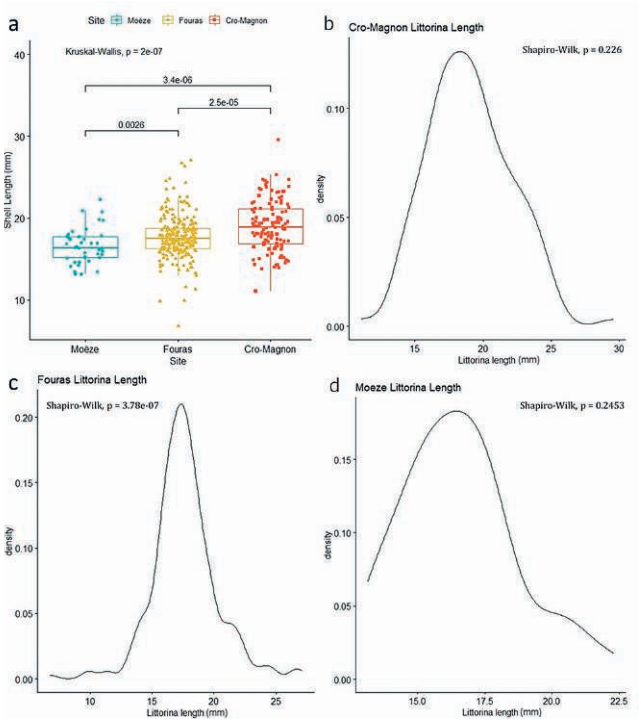


FIGURE 17

Archaeological and modern reference samples shell lengths: a) shell lengths box plots with Kruskal-Wallis values, b) shell length distribution of Cro-Magnon *L. littorea* with Shapiro-Wilk normality value, c) distribution of *L. littorea* length from Fouras with Shapiro-Wilk normality value, d) distribution of *L. littorea* length from Moëze with Shapiro-Wilk normality value.

Longueurs des coquilles des échantillons de référence archéologiques et modernes : a) box plots des longueurs des coquilles et résultat du test de Kruskal-Wallis, b) distribution des longueurs des coquilles de L. littorea *de Cro-Magnon avec le résultat du test de normalité de Shapiro-Wilk, c) distribution des longueurs de* L. littorea *de Fouras avec le résultat du test de normalité de Shapiro-Wilk, d) Distribution des longueurs de L. littorea de Moëze avec le résultat du test de Shapiro-Wilk.*

6.2.5 | Ochre

Ochre residue is observed on thirteen *L. littorea* (10.48 %). A bright 1 mm wide red patch, clearly different in consistency and colour from the ochre residue, was observed on one *L. littorea* (**fig. 16a, b**).

6.2.6 | Morphometric analysis

The *L. littorea* from Cro-Magnon are significantly larger than those from both the Moëze and Fouras modern reference samples (Kruskal-Wallis U-test: $P < 0.05$, **fig. 17a**, **tabl. 7, tabl. 8**). The Moëze and Fouras collections also exhibit significantly different lengths from one another. *L. littorea* lengths of Cro-Magnon and Moëze are normally distributed (**fig. 17b, d**), but those from Fouras are leptokurtic (**fig. 17c**).

6.2.7 | Shell origin

The *L. littorea* and *N. lapillus* from Cro-Magnon were collected on the Atlantic coast (Burman and Påsse 2008; Leifsdóttir, Símonarson 2001; Palacios, Vega 1997). The *L. lurida* was collected on the Mediterranean coast (Ávila *et al*. 2007; Rivière 1904). The four *Turritella* sp. specimens (**fig. 2**), are discoloured and present a much worse state of preservation than the other shells. This suggests that they were collected at Miocene fossil outcrops, the closest of which are located around one hundred km from the site (Cossmann, Peyrot 1915). According to Taborin (1993 p. 404) the *Ostrea* sp. fragment also belongs to a fossil specimen (**tabl. 6**) available at Miocene outcrops.

6.3 | Red Deer canine

The original surface of the Red Deer canine is damaged at places by surface exfoliation. The tooth was identified as a left canine of a Red Deer stag (**fig. 18a, b**). Based on the level of root development, occlusal wear, the degree of pulp cavity calcification and the removal of the DLCL, the animal was an old adult (nine to eleven years of age) (**fig. 18a, b**). The single perforation is located in the centre of the root, it is circular and bi-conical indicating the root was perforated by rotation on both sides with a stone tool. There were likely three distinct steps involved in the production of the perforation. Firstly, a facet was created

Sites	Shell Length P value Kruskal-Wallis
Cro-Magnon - Moëze	0.000003435
Cro-Magnon - Fouras	0.00002543
Moëze - Fouras	0.002625

TABLEAU 7

Kruskal-Wallis test results established between the *L. littorea* modern reference and archaeological samples.

Résultats du test de Kruskal-Wallis calculé entre les collections de référence modernes et les spécimens archéologiques de L. littorea.

Site	N	Mean Length (mm)	SD	Min	Max
Cro-Magnon	124	19.03	3.06	11.07	29.56
Moëze	40	16.58	2.14	13.14	22.28
Fouras	248	17.67	2.61	6.77	27.09

TABLEAU 8

Mean, minimum and maximum length of *L. littorea* from modern reference collections of L. littorea and archaeological specimens.

Longueur moyenne, minimale et maximale des L. littorea *des collections de référence modernes et des spécimens archéologiques.*

FIGURE 18

Red Deer canine pendant: a) lingual aspect (scale = 1 cm), b) buccal aspect (scale = 1 cm), c) close-up view of the perforation on the lingual aspect (scale = 1 mm), d) close-up view of the perforation on the buccal aspect (scale = 1 mm).

Canine de cerf perforée : a) vue linguale (échelle = 1 cm), b) vue labiale (échelle = 1 cm), c) photo de la perforation sur la face linguale (échelle = 1 mm), d) photo de la perforation sur la face labiale (échelle = 1 mm).

on the surface of the buccal and lingual aspects of the crown with the spool of a burin, creating a concave area (**fig. 18a, b**). Secondly, the canine was scraped to further thin the crown (**fig. 18c**). The longitudinal striations created from this also then acted to stabilise the tool for the next step. The perforation was then created by manually rotating a pointed stone tool (Vercoutère *et al*. 2007) (**fig. 18c, d**). The perforation displays clear use-wear on its apical edge where the striations produced by rotation are smoother than those present on the opposite side (**fig. 18c, d**). The canine is covered with red-orange ochre which is particularly abundant inside the perforation (**fig. 18c, d**).

6.4 | Bovid incisor

The incisor is well preserved but there is exfoliation over 40 % of the surface (**fig. 3d**). The incisor very likely originates from a Bovidae. However, the species and anatomical provenance are difficult to establish (pers. com. D. Armand 2022). The crown morphology suggests it comes from an adult animal. Two steps were involved in the production of the perforation. Firstly, longitudinal scraping using a robust lithic point was applied to thin the root and create two longitudinal elongated concavities on both the mesial and distal sides of the tooth. This was then followed by more focused scraping. The root apex is very polished by use-wear. A wide indentation on the lingual aspect, also due to use-wear, suggests a string was in contact with the tooth at this location.

6.5 | Lion Canine

The apex of the lion canine bears two parallel cut marks on the buccal aspect (**fig. 8a**) but it is too broken to reliably identify it as a pendant.

6.6 | Shaped pendants

The bi-perforated ivory pendant has an asymmetrical elliptical shape and has a spindle section (**fig. 19a, b, fig. 20a, b**). The dimensions of the pendant are 31.5 mm in length, 23 mm in width and 5 mm in thickness. Four post-depositional types of damage are recorded: ancient breakage removing the top edge, recent flake removal close to the bottom edge, fragments of the object glued close to the perforation and the bottom edge, root etching (**fig. 19a, b, f**). The pendant is covered with varnish which is particularly abundant on the aspect where the labelling of the pendant is written with ink. At the centre of this aspect the varnish was removed which gives access to the original surface of the object (**fig. 19b**).

Several areas feature concentrations of dark ochre. The two perforations are similar in shape and have the same diameter (3 mm). Technological analysis shows that the perforations were produced by rotation (**fig. 19c, d**). Slight use-wear is observed on the edges of the perforations. Extensive striations run down the length of the pendant. Based on their morphology, the striations were produced by scraping with a retouched tool (**fig. 19a, b, e**). The striations fade towards the centre of the surface due to use-wear. The perforations cross-cut the striations indicating that they were produced after the object was carved (**fig. 20**).

The mono-perforated ivory pendant is drop-shaped and has one curved and one flat side (**fig. 21, fig. 22**). The perforation is freshly broken (**fig. 21c, d**). The present dimensions are 16 mm in length, 13.2 mm in width and 4.5 mm in thickness. The flat aspect of the object is well preserved (**fig. 21b**). The curved one bears exfoliation removing approximately 10% of the original surface (**fig. 21a**). Two triangular incisions (**fig. 21d**) in contact with

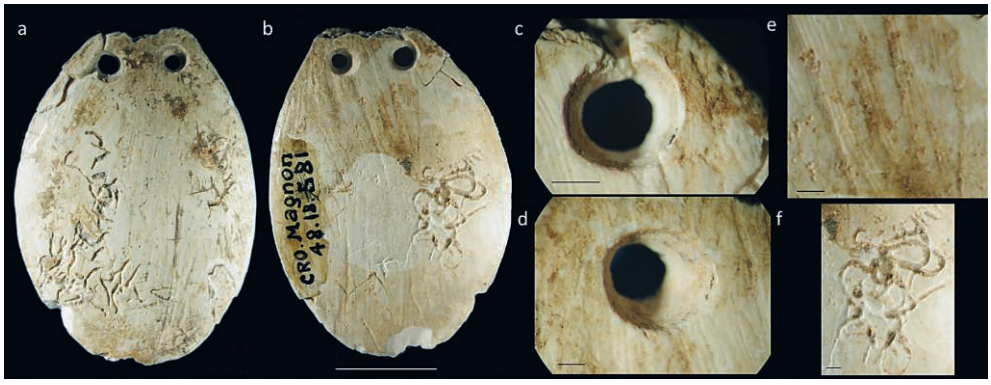


FIGURE 19

Bi-perforated ivory pendant (a & b), c) right perforation, d) left perforation, e) parallel striations resulting from scraping, f) root etching damage. (Scale bar a & b = 10 mm, c - f = 1 mm).

Pendentif en ivoire biperforé (a & b), c) perforation droite, d) perforation gauche, e) stries parallèles résultant du raclage, f - altérations résultant d'une dissolution par impact racinaire. (Échelle a & b = 1 mm, c - f = 1 mm).

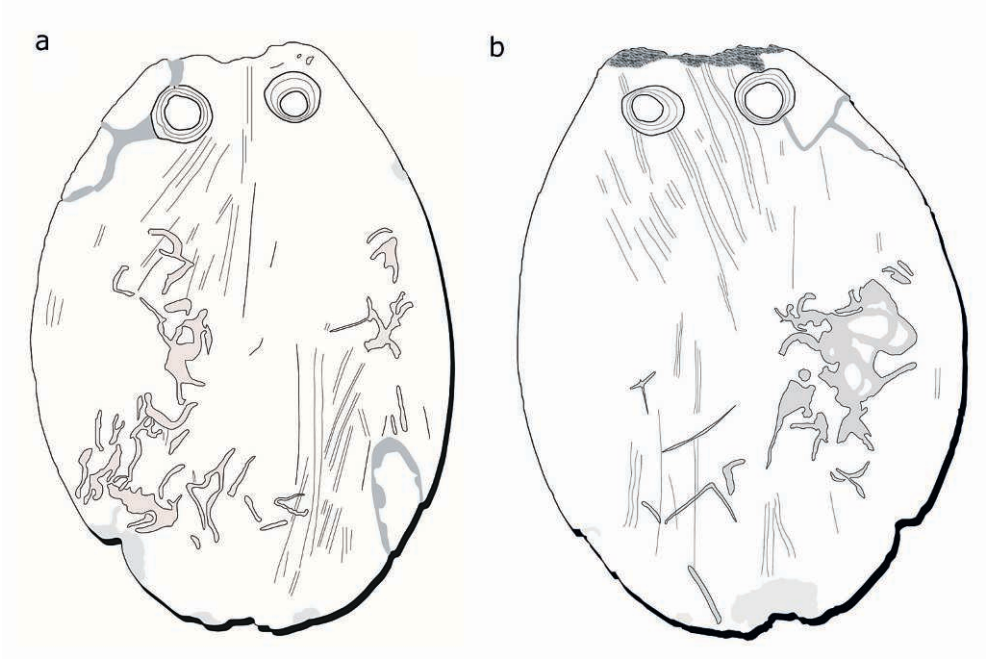


FIGURE 20

Tracing of the bi-perforated ivory pendant showing surface features marks (a & b).

Dessin du pendentif en ivoire bi-perforé montrant les marques des caractéristiques de surface (a & b).

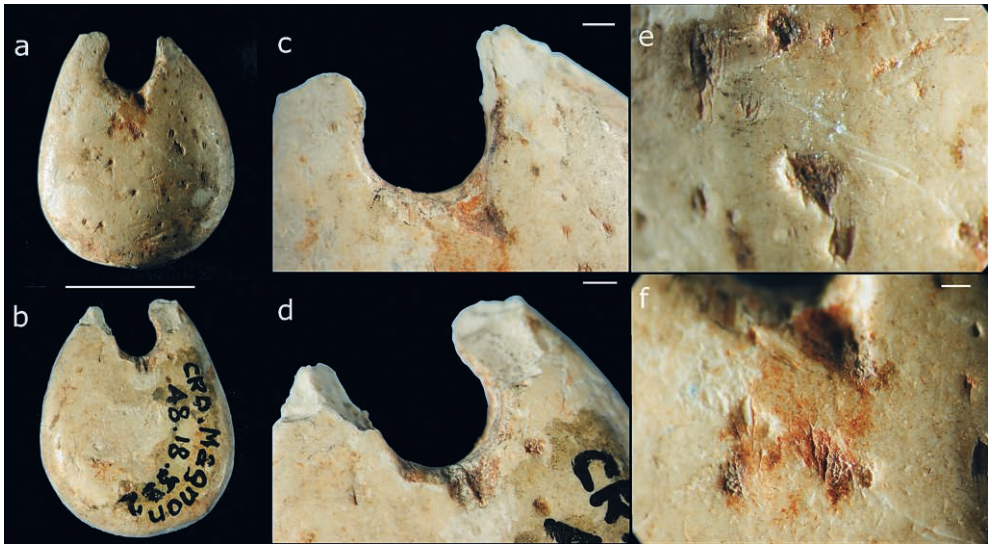


FIGURE 21

Mono-perforated ivory pendant with punctures (a & b) a) curved aspect of the pendant, b) flat aspect of the pendant, c) perforation on the curved aspect. d) perforation on the flat aspect. e & f) puncture marks recorded on the curved surface filled in some cases with ochre. (Scale bar a & b = 10 mm, c - f = 1 mm).

Pendentif en ivoire mono-perforé avec des perforations (a & b) a) face courbe du pendentif, b face plane du pendentif, c) perforation Observée sur la face courbe, d) perforation observée sur la face plane, e & f) marques poinçon enregistrées sur la surface courbe remplies dans certains cas d'ocre. (Échelle a & b = 10 mm, c - f = 1 mm).

the perforation edge on one side and a single similar incision (**fig. 21c**) on the other side likely correspond to grooves made on the object's surface to stabilise the tip of the tool used to perforate it. The few residual striations on the perforation's surface demonstrate that it was then produced by rotation (**fig. 21c, d**).

In well-preserved areas, the surface appears highly polished. Several elongated parallel grooves close to the edge opposite to the perforation, produced by a stone tool are heavily smoothed. This could be due to a deliberate polishing to homogenise the surface or to use-wear.

Forty-eight puncture marks are present on the curved side (**fig. 22a**) and two on the flat side of the pendant (**fig. 22b**). Their morphology indicates, by comparison with experimentally produced marks, that they were either produced by pressure or more probably indirect percussion with a pointed tool (d'Errico 1995; Doyon *et al.* in press). Experimental reproduction of this technique has shown that one can identify the use of the same tool by examining the shape and internal morphology of the punctures. The punctures show two distinct morphologies, present on both sides of this pendant, one 'star' (**fig. 21e**) and the other 'spindle' shaped (**fig. 21f**), indicating they were produced by two distinct points. Ochre residue, abundant inside the punctures (**fig. 21f**), certainly played a role in increasing their visibility. Ochre is also present all over the surface. Although now lost, the other ivory pendant featured by Lartet *et al.* (1875) also displayed a single perforation and had dimensions similar to the mono-perforated specimen (**fig. 1f**).

The third shaped pendant has a conical and slightly curved shape (**fig. 23a, b**). No diagnostic features appear on its surface demonstrating that it is made of ivory. It has dimensions of 33 mm in length, a maximum width of 11.8 mm and minimum width of 4.2 mm. The perforation

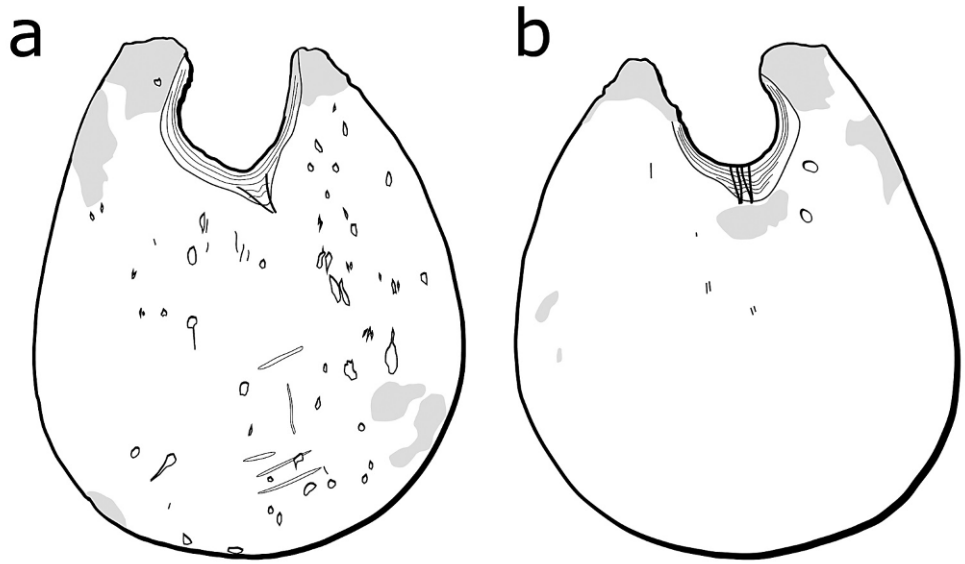


FIGURE 22

Tracing of the mono-perforated ivory pendant indicating the location of the punctures (a & b).

Dessin du pendentif en ivoire mono-perforé indiquant l'emplacement des traces de poinçon (a & b).

FIGURE 23

Elongated shaped pendant (a & b). (Scale bar = 10 mm).

Pendentif de forme allongée (a & b). (échelle = 10 mm).

is situated at the wider end and has a diameter of 2.7 mm. Damage at the tip, and inside and around the perforation shows that the object is made of a bright white, homogenous material. Additional analyses are necessary to clarify whether this is the original pendant described by Lartet or a cast of it. No traces of rotation are visible on the perforation.

7 | DISCUSSION

In spite of their complex curatorial history, our reappraisal of the Cro-Magnon ornaments was able to extract novel information on their provenance, production and use. The excavation of Cro-Magnon did not follow the standards of today, such as implementing wet sieving. Recent work has shown that approximately only 10 % and 40 % of personal ornaments are found at older and modern excavations without wet sieving, respectively (Granger, Airvaux 2010; Peschaux *et al*. 2022), and thus perhaps a large proportion of the ornaments from Cro-Magnon were not recovered. However, at the site of Rochereil (Rigaud *et al*. 2022) excavated from 1937-1947, recent wet sieving of the backdirt has allowed the recovery of many mammal bone remains and stone tools but no personal ornaments nor any examples of mobiliary art were found despite their high frequency in the old collection, showing that excavators paid attention to specific categories of remains during fieldwork (pers. com. P. Paillet). Additionally, the smallest ornaments recovered at Cro-Magnon were around 10 mm in length, which is the same length of the smallest ornaments recovered in the excavation of the nearby and penecontemporaneous site of Abri Pataud, which was excavated with wet sieving (Bricker 1995). Although the percentage of personal ornaments directly found from wet sieving is not known for Abri Pataud, the similar minimum

lengths of the recovered personal ornaments from both sites suggests that smaller ornaments were not lost during the excavation of Cro-Magnon. Thus, whilst we do not know what the proportion of personal ornaments recovered from Cro-Magnon is compared to their original number, there are reasons for thinking that the recovered collection is representative of the bead types present in the original assemblage.

Of the approximately three hundred personal ornaments mentioned in the original publications (Lartet 1868; Lartet *et al*. 1875), a total of one hundred forty-two (*circa* 47 %) were analysed in our study (**tabl. 4**). This collection includes all of the different ornament categories found at the moment of the discovery of the human remains.

The association of the ornaments with the Cro-Magnon individuals is supported by the original publication, which explicitly mentions their association (Lartet 1868 p. 346), and the presence of ochre on both the ornaments and the human remains (Henry-Gambier 2002; Henry-Gambier *et al*. 2013). Our results are consistent with this view since they highlight the homogeneous state of preservation of the most represented bead category, *i.e*., perforated *L. littorea*. The exceptional preservation of these beads suggests a similar taphonomic history indicating their burying in a similar depositional environment, which is consistent with the first excavation report mentioning their clear association with the human remains. Although all available evidence points towards a direct association of the *L. littorea* with the Cro-Magnon human remains, it is difficult to ascertain that this was the case for the other types of ornaments.

For example, in the original report, the discovery of the bi-perforated pendant is described as follows; 'Not far from the skeletons, I found a pendant or amulet of ivory, oval, flat, and pierced with two holes.' (Lartet 1868 p. 346-347). Since we do not know what Lartet means precisely by 'not far' we cannot be sure if this ivory pendant was directly associated with the burials. This may also be the case with the perforated teeth: 'There were also found near the skeletons several perforated teeth' (Lartet 1868 p. 347). Nevertheless, it is clear from his report that both the ivory pendant and teeth came from the same layer as the human remains.

7.1 | Shell ornaments

The site of Cro-Magnon was approximately three hundred and three hundred fifty km from the Atlantic and Mediterranean coasts during the Gravettian occupation of the site, respectively (**fig. 1a**) (Lambeck, Chappell 2001; Lambeck *et al*. 2002). Two of the seven shell species reported at the site, *L. littorea* and *N. lapillus,* cannot be found at fossil outcrops and, considering their known palaeobiogeography and state of preservation (Burman and Påsse 2008; Leifsdóttir and Símonarson 2001; Palacios, Vega 1997), must have been collected from the Atlantic coast during the Gravettian. The potential presence of a single *L. lurida*, however, demonstrates that some shells found at Cro-Magnon may have come from the Mediterranean coast. The home range of historically known hunter-gatherers was approximately one hundred seventy-five km^2 (Marlowe 2005) whilst their daily range is estimated to have been around ten km (O'Keefe *et al*. 2011; Pontzer *et al*. 2012). Both of these values are much lower than the distance from the site to both coasts, which would suggest that some or all of the shells found at Cro-Magnon may have been indirectly acquired through circulation networks. Networks of this size, implying the circulation of lithic and shell material, are attested at other Gravettian sites, such as Gargas (Aventignan, France), Isturitz (Isturitz, France) and La Gravette (Bayac, France) (Couche Noire) (Arrizabalaga *et al*. 2014; San Juan-Foucher, Foucher 2008; Taborin 1993). These three sites likewise contained *L. littorea* and *N. lapillus* specimens, which were introduced to the sites from the Atlantic coast. However, recent work (Delvigne 2016; Delvigne *et al*. 2020; Foucher *et al*. 2016) has suggested that long-distance movement of people, probably during seasonal migration, was a regular occurrence during the Gravettian. This implies that marine shells may have been collected by the Cro-Magnon group when visiting coastal areas.

Collection of fossil shells, namely *Turritella* sp., is attested at Cro-Magnon. The collection of shells at Miocene outcrops during the Gravettian in the Aquitaine region is also attested at Laussel (Marquay, France), which has a fossil *Nerita* sp. specimen (Lalanne, Bouyssonie 1946; Roussot 2000; Taborin 1993), Gargas, which has a single specimen of *Neritina picta* and *Granulolabium plicatum* (San Juan-Foucher, Foucher 2008) and Abri Pataud which has four specimens of *Granulolabium plicatum* (Taborin 1993). Although the Gravettian *facies* to which the shells could be attributed at Laussel is unknown, these three sites confirm that during the Gravettian, fossil outcrops were exploited and collected shells could travel over long distances to other locations within and outside of the Dordogne region (San Juan-Foucher, Foucher 2008; Taborin 1993).

Modern-day biocenoses in which the species used as beads at Cro-Magnon are found also include numerous other shell species, some of which could be used as ornaments (Monteiro *et al*. 2013) and were used for this function in other periods of the Upper Palaeolithic (Taborin 1993; Vanhaeren, d'Errico 2006). The overrepresentation of one of these species, *L. littorea*, is therefore the result of a deliberate cultural choice. The use of this species was widespread across Western Europe throughout the Gravettian (**fig. 24**). Similarities in the choice of other shell species, *e.g*., *N. lapillus*, are recorded at six Gravettian sites [El Cuco (Castro-Urdiales, Cantabria), Gargas, Garma (Omoño, Cantabria), Isturitz, La Gravette and Le Flageolet (Bézenac, Dordogne) (Arrizabalaga *et al*. 2014; San Juan-Foucher, Foucher 2008; Taborin 1993)] which also have *L. littorea*. This is probably indicative of similarities in Gravettian garments and their attached symbolic meaning.

Microscopic analysis identified traces left by predators and sponges indicating that the shells were collected after their death, apparently with the sole purpose of being transformed into ornaments, and not for consumption (Dupont 2019). Comparison with modern assemblages initially suggests that *L. littorea* size was a factor at the moment of collection. However, because sea surface temperature and marine shell size are inversely correlated (Bailey and Craighead 2003; Gutierrez-Zugasti 2011), the

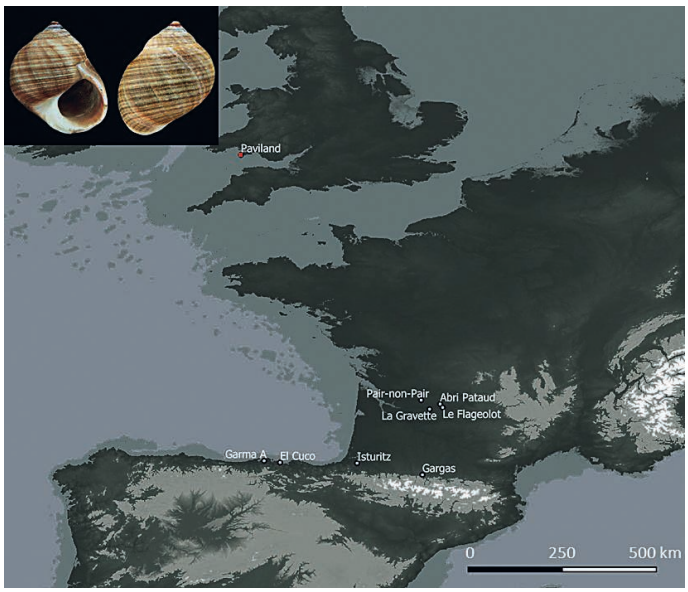


FIGURE 24

Occurrences of *L. littorea* ornaments at Gravettian sites from western Europe. Red - burial sites, white - habitation sites.

Occurrences de parures de L. littorea *sur des sites gravettiens d'Europe occidentale. Rouge - sites funéraires, blanc - sites d'habitation*

larger size of the Cro-Magnon shells is therefore likely the product of the lower sea surface temperatures during the Upper Palaeolithic rather than a cultural choice.

One specimen of *L. littorea*, one *N. lapillus* and the sole *L. lurida* are not perforated and do not bear any other trace of anthropogenic modification. They may still have been used for this purpose by using another attachment, possibly involving the use of an adhesive (Dayet *et al*. 2017; Rigaud *et al*. 2014). Alternatively, they could represent manuports kept by the Cro-Magnon people for exchange (Mansur *et al*. 2020). This would suggest that either they were not associated with the burial or were grave goods deposited close to the human remains.

A variety of production methods were employed to perforate the shells, with exerting a pressure through the aperture being the most favoured technique. The propensity to use this method may be linked to the morphology of the *L. littorea* shell. Puncturing the shell through the aperture is probably the easiest method and the one which minimises the chances of breaking the shell.

Morphometric analysis of the perforations and their location on the shells highlight interesting trends. The minimum/maximum diameter ratio of the perforations indicates that the will of the crafter was to produce subcircular holes (**fig. 12c**), the best strategy to thread the shell with a thin string. Some of the largest perforations probably correspond to the more heavily worn shells. The minimum diameter of the perforations demonstrates that the thread was probably smaller than 2 mm in diameter and must have been in some cases narrower than 1.2 mm, the minimum diameter of the smallest perforation. The fact that the maximum diameter of the perforations is not correlated with the shell size (**fig. 12a**) may be explained by differential use-wear or the application of similar threading methods not requiring specific hole size for larger shells. Smaller shells tend to have a larger minimum perforation diameter (**fig. 12b**). This is the probable result of the thinner shell wall of smaller shells being more heavily impacted by the puncture during perforation, which produced larger minimum perforation diameters. The bridge width, (*i.e.*, the distance between the labre and perforation), is independent of shell length (**fig. 12d**). This could either indicate that the tool tip morphology was the same for each shell or could be the result of use-wear altering the width of the bridge.

The presence of different degrees of use-wear on the *L. littorea* could result from the fact that the shell bead collection includes shells that were originally integrated into different beadworks, used for different time spans, that these beadworks were rejuvenated or reassembled with new shell beads, or that the intensity of use-wear depends on the type of ornament the shell beads were integrated in with necklaces, for instance, producing a higher degree of movement than bracelets or shells sewed onto clothing. We do not have enough contextual information to favour one of these hypotheses in particular.

Many of the shell surfaces present ochre, indicating that they were at some point in contact with it. The number of *L. littorea* shells with ochre (n=13) is very unequal depending on the museum that houses it. Nine of the twenty-nine *L. littorea* shells at the MNP (31.03 %) present ochre, whereas only one of the twenty-seven *L. littorea* shells (3.7%) at the MdH is ochred. This suggests that the shell beads were more ochred at the moment of discovery and that curatorial processes removed the residue on many of them.

The ochre may have come from contact with ochred surfaces (*e.g.*, skin, clothing or thread), or may have been deliberately applied to the shells to change their colour (Bouzouggar *et al*. 2007; d'Errico *et al*. 2009). The presence of ochre both inside and outside of the shells is consistent with its presence on both the thread and the material to which the shells were in contact (clothing, human skin). The presence of ochre on both the shells and the human remains indicate that either ochre was present on the ornaments and Cro-Magnon people during life , or was present on a cloth which protected the bodies or was poured on them whilst putting them in the grave, none of these hypotheses being mutually exclusive or easy to test at this site (Belcastro *et al*. 2010; Garilli *et al*. 2020; Mussi 2006; Reynolds *et al*. 2017; Villotte *et al*. 2019). Whatever

the case, it is noteworthy that the occurrence of ochre is a common feature of Gravettian burials across Europe (d'Errico, Vanhaeren 2015; French, Nowell 2022).

The bright red patch observed on one of the *L. littorea* could either be a residue of wax lacquer remaining from curatorial processes or is a residue of a special type of ochre. Further spectroscopic investigation should be carried out to ascertain the exact composition of this residue.

7.2 | Shaped pendants

Mammoth bone fragments were found at Cro-Magnon (Lartet 1868; Movius 1969), indicating that ivory was available locally and that the pendants could have been produced by the Cro-Magnon people rather than obtained through exchange. This is confirmed by the presence of similar, unfinished ivory pendants in Early Gravettian levels at Abri Pataud (Henry-Gambier *et al.* 2013) (**fig. 25**).

Microscopic analysis of the pendant identified how the perforation was made and the technique used in their last stage in their manufacture. CT scans of the pendant may allow in the future to identify the precise provenance of the ivory fragments on the tusk.

The four shaped pendants found at Cro-Magnon are substantially different in technology, size, shape and decoration. The elongated specimen is rare at Gravettian sites; the closest example being known at Grub-Kranawetberg (Antl-Weiser 2008). Of the three flat specimens, one is symmetrical in section, flat, elliptical and bi-perforated, the other two are drop-shaped and differ from one another, due to the presence of numerous punctures on both sides. Differences are also observed in the studied specimens in the way the perforations were made and the objects finished.

Experimental reproduction by indirect percussion of punctures of sizes similar to those observed on the ivory pendant shows that substantial force needs to be exerted to produce visible punctures (d'Errico 1993, 1995; Doyon *et al.* in press). This could easily lead to the fracture of a thin object, such as the Cro-Magnon pendant. This implies that

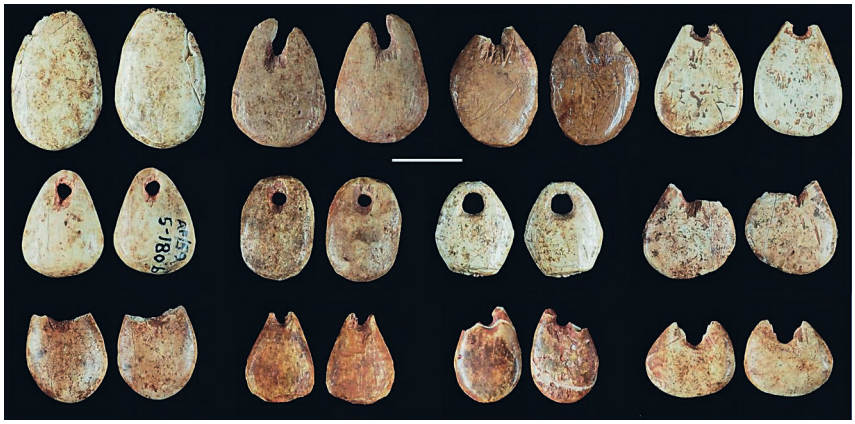


FIGURE 25

Mono-perforated ivory ornaments from Level 5 of Abri Pataud. (Scale bar = 10 mm), adapted from Henry-Gambier *et al.* (2013).

Ornements en ivoire mono-perforés provenant du niveau 5 de l'Abri Pataud. (Échelle = 10 mm), adapté de Henry-Gambier et al. *(2013).*

— FIGURE 26 —

Occurrences of Gravettian drop-shaped mono-perforated and elongated shaped pendants. Red - burial sites, white - habitation sites. A – Brillenhöhle, B – Geißenklösterle, C - Hohle Fels.

Occurrences des pendentifs en ivoire mono-perforés en forme de goutte et des pendentifs de forme allongée attribués au Gravettien. Rouge - sites funéraires, blanc - sites d'habitation. A - Brillenhöhle, B - Geißenklösterle, C - Hohle Fels.

the Gravettian crafter must have mastered the puncturing technique, and the number of punctures suggests that their production was deliberate. This contrasts with their apparent random distribution on the surface and the presence of two of them on the flat surface of the object which is likely the one which was worn against the body. The use of two distinct points for their production may indicate that the markings occurred at different times suggesting they correspond to a form of symbolic notation.

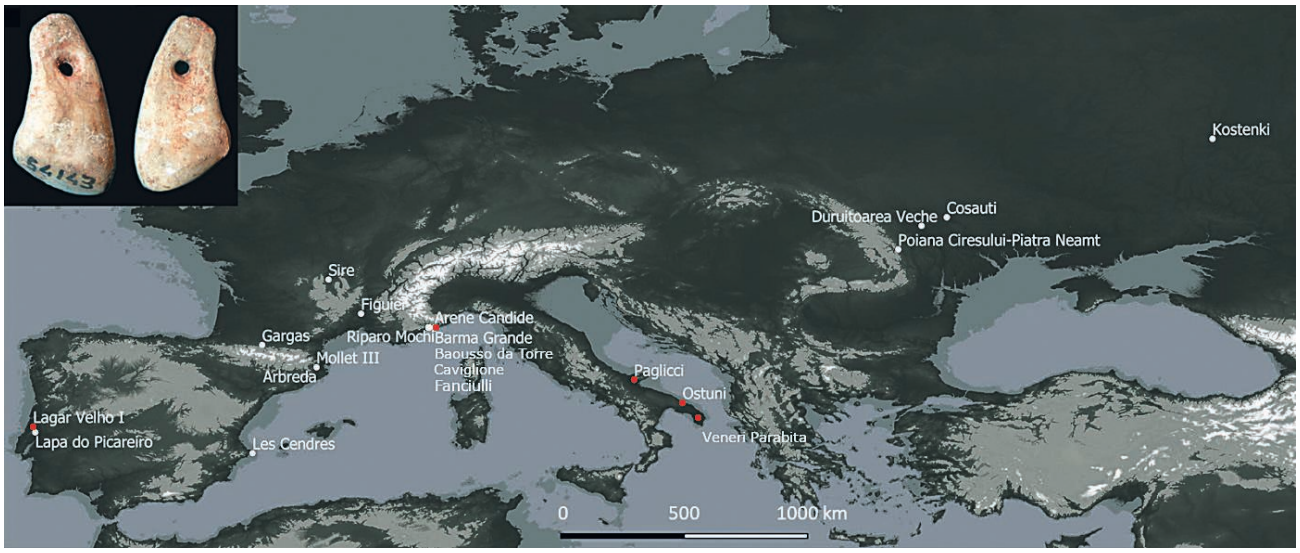
Interestingly, although drop-shaped ivory pendants are common throughout the Gravettian across Europe (**fig. 26**), none feature the puncture marks present on the mono-perforated pendant from Cro-Magnon (Antl, Bosch 2015; Antl-Weiser 2008; Broglio *et al*. 2004; Cârciumaru *et al*. 2019; Conard, Moreau 2004; Lázničková-Galetová 2015, 2019, 2021; Vercoutère, Wolf 2018).

Likewise, no bi-perforated ivory pendants similar to that from Cro-Magnon are found at Gravettian sites. Therefore, although the use of ivory for personal ornaments was widespread throughout the Gravettian, the bi-perforated, and to a lesser extent, the mono-perforated pendant are peculiar in regards to their shape, presence of punctures and double perforation. An explanation for these idiosyncrasies may be that the Cro-Magnon burial recruited individuals who had exceptional social status associated with exceptional ivory pendant types. This difference is also observed in the proportion these pendants occur at Cro-Magnon compared to the neighbouring site of Abri Pataud. Cro-Magnon features an abundance of *L. littorea* (*circa* three hundred) and a relative paucity of ivory pendants (n=3), whereas the contemporaneous Level 5 of Abri Pataud displays the reverse (two *L. littorea* and 12 ivory pendants) (Bricker 1995; Henry-Gambier *et al*. 2013). This difference may be due to the sites' functions, *i.e*., habitation vs burial. An alternative hypothesis is that in spite of their proximity and penecontemporaneity, Cro-Magnon and Abri Pataud were frequented by different Gravettian groups wearing the same ornaments but in different proportions. Lartet (1868 - p. 346 – 347) mentions that the bi-perforated ivory pendant was found slightly away from the human remains. It is possible that the ivory pendants were not worn on the people's body but rather used to decorate items such as bags, blankets and wooden objects, which would have resulted in their under-representation in burial contexts. This hypothesis is however partially contradicted by the discovery of similar ivory pendants in primary Gravettian burials from Eastern Europe (Pettitt 2013; Teschler-Nicola *et al*. 2020).

7.3 | Tooth ornaments

The remains of many different faunal species (cave lion, bear, squirrel, wolf, ibex, fox, hare, wild boar, horse, reindeer and an unknown bird species (Movius 1969 p. 331)) which could have been used to make personal ornaments were found at Cro-Magnon. However, only three taxa (mammoth, Red Deer, and a *Bovidae* species) were used for this purpose, suggesting a cultural choice.

Two production methods were used to perforate the animal teeth, longitudinal scraping and scraping followed by rotation. The low sample size makes it difficult to understand the reason for such a technological variability. The use of Red Deer canines as personal ornaments is well documented throughout all phases of the Gravettian across Europe (**fig. 27**). It is, however, noteworthy that the perforation method seen at Cro-Magnon is the one used at other Gravettian sites in the region, such as the specimen from Le Sire (d'Errico, Rigaud 2011), but different from specimens found in neighbouring regions, such as those from Arbreda Cave and Duruitoarea Veche Cave (Cârciumaru *et al*. 2019; Rufí *et al*. 2021). Future research focusing on the variability of perforation methods may identify geographic consistencies suggesting technology was culturally determined rather than depending on individual variation.



— FIGURE 27 —

Occurrences of perforated Red deer canines at Gravettian sites. Red - burial sites, white - habitation sites. Red - burial sites, white - habitation sites.

Occurrences de canines de cerf perforées sur des sites attribués au Gravettien. Rouge - sites funéraires, blanc - sites d'habitation.

7.4 | Chronological attribution

The overlapping radiocarbon ages, geographical proximity and the typological similarities between the personal ornaments of Level 5 of Abri Pataud and Cro-Magnon has led numerous authors to suggest that they were contemporaneous and dated to the Early Gravettian (Bougard 2014; Henry-Gambier *et al*. 2013; Movius 1969; Villotte, Balzeau 2018).

The radiocarbon age obtained from the *L. littorea* shell was 27,680 ± 270 BP, calibrated with the calibration curve available at the time to an age of 31,324 – 32,666 cal. BP (Henry-Gambier 2002; Henry-Gambier *et al*. 2013; Reimer *et al*. 2009). When recalibrating this date using the currently accepted calibration curve (Intcal20), we obtained a more recent age of 31,126 – 32,752 cal. BP (Reimer *et al*. 2020), which is largely in agreement with the original calibration.

However, because the radiocarbon date came from a marine shell, one must take the marine reservoir effect, *i.e.*, the general overestimation of the radiocarbon age obtained from marine organisms (Ascough *et al*. 2005; Mangerud 1972; Pettitt *et al*. 2003; Soares *et al*. 2016), into consideration when discussing the age obtained. When one applies the Marine20 calibration curve (Heaton *et al*. 2020), which attempts to take this marine reservoir effect into account, the calibrated age obtained is 30,396 – 31,509 cal. BP (although a specific correction based on geographic location must still be applied (Heaton *et al*. 2020; Heaton *et al*. 2022)). This is approximately one thousand years younger than the original calibrated age obtained by Henry-Gambier *et al*. (2013). Although this does not change the attribution to the Early Gravettian, it highlights the need for additional radiocarbon dating to more precisely assess the chronology of this key site. This endeavour is now facilitated by the recently improved chronological timeframe of the Western Upper Palaeolithic (Banks *et al*. 2019). Because the skeletons themselves do not contain collagen (Henry-Gambier 2002), it is clear that new ^{14}C dating should be performed on the shells or other organic artefacts.

CONCLUSION

Our reassessment of the available historical information on the circumstances leading to the discovery of the Cro-Magnon human remains and personal ornaments indicates that most of the ornaments, particularly the marine shells, were associated with the human remains. This is consistent with the presence of ochre residue on both the human remains and ornaments. The dispersal of the Cro-Magnon ornaments to numerous conservation institutions has prevented their comprehensive study. By combining modern taphonomic, morphometric and microscopic analyses and through comparison with more recently discovered sites and reference collections, this study has attempted to improve our understanding of Gravettian ornamental practices. The Cro-Magnon people profited from extensive exchange networks or long-distance movements as well as collection at fossil outcrops, hunting and possibly scavenging, to obtain the raw material to be used for personal ornamentation. Microscopic analysis has allowed us to identify the techniques used to perforate or to carve the ornaments as well as to evaluate the degree of use-wear. Despite sharing similarities with those from other groups, the ornaments from Cro-Magnon display a degree of distinctiveness emphasising the people's desire to demonstrate their ownness within a wider symbolic framework. Recalibration of the only available radiocarbon age suggests that a dating campaign is necessary to more precisely attribute this iconic site.

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