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A MODIFIED CAVE BEAR SKULL FROM THE EARLY UPPER PALAEOLITHIC

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Abstract. This article presents an analytical description of a modified cave bear cranium in a private collection, reportedly from a cave in the Bihor region of western Romania. The specimen, dated to 34,472–35,277 cal BP (Early Upper Palaeolithic), exhibits extensive, bilateral, near-symmetrical perforations through the frontal vault. A systematic taphonomic assessment evaluates and excludes natural formation processes—including carnivore activity, mechanical damage, and chemical erosion—based on controlled fracture margins, the preservation of fragile internal sinus architecture, and fracture morphologies consistent with modification of fresh, collagen-rich bone. The observed patterning is most parsimoniously consistent with deliberate human intervention. The configuration of the frontal perforations possesses ‘exogrammatic’ properties, reliably eliciting a face-like perception (pareidolia), suggesting the modification may have been intended for visual transformation or display. The findings place the cranium within a broader European context of structured, non-utilitarian handling, curation, and deposition of cave bear remains documented at several Palaeolithic sites, supporting its interpretation as an intentionally altered object.

Introduction

The Carpathian Mountain arc extends across Central and Eastern Europe, with its core spanning Romania, Slovakia, Poland, Ukraine and Hungary, and marginal or transitional sectors extending into adjacent regions of Austria, the Czech Republic, and Serbia. Within this system, Romania stands out for hosting the largest extant population of brown bears in Europe (Swenson et al. 2021) and for its exceptional karstic development. More than 12,000 caves are currently documented, nearly a quarter of which have yielded fossil material (Dobos and Chu 2019). Among these assemblages, remains of cave bear (predominantly *Ursus spelaeus*) are particularly abundant and, in several instances, occur in association with archaeological horizons.

Despite this richness, the interpretive potential of Romanian Palaeolithic material has been undermined by poor documentation, post-excavation loss and the dispersal of finds into private collections. Dumitru (2006) reports that almost a quarter of more than sixty palaeoart objects recovered from Romanian excavations are now lost. A particularly instructive example is provided by the Buda excavations, where a repeated and apparently non-random arrangement of bones was recorded in 1962; today, the published description constitutes the sole surviving evidence of this configuration. Such cases underscore both the

fragility of the archaeological record and the difficulty of evaluating claims for intentional bone arrangement or symbolic behaviour.

Within this broader context, several Romanian sites are of relevance to discussions of Pleistocene human–bear interaction and deliberate manipulation of bear remains (Fig. 1). In the Bihor Mountains, four cave bear skulls—one large and three smaller—were arranged along two perpendicular axes at Pietra Alta-rului (Bednarik 2010; 2017). Nearby, at Peștera Igrita, a bear skull was discovered within a box-like structure formed by stone slabs, suggesting architectural containment rather than natural deposition (Bednarik 2017: 183). From the same site, a bear-bone implement was assigned by Breuil (as reported in Dumitru 2006: 201) to the Aurignacian level; the specimen preserves sixteen incisions arranged in two parallel rows.

Further south, Cioarei Cave (Gorj County) yielded two cave bear skulls placed back-to-back on limestone slabs at a level dated to 47,900 ±1800–1500 BP (Cârciumaru et al. 2002; Cârciumaru and Cîrstina 2003). The authors note ‘... other skulls were also identified in curious situations, sometimes isolated, occasionally associated with long bones, whose positions are difficult to explain, but which give the impression of intentional arrangement.’ (Cârciumaru and Cîrstina 2003; author’s translation), raising the possibility of repeated, structured behaviour or engagement with



Figure 1. Location of the principal European sites used for comparison in this study. Numbers correspond to Table 3. The Romanian sites forming the primary regional framework of the discussion are indicated by 3, 7, 8, 13 and 15. The background relief emphasises the Carpathian mountain arc. © 2026 Mapbox © OpenStreetMap.

bear remains.

Perhaps the most compelling comparative example derives from Peștera Coliboaia, located in the Apuseni Mountains of Romania. Here, Aurignacian-aged parietal art, including a possible charcoal depiction of a ‘bear’, occurs in association with a long bone placed in axial alignment with a cave bear skull (Gély et al. 2014). This configuration closely parallels the two arrangements documented in Chauvet Cave’s Salle du Crâne, where long bones are placed vertically in the sediment and axially aligned with ursine skulls in a virtually identical manner (Bednarik 2020: Fig. 8b).

Finally, at Homoródalmás Cave, Vértés (cited in Bednarik 2017: 181) reported three cave bear skulls arranged face-to-face; although the loss of this material prevents verification, the described configuration is consistent with independently documented arrangements elsewhere. A later discovery of a deliberately oriented skull at the same site (Vértés 1959) provides limited but supporting evidence for intentional placement.

The present article contributes to this discussion through the analytical description of a cave bear cranium exhibiting unusual modifications. The specimen, designated here as RCBS19/37, forms part of the author’s private collection and is purported to originate from a karstic chamber in the Bihor region of western Romania. Its removal from its original depositional context and subsequent circulation within the fossil trade have resulted in the loss of stratigraphic and spatial information, including the precise find location. While the lack of excavation context limits behavioural interpretation, object-based taphonomic analysis re-

mains a valid and widely used approach for assessing modification processes. Consequently, the analysis presented here is necessarily restricted to morphological, taphonomic and surface-based observations. In the absence of archaeological association, attribution of the specimen to intentional human modification must rest solely on evidence preserved on the object itself.

Description

The specimen represents a largely complete adult cave bear cranium (Fig. 2), retaining the frontal, parietal, occipital, sphenoid, basicranial, and most facial elements. Adult bones are more likely to survive due to their greater structural density and lower porosity compared with juvenile elements (Lyman 1994: 72). It is estimated to have been at least 15 years old at death (pers. comm., G. Rabeder 2025). Although *Ursus ingressus* has been identified in limited parts of the Carpathian, *Ursus spelaeus* was the dominant species (Baca et al. 2016). *Ursus ingressus* tends to be larger, with some specimens exceeding 500 mm in length; however, the differences are considered not to exceed those between subspecies of the recent brown bear (Gennady and Puzachenko 2011). A total length (prosthion-acrocranium) of 449 mm suggests this specimen is *Ursus spelaeus*, but since there is evidence of sympatry in the region, genetic testing would be required to resolve this question. Overall morphology is robust and undistorted, with no evidence for large-scale plastic deformation or sedimentary compression. Breakage is localised and patterned, rather than catastrophic. Cranial and maxilla measurements are provided in Table 1.

The subfossil exhibits good surface preservation,



Figure 2. Six orthographic views of the cave bear cranium RCBS19/37 showing overall morphology, fracture patterning, and the position of the bilateral frontal perforations. The views provide complete visual coverage of the specimen discussed in the text.

Cranial measurements	mm	Cranial measurements continued	mm
c1-total length (prosthion-acrocranium)	449	c18-breadth at zygomatic arches (zygion-zygion)	~240
c2-condylobasal length (prosthion-occipital condyles)	430	c19-postorbital least breadth (postorbital bar)	80
c3-basal length (prosthion-basion)	405	c20-frontal breadth (ectorbital-ectorbital)	~125
c4-basicranial length (synsphenion-basion)	118	c21-least breadth between orbits (entorbital-entorbital)	96
c5-basifacial length (prosthion-synsphenion)	285	c22-cranial height (acrocranium-basion)	80
c6-neurocranium length (point F-acrocranium)	258	c23-maximal cranial height (staphylion-frontal)	159
c7-viscerocranium length (prosthion-point F)	194	c26-maxilla breadth at nasal aperture	28
c8-facial length (prosthion-point F)	226	c27-least breadth between infraorbital foramens	86
c9-nasal length (rhinion-nasion)	68	Maxilla measurements	mm
c10-rostrum length (prosthion-infraorbital)	164	m1-upper jaw maximal breadth	112.4
c11-palatal length (prosthion-staphylion)	246	m2-upper jaw minimal breadth	82.5
c12-breadth at the processus paraoccipitalis	84	m4-maximal breadth at the M2 alveoli	115.6
c13-maximal breadth of occipital condyles	82	m5-external length C1-M2 (anterior margin of alveole of c1-posterior margin of alveole of M2)	167
c14-mastoid breadth (otion-otion)	218	m6-internal length C1-M2 (posterior margin of alveole of C1-posterior margin of alveole of M2)	~129
c15-breadth of foramen magnum	36	m7-upper tooth row length (anterior margin of alveole of P4-posterior margin of alveole of M2)	105
c16-height of foramen magnum (basion-opisthion)	28	m8-upper molars row length on alveoles (anterior margin of alveole of M1-posterior margin of alveole of M2)	70.4
c17-maximal neurocranium breadth (euryon-euryon)	108	M9-diastema length (posterior margin of alveole of C1-anterior margin of alveole of P4)	~25

Table 1. Cranial and maxilla measurements of RCBS19/37. Measurements follow standard osteological landmarks (after Schmid 1972). Approximate measurements are provided where precise reference points are absent.



Figure 3. (A) Typical surface characteristics of mineralisation in a stable karstic microenvironment. (B) Weathering crack running parallel to the sagittal plane. (C) Peeling of cortical bone consistent with fresh-bone modification, with continuity of patina across the boundary. (D) Right postorbital process showing identical patina and a small, more recent patinated flake scar on the left.

with limited diagenetic alteration consistent with prolonged residence in a stable karstic microenvironment rather than exposure on an open palaeosurface (Fig. 3a). The overall preservation of the cranium suggests that it was situated in a depositional setting that afforded some protection from extensive mechanical disturbance and other taphonomic agents. Weathering is minimal, restricted primarily to a small number of cracks running parallel to the sagittal plane (Fig. 3b). Several localised areas display a polished appearance. While such polishing can result from limited post-depositional handling or sedimentary micro-movement, its restricted distribution argues against extensive transport or fluvial reworking. There is some evidence for slight chemical erosion in restricted zones, but most of the cortical surface remains intact.

Notably, a substantial area of the cranial vault lacks cortical bone, exposing underlying cancellous tissue across the fossa frontalis region to the extent of both postorbital processes. This exposed zone measures approximately 30 mm at its narrowest point along the midline and expands to a maximum of 78 mm on the left side, tapering out toward the maxilla. The patina is continuous across both the exposed cancellous surface and adjacent intact cortical bone (Fig. 3c and 3d), indicating that the removal of cortical tissue occurred prior to mineralisation.

Within this modified region, the skull shows bilateral perforations through the frontal region, creating two roughly circular-oval openings that are:

- Positioned symmetrically on either side of the

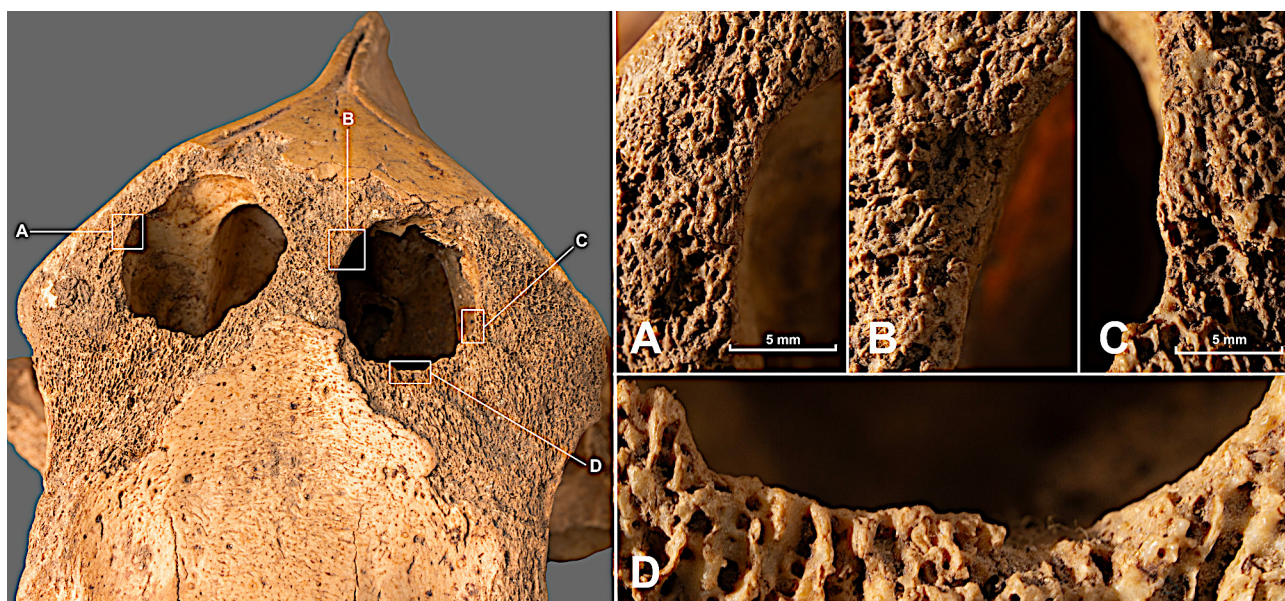


Figure 4. Bilateral frontal perforations in the fossa frontalis. (A) Rounded perforation margin with continuous surface patination. (B) Edge of the preserved inter-sinus bridge, with transmitted light visible through the septum. (C) Localised thinning and rounding of the perforation margin. (D) Close-up of the margin showing continued mineralisation and smoothing of exposed trabecular bone.

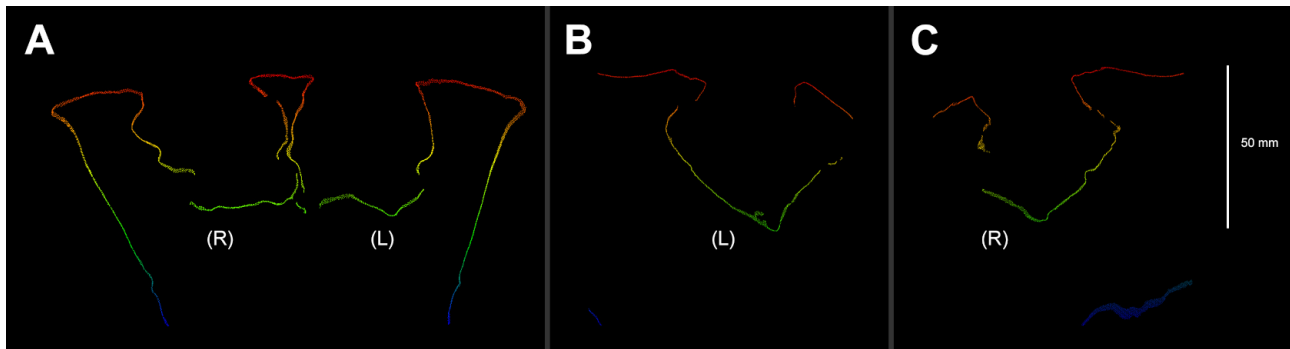


Figure 5. Depth-coloured 2 mm sectional profiles extracted from the laser point cloud of RCBS19/37, showing depth variation and wall geometry of the frontal perforations. (A) Section passing through both frontal perforations. (B–C) Orthogonal sections (90° rotated) through the centres of the left and right perforations, respectively. The profiles display smooth, continuous curvature and acute margins, with no evidence of internal stepping, crushing, microfracture halos, or occlusal break-through. Colours represent distance to the fitted reference plane (depth, mm); all sections share the same scale. Depth values within the deepest portions of the perforations may be locally affected by occlusion and line-of-sight limitations during laser acquisition.

midline

- Internally smoothed and rounded, with bevelled edges rather than jagged fracture planes
- Cut through compact cortical bone, exposing cancellous bone that has subsequently been worn smooth
- Consistent in size and morphology, not following natural sutures or weak points
- Accompanied by localised thinning and regularisation of the margins, consistent with repeated abrasion or scraping rather than a single break
- There is no evidence of radiating fracture lines, hinging or crushing typical of high-energy breakage.

The right perforation (specimen right, rostral view) is slightly elliptic (Fig. 4), measuring approximately 30 mm in lateral diameter and 36 mm longitudinally. The left perforation (Fig. 4) is more regular, though still elliptic, with dimensions of roughly 26 mm laterally and 30 mm longitudinally. The bridge of bone preserved between the two perforations tapers to just 12 mm at the narrowest point. Remarkably, below it, the inter-sinus septum—paper-thin in the sagittal plane—remains fully intact.

Methods: 3D digitisation and sectional analysis

To characterise the geometry of the frontal perforations, RCBS19/37 was digitised using high-resolution laser scanning, producing a three-dimensional point cloud of the cranial surface. Sectional profiles were extracted at 2 mm thickness through the perforations and colour-mapped by distance to a fitted reference plane in order to visualise depth variation and wall geometry (Fig. 5). Because of line-of-sight limitations inherent to laser scanning, minor occlusion and shadowing may occur within the deepest portions of narrow cavities; these effects primarily influence absolute depth values and do not affect wall curvature, margin morphology, or overall profile geometry used for interpretation.

Fracture patterning and cranial damage

Both zygomatic arches are broken, with the squamosal components truncated bilaterally. Breakage at the zygomatic roots is asymmetrical in extent and dissimilar in character: on the right side, the arch is entirely absent, the cancellous bone is exposed, and the fracture surface is spiral (Fig. 6a). The fracture margins exhibit the same patina as the surrounding cranial surface, indicating that breakage and subsequent surface alteration occurred within the same relative taphonomic phase. On the left side, the jugal portion of the zygomatic bone remains attached, the cortical margins of which are abraded, rounded and polished (Fig. 6b). Again, the patina in this region is uninterrupted.

The cranial vault is intact, with no large fractures, collapse or exfoliation. The frontal and parietal bones show continuous cortical surfaces with mild surface abrasion and micro-pitting, likely related to sediment contact and low-grade chemical weathering. The sagittal region and nuchal crest are preserved, with no evidence of impact fractures or peeling. Finally, the occipital cavity retains a dense mineralised mass consistent in position and morphology with intracranial material. Preservation of such material is uncommon in cave bear crania and, where documented, is generally associated with early sealing of the cranial cavity within a chemically stable microenvironment (Fig. 6c).

Both upper second molars (M2s) are complete (Fig. 2), exceptionally well preserved, and exhibit wear patterns indicative of a mixed diet incorporating forest herbs, tree leaves, and a substantial proportion of grasses (pers. comm., G. Rabeder 2025). This dietary signal is consistent with occupation at lower altitudes rather than exclusively high-mountain environments. Roots of both I2s, I3 and I1 are preserved in situ, together with partial roots from P1 and M1. The latter two were extracted and submitted to Beta Analytic LLC for radiocarbon dating. The sample (Beta-778224; 30,450 ± 190 BP, 95.4% probability), calibrated using

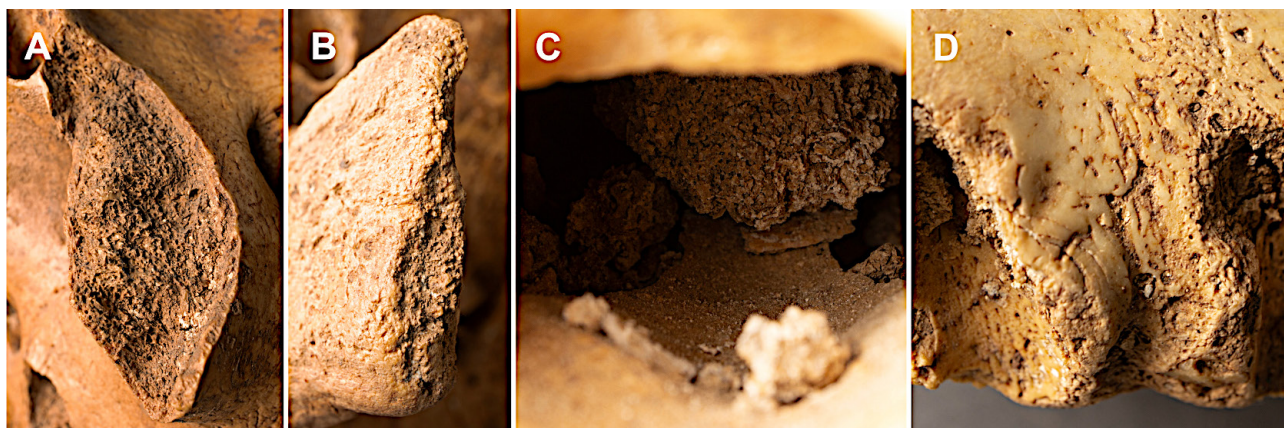


Figure 6. (A) Spiral fracture of the right zygomatic arch. (B) Prominent edges showing abrasion, rounding and polish. (C) Mineralised brain tissue in the occipital cavity, viewed through the foramen magnum. (D) Antemortem bone regeneration, with prominent edges showing rounding and abrasion.

BetaCal 5.0 and IntCal20 (Reimer et al. 2020), yielded an age range of 34,472–35,277 cal BP. The alveolus of one I1 exhibits ante-mortem remodelling, consistent with tooth loss during life. Prominent areas of the cranium display advanced rounding and abrasion (Fig. 6d).

The occipital condyles are intact, though their margins show slight rounding. Portions of the basicranium (including parts of the sphenoid and basioccipital) are present but display irregular breakage along thinner elements, especially around foramina. Fracture edges in this region reveal a brittle structure suggesting post-mortem breakage after drying, rather than perimortem damage (Figs 7 and 8). There are no radiating fracture lines, no crushing and no adhering tooth scores associated with these breaks.

The cranium records essentially a three-stage relative chronology of modification. An initial phase is represented by fresh-bone damage and modification, most clearly expressed in the bilateral frontal perforations and by a spiral fracture on the right zygomatic arch, both indicating breakage while the bone retained collagen and elasticity, either perimortem or shortly post-mortem. This was followed by a prolonged interval of post-depositional exposure, during which

fracture margins became rounded, exposed surfaces mineralised, and cortical surfaces showed general abrasion and patination, consistent with low-energy mechanical processes acting over time in a cave environment. The final stage(s) comprise breakage of foramina and other thin cranial elements, characterised by friable, crumbly fracture edges lacking spiral morphology, indicating damage incurred after complete drying of the bone, when structural cohesion had been significantly reduced.

The descriptive observations outlined above define a specimen that is anomalous within the range of naturally accumulated cave bear crania. The combination of extensive but spatially restricted cortical bone removal, bilateral and near-symmetrical perforations, acute-edged margins, preservation of an exceptionally fragile inter-sinus septum, and fracture morphologies consistent with fresh bone breakage collectively warrant closer scrutiny. At the same time, the absence of stratigraphic context and associated artefacts precludes direct attribution to human agency on contextual grounds.

The following analytical section, therefore, evaluates alternative formation processes as they apply specifically to the modifications across the cranial



Figure 7. (A–B) Friable post-depositional fractures affecting projecting elements of the basicranium. Both panels show highly porous, crumbly fracture surfaces with an open cancellous texture and irregular margins, characteristic of breakage in fully dried bone. The absence of spiral morphology, crushing, or impact-related features indicates late-stage damage incurred after complete loss of collagen and structural cohesion. (C) Tooth roots selected for sampling.



Figure 8. The perforated cave bear skull RCBS19/37 from the Bihor region of Romania.

vault—natural taphonomic modification, carnivore activity, sedimentary abrasion and post-depositional chemical erosion—before considering whether the observed patterning is more parsimoniously explained by deliberate modification. Emphasis is placed on experimentally and archaeologically documented criteria for identifying intentional bone working, as established in foundational zooarchaeological and taphonomic studies (Binford 1981; Lyman 1994; Fernández-Jalvo and Andrews 2016).

Evaluation of alternative formation processes

The interpretation of RCBS19/37 as an intentionally modified object requires the systematic exclusion of natural, pathological and non-symbolic anthropogenic processes. Given the well-documented problem of equifinality in bone modification, the following assessment evaluates each plausible alternative in turn, drawing on established taphonomic criteria.

Rodent and carnivore gnawing

Rodent gnawing produces highly diagnostic traces characterised by paired, parallel incisions with flat or U-shaped cross-sections created by the opposing incisors. These grooves are typically repetitive, closely spaced, and often concentrated along exposed edges. No such paired incisions, flat-bottomed grooves or characteristic chisel-like marks are present on RCBS19/37.

Carnivore modification is similarly absent. Typical carnivore damage includes pits (localised tooth punctures), scores (elongated linear grooves from tooth drag), and furrows (deep channels produced during marrow extraction), often accompanied by radial cracking, bevelled fracture margins and arcuate bite patterns. Carnivores preferentially target epiphyseal regions and thinner cortical areas to access cancellous bone and marrow, frequently resulting in scooped or crushed margins with V-shaped notches. The frontal vault of RCBS19/37 exhibits none of these features. Fracture planes are acute rather than crushed, lack radial cracking or pressure-release fracturing, and do not conform to known carnivore puncture morphologies.

Avian and large carnivore punctures

Avian punctures and large-carnivore canine impressions are typically characterised by localised crushing, irregular pressure-release cracking, and asymmetrical deformation of the cortical surface. The paired frontal perforations of RCBS19/37 lack these attributes. Their position, symmetry and edge morphology are inconsistent with the force applied by a lower mandible or canine tooth. The absence of associated crushing or micro-fracturing excludes avian or large-carnivore puncture as a viable explanation.

In addition, the spatial arrangement of the perforations is incompatible with any realistic large carnivore bite mechanism. To produce two matched openings in this position, a predator would need either to approach from behind the cranium and close its jaws at an angle exceeding normal mandibular articulation, or to envelop a substantial portion of the snout and facial skeleton within its oral cavity before biting down on the frontal vault. Neither scenario is readily compatible with the jaw gape, dental arc and cranial geometry of documented Pleistocene carnivores in the Carpathian region.

Erosion, root etching and chemical alteration

Natural erosional processes, including bacterial action, hydro-chemical dissolution and root etching, produce distinctive surface signatures. Root etching manifests as fine, sinuous, dendritic grooves created by organic acids leaching calcium from the bone surface. These features are superficial, irregular and lack sharp margins. No such dendritic or sinuous patterns are present on the frontal modifications of RCBS19/37.

Water abrasion or fluvial transport typically results in generalised surface rounding, polishing and the

preferential removal of exposed features. Critically, such erosion extends beneath existing marks and produces diffuse, non-localised modification. In contrast, the modifications observed on RCBS19/37 are spatially restricted, preserve acute internal angles, and retain delicate structures such as the inter-sinus septum, which would be unlikely to survive prolonged mechanical or chemical erosion.

Subaerial weathering produces cracking, exfoliation, bleaching and progressive surface flaking, commonly classified using weathering-stage systems such as those developed by Behrensmeyer (1978). This specimen does not display the cracking patterns, cortical exfoliation or colour differentiation characteristic of advanced weathering stages. Patination is continuous across both modified and unmodified surfaces, indicating that the observed alterations predate diagenetic mineralisation.

Karstic corrosion enlarges cavities opportunistically along trabecular bone and sutures, producing irregular, undercut forms rather than paired, standardised apertures.

Mechanical damage: trampling and rockfall

Mechanical forces such as trampling or roof collapse typically generate irregular, jagged fractures, splintering and non-patterned breakage. Edges produced by such processes are variable in angle and frequently accompanied by microchipping and uncontrolled fragmentation. The bilateral frontal perforations of RCBS19/37 are morphologically coherent, spatially symmetrical and bounded by controlled fracture margins. The absence of chaotic breakage patterns argues strongly against accidental mechanical damage. Sediment abrasion or trampling would affect exposed surfaces broadly, not create discrete, matched perforations.

Pathology and antemortem lesions

Pathological explanations, including osteolytic disease, abscess formation or infectious conditions such as treponemal disease, are highly unlikely on morphological grounds. While bears are known to develop pathological cranial lesions, these typically exhibit irregular resorption fronts, reactive bone formation, diffuse pitting or progressive remodelling rather than sharply bounded apertures. The perforations and localised cortical removal observed here are discrete, symmetrical and sharply delimited, and they lack any evidence of reactive or regenerative bone growth (cf. Ortner 2003; Marciszak et al. 2024). Evidence of normal ante-mortem bone healing elsewhere on the cranium further indicates that the skeletal tissue retained normal physiological responses and that the frontal modifications are not attributable to disease processes.

Utilitarian anthropogenic modification

Functional explanations related to subsistence activities, such as brain extraction, skinning or mar-

row access, are also implausible. The bilateral frontal perforations do not provide efficient access to the occipital cavity, and the mineralised brain mass remains largely intact. If nutritional exploitation had been the objective, modification of the occipital or basal regions would be expected. The absence of cut marks or other traces consistent with systematic disarticulation further argues against butchery or utilitarian processing.

Timing of modification and bone condition

Fracture morphology provides important constraints on the timing of modification. Experimental and archaeological studies demonstrate that fresh or green bone tends to fracture spirally, producing smooth surfaces and acute or obtuse fracture angles, whereas dry or fossilised bone fractures irregularly and exhibits rough, stepped surfaces. The acute-edged flake scars and oblique fracture planes observed on RCBS19/37 are consistent with breakage of fresh or only partially desiccated bone. Crucially, the colour and patina of fracture surfaces match those of adjacent cortical bone, indicating that modification occurred prior to significant collagen degradation and mineralisation.

Although the bear likely died of natural causes—potentially during winter torpor, given its maturity and karstic context—the modifications need not have been contemporaneous with death. In cool, stable cave environments, decomposition and skeletonisation are substantially slowed, allowing fresh-bone properties to persist for extended periods (Lyman 1994: 95–96). Processes such as adipocere formation may further retard decay, permitting modification months after death while the bone remained mechanically responsive.

Synthesis

As Lyman (1994: 339–340) observes, the more extensive and spatially structured a modification, the less likely it is to result from coincidental natural processes. The symmetry, location and finish strongly suggest intentional human modification of a fresh or partially de-fleshed skull. Localisation of cortical removal to the frontal vault, the preservation of the inter-sinus septum, and the bilateral symmetry of the perforations collectively indicate deliberate intervention. The intact septum, in particular, implies controlled modification that avoided collapse of the sinus architecture, suggesting either anatomical familiarity or repeated practice. The openings are consistent with manual enlargement by scraping, gouging or rotational abrasion with stone tools. The smoothing of trabecular bone implies repeated handling or prolonged exposure after modification, rather than rapid burial.

The cave bear skull exhibits intentional, almost symmetrical perforations with smoothed margins, incompatible with natural taphonomic agents alone. In taphonomic terms, the most plausible cause is deliberate human modification of a fresh or semi-fresh skull

(evidenced by fresh-bone fracture characteristics), followed by exposure or curated deposition that allowed abrasion and surface regularisation. This places the specimen firmly within a framework of structured post-mortem treatment, rather than accidental damage, carnivore activity or geological alteration.

Following Binford's (1981) criteria for identifying purposeful modification—namely redundancy, patterning and controlled execution—the frontal perforations of RCBS19/37 are best understood as the result of intentional engagement with the object rather than as the by-product of natural taphonomic processes. The systematic and planned nature of the alterations places this specimen within the category of manufactured modification *sensu* Lyman and supports its interpretation as an intentionally altered cave bear cranium rather than a product of equifinal natural processes. The modifications may have facilitated visual transformation (mask-like appearance), suspension or placement, rather than utilitarian processing for marrow or brain extraction. Such modifications fit well with structured manipulation of bear crania, documented at several Palaeolithic sites, where skulls were curated, displayed, or deposited in caves.

The assessment presented here is intentionally conservative, privileging exclusion of incompatible processes over attribution of intent, and restricting interpretation to what is supported by observable morphology and comparative reference. Taken together, the absence of diagnostic features associated with known non-anthropogenic processes supports intentional modification as the most parsimonious explanation for the observed patterning.

On the exogrammatic properties of RCBS19/37

Human perception is strongly predisposed toward the recognition of face-like configurations. The tendency to interpret two circular forms in proximity as eyes is just one example of a well-documented phenomenon known as pareidolia, in which the visual system extracts meaningful patterns from ambiguous stimuli. This tendency is not arbitrary but reflects a combination of evolutionary pressures, specialised neural circuitry and extensive developmental learning associated with face recognition.

Neurocognitive research has demonstrated that facial perception engages dedicated regions of the visual cortex, most notably the fusiform face area within the fusiform gyrus. Activation of this region does not require a detailed or realistic depiction; rather, a minimal 'first-order configuration'—typically two elements positioned above a third, mouth-like form—is sufficient to elicit rapid face-detection responses. Such processing occurs at an early stage of visual processing, often prior to higher-order cognitive evaluation.

From infancy, humans display a marked preference for face-like stimuli, a bias that scaffolds a lifetime of perceptual expertise. Because all human faces share a broadly consistent structural template, the visual

Proposed agent/process	Expected diagnostic features	Comparative references	Observations on RCBS19/37	Assessment
Rodent gnawing	Paired, parallel incisions; U- or flat-bottomed grooves; repetitive spacing; chisel-like edges	Fernández-Jalvo and Andrews (2016: A.131–A.226).	No paired or parallel incisions; no flat-bottomed grooves; edges acute	Inconsistent with observed morphology
Carnivore gnawing	Pits, scores, furrows; scooped cancellous bone; V-shaped notches; radial cracking; bevelled margins	Haynes (1980); Fernández-Jalvo and Andrews (2016: A.355–A.422); Rodríguez-Almagro et al. (2024).	No pits, scores, furrows, radial cracking, bevelling or bite arcs; intact sinus septum	Inconsistent with observed morphology
Avian puncture	Localised crushing; irregular pressure-release cracking; asymmetrical deformation	Fernández-Jalvo and Andrews (2016: A.355–A.422).	No crushing or irregular micro-fracturing; perforations bilateral and symmetrical	Inconsistent with observed morphology
Large carnivore puncture	Canine punctures with crushing, microfractures, pressure-release cracks	Fernández-Jalvo and Andrews (2016: A.355–A.422).	Edge profiles acute; no crushing or associated fractures	Inconsistent with observed morphology
Root etching	Sinuuous, dendritic, shallow grooves; irregular paths; diffuse surface modification	Fernández-Jalvo and Andrews (2016: A.227–A.276).	No dendritic or sinuous grooves; modifications are sharply bounded	Inconsistent with observed morphology
Chemical/hydro erosion	Diffuse surface rounding; loss of delicate structures; undercutting of features	Fernández-Jalvo and Andrews (2016: A.786–A.815).	Modifications localised; acute internal angles preserved; septum intact	Inconsistent with observed morphology
Subaerial weathering	Cracking, exfoliation, bleaching; staged deterioration	Behrensmeyer (1978); Fernández-Jalvo and Andrews (2016: A.639–A.743).	Minimal cracking; no exfoliation or bleaching; continuous patina	Inconsistent with observed preservation state
Fluvial transport/sediment movement	Generalised rounding and polishing; obscured or removed edges	Fernández-Jalvo and Andrews (2016: A.541–A.587).	No rounding of perforation edges; patterning preserved	Inconsistent with observed edge preservation
Trampling/rockfall	Jagged, irregular fractures; chaotic breakage; splintering	Fernández-Jalvo and Andrews (2016: A.951–A.1000).	Perforations coherent, symmetrical, and controlled	Inconsistent with observed fracture coherence
Pathological lesion	Irregular resorption; reactive bone; diffuse pitting; abscess margins	Ortner (2003).	No reactive bone or pathological morphology	Inconsistent with pathological modification
Utilitarian processing (brain extraction)	Access via occipital or basal regions; fractured vault; brain removal	Binford (1981); Marquer et al. (2012); Münzel and Conard (2004a).	Brain mass preserved; frontal perforations are inefficient for access	Inconsistent with functional access patterns
Post-depositional breakage	Colour mismatch; rough fracture surfaces; stepped or longitudinal breaks	Fernández-Jalvo and Andrews (2016: A.951–A.1000).	Patina continuous; fracture surfaces inconsistent with fully dry-bone breakage	Inconsistent with fracture surface characteristics
Intentional anthropogenic modification	Localised, redundant patterning; symmetry; controlled fracture planes; fresh-bone characteristics	(diagnosed by exclusion and pattern coherence)	Bilateral frontal perforations; acute edges; preserved septum; patterned morphology	Most parsimonious explanation given the cumulative exclusions

Table 2. Summary of diagnostic criteria used to evaluate alternative formation processes for the bilateral frontal perforations observed on RCBS19/37. Each proposed natural, pathological or non-symbolic anthropogenic agent is assessed against established taphonomic expectations, including edge morphology, fracture patterning, surface modification, spatial distribution, and bone-condition indicators. Processes such as rodent or carnivore gnawing, avian or large-carnivore puncture, root etching, chemical or hydro erosion, subaerial weathering, mechanical damage, pathology and utilitarian processing are excluded on morphological and contextual grounds. The localisation, bilateral symmetry, controlled fracture planes, preservation of fragile sinus architecture, and fresh-bone fracture characteristics observed on RCBS19/37 are most parsimoniously explained by deliberate modification occurring prior to subfossilisation, while acknowledging the absence of stratigraphic association and the resulting interpretive limitations.

system is highly efficient—and correspondingly permissive—in detecting this configuration. As a result, even crude or schematic arrangements of paired circular forms can reliably activate face-recognition pathways. Importantly, this perceptual response is obligatory: once the minimal configuration is present, face perception is triggered regardless of cultural background or conscious interpretive intent.

In this context, the bilateral frontal perforations of RCBS19/37 possess what may be described as exogrammatic properties. Here, the term ‘exogrammatic’ is not used to imply representational symbolism or encoded meaning in the conventional semiotic sense, but rather to denote information embedded directly within material form and rendered intelligible through shared human perceptual mechanisms. The configuration of the perforations, by virtue of their symmetry, spacing and placement on the frontal plane, affords an immediate face-like reading independent of any demonstrable iconographic program.

Crucially, the presence of such an affordance does not, in itself, demonstrate symbolic intent on the part of the modifier. Pareidolia cautions against the uncritical projection of meaning onto ambiguous forms. However, it also establishes a cognitive constraint: once two perforations are created in this specific spatial relationship on the frontal aspect of a cranium, the resulting object becomes perceptually non-neutral. Human observers would be strongly predisposed to process the form through face-detection pathways. In this sense, while iconographic intent cannot be proven, the perceptual consequences of the modification are effectively unavoidable. In other words, *any* bilateral perforation in this location would trigger the same perceptual response, whether intended or not; face-likeness is a *consequence*, not a claimed intention.

One interpretive framework consistent with this observation is that of anthropomorphous transformation, whereby an animal cranium is modified in a manner that evokes aspects of human faciality. Within this framework, the bear skull may have been altered to function as a mask, effigy, or focal object in which animal and human attributes are perceptually conflated. Such an interpretation remains hypothetical, but it provides a coherent explanation for the emphasis placed on the frontal region and the bilateral symmetry of the perforations.

Comparative material (see Table 3) lends cautious support to the significance of the frontal aspect of bear crania. At Piatra Altarului, the frontal region is oriented outward (Bednarik 2010: Fig. 5), as it is at Chauvet. In contrast, the skulls at Homoródalmás were facing inward, suggesting that cranial orientation was not uniform but deliberately structured.

While some of these assemblages remain controversial and cannot be straightforwardly interpreted as evidence of patterned behaviour, the recurrent and non-random manipulation of cave bear skulls suggests that skull orientation was sometimes structured and

may have had display or perceptual relevance.

Taken together, the morphology of RCBS19/37, the perceptual affordances generated by its modification, and comparative patterns of cranial emphasis in cave bear assemblages indicate that the observed perforations are unlikely to be accidental or perceptually neutral. Although the absence of archaeological context precludes definitive attribution of symbolic intent, deliberate modification of the frontal region in a configuration that reliably elicits face perception remains a parsimonious explanation and merits serious consideration within broader discussions of human–bear interaction during the Pleistocene.

Discussion

Bears provided Palaeolithic groups with substantial quantities of edible meat as well as furs, raw materials for tools, fuel and ornaments—categories well represented in the archaeological record (Withalm 2004; Wojtal et al. 2015; Majkić et al. 2018; Verheijen et al. 2022; Chu et al. 2024). At sites such as Hohle Fels (Münzel et al. 2004b; 2014; Kitagawa et al. 2012), there was seasonal exploitation of torpid cave bears. Bednarik’s (1994) proposal of noose use at Drachenhöhle further indicates planning and technical knowledge specific to bear acquisition. Beyond subsistence, several studies have noted that bear exploitation frequently involved behaviours that far exceed the immediate requirements of nutritional procurement. Grimm (2023) summarises Marvin’s observation that bear hunting frequently involved social display, risk negotiation and collective meaning-making beyond immediate subsistence needs. Archaeological examples supporting this observation include the clay bear effigy at Montespan, which exhibits multiple spear impacts and has been interpreted as evidence for non-utilitarian interaction.

Independent of hunting practices, a number of European cave sites preserve evidence for the non-random placement and modification of cave bear remains. Comparable skull-focused arrangements are documented at sites across Central Europe, indicating that such practices were geographically widespread during the Pleistocene (Table 3). For example, at Vaternica Cave near Zagreb, two discrete niche contexts contained cave bear skulls and long bones that were deliberately isolated from surrounding deposits (Bednarik 2017, 2020). One niche was sealed by a purpose-built stone wall constructed on a specific sedimentary horizon, while a second was closed by the placement of a large boulder. Stratigraphic relationships demonstrate that these closures predate subsequent sediment accumulation, excluding natural rockfall or sediment movement as plausible explanations. The energetic investment required to construct barriers or reposition large stones strongly supports intentional human action. Additional finds from Vaternica, including perforated mandibles and a charred skull in proximity to a hearth, further document re-

Site / Country	Chronological attribution	Documented arrangement	Interpretative significance	Figure 1 map reference; key references
Caverne des Furtins France	Early Upper Palaeolithic	Striking positioning of ten bear skulls (arranged in a circle).	Provides an early, central French instance of skull clustering, aligning with the patterned arrangements reported elsewhere across Europe.	1. Bednarik (2017; 2020).
Chauvet France	Early Upper Palaeolithic	Upright long bone embedded vertically in sediment, axially aligned with skull × 2 (Salle du Bauges). Bear skull on plinth and surrounded by 52 skulls. Stones arranged as seating in a possible 'theatre' (Salle du Crâne). Cave bear bones including a canine, vertebra, baculum, ribs and phalanges disposed of in places inaccessible to bears.	The exceptional preservation of the deposits and their close association with Aurignacian parietal art render purely taphonomic explanations highly implausible for these specific arrangements. In addition, many of the skulls in the Salle du Crâne appear to be axially aligned with the central plinth.	2. Bednarik (2004; 2020; pers. comm., 2025); Germonpré and Hämäläinen (2007).
Cioarei Romania	Middle Palaeolithic	Two bear skulls back-to-back, surrounded by ochre stones, were excavated next to a hearth. Multiple disarticulated cave bear limb bones showing intentional breakage and scoring marks.	Suggests intentional human processing and manipulation of bear remains beyond natural death/decay.	3. Bednarik (2017; 2020); Cărciumaru et al. (2002); Cărciumaru and Cîrstina (2003).
Divje babe I Slovenia	Middle Palaeolithic	Well-preserved adult male and female cave bear skulls were discovered near a large hearth. Placed with their sagittal surfaces downwards and occipital regions facing each other. The female cranium faced approximately east, the male faced west. The latter had its foramen magnum artificially enlarged and was symmetrically pierced on both processus mastoideus.	Provides another instance of skull clustering, aligning with the patterned arrangements reported elsewhere. Modification of one skull suggests processing beyond sustenance.	4. Turk and Dirjec (2007); Turk et al. (2014).
Drachenloch Switzerland	Middle Palaeolithic	Stone chest containing seven cave bear skulls oriented towards the cave entrance, with associated long bones.	Historically influential 'cult' site; highly contested due to poor documentation.	5. Bednarik (2017, 2020).
Goyet Belgium	Upper Palaeolithic	Cave bear bones stained with ochre.	Possible symbolic management.	6. Germonpré and Hämäläinen (2007).
Ho-moródalmás Romania	Early Upper Palaeolithic	Three cave bear skulls arranged face-to-face. Intentionally placed skulls.	Fits the clustering pattern. Earlier evidence was lost but aligns with surrounding regional practices.	7. Bednarik (2017, 2020); Vértes (1959).
Igrița Romania	Middle Palaeolithic/ Early Upper Palaeolithic	Cave bear skull in a 'box' formed by stone slabs.	Early example of a deliberately contained arrangement comparable to later structured deposits.	8. Bednarik (2017, 2020).
Istállóskő Hungary	Early Upper Palaeolithic	Extensive cave bear bone remains associated with human occupation deposits.	No clearly structured or patterned placement reported.	9. Bednarik (2017, 2020).
Kőlyuk Hungary	Early Upper Palaeolithic	Skulls and long bones deliberately placed in structured positions, including skulls set in niches or on stones and long bones arranged to flank or accompany them.	Supports the general interpretation of intentional, patterned deposition of cave bear remains.	10. Bednarik (2017; 2020).

Montespan France	Upper Palaeolithic	Life-size clay sculpture of a headless bear, fixed in place and perforated by multiple punctures interpreted as spear or projectile impacts. Also associated with other sculptures and engravings.	Provides evidence for performative and symbolic engagement with the bear, demonstrating intentional ritualised action rather than subsistence processing. A clear example of structured human–bear interaction.	11. Bednarik (2010, 2017, 2020).
Mornova zijalka Slovenia	Early Upper Palaeolithic	Single cave bear skull recorded on the excavation plan; no formal hearth documented, though charcoal concentrations were present.	No clearly structured or patterned placement reported.	12. Brodar (1996).
Peștera Coliboaia Romania	Early Upper Palaeolithic	Upright long bone embedded vertically in sediment, axially aligned with skull, paintings including a possible ‘bear’.	Provides a close parallel to the skull–long bone alignments documented at Chauvet.	13. Bednarik (2020); Gély et al. (2014).
Petershöhle Germany	Middle Palaeolithic	Bear skull discovered on a rock ridge. Hörmann also described ‘groups’ or ‘sets’ of bones that he thought were deliberately arranged.	Fits the pattern of intentional skull placement and arrangement of bear remains.	14. Bednarik (2020); Germonpré and Hämäläinen (2007).
Piatra Altă-rului Romania	Early Upper Palaeolithic	Four bear skulls arranged in a cross. Cave bear bones and skulls found selectively deposited in areas difficult to access.	Confirms the recurring pattern of separating cave bear remains from general deposits for special placement.	15. Bednarik (2010, 2017); Cârciumaru et al. (2015).
Regourdou France	Late Middle Palaeolithic	Neanderthal male internment found in a rectangular stone pit covered by large stone slab and adjacent to a full skeleton of a bear and 20 skulls.	A built structure directly associated with bear and human remains.	16. Bednarik (2020); Rougier (2021).
Reyersdorfer Cave Poland	Early Upper Palaeolithic	Arrangement of cave bear bones. Zötz found a skull of a cave bear in a niche, next to 3 cervical vertebrae and a mandible.	Suggests intentional human processing and manipulation of bear remains beyond natural death/decay.	17. Bednarik (2017).
Salzofen Cave Austria	Early Upper Palaeolithic	Cave bear skull with a long-bone inserted through the eye socket (orbit) – disputed by some.	Non-natural modification that is difficult for sceptics to explain via rockfall or bear activity.	18. Bednarik (2010).
Veternica Cave Croatia	Late Middle Palaeolithic / Early Upper Palaeolithic	63 skulls and several hearths. Skulls found in rows. 2 m artificial wall concealed a niche containing a cave bear skull and femur. Another recess sealed by a large boulder contained the largest skull found in the cave, along with polished mandibles.	Critical evidence: the masonry wall is strong evidence of human agency and intentional containment/concealment. Again, consistent with the pattern of intentional skull placement and arrangement of bear remains.	19. Bednarik (2010, 2017, 2020).

Table 3. Selected Palaeolithic sites with reported structured arrangements or modifications of cave bear remains, showing site, chronology, documented configuration and references.

peated manipulation of cave bear remains at the site. Across the sites mentioned, recurring emphasis on skulls, their spatial isolation, and their association with constructed or modified contexts suggests a degree of structured depositional behaviour that differs from unmodified discard. These cases are cited here not as direct analogues for the Bihor specimen, but as indications that bear-related behaviours in the Pleistocene were not uniformly limited to subsistence activities.

The Bihor specimen exhibits two perforations on the frontal vault that readily evoke the appearance of bilateral ‘eyes’, a perception consistent with documented tendencies toward pareidolia in the human

visual system. While perceptual response alone cannot establish intent, the symmetry, placement and morphology of the perforations—together with the exclusion of pathological, utilitarian and taphonomic explanations—are consistent with purposeful modification. Notably, there is no evidence that the cranial cavity was accessed for nutritional purposes, suggesting that the modification targeted the external appearance of the cranium rather than its contents.

Taphonomic assessment indicates that the modifications occurred while the bone retained structural integrity characteristic of collagen-rich ‘green’ bone. Fracture edges and surface characteristics are incon-

sistent with damage produced by post-depositional processes such as sediment pressure, carnivore activity or weathering in karstic environments. A radiocarbon date of 34,472–35,277 cal BP places the death of the animal in the terminal phase of cave bear persistence and situates the modification within the Early Upper Palaeolithic, broadly contemporaneous with Aurignacian contexts in south-western Romania.

At minimum, and within a strictly conservative framework, this behaviour may be described as artification (*sensu* Dissanayake and Malotki 2018), without recourse to inferred belief systems or symbolic taxonomies. The focused alteration of the frontal vault is comparable to several documented cases in which animal crania appear to have been treated differently from general carcass processing, for example, the Star Carr ‘frontlets’ (Little et al. 2016).

The concept of exograms is employed here in its narrowest sense, referring to durable, externally stored memory traces that stabilise or cue culturally relevant information beyond individual memory. The Bihor cranium may represent such a phenomenon: a materially altered object whose form would have been visually salient and readily distinguishable from unmodified remains. When evaluated alongside a broader European record of structured cave bear deposition, the Bihor specimen can be situated within a pattern of recurrent, non-random handling of cave bear remains documented at several Early Upper Palaeolithic sites. While the specific meanings attached to such practices cannot be recovered, the available evidence is compatible with deliberate modification, spatial organisation and recurrent handling practices among Early Upper Palaeolithic hominins.

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