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News and Views

Early modern human cranial remains from the Peştera cu Oase, Romania

Erik Trinkaus[a]*, Ştefan Milota[b], Ricardo Rodrigo[c], Gherase Mircea[b], Oana Moldovan[d]

[a] *Department of Anthropology, Campus Box 1114, Washington University, St. Louis, MO 63130, USA*
[b] *PRO ACVA GRUP, Str. Surduc 1, 1900 Timişoara, Romania*
[c] *Centro Nacional da Arqueologia Náutica e Subaquática, Instituto Português de Arqueologia, Avenida da India 136, 1300 Lisboa, Portugal*
[d] *Institutul de Speologie "Emil Racoviţă," Clinicilor 5, P.O. Box 58, 3400 Cluj, Romania*

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In February 2002, during speleological exploration of a karstic system in the southwestern Carpathian Mountains, Stefan Milota, Adrian Bîlgar and Laurentiu Sarcina discovered a previously unknown karstic chamber with abundant remains of *Ursus spelaeus*, occasional other mammalian skeletal elements, and a largely complete human mandible on the paleosurface. The karstic chamber was designated the Peştera cu Oase (Cave with Bones) and the human mandible Oase 1 (Trinkaus et al., 2003). The site served primarily as a hibernation chamber for Late Pleistocene cave bear, but the presence of the human mandible and several unusual arrangements of cave bear remains, including placement on raised rocks, indicates some human involvement in the accumulated deposits.

Oase 1 was directly ^{14}C AMS dated to >35,200 years BP (OxA-11711) and 34,290, +970, −870 years BP (GrA-22810), which together provide a finite age of 34,950, +990, −890 years BP (Trinkaus et al., 2003). Since the mandible has a distinctive modern human feature, a prominent *tuber symphyseos*, and a suite of discrete traits and overall proportions which place it close to European early modern humans among Late Pleistocene samples, this directly dated specimen is the oldest known diagnostic early modern human fossil from Europe. From a location close to the Iron Gates in the Danubian corridor, it may represent one of the earliest modern human populations in Europe.

In this context, it is of note that Oase 1 exhibits a very wide ramus, unilateral lingular bridging of the mandibular foramen, and in particular, exceptionally large distal molars for a Late Pleistocene human (Trinkaus et al., 2003). It therefore combines a derived early modern morphology with archaic *Homo* features and, possibly, a Neandertal trait.

* Corresponding author. Tel./fax: +1-314-935-5207
E-mail addresses: trinkaus@artsci.wustl.edu (E. Trinkaus), deepfane@hotmail.com (Ş. Milota), ricardo.cnans@ipa.min-cultura.pt (R. Rodrigo), mirceagherase@xsportsnet.org (G. Mircea), oanamol@hasdeu.ubbcluj.ro (O. Moldovan).

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Fig. 1. Anterior (right) and right lateral (left) views of the Oase 2 anterior cranial skeleton. Scale in centimeters. Note that the frontal squamous piece does not approach the midline and therefore gives the impression in lateral view of a more retreating frontal that was the case.

Given the age and morphology of Oase 1 and the paleontological richness of the Peştera cu Oase, we undertook in June 2003 a field season to generate a detailed paleosurface map of the Peştera cu Oase as a basis for future fieldwork. On June 20, 2003, during mapping of the current entrance passageway into the Peştera cu Oase, Ştefan Milota, Ricardo Rodrigo and Gherase Mircea discovered additional human remains on the cave's surface.

The Oase human cranial remains

The initial piece discovered is an anterior cranial skeleton (Fig. 1), which was found face down in a small alcove. This facial piece was accompanied on the surface by a largely complete left temporal bone (Fig. 4) and a number of frontal, parietal and occipital bone segments, as well as remains of *U. spelaeus*. Only surface pieces likely to be human, as well as some adjacent bear bones, were plotted in and collected, with further recovery of skeletal elements on hold until appropriate excavation procedures can be established in the cave.

The Oase 1 mandible is fully mature (M_3s in occlusion and worn). The facial skeleton in contrast is that of an adolescent with unerupted M^3s and an unfused sphenooccipital synchondrosis, and it therefore represents a second individual, Oase 2. Moreover, the Oase 2 palate is too wide for the M^1s and M^2s to occlude properly with those of Oase 1. In addition, the glenoid fossa of the temporal bone is too narrow to fit the left condyle of Oase 1, indicating that it too does not derive from Oase 1.

Since there is no apparent duplication of the cranial elements, it was initially assumed that all of

Fig. 2. Occlusal view of the Oase 2 palate and molars. Scale in centimeters. Note that the M^3s are still in their crypts and are partially visible distal of the M^2s.

the new human cranial remains belonged to the same individual. However, during cleaning and refitting, it was discovered that the facial piece and the left temporal bone do not derive from the same cranium. Both preserve the complete left sphenosquamosal suture. The two sutural edges are about the same length, but the temporal one is markedly wider inferiorly and the interdigitations do not match. Moreover, approximation of the two sphenosquamosal sutural edges places the temporozygomatic suture on the temporal bone too far anterosuperiorly and makes the anteromedial petrous impinge on the left pterygoid plates. Appropriate anatomical positioning of the zygomatic process and petrous portion relative to the anterior cranial skeleton leaves a gap of ca. 5 mm between the two sphenosquamosal sutures. As a result, the temporal bone becomes Oase 3.

In addition, the left parietal bone preserves the complete parietomastoid sutural edge and a small portion of the posterior squamous sutural edge. The same sutural area is preserved on the temporal bone, and they do not fit, in either length or interdigitations. The bi-parietal assembly (Fig. 3) therefore does not fit with Oase 3, yet there are no contacts between it and the Oase 2 facial skeleton. All of the sutural edges around the parietal bones are completely open, including the section of left coronal suture. The midparietal bone is relatively thin (ca. 5 mm) for a Late Pleistocene adult (early Upper Paleolithic: 6.7 ± 1.2 mm, N=20; Neandertals: 7.8 ± 1.4 mm, N=17), has little diploë in its cross section, and exhibits moderately thick tables. These patterns argue for a young age for the parietal bones, one that would be compatible with the adolescent age for the Oase 2 anterior cranial skeleton. Consequently, the parietal bones and a large but separate section of inferior right nuchal plane are tentatively assigned to Oase 2, pending verification

Fig. 3. Lateral (left) and posterior (right) views of the Oase 2 bi-parietal pieces. The coronal contour of the parietal bones is truncated just below the parietal bosses due to bone absence, which accentuates the impression of lateral verticality in occipital view. The parietal bones fit tightly along the sagittal suture despite the open interdigitations, allowing little variation in mid-sagittal curvature and bi-asterionic breadth from reassembly. Scale in centimeters.

through the expected discovery of additional pieces of the neurocranium.

The individual bones were coated with a thin layer of carbonaceous cave earth, most of which was easily removed through gentle brushing and mechanical removal with a soft wooden tool after air drying; the resistant matrix was left in place, and it does not obscure relevant morphological details. It is not known how the remains arrived at their location in the cave, but the multiple refits across old fossilization breaks, especially between the frontal squamous and the face and between sections of the parietal bones, suggest that at least the Oase 2 cranium arrived there largely intact and was broken in place. The facial section, which was found face-down in the sediment, sustained abrasion across the supraorbital and superior nasal areas, suggesting that it was pushed horizontally across the cave's surface in the past. Interestingly, four of the alveoli lack matrix (for both I^1s and the right C^1 and P^4), and it is probable that at least those teeth are present in the underlying soft cave earth. Additional pieces of the neurocranial vault are also likely to be present.

The geological age of the additional Peştera cu Oase human remains is not currently known, since they are a paleosurface find within the cave. The remains will be dated directly by ^{14}C AMS (samples have been taken from the left parietal endocranial table and an associated cave bear metapodial diaphysis), but in the meantime the morphological parallels with Oase 1 (see below) argue in favor of contemporaneity, between ca. 34,000 and ca. 36,000 years BP.

The analysis of these remains is preliminary, especially given that additional pieces of at least the Oase 2 cranium are very likely preserved in the Peştera cu Oase and a direct date on the remains is not available. This note is intended to serve as an announcement of these fossils and provide a limited description and comparative framework for the remains. Cranial morphometrics available on the preserved pieces are in Table 1, and some comparative data for select measurements of Late Pleistocene northwestern Old World samples are in Tables 2–4. The trivial level of changes in the neurocranial bones during later adolescence means that the Oase 2 frontal squamous and parietal measurements accurately represent its projected mature dimensions. However, the facial skeleton is likely to have changed modestly had the individual lived to maturity.

Table 1
Morphometric dimensions of the Oase 2 and 3, in millimeters and degrees. As appropriate, measurements designations from Bräuer (1988) and Howells (1973) are included

	Right		Left
Oase 2			
Minimum frontal breadth (M-9)		97.5	
Bi-stephanic breadth (M-10b, STB)		(105.0)[a]	
Maximum frontal breadth (M-10, XFB)		(112.0)[a]	
Interorbital breadth (DKB)		28.5	
Orbital height (M-52, OBH)	(32.0)[b]		(31.0)[b]
Orbital breadth (M-51a, OBB)	42.0		41.3
Nasion-prosthion height (M-40, NPH)		69.0	
Nasal height (M-55, NLH)	47.0		48.5
Nasal breadth (M-54, NLB)		25.0	
Bi-frontal breadth (M-43A, FMB)		107.5	
Frontomalare anterior to nasion	57.5		57.8
Nasiofrontal subtense (M-43b, NAS)		20.8	
Nasiofrontal angle (NFA)		138°	
Bi-jugal breadth (M-45(1), JUB)		(128.0)[c]	
Cheek height (M-48d, WMH)	25.1		26.0
Bi-maxillary breadth (M-46b, ZMB)		101.0	
Zygomaxillare anterior to subspinale	57.2		58.0
Zygomaxillary subtense (M-46c, SSS)		27.7	
Zygomaxillary angle (SSA)		123°	
Bregma-lambda chord (M-30, PAC)		117.3	
Bregma-lambda arc (M-27)		133.0	
Parietal angle (M-33e, PAA)		129°	
Bregma-asterion chord	–		136.7
Lambda-asterion chord	87.3		78.5
Bi-asterionic breadth (M-12, ASB)		100.5	
External palate breadth (M^2) (M-61, MAB)		72.2	
External canine breadth (C^1/P^3)		50.7	
External incisor breadth (I^2/C^1)		33.0	
Oase 3			
Mastoid height (M-19a, MDH)	–		(24.0)
External auditory porous height	–		11.2
External auditory porous breadth	–		6.8

[a]Double the distance from the mid-sagittal plane to the lateral frontal bone.
[b]Estimated due to damage to the superior orbital margins.
[c]Estimated due to damage to the posterolateral zygomatic bones. Listed to provide an indication of overall facial breadth.

The Oase 2 cranium

The Oase 2 cranium (Figs. 1–3) is that of a mid second decade adolescent; the M^3s appear to have complete crown formation but have just reached alveolar eruption, and the sphenooccipital synchondrosis is completely patent. Oase 2 is well preserved in those regions which are usually fragmentary in fossil human crania. These areas include the anterior maxillae and adjacent zygomatic bones, the internal orbital surfaces, the internal nasal, posterior choanal and ethmoid region, and the sphenoidal area. There is also a piece of right frontal squamous which extends to the coronal suture around stephanion. The facial skeleton exhibits a mild asymmetry, in which the left side is higher than the right side (using the mid-sagittal plane for reference), but it is not reflected in individual measurements.

The separate bi-parietal piece (Fig. 2) retains the sutural margin on the left bone from the mid-coronal suture to the posterior squamous suture via bregma, lambda, asterion and entomion. Much of the intervening bone is present in good condition. The right parietal bone retains the sutural edge from the middle of the sagittal suture to the posterior squamous suture via lambda, asterion and entomion. The two pieces fit together snugly along the open sagittal suture.

Oase 2 is similar to Oase 1 in representing a large early modern human. The superciliary arches are modest where preserved and provide no evidence of either a supratoral sulcus or a thickening of the lateral trigone. There is some swelling of the glabellar region and an associated depression of nasion, as is evident in lateral view (Fig. 1). The small size of the arches may be due in part to the immature status of Oase 2, but they are unlikely to have become larger than those common among later European Aurignacian or Gravettian crania. The orbits are subrectangular and appear relatively low, or wide. The nasal aperture is eroded superiorly, but it retains the complete inferior and inferolateral aperture margins, with slight damage to the anterior nasal spine. Its original breadth was modest, similar to early Upper Paleolithic Europeans and distinct from Middle Paleolithic archaic and early modern human remains (Table 2). The inferior margin has separate lateral crests with joined turbinal and spinal crests (category 3 of Franciscus, 2003); this pattern is absent from all Neandertals (except the earlier Krapina

Table 2
Facial measurements of Oase 2, with mean ± standard deviation (N) for the comparative samples, in millimeters and degrees

	Nasiofrontal Angle	Zygomaxillary Angle	Nasal Breadth	Interorbital Breadth	Interorbital/Nasal Breadth Index
Oase 2	138°	123°	25.0	28.5	114.0
Early Upper Paleolithic	141.4° ± 6.2° (12)	129.9° ± 12.2° (4)	26.0 ± 2.3 (21)	25.4 ± 1.7 (16)	98.5 ± 7.2 (4)
Qafzeh-Skhul	147°, 152°	124°, 133°	31.0, 32.3, 32.5	24.0, 27.0, 28.2	86.8
Neandertals	134.8° ± 5.9 (10)	113.3° ± 6.3° (9)	32.2 ± 3.2 (14)	28.1 ± 2.1 (6)	83.5 ± 5.7 (16)

Table 3
Comparative neurocranial morphometrics of Oase 2, with mean ± standard deviation (N) for the comparative samples

	Parietal Chord/Arc Index	Parietal Angle	Bi-Asterionic Breadth/Parietal Arc Index
Oase 2	88.2	129.5°	85.7
Early Upper Paleolithic	90.4 ± 2.4 (34)	136.5° ± 4.0° (16)	83.0 ± 6.5 (14)
Qafzeh-Skhul	90.6 ± 2.5 (6)	134°, 134°, 142°	92.7 ± 10.3 (6)
Neandertals	92.2 ± 1.9 (15)	143.5° ± 4.5 (14)	100.6 ± 5.5 (9)

Table 4
Comparative dental buccolingual crown diameters for Oase 2 maxillary molars, in millimeters. Mean ± standard deviation (N) and range provided for each comparative sample. Oase 2 M^3 crown diameters not provided, since they remain in their crypts; they are greater than those of the M^2s

	M^1	M^2	M^3
Oase 2 (right, left)	14.0, 14.1	14.3, 14.3	–
Early Upper Paleolithic	12.2 ± 0.8 (37)	12.4 ± 0.9 (32)	11.6 ± 1.1 (27)
Qafzeh-Skhul	12.2 ± 0.7 (18)	12.0 ± 0.7 (9)	11.7 ± 0.6 (6)
Neandertals	12.0 ± 0.8 (34)	12.3 ± 1.0 (25)	11.9 ± 1.4 (29)

47) and variably present in African *Homo* and western Eurasian early modern humans. The infraorbital area on both sides presents a distinct and deep canine fossa, accentuated by the anterior positioning of the zygomatic bone.

Despite these derived features of early modern humans, or features that occur more frequently among them, Oase 2 is similar to Oase 1 in presenting several aspects that would be unusual to find in a more recent early modern European. The zygomatic arches are large, and their inferior margins flare slightly laterally, a pattern which may correlate with wide mandibular rami similar to those of Oase 1. The height between the inferior zygomatic bones and the alveolar plane is pronounced, resulting in the appearance of a relatively long face. The palate is large, especially across the anterior dentition (Fig. 3). The depth of the palate appears to be pronounced, even compared to adolescent or young adult Gravettian specimens (e.g., Dolní Věstonice 13 and 14). And in contrast to the nasal breadth, the interorbital breadth is pronounced, falling at the top of the early modern human range of variation and slightly above the Neandertal mean, being matched among those early modern humans only by Mladeč 2 and Qafzeh 9 and some African specimens. In particular, the index of interorbital to nasal breadth (Table 2) shows the degree of contrast between these two nasal features, since the Oase 2 value falls above the combined Late Pleistocene range. The large dimensions of the Oase 2 face (see Table 1) are especially notable, given the mid-adolescent age of the specimen.

The pattern of anterior projection of the midface, as reflected in part in the nasiofrontal and zygomaxillary (subspinale) angles of Oase 2, appears intermediate between the reference samples. Both angles for Oase 2 fall between the means for the Late Pleistocene comparative samples (Table 2), indicating that Oase 2 has a moderately projecting midface for an early modern human.

The bi-parietal bones provide an evenly rounded contour across the mid-sagittal plane in occipital view, a rounded contour that continues across the parietal bosses (Fig. 2). This is a pattern more commonly seen among the Neandertals. However, the region preserved down to asterion and the parietal notch on each side suggests that the inferior parietal contours were straighter and relatively vertical. If Oase 2 had laterally bulbous mastoid processes, similar to that of Oase 3 (see below), the overall mid-parietal coronal contour would have resembled the more angled (pentagonal) one characteristic of early modern humans but with an unusual rounding of the superior portion.

The parietal bones of Oase 2 otherwise indicate a narrow, high and curved neurocranium. The mid-sagittal arc of Oase 2 is strongly curved, with a parietal angle at the bottom of the early Upper Paleolithic range of variation and a relatively low bregma-lambda chord/arc index (Table 3). In addition, an index of bi-asterionic breadth to the parietal arc (Table 3) places Oase 2 with the early Upper Paleolithic crania and distinct from low and broad Neandertal neurocrania.

The parietal bones exhibit a slight concavity in *norma lateralis* just anterior of lambda, or a supralambdoid flattening, suggesting the original presence of an occipital bun such as are found in Neandertals, early modern humans and other later Pleistocene *Homo*. The lambdoid and sagittal sutures, as well as the region by asterion, appear to be devoid of the sutural ossicles common among both Neandertals and European early modern humans (at least as indicated by the parietal sides of those sutures).

The M^1s and M^2s have moderate occlusal attrition which partially obscures their surface details (Fig. 3), but they exhibit large hypocones (ASUDAS (Turner et al., 1991) grades 5 and 4 respectively), have distinct metaconules (grades 5 and 4 respectively) and appear to lack parastyles. The M^3 occlusal morphology is largely visible through the resorbed and damaged alveolar bone; both of the teeth have markedly crenulated crowns with large hypocones (grade 4 or 5), large parastyles (grade 3) and appear to lack metaconules.

As with Oase 1, the molars are pronounced in their dimensions. The breadths of the mesial two molars are at the upper limits of the Late Pleistocene ranges of variation (Table 4). The dimensions of the M^3s are large, especially in their breadths, but they are as yet not directly measurable. Observation of them in their crypts indicates that their buccolingual diameters exceed those of the more mesial molars (the right one has a breadth >15 mm), paralleling the pattern of progressive distal molar enlargement seen in Oase 1. Among Late Pleistocene humans, the M^3 breadths are generally smaller than those of the M^1s and M^2s (Table 4); among Pleistocene northwestern Old World *Homo*, only the La Chapelle-aux-Saints 2 M^3 with a breadth of 15.0 mm exceeds 13.7 mm. As with the mandibular molars of Oase 1, the combination of large and progressively larger distal molars in Oase 2 is unusual for a Late Pleistocene northwestern Old World human, most similar to what is seen in the Neandertals, and generally archaic for later Pleistocene humans.

Oase 3 temporal bone

The Oase 3 left temporal bone (Fig. 4) is largely complete, having lost its anterosuperior squamosal sutural edge and sustained some damage to the lateral superior petrous above the mastoid air cells. It appears to be fully mature, and found alone it would be considered so. However, except for male mastoid growth, there are few changes in the temporal bone after the mid second decade, making assessments of adolescent versus mature status ambiguous. It is treated here as adult.

The height of the mastoid process from the Frankfurt horizontal (assessed using the external auditory porous and the zygomatic process) is

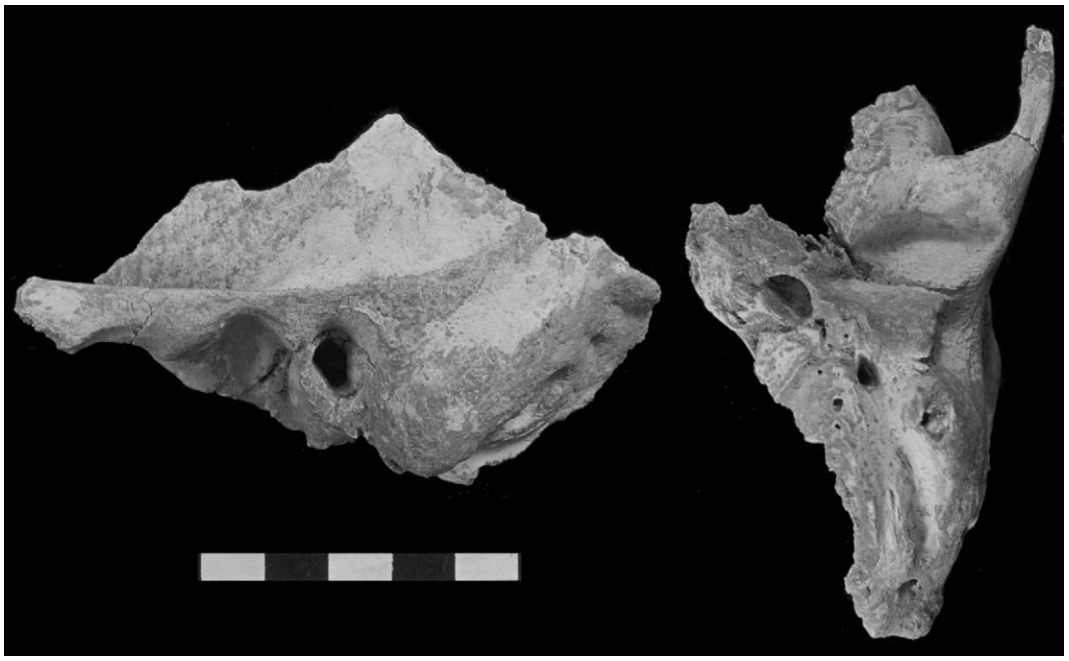

Fig. 4. Lateral (left) and inferior (right) views of the Oase 3 left temporal bone. The bone is oriented relative to the horizontal plane of the glenoid fossa, articular eminence and petrous process and to the long axis of the zygomatic process. Scale in centimeters.

ca. 24.0 mm. This value is relatively small, even for a recent human (Howells, 1973), suggesting that Oase 3 is female.

The Oase 3 temporal bone is essentially modern in overall morphology. The zygomatic arch is horizontal above the porous. The external auditory porous is slightly keyhole-shaped in outline with the long axis oriented anterosuperior to inferoposterior ca. 10° from vertical. There is a modest thickening of the lateral tympanic margin, a moderately bulbous mastoid process which has a straight posterior margin descending from near asterion, and a deep glenoid fossa with a very small postglenoid process. There is little development of the supramastoid crest. The stylomastoid foramen is in line with the digastric sulcus.

However, Oase 3 presents a pronounced juxtamastoid eminence along the mastooccipital suture with a deep digastric sulcus between it and the mastoid process. The maximum development of the juxtamastoid eminence is unknown without the adjacent occipital bone, but the preserved temporal portion of it has an inferior extent which is at or beyond to the inferior tip of the mastoid process (with the horizontal plane of the bone determined by the temporomandibular articulation and petrous process) (Fig. 4). Even with the modest height of the Oase 3 mastoid process, this is an unusual projection of the juxtamastoid eminence for a small early modern human.

Summary

The recently discovered human cranial remains from the Peştera cu Oase emphasize a pattern already known from the probably contemporaneous Oase 1 mandible. The remains are essentially "modern" in the cladistic sense of the term, since the three main pieces, the facial skeleton and bi-parietal section of Oase 2 and the temporal bone of Oase 3, exhibit a suite of derived "modern human" features. Yet, these diagnostic features are associated with several archaic aspects of the

cranium and dentition, including the pronounced juxtamastoid eminence of Oase 3, the robust and flaring zygomatic bones of Oase 2, and especially the large dimensions of the Oase 2 molars. More precise assessment of the affinities of the Oase human remains, however, must await further fieldwork at the Peştera cu Oase and more detailed comparative analyses of these recent discoveries.

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