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Chapter 7

THE PLEISTOCENE HUMAN REMAINS

During the excavations in the Peştera Muierii in 1952, a series of human remains were noted by Nicolăescu–Plopşor in his field diary (tabl. 19). A number of the remains were discovered in the upper levels of the Galeria Principală, and they derive from later Holocene (Bronze Age) deposits in the cave (see Chapter 8). There was an isolated tooth from the Galeria Principală (Muierii 4), which appears to have been associated with Pleistocene fauna.

Of direct concern here are the remains discovered in the Galeria Musteriană, remains which were associated in the cave with Middle Paleolithic technology but which appear, on the basis of direct radiocarbon dating of two of the preserved bones and inferred depositional history (Chapter 2), to date to the earlier Upper Paleolithic (Muierii 1 to 3).

The Galeria Principală Pleistocene Human Remains

In the field notes of Nicolăescu–Plopşor (1952; tabl. 19), a third molar was listed as having been found in the Galeria Principală at a depth of 3.35 m, associated with a Pleistocene fauna. As subsequently noted by Daicoviciu and colleagues (1953:203), "Without any change of the structure (in the layers), in the superior side, between 3.50 – 3 m, the level contained 40 cm of porous soil, which provided a fragment of a flint blade and two splinters of quartz which belong to the Upper Paleolithic, and a third left maxillary molar in association with: *Ursus spelaeus* Blum, *Felis leo* L. *rasa spelaea* Goldf., *Canis lupus spelaeus* Goldf., *Bison* (*priscus* Boj.)" (our translation).

The tooth was originally referred to as a mandibular third molar and later as a third left maxillary molar, probably as a result of further assessment in the laboratory. The molar was subsequently listed as part of the human remains from the Peştera Muierii in a museum exhibition (Haas 1956), but its current whereabouts is not known.

In addition to the original attribution of it to the Upper Paleolithic based on associated lithic remains, the association with extinct cave bear (*U. spelaeus*) serves to place it within the earlier Upper Paleolithic, since cave bears went extinct at least by ~24,000 ^{14}C years BP (or ~28,000 cal BP) (Pacher & Stuart 2009). It therefore represents an additional Pleistocene individual from the Peştera Muierii; it is designated Muierii 4, even though it was actually found first (August 9, 1952, three days before the first pieces of Muierii 1 were discovered).

The Galeria Musteriană Human Remains – Preservation, Age and Sex

In the field catalogue (Nicolăescu–Plopşor 1952), the Galeria Musteriană Paleolithic human remains consisted of a neurocranial vault retaining major portions of the frontal, left parietal and occipital bones, a left temporal bone, a maxilla (or both maxillae), the right side of a mandible, ten teeth associated with the mandible and maxillae, two thoracic vertebrae, a scapula and a right tibia. Based on color and degree of fossilization, it was inferred that all of these remains derived from one individual. Published description of these remains shortly thereafter (Daicoviciu *et al.* 1953; Gheorghiu & Haas 1954) listed the cranium with the maxillae, the partial mandible, the scapula and tibia. Moreover, the latter publication provided photographs of all of these bones. More recently, Olariu and colleagues (2001, 2003, 2005), in their direct radiocarbon dating of the human bones in 2001, listed their samples as deriving from the human scapula and the tibia.

In our re-analysis of the Muierii Pleistocene human remains since 2005, we were able to locate only some of the bones originally listed by Nicolăescu–Plopşor and illustrated in the 1950s. These remains, for reasons unknown to us, are divided between the Muzeul Olteniei in Craiova and the Institutul de Speologie "Emil Racoviţă" in Bucharest.

In the Muzeul Olteniei there is most of the cranium, retaining portions of the frontal, right and left parietal and occipital bones, as well as the maxillae. There are eight teeth associated with the maxillae, the right second incisor (I^2), the right first premolar (P^3), the three right molars (M^1 to M^3), the first two left molars (M^1 and M^2), plus the right mandibular canine (C_1).

The last tooth was associated with the maxillae, inserted into the left maxillary canine socket (fig. 13; Gheorghiu & Haas

1954; Soficaru *et al.* 2006). However, in 2008 we realized that it did not fit the C^1 maxillary socket appropriately and that it is a perfect fit for the distal right canine socket preserved on the mandible. It is also morphologically a mandibular, and not a maxillary, canine (fig. 62). In the field diary of Nicolăescu–Plopşor (1952), it is noted that the a maxilla (right) and six teeth were found on August 19, 1952 and that the left maxilla, an incisor and a premolar were found on August 20, 1952 (tabl. 19). In the "in situ" photograph (fig. 13) all of these teeth were inserted into the maxillae, including the mandibular canine. The original misidentification of the C_1 therefore took place during the excavations, when the maxillae were posed for the "in situ" photograph.

The remainder of the currently known Pleistocene human remains from the Galeria Musteriană is in the Institutul de Speologie "Emil Racoviţă." They include the right mandibular corpus and ramus with the first two molars (M_1 and M_2), the body of the left zygomatic bone, a left temporal bone, a major portion of a right scapula, and a diaphyseal section of a fibula. The zygomatic bone articulates with the frontal bone and maxillae in the Muzeul Olteniei and provides an anatomical connection between the two sections of the cranium. The temporal bone is assumed to be the one listed by Nicolăescu–Plopşor, and for reasons provided below is unlikely to derive from the same individual as the remainder of the cranial elements. It has no direct contacts with the remainder of the cranial remains. The piece of a fibula, which is labeled "BF 52" (Baia de Fier 1952), does not appear in any of the previous lists or illustrations of human remains from the site. And the human tibia, illustrated by Gheorghiu & Haas (1954: fig. 5) and apparently dated by Olariu and colleagues, was not located in either institution (only photographs in the Institutul de Antropologie "Fr.J. Rainer"), nor were the thoracic vertebrae that were listed in the field notes.

The available sample of Pleistocene human remains from the Galeria Musteriană therefore consists of a cranium with the major portions of the neurocranial vault, a zygomatic bone and the maxillae, a right partial mandible, ten teeth, a temporal bone, a scapula, and a partial fibula. Additional brief notes are possible from the earlier publication and photographs of the tibial diaphysis. Based on morphological considerations (see discussion below), the cranial vault with its attached upper facial skeleton, the mandible, the scapula and the tibia are inferred to represent one individual, Muierii 1. The temporal bone is separated to represent a second individual, Muierii 2. The fibula is designated Muierii 3.

The Muierii 1 Cranium

The Muierii cranium consists of a largely complete cranium from the anteroinferior maxillae around the neurocranial vault to opisthion. The sphenoid bone is largely absent, as are both of the temporal bones and the basioccipital. There are seven teeth preserved in the largely complete maxillary alveolar process.

The neurocranium

The bones of the neurocranium fit well with each other. There is distortion along a transverse postmortem break in the anterior left parietal bone, from the middle of the right parietal bone to the coronal suture on the left parietal bone. In 2008 the glue join was cleaned and the bones repositioned relative to each

Discovery date	Human bones	Cave and stratigraphic context	Associated faunal species	Archeological associations	Age	Comments	Nicolăescu-Plopşor's notes
09.08.1952	Mandibular third molar	Galeria Principală, C1, –3.35 m	*Ursus spealeus, Felis leo, Canis lupus, Bos primigenus*	Fragment of flint blade (burned)	--	--	Page 62, lines 1–8
12.08.1952	Frontal and a piece of left parietal, occipital	Galeria Musteriană, sector A, –1.15 m	*Ursus spelaeus*	Quartzite tools	Mature	"Coronal and sagittal sutures are completely closed; frontal torus missing; occipital *chinion*; large nose"	Pages 62b – 64
18.08.1952	Right tibia and thoracic vertebrae	Galeria Musteriană, sector A, –0.55 m	*Ursus spelaeus*	eight quartzite tools	--	"by color and fossilization they could belong to the same skeleton as the skull fragments"	Pages 69b, lines 9–20
19.08.1952	Maxilla with six teeth	Galeria Musteriană, sector A	--	Flints and quartzite fragments	--	--	Page 72, lines 1-6
20.08.1952	Scapula, left temporal, maxilla left lateral incisor and premolar, thoracic vertebra	Galeria Musteriană, sector A, –0.95 m	*Ursus spelaeus, Canis lupus* teeth	Charcoal, two quartzite tools	--	"all the human bones belong to the same skeleton"	Page 72b, lines 16–76
22.08.1952	Right half of mandible with first and second molars	Galeria Musteriană, sector A, - 0.65 m	*Ursus spelaeus, Canis lupus* fragments	six quartzite tools	--	--	Page 80, lines 13 – 82

Table 19 - The Pleistocene human remains discovered in the Galeria Principală and the Galeria Musteriană of the Peştera Muierii, as determined from the field notes of C.S. Nicolăescu–Plopşor (Nicolăescu–Plopşor 1952).

other, but modest distortion remains. This parietal distortion does not appear to have affected the midline sagittal contour.

The frontal bone preserves a largely complete squamous portion and supraorbital region. The orbital margins and superciliary arch region are especially well preserved. There are two radiating cracks in the squamous portion rising above each supraorbital notch; there are only slight exocranial expansion cracks, and they do not affect the external contour of the bone. The interorbital portion of the frontal bone is complete across the frontonasal and frontomaxillary sutures. The left orbital roof is largely absent, but a portion of the right one is preserved, especially laterally. The right frontozygomatic suture is complete, and the left one sustained only minimal abrasion. The right suture for the greater wing of the sphenoid bone is slightly abraded but otherwise complete; the left one is less complete but extends well below the temporal line and is close to the original sutural margin. The right coronal suture is complete and the left one is preserved to stephanion. However, the coronal suture is completely fused and obliterated endocranially and is evident only as a fine line exocranially.

The right parietal bone is essentially complete with almost all of its sutures intact. The only marginal bone loss is along the anterior squamous suture, but 27 mm of the suture remains from mid-suture posteriorly to entomion. There was a postmortem break centered close to the eminence along the superior temporal line, with radiating cracks to the mid-sagittal, mid-squamous and anterior sagittal suture. The pieces rejoined with no apparent deformation and minimal bone loss exocranially.

The left parietal bone is less complete. There is a strip of bone 10 to 12 mm wide along the coronal suture extending inferolaterally to the area of stephanion. The larger piece is a medial section of the bone from the sagittal suture to the vicinity of the eminence and continuing along the sagittal suture to the medial half of the lambdoid suture. The region from the parietal eminence to the parietal striae is absent. In the posterior half of the bone, a hole 21 by 26 mm was drilled for geochemical analysis, the results of which were never received by the Muzeul Olteniei (Chapter 2); it does not affect morphological interpretation of the bone. Along the break between the anterior piece of left parietal bone and the larger posterior piece there is a slight distortion, such that the portion anterior of the eminence is displaced slightly superiorly. This distortion appears to be localized and does not affect the coronal or sagittal sutural contours or dimensions.

The complete sagittal suture is clear exocranially. It is fused and obliterated along its anterior one-third endocranially, and it is present as a thin open line along its posterior two-thirds. Approximately 3, 8 and 17 mm above lambda, there are small postmortem holes in the external suture, 2.2, 5.2 and 5.2 mm in diameter respectively, which have been partially filled with glue.

The squamous portion of the occipital bone is complete on the right side, retaining all of the right lambdoid suture and 19 mm of the right occipitomastoid suture. On the left side, it preserves the medial 38 mm of the lambdoid suture, and then it is broken from that point, along an irregular line, to the left lateral side of the foramen magnum. The midline is intact from lambda to opisthion, but the foramen magnum margin is present only posterolaterally on the right side and around to the area just posterior of the condyle on the left side. There is no trace of the condyles, and the entire basioccipital region is absent. The lambdoid suture is open, and the occipital bone has been glued cleanly to the parietal bones.

The Splanchnocranium

The facial skeleton consists of nasal bones attached to the frontal bone, portions of both zygomatic bones, major portions of both maxillae, both palatine bones at the posterior maxillae, and a fragment of the left sphenoid bone. The only connection between the splanchnocranium and the neurocranium is through the anterior left zygomatic bone. That bone connects securely to the left maxilla, but its contact with the left frontal bone is more tenuous. Using the midlines of the maxillae and the frontal bone, it is possible to align the face using the two mid-sagittal planes. The angle of the face, and hence its degree of prognathism, is more approximate and requires using the contours of the left frontozygomatic region.

To approximate the original position of the splanchnocranium relative to the neurocranium, in 2008 in the Muzeul Olteniei we separated the maxillae from the frontal (where it had been attached with plaster) and glued the left zygomatic bone to the maxillae. Then using the left frontozygomatic suture as a pivot point, we aligned the maxillae using the mid-sagittal planes of the neurocranium and the maxillae and the anterior contour of the left frontozygomatic region. The right temporal bone is absent, but we were able to articulate the right mandibular and maxillary molars in centric occlusion, and thereby we could verify that the right mandibular condyle was close to the original position of the temporomandibular joint (fig. 30). The maxillae were held in position relative to the neurocranium using thin wooden dowels; unfortunately, the zygomatic bone had to be subsequently removed and returned to the Institutul de Speologie "Emil Racoviţă" in Bucharest.

It is possible that there is a modest error in the degree of prognathism in our reconstruction. However, given the oblique rotation around the frontozygomatic suture and the constraints of the mid-sagittal plane, it is likely to be modest. Measurements that are dependent on the reconstruction are indicated as estimated.

Attached to the frontal bone are the superior portions of the nasal bones, ~12 mm long on the right side and ~8 mm long on the left side. All of the frontonasal suture is preserved on the nasal bones, and well as the superior portion of the internasal suture.

The more complete left zygomatic bone retains the lateral orbital margin between the maxilla and the frontal bone, a portion of the lateral internal orbital surface (sampled for direct radiocarbon dating of the cranium in 2005; see Chapter 2), and a portion of the lateral and posterior surfaces of the frontal process. The temporal process and the inferior margin of the maxillary process are absent. The right zygomatic bone is present only as

Figure 30 - Right lateral view of the Muierii 1 cranium with the articulated right mandible.

a small piece, ~10 mm anteromedial to posterolateral, along the zygomaxillary suture. It retains the anterior margin of the masseter origin and therefore provides zygomaxillare anterior.

The right maxilla has its external surface largely complete from the zygomaxillary suture to the complete alveolus, to the nasal margin, and to the intermaxillary suture subnasally and along the palate. The damage to the bone includes all of the orbital floor and most of the inferior orbital margin, the posterior midline of the palate, the anterior nasal spine and the lateral wall of the nasal cavity. There is also damage to the frontal process, such that it is broken and abraded near the superolateral nasal aperture. A small piece of the process with the frontomaxillary suture remains attached to the nasal and frontal bones. The right alveoli are complete except for a small chip buccally adjacent to the M^2.

The left maxilla is more complete, and it lacks only the medial orbital floor, the lateral nasal cavity wall, the anterior nasal spine, and most of the frontal process. The alveoli are complete except for small chips of bone absent from the lingual M^1 alveolus and the buccal M^3 alveolus.

The palatine bones are present around their greater palatine foramina and along the lateral portions of the palatomaxillary sutures. There is also a small piece of the left pterygoid base fused onto the retromolar process of the left maxilla.

The Muierii 1 Mandible

The Muierii mandible is a largely complete right ramus and corpus, from the distal C_1 alveolus to the condyle. The bone was originally more slightly more complete (fig. 57), but the anteroinferior corner was rounded off to obtain a radiocarbon dating sample at some point, and a small corner along the anteromedial corpus break was removed in 2005 for further dating and isotopic analysis (fig. 58). Neither of these sampling events detracts from the observed morphology, but the former needs to be mentioned since it may falsely give the impression of a rounding in the region of the anterior marginal tubercle.

The mesial break of the mandibular corpus is through the distal C_1 socket, with 13 mm of the superior distal socket with ~1 mm of lingual and labial lamina dura remaining. The break slopes distoinferiorly, to end below the P_4 alveolus. The lateral corpus is then intact from P_3/P_4 to the ramus, with only small hairline cracks, especially mesial of the mental foramen. Medially, the bone is intact with a hairline crack below P_4/M_1.

The ramus is largely intact with a lateral crack from the inferior margin below the M_3 running posterosuperiorly and then fading out 10 mm anterior of the condylar neck. The medial ramus is intact despite some trivial loss of bone on the posteroinferior margin of the lingula. The condyle is complete, as is the coronoid process. However, the mandibular notch is missing bone from its anteroinferior margin, but the margin is intact for 15 mm posteroinferior from the coronoid tip and for 9 mm anteriorly from the condylar margin.

The Muierii 1 Associated Dental Remains

The ten teeth preserved from the Pleistocene deposits of the Peştera Muierii are all in the alveoli of the maxillae or mandible or, in the case of the lower canine, fits cleanly onto the preserved distal socket. Consequently, all of them are securely associated with the mandible and the maxillae. They include an I^2, a P^3, both M^1s, both M^2s, an M^3, a C_1, an M_1 and an M_2.

The maxillary alveoli and dentition

All sixteen alveoli of the maxillary dentition are present and largely intact. There are small chips of bone absent from the left lingual M^1, the right buccal M^2, and the left buccal M^3. Even though there has been supereruption of the dentition associated with occlusal attrition (see below), there is no apparently pathological alteration of the alveoli or destruction of the interdental septa. Moreover, the even supereruption of the teeth and maintenance of the occlusal plane, especially in the maxillae, indicates normal occlusion around the mandibular dentition (most of which is missing). All of the teeth were in occlusion at the time of death.

The teeth are extensively worn, but there is little damage to the crowns or the roots. There is a small chip gone from the mesiolabial occlusal edge of the I^2. There is a small chip gone from the buccal edge of the distal interproximal facet of the left M^2. There is minimal calculus on the buccal left M^1 and M^2.

The Mandibular Alveoli and Dentition

The mandibular alveoli are present from the distal C_1 alveolus to the distal M_3 alveolus. The distal C_1 socket is intact. The P_3 socket is intact, but there is a possible reduction of ~1 mm of the buccal margin. There is a slight loss of bone on the distolingual margin of the P_4 socket.

The M_1 alveolus is less well preserved. Buccally there is a chip of bone absent along the roots, exposing 4.7 mm of the roots below the alveolar plane. The lateral surface of the M_1/M_2 septum has also lost bone down ~1 mm from the alveolar plane. Mesially and distally the bone is intact, although there may have been a little erosion of the septum distally. Lingually, the M_1 alveolar margin has lost thin bone from the distal root to the P_4/M_1 septum, extending ~2.5 mm down from the alveolar plane. It has exposed the roots almost to the root bifurcation.

The M_2 alveolus is intact mesially and lingually, but distally it has lost bone buccally. On the buccal side, there is bone loss all along the margin, continuing the damage to the M_1 alveolus, down to the root bifurcation. Based on the M_1/M_2 septum, ~3.7 mm of bone is gone from the mesial root buccal alveolus. The empty M_3 socket is nibbled a small amount, especially on the mesial 4.0 mm, and the otherwise intact distal margin is slightly porous. Buccally, there is slight bone loss along the mesial margin and almost to the distobuccal corner.

There are only three preserved teeth, the right C_1, M_1 and M_2. Given clear interproximal facets on the mesial $M_1$and the distal M_2 and the intact sockets for the C_1 to P_4 plus M_3, at least the right C_1 to M_3 were in occlusion at death. The C_1 is complete with a buccolingual hairline crack through the middle of the crown. The M_1 appears complete with marked attrition, but the mesiobuccal corner of the crown has some enamel loss near the cervix. There are cracks in the crown, in both the enamel and the dentin, on the mid-mesial margin, the mesiobuccal cusp, and down the mesiodistal midline. The M_2 is complete with hairline cracks in the enamel and occlusal dentin. There is a notch 2.0 mm wide on the distolingual M_2 corner, but it was antemortem given rounding of the enamel and dentin margins.

As with the maxillary dentition, there has been marked but even supereruption of the mandibular dentition. It is most evident relative to the largely intact interdental septa, given the minor damage to the molar alveolar margins. The pattern of wear of both maxillary and mandibular dentitions and their even supereruption suggests that all of the mandibular teeth, as well as the maxillary ones, were in occlusion at death.

The Muierii 1 Scapula

The Muierii scapula retains most of the glenoid fossa, most of the axillary border, and the lateral spine. The glenoid fossa is essentially complete, with minor edge damage dorsally to 9.0 mm on the caudal half of the fossa and ventrally to 11.7 mm of the caudal half. The damage to the caudal ventral margin has been reconstructed with plasticene; since the damage only goes medially 4.2 mm from the articular surface, it is straightforward to reconstruct the missing portion using the contours of the glenoid fossa and the adjacent ventral bone. Any error in the resultant glenoid breadth is likely to be minimal (≤ 0.5 mm).

The infraglenoid tubercle is intact, as is the axillary border for 63 mm from the glenoid caudal margin. The caudal end of the axillary border should be close to the teres major surface, but there is no evidence of that surface. The coracoid process preserves only its broken base, up to 13.5 mm from the glenoid margin. The acromion is absent. The lateral spine retains the lateral base, extending up to 65.5 mm from the glenoid fossa. The dorsal edge of the spine is preserved for only 23 mm in mid spine, which can be used for spinous orientation but provides no other morphological information. The supraspinous and infraspinous surfaces exist only as thin edges along the spine and the axillary border.

A small notch, 6.2 mm mediolateral and 3.5 mm craniocaudal was removed from the broken supraspinous edge by E. Alexandrescu for radiocarbon dating (Olariu *et al.* 2003). The maximum preserved dimension of the bone, from the coracoid base to the caudal axillary border, is 113.7 mm.

The Muierii 1 Tibia

A largely complete tibial diaphysis was discovered with the other Muierii human remains, and it was illustrated by Gheorghiu and Haas (1954; fig. 5). It was part of the radiocarbon bone sample taken by Alexandrescu (Olariu *et al.* 2003). The whereabouts of this bone are currently unknown. The only data available for it derive from the published photograph and from a set of photographs taken at some point and currently in the Institutul de Antropologie "Fr.J. Rainer." The latter photographs show a more complete diaphysis, both proximally and distally, indicating some deterioration of the specimen between the time of its discovery on August 18, 1952 and the time of the preparation for the article by Gheorghiu & Haas, published in 1954. The original tibial diaphysis extended from the proximal metaphyseal area, at the distal end of the tibial tubersity to the beginning of the flare for the distal epiphysis. The distal end of the rugosity for the tibial tuberosity appears to have been present, as is evident in the anterior view, and most of the dorsal flare for dorsally displaced tibial condyles is preserved. Distally there was the beginning of the anterior curve of the interosseus line for its termination at the anterolateral corner of the lateral surface, and part of the rugosity for the distal tibiofibular syndesmosis. The bone between these ends appears to have been otherwise complete. None of the preserved photographs contains a scale, so the original dimensions of the bone are not known.

The Muierii 2 Temporal Bone

The Muierii temporal bone consists of a largely complete core of a left bone. The core of the bone is intact, but it has lost several marginal portions. Almost all of the squamous portion is absent, except for the posterior end next to the parietal notch. Only the base of the zygomatic process remains. There was bone loss to the medial mastoid process. The anteromedial end of the petrous portion is absent. There is a small perforation of the superolateral petrous portion into the paramastoid air cells. And only the base of the styloid process is present. Where internal bone is exposed, on the petrous portion of the bone, there is a hard, dark brown matrix filling the spaces. A small piece of bone, 10 mm anteroposterior and 5 mm superoinferior, was removed in 2005 from the preserved based of the squamous portion for radiocarbon dating.

The maximum anteroposterior dimension of the bone, from asterion to the temporosphenoidal suture, is 81.8 mm. Its maximum mediolateral dimension, from the zygomatic process base to the medial petrous portion, is 59.2 mm.

The Muierii 3 Fibula

A diaphyseal section of a left human fibula is curated with the Muierii remains in the Institutul de Speologie "Emil Racoviţă" in Bucharest and labeled "BF 52" (Baia de Fier 1952), in the same manner as the faunal remains from the site. There is no mention of it in earlier publications, and it is unclear when it was identified as human, or where it comes from in the cave. Its preservation matches that of the other Pleistocene material and contrasts with the Holocene human remains from the cave. A sample of distal diaphysis was submitted to the Oxford Radiocarbon laboratory (ORAU). It produced a C:N atomic weight ratio of 3.7, which is outside of normal limits (DeNiro 1985), and there was insufficient collagen to properly decontaminate the sample. The dating of it was therefore failed. It is assumed to be Late Pleistocene in age, probably contemporaneous with the other Muierii Late Pleistocene human remains.

The bone is a midshaft section, 101.6 mm long, with all surfaces preserved. There is a chip of bone 9.6 mm long gone from the interosseus crest, especially medially. There are two chips absent from the posteromedial edge, a deeper one 9.9 mm proximodistal and a shallower one 15.5 mm proximodistal. The proximal break is oblique and irregular, distolateral to proximomedial. The distal break is uneven and more distal, proximomedial to distolateral. At the proximal break there is only cortical bone, but at the distal break small trabeculae exist along the lateral and dorsal edges.

Associations of the Human Remains by Individual

In the original field notes, and in subsequent treatment of the human remains from the Galeria Musteriană of the Peştera Muierii, it was assumed that the remains all derived from one individual. Clearly, given articulation, the neurocranium and splanchnocranium fit together to become Muierii 1. The seven associated teeth, two of which (the I^2 and P^3) were found separately, fit cleaning into their appropriate alveoli. The mandible with its associated teeth (now including the C_1 formerly with the cranium) represents the same individual. It is the appropriate size for the cranium. The upper and lower dentitions have matching wear. And the mandibular and maxillary right molars occlude properly.

It is not possible to articulate the left temporal bone with the left occipital and parietal bones of Muierii 1, given the almost complete absence of the squamous portion of the temporal bone and the absence of temporal sutures (squamous, parietomastoid and occipitomastoid) on the left side of the Muierii 1 neurocranium. The temporal bone, nonetheless, does not appear to be a good fit for the neurocranium. It is substantially more robust. It does not provide a good match (through visual assessment) to the right asterionic region. And the assessment of the sexes of the two pieces (see below) strongly suggests that Muierii 1 is female and the temporal bone is male. They also differ in preservation, with the Muierii 1 cranium being less thoroughly mineralized than the temporal bone. As a result, the temporal bone is considered here to represent a second individual, Muierii 2. Should it be decided in the future that they do indeed derive from one individual, the primary assessment that will change is the determination of the sex of the individual, since it would then combine a rather male mastoid region with a gracile cranium and an apparently female supraorbital morphology.

The scapula is from a relatively small individual, has a preservation similar to that of Muierii 1, and therefore is included as part of that individual. The tibia is described as being similar in preservation, and for lack of information to the contrary, it will be retained within Muierii 1. The fibular diaphysis has a somewhat different preservation, and it may derive from a different portion of the deposits than the other bones. Although it could be part of Muierii 1 or 2, it will be referred to as Muierii 3.

Ages-at-Death of the Muierii Human Remains

The Muierii 1 Age-at-Death

The assessment of the age-at-death of the Muierii 1 remains is based on its dental attrition and neurocranial suture closure, neither of which provides a precise indication. The remains are clearly full mature, as it indicated by the full eruption of both maxillary M^3s and the right mandibular M_3, plus the presence of moderate occlusal wear on the right M^3 (Tabl. 31; fig. 62). There is no evidence of developmental lines on the scapula. Comparisons of the degree of occlusal attrition on the first and second molars in comparison to other Late Pleistocene humans with multiple age indicators (Trinkaus 1995; Hillson *et al.* 2006), as well as to recent high attrition populations (Davies & Pedersen 1955; Moorrees 1957; Brothwell 1963), indicates an age-at-death in the fourth or fifth decade.

The neurocranial sutures are in general agreement with this assessment. The coronal suture is fused and obliterated endocranially and evident only as a thin line exocranially. The sagittal suture is fused and obliterated on its anterior one-third, and then evident as a thin, open lines along the endocranial posterior two-thirds. Exocanially the sagittal suture is evident from bregma to lambda but only as a thin line following the interdigitations. The lambdoid suture appears unfused, but there is a possible area of partial endocranial fusion 9.6 mm long starting 37.6 mm from the right asterion; postmortem separation along the suture and subsequent regluing makes its diagnosis tenuous. The right squamous, parietomastoid, and occipitomastoid sutures were all unfused. Following Meindl and Lovejoy (1985), the anterior sagittal and coronal sutures provide modal ages in the middle to late fifth decade, and the posterior sagittal and lambdoid sutures provide model ages in the fourth to early fifth decade. However, as with all sutural fusion age assessments, there are potential errors in excess of a decade, so that the sutures, as with the dental attrition, provide only a general age assessment for Muierii 1.

The Age-at-Death of Muierii 2

The isolated Muierii 2 temporal bone is fully mature with complete fusion of all of the intratemporal synchondroses. There are no degenerative lesions on the bones. All of the adjacent sutures which are preserved (sphenotemporal, posterior squamous, parietomastoid, and occipitomastoid) are completely open. These observations suggest, but do not confirm, a young adult age for the bone.

The Age-at-Death of Muierii 3

There are no preserved age indicators on this partial diaphysis. The morphology of the bone with its well formed musculo-ligamentous crests indicates an adolescent or, more likely, adult status.

The Sexes of the Muierii Human Remains

The Sex of Muierii 1

The sex of Muierii 1 cannot be determined directly, since no pelvic remains are preserved. However, the specimen has a relatively small and gracile cranium, especially with respect to the facial skeleton. In particular, the mandibular corpus dimensions are among the smaller of known Late Pleistocene specimens (fig. 59), and the development of the superciliary arches is very modest (fig. 48). In comparison to the probably male Cioclovina 1, Cro-Magnon 3, and Mladeč 5 and 6 earlier Upper Paleolithic specimens, as well as the pelvically-sexed male Cro-Magnon 1 and Nazlet Khater 2 males, Muierii 1 has a very modest development of these supraorbital features. It is approached by the probably female Mladeč 2 cranium and is less developed than the probably female Mladeč 1 cranium, as well as the probably female Cro-Magnon 2 cranium. More specifically, the contour of the orbital margin just lateral of the supraorbital notch is thin and relatively sharp (see below); it should be categorized as stage 1 or 2 of Walker (1994, 2008), which are referred to as "female" or "probably female" (Buikstra & Ubelaker 1994) but exhibit considerable frequencies among both males and females in recent human samples (Walker 2008). In addition, the Muierii 1 right scapular glenoid height of 34.3 mm, which generally reflects upper limb articular dimensions (Churchill & Trinkaus 1990), is below the mean (37.7 ± 3.1 mm, N = 17) of a Mid Upper Paleolithic right scapular sample, but nonetheless only 1.1 standard deviations below that mean (fig. 73). These data combine to strongly indicate, but not confirm, a female diagnosis for Muierii 1.

The Sex of Muierii 2

The sex of the individual is based solely on the size and shape of its mastoid process. Its height from the Frankfurt horizontal (approximated using the zygomatic arch and glenoid fossa) is ~30.0 (±1.0 given orientation uncertainties). This measurement falls towards the upper end of the range of means provided by Howells (1973) for 17 recent human male samples (25.9 ± 2.4 to 30.9 ± 3.1 mm) and largely separate from his range of female means (23.0 ± 2.6 to 26.3 ± 2.9 mm). It is nonetheless within the individual ranges of variation of both sexes. Comparable measurements are not available for earlier Upper Paleolithic pelvically sexed crania, but the range of variation for the Cioclovina and Mladeč crania suggests a similar pattern of sexual dimorphism (Frayer *et al.* 2006; Wolpoff *et al.* 2006; Soficaru *et al.* 2007). Yet, the mastoid height of the Oase 2 cranium is more ambiguous (Rougier *et al.* 2007).

In addition, the shape of the mastoid process, in which it extends well below the tympanic bone, is laterally bulbous and has a straight to minimally convex posteroinferior margin. The mastoid profile and its relation to the auditory porous most closely matches Walker's (1994, 2008) stage 4, designated as "probably male." Based on mastoid size and shape, therefore, Muierii 2 was probably male.

The Sex of Muierii 3

There is little to indicate the sex of Muierii 3.

Summary

The human remains from the Pleistocene deposits of the Peştera Muierii therefore consist principally of a cranium lacking the temporal bones and neurocranial base, a lateral mandibular corpus and ramus, ten teeth, a scapula and a (now lost) tibial diaphysis of one individual (Muierii 1). Probably separate are a largely complete temporal bone mostly lacking the squamous portion (Muierii 2) and a partial fibular diaphysis (Muierii 3). Muierii 1 probably represents a female who died in the fourth or fifth decade, whereas Muierii 2 appears to derive from a younger adult male.

Comparative Materials and Methods

Comparative Considerations

Since all description is by its nature comparative, aspects of the Pleistocene Muierii human remains for which there are meaningful comparative data are compared to relevant samples of Late Pleistocene humans and, when appropriate, to samples of recent (late Holocene) humans. To properly evaluate the Muierii human remains, they are compared principally to their temporal and geographic neighbors, to the extent possible given known fossil remains and the data available for them.

The approach here is populational, since the ultimate concerns are the population dynamics, paleobiology and behavior of Late Pleistocene humans. The Muierii human remains represent, to the extent reasonable given the ages and sexes of the preserved bones and teeth, a population of humans that occupied the southwestern Carpathians during the Interpleniglacial (MIS 3). The morphological patterns and variation of their temporal and geographical neighbors serve to assess both population relationships and, for some of the traits, which prior group of humans provides the most probable source for the morphological pattern observed in the Muierii human remains. For a few of the traits, there is a concern with the polarities of the traits, or whether they are ancestral or derived for a given human sample (*cf.*, Trinkaus 2006a). However, given within sample variation in almost all of these morphological aspects, strict assessment of polarity is biologically inappropriate.

Comparative Materials

The principal sample of comparison includes other Early Upper Paleolithic humans from Europe. This includes remains from the Romanian sites of Peştera Cioclovina Uscată (Rainer & Simonescu 1942; Soficaru *et al.* 2007; Soficaru & Petrea 2009) and Peştera cu Oase (Trinkaus *et al.* 2003a,b; Rougier *et al.* 2007; Trinkaus *et al.* n.d.), the Moravian site of Mladeč (Wild *et al.* 2005; Teschler-Nicola 2006; see especially Frayer *et al.* 2006; Wolpoff *et al.* 2006; Trinkaus *et al.* 2006b), and the French site of La Crouzade (Henry-Gambier & Sacchi 2008). The human remains from Cioclovina and Oase have direct radiocarbon dates, as do several of the remains from the main chamber at Mladeč and the isolated maxilla of La Crouzade 6 (tabl. 6). Several of the more complete remains from Mladeč, in particular the Mladeč 5 neurocranium and the now lost Mladeč 6 neurocranium, Mladeč 52 and 54 mandibles, and some of the isolated teeth, derive from different "halls" in the Mladeč cave system; they are assumed to be the same age as the directly dated sample. Similarly, the La Crouzade 5 frontal bone is not directly dated, but it appears to derive from the same level and jumble of bones as the dated maxilla (Henry-Gambier & Sacchi 2008).

In addition to these larger pieces, there are Early Upper Paleolithic fragmentary remains (mostly teeth and partial mandibles) from several western and central European sites (Abeille, Battuts, Brassempouy, Castanet, El Castillo, La Ferrassie, Fond-de-Gaume, Le Piage, La Quina Aval, Les Rois and Vindija), none of which have direct dates on the human remains but appear on stratigraphic grounds to derive from the Aurignacian *sensu lato*. Data are also included for three other "Early Upper Paleolithic" specimens dated between 35,000 and 40,000 cal BP, Nazlet Khater 2 from Egypt (Crevecoeur 2008; Franciscus 1995), Hofmeyr 1 from South Africa (Franciscus 1995; Grine *et al.* 2007; Stringer pers. comm.), and Tianyuan 1 from China (Shang *et al.* 2007; Shang & Trinkaus 2010). The similarly aged peninsular southeast Asian Niah 1 specimen is fragmentary and immature (Brothwell 1960; Barker *et al.* 2007). The only other potentially relevant Early Upper Paleolithic fossil is an associated tibia and fibula from Kostenki I (Sinitsyn 2004); however the specimen has never been published, is unavailable, and therefore cannot be included.

In these Early Upper Paleolithic comparisons, it is the remains from Cioclovina, La Crouzade, Mladeč and Oase, plus Nazlet Khater and Hofmeyr, which provide data on the cranium. It is primarily the Oase 1, plus Nazlet Khater 2 and Tianyuan 1 which provide mandibular comparative data, although some relevant data are available on the now lost Mladeč 52 and 54 mandibles. For the scapula, none of these European specimens provides data, but Nazlet Khater 2 and Tianyuan 1 have partial scapulae. The remainder of the Early Upper Paleolithic comparative data concerns only teeth.

The Muierii remains also need to be bracketed in time in the Late Pleistocene. The relevant preceding Late Pleistocene samples are those of 1) western Eurasian late archaic humans (Neandertals), 2) southwestern Asian and eastern and northeastern African Middle Paleolithic / Middle Stone Age early modern humans, and 3) Middle Paleolithic / Middle Stone Age African late archaic humans.

The first consists of remains from a long list of western Eurasian sites from the Zagros and Caucasus Mountains in the east to the Atlantic coastlines of western Europe. They are almost all Middle Paleolithic associated and derive from earlier Late Pleistocene (MIS 4 to 3) time periods. The sites providing data include Amud, Arcy-Bison, Arcy-Hyène, Banyoles, Boccard, Bombarral, Camerota, Caminero, Carihuela, La Chapelle-aux-Saints, Châteauneuf-sur-Charente, Combe Grenal, Croze-del-Doua, Devil's Tower, Fate, Feldhofer, La Ferrassie, Fossellone, Dederiyeh, Fenera, Forbes' Quarry, Genay, Guattari, Hortus, Kebara, Kiik-Koba, Kůlna, Leuca, Macassargues, Malarnaud, Marillac, Merveille, Monsempron, Montgaudier, Le Moustier, La Naulette, Neussing, Palomas, Petit-Puymoyen, Peyrards, Poggi, Portel, La Quina, Regourdou, Saccopastore, Saint-Brelade, Šala, Salzgitter-Lebenstedt, Shanidar, El Sidrón, Spy, Subalyuk, Švédův stůl, Tabun B, Taddeo, Taubach, Valdegoba, Vaufrey, Vindija, Zafarraya and Zaskalnaya. The exceptions are the western and central European Initial Upper Paleolithic remains from Arcy-Renne, Saint-Césaire, Spy and part of the Vindija sample.

The second sample dates to the terminal Middle Pleistocene and earlier Late Pleistocene (MIS 6 to 4) and comes from east and northeast African and southwest Asian sites. The overwheming majority of the available data derives from the associated skeletons from the MIS 5 Qafzeh and Skhul samples (McCown & Keith 1939; Vandermeersch 1981; Tillier 1999). Additional data are provided by the isolated crania and mandibles from the MIS 6 and 5 east and northeast African sites of Aduma, Bouri, Haua Fteah, Herto and Omo-Kibish (Tobias 1967; White *et al.* 2003; Haile-Selassie *et al.* 2004).

The last of these earlier samples derives from primarily from Middle Paleolithic (including Aterian) remains from the northwest African sites of Dar-es-Soltane, El Harhour, Irhoud and Témara; additional data are provided for the later Middle Pleistocene archaic human remains from sub-Saharan Africa. Although some specimens in this last set of fossils have been considered to be early modern humans (Hublin 1992; Bräuer 2008), they lack a full suite of distinctive derived modern human features (Vallois & Roche 1958; Ferembach 1976, 1998; Ménard 1998; Trinkaus 2005; Harvati & Hublin 2009) and have principally been shown to be non-Neandertal, as opposed to anatomically modern.

To one of these "African" samples can be added the enigmatic and undated maxilla and mandible from the east African locality of Loiyangalani. Originally compared to Middle Pleistocene remains based on its size and robusticity (Twiesselmann 1991), it exhibits two derived modern human features, a prominent tuber symphyseos and a narrow nasal aperture. Yet its large size, exceptional robusticity and ramal morphology make it unlikely to be Holocene (Muteti *et al.* 2010). It is included here along with other isolated, non-European specimens.

The succeeding sample consists principally of western Eurasian Mid Upper Paleolithic (Gravettian *sensu lato*) modern humans, from approximately between 20,000 and 28,000 ^{14}C BP (~24,000 – 32,500 cal BP). The sites with fossil specimens providing relevant comparative data are Arene Candide, Barma Grande, Bausu da Ture, Brno-Francouzská, Calanca, Caldeirão, Castanet, Caviglione, Cro-Magnon, La Crouzade, Dolní Věstonice, Grotte des Enfants, Isturitz, Kostenki, Lagar Velho, Miesslingtal, Nahal-ein-Gev, Paglicci, Pataud, Paviland, Pavlov, Předmostí, Les Roches, Silická Brezová, Sunghir and Vachons. A couple of these samples are close in age to the Muierii 1 remains, in particular those from Cro-Magnon (Henry-Gambier 2002) and Paviland (Jacobi & Higham 2008), and others [e.g., Dolní Věstonice, Pavlov and Sunghir (Svoboda 2006; Sulerzhitski *et al.* 2000; Kuzmin *et al.* 2004)] may only be a few millennia more recent.

Descriptive and Comparative Methods

The comparative data provided for the Muierii Late Pleistocene humans remains, in addition to verbal descriptions of the preservation, morphology and paleopathology, include linear and angular morphometrics and discrete traits. The morphometrics largely following the Martin system (Bräuer 1988). To these measurements are added additional ones, which are defined in the appropriate tables or text when first employed. The discrete traits are a series of variants which have been employed for recent human cranial variation (Hauser & DeStefano 1989), recent and Pleistocene human dental variation (Scott & Turner 1997; Bailey 2006), Pleistocene mandibular variation (*e.g.*, Lebel & Trinkaus 2002; Rosas 2001; Soficaru *et al.* 2006; Walker *et al.* 2010), and recent human and Pleistocene scapular variation (Eickstedt 1925; Churchill 1994). Some of these traits change through development, especially with changing proportions of the facial skeleton, and they are therefore only recorded for mature specimens. Others appear to be stable from relatively early in postnatal development, and for them immature as well as mature specimens are employed in the comparative samples.

The osteometrics of the Muierii specimens were taken principally with plastic digital calipers to the nearest 0.1 mm. However, a series of landmarks of the cranium were recorded using a Microscribe G2 three-dimensional digitizer (Immersion Corp.), which provides x, y and z coordinates for each of the points recorded. The neurocranium and the maxillae were digitized separately, given the approximate orientation between them (see above). These data are provided in tables 20 and 24. They were also used to compute, using the three-dimensional Pythagorean theorem [distance = $((x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2)^{1/2}$], linear measurements of the cranium.

The comparative data derive extensively from personal measurement and observation of the original human remains, but this has been supplemented with data (principally osteometrics) derived from the primary paleontological descriptions of the fossil specimens and personal communications from colleagues who measured the original specimens. The individual sources for published data are not provided, except when a substantial part of the data set has come from a particular source. In a few cases, non-metric observations have been obtained from high quality casts of the specimens and from the published photographs in the case of the now lost mandibles from Mladeč. Such secondary sources were only employed when the observation could be made unambiguously.

The comparisons involve principally distributions of linear and angular morphometrics and frequency distributions of discrete traits. The linear measurements are compared using ratios and, when possible, bivariate plots and associated residuals from reference sample least squares regression lines.

The Muierii 1 Cranium

The Muierii 1 cranium, with most of the frontal, parietal and occipital bones plus the maxillae connected to the neurocranium through the left zygomatic bone (fig. 31 and 32) provides considerable information on its skeletal morphology. Given the minimal distortion of the mid-sagittal contour from nasion to opisthion, as well as cranial breadth landmarks on at least one side, it is possible to assess its overall and more detailed calvarial size and proportions, plus detailed morphological characteristics. The complete supraorbital region furnishes data on that evolutionarily dynamic region, and the largely complete maxillae permit assessment of its facial configuration.

As such, the Muierii 1 cranium joins a small sample of Early Upper Paleolithic modern human crania from Europe. The specimens of particular concern are the largely complete Mladeč 1 and 2 and Oase 2 crania, and the Cioclovina 1 and Mladeč 5 and 6 neurocrania. To these specimens are added the Mladeč 8 maxilla and the La Crouzade 1 frontal bone and partial maxilla. Although they are technically Mid Upper Paleolithic by their archeological association, the Cro-Magnon 1 to 3 partial crania are close in time to this sample. Further afield are two African crania, the northeast African Nazlet Khater 2 one and the geographically more distant South African Hofmeyr 1 cranium. Approximately contemporaneous eastern Eurasian remains either lack the cranium (Tianyuan 1) or are immature (Niah 1).

The morphology of the Muierii 1 cranium is therefore presented here in terms of its overall neurocranial proportions, aspects of the individual vault bones, the supraorbital region, and the upper facial skeleton. The alveolar process is considered with the dentition below. Primary metric data are presented in tables 20 to 25, and the relevant metric comparisons for which adequate comparative data are available are provided graphically.

Late Pleistocene Cranial Morphomics

Probably more has been written about Late Pleistocene human cranial morphology and variation than any other aspect of human paleontological morphology, starting with the mid-nineteenth century descriptions of the Feldhofer and Cro-Magnon remains (Schaaffhausen 1858; Broca 1868). In addition to the multitude of overall evaluations, there has been a plethora of morphometric assessments using a variety of techniques, and these analyses have been joined by characterizations employing discrete (or ordinal) features, particularly of the supraorbital region, the maxillae and the occipital bone (temporal ones are considered with respect to the Muierii 2 temporal bone). In these considerations, there have been attempts to define Neandertal and modern human uniquely derived characteristics and

Figure 31 - The Muierii 1 cranium in left lateral view. Scale bar equals 5 centimeters.

Figure 32 - The Muierii 1 cranium in superior view. Scale bar equals 5 centimeters.

to provide metric evaluations of proportions, joined by some efforts to assess possible patterns of the integration of features across the cranium.

Following recent evaluations, the assessment of the Muierii 1 cranium here will present detailed descriptions of the preserved portions, along with metric and discrete trait comparisons to the relevant comparative samples. There is little question that the Muierii 1 cranium is best described as "modern human." The questions of relevance are therefore where it falls with respect to the variation of other Late Pleistocene humans, and whether it exhibits features not usually found among the early modern humans samples. Some of these comparisons are straight-forward; other require some discussion of the natures of the traits in question.

The Neurocranium

The morphological assessment of the Muierii 1 neurocranium consists primarily of its largely complete mid-sagittal contour, combined with breadth assessments for the frontal and parietal bones and for the occipital bone to asterion. Sufficient portions of the neurocranial vault are preserved to provide additional morphological information. The supraorbital region, as an interface between the neurocranium and the splanchnocranium, is considered separately, even though the frontal bone mid-sagittal contour and breadth/length assessment include measurements to nasion.

Overall Neurocranial Shape

It is apparent from the lateral and superior views of the Muierii 1 cranium (fig. 31 and 32) that it has a relatively high and rounded neurocranial vault, albeit a moderately narrow one for its length. The length is in part exaggerated by the presence of a prominent occipital bun (chignon), but that is compensated in a Late Pleistocene context by the minimal anterior projection of the interorbital region (glabella and nasion). It is, at the same time, a small cranium (tabl. 20 and 21).

Relative Breadth Assessments

These overall size and proportion observations are illustrated by Late Pleistocene comparisons of neurocranial breadths to lengths. The distribution of maximum cranial breadth (eurion-eurion) to length (glabella-opistocranion) (fig. 33) provides considerable scatter within samples and a general trend for the Middle Paleolithic crania (Neandertal, northwest African and modern human) to be both longer and wider than the Mid Upper Paleolithic ones. The other Early Upper Paleolithic ones scatter among the larger of the Mid Upper Paleolithic ones. There is a trend for the late archaic crania (European, southwest Asian and northwest African) to be wider relative to length, albeit with considerable overlap across the comparative samples. This is evident in both the bivariate plot of the measurements and the distribution of the residuals from the pooled least squares line (fig. 33). Muierii 1 is well within the overall distribution, but it is moderately narrow, falling below the Neandertal and northwest African range in the residuals, at the bottom of the Middle Paleolithic and Early Upper Paleolithic modern human ranges of variation, but close to the middle of the Mid Upper Paleolithic distribution.

A more localized assessment is possible comparing maximum frontal breadth, at the coronal suture, to it mid-sagittal nasion-bregma chord (fig. 34). The Neandertals and northwest African late archaic humans fall largely within the relatively wider portion

	X	Y	Z
Nasion	192.3	321.3	–220.6
Glabella	191.8	327.9	–215.4
Supraglabellare	194.4	336.1	–205.2
Metopion	216.1	349.4	–164.7
Bregma	256.5	329.5	–127.4
Lambda	322.2	235.0	–137.4
Opistocranion	325.1	211.9	–157.7
Inion	308.4	200.8	–184.0
Opisthion	276.6	210.9	–214.7
Asterion right	321.1	248.9	–223.8
Entomion right	317.0	266.8	–230.0
Stephanion right superior[1]	278.9	346.0	–191.6
Stephanion right inferior[1]	276.2	344.0	–203.4
Stephanion left superior[1]	204.5	292.4	–133.6
Stephanion left inferior[1]	198.0	285.2	–139.6
Frontomalare anterior right[2]	242.1	335.6	–246.3
Frontomalare posterior right[2]	246.5	334.7	–243.3
Frontomalare anterior left[2]	170.6	280.3	–187.2
Frontomalare posterior left[2]	171.9	278.9	–180.8
Dacryon right	205.1	320.8	–228.4
Dacryon left	188.1	308.1	–209.7

[1] The landmarks for stephanion are the intersections of the superior and inferior margins of the temporal lines and the coronal suture.

[2] The anterior and posterior frontomalare points are taken on the frontal bone.

Table 20 - Three dimensional Cartesian coordinates of landmarks on the Muierii 1 neurocranium, derived using a Microscripe G2 digitizer, in millimeters. The position of the 0-0-0 point is posterior of the neurocranium but otherwise arbitrary.

Nasion-lambda length (M-3a)[1]	177.0
Nasion-inion length (M-2a)	168.0
Nasion-opistocranion length (M-1d)	182.0
Glabella-inion length (M-2)	174.0
Glabella-opistocranion length (M-1; GOL)	184.0
Opisthion-bregma height	148.6
Basion-bregma height (M-17; BBH)	(135.0)[2]
Glabella-opistocranion frontal angle (M-32d)	48°
Nasion-inion frontal angle (M-32(1))	60°
Bi-parietal breadth (eu-eu) (M-8; XCB)	(135.0)
Maximum frontal breadth (M-10; XFB)	121.0
Minimum frontal breadth (M-9)	105.2
Bi-stephanic superior[3]	107.5
Bi-stephanic superior arc	128.0
Bi-stephanic inferior[3]	116.5
Bi-stephanic inferior arc	149.0
Asterion-opisthion right	59.7
Asterion-opisthion arc right	64.0
Asterion-lambda right	87.8
Asterion-lambda arc	100.0
Bi-asterionic breadth (M-12; ASB)	(108.0)[4]
Asterion-entomion right	19.4
Bregma-asterion right	141.3

[1] M-# refers to the Martin measurement number (Bräuer 1988), and the three letters refer to the designation in Howells (1973).

[2] The basion-bregma height (BBH) is estimated from the opisthion-bregma height (OPH) using a least squares regression based on a pooled sample of Late Pleistocene and recent humans (N = 38) BBH = 0.828 x OBH + 11.9, r^2 = 0.640. The estimated value (134.8 ± 4.0 mm; SE_{est}: 2.96%) is rounded off to 135 mm.

[3] The bistephanic breadths and arcs are to the superior and the inferior markings of the temporal lines at the coronal sutures.

[4] Bi-asterionic breadth is twice the measurement from the right asterion to the sagittal midline.

Table 21 - Overall and individual bone neurocranial measurements for Muierii 1, in millimeters. All measurements are direct distances unless qualified as arcs.

of the Late Pleistocene distribution, even though they all have prominent supraorbital tori which should increase the relative dimensions of the nasion-bregma chords and hence make them appear narrower than they are in absolute terms. Muierii 1 falls in the middle of the overall distribution, along the relatively narrower portion of the late archaic samples. It is indistinguishable in this aspect from all three of the early modern human samples.

Further posteriorly and inferiorly, it is possible to estimate the bi-asterionic breadth of Muierii 1, by doubling the distance from the midline to the right asterion. In comparing bi-asterionic breadth to neurocranial length, the late archaic humans continue to exhibit relatively wide neurocrania (fig. 35). There is a trend for the more recent crania to be relatively narrower, which is reflected in the residuals from the pooled least squares line through the distribution (fig. 35). Muierii 1 is principally among the Upper Paleolithic modern human crania, although it overlaps the ranges of variation of the Neandertals and the Middle Paleolithic modern humans, but not that of the small northwest African late archaic sample.

Relative Height Assessments

It is more difficult to assess the relative height of the Muierii 1 neurocranium, even though it appears high and rounded in lateral view (fig. 31). The cranium does not preserve either basion or the auditory porus, but it retains opisthion without distortion. Moreover, few crania prior to the Mid Upper Paleolithic retain basion, opisthion or even the temporal regions. To permit some cranial height assessment, basion-bregma height was therefore predicted from the opisthion-bregma distance of Muierii 1 (tabl. 21). The resultant measure has a moderately high SE_{est} compared to Late Pleistocene variation (±4 mm), but it permits an evaluation of its relative height. The distribution of basion-bregma heights relative to cranial length (fig. 36) shows that there is little difference in absolute neurocranial height across these samples, despite a few low values for Middle Paleolithic specimens and higher values for Mladeč 1 and a Oase 2 estimate from its opisthion-bregma and midline porion-bregma distances. The presumed platycephaly of late archaic humans is a product principally of their longer neurocrania, although one Neandertal (Guattari 1) has an absolutely low height and La Chapelle-aux-Saints 1 has a low height relative to its length. The

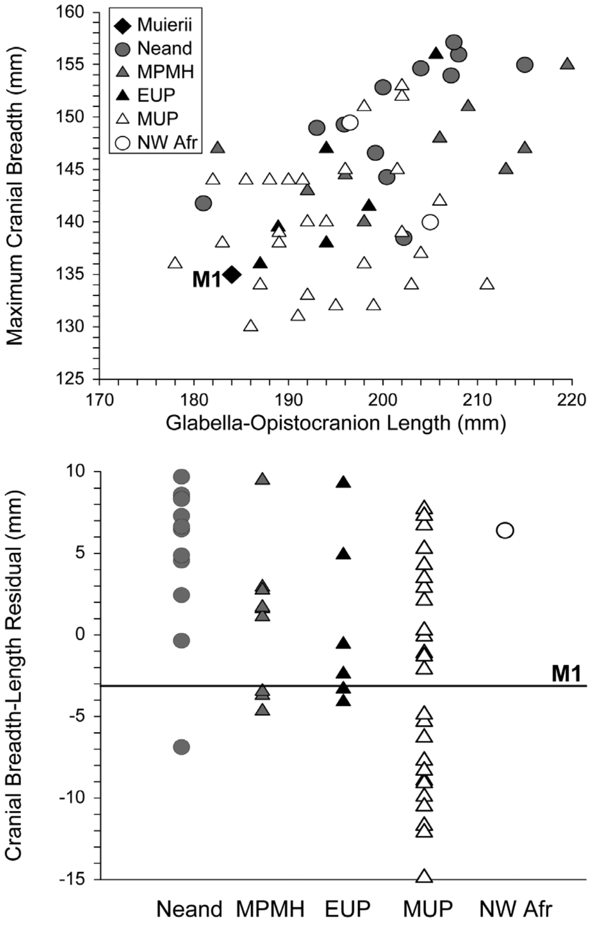

Figure 33 - Bivariate plot of maximum cranial breadth (eurion-eurion) versus neurocranial length (glabella-opistocranion) (above), and distributions of the raw residuals from the least squares line through the cranial breadth (XCB) versus length (GOL) data points for the pooled comparative sample (below). For the residuals, XCB = 0.398 x GOL + 64.9, $r^2 = 0.246$, N = 27. Muierii 1 (M1) residual: –3.12. Kruskal-Wallis P-value across the comparative samples: 0.009. Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic modern humans; MUP: Mid Upper Paleolithic humans; NW Afr: northwest African Middle Paleolithic humans.

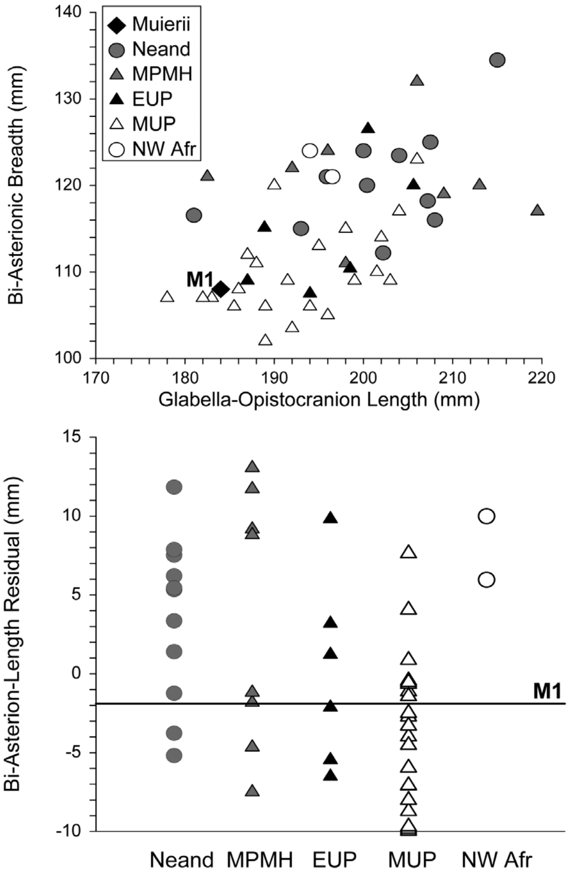

Figure 35 - Bivariate plot of bi-asterionic breadth (ASB) versus neurocranial length (GOL) (above), and distributions of the raw residuals from the least squares line through the bi-asterionic breadth (ASB) versus length (GOL) data points for the pooled comparative sample (below). For the residuals, ASB = 0.411 x GOL + 34.2, $r^2 = 0.253$, N = 27. Muierii 1 (M1) residual: –1.90. Kruskal-Wallis P-value across the comparative samples: 0.008. Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic modern humans; MUP: Mid Upper Paleolithic humans; NW Afr: northwest African Middle Paleolithic humans.

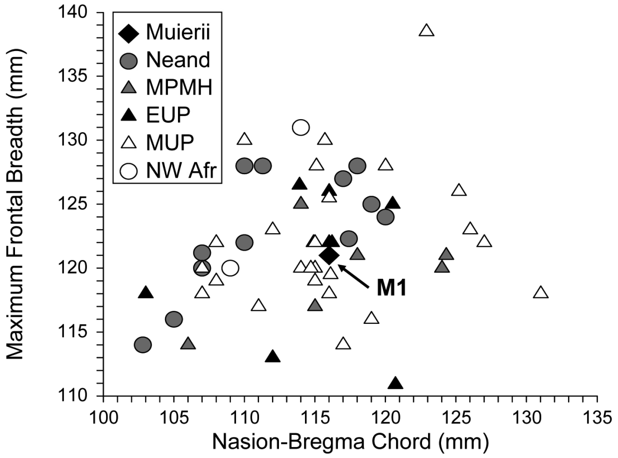

Figure 34 - Bivariate plot of maximum frontal breadth (XFB) versus frontal (nasion-bregma) length (FRC). Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic modern humans; MUP: Mid Upper Paleolithic humans; NW Afr: northwest African Middle Paleolithic humans.

latter is joined by the estimated values for the (albeit distorted) Middle Paleolithic modern human, Skhul 4. The Muierii 1 mean estimate of 135 mm is in the middle of the principal distribution, similar to other Upper Paleolithic modern humans and a couple of Neandertals. Its range indicated by ±1 SE$_{est}$ spans the absolute range for the early modern humans.

An alternative approach to assess the relative height of the neurocranium is to use a frontal angle, or the angular elevation of bregma relative to a horizontal plane of the neurocranium. The best anterior landmark for the reference plane is nasion, given it position at the superior interface of the neurocranium and the splanchnocranium. Posteriorly, the best available exocranial landmark for which data are available is inion, the midline of the superior nuchal line. However, inion varies with respect to the more important posterior anatomical structures, for which the plane of the transverse sinuses, and hence of the tentorium cerebelli, is the most relevant, since it separates the cerebral hemispheres from the cerebellum. Yet, given the absence of

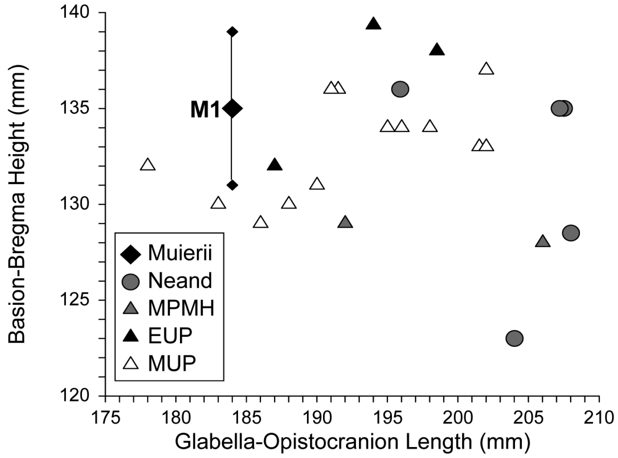

Figure 36 - Bivariate plot of basion-bregma height (BBH) versus neurocranial length (GOL) for Muierii 1 and Late Pleistocene comparative samples. Since the Muierii 1 value is estimated from its opisthion-bregma height of 148.6 mm, the mean estimate ± 1 SE_{est} is provided for it. Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic modern humans; MUP: Mid Upper Paleolithic humans; NW Afr: northwest African Middle Paleolithic humans.

internal data on the position of the transverse sinuses (or endinion), the close approximation of inion and endinion in most Late Pleistocene specimens, and the comparative data available, the angle between the nasion-inion and the nasion-bregma chords is employed here. In addition, it is possible to assess this proportion using the angle at glabella between the bregma, glabella and opistocranion, even though the latter two landmarks are less precise and the last varies vertically with subtle changes in occipital squamous curvature.

In the bregma-nasion-inion comparison, the late archaic humans (Eurasian and northwest African) have relatively low values, and only one early modern human, the early Mid Upper Paleolithic Cro-Magnon 1 cranium, overlaps their range of variation (fig. 37). A similar pattern is evident in the bregma-glabella-opistocranion comparison, although there is more overlap between the samples. In each of these comparisons, Muierii 1 is in the middle of the Mid Upper Paleolithic distribution and among the higher of the earlier modern human specimens.

From these comparisons, despite the limitations of each one, it is apparent that Muierii 1 has a relatively high neurocranium, at least in the context of Late Pleistocene late archaic and early modern humans.

The Frontal Squamous Portion

The frontal squamous has an evenly convex curve from the supraorbital region to the coronal suture and transversely between each temporal fossa (fig. 38 and 39). The midline curvature can be assessed as a comparison of the nasion-bregma arc to its chord (tabl. 22), even though this does not take into account the concavoconvex irregularities produced by pronounced glabellar regions in specimens with supraorbital tori or pronounced midline superciliary arches.

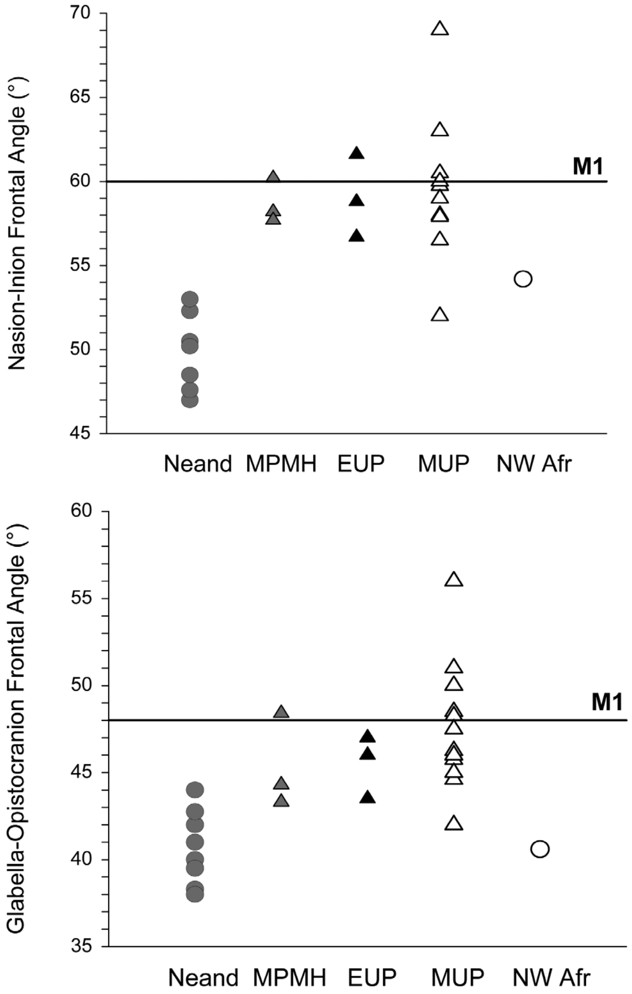

Figure 37 - Bregma-nasion-inion frontal angles (above) and bregma-glabella-opistocranion frontal angles (below) for Muierii 1 (M1) and comparative later Pleistocene samples. Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic modern humans; MUP: Mid Upper Paleolithic humans.

Nasion-bregma (M-29; FRC)	116.0
Nasion-bregma arc (M-26)	131.0
Glabella-bregma arc (M-26a)	123.0
Bregma-lambda (M-30; PAC)	116.0
Bregma-lambda arc (M-27)	129.0
Lambda-opisthion (M-31; OCC)	93.0
Lambda-opisthion arc (M-28)	111.0
Lambda-inion (M-31(1))	61.0
Lambda-inion arc (M-28(1))	68.0
Inion-opisthion (M-31(2))	44.5
Inion-opisthion arc (M-28(2))	43.0
Nasion-opisthion arc (M-25)	371.0
Nasion-inion arc (M-25a)	328.0
Glabella-opisthion arc	363.0
Glabella-inion arc (M-25b)	320.0

Table 22 - Median sagittal chords and arcs for Muierii 1, in millimeters.

Figure 38 - The Muierii 1 cranium in right lateral view. Scale bar equals 5 centimeters.

Figure 39 - The Muierii 1 cranium in anterior view. Scale bar equals 5 centimeters.

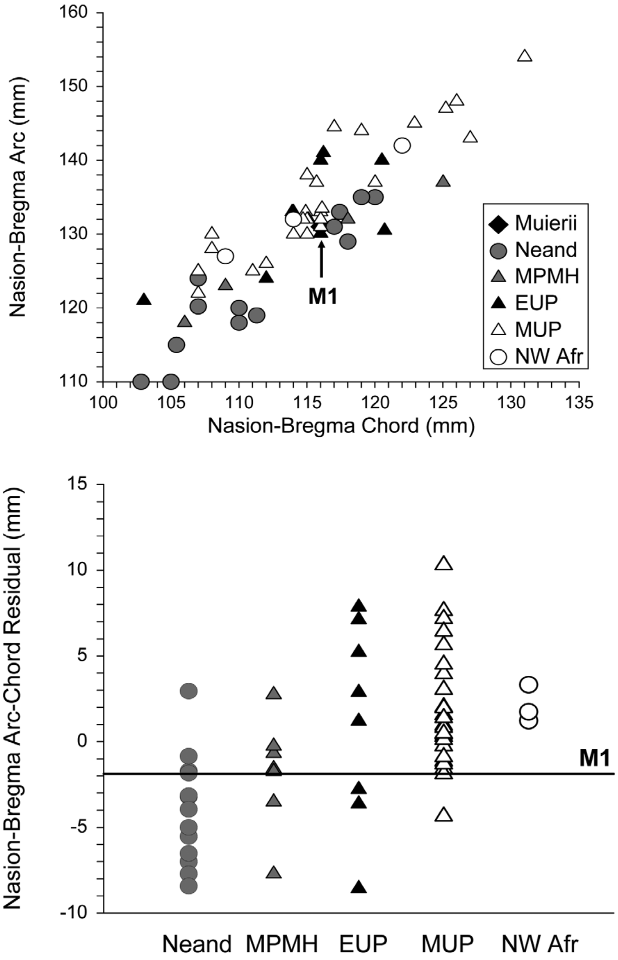

Figure 40 - Bivariate plot of frontal (nasion-bregma) arc (NBA) versus chord (FRC) for Muierii 1 (M1) and the comparative samples (above), and distributions of the raw residuals from the least squares line through the frontal arc (NBA) versus chord (FRC) data points for the pooled comparative sample (below). For the residuals, NBA = 1.315 x FRC – 19.7, $r^2 = 0.776$, N = 23. Muierii 1 (M1) residual: –1.89. Kruskal-Wallis P-value across the comparative samples: <0.001. Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic modern humans; MUP: Mid Upper Paleolithic humans; NW Afr: northwest African Middle Paleolithic humans.

In the bivariate plot of these measures (fig. 40), the Neandertals have among the shorter of the nasion-bregma chords, despite their supraorbital tori, and in that context cluster along the lower (or flatter) portion of the distribution. In this, they are joined by Oase 2 and Cioclovina 1 and all of the Middle Paleolithic modern human crania (bearing in mind that there are estimated values due to distortion and/or reconstruction for Omo-Kibish 1 and Skhul 4 and 9). The remainder of the Early Upper Paleolithic crania aligns with the Mid Upper Paleolithic remains. The Irhoud crania have exceptionally high values for otherwise late archaic humans. Muierii 1 is buried in the plot in the middle of the distribution, among Neandertals and Mid Upper Paleolithic modern humans in their overlap zone.

These comparisons are further illustrated by the residuals from the least squares line through the pooled comparative sample (fig. 40), in which the residuals are significantly different across the samples ($P < 0.001$). The Muierii 1 residual is among the rounder of the Middle Paleolithic humans but relatively flat for an Upper Paleolithic frontal bone.

The external squamous surface is smooth with bilateral vascular lines running anteroinferior to posterosuperior parallel to and above the temporal lines. These grooves are located slightly beyond the bilateral postmortem cracks in the frontal squamous which are evident in figure 39.

The temporal crests are bilaterally sharp and prominent, but they become temporal lines above pterion. The posterior ends of the distinct crests from frontozygomatic posterior, measured as chords, are 29.2 mm on the right and 26.8 mm on the left. The right temporal line is clear to the region of the parietal eminence. On the left side, it fades out immediately posterior of the temporal crest. Both of the temporal lines are double, with superior and inferior distinct lines. At the coronal suture, they are 17.5 mm apart on the right side and separated by 13.7 mm on the left side. It is this separation which produces the superior and inferior stephanion landmarks and bi-stephanic breadths for the cranium (tabl. 20 and 21).

The metopic suture is completely fused and obliterated, but there is a slight irregular depression just above nasion. This area is similar to the zig-zag shape of the supranasal suture of Hauser & DeStefano (1989). The coronal suture is largely straight and regular, with no sutural bones. At bregma, the medial right coronal suture deviates 5.7 mm anterior of the left medial coronal suture, which is associated with a left deviation of the anterior sagittal suture (see below).

Endocranially, the frontal crest is sharp for ~37 mm above the level of nasion. It is slightly deviated to the left at it approaches the ethmoid bone.

The Parietal Bones

The parietal bones have largely even anteroposterior and mediolateral curvatures along their medial portions and then vertical inferolateral walls to the mastoid regions (at least on the more complete right side) (fig. 38). There is little exocranial relief on the parietal bones, but more marked relief from the meningeal vessels and Pacchonian depressions endocranially.

Anteroposteriorly, the sagittal suture has an even convex curve from bregma to the area above lambda. Then, for ~12 mm on the right and for ~20 mm on the left, there is a marked posterior inflection. This creates a distinct supralambdoid depression, or transverse sulcus, a reflection of the normal growth processes (Trinkaus & LeMay 1982) associated with the formation of an occipital bun (see below).

Quantification of the mid-sagittal parietal curvature using the bregma-lambda arc and chord (fig. 41) provides a pattern across these Late Pleistocene humans. The bivariate plot of the two variables aligns most of the specimens along a relatively tight distribution, with the Neandertals clustering in the smaller half of the distribution. The Middle Paleolithic humans, both late archaic and early modern, appear to have relatively flatter parietal arcs, and this is confirmed by their residuals (fig. 41), which are significantly different across the comparative samples (P = 0.003). The northwest African crania have among the flattest sagittal suture arcs. Muierii 1, in both plots, is among the rounder of the early modern humans and separate from the late archaic humans.

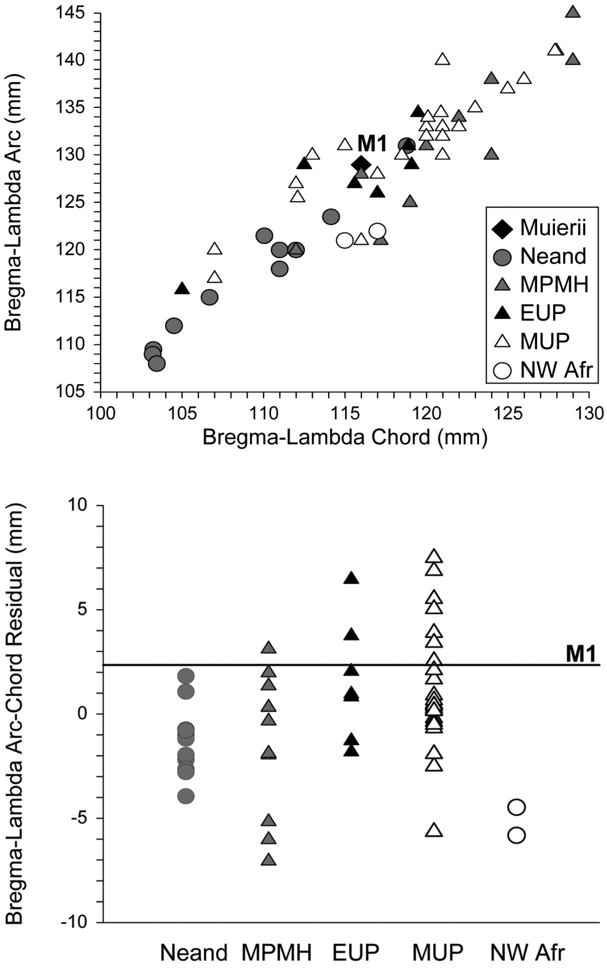

Figure 41 - Bivariate plot of mid-parietal (bregma-lambda) arc (BLA) versus chord (PAC) for Muierii 1 and later Pleistocene comparative samples (above). The high size outlier value for Barma Grande 2 is not included on the plot, but it is in the residual calculations and distribution plot (below). Distributions of the raw residuals from the least squares line through the parietal arc (BLA) versus chord (PAC) data points for the pooled comparative sample (below). For the residuals, BLA = 1.172 x PAC – 9.3, r^2 = 0.888, N = 25. Muierii 1 (M1) residual: 2.36. Kruskal-Wallis P-value across the comparative samples: 0.003. Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic modern humans; MUP: Mid Upper Paleolithic humans; NW Afr: northwest African Middle Paleolithic humans.

The relative mid-sagittal curvatures of the Muierii 1 frontal and parietal bones, however, make it (and a couple of the Early Upper Paleolithic specimens) relatively unusual for an early modern human (fig. 42). The Neandertals generally have lower values for both residuals, indicating their largely low frontal and parietal curvatures. The Mid Upper Paleolithic crania mostly have higher values for both curvature indicators, and the Middle Paleolithic modern human crania fall between the two larger samples. The Middle Paleolithic Irhoud crania are anomalous in having relatively curved frontal bones for their low parietal curvature; the Early Upper Paleolithic specimen close to them in this regard is Mladeč 5, whose frontal curvature is accentuated by both a prominent bulge near metopion and a very pronounced glabella with a low position for nasion. Muierii 1 is low and to the right in the distribution, indicating a relatively flat frontal arc compared to its parietal arc, or a relatively curved parietal arc compared to its frontal one. It is adjacent to Qafzeh 9 and several Mid Upper Paleolithic specimens. The very low Early Upper Paleolithic cranium is Oase 2,

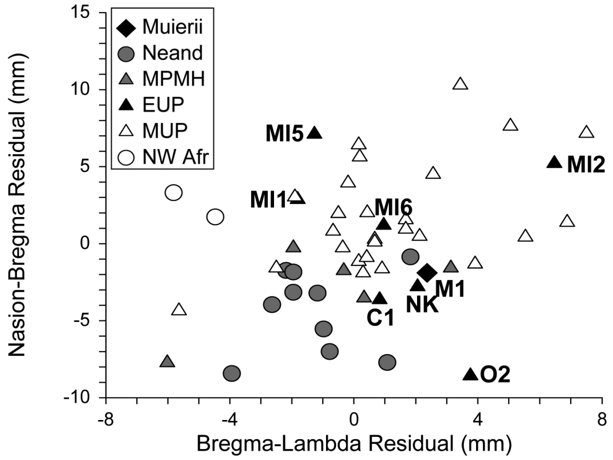

Figure 42 - Bivariate plot of the frontal (nasion-bregma) versus parietal (bregma-lambda) arc-chord residuals, for Muierii 1 (M1) and comparative specimens. Abbreviations as in figure 33. For the Early Upper Paleolithic specimens, C1: Cioclovina 1; Ml1, Ml2 and Ml5: Mladeč 1, 2 and 5; NK: Nazlet Khater 2; O2: Oase 2. Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic modern humans; MUP: Mid Upper Paleolithic humans; NW Afr: northwest African Middle Paleolithic humans.

which is similar to the Shanidar 1 and Spy 1 Neandertals but otherwise an outlier.

Transversely through the mid-parietal bones, there is an even curve from one parietal eminence to the other one (see fig. 47 below). There is no angle or swelling along the sagittal suture. The vault is then angled at the parietal eminences and, especially on the better preserved right side, descends vertically to the mastoid region.

The sagittal suture deviated 5.6 mm of the midline for its anterior 8.1 mm to bregma, which is associated with the anterior deviation of the left medial coronal suture (see above). It is then straight once posterior of that deviation, with the normal, and largely fused, interdigitations. There are no sutural bones in the sagittal suture. The lambdoid suture has modest interdigitations along its preserved length (preserved for all of the right side and the medial half of the left side), and there are no sutural bones.

The right parietomastoid suture slopes posteroinferiorly from entomion to asterion at an angle of ~30° to the estimated Frankfurt horizontal. This line tends to be more horizontal in Neandertals and posteroinferiorly sloping in early modern humans, but it is variable within both samples (Trinkaus 2002). The clear slope of the Muierii 1 suture aligns it more with other early modern humans. There is no evidence of a sutural bone at asterion, so that if such existed, it would have been into the missing temporal bone.

Endocranially, there are deeply excavated meningeal sulci on the more complete right parietal bone (fig. 43). In particular, there is a marked sulcus for the middle meningeal vessel approximately parallel to the coronal suture, which zig-zags slightly as it rises toward bregma. It ends just below a Pacchonian depression, but it does not appear to have been associated with a Breschet sinus. At pterion, there is a branch moving posterosuperiorly from it, and then above pterion a large vertical branch forms off of it, which is convexly posterior and converges towards it further superiorly. This vertical branch then gives rise to three primary branches extending posterosuperiorly from it. There appear to be anastomoses between these three branches. In addition there is a strongly marked posterior meningeal sulcus, which crosses the squamosal suture anterosuperior of entomion, to then rise parallel to the lambdoid suture and fade out near lambda. Only the superior portions of the left meningeal sulci are preserved, but they appear to conform in their general pattern to what is evident on the right side, albeit with asymmetrical variation in the finer branching patterns. Neandertals, in contrast to early and recent modern humans, appear to be characterized by a dominant coronal (middle meningeal) branch, little complexity to the branches coming off of the coronal branch, a simple set of posterior branches, and the frequent presence of a Breschet sinus (Saban 1986; Grimaud-Hervé 1997). Given this dichotomy, which ignores variation within both late archaic and early modern human samples, the Muierii 1 pattern appears to be aligned with the more common modern human pattern.

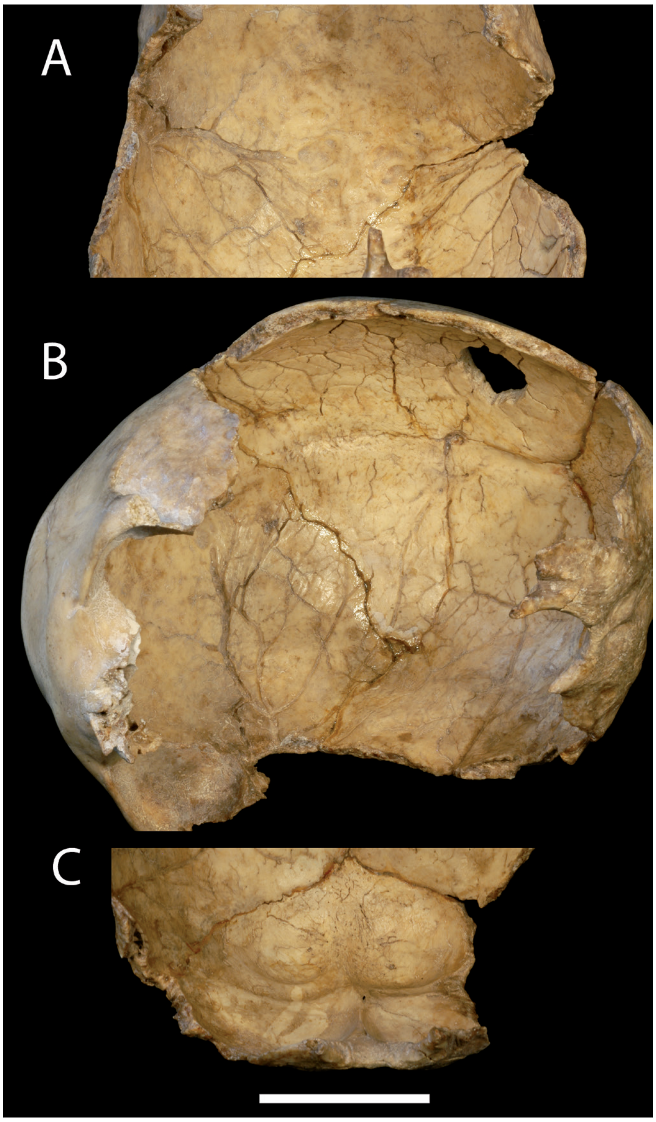

Figure 43 - Endocranial views of the Muierii 1 neurocranium. A: inferior view of the bregmatic area. B: internal view of the right parietal bone. C: anterior view of the occipital squamous portion.

At the same time, there are bilateral Pacchonian depressions on the anteromedial parietal bones, just posterior of the coronal suture. On the right parietal bone, there it is an ovoid depression, ~12 mm mediolateral and ~9 mm anteroposterior, which then continues posteriorly as a sulcus 10-11 mm wide that gradually fades out along the sagittal suture. On the left parietal bone, the depression is larger and more oblique in its major axis orientation, being ~13 mm anterolateral to posteromedial and ~19 mm anteromedial to posterolateral (diameters are approximate given the normally rounded margins of the depressions). The left depression then continues into a shallow groove with less distinct borders, 1 mm wide, along the sagittal suture.

The Occipital Bone

The Muierii 1 occipital bone retains almost all of the right side of the squamous portion and a substantial portion of the left side (fig. 38 and 44).

The occipital plane is dominated by a pronounced occipital bun, readily evident in lateral view. The curvature, as noted above, begins 12-20 mm above the lambdoid suture on the posterior parietal bones, continues across the lambdoid suture and around the superior occipital bone, to curve inwards in the vicinity of the internal transverse sinus sulci (or the tentorium cerebelli). As such, the inferior margin of the bulge is below the superior nuchal lines (or below inion) in the superior portion of the nuchal plane. Unfortunately, the sagittal curvature of this area tends to be assessed exocranially, whereas an occipital bun is the product of differential cerebral growth and a posterior displacement of the superior occipital bone with additional bony deposition along the lambdoid suture (Trinkaus & LeMay 1982).

The occipital bun is also evident in inferior view (fig. 44). Rather than rounding evenly from the mastoid regions to the mid-posterior occipital bone, the posterolateral contour of the occipital bone, best evident on the more complete right side, is largely straight with a slight concavity in the vicinity of asterion. The contour in inferior view then rounds onto the transverse plane of the middle of the superior nuchal line and the associated modest nuchal torus.

Occipital buns are present on most of the Neandertals (93.3%, N = 15). They are usually described as being completely absent from the Middle Paleolithic modern humans (N = 13) (White *et al.* 2003; Trinkaus 2007). Herto 1 does have a distinct protuberance of the superior occipital squamous portion along the lambdoid suture and what appears to be a small supralambdoid depression, but this may be the product of a fossilization crack and not a true occipital bun (White *et al.* 2003). Irhoud 1 lacks one, but Irhoud 2 may have one (Ennouchi 1968). Occipital buns are variably present in Mid Upper Paleolithic modern humans, with pronounced ones being present in 18.9% (N = 37) of the European Mid Upper Paleolithic crania (Trinkaus 2007). Among the Early Upper Paleolithic humans, Mladeč 5 and 6, plus Muierii 1, have pronounced buns, Cioclovina 1, Mladeč 1 and Oase 2 have small ones, or hemi-buns (Smith 1984), and Nazlet Khater 2 lacks any occipital protrusion [Niah 1 is insufficiently complete to provide an indication of its occipital protuberance (Brothwell 1960)].

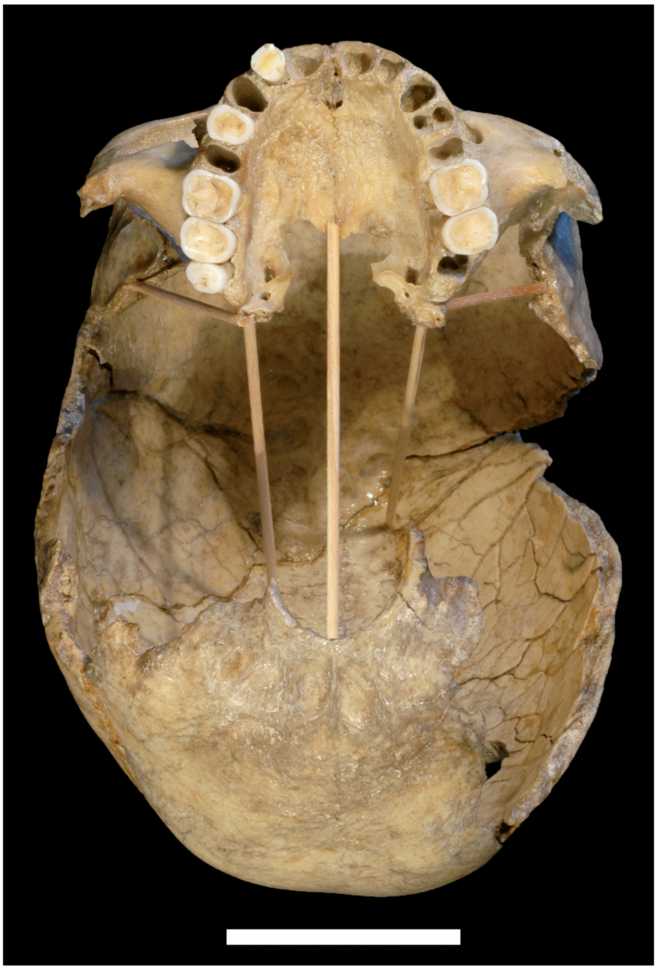

Figure 44 - Inferior view of the Muierii 1 cranium. Scale bar equals 5 centimeters.

The closest morphometric exocranial approximation of the occipital bun of Muierii 1, for which comparative data are available, are the arc and chord measures from lambda to inion, which neglect the posterior parietal contribution and the area below inion. Nonetheless, there is a pattern in this in which the Neandertals, with their high frequency of occipital buns, have higher values, and several of the Middle Paleolithic modern humans, with their absence of buns, have the low values. Yet, Herto 1, with its protuberant occipital squamous has one of the highest residuals for this comparison (fig. 45). The Early Upper Paleolithic samples, plus the two Irhoud crania, with variable development of occipital buns, have intermediate values, and Muierii 1 falls in the overlap zone of these samples. The Mid Upper Paleolithic ones tend to have smaller residuals, or less projection of the lambda-inion arc. Nonetheless, despite considerable overlap, a comparison of the lambda-inion residuals for Late Pleistocene crania with and without occipital buns (absent: -1.39 ± 2.24, N = 18; present: 1.19 ± 2.49, N =16) provides a significant difference between the samples (Wilcoxon P = 0.005), and once again Muierii 1 falls in the overlap zone given its relatively high position for inion.

Exocranial and Endocranial Occipital Morphology

Relatively high on the external occipital plane, 20.4 mm below lambda, there is a rugose and slightly depressed oval area

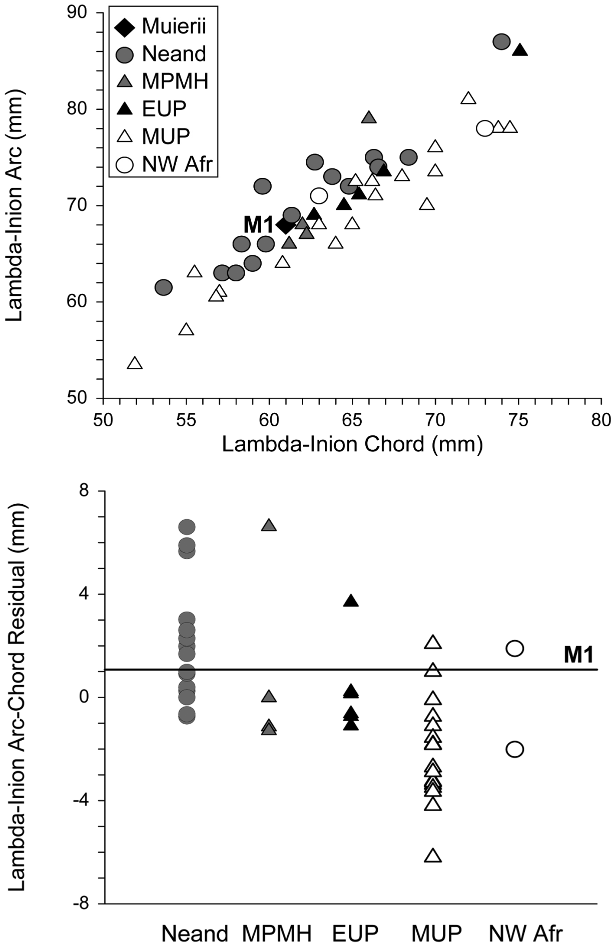

Figure 45 - Bivariate plot of superior occipital (lambda-inion) arc (LIA) versus chord (LIC) for Muierii 1 and later Pleistocene comparative samples (above), and distributions of the raw residuals from the least squares line through the superior occipital arc (LIA) versus its chord (LIC) data points for the pooled comparative sample (below). For the residuals, LIA = 1.091 x LIC + 0.4, $r^2 = 0.828$, N = 32. Muierii 1 (M1) residual: 1.08. Kruskal-Wallis P-value across the comparative samples: <0.001. Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic modern humans; MUP: Mid Upper Paleolithic humans; NW Afr: northwest African Middle Paleolithic humans.

5.3 mm in diameter (fig. 46). It has the surface irregularity normally seen in a suprainiac or supranuchal fossa, but it located too high on the occipital bone to be homologous with those features. Its significance is unclear. In the suprainiac region proper, there is a distinct fossa on the midline at the superior margin of the swelling above the superior nuchal lines. Its breadth is 21 mm. The inferior margin is transversely straight across the middle and then rounds up on the sides. The superior margin is a raised area that descends inferiorly in the middle. These features produce a depression which resembles an irregular lunate shape. It is unclear whether this represents a poorly formed suprainiac fossa, in the sense of a transversely oval depression with an irregular or rugose floor and an incurving of the external table (*cf.* Balzeau & Rougier 2010). At the same time, it does not represent a supranuchal fossa (*sensu* Sládek 2000), since it lacks the inferiorly projecting midline portion, extending down onto the superior portion of an external occipital protuberance.

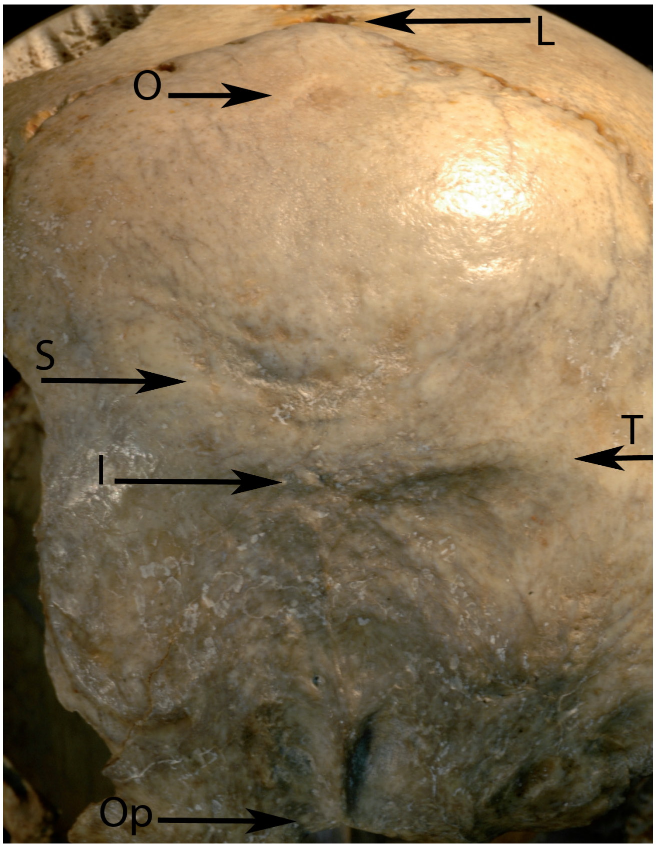

Figure 46 - Posteroinferior view of the Muierii 1 occipital bone. L: lambda; O: superior oval depression; S: depression above inion; I: inion; T: occipital transverse torus; Op: opisthion.

Slightly below this fossa is the region of inion, which completely lacks any evidence of an external occipital protuberance. For measurement purposes, inion has been located by the convergence of the superior nuchal lines and not by any distinct feature on the midline. On the left side, the superior nuchal line is weakly marked, and there is no nuchal torus; there is only a transition from a concavity of the nuchal plane to the convexity of the occipital plane. On the right side there is a clear raised ridge, 2.8 mm in height, that extends for 19 mm laterally from the midline. The clearest portion of it is the muscle line on its inferior portion, but there is still a swelling above the muscle (superior nuchal) line rather than just a rugose line for the muscle insertion. This will be referred to here as a nuchal torus, although it is mostly unilateral in development and is modest. Further laterally, the nuchal line fades out, and it is barely evident closer to asterion.

It is unclear whether this configuration of features represents an incipient form of the suprainiac complex, best defined for the Neandertals (Hublin 1978; Santa Luca 1978; Trinkaus 2004a; Caspari 2005). In those specimens, the complex is normally defined as consisting of 1) a distinct, transversely oval (single or double) depression above the midline of the superior nuchal lines and the associated nuchal torus, 2) the complete absence of an external occipital protuberance, and 3) a modest nuchal torus that is limited to the medial halves of occipital bone. Muierii 1 can be seen as exhibiting all of these features in the Neandertal combination. However, the fossa is small and not highly distinct, and the nuchal torus is mostly on one side. Is this the "Neandertal" combination in an incipient form, or reduced expression, or is it something different? Since this is clearly an early modern human cranium, with a contrasting overall shape to those of the Neandertals, to what extent is the diagnosis of these features influenced by that context?

Among the known western Eurasian Neandertals, all three of these features are present with some degree of development in 100% (N = 23). Among the Middle Paleolithic modern humans (N = 16), 87.5% of the specimens lack any evidence of a suprainiac fossa. The immature Qafzeh 10 has slight suprainiac porosity but no fossa (Tillier 1999). Aduma 3 has a suprainiac fossa, but it lacks a nuchal torus and has a prominent external occipital protuberance (Haile-Selassie *et al.* 2004). Therefore, none of the Middle Paleolithic modern humans have the full Neandertal iniac morphology. Similarly, most of the Early Upper Paleolithic specimens (Mladeč 1 and 5, Nazlet Khater 2, Oase 2) lack this complex; Mladeč 5 has a prominent external occipital protuberance, Nazlet Khater 2 has a continuous nuchal torus with a slight irregularity in the suprainiac area and little development of the external occipital protuberance, and Oase 2 is almost featureless in this region (Frayer *et al.* 2006; Rougier *et al.* 2007; Crevecoeur 2008). Mladeč 6 does have a distinct oval suprainiac depression but also exhibits a complete transverse nuchal torus (Frayer *et al.* 2006). Cioclovina 1 has a shallow, but broad and oval suprainiac fossa with a median nuchal torus; it lacks a distinct external occipital protuberance but it has a small triangular projection below the torus at the superior end of the crest between the semispinalis capitis insertions (Soficaru *et al.* 2007).

It is therefore apparent that there is considerable variation in this external occipital region among Early Upper Paleolithic modern humans (and to a lesser extent among Middle Paleolithic modern humans). None of these early modern humans appear to have both the complex of features *and* the degree of expression of them commonly seen among the Neandertals. However, unless one is going to deny all homology of these features *a priori* (see Caspari 2005 for discussion), it is evident that Cioclovina 1 and Muierii 1 have modest development of the same complex of features as do the Neandertals.

The Muierii 1 semispinalis capitis fossae are a broadly rugose area with their concavity evident mostly adjacent to the nuchal lines. The midline crest between them is prominent, and it continues as a thin crest to opisthion. There are two distinct fossae, on either side of the midline crest just posterior of the foramen magnum and slightly longer on the left side; they should be reflections of the insertions for the rectus capitis posterior minor muscles. The right occipitomastoid suture is present, and there is little evidence of the juxtamastoid eminence. The juxtamastoid eminence was therefore either entirely temporal in distribution or very weakly expressed.

Endocranially, there are clear sulci for the transverse sinuses (fig. 43). Superiorly for the sagittal sinus there is a swelling without a distinct sulcus. Inferiorly there is a sharp crest and no evidence of a sulcus for the occipital marginal sinus. The right transverse sinus sulcus is above the left one at midline, indicating its (normal) predominant communication with the sagittal sinus. The right sigmoid sinus traverses the posteroinferior corner of the parietal bone, fully onto the parietal bone, before crossing the parietomastoid suture and descending to the jugular foramen.

The Posterior Neurocranial Profile

Among Late Pleistocene crania, the Neandertals have been noted as having a neurocranial outline that is largely ovoid, with a smooth rounding from mastoid process to mastoid process, little or no protuberance of the parietal eminences, no elevation along the sagittal suture, and lateral mastoid processes that curve inwards inferiorly (Boule 1911-13). Referred to as the *forme en bombe* (rounded, with reference to a traditional riding hat), it has been used as a uniquely derived characteristic of the Neandertals (Hublin 1983). In comparison to earlier, more angular *Homo* crania, this form is a product of a loss of sagittal keeling and angular tori, lateral expansion of the parietal region, with retention of the in-curving mastoid processes (Trinkaus 2006a). This Neandertal profile has been contrasted with the purported modern human form of a pentagonal shape, with angulation at the sagittal suture and parietal eminences combined with laterally protruding mastoid processes, referred to by Eurocentric term *forme en maison* (Hublin 1983). This pentagonal shape has been considered to be ancestral for *Homo* crania, but such an inference confuses non-homologous structures (e.g., angular tori with parietal eminences, relatively wide cranial bases with laterally prominent mastoid processes) and is therefore not valid.

In this context, the Muierii 1 cranium more closely resembles the derived modern human form, with prominent parietal eminences and (probably) prominent mastoid processes (judging from Muierii 2), but it lacks the mid-sagittal angulation (fig. 47). It should therefore be referred as *forme en fesses de cheval* (referring to the equine profile in caudal view). This same form is present on some other Early Upper Paleolithic crania, in particular Oase 2 (Rougier *et al.* 2007), Mladeč 2 (Wolpoff *et al.* 2006), and to a lesser extent, Cioclovina 1 (Soficaru *et al.* 2007). The other sufficiently complete Early Upper Paleolithic crania (Mladeč 1, 5 and 6) exhibit the pentagonal form. The four sufficiently complete and undistorted Middle Paleolithic modern human crania, Omo-Kibish 1 and 2, Qafzeh 6 and Skhul 5, conform to the pentagonal profile. Among Mid Upper Paleolithic humans, however, 36.3% (N = 22) have the rounded mid-sagittal profile and therefore are similar to the Muierii 1 profile. In the last sample, many of the specimens also have rounded parietal eminences, lacking the distinct superolateral angulation seen in Muierii 1.

All Neandertal crania conform to, or appear to match, the rounded posterior profile. The Irhoud 1 and 2 crania are basically similar to the Neandertal pattern with rounded superior profiles and in-curving mastoid processes, but they have modestly more angulation of the parietal eminences than do the Neandertals. Interestingly, the east Asian late archaic human cranium from Maba (Woo & Peng 1959) has a completely rounded profile, from the inferior parietal bone and then across the regions of the parietal bosses and sagittal suture; it only lacks the temporal bones to ascertain whether is had the complete Neandertal profile, but the ancestral nature of the in-curving mastoid processes suggests that it did. The Aterian (northwest African Middle Paleolithic) posterior neurocranium from Témara (Ferembach 1998) also has the completely rounded profile seen in the Neandertals, but it lacks the mastoid processes and therefore their degree of incurving cannot be assessed. As with Maba 1, the generally archaic nature of the Témara neurocranium and other Témara remains suggests that it had the ancestral pattern of incurving mastoid processes and hence the ovoid *forme en bombe* of the Neandertals.

Figure 47 - Posterior view of the Muierii 1 cranium. Scale bar equals 5 centimeters.

Neurocranial Petalias

The Muierii 1 neurocranium shows little asymmetry of the frontal squamous, with only a suggestion of an anterolateral bulge of the frontal region but no real difference in the external directly anterior projection of the right versus left sides (fig. 32). The occipital bone exhibits a distinct posterior projection of the left squamous portion, evident in superior view (fig. 32) but particularly apparent in inferior view (fig. 44). The occipital protrusion represents a normal left occipital petalia, reflecting the more posterior projection of the underlying left cerebral occipital lobe. As such it conforms to the normal pattern of recent humans, in which left occipital petalias are common but right frontal ones are less frequent (LeMay 1976; Chui & Damasio 1980), a pattern also evident in Pleistocene later archaic humans (Holloway 1981a,b).

The Supraorbital Region

The Muierii 1 supraorbital region is, as noted above with respect to sex assessment, very modest for a Late Pleistocene human (fig. 39 and 48) . There are clear superciliary arches, but they are smooth and rounded. They extend from mid-orbit to mid-orbit, for a total breadth of ~74 mm, which is 68.5% of its bi-frontozygomatic anterior breadth. The superciliary arches are above and separate from the orbital margins, and they are continuous across glabella. There are clear sulci bilaterally between the superciliary arches and the supraorbital trigones, producing segmentation of the supraorbital region (*cf.*, Sládek *et al.* 2002) and a "pinched" appearance (Smith & Ranyard 1980) to the middle of the supraorbital region. The lateral trigones are flat and then grade on to a slight swelling laterally above the frontozygomatic sutures. In lateral view (fig. 31 and 38) there is a distinct swelling at glabella and an associated supraglabellar sulcus, but the contour remains rounded and smooth.

Among Early Upper Paleolithic modern humans, only La Crouzade 5 and Mladeč 2 closely approach the modest degree of su-

Figure 48 - Anterior view of the Muierii 1 frontal bone. The bi-frontozygomatic chord is 108 mm.

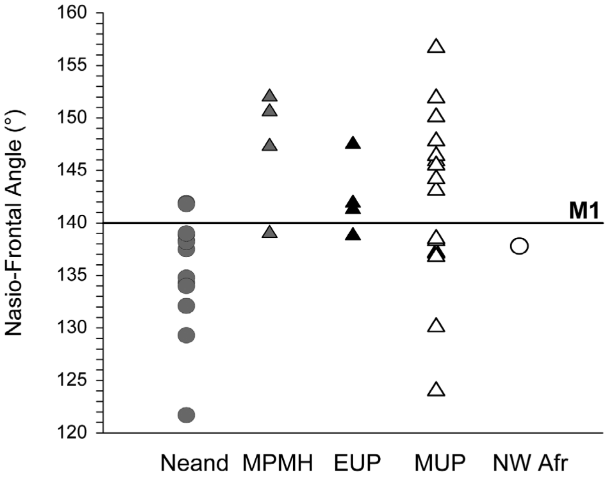

Figure 49 - Nasiofrontal angles (each frontozygomatic anterior to nasion) for Muierii 1 (M1) and the comparative samples. Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic modern humans; MUP: Mid Upper Paleolithic humans; NW Afr: northwest African Middle Paleolithic humans.

perciliary arch development seen on Muierii 1, although among Mid Upper Paleolithic humans several crania, including those of Dolní Věstonice 3, Cro-Magnon 2, Paglicci 25 and Pataud 1, are similar. Most of the remainder of the Early and Mid Upper Paleolithic humans in Europe exhibit more pronounced superciliary arches, especially in the region of glabella, as does Nazlet Khater 2. The contemporaneous Hofmeyr 1 cranium has a thin but distinct supraorbital torus (*sensu* Cunningham 1908; Grine *et al.* 2007). Neandertals universally possess full supraorbital tori. Among the Middle Paleolithic modern humans there is variation, with a couple of the Skhul crania having thin supraorbital tori, Herto 1 having a pronounced torus but one divided into medial and lateral halves, and the remainder exhibiting variable development of the superciliary arches but no tori (McCown & Keith 1939; Vandermeersch 1981; White *et al.* 2003). The northwest African late archaic humans from Irhoud and especially Dar-es-Soltane all have variably robust but pronounced supraorbital tori (Ennouchi 1962, 1968; Ferembach 1976; Hublin 1991; Harvati & Hublin 2009).

The orbital margins have a relatively sharp angle between the orbital roofs and the anterior supraorbital surfaces, especially medial of the supraorbital notches to the regions of dacryon. The anterior surface becomes more rounded laterally, making the angle less sharp. Just lateral of the supraorbital notches, where there are distinct orbital margins below the lateral superciliary arches, the thickness is 1.5 and 1.1 mm on the right and left sides respectively. The margin then thickens laterally, with the thickness from the orbital roofs becoming 6.9 and 7.4 mm respectively at the frontal sides of the frontozygomatic sutures.

The degree of midline projection of the Muierii 1 supraorbital region, which reflects both midline projection and relative posterior positioning of the frontozygomatic sutures, is approximated by the nasiofrontal angle (tabl. 23). Its value of 140° for Muierii 1 falls in the middle of the overall range of variation for both Late Pleistocene humans (fig. 49) and recent humans. Howells (1973) provided a range of means for 17 samples of recent human males of 137.4° ± 4.1° to 146.9° ± 4.8° and 139.0° ± 3.7° to 146.6° ± 3.3° for females. The Muierii 1 value is very close to those for Oase 2 (139°), Cioclovina 1 (141°) and Mladeč 5 (142°). Neandertals tend to have lower angles, reflecting both their prominent nasal regions and their posteriorly positioned zygomatic regions (Trinkaus 1987). The Mid Upper Paleolithic sample has generally higher angles, but two individuals with prominent midline regions (Brno-Francouzská 2 and Sunghir 5) provide a range encompassing the remainder of the later Pleistocene specimens. Irhoud 1, with less midfacial projection, has an intermediate value.

The passageways for the supraorbital branches of the frontal branches of the ophthalmic nerves (CN-V1) and associated arteries from the orbital cavity to the anterior frontal squamous are notches bilaterally. The right supraorbital notch is fully open with a slight incurving of the anteroinferior margins, such that the maximum breadth is 5.2 mm and the anterior opening is 4.6 mm wide. It is 27.2 mm from nasion. The left notch almost closed, with a maximum breadth of 5.2 mm and an opening of 0.9 mm. It is located 28.1 mm from nasion. With associated connective tissue, these "notches" would have been effectively foramina antemortem. Following Hauser & DeStefano (1989), they can be categorized as bilateral, medial, notches, single and large. Slightly above the left supraorbital notch is a small foramen, whose original contents are uncertain.

	Right	Left
Nasion-glabella chord	8.0	
Nasion-glabella arc	8.0	
Nasion-supraglabellare chord	21.5	
Bi-frontozygomatic anterior chord (M-43a; FMB)	108.0	
Bi-frontozygomatic posterior chord	112.1	
Nasion-frontozygomatic anterior chord	57.8	57.2
Nasion projection (M-43b; NAS)	19.8	
Nasiofrontal angle (M-77a; NFA)	140°	
Glabella-frontozygomatic anterior chord	59.5	59.3
Glabella projection[1]	24.7	
Glabellofrontal angle[1]	131°	
Bi-dacryon (M-49a; DKB)	26.8	
Simotic br (min bi-nasals) (M-57; WNB)	11.5	
Frontozygomatic suture anteroposterior	7.8	8.1
Frontozygomatic suture superoinferior	9.2	9.3

[1] The projection of glabella in front of the bi-frontomalare anterior chord and the angle at glabella between each glabella-frontomalare anterior chord.

Table 23 - Measurements of the Muierii supraorbital region, in millimeters and degrees.

The relative degree of projection of glabella versus nasion is indicated by both its larger projection value from the bi-frontozygomatic anterior chord (24.7 mm versus 19.8 mm) and by its lower glabellofrontal angle (131° versus 140°) (tabl. 23). The glabellofrontal angle is not available for the comparative samples, but it can be calculated for Cioclovina 1 (127°) and Oase 2 (128°). The difference between the glabellofrontal angle and the more usual nasiofrontal angle indicates that Muierii 1 possessed a moderately projecting glabellar region despite the overall gracility of its supraorbital region. In this aspect, it resembles most European Early Upper Paleolithic, and even Mid Upper Paleolithic, modern humans, many of whom have pronounced swelling of the glabellar region and a continuous connection between the two superciliary arches (Franciscus & Vlček 2006; Wolpoff *et al.* 2006; Frayer *et al.* 2006; Soficaru *et al.* 2007). The La Crouzade 5 frontal, in contrast, has essentially no glabellar projection (Henry-Gambier & Sacchi 2008).

The right frontozygomatic suture is intact, but the left one is modestly abraded. Neither one shows any signs of antemortem fusion. Their dimensions are provided in table 23.

From a clinical computer tomography scan (3 mm slices), it is possible to see that the frontal bone has well-developed frontal sinuses. There are well formed right and left sinus air cells with a midline septum, that extend up into the area of glabella just above the nasal root, and then at least two larger air cells at least on the left side. Following Szilvassy (1982) and Hauser & DeStefano (1989), Muierii 1 exhibits frontal sinus form "b" (leaf shape). In frontal view, the right and left ones are 4.9 and

4.6 cm^2 in area respectively, a relatively common size among recent human; between ~20% and ~50% of continental recent humans have frontal sinus areas in the 3 to 6 cm^2 range (Hauser & DeStefano 1989).

The Facial Skeleton

The Muierii 1 facial skeleton consists of the superior nasal bones adherent to the frontal bone, and then a larger piece of the maxillae and palatine bones connected to the neurocranium through the anterior left zygomatic bone (fig. 31, 39 and 44; tabl. 24 to 26). Despite missing portions of the interorbital and right orbital regions, the facial skeleton provides considerable morphological information. The alveolar process and teeth are described with the dentition.

Overall Facial Size and Projection

Approximations of overall facial size and proportions can be provided by comparing the prosthion radius (mid-sagittal bi-porial axis to prosthion) and the zygomaxillary breadth (bi-zygomaxillare anterior) to nasion-prosthion height. The first and last of these measurements have required some estimation for Muierii 1. The first was estimated from its nasion-opisthion and prosthion-opisthion distances, and it has an SE_{est} of 2.8 mm (tabl. 25). The last was measured directly on the reassembled facial skeleton, and it is dependent upon the correct positioning of the maxillae relative to the frontal bone; it is not likely to be more than a couple of millimeters in error.

The result bivariate plots of these pairs of measurements (fig. 50) show a generally similar relationship between the two pairs of measurements across the later Pleistocene samples, with the Neandertals and a couple of the Middle Paleolithic modern humans having larger faces overall. The Upper Paleolithic modern humans have smaller and less projecting faces. Muierii 1, as with its neurocranium, is among the smallest of the individuals represented. In the context of these comparisons, the Muierii 1 face is among the less projecting and wider of the available facial skeletons. Minor adjustments for estimation uncertainties will have little effect on this inference.

The Orbits

The orbits (fig. 39) retain the frontal margins bilaterally, the lateral and inferior margins on the left side, and most of the medial margin on the right side. They are generally subrectangular in shape, with gently convex superior, inferior, lateral and probably medial sides. They best fit category "a" of Hauser & DeStefano (1989). The inferior and superior margins slope slightly inferolaterally, producing orbits that are lower laterally than they are medially. The inferior margins also slope slightly posterolaterally. Nothing remains of the interior orbital walls more than a few millimeters from the anterior margins of the orbits. Whereas the superior orbital margins are relatively sharp (see above), the left lateral margin is partly rounded and the inferior margins are angled but not sharp.

	X	Y	Z
Prosthion	230.2	361.8	–94.1
Subspinale	227.8	361.0	–102.0
Nasospinale	224.5	359.5	–110.3
Lateral nose right	210.2	352.6	–111.8
Lateral nose left	233.0	362.5	–121.3
Zygoorbitale left	243.7	366.2	–140.5
Zygomaxillare anterior right	190.1	323.2	–96.8
Ektochonion left	258.5	365.9	–165.8
Frontomalare anterior left[1]	251.8	372.6	–172.4
Orale	230.4	355.8	–99.7
Palalatine[2]	232.0	328.5	–119.8
C buccal alveolus right	212.6	344.4	–89.2
M^1 buccal alveolus right	209.8	321.4	–94.9
M^2 buccal alveolus right	210.7	314.3	–101.8
M^3 distal right	217.1	310.1	–105.0
Posterior alveolus right	221.1	306.9	–109.2
C buccal alveolus left	252.0	358.7	–105.8
M^1 buccal alveolus left	263.5	342.3	–118.5
M^2 buccal alveolus left	263.3	335.7	–123.6
M^3 distal left	259.5	326.3	–124.4
Posterior alveolus left	255.5	322.4	–128.4

[1] The frontomalare anterior point is on the left zygomatic bone attached to the left maxilla.

[2] Intersection of the intermaxillary and palatomaxillary sutures on the palate.

Table 24 - Three dimensional Cartesian coordinates of landmarks on the Muierii 1 facial skeleton, derived using a Microscripe G2 digitizer, in millimeters. The position of the 0-0-0 point is posterior of the neurocranium but otherwise arbitrary.

The Zygomatic Bones

Little remains of the zygomatic bones, other than the lateral portion which connects the left maxilla to the frontal bone and a small section along the zygomaxillary suture on the right side. It is nonetheless possible to assess the development of zygomatic marginal tubercle, which projects posteriorly lateral of the temporal fossa and provides attachment for the temporal fascia. There is a modest development of a marginal tubercle on the left zygomatic bone, which conforms to category "b" (weak expression) of Hauser & DeStefano (1989).

The Nasal Region

The nasal bones are strongly curved transversely, and this is reflected as well in the frontonasal suture. The suture makes an even arc across the posterosuperior nasal bones. However, the internasal suture, which is in the middle at the anterior break of the nasal bones, curves superiorly to the right, such that it meets the frontonasal suture to the right of the midline (Fig. 48).

The nasal cavities, to the extent that can be determined from their incomplete superior portions, conform to Hauser & DeStefano's category "b" (trapezoid).

	Right	Left
Nasion-opisthion length (M-5(1))	139.0	
Nasion-basion length (M-5; BNL)	(102.0)[2]	
Nasion radius (NAR)	(95.0)[3]	
Prosthion-opisthion length	122.7	
Prosthion-basion length (M-40; BPL)	(89.0)[4]	
Prosthion radius (PRR)	(97.0)[5]	
Alveolare-opisthion length	118.0	
Zygomaxillare anterior – opisthion length	109.2	107.2
Zygomaxillare anterior – opisthion (midline)	96.8	
Zygomaxillaire anterior – basion length	(79)[6]	(78)[6]
Zygomaxillaire anterior – basion (midline)	(62.0)[7]	
Zygomaxillare radius (ZMR)[8]	(67.0)[9]	
Distal M^3 – opisthion length	76.6	79.3
Distal M^3 – opisthion (midline)	74.6	

[1] Given the absence of basion, the primary measurements are from opisthion, and therefore dependent in part on the alignment of the facial skeleton. Measurements from basion or porion (radii) are then estimated from a reference sample.

[2] The nasion-basion length (NBL) is estimated from the nasion-opisthion length (NOL) using a least squares regression based on a pooled sample of recent and Late Pleistocene humans (N = 38): NBL = 0.705 x NOL + 4.3, r^2 = 0.913. The estimated value (102.3 ± 2.1 mm; SE_{est}: 2.05%) is rounded off to 102 mm.

[3] The nasion radius (NAR) is estimated from the nasion-opisthion length (NOL) using a least squares regression based on a pooled sample of recent and Late Pleistocene humans (N = 38): NAR = 0.673 x NOL + 1.7, r^2 = 0.865. The estimated value (95.3 ± 2.6 mm; SE_{est}: 2.73%) is rounded off to 95 mm.

[4] The prosthion-basion length (PBL) is estimated from the prosthion-opisthion length (POL) using a least squares regression based on a pooled sample of recent and Late Pleistocene humans (N = 38): PBL = 0.754 x POL – 3.3, r^2 = 0.942. The estimated value (89.1 ± 2.6 mm; SE_{est}: 2.69%) is rounded off to 89 mm.

[5] The prosthion radius (PRR) is estimated from the nasion-opisthion length (NOL) using a least squares regression based on a pooled sample of recent and Late Pleistocene humans (N = 38): PRR = 0.700 x NOL + 10.9, r^2 = 0.919. The estimated value (96.7 ± 2.8 mm; SE_{est}: 2.90%) is rounded off to 97 mm. Using the slightly estimated prosthion-opisthion length (POL) (estimated given facial positioning through the left zygomatic bone) provides an identical result: PRR = 0.722 x POL + 7.9, r^2 = 0.923, Muierii 1 PRR: 96.6 ± 2.8 mm; SE_{est}: 2.90%.

[6] The right and left basion – zygomaxillaire anterior chords (BZA) were estimated from the right and left opisthion – zygomaxillaire anterior chords (OZA) respectively, based on a least squares regression from a pooled sample of recent and Late Pleistocene humans (N = 38): (right: BZA = 0.669 x OZA + 5.9, r^2 = 0.908; 78.9 ± 2.0 mm, rounded off to 79 mm, SE_{est}: 2.53%; left: BZA = 0.638 x OZA+ 9.9, r^2 = 0.879; 78.3 ± 2.2 mm, rounded off to 78 mm, SE_{est}: 2.81%).

[7] Basion – zygomaxillaire anterior midline calculated from the estimated basion – zygomaxillare anterior chords and the bi-zygomaxillare breadth.

[8] The zygomaxillare radius is from the bi-porion axis to the bi-zygomaxillare axis, and as such it may differ trivially from the ZMR of Howells (1973), which is to the left zygomaxillare anterior.

[9] The zygomaxillare radius (ZMR) is estimated from the midline opisthion-zygomaxillare anterior distance using a least squares regression based on a pooled sample of recent and Late Pleistocene humans (N = 37): ZMR = 0.540 x Op-Zma + 15.0, r^2 = 0.773. The estimated value (67.3 ± 2.6 mm; SE_{est}: 3.86%) is rounded off to 67 mm. It is included, even though its larger precentage prediction error (>3%) limits its precision.

Table 25 - Measurements of the Muierii 1 splanchnocranial projection, in millimeters.[1]

	Right	Left
Nasion-prosthion height (M-48; NPH)	(62.7)[1]	
Prosthion-nasospinale height	17.3	
Subspinale-zygomaxillare anterior	53.7	55.0
Bi-zygomaxillare anterior breadth (M-46b; ZMB)	96.8	
Zygomaxillary angle (M-76a; SSA)	126°	
Prosthion-palatine[2]	42.1	
Orale-palatine	34.0	
Orbital height[7] (M-52)	(33.0)[1]	(33.8)[1]
Orbital breadth (M-51)	--	(43.1)
Nasal height (M-55; NLH)[3]	(49.6)[1]	(49.4)[1]
Nasal breadth (M-54; NLB)	25.3	

[1] Measurements that are dependent upon the correct alignment of the maxillae with the frontal bone, and are therefore estimated even though the landmarks are preserved and evident.

[2] Palatine – intersection of the mid-palatal suture and the maxillopalatine suture.

[3] Nasal height is normally measured from nasion to the inferior left nasal margin. The distances to both the right and the left inferior margins are provided.

Table 26 - Measurements of the facial skeleton in millimeters and degrees.

The complete nasal floor is largely flat and level with the inferior nasal aperture. It descends slightly inside of the inferior nasal aperture rim, and then remains level posteriorly. In this, it is similar to Mladeč 8, Oase 2 and Nazlet Khater 2, and to 88.2% (N = 17) of Mid Upper Paleolithic humans (Franciscus 2003; Rougier *et al.* 2007). It contrasts with 96.0% of the Neandertals (N = 25), all but one of which have bilevel or sloped nasal floors (Franciscus 2003). Middle Paleolithic modern humans have a mixed pattern, with only 40.0% (N = 5) plus Loiyangalani 1 having a level floor, something which is absent from Irhoud 1.

The nasal aperture inferior margin (fig. 51) has spinal and turbinal crests that are fused at the lateral turbinal margin, separate for 2 mm, and then join again lateral of the anterior nasal spine. The lateral crest curves slightly onto the anterior or subnasal surface, and then it arcs to the anterior edge of the anterior nasal spine area. If the spinal and turbinal crests are considered fused, despite their slight separation inferolaterally, and the lateral crest is considered to fade out as it approaches the anterior nasal spine, then the configuration approximates the category 3 of DeVilliers (1968) and Franciscus (2003). There is damage to the anterior nasal spine region, and it is possible that the fused spinal and turbinal crests separated again as they approached the spine. If this was the case, then the Muierii 1 nasal margin would more closely match category 6 of Franciscus (2003).

Nasal crest category 3 is the pattern seen in Oase 2 and Nazlet Khater 2, but different from the Mladeč 8 nasal margin (category 4). The category 3 pattern is only present in one of the Neandertals, a relatively early one (Krapina 47), out of 21. It is present in only one of the five Middle Paleolithic modern humans preserving the region, but it is evident in three of the earlier archaic African specimens (Florisbad 1, Laetoli 18, and Rabat 1). It is more common among Mid Upper Paleolithic humans (37.5%, N = 16).

The breadth of the nasal aperture decreases from the Middle Paleolithic archaic and modern humans to Mid Upper Paleolithic modern humans, with an intermediate position for the Early

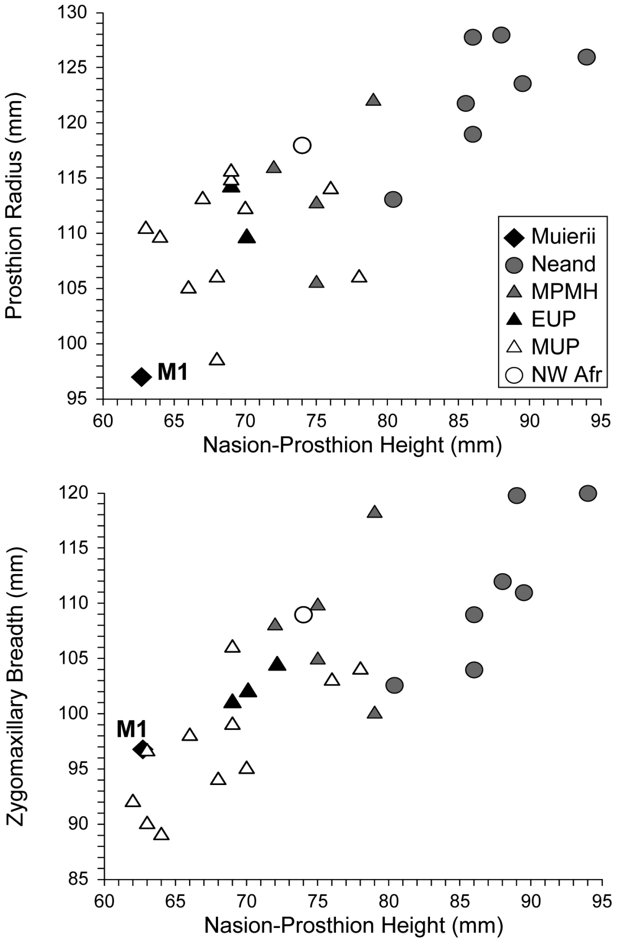

Figure 50 - Bivariate plots of prosthion radius (from the bi-porion axis) (above) and the zygomaxillary breadth (below) versus nasion-prosthion height. M1: Muierii 1; Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic modern humans; MUP: Mid Upper Paleolithic humans; NW Afr: northwest African Middle Paleolithic humans.

Figure 51 - Views of the Muierii 1 nasal aperture and cavity. Upper left: anterior view. Lower left: superior view: right: anterosuperior view. Scale bar is 5 centimeters long.

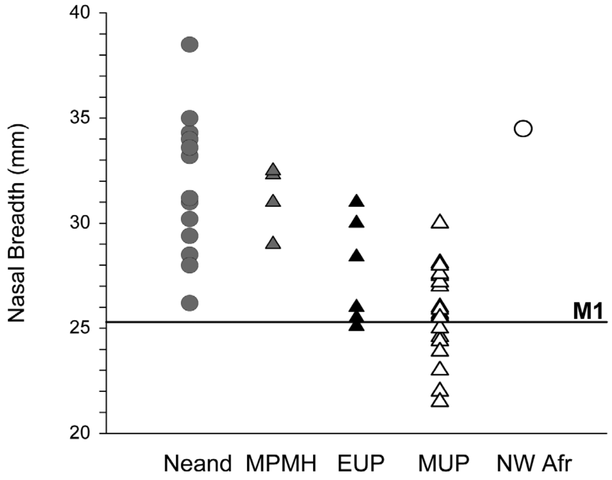

Figure 52 - Nasal aperture breadth for Muierii 1 (M1) and comparative samples. The samples sizes are larger than in Figure 53, since incomplete maxillae can provide nasal breadths. Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic modern humans; MUP: Mid Upper Paleolithic humans; NW Afr: northwest African Middle Paleolithic humans.

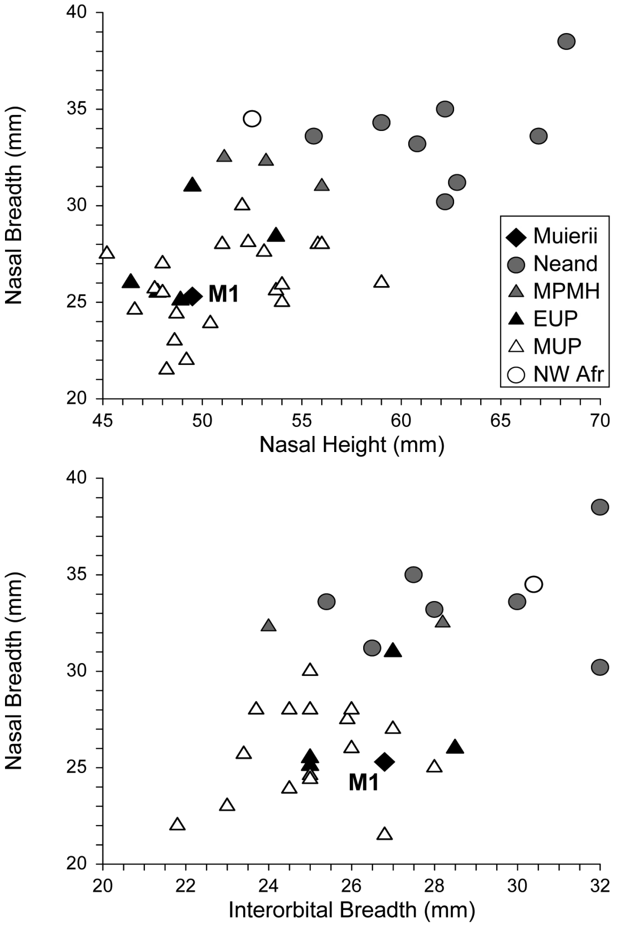

Figure 53 - Nasal aperture breadth versus nasal height (above) and interorbital breadth (below) for Muierii 1 (M1) and comparative samples. Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic modern humans; MUP: Mid Upper Paleolithic humans; NW Afr: northwest African Middle Paleolithic humans.

Upper Paleolithic humans (fig. 52). Among the last, Hofmeyr 1 and Mladeč 8 have relatively wide nasal apertures, whereas Mladeč 1 and 2 and Oase 2 have more modest dimensions. The Loiyangalani 1 nasal breadth is modest, probably ~26 mm. The Muierii 1 nasal breadth of 25.3 mm falls below the Middle Paleolithic ranges of variation, among the narrower of the Early Upper Paleolithic breadths, and in the middle of the Mid Upper Paleolithic range of variation.

If the nasal breadth is compared to either nasal height or interorbital breadth (fig. 53), the absolute contrasts largely remain (despite smaller sample sizes). Nasal breadth partially scales with nasal height across the samples ($r^2 = 0.500$), even though the Middle and Upper Paleolithic distributions are separate. There is less of an apparent correlation with interorbital breadth ($r^2 = 0.374$), although there is a general trend for both to be larger among the Middle Paleolithic crania. In each comparison, Muierii 1 and the European Early Upper Paleolithic crania are securely within the Mid Upper Paleolithic distribution, although Hofmeyr 1 has a somewhat wider nasal aperture relative to nasal height.

The Infraorbital Region

The area of the right infraorbital foramen (fig. 54) is damaged and preserves only the inferior portion of the infraorbital foramen area and only the inferior margin of the foramen proper. The left infraorbital area is complete, and the foramen is intact, single, and points inferiorly. There is a weak expression of internal division. It is located 7.3 mm below the orbital margin and has a maximum diameter of 4.3 mm. The preserved portion of the right foramen is symmetrical.

Figure 54 - Anterolateral oblique views of the Muierii 1 maxillae. Scale bar equals 5 centimeters.

Between the molar alveoli and the zygomaxillary suture, bilaterally, there is a strongly concave curve to the maxilla. The bony profile rises vertically from the molar alveoli, and then it forms a constant radius curve ending in the broken anterior maxillary tubercle at the suture. The top of the curve is above the tubercle. As such, the zygomaxillary profile of Muierii 1 contrasts markedly with the "inflated" profile of the Neandertals (Sergi 1947). It is close to, but more pronounced than, the concave profiles of Mladeč 2 and Oase 2 and contrasts with the modestly concave profile of Mladeč 1 (Wolpoff *et al.* 2006; Rougier *et al.* 2007). Hofmeyr 1 and Nazlet Khater 2 are similar in this respect to Mladeč 2 and Oase 2. Although the most pronounced of these Early Upper Paleolithic maxillae in the height of this notch, the Muierii 1 concavity is not as pronounced as the distinct notches found on the inferior zygomaxillary areas of both late archaic and early modern human East Asian crania (Pope 1992).

Associated with this concavity there is a clear zygomaxillary tubercle, preserved on the right side. It matches the medium expression of Hauser & DeStefano (1989), and it is sutural in that the zygomaxillary suture bisects the tubercle.

Between each nasal margin, infraorbital foramen and inferolateral maxillary margin is a deeply excavated canine fossa. They are rugose depressions, especially on the better preserved left side, with clear anteromedial and superior margins. The right one is 6.6 mm wide, has a small foramen at the superior margin, extends inferiorly almost to the alveolar margin, and is above the P^3/P^4 interdental septum and the P^4 socket. The left canine fossa has a rugose area 7.6 mm wide and 8.4 mm high, with its inferior margin 8.4 mm above the alveolar margin. There is a small foramen at the superolateral margin. There is an additional lunate shaped depression ~3.5 mm wide superolateral of the primary depression. The main fossa extends from the mid-P^3 to the mid-P^4 alveoli.

These canine fossae are clear, distinctly bounded, depressions in the infraorbital area. They are not merely concavities in this portion of the anterior maxillae. They are distinct morphological features by themselves, independent of being in otherwise concave anterior maxillae. As such, they are closely paralleled by the canine fossae on Oase 2, also distinct ovoid depressions (Rougier *et al.* 2007). However, they contrast with those of Mladeč 1 and 2; the latter has smooth and mildly concave bone in this region, and the former appears to have the same configuration despite the thin later of carbonate on the surface bone (Wolpoff *et al.* 2006). Such canine fossae are completely absent from Neandertals although some earlier Neandertal specimens [e.g., Shanidar 2 and 4 (Trinkaus 1983)] have modestly concave infraorbital regions. Irhoud 1 has slightly concave infraorbital regions similar to earlier Neandertals, but it lacks distinct canine fossae. Distinct canine fossae are present in 37.5% (N = 8) of the Middle Paleolithic modern human maxillae; the other Middle Paleolithic modern human maxillae vary in their degrees of concavity, with all but the juvenile Qafzeh 10 being concave to some degree. Nazlet Khater 2 and Hofmeyr 1 have, or appear to have had, generally concave maxillae but without the distinct fossae of Oase 2 and Muierii 1, whereas the Loiyangalani 1 maxilla has only a slight depression next to the zygomatic root. Distinctly concave infraorbital regions with canine fossae become ubiquitous in the Mid Upper Paleolithic across Eurasia.

Midfacial "Projection"

The anterior zygomatic roots of Muierii 1, the middle of the anteroinferior zygomatic root as is descends the lateral maxilla towards the postcanine teeth, is above the middle of the M^1 root on the right side and above the distal M^1 root on the left side (fig. 31, 38, 55). The position of the zygomatic root relative to the dentition combines reflections of the dental arcade length, overall facial length, temporal fossa length and hence anterior positioning of the zygomatic bone, in a manner similar to retromolar space presence or mental foramen position in the mandible (Trinkaus 1987). However, it nonetheless provides some indication of overall facial shape, especially for less complete crania, and it can be observed on partial maxillae such as those of La Crouzade 6 and Mladeč 8.

In this feature, the configuration of Muierii 1 is in the middle of the Early Upper Paleolithic range of variation. Hofmeyr 1 has it above M^1/M^2 (as does the Loiyangalani 1 maxilla), Nazlet Khater 2 has it above P^4/M^1, but La Crouzade 6, Mladeč 1, 2 and 8, and Oase 2 all have it above M^1. In at least Nazlet Khater 2, the moderately more anterior position of the zygomatic root is associated with a very wide mandibular ramus (Crevecoeur 2008). Yet, among those with it above the M^1 or M^1/M^2, Muierii 1 and Hofmeyr 1 have moderately narrow rami whereas Oase 2 (in part by inference from Oase 1) probably had a wide ramus, and the Loiyangalani 1 ramus is wide (Twiesselmann 1991). There is also variation in at least molar dimensions, with Hofmeyr 1, Mladeč 8 and Oase 2 having large teeth whereas those of the other specimens are smaller and unexceptional for the Late Pleistocene.

Middle Paleolithic modern humans tend to have the zygomatic root more posteriorly positioned, with two above M^1, one above M^2, and four above M^1/M^2. Neandertals, with their "midfacial prognathism" (but see Trinkaus 2003), have it more posteriorly positioned relative to the dentition, three earlier specimens having it above M^2 and five later ones having it above M^2/M^3 (Trinkaus 1987). Irhoud 1 has it above the M^1/M^2. Western Eurasian Mid Upper Paleolithic individuals have generally more mesial positions for the zygomatic root, with it varying from M^1/M^2 (11.8%), to M^1 (52.9%), to P^4/M^1 (29.4%) to P^4 (5.9%) (N = 17).

A further, metric reflection of the degree of midfacial projection is provided by the zygomaxillary angle, between each zygomaxillare anterior and subspinale (fig. 56). The Neandertals, with their long faces and relatively posterior zygomatic bones, tend to have low angles; the two highest of their angles are from the earlier Shanidar 2 and 4 (Trinkaus 1983, 1987), who have among the more anteriorly placed zygomatic bones for the sample. The shorter-faced early modern humans, plus Irhoud 1 have higher, or more open angles. The Muierii 1 angle of 126° is in the middle of the early modern human distribution.

The Palate

The largely complete palate of Muierii 1 (fig. 55; tabl. 27) presents an evenly rounded dental arcade with moderate rugosity anteriorly and small longitudinal ridges adjacent to the M^1s, especially on the right side. There is no evidence of a midline palatine torus, nor is there evidence of alveolar tori. There are small extensions of the alveolar process distal of the M^3s, or maxillary retromolar spaces. The right one is 5.8 mm long and the left one is 6.5 mm from the distal M^3 socket. There are bilateral small crests of bone on the posterior margins of the palatine foramina, or marginal crests.

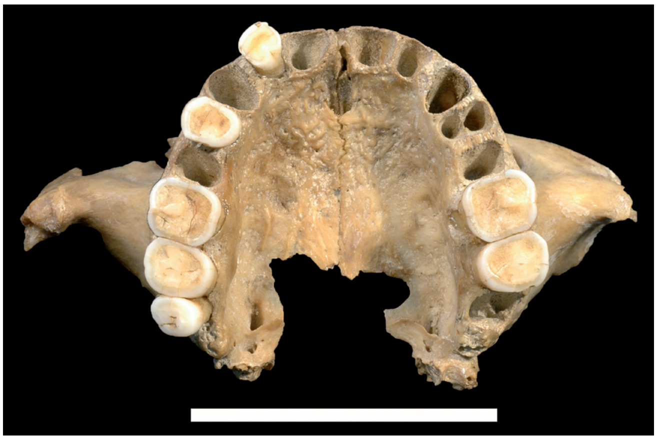

Figure 55 - Inferior view of the Muierii 1 maxillae and palatine bones. Scale bar equals 5 centimeters.

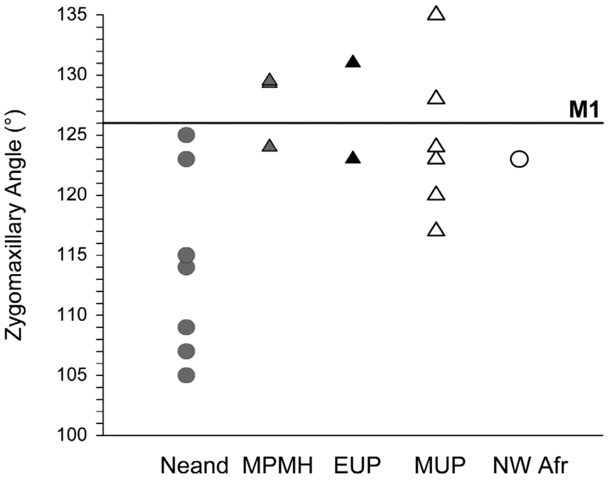

Figure 56 - Zygomaxillary angle (each zygomaxillare anterior to subspinale) for Muierii 1 (M1) and the comparative samples. Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic modern humans; MUP: Mid Upper Paleolithic humans; NW Afr: northwest African Middle Paleolithic humans.

The intermaxillary suture is clear from the incisive foramen to the palatine bones, with interdigitations anteriorly and then a straight suture for the posterior two-thirds. Anterior of the incisive foramen, along the lingual half of the inter-incisive intermaxillary suture, there is slight separation of the two maxillae. The transverse palatine sutures are partially preserved and largely obliterated, and the right one appears to be located more anteriorly than the left one. This sutural asymmetry is not associated with any apparent asymmetry of the palate or of the alveolar arcade.

The lesser palatine foramina are preserved bilaterally. There are major ones medial of the M^3s, and smaller minor ones distal of the M^3s adjacent to the joins between the retromolar processes and the pterygoid processes of the sphenoid bone. There is one of each size on each side, and the major ones have a slit form. In association with the bilateral presence of marginal crests, of which only the lateral portions are preserved, they conform to Hauser & DeStefano's (1989) category "e" (a marginal crest with one minor palatine foramen situated close to the crest).

	Right	Left
Bi-external I^1 transverse diameter	21.1	
Bi-external dist I^2 transverse diameter	33.0	
Bi-external C^1 transverse diameter	45.5	
Bi-external M^1 transverse diameter	62.5	
Bi-external M^2 transverse diameter	64.0	
Bi-external posterior M^3 transverse diameter	(53.0)	
Bi-external posterior alveoli transverse diameter	42.4	
Prosthion-C^1 oblique distance	25.2	24.9
Prosthion-M^1 oblique distance	45.2	45.6
Prosthion-M^2 oblique distance	51.8	51.4
Prosthion-posterior M^3 oblique distance	54.4	55.5
Prosthion-posterior alveoli oblique distance	57.6	58.0

Table 27 - Dimensions of the Muierii 1 palate, in millimeters.

Summary

The cranium of Muierii 1 is therefore small, relatively gracile, and moderately high and rounded. It exhibits several features that are derived for recent humans and securely place it within that context. These characteristics include its reduced supraorbital region, the complete absence of a supraorbital torus, its infraorbital regions with distinct canine fossae, the high frontal profile and rounded parietal arc, its small face with anteriorly positioned zygomatic roots, and its narrow nasal aperture. These aspects are joined by features that occur more commonly among modern humans, including its meningeal groove pattern, parietomastoid suture inclination, neurocranial profile in posterior view (mostly its prominent parietal eminences), the subrectangular orbits, and its nasal crest configuration.

As the same time, as with other aspects of its morphology (see mandible and scapula below), there are features which are rare or absent in earlier Middle Paleolithic modern human crania, occur in high frequencies among the Neandertals, and appear occasionally among Upper Paleolithic modern humans. Muierii 1 has a prominent occipital bun, which is evident in its parietooccipital contour in lateral view and its temporooccipital contours in inferior view. The iniac region does not have the prominent development of the features characteristic of the Neandertals, but it shows incipient development of a suprainiac fossa in combination with a modest median nuchal torus and the complete absence of an external occipital protuberance. In the latter features, it approximates the situation with Cioclovina 1, close to the Neandertal pattern if not identical to it in form or degree of development.

The Mandibular Corpus and Ramus of Muierii 1

The Muierii 1 mandible (fig. 57 and 58) provides morphological information on the lateral corpus from the P_3 alveolus to the ramus and then for most of the ramus. The minor damage to the inferior corpus below the P_3 and to the anterior mandibular notch margin can easily be visually corrected. As such, it is one of the few Early Upper Paleolithic mandibles preserving the ramus and adjacent corpus, although it lacks the entire symphyseal region. Among these Early Upper Paleolithic humans, it is principally Oase 1 and Nazlet Khater 2 that provide mandibular data, with some data coming from published descriptions of the now lost Mladeč 52 and 54 mandibles and the Tianyuan 1 partial mandible (Trinkaus *et al.* 2003a; Frayer *et al.* 2006; Crevecoeur 2008; Shang & Trinkaus 2010). The other Early Upper Paleolithic mandibles are fragmentary and mostly immature (e.g., from Les Rois and La Quina Aval) and largely lack the regions preserved on the Muierii 1 mandible.

Figure 57 - Medial view of the Muierii mandible in 1952, prior to sampling of bone from the inferior corpus below the premolars and recognition that the canine fits onto the mesial end of the corpus. Photo: Institutul de Antropologie "Fr.J. Rainer."

Figure 58 - Overall views of the Muierii 1 mandible. Upper left: lateral corpus and ramus. Lower left: medial corpus and ramus. Right: superior. Note that the rounding of the inferior corpus below the P_4 and M_1 alveoli is an artifact of radiocarbon sampling; the original basal margin was essentially straight. The original margin line is indicated in the lateral view, as is the original anteroinferior margin of the mandibular notch. Scale bar is 5 centimeters.

Mandibular Morphomics

In the western Eurasian Late Pleistocene, there was a series of changes in mandibular morphology. Since the size and the proportions of the mandible are in many ways reflections of the more primary physiological demands placed on the cranium through the orbital, nasal and pharyngeal regions (Enlow & Hans 1996), combined with the more strictly biomechanical demands of mastication and deglutition, many of the varying features of the mandible are secondary reflections of changes in cranial architecture. With relatively complete mandibles, and especially with associated complete mandibles and crania, it is possible to address some of these issues. However, the dearth of such human remains prior to the Mid Upper Paleolithic means that a variety of secondary morphometric and discrete traits have been used to assess the morphological affinities and implications of at least Middle Pleistocene, Middle Paleolithic and earlier Upper Paleolithic human mandibles (e.g., Stefan & Trinkaus 1998a,b; Lebel & Trinkaus 2001; Rosas 2001).

A few of the morphological aspects of the lateral corpus and ramus, those portions preserved on the Muierii 1 mandible, can be assessed morphometrically. However, most of the relevant features are more easily characterized as discrete variants, even though some of them exhibit continuous variation across samples. Moreover, very few of them reach 100% of a given character state in even one sample, no less in all of the relevant samples, such that characterizations are in terms of frequency distributions rather than "types" for a given paleontological group.

Some of these features appear to relate only to the anatomical unit in question, such as the presence or absence of bridging across the mandibular foramen. Others, such as retromolar space presence, are secondary reflections of overall mandibular proportions, being due to a combination of mandibular length, dental arcade length and ramal breadth (Franciscus & Trinkaus 1995). It is very likely that mental foramen position is similarly a secondary reflection of other aspects, in this case dental arcade length, inferior alveolar nerve canal length, and overall mandibular length (Rosas 2001; Trinkaus 1993, 2006a). The position of the lateral eminence relative to the dentition (Rosas 2001) similarly should reflect anteroposterior proportions between the corpus, dentition and ramus.

There are other features which may well be secondary aspects of mandibular morphology. The enlargement of the superior medial pterygoid tubercle, seen in most Neandertals, may be related to their facial configurations and the differential roles of the fiber bundles of the medial pterygoid muscle during mastication (Richards *et al.* 2003). The more medial position of the mandibular notch crest relative to the condyle, which occurs in many Neandertals but is virtually unknown in other human samples, may be a reflection of a more lateral position of the temporomandibular joint relative to the core of the ramus and hence the masticatory muscle insertions on it. The asymmetrical mandibular notch, found in most Neandertals but absent from early modern humans, probably reflects relative coronoid versus condylar heights, although the implications of relative coronoid height for a human skull remain obscure, since it will have little effect on temporalis muscle effectiveness.

The Lateral Corpus

The Muierii 1 mandibular corpus is generally smooth and evenly rounded, including around the lateral eminence laterally and the mylohyoid line medially.

The Mental Foramen

The mental foramen has a sub-rectangular opening that has its long axis tilted ~25° relative to the alveolar plane. The posteroinferior edge is slightly raised and rounded relative to the plane of the lateral corpus. The foramen narrows slightly posterosuperiorly. Its length is 2.6 mm, its maximum inferoanterior breadth is 2.0 mm, and the breadth reduces to 1.4 mm at the posterosuperior end. The middle of the foramen is located 17.6 mm below the alveolar plane, or 64% of the estimated distance from the alveolar plane to the basilar margin of the corpus at the foramen.

There is a smaller foramen directly posterior of the primary mental foramen, 0.8 mm in diameter and 6.5 mm posterior of the middle of the main mental foramen. As such, it is positioned below the distal root of the M_1. It probably represents a secondary opening for the fibers of the inferior alveolar nerve.

The position of the principal mental foramen is below the P_4/M_1 interdental septum; averaging its position with that of the smaller and more distal foramen would produce a position below the mesial M_1. As such, its anteroposterior position relative to the dentition is in the overlap zone between the distributions of the Neandertals with their more "posteriorly" located foramina and early modern humans with their more "anteriorly" positioned foramina (tabl. 28); it would be more closely aligned with the Neandertals if the average position of the two foramina were used. Similarly distal positions of the foramen are present on a minority of the Middle Paleolithic modern humans and Mid Upper Paleolithic humans, plus the Tianyuan 1 mandible. It is possible, as with Tianyuan 1 (Shang & Trinkaus 2010), that its slightly more distal position relative to the other western Early Upper Paleolithic mandibles is a reflection of the interproximal wear, and hence mesial drift, of the Muierii 1 dentition. However, many of the Neandertals and Mid Upper Paleolithic modern humans have similarly pronounced dental attrition, so this aspect alone is not likely to have affected the relative scoring for Muierii 1. Interestingly, although late archaic and early modern western Old World non-Neandertal humans tend to have more mesially positioned mental foramina (tabl. 28), the mental foramen positions on eastern Eurasian early modern humans are generally more distal (Shang & Trinkaus 2010).

The Lateral Eminence

The lateral eminence begins anteroinferiorly as a slight swelling below the middle of the M_2 and then becomes a clear angle by the distal M_2. Its position is therefore relatively mesial compared to those of the Neandertals and similar to those of many early modern humans (Rosas 2001). Its swelling creates a slight hollow between it and the mental foramen anteriorly and the masseteric surface posteroinferiorly.

Samples[1]	P_3, P_3/P_4[2]	P_4	P_4/M_1	M_1	N
Muierii 1			P_4/M_1		
Neandertals		2 (7.7%)	10 (38.5%)	14 (53.8%)	26
MPMH		4 (57.1%)	2 (28.6%)	1 (14.3%)	7
EUP		3 (100%)			3
MUP[3]	3 (11.1%)	18.5 (68.5%)	3.5 (13.0%)	2 (7.4%)	27
NW Africa MP		1 (100%)			1
Nazlet Khater 2		P_4			
Tianyuan 1			P_4/M_1		
Loiyangalani 1[4]		P_4	P_4/M_1		

[1] MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic humans; MUP: Mid Upper Paleolithic humans; NW Africa MP: northwest African Middle Paleolithic (Aterian).

[2] P_3 and P_3/P_4 are combined, given the scarcity of that anterior position among Late Pleistocene humans.

[3] Counts of 0.5 reflect bilateral asymmetry, in every case (N = 4) adjacent positions are present on the mandible.

[4] The Loiyangalani 1 mental foramen position is asymmetrical, hence indications for both P_4 (right) and P_4/M_1 (left).

Table 28 - Distributions of mental foramen position relative to the mandibular dentition for Late Pleistocene humans.

The Medial Corpus

The medial corpus below the P_3 and P_4 is smooth and gently convex superoinferiorly, becoming gently concave inferiorly. There is a hint of an incurving towards the lingual symphysis, which implies a weak expression of a mandibular torus, following Hauser & DeStefano (1989). The mylohyoid line has a series of small nubbins along it from the middle of the M_1 to the distal M_3, but they are clearest from the mesial M_2 to the distal M_3. The mylohyoid line remains distinctly separated from the alveolar margin (tabl. 29), sloping modestly superiorly as it goes distally. Below the mylohyoid line there is a smooth concavity, with no trace of the mylohyoid canal until the distal M_3. The Muierii 1 mylohyoid line and surface below it therefore do not conform with the more steeply sloping lines and inferior concavities described for this area by Rosas (2001) for the Neandertals; however, he documented considerable variation in this feature among those late archaic humans, and similar variation exists among early modern humans (Trinkaus pers. observ.).

Corpus Proportions

The inferior margin below the P_4 and M_1 was removed at some point, for a ^{14}C dating attempt (Chapter 2), but it is apparent from earlier photographs of the mandible (Daicoviciu *et al.* 1960; compare figures 57 and 58) that the inferior border continued anteriorly along the same line as the more distal, intact border. This has yielded a mental foramen (P_4/M_1) corpus height of ~27.5 mm, which is essentially the same as the measure of 27.6 mm below M_1/M_2 (tabl. 29). These values are relatively small for a Late Pleistocene human (tabl. 30), most similar to the Mid Upper Paleolithic values, below the ranges for the Early Upper Paleolithic and Middle Paleolithic modern human samples, but among the smaller of the Neandertal mandibles.

Corpus heights	P_4/M_1 (mental foramen)	(27.5)
	M_1	28.0
	M_1/M_2	27.6
	M_2/M_3	27.3
Corpus breadths/thicknesses	P_4/M_1 (mental foramen)	11.6
	M_1	13.0
	M_1/M_2	13.3
	M_2/M_3	15.5
Mylohyoid line to alveolar plane	M_1	12.5
	M_2	10.0
	M_3	6.5
Minimum ramus breadth		35.1
Coronoid height	to alveolar plane	43.0
Condylar height	to alveolar plane	30.5
Mandibular notch basal curve: lowest point to:	horizontal to anterior coronoid	25.0
	horizontal to coronoid tip	20.0
	horizontal to anterior condyle	9.3
	horizontal to mid condyle	13.5
	horizontal to posterior condyle	17.0

Table 29 - Morphometrics of the Muierii 1 right mandibular corpus and ramus.

Corpus breadths, despite the variance in mental foramen position relative to the dentition, appear to be most consistently measured there rather than with respect to the molars. The more posterior position of the foramen among most Neandertals means that the breadths are beyond any effect of symphyseal morphology for them, and the more anterior position among most modern humans means that there is little effect of the lateral eminence. Indeed, comparisons across the Late Pleistocene samples (tabl. 30) show that there is a highly significant difference in corpus breadths at the mental foramen, whereas the level of difference is markedly less at the mesial molars.

As is apparent in figure 59, there is considerable overlap in corpus height measurements across these samples. Muierii 1, although small, is within the ranges of variation in height. In contrast, there is only one Neandertal mandible with a corpus breadth below ~14 mm, Palomas 59 (Walker *et al.* 2008), and most of the early modern human mandibles are below this value. Among the western Eurasian Early Upper Paleolithic mandibles, Mladeč 52 and Nazlet Khater 2 have rather thick mandibles, similar to Neandertals and some of the Middle Paleolithic modern humans, but Oase 1 is relatively gracile. The Loiyangalani 1 mandible is exceptionally thick. The Muierii 1 mandible, with its modest thickness, is below all of the Neandertals (including Palomas 59) and among the more gracile of the early modern humans.

The Ramus

Since most of the ramus is well preserved, it presents data on a variety of features relevant to Late Pleistocene mandibular variation (fig. 60). A portion of the anterior mandibular notch

Sample[1]	Mental foramen corpus height	Mental foramen corpus breadth	M_1/M_2 corpus height	M_1/M_2 corpus breadth	Minimum ramus breadth	Mandibular angle
	M-69(1)	M-69(3)			M-71	M-79
Muierii 1	(27.5)	11.6	27.6	13.3	35.1	110°
Neandertals	32.4 ± 3.5 (26)	15.5 ± 1.8 (26)	31.5 ± 3.4 (24)	16.2 ± 1.6 (24)	41.8 ± 2.6 (14)	109.8° ± 4.6° (16)
MPMH	35.0, 36.0, 40.5	13.2, 15.0, 16.6	31.0, 33.0, 35.5	12.0, 19.5, 20.0	42.5, 43.0, 44.0	107°, 107°, 124°
EUP	33.2	12.2	31.4, 32.0, 36.0	13.3, 16.0	46.2	96°
MUP	31.7 ± 4.6 (11)	12.3 ± 1.4 (10)	29.9 ± 3.5 (10)	14.1 ± 2.0 (10)	38.8 ± 2.6 (11)	115.8° ± 5.8° (17)
Kruskal-Wallis P[2]	0.261	<0.001**	0.299	0.063	0.004*	0.012*[3]
Nazlet Khater 2	35.3	15.7	33.1	16.3	51.0	107°
Tianyuan 1	29.7	12.1	29.6	11.7	39.5	(114°)

[1] MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic humans; MUP: Mid Upper Paleolithic humans.

[2] Significant at $P < 0.01$ (**) and $P < 0.05$ (*) using a sequential multiple comparison correction on the Kruskal-Wallis test across the first four comparative samples only.

[3] Kruskal-Wallis P = 0.014 without the very low value for Oase 1. Kruskal-Wallis P = 0.018 if Oase 1, Nazlet Khater 2 and Tianyuan 1 are included as an pooled Early Upper Paleolithic sample. A Wilcoxon comparison between the Neandertal and Mid Upper Paleolithic samples yields a P = 0.002.

Table 30 - Comparative morphometrics for the Muierii 1 mandible and other Late Pleistocene samples and specimens, in millimeters and degrees. Mean ± standard deviation (N) provided for samples >3.

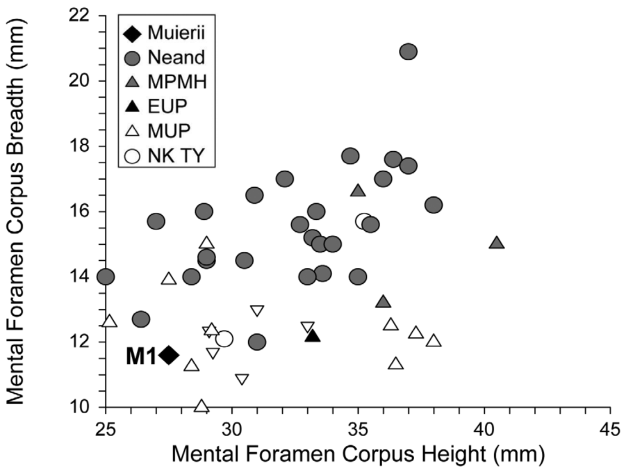

Figure 59 - Bivariate plot of mandibular corpus breadth versus corpus height at the mental foramen. Abbreviations: M1: Muierii 1. Neand: Neandertals. MPMH: Middle Paleolithic modern humans. EUP: Early Upper Paleolithic humans. MUP: Mid Upper Paleolithic humans. NK TY: Nazlet Khater 2 and Tianyuan 1 early modern humans.

Figure 60 - Lateral (left), medial (middle) and superior (right) views of the Muierii 1 mandibular ramus. The line in the mandibular notch in lateral view approximates the original margin of the notch, based on the preserved contours. The arrow below the mandibular condyle highlights the position of the mandibular notch crest where it meets the anterior condyle. Scale bar equals 5 centimeters.

margin requires visual interpolation, but the critical elements, the posterior coronoid process and the lowest point on the contour, are intact.

The ramus is relatively vertical in its orientation. Its mandibular angle, between the basal corpus and the posterior ramus (tabl. 30) is relatively low. It is similar to those of the three other (widely dispersed) Early Upper Paleolithic mandibles providing the angle, between those of Nazlet Khater 2 and Tianyuan 1 and well above the exceptionally low value for Oase 1 (due in part to its protruding and rounded gonial region). All of these Early Upper Paleolithic angles are similar to Neandertal values and moderately low relative to the Mid Upper Paleolithic ones. The Middle Paleolithic modern humans are quite variable, with Skhul 4 and 5 having angles similar to their contemporaries but Qafzeh 9 exhibiting a high angle (124°), more in line with later humans and exceeded in these comparative samples only by Cro-Magnon 1. Muierii 1, with an angle of 110°, therefore follows the pattern evident in both late archaic and the majority of early modern humans in having a relatively vertical ramus.

The Retromolar Space

There is no evidence of a retromolar space, since the antero-inferior margin of the ramus crosses the middle of the distal half of the intact M_3 alveolus in approximate *norma lateralis*. This is associated with a relatively modest minimum ramus breadth, one which is below the breadths of all of the Middle Paleolithic mandibles (archaic and modern) and matched only by the Eurasian Mid Upper Paleolithic Dolní Věstonice 3 and Pavlov 1 mandibles. In particular, it contrasts markedly with the very wide rami of Oase 1 and especially Nazlet Khater 2 (as well as Loiyangalani 1), and it is even exceeded by the value for Tianyuan 1 (tabl. 30; fig. 61). In lacking a retromolar space, Muierii 1 is similar to the majority of the early modern humans (tabl. 31), although a quarter of the Neandertals also lack this secondary spatial feature (*cf.*, Franciscus & Trinkaus 1995).

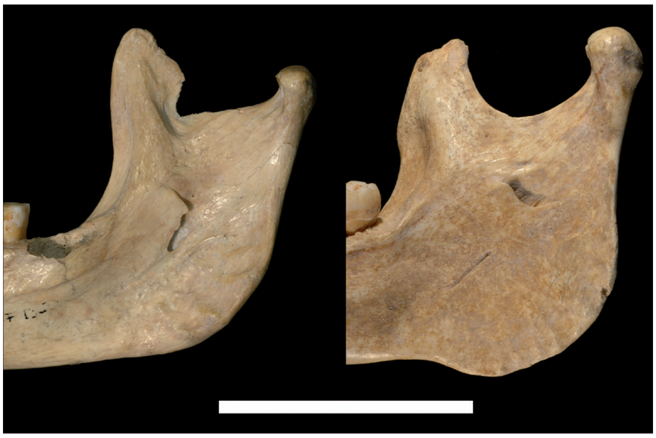

Figure 61 - Medial views of the Muierii 1 right and Oase 1 left (reversed) mandibular rami. Scale bar is 5 centimeters.

It has been argued (Rak *et al.* 2002) that variation in retromolar space presence is in part due to the concavity of the anterior ramal profile, between the M_3 and the coronoid process. In this, Neandertals are presumably characterized as having relatively straight anterior rami and early modern humans possessing ones with a distinct concavity. There are indeed very few mandibles of either group that lack some concavity, so they have been categorized as having a distinct concavity, usually produced by an anterior projection of the base of the coronoid process, as opposed to ones where the anterior margin is only slightly concave. To the extent that it can be determined, given the taphonomic fragility of anterior rami, most Neandertals indeed lack a clear concavity, Oase 1 and Nazlet Khater 2 possess it, as do two-thirds of the Middle Paleolithic modern humans but only one-third of the Mid Upper Paleolithic humans (tabl. 31). The Muierii 1 anterior ramus (fig. 60) is best characterized as lacking a distinct concavity.

The Coronoid Process, Mandibular Notch and Condyle

The coronoid process has a prominent endocoronoid ridge. There is a clear sulcus between it and the anterior ramal margin, and there is a fossa separating the ridge from the mandibular notch margin. Relative to the occlusal plane and the vertical plane through the lateral corpus, the coronoid process is strongly laterally tilting, ~19° relative to the corpus at P_4/M_1. The tip of the coronoid process is intact and vertically prominent, with a height above the alveolar plane at the M_3 of 43 mm. This height is 41% higher than that of the condyle with reference to the same plane. In contrast, Oase 1 has essentially identical heights for the coronoid process and the condyle from the alveolar plane (fig. 61).

Associated with this differential height, the mandibular notch is markedly asymmetrical. The mandibular notch is missing a triangle of bone along its anteroinferior margin, but the margin on the coronoid process and the posterior portion to the condyle are intact; there is no question as to the form of the notch. The horizontal distance from the coronoid tip to the lowest point of the notch (20.0 mm) is more than twice the distance from that lowest point to the anterior condylar margin (9.3 mm). Similar notch asymmetry, although variably common among recent humans, is otherwise unknown among early modern humans (tabl. 32). In fact, the oldest earlier modern human specimen with an asymmetrical notch is Ohalo 2, which dates to MIS 2 and the beginning of the Late Upper Paleolithic (Hershkovitz *et al.* 1995). The undated Loiyangalani 1 mandible also has an asymmetrical notch (Twiesselman 1991), but its coronoid process is low and its notch resembles those of Middle Pleistocene *Homo*. In contrast, two-thirds of the Neandertals exhibit a similar asymmetry.

As mentioned above, the significance of a high coronoid process and associated asymmetrical mandibular notch is unclear; it is possible that it would increase the effective mechanical advantage of the posterior fibers of the temporalis muscle. Among the Neandertals, but not Muierii 1, it is tempting to relate this to their paramasticatory use of the anterior dentition (Heim 1976; Trinkaus 1983). Yet, the apparent inability of Neandertal faces to withstand high anterior bite forces (Anton 1994; O'Connor *et al.* 2005) would mitigate against such an explanation, as would the frequent presence of high coronoid processes among recent humans.

The crest of the notch meets the condyle medially from the lateral margin of the condyle. The crest, in superior view, heads

Sample[1]	Retromolar space: % absent	Anterior ramal margin: % concave	Large medial pterygoid tubercle: % absent	Basal to gonial curve: % straight
Muierii 1	absent	straight	absent	straight
Neandertals	27.6% (8/29)	20.0% (4/20)	18.8% (3/16)	60.0% (12/20)
MPMH	57.1% (4/7)	66.7% (2/3)	100% (8/8)	66.7% (2/3)
EUP	100% (2/2)	100% (1/1)	100% (1/1)	50.0% (1/2)
MUP	81.3% (19.5/24)	33.3% (5/15)	90.0% (9/10)	96.4% (19/22)
NW Africa MP	100% (2/2)	~concave	--	curved
Nazlet Khater 2	absent	concave	absent	straight
Tianyuan 1	absent	--	absent	straight
Loiyangalani 1	absent	~straight	absent	curved

[1] MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic humans; MUP: Mid Upper Paleolithic humans; NW Africa MP: northwest African Middle Paleolithic (Aterian).

Table 31 - Discrete traits of the Muierii 1 anterior and gonial mandibular ramus and comparative Late Pleistocene samples. In each case, the frequency reflects the presence of the defined trait. For each sample, the percent, followed by the count for the stated configuration and the sample size (#/N), is provided.

Sample[1]	Mandibular foramen bridging: % absent	Mandibular notch: % symmetrical	Mandibular notch crest: % lateral
Muierii 1	absent	asymmetrical	medial
Neandertals	60.9% (14/23)	28.6% (4/14)	52.9% (9/17)
MPMH	100% (5/5)	100% (6/6)	100% (8/8)
EUP	50.0% (0.5/1)	100% (1/1)	100% (1/1)
MUP	100% (20/20)	100% (23/23)	100% (17/17)
NW Africa MP	--	100% (1/1)	--
Nazlet Khater 2	absent	symmetrical	lateral
Tianyuan 1	absent	symmetrical	--
Loiyangalani 1	absent	asymmetrical	lateral

[1] MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic humans; MUP: Mid Upper Paleolithic humans; NW Africa MP: northwest African Middle Paleolithic (Aterian).

Table 32 - Discrete traits of the Muierii 1 mandibular notch and foramen and comparative Late Pleistocene samples. In each case, the frequency reflects the presence of the defined trait. For each sample, the percent, followed by the count for the stated configuration and the sample size (#/N), is provided.

towards the middle of the lateral half of the condylar surface, and then in the last 2-3 mm, broadens. The lateral margin of that broadening is 5.5 mm from the lateral condyle, and its medial margin is 9.0 mm from the lateral condyle, giving a crest midline 7.3 mm from the lateral margin. This is one-third of the distance across the condyle. A similar pattern of crest to condyle positioning is unknown among early modern humans (tabl. 32), all of whom follow the pattern of earlier *Homo* of having the crest meet at or adjacent to the lateral condylar margin. In contrast, half of the Neandertals have a more medial position for the notch crest (and this figure does not include specimens such as La Ferrassie 1, which have a laterally positioned crest but a greatly expanded lateral tubercle). This crest position of Muierii 1 occurs in the context of a condyle whose medial and lateral tubercles are barely visible.

The Medial and Lateral Ramus

The mandibular foramen has the form of an open "V". The large, intact and rounded lingula extends ~6.5 mm posteriorly, sloping posteroinferiorly at ~48° relative to the alveolar plane. The anterosuperior margin of the foramen is ~63° relative to the alveolar plane and 9.6 mm long. Its posteroinferior margin is 7.5 mm long, providing a posterosuperior opening of 3.7 mm. Posteroinferior of the posteroinferior margin of the foramen is a small crest, probably related to the medial pterygoid muscle attachment area, running parallel to the foramen 2.5 mm from it. There is a shallow sulcus running on the surface parallel to the inferior alveolar nerve canal from the inferior side of the foramen to the level of the M_3. Only its superior edge is distinct, and there is no bridging of the sulcus. Further anteriorly there is no evidence of a sulcus.

An open mandibular foramen is both the ancestral *Homo* pattern and the dominant one among modern humans (Smith 1978; Jidoi *et al.* 2000; Richards *et al.* 2003), with bridging of the foramen (the horizontal-oval form) occurring particularly among Neandertal lineage specimens (Kallay 1970; Smith 1978; Lebel & Trinkaus 2001). The bridging of the foramen is rare among early modern humans, being absent from Middle Paleolithic modern humans and most Early Upper Paleolithic and Mid Upper Paleolithic specimens (tabl. 32). The one other European Early Upper Paleolithic specimen preserving the region, Oase 1, has it unilaterally, on the left side but not on the right ramus (fig. 61). It may have been present on Předmostí 3 and 4, but that cannot be confirmed. Further east, bridging is bilaterally present on the Mid Upper Paleolithic Zhoukoudian-Upper Cave 104 mandible.

The gonial angle is rounded and smooth around the curve. It lacks the projecting downward curve and associated concavity below the coronoid process seen in the Oase 1 mandible (fig. 60) but absent from Nazlet Khater 2 and apparently from Mladeč 54. There is a small notch on the Loiyangalani 1 mandible, but not on Tianyuan 1. Notches similar to the Oase 1 one and associated with an inferiorly extending gonial curve are relatively rare among early modern humans, occurring only in Skhul 5 and, to a smaller degree, in three Mid Upper Paleolithic specimens. They are, however, present in almost half of the Neandertals and in Dar-es-Soltane 5 (tabl. 32).

The Muierii 1 gonial angle is strongly medially inflected. As with the coronoid process, the posterior margin of the ramus has a strong lateral tilt superiorly, such that it is ~17° relative to the P_4/M_1 corpus.

The Muierii 1 mandible has four prominent but rounded medial pterygoid tubercles around the gonial angle. The tubercles, from anteroinferior to posterosuperior, are 3.7, 3.7, 5.3 and 1.8 mm in breadth and extend 10.8, 7.1, 7.7 and 8.7 mm from the mandibular edge. There is no prominent superior medial pterygoid tubercle. In the last feature, Muierii 1 is similar to all but one of the western early modern human mandibles [the exception is Dolní Věstonice 3, whose face is pathological (Trinkaus *et al.* 2006a)] and contrasts with the majority of the Neandertals (tabl. 31).

The medial pterygoid muscle attachment area is clearly delimited along its anterosuperior margin by a line ~42 mm long, which runs straight for 33 mm from its posterosuperior end and then curves down to the inferior mandibular margin. As mentioned, the extra small crest along the mandibular foramen is associated with this muscle line.

The lateral ramus is largely featureless. The masseter attachment has generated a slight lip around the gonial margin, and there are two raised ridges and a slightly rugose area 10.8 mm anteroposterior and 11.6 mm superoinferior above the lip. The more superior portion of the ramus, including the lateral coronoid process and the neck to the condyle, is smooth.

Summary

Even through the Muierii 1 mandible preserves only the lateral corpus and the ramus, it provides considerable data on morphometric and especially discrete traits that have been employed, mostly in a distributional sense, to provide contrasts between

Neandertal and western Eurasian early modern human mandibles. In keeping with the facial morphology of Muierii 1, the mandible is a small, gracile bone. This is reflected particularly in its narrow corpus breadths and modest muscle markings, including the absence of a prominent superior medial pterygoid tubercle. It conforms to the relatively short face indicated by the maxillae, particularly in its complete absence of a retromolar space, even though its mental foramen position is relatively posterior for a Late Pleistocene early modern human.

At the same time, the Muierii 1 mandible contrasts with those of most early modern humans in lacking features that distinguish them from most Neandertals. It has a high coronoid process with an asymmetrical mandibular notch. The anterior ramus lacks a distinct concavity. The mandibular notch crest does not meet the condyle clearly laterally. It is difficult, in the context of Late Pleistocene human faces, and in particular in the context of the distinctly "modern" Muierii 1 upper facial skeleton, to view these features as secondary reflections of spatial and/or biomechanical relationships within the face. They are more easily seen as epigenetic, and as such, suggest close, but not exclusive, morphological affinities to the Neandertals.

The Dental and Alveolar Remains of Muierii 1

The dental and alveolar remains of Muierii 1 (fig. 62) consist of almost complete and undamaged maxillary alveoli (minor damage only to the lingual M^1 and buccal M^3 alveoli), largely intact P_3, P_4 and M_3 alveoli with damage to the M_1 and M_2 alveoli, plus ten teeth. Seven of the teeth were found in their alveoli, five maxillary molars and two mandibular ones. The mandibular right canine, although listed in the field notes on August 19, 1952 as associated with the maxilla ((Nicolăescu–Plopşor 1952) and inserted into the left C^1 alveolus shortly thereafter (Gheorghiu & Haas 1954), must have been found loose in the sediments. The last two teeth, the I^2 and P^3, found on August 20, 1952, fit cleanly into their respective maxillary alveoli.

These dental and alveolar remains therefore permit assessments of dental and alveolar paleopathology, dental crown and (to some extent) root size and proportions, and assessments of dental attrition. These considerations are limited principally by the dearth of anterior teeth for Muierii 1, the I^2 and the C_1, which is relevant in light of the changing size and proportions of the anterior dentition in particular during the Late Pleistocene of western Eurasia.

Dental and Alveolar Considerations

These considerations of the Muierii 1 teeth fall into the context of assessments of changes in human dental morphology, proportions and attrition with the emergence of modern humans in Europe. The preserved Muierii 1 dentition, although heavily worn and lacking most of the anterior dentition, is one of the few from the Early Upper Paleolithic of Europe which preserves some anterior and posterior teeth, which are sufficiently worn to exhibit patterns of wear. Those from Oase consist solely of molars (Trinkaus *et al.* 2003a; Rougier *et al.* 2007), as do those of the currently available Mladeč teeth other than the Mladeč 8 palate (Frayer *et al.* 2006; Wolpoff *et al.* 2006). La Crouzade 6 has the molars and a P^4 (Henry-Gambier & Sacchi 2008). Les Rois 1 retains the anterior and more mesial molars of an early adolescent (Vallois 1958b; Ramirez Rossi *et al.* 2009). Further afield, the Nazlet Khater 2 teeth were heavily damaged (Crevecoeur 2008), and the mandibular teeth of Tianyuan 1 were even more heavily worn than those of Muierii 1 (Shang & Trinkaus 2010). The remainder of the securely dated Early Upper Paleolithic teeth are deciduous, isolated and/or have only crown diameters available for them.


Figure 62 - Occlusal views of the Muierii 1 maxilla (left) and mandible (right). Scale bar is 10 centimeters.

In this context, there are three trends that appear to characterize the transition from Middle Paleolithic and Initial Upper Paleolithic Neandertals to the early modern humans of the Mid Upper Paleolithic in particular. There was a general loss of the more derived discrete morphological characters of the Neandertals (Patte 1962; Hillson 2006; Bailey 2006). There was a reduction in anterior dental dimensions, absolutely but in particular relative to postcanine tooth size (Stefan & Trinkaus 1998b; Trinkaus 2004b). And there was a general reduction in the rate of anterior dental attrition relative to that of the posterior teeth, presumably as a result of less habitual use of the anterior teeth for paramasticatory purposes.

Dental and Alveolar Paleopathology

The alveolar processes of Muierii 1 are remarkable for their absence of pathological degenerations (fig. 63 to 65). There are no abscesses. There are no bony pockets on the interdental septa. There is no evidence of porosity lingually or buccally on the maxillae or the mandible. There are very small fenestrations buccally over the roots of the right I^2 and the left P^3 (fig. 63). The one over the P^3, which is 9.5 mm above the alveolar margin, is from postmortem breakage of the thin bone over the root sockets. The one over the I^2, 6.5 mm above the alveolar margin, has rounded edges into the socket and therefore was antemortem. All of the tooth loss was postmortem and involved those teeth with tapering roots. The even wear and supereruption of the maxillary teeth (see below) imply no antemortem tooth loss of the missing anterior and left mandibular dentition.

Figure 63 - Buccal views of the Muierii 1 maxillary dentition and alveoli. Upper left: right lateral. Upper right: left lateral. Lower left: right anterolateral. Lower right: left anterolateral. Scale bar is 5 centimeters.

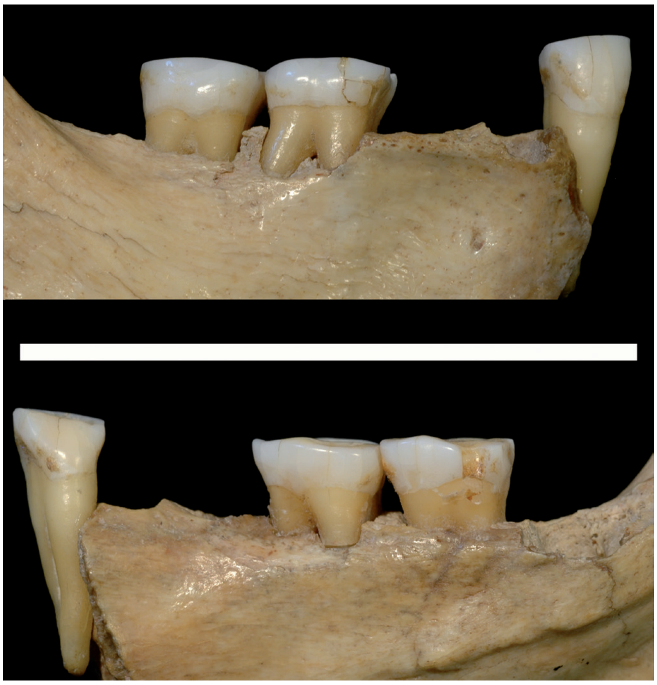

Figure 65 - Buccal (above) and lingual (below) views of the Muierii 1 mandibular alveoli and teeth. Scale bar is 5 centimeters.

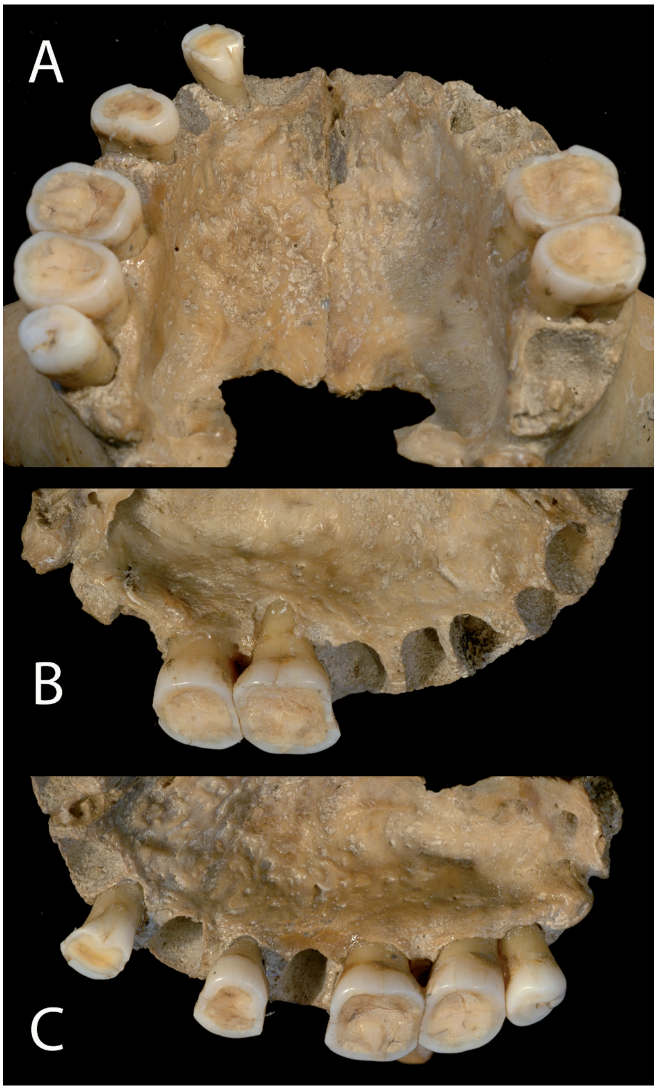

Figure 64 - Oblique views of the Muierii 1 maxillary lingual alveoli, to approximately the same scale. Top: anterior lingual. Middle: left lingual. Bottom: right lingual.

	I^2-Rt	P^3-Rt	M^1-Rt	M^1-Lt	M^2-Rt	M^2-Lt	M^3-Rt	C_1-Lt	M_1-Rt	M_2-Rt
MB crown height	5.6	5.1	4.6	4.6	5.6	5.0	5.2	7.4	4.1	4.5
DB crown height			4.8	3.7	5.8	4.6	4.9		3.7	4.7
ML crown height	4.6	3.7	3.5	3.7	4.1	3.0	4.3	--	3.8	4.6
DL crown height			2.8	3.8	3.2	3.3	4.2		3.8	3.5
CEJ-AC buccal	2.0	1.9	1.7	1.8	--	2.6	3.1	--	(2.1)	(0.7)
CEJ-AC lingual	2.7	2.2	2.7	2.2	2.2	2.3	4.2	--	1.3	1.6
Mesial IP facet br	3.0	4.9	5.3	5.1	6.7	6.5	3.5	3.5	5.0	5.1
Distal IP facet br	3.4	4.5	7.2	6.5	5.1	4.8	--	3.5	(5.2)	5.4
Molnar wear[2]	5	6	6	6	6	6	2	4	6	6
Smith wear[2]	4.5	6a	6b	6c	5c	5c	3b	4	6a	6b

[1] Crown heights are at the indicated corners for the molars; they are mid-buccal (-labial) and mid-lingual for the incisor, canine and premolar. M: mesial; D: distal; B: buccal/labial; L: lingual. CEJ-AC is the mid-buccal or mid-lingual vertical distance from the cervix (CEJ – cervical-enamel junction) to the alveolar crest (AC). IP: interproximal.

[2] Wear stages from Molnar (1971) and Smith (1984).

Table 33 - Attritional effects on the Muierii 1 dentition.[1]

In the context of these healthy alveoli, there is considerable supereruption of the teeth. In living individuals with healthy gingival tissues, it is normal for 1–2 mm of root to be evident between the cervix and the crest of the alveolar process (the CEJ-AC or cervix to alveolar crest height) (Whaites 1992; Goaz & White 1994). Of the sufficiently preserved teeth and alveoli providing 17 height measurements on Muierii 1, ten have CEJ-AC heights greater than 2 mm, and all but two are close to or greater than 2 mm (tabl. 33). Given the occlusal wear on these teeth, and their associated reductions in crown heights, such supereruption of the teeth is normal (Costa 1982; Newman 1998).

The teeth themselves have few pathological alterations. There are a few very minor pits on the buccal crowns which are probably trivial developmental defects, or dental enamel hypoplasias (DEH). There is a hint of a linear hypoplasia (LEH) on the mid-buccal I^2. There is a mid-buccal pit on the right M^1, a smaller pit on the mesiobuccal right M^3, and several small pits on the mid-buccal left M^2. The other teeth, to the extent that their crowns remain, do not show such defects. Similar minor hypoplastic defects are ubiquitous on Late Pleistocene human teeth (Ogilvie *et al.* 1989; Guatelli-Steinberg *et al.* 2004; Trinkaus *et al.* 2006a) and all of the samples have frequencies which fall within the ranges of variation of recent human samples (Larsen 1997). The Muierii 1 specimen may be of note only in its DEH on the M^3; M3 hypoplasias are unusually common among Neandertals (Ogilvie et al. 1989), and they are relatively rare among other human samples (El-Najjar *et al.* 1978; Trinkaus *et al.* 2006a).

There is minor calculus accumulation along the gingival margin buccally, especially on the maxillary molars on both sides but with traces of it on the I^2 and P^3. There is no evidence of calculus on the mandibular molars, but there is a hint of it around the mesiolingual and distobuccal C$_1$. Judging by the radicular margins of the calculus on the maxillary molars close to the cervices, which should correspond to the original gingival margins, the supereruption of the teeth should not have been associated with gingival recession. There is no evidence of hypercementosis on any of the exposed roots or through alteration of the sockets.

As with the overwhelming majority of other Middle Paleolithic and earlier Upper Paleolithic humans (Brennan 1991; Trinkaus *et al.* 2006a; Trinkaus & Pinilla 2009), there are no dental carious lesions, occlusal, cervical or radicular.

Dental attrition

The occlusal surfaces of the Muierii 1 teeth exhibit considerable attrition (fig. 62 to 66), as noted above.

The I^2 has a horizontal (occlusal plane) occlusal surface with a central darker area of secondary dentin. It has not been possible to measure the beveling angle of the I^2, but visual inspection indicates that the tooth exhibits normal rotation with occlusal attrition, becoming more vertical and maintaining the occlusal surface in the occlusal plane (*cf.*, Ungar *et al.* 1997).

The P^3 is also worn flat, with a large secondary dentin patch buccally and a smaller one lingually. The crown was planed off mesially and distally through interproximal wear. The M^{1}s retain a full enamel ring and a tongue of occlusal enamel extending between the paracone and the metacone to the middle of the occlusal surface. Lingually there is more of a basin with secondary dentin, especially below the protocones. The distal and especially mesial surfaces have lost up to half of the enamel through interproximal wear. The M^{2}s are similarly worn, but they have only slight distal crown enamel loss through interproximal wear. The M^3 is polished on its mesial cusps, but there is no exposed dentin.

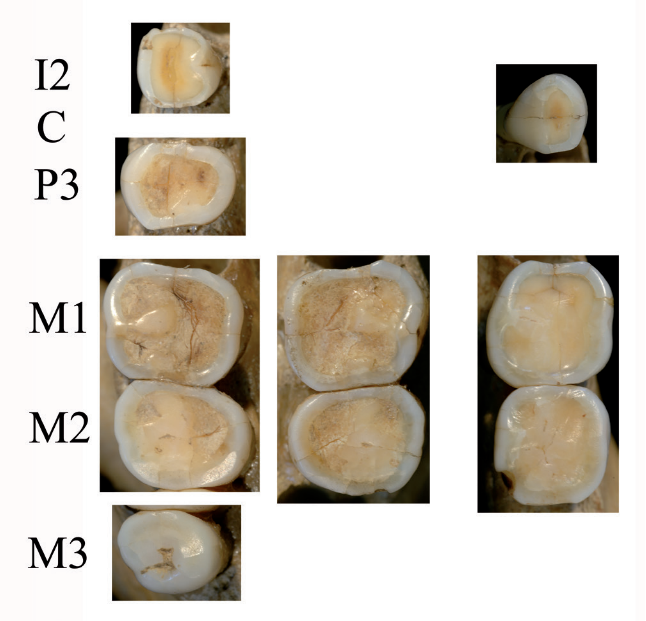

Figure 66 - Occlusal views of the Muierii 1 teeth, approximately to the same scale. Left column: maxillary right. Middle column: maxillary left. Right column: mandibular right.

In the mandibular dentition, the C$_1$ has only a modest area of dentin exposure, in the occlusal plane. The mandibular molars are similar to the maxillary ones, in that their occlusal surfaces consist of enamel rings around dentin basins with small amounts of remaining occlusal enamel extending into the basins, in this case from the lingual side given a normal overbite. The interproximal wear is less pronounced than on the M^1, but similar to that of the M^2.

In addition there is a notch missing from the distolingual corner of the M$_2$. It is 2.0 mm wide, and it represents an antemortem loss of enamel from the occlusal corner. There is rounding of the adjacent enamel edges, onto the lingual and distal surfaces, and the dentin within the notch rounds onto the occlusal surface.

In order to assess where Muierii 1 falls with respect to the more pronounced anterior tooth attrition of the Neandertals versus early modern humans (Trinkaus 1983, 1992), the buccolingual diameters of the anterior teeth and of their respective M1s (tabl. 34) were multiplied by their wear scores in the Molnar system. Since a smaller tooth is likely to wear down faster in the same attritional environment, this adjustment should permit the assessment of relative wear while taking into account the variation in anterior to posterior dental dimensions. In both the

	I^2-Rt	P^3-Rt	M^1-Rt	M^1-Lt	M^2-Rt	M^2-Lt	M^3-Rt	C_1-Lt	M_1-Rt	M_2-Rt
MD crown[1]	[6.6]	[7.3]	[9.9]	[10.2]	[9.3]	[9.4]	7.0	[7.8]	[11.3]	[10.6]
BL crown	7.1	10.0	12.3	12.1	11.6	11.6	8.6	8.5	11.6	10.7
MD cervix	4.9	8.3	7.4	7.4	7.2	7.6	5.6	5.9	10.1	8.5
BL cervix	5.6	5.1	4.5	4.6	5.5	4.9	5.7	7.4	8.8	8.9
Cervix to roots[2]	--	--	--	--	--	--	--	--	3.8	3.3
Diagonal MB-DL[3]			12.5	12.4	11.8	11.6	8.9			
Diagonal ML-DB[3]			11.9	12.2	10.8	11.0	7.3			

[1] All of the mesiodistal (MD) crown diameters except for the M^3 are reduced through occlusal and interproximal attrition, and hence are minimum values only (indicated by [##.#]). M: mesial; D: distal; B: buccal/labial; L: lingual.

[2] Cervix to roots: vertical distance from the cervix to the buccal root bifurcation.

[3] Diagonal diameters are obliquely across the maxillary molar crowns as indicated.

Table 34 - Morphometrics of the Muierii 1 teeth.

maxillary and the mandibular plots (fig. 67 and 68), the Neandertals have a uniform pattern with increasing dental attrition. The limited data for early modern humans places them among the Neandertals for minimally worn teeth, but increasingly separate with more worn dentitions, in each case with less relative anterior tooth wear.

In both dentitions, Muierii 1 is among those with the least relative anterior tooth wear. In the maxillary distribution, it is joined by two Middle Paleolithic modern humans, Skhul 4 and 5. In the mandibular plot it is separate from the others, although it is approached by Skhul 4 and 5 and the Dolní Věstonice 3 and Předmostí 3 Mid Upper Paleolithic dentitions. Increasing the Muierii 1 C_1 wear score to an unreasonable stage 5 would place it next to Předmostí 3.

Dental Discrete Morphology

The marked occlusal and interproximal wear of the Muierii 1 teeth (fig. 62) has removed most evidence of their discrete dental morphology. Despite the wear, it is nonetheless possible to approximate a few aspects and score some of them using the Arizona State University Dental Anthropology System (ASU-DAS) (Turner *et al.* 1991; Scott & Turner 1997; see also Bailey 2006).

The Muierii 1 I^2 exhibits shoveling (marginal ridge development) ASU-DAS stage 5 or 6, labial curvature stage 2, and lingual tuberculum stage 1. The C_1 has a very modest lingual tubercle and little or no development of the marginal ridges. All of the maxillary anterior tooth roots are subconical, as is that of the C_1.

There is only a general crown outline for one P^3 among the premolars, which is unexceptional. However, the P^3s have distinctly double roots, and the right P_3 had a double root, consisting of a large buccal root, a much smaller lingual one and a bony septum separating them (fig. 62). The root sockets of the absent second premolars, maxillary and mandibular, indicate single roots with little formation of a vertical developmental groove.

The M^1s and M^2s lack the oblique parallelogram shape of many Neandertal maxillary molars (Bailey 2004), which is reflected in the similar oblique crown diameters of the Muierii 1 molars (tabl. 34). There is no evidence of a Carabelli's cusp on any of

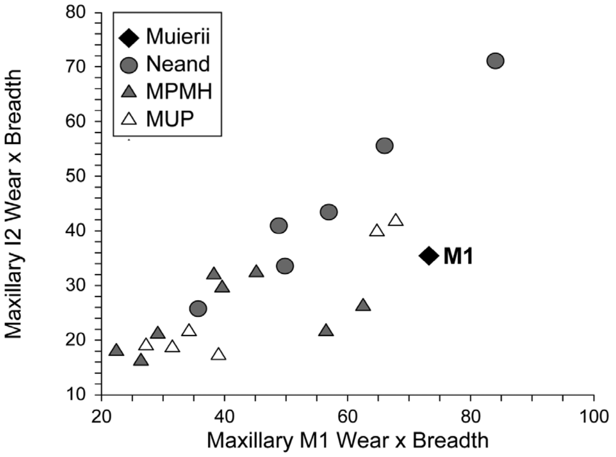

Figure 67 - Bivariate plot of crown breadth times Molnar wear scale value for the maxillary I^2 versus the M^1. There are no Early Upper Paleolithic or northwest African Middle Paleolithic specimens providing data. M1: Muierii 1; Neand: Neandertals; MPMH: Middle Paleolithic modern humans; MUP: Mid Upper Paleolithic humans.

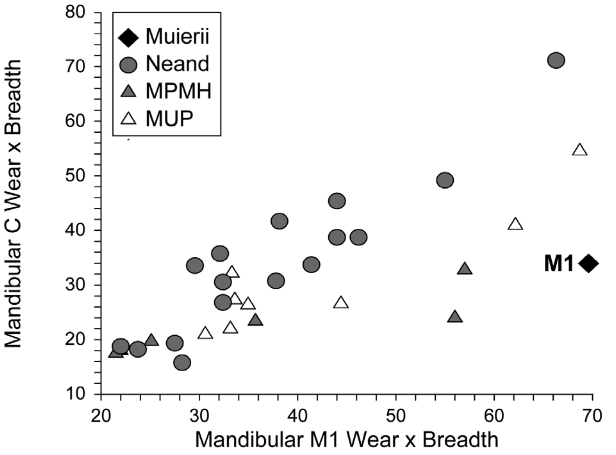

Figure 68 - Bivariate plot of crown breadth times Molnar wear scale value for the mandibular C_1 versus the M_1. There are no Early Upper Paleolithic or northwest African Middle Paleolithic specimens providing data. M1: Muierii 1; Neand: Neandertals; MPMH: Middle Paleolithic modern humans; MUP: Mid Upper Paleolithic humans.

them. The M^{1}s appear, based on crown outline shape, to have had little or no hypocone reduction, but the M^{2}s may have had modest hypocone reduction. The M^{1}s are three-rooted, and the M^{2}s appear to have been so as well.

The right M^3 is greatly reduced, with loss of the hypocone and marked reduction of the metacone. Even though it may not qualify as a "peg" third molar, since it has two prominent cusps remaining, it is markedly reduced. Similar M^3 reduction is evident in at least one Neandertal, Amud 1 (Sakura 1970), and *contra* Bailey (2006) it is evident in two Mid Upper Paleolithic individuals, Dolní Věstonice 33 and Paglicci 36 (Mallegni & Palma di Cesnola 1994; Hillson 2006). The left M^3, based on its reduced and constricted root socket, was probably similarly diminutive. The Muierii 1 M^3 was nonetheless in occlusion. The right M^3 root appears to be fused into one, but the left socket makes it apparent that they retained the three roots, at least at their apical ends. Interestingly, while Muierii 1 has among the smallest M^{3}s of any of the Late Pleistocene humans of concern, the Oase 1 and 2 early modern humans from nearby Caraş-Severin have the largest M3s known for the last half-million years of the genus *Homo* (Trinkaus *et al.* 2003a; Rougier *et al.* 2007). Mladeč 8 and Hofmeyr 1 have large more mesial molars, but they lack their M^{3}s.

The wider talonid than trigonid of the M$_1$ implies a five-cusped first lower molar, and by the same reasoning, the more rectangular M$_2$ suggests cusp reduction and possibly only four cusps. The relatively high positions of the bifurcations of the mesial and distal roots on both teeth (tabl. 34) indicate that they are non-taurodont. The M$_3$ is absent, but the dimensions of its socket (tabl. 35) indicate that its cervical diameters were similar to those of the M$_1$ and M$_2$. The third molar reduction in the maxilla therefore appears not to have been present in the mandible.

Dental Size and Proportions

The heavy occlusal and especially interproximal wear on the Muierii 1 teeth has reduced the number of crown diameters that can be employed to assess their size and proportions. It is nonetheless possible to compare bucco (labio) lingual crown diameters for the ten teeth (tabl. 34) to those of other Late Pleistocene humans (tabl. 36). Given anterior occlusal wear and posterior interproximal wear, none of the mesiodistal diameters is more than a minimum. In addition, cervical diameters are provided (tabl. 37), and it has been possible to measure or estimate the two anterior tooth root lengths (tabl. 37).

The buccolingual diameters of the Muierii 1 P^3, M^{1}s, M$_1$ and M$_2$ are close to the means of the other Late Pleistocene samples, which are insignificantly different from each other (after a multiple comparison correction). The M^{2}s and especially the M^3 are somewhat smaller. The M^2 diameter is within one standard deviation of the Neandertal, Middle Paleolithic modern human and Mid Upper Paleolithic samples, but it is 2.1 standard deviations from the sample of large Early Upper Paleolithic M^{2}s (which includes the rather large teeth of Mladeč 8 and Oase 2). The Muierii 1 diameters are also below the values for Nazlet Khater 2, Hofmeyr 1 and the northwest African Middle Paleolithic sample.

	MD socket diameter	BL socket diameter	Socket depth middle or buccal
I^1 right	7.2	7.0	12.1
I^1 left	7.6	6.5	10.4
I^2 right	5.9	7.0	--
I^2 left	6.1	7.2	11.1
C^1 right	6.3	9.6	16.7
C^1 left	6.5	8.9	16.4
P^3 right	5.9	8.4	--
P^3 left	5.4	9.2	--
P^4 right	6.0	8.3	13.5
P^4 left	5.0	8.5	12.8
M^1 right	8.1	11.4	--
M^1 left	7.8	11.9	--
M^2 right	7.5	10.7	--
M^2 left	7.2	11.0	--
M^3 right	5.2	7.9	--
M3 left	(6.6)	--	--
C$_1$ right	--	8.6	--
P$_3$ right	5.2	(7.9)	14.5 (B), 10.8 (L)
P$_4$ right	5.0	7.2	15.1
M$_1$ right	9.6	--	--
M$_2$ right	8.6	9.6	--
M$_3$ right	9.3	10.1	11.3

Table 35 - Mesiodistal and buccolingual diameters of the socket openings, plus maximum socket depths from the interdental septa of the Muierii 1 alveolar processes.

The molar proportions are illustrated in part by a plot of M^2 breadth versus M^1 breadth (fig. 69). There is little difference between the larger Neandertals and the Mid Upper Paleolithic sample. The few Early Upper Paleolithic specimens, despite their large molar dimensions, are similar proportionately, although the variable Middle Paleolithic modern human sample has a few specimens with relatively smaller M^{2}s. The last are joined by the Aterian Dar-es-Soltane 6 dentition. In this context, Muierii 1 has one of the relatively smallest M^{2}s, falling at the bottom of the Neandertal and Mid Upper Paleolithic distributions and among a few of the Middle Paleolithic modern human fossils plus Dar-es-Soltane 6.

The reduced M^3 buccolingual diameter of 8.6 mm is at least 2.6 standard deviations below the means of the four other reference samples, and it is exceeded in smallness only by one of the Amud 1 M^{3}s (7.7 mm), the Paglicci 36 M^3 (8.2 mm) and the Dolní Věstonice 33 probable M^3 (7.6 mm). Even with Dolní Věstonice 33 added to the Mid Upper Paleolithic sample, the Muierii 1 M^3 diameter remains 2.1 standard deviations from the Mid Upper Paleolithic mean (11.5 ± 1.4 mm, N = 24).

The I^2 labiolingual diameter is relatively modest, falling on the Mid Upper Paleolithic mean and below all of the Early Upper Paleolithic diameters and almost all of the Middle Paleolithic values. In the comparative samples prior to the Mid Upper Paleolithic, it is matched only by the Middle Paleolithic modern

Sample[2]	I^2	P^3	M^1	M^2	M^3	C_1	M_1	M_2
Muierii 1[3]	7.1	10.0	12.3 / 12.1	11.6 / 11.6	8.6	8.5	11.6	10.7
Neandertals	8.1 ± 0.5 (35)	10.4 ± 0.6 (30)	11.9 ± 0.8 (36)	12.2 ± 1.0 (28)	12.0 ± 1.3 (31)	8.9 ± 0.8 (37)	10.9 ± 0.6 (51)	11.0 ± 0.7 (39)
MPMH	7.5 ± 0.6 (11)	10.4 ± 0.4 (9)	12.1 ± 0.6 (19)	12.1 ± 0.7 (10)	11.7 ± 0.6 (7)	8.3 ± 0.8 (10)	11.4 ± 0.6 (15)	10.9 ± 0.7 (10)
EUP	7.2, 7.3, 8.4	10.2 ± 0.5 (4)	12.7 ± 0.8 (8)	13.1 ± 0.7 (7)	12.3 ± 1.4 (5)	8.9 ± 0.7 (6)	10.9 ± 0.7 (8)	10.8 ± 0.7 (16)
MUP	7.1 ± 0.5 (20)	9.9 ± 0.6 (26)	12.1 ± 0.8 (31)	12.4 ± 0.9 (29)	11.7 ± 1.2 (23)	8.6 ± 0.7 (19)	11.2 ± 0.7 (33)	11.0 ± 0.8 (28)
K-W P-value[4]	<0.001**	0.033	0.188	0.165	0.594	0.186	0.038	0.87
NW Africa MP	--	--	13.9, 14.0, 15.0	13.2, 13.7, 13.7	12.3	--	12.0, 12.1, 12.2	12.0, 12.2, 12.7
Nazlet Khater 2	--	10.3	11.9	12.8	12.3	--	11.8	11.5
Tianyuan 1	--	--	--	--	--	8.8	11.1	10.2
Hofmeyr 1	--	--	--	14.6	--	--	--	--

[1] Right and left diameters, when available, were averaged for other specimens prior to computation of sample statistics. Mean ± standard deviation (N) provided for samples >3.
[2] MPMH: Middle Paleolithic modern humans; EUP: European Early Upper Paleolithic humans; MUP: European Mid Upper Paleolithic humans; NW Africa MP: northwest African Middle Paleolithic (Aterian) humans.
[3] For the Muierii 1 maxillary M^1s and M^2s, right / left values are provided.
[4] ** significant at $P < 0.01$ using a sequential multiple comparison correction on the Kruskal-Wallis test across the first four comparative samples only.

Table 36 - Buccolingual breadths, in millimeters, of the Muierii 1 teeth and summary statistics for comparative Late Pleistocene samples.[1]

	I^2 root length	C_1 root length
Muierii 1[1]	~13.1	17.6
Neandertals	16.5 ± 1.8 (12)	19.0 ± 2.6 (11)
Early Upper Paleolithic	~17.0	17.3, 17.5, 19.0
Mid Upper Paleolithic	14.7 ± 1.3 (4)	16.7 ± 2.4 (8)
Kruskal-Wallis P	0.163	0.229

[1] For the Muierii 1 lower canine (C_1), the root length measured on the exposed root is provided. For the upper second incisor (I^2), the left socket depth (11.1 mm) is added to the right CEJ-AC (2.0 mm) to provide an estimated root length of 13.1 mm.

Table 37 - Comparisons of available anterior tooth root lengths for Muierii 1 and Late Plesitocene samples.

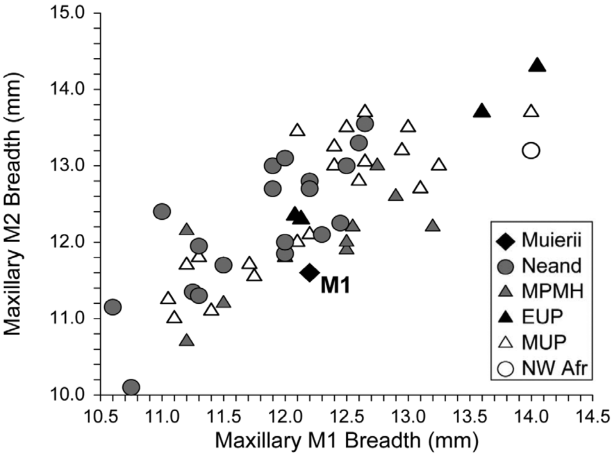

Figure 69 - Bivariate plot of maxillary M^2 breadth (buccolingual diameter) versus M^1 breadth. M1: Muierii 1; Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic humans; MUP: Mid Upper Paleolithic humans; NW Afr: northwest African Middle Paleolithic human.

human Qafzeh 5 and the Palomas 43 Neandertal and none are smaller. The diameter of the C_1 is also modest, but it is well within the ranges of variation of the comparative samples.

In general, relative to early modern humans, Neandertals have proportionately large anterior teeth, which is primarily reflected in a decrease in anterior dental dimensions between Neandertals and early modern humans (Stefan and Trinkaus 1998b; Trinkaus 2004b). This is reflected in plots of I^2 versus M^1 and C_1 versus M_1 for the later Pleistocene comparative samples (fig. 70 and 71). The separation of the samples is less than with the summed anterior teeth versus the summed posterior teeth, but there is little overlap in the maxillary comparison and minor overlap of the distributions in the mandibular one. In the maxillary plot, Muierii 1 falls in the middle of the Mid Upper Paleolithic and Middle Paleolithic modern human distribution, adjacent to the Early Upper Paleolithic Mladeč 51, and separate from the Neandertals. In the mandibular distribution, Muierii 1 is among the early modern humans with the relatively smaller canines, but it is also proportionately similar to the Hortus 4 and Vindija 206 Neandertals and the Aterian Témara 1.

The estimated I^2 lingual root length and the measured value for the C_1 are unexceptional in a Late Pleistocene context. Bailey (2005) noted significant differences between Neandertals and Upper Paleolithic humans (data are unavailable for the Middle Paleolithic modern human sample). However, if one resorts the specimens into directly relevant samples and completes the available data set (tabl. 37; see also Trinkaus *et al.* 2010), the significance disappears. In this, the Neandertal sample is restricted to Late Pleistocene specimens and includes the late Palomas Neandertals (Walker *et al.* 2008), and the Upper Paleolithic sample is limited to Early and Mid Upper Paleolithic specimens [excluding Late Upper Paleolithic specimens, who have generally smaller teeth (Frayer 1978; Trinkaus 2004b)]. The Muierii 1 I^2 estimated root length is relatively short. It is below the observed Neandertal and one estimated Early Upper Paleolithic value, but it remains within two standard deviations of the Neandertal mean. It is close to the value for Předmostí 5. The C_1 root length is well within the ranges of variation of

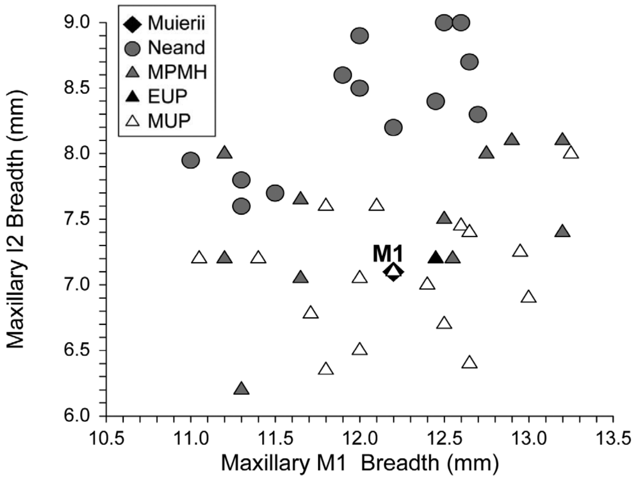

Figure 70 - Bivariate plot of maxillary I^2 breadth versus M^1 breadth. M1: Muierii 1; Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic humans; MUP: Mid Upper Paleolithic humans.

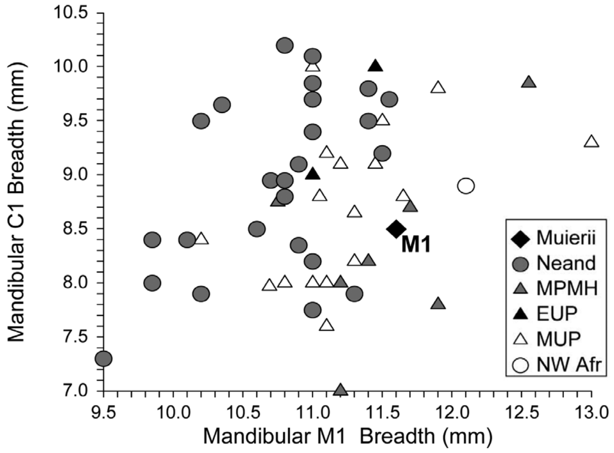

Figure 71 - Bivariate plot of mandibular C$_1$ breadth versus M$_1$ breadth. M1: Muierii 1; Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic humans; MUP: Mid Upper Paleolithic humans; NW Afr: northwest African Middle Paleolithic human.

all of the comparative samples, albeit moderately high for a Mid Upper Paleolithic human.

Muierii 1 therefore has relatively modest overall dental dimensions, maxillary but not mandibular distal molar reduction, and relative anterior to posterior tooth dimensions that align it with early modern humans to the exclusion of most Neandertals.

Summary

The preserved dentition and alveolar processes of Muierii 1 therefore present an older individual with moderately advanced occlusal and postcanine interproximal attrition, associated supereruption of most of the teeth and vertical rotation of the incisor, trivial evidence of developmental hypoplasias, and no evidence of degenerative lesions (carious lesions, periodontal disease, hypercementosis or antemortem tooth loss). The occlusal attrition was evenly distributed across the arcade and, if anything (given minimal preservation of the anterior dentition), less on the anterior teeth than would be expected for even a Late Pleistocene early modern human.

These paleobiological aspects are associated with moderately sized maxillary first molars and mandibular molars, but progressive reduction of the more distal maxillary molars. The M^2 breadth, relative to that of the M^1, is among the smallest of the Late Pleistocene specimens. The maxillary third molars, from the right crown and the left socket, are among the smallest of the known Late Pleistocene M^{3}s. The anterior teeth relative to the M1s are also modest in size, but in that they approximate the proportions of other Late Pleistocene early modern humans. To the extent that it can be determined given dental attrition, the teeth present none of the derived discrete traits noted for the Neandertals.

The Right Scapula of Muierii 1

The Muierii 1 associated remains retains a partial right scapula (fig. 72), the only human upper limb element recovered from the Paleolithic deposits in the Galeria Musteriană. It is the only scapula known for European Early Upper Paleolithic modern humans, although it is joined by a series of arm and hand remains from Mladeč (Trinkaus *et al.* 2006b). Scapulae are known from the Early Upper Paleolithic Nazlet Khater 2 and Tianyuan 1 partial skeletons (Crevecoeur 2008; Shang & Trinkaus 2010), as well as from the initial Mid Upper Paleolithic Cro-Magnon and Paviland remains (Vallois & Billy 1965; Trinkaus & Holliday 2000).

The bone has most of the glenoid fossa with only minor restoration of the inferior portion of the ventral edge. It retains the entire axillary border from the glenoid margin to the cranial end of the teres major surface, the lateral half of the spine with damage to its dorsal surface, and the base of the corocoid process. As such, in a Pleistocene *Homo* context, the Muierii 1 scapula provides comparative data on the form and proportions of its glenoid surface and on the cross-sectional shape of its axillary border. It also provides an axilloglenoid angle. It is possible to estimate its mediolateral dimension, although the absence of associated humeral or clavicular lengths makes the significance of such a dimension difficult to assess beyond considerations of overall size.

Aspects of the Muierii 1 scapula have previously been presented (Gheorghiu & Haas 1954; Soficaru *et al.* 2006; Trinkaus 2008a). These aspects are included here, assessed and modified in light of further analysis, and additional features are considered.

Late Pleistocene Scapular Morphomic Considerations

Since the early descriptions of Testut (1890), Schwalbe (1901), Gorjanović-Kramberger (1906), Verneau (1906) and Boule (1911-13) of Late Pleistocene human postcranial remains, a series of morphological changes in the shape of the human scapula between late archaic and early modern humans in Europe have been identified. In particular, these changes involve

Figure 72 - Dorsal (left) and ventral (right) views of the Muierii 1 right scapula. Scale bar is 5 centimeters.

the relative (but not absolute) mediolateral dimension (the morphological length), the relative breadth of the glenoid fossa, and the form of the axillary border, as well as some angular changes between portions of the scapula (e.g., Eickstedt 1925; Vallois 1928-1946; Haas 1957; Heim 1982; Trinkaus 1977, 1983, 2006b, 2008a,b; Churchill & Trinkaus 1990; Vandermeersch 1991; Churchill 1994; Carretero *et al.* 1997; Crevecoeur 2008; Shang & Trinkaus 2010). In particular, what has emerged is that a more frequent dorsal sulcus pattern seems to be a derived Neandertal feature, and a broader glenoid fossa appears to be a derived modern human (or at least Upper Paleolithic and Holocene) characteristic. Angular proportions are inadequately known for Middle and Early Pleistocene *Homo* to assess their polarities, but data are available for these earlier scapulae. It is therefore in this context that the Muierii 1 scapula is considered here.

It should also be noted that the Muierii 1 scapula is a right scapula. Even though assessments of glenoid fossa proportions have tended to pool right and left bones (or averaging right and left dimensions by individual when available) (e.g., Churchill & Trinkaus 1990) and upper limb articular asymmetry tends to be modest if right-side biased (Trinkaus *et al.* 1994; Auerbach & Ruff 2006), it has become apparent (Trinkaus 2006b) that there are differences in the patterns of change in right versus left glenoid fossa proportions through the Late Pleistocene. Asymmetry in axillary border form does exist, and it tends to have the sulcus more dorsal on the right side when asymmetry is present (Trinkaus 1977; Chambers 1992; Franciscus & Schoenebaum 2000). To the extent possible, therefore, both glenoid fossa proportions and axillary border morphology are compared preferentially, but not exclusively, to those of right scapulae.

Overall Size

The Muierii 1 scapula derives from a small individual for a Late Pleistocene human. The only measure of absolute size that is directly preserved on the individual is glenoid articular height, which correlates with humeral articular dimensions (Churchill & Trinkaus 1990) and therefore should be generally indicative of overall size given only minimal differences in the ratio of humeral distal articular breadth to length across Late Pleistocene samples (Trinkaus 1983). The Muierii 1 right glenoid articular height of 34.3 mm is among the smaller of the Late Pleistocene specimens, but it is not exceptional for any of the comparative samples. Comparing it to the pooled, or averaged, right and left values (fig. 73), it is close to the Skhul 5 male Middle Paleolithic modern human and the Paglicci 25 and Předmostí 9 Mid Upper Paleolithic females. It remains above those of four Neandertals, the La Ferrassie 2 female and the Shanidar 1 and 4 males plus Vindija 209, as well as the Dolní Věstonice 3 Mid Upper Paleolithic female.

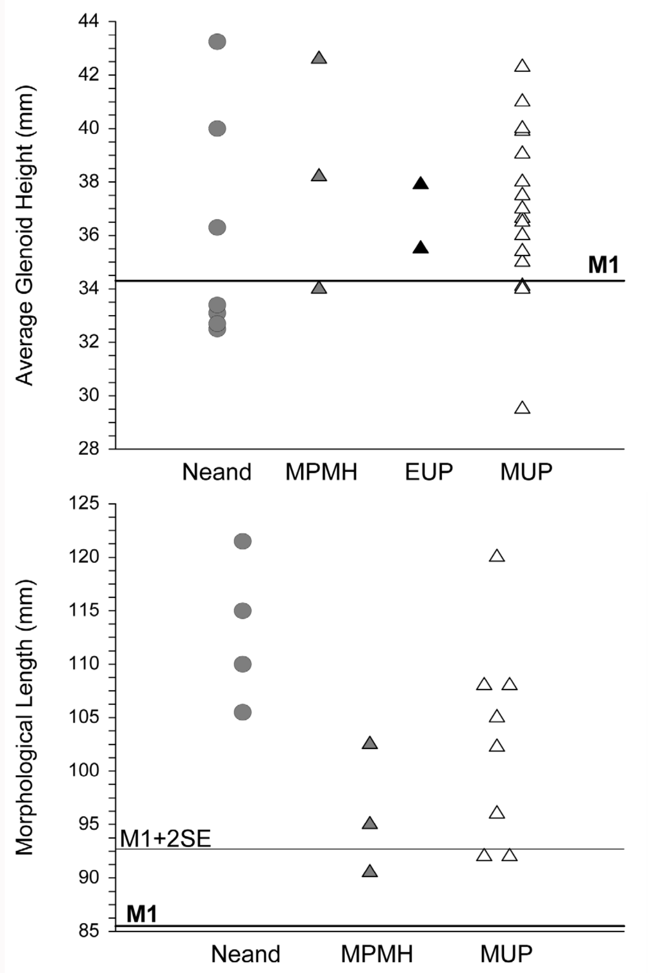

Figure 73 - Distributions of average (right and left as available) glenoid articular height (above) and scapular morphological length (below) for Muierii 1 and Late Pleistocene humans. M1: Muierii 1 height of 34.3 mm. Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic Nazlet Khater 2 and Tianyuan 1; MUP: Mid Upper Paleolithic humans. For the morphological length, the estimated value plus 2 standard errors of the estimate (M1+2SE: 92.7 mm) for Muierii 1 are provided.

A better indication of overall size might be its morphological length, the mediolateral distance from the mid-glenoid fossa to the vertebral border at the medial end of the spine. This standard length (Martin #2) is not preserved on Muierii 1, but the lateral three-quarters is present from the glenoid fossa to the point at which the dorsal spine narrows for the thin portion leading down to the vertebral border (65.5 mm). The medial landmark on the bone is not a precise one, nor is it particularly well delimited on complete scapulae. However, it can be approximated to within a couple of millimeters. Consequently, the morphological length was measured on a sample of recent human scapulae (N = 40) and casts of three Late Pleistocene scapulae (La Ferrassie 1, Kebara 2 and Qafzeh 9). On those same 43 specimens the distance from the glenoid fossa to the medial narrowing of the dorsal spine was measured. The resultant least squares regression line [MorphLen = (0.970 x Muierii length) + 21.5; r^2 = 0.793] provides a reasonably good fit with a standard deviation of 3.4 mm for its standard residuals. The three fossil specimens have z-scores of –0.08, 0.02 and 0.90 respectively, and they therefore fit the recent human distribution. Using the pooled recent and Late Pleistocene human sample provides a morphological length estimate of 85.5 ± 3.6 mm for Muierii 1.

Reliable morphological lengths are rarely preserved for fossil human scapulae (Churchill 1994), but it is possible to assemble a sample of 14 individuals (fig. 73). The mean estimated value for Muierii 1 is below those of all of the other sufficiently preserved Late Pleistocene scapulae. To adjust for possible underestimation of the Muierii 1 value, its mean plus 2 SE_{est} value (92.7 mm) is also included. That value is close to the smallest values for Late Pleistocene specimens, all of which are estimated (Arene Candide 1 and Qafzeh 9) or derive from a very small (and pathological) individual (Dolní Věstonice 15). The mean estimation minus 2 SE_{est} of 78.3 mm would be exceptionally low, for either a Late Pleistocene human or a small-bodied recent human (Vallois 1928-46).

Although the estimated morphological length for Muierii 1 makes it unlikely that it derives from an average or large Late Pleistocene individual, the comparison needs to be made in the context of changing shoulder proportions. On average, Middle Paleolithic and Mid Upper Paleolithic modern humans have absolutely narrower scapulae (Kruskal-Wallis P = 0.045), and narrower scapulae relative to both humeral length (Trinkaus 1983) and clavicular length (Trinkaus 2006b), than do the Neandertals. It is therefore not clear whether the small mediolateral dimension of the Muierii 1 reflects small body size, a relatively narrow scapula similar to those of other early modern humans, or (most likely) both.

Scapular Angulation

There has been abundant consideration of the various angles between the craniocaudal plane of the glenoid fossa, the scapular spine and the axillary border (Vallois 1928-46) with standard angles between each pair (Bräuer 1988). Of these, only the axilloglenoid angle can be taken reliably on the Muierii 1 scapula (the spinoglenoid angle is 90° ± 5°, depending upon how one assesses the original medial curvature of the spine and hence the position of the spine and the vertebral border). There is also variation in the methods used to measure the axilloglenoid angle (Carretero *et al.* 1997), depending principally upon whether one employs the dorsal bar versus the lateral margin. There is also considerable variation within and between recent human samples (Vallois 1928-46).

Among Late Pleistocene humans, sample sizes are small and many of the values are estimated given damage to axillary borders, especially in the region of the teres major insertion. There is nonetheless a general pattern in which the Neandertals tend to have the highest values, but they are joined by the small Mid Upper Paleolithic human sample (fig. 74). The earlier Qafzeh and Skhul specimens, plus the Early Upper Paleolithic Nazlet Khater 2, all have smaller angles, indicating less vertical axillary borders. Interestingly, the MIS 6-5 Krapina and Tabun early Neandertal scapulae have variable but smaller angles (fig. 74), whereas the earlier Middle Pleistocene Atapuerca-SH sample provides two values of 140° and 144° (Carretero *et al.* 1997). The Early Pleistocene Dmanisi 4166 and KNM-WT 15000 scapulae have among the lowest angles, 129° and 127° respectively (Jashashvili 2005), but ones nonetheless within more recent human ranges of variation but at the top of African ape ranges of varition. The Muierii 1 angle (143°) is in the middle of the Neandertal and Mid Upper Paleolithic values, above all of the other angles.

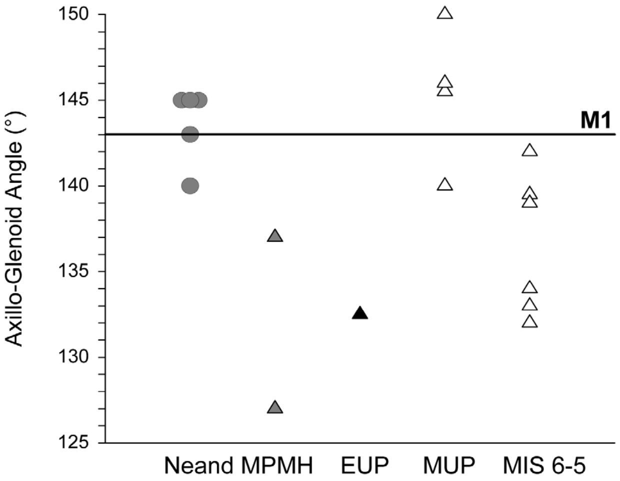

Figure 74 - Axilloglenoid angles for Muierii 1 (143°) and later Pleistocene humans. M1: Muierii 1; Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic Nazlet Khater 2; MUP: Mid Upper Paleolithic humans; MIS 6-5: Krapina and Tabun 1 early Neandertals.

The significance of variation in the axilloglenoid angle is unclear. For fully bipedal humans, it is assumed that the scapular resting position would be one in which the plane of the glenoid fossa is parasagittal, although cranial deviation through rotation around the coracoclavicular ligaments is normal with shoulder abduction (Levangie & Norkin 2005). The smaller angles of large-bodied apes are assumed to be associated with a cranial deviation of the glenoid fossa (Stern & Susman 1983). Among recent humans, Vallois (1928-46) provided a range of 15 means from 129° to 140° (not including four pygmoid individuals), with an individual range of 124° to 153°. It is tempting to see the similarities of the Neandertal, Mid Upper Paleolithic plus Muierii 1 axilloglenoid angles as reflecting a derived pattern relative to the Nazlet Khater, Qafzeh and Skhul values, as well as the Krapina and Early Pleistocene ones, but the higher angles for the two Atapuerca-SH scapulae plus the large recent human variation makes the broader

Figure 75 - Views of the Muierii 1 glenoid fossa and infraglenoid tubercle. Left: lateral view of the glenoid region, taken from a slightly caudal angle. Right: detail of the glenoid fossa with the damaged ventral margin restored in white plasticene. Scale equals 5 centimeters.

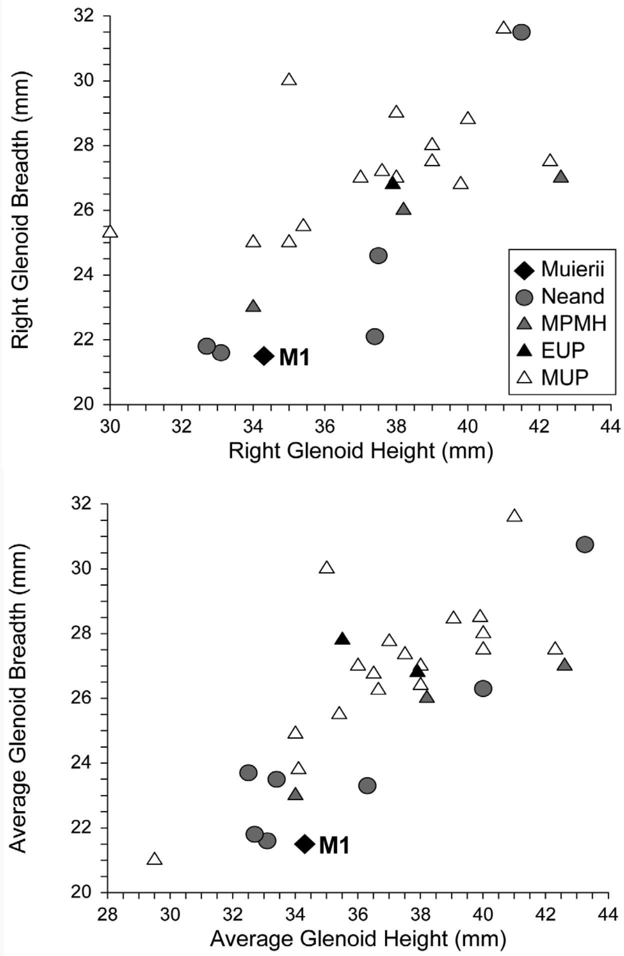

Figure 76 - Bivariate plot of glenoid articular breadth versus height for Late Pleistocene right scapulae (above) and for pooled right and left Late Pleistocene scapulae (below). In the latter graph, right and left values, when available, are averaged; otherwise, the preserved right or left values are employed. M1: Muierii 1; Neand: Neandertals; MPMH: Middle Paleolithic modern humans; EUP: Early Upper Paleolithic Nazlet Khater 2 and Tianyuan 1; MUP: Mid Upper Paleolithic humans.

implications of these angles unclear. It is not likely to reflect habitual shoulder posture.

The Glenoid Fossa

The Muierii 1 right glenoid fossa is almost complete, having sustained only minor erosion to the caudal half of the ventral margin (fig. 75). The fossa subchondral bone is gently concave dorsoventrally. Craniocaudally it is shallow at its cranial end. There is a raised area in the middle, and then there is a more pronounced depression caudally with a raised caudal margin. The subchondral bone is gently granular without any signs of degeneration. The margins are smooth to rounded, and there is no evidence of capsular ossification.

Given the preserved contour of the glenoid fossa and of the adjacent ventral bone (see fig. 75), it is possible to infer the original contour of the fossa. The restoration with plasticene should be within ~0.5 mm of the original bone contour. Unless the glenoid fossa had an unusual ventral bulge, the restoration should err on the side of making the glenoid fossa breadth too large. It therefore has a glenoid articular height of 34.3 mm and a restored glenoid fossa articular breadth of 21.5 mm; the respective maximum diameters are 36.1 mm and ~22.5 mm. These values were formerly (Soficaru *et al.* 2006) compared using a glenoid index (62.7), which indicates a relatively narrow glenoid fossa, similar to those of the Neandertals and at the bottom of the range of variation of Mid Upper Paleolithic and recent human right scapulae. However, there are limitations to the use of indices, since they rarely adequately remove the effects of size.

The glenoid fossa proportions are therefore compared here using bivariate plots of glenoid articular breadth versus height, initially for right fossae and then for pooled right and left fossae, averaging right and left values as available (fig. 76). In the right glenoid fossa comparison, Muierii 1 has the narrowest absolute articular breadth, approached only by three Neandertals, La Ferrassie 2, Shanidar 4 and Spy 2. In relative breadth, it clusters with the other Neandertals, below all of the Mid Upper Paleolithic right glenoid fossae and similar to or below the few Middle Paleolithic modern human fossae.

However, it needs to be emphasized that *all three* of the Middle Paleolithic modern human glenoid fossae, Qafzeh 8 and 9 and Skhul 5, lack intact glenoid breadths and have sustained considerably more fossilization damage than the Muierii 1 fossa (McCown & Keith 1939; Vandermeersch 1981; Trinkaus pers. observ.). The values for these three southwest Asian Middle Paleolithic fossae should therefore be considered as minimum values, especially the largest of the three, Qafzeh 8. It is likely that the proportions for the glenoid fossae of these Neandertal contemporaries were intermediate between the majority of the Neandertals and Mid Upper Paleolithic humans.

When the right and left values are pooled, the sample sizes increase, and there is more overlap between the samples. However, most of the Upper Paleolithic early modern human scapulae, including those of the Early Upper Paleolithic Nazlet Khater 2 and Tianyuan 1, have relatively broad glenoid fossae. Muierii 1 remains among the relatively narrowest of the Late Pleistocene specimens.

There is also a number of intact glenoid fossae from earlier archaic *Homo* specimens, especially from the Neandertal lineage sites of Atapuerca-SH, Krapina and Tabun, plus two Early Pleistocene ones (KNM-WT 15000 and Dmanisi 4166). All of these earlier archaic *Homo* scapulae have relatively narrow glenoid fossae (fig. 77). The Muierii 1 fossa remains among them, falling along the proportionately narrow border of the overall distribution.

The Neandertals and Muierii 1 therefore retain the ancestral form of a relatively narrow glenoid fossa, with the wider one of recent humans appearing principally with the earlier Upper Paleolithic spread of modern humans. The position in this feature of the Middle Paleolithic modern humans is ambiguous, being either close to the more archaic *Homo* samples or intermediate between them and the Upper Paleolithic and recent human samples depending upon how their incomplete glenoid breadths are restored. In either case, the Muierii 1 scapular glenoid fossa falls securely among archaic *Homo*, uniquely for an Upper Paleolithic modern human.

The Infraglenoid Tubercle

The infraglenoid tubercle is a modest and rounded ridge, 9.2 mm dorsoventral and projecting laterally ~3.5 mm from the dorsal axillary border (fig. 75 and 78). It starts cranially along the dorsocaudal margin of the glenoid fossa and then arches to the mid-lateral border where it meets the mid-axillary crest.

The Axillary Border

The Muierii 1 scapula preserves almost all of its axillary border without damage, from the glenoid fossa to the cranial end of the teres major insertion area (fig. 78). It is only one of two Early Upper Paleolithic scapulae to do so, along with Nazlet Khater 2 (Crevecoeur 2008), although the configuration of the Tianyuan 1 border can be estimated (Shang & Trinkaus 2010). Since axillary border morphology has figured prominently in discussions of Late Pleistocene shoulder morphology and trait polarity, its configuration as the oldest European modern human scapula has relevance.

The Muierii 1 axillary border has a prominent dorsal ridge that is projecting for 59 mm from the glenoid fossa and then fades out into the dorsal surface 67 mm from the glenoid margin. There is a modest rugosity on it for the teres minor muscle insertion, but the ridge is otherwise rounded mediolaterally. There is a clear longitudinal sulcus between the dorsal ridge and the infraspinatus surface.

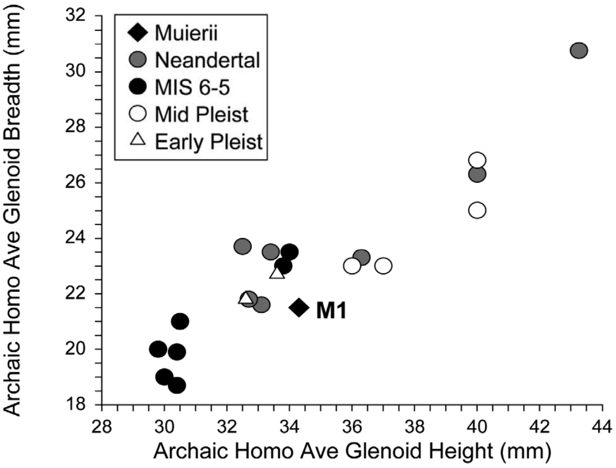

Figure 77 - Bivariate plot of glenoid articular breadth versus height for earlier Pleistocene right and left scapulae. M1: Muierii 1; MIS 6-5: Krapina and Tabun earlier Neandertals; Mid Pleist: Atapuerca-SH; Early Pleist: KNM-WT 15000 and Dmanisi 4166.

Figure 78 - The axillary border of the Muierii 1 scapula. Left: axillary (caudolateral) view of the border. Right: cross section of the mid axillary border. D: dorsal; V: ventral; L: lateral. Scale bar for the axillary view is 5 centimeters.

The lateral margin, depending upon subtle orientation variation, is modestly ventrally oriented cranially and is directly lateral through the middle (as in fig. 78) or slightly dorsolateral to ventromedial. There is a strong central crest running down the lateral side, almost exactly in the dorsoventral middle of the lateral side in the middle of the axillary border. The crest arcs slightly ventrally convex through the middle of the border, and then curves dorsally in its caudal portion. There is a prominent longitudinal sulcus between the crest and the dorsal ridge through the middle of the axillary border, and a shallower sulcus on the ventral side. The ventral sulcus appears to be formed entirely from the projection of the mid-border crest, whereas the dorsal sulcus is created by the mid-border crest in combination with the dorsal ridge.

The ventral margin is an evenly convex rounded edge, forming a rounded right angle in the middle of the border and then becoming more acute, ~60°, caudally. There is no sulcus between the ventral margin and the subscapularis surface, other than the gentle concavity which originally existed further medially between the lateral thickening for the axillary border and the broad concavity in the middle of the subscapularis surface.

In the previous assessments of the morphology, the morphology has been categorized as ventral-bisulcate (Soficaru *et al.* 2006) and bisulcate with a prominent dorsal margin and sulcus (Trinkaus 2008a) in the Eickstedt (1925) system. The confusion comes from the characterization of it depending upon whether the whole of the border was considered or just the middle portion. Since most assessments of axillary border morphology rely on mid-border cross-sectional shape, and the more cranial morphology is influenced by the infraglenoid tubercle, the original characterization of it as slightly ventral is inappropriate. The question then remains as to whether it is best considered as bisulcate, which the position of the lateral crest would indicate, or whether it should be viewed as somehow between the bisulcate and the dorsal sulcus pattern. As concluded in Trinkaus (2008a), it is best considered as bisulcate, fitting the category 5 of Churchill, "axillary crest bisects the axillary border, strong dorsal buttress, sulcus is dorsal to crest" (1994:283), which is best subsumed in the "bisulcate" category in the more commonly employed three-part system of Eickstedt (1925).

Assuming that this categorization is correct, the Muierii 1 axillary border morphology is among the more frequent configurations for early modern humans (tabl. 38 and 39). It is the dominant one among the Middle Paleolithic modern humans, Nazlet Khater 2 and the Mid Upper Paleolithic sample, both with respect to right scapulae and pooled right and left scapulae. The Tianyuan 1 left scapula appears to have had the ventral sulcus pattern (Shang & Trinkaus 2010).

The bisulcate configuration is absent from the two Early Pleistocene *Homo* scapulae (both of whom have a ventral sulcus), and the four earlier Middle Pleistocene specimens (albeit European ones) (all of whom have a dorsal sulcus). Early and later Neandertals have a preponderance of the dorsal sulcus pattern, but the bisulcate pattern is well represented among them.

Axillary Border Pattern[1]	Ventral Sulcus	Bisulcate	Dorsal Sulcus	N
Early Pleistocene *Homo*[2]	100%	0.0%	0.0%	2
Middle Pleistocene Europe[3]	0.0%	0.0%	100%	1
Early Neandertals MIS 6-5	5.0%	30.0%	65.0%	10
Mid Paleol Mod Hum	0.0%	100%	0.0%	3
Neandertals MIS 4-3	0.0%	12.5%	87.5%	8
Early Upper Paleolithic	0.0%	100%	0.0%	1
Mid Upper Paleolithic	18.4%	60.5%	21.1%	19

[1] The axillary border morphology is divided into three general categories following Eickstedt (1925) so as to include as many comparative samples as possible. The more detailed systems of Eickstedt (1925) and the seven-part system of Churchill (1994) better characterize the continuous variation of the region, but their finer distinctions are sometimes difficult to make on fragmentary scapulae.
[2] KNM-WT 15000 (Walker & Leakey 1993), Dmanisi 4166 (Jashashvili 2005).
[3] Atapuerca-SH (Carretero *et al.* 1997).

Table 38 - Comparative sample frequencies for Pleistocene human right axillary borders.

Axillary Border Pattern	Ventral Sulcus	Bisulcate	Dorsal Sulcus	N
Early Pleistocene *Homo*	100%	0.0%	0.0%	2
Middle Pleistocene Europe	0.0%	0.0%	100%	4
Early Neandertals MIS 6-5	1.2%	32.4%	64.7%	17
Mid Paleol Mod Hum	20.0%	80.0%	0.0%	5
Neandertals MIS 4-3	0.0%	8.3%	91.7%	12
Early Upper Paleolithic	50.0%	50.0%	0.0%	2
Mid Upper Paleolithic	15.4%	61.5%	23.1%	26

Table 39 - Comparative sample frequencies of axillary border morphology of Pleistocene humans for pooled right and left scapulae, averaging the right and left ones in cases of bilateral asymmetry.

The significance of the axillary border has been variously considered as an epigenetic marker and as a reflection of shoulder muscular hypertrophy. The latter was proposed by Trinkaus (1977; Trinkaus & Howells 1979), who attributed it to teres minor and by extension rotator cuff muscle hypertrophy [he subsequently (Churchill & Trinkaus 1990) withdrew that interpretation, although it continues to be quoted (Condemi 2001; Odwak 2006)]. The emerging consensus is that it is a epigenetic trait. This inference is supported by the relatively early developmental appearance of distinct variation in some specimens (Trinkaus 2006c, 2008b), the lack of correlation between axillary border form and indicators of upper limb musculoskeletal hypertrophy (Churchill 1996; Franciscus & Schoenebaum 2000; Odwak 2006), and the variation across recent human samples that does not appear to follow expected patterns of skeletal robusticity (Eickstedt 1925; Dittner 1976; Trinkaus 1977; Chambers 1992; Churchill 1994; Carretero *et al.* 1997; Moran & Chamberlain 1997; see Trinkaus 2008a). The only persistent pattern that suggests some role for skeletal hypertrophy is, in recent human cases of bilateral asymmetry, a higher frequency for the more dorsal pattern on the right side (Trinkaus 1977; Chambers 1992; Franciscus & Schoenebaum 2000).

As an epigenetic marker, it appears that the ventral sulcus pattern is the ancestral one, based on its presence in the two Early

Pleistocene *Homo* specimens plus samples of African great-apes and *Australopithecus*. In this case, the dorsal sulcus pattern is derived, particularly for the Neandertal lineage beginning in the Middle Pleistocene with the Atapuerca-SH sample. However, the bisulcate pattern, subsequently in most early modern humans, including Muierii 1, would therefore also be derived. Interestingly, the distinct ventral sulcus pattern becomes the dominant form again in the late Holocene, although the bisulcate pattern and (rarely) the dorsal sulcus pattern persist.

These considerations, however, assume that these are distinct character states. It has long been recognized (Eickstedt 1925; Churchill 1994) that there is continuous variation in sufficiently large samples of recent humans from the strictly ventral to the strictly dorsal sulcus patterns. The evolutionary trajectory, assuming a ventral sulcus pattern as the ancestral form, therefore becomes one of expanding the range of variation. In the Neandertal lineage, the range seems to have expanded, and shifted, more towards the dorsal sulcus variant than elsewhere. In the early modern human lineage, it expanded but less so, only into the bisulcate range. Among Mid Upper Paleolithic humans, who show all three patterns in substantial frequencies, albeit with a predominance of the intermediate form, it is likely that some complex combination of frequency shift and population dynamics was responsible (Frayer 1992; Trinkaus 2007). The Muierii 1 scapula takes its place in this dynamic mix.

Summary

Despite its incompleteness and isolated element from the upper limb, the Muierii 1 scapula provides several insights into European Early Upper Paleolithic human morphology. It is an absolutely small scapula, and its probably very small mediolateral dimension suggests that it exhibited the reduced relative scapular breadth characteristic of most early modern humans, Middle and Upper Paleolithic. Its glenoid fossa is narrow, in the archaic *Homo* pattern present in Early and Middle Pleistocene humans, among most Neandertals, but also possibly among the Middle Paleolithic modern humans. As discussed elsewhere (Trinkaus 2008a), this may have implications for Early Upper Paleolithic weapon use, beyond comparative morphological considerations. Its narrowness implies relatively less loading of the joint in the extremes of medial and lateral rotation, both positions which are associated with powerful throwing (Churchill & Trinkaus 1990; Trinkaus 2008a). And finally, its axillary border morphology, at the dorsal sulcus end of the bisulcate category, reinforces the spectrum of axillary border morphology in the Late Pleistocene, in between the ancestral ventral sulcus pattern which only becomes dominant again in the Holocene.

The Muierii 1 Left Tibia

As noted above, the Muierii 1 tibia was mentioned in the original field notes as discovered on August 18, 1952 (Nicolăescu–Plopşor 1952), illustrated by Gheorghiu & Haas (1954), sampled by Alexandrescu for radiocarbon dating (Alexandrescu *et al.* 2010), and has now disappeared. The only information available for it derives from the unscaled photograph published by Gheorghiu and Haas (1954), and the photographs of it from the Institutul de Antropologie "Fr.J. Rainer," reproduced here (fig. 79). It is assumed to derive from Muierii 1, along with the cephalic remains and the scapula, given its proximity to those bones in Galeria Musteriană, similar preservation noted by Nicolăescu–Plopşor, and the lack of evidence to contradict such an attribution. The bone is an essentially complete diaphysis from metaphysis to metaphysis but lacking all of both epiphyses.

Even though tibiae are reasonably well-represented for Middle Paleolithic late archaic and early modern humans, and especially for Mid Upper Paleolithic humans, they are rare for the Early Upper Paleolithic. There is a partial distal tibia from Mladeč, Mladeč 29 (Trinkaus *et al.* 2006b). Nazlet Khater 2 has two proximal epiphyses with an eroded partial diaphysis (Crevecoeur 2008). And further away Tianyuan 1 retains two distal epiphyses and a partial diaphysis (Shang & Trinkaus 2010). To these can be added the initial Mid Upper Paleolithic tibiae from Cro-Magnon and Paviland (Vallois & Billy 1965; Trinkaus & Holliday 2000). Therefore, even though data are available only from photographs, the Muierii 1 tibia is therefore relevant to our knowledge of European Early Upper Paleolithic locomotor morphology.

Late Pleistocene Tibial Diaphyseal Morphomics

The analysis of Late Pleistocene human tibial diaphyses, considering both external diaphyseal morphology and cross-sectional geometry (Matiegka 1938; Lovejoy & Trinkaus 1980; Heim 1982; Trinkaus *et al.* 1999b; Trinkaus 1983, 2006d, 2009; Shang & Trinkaus 2010) has shown that there is little difference across these samples in properly scaled diaphyseal rigidity, no apparent changes in muscle insertion areas or markings, but a shift in cross-sectional shape. In particular, late archaic humans largely have tibial subperiosteal cross-sections in which the various surfaces are flat to distinctly convex. This pattern appears to be ancestral for the genus *Homo* (Leakey *et al.* 1978; Stringer *et al.* 1998; Churchill *et al.* 2000; Trinkaus 2009). In contrast, early modern human tibiae, both Middle Paleolithic and Mid Upper Paleolithic, tend to have distinct longitudinal sulci, especially laterally between the anterior crest and the interosseus line and, less marked, between the posterolateral border and the interosseus line. There does not appear to be a functional significance to this change in the cross-sectional contour. The muscle markings are located in the same places across the samples, and cross-sectional analyses of the bones provide both similar levels of robusticity, similar percent cortical areas, and similar anteroposterior versus mediolateral distributions of cortical bone.

At the same time, there is variation across these samples in the degree of posterior displacement of the tibial plateau, apparently related to body linearity since scaling the resultant quadriceps femoris moment arm to body mass times its load arm produces little difference across these samples (Trinkaus & Rhoads 1999; Trinkaus 2009). The plateau is not preserved on the Muierii 1 tibia, but the proximal metaphyseal break gives some impression as to whether there was marked posterior condylar displacement in the bone.

The Muierii 1 Tibia

To the extent that it can be determined, the Muierii 1 tibia appears to be a relatively linear bone that conforms to the pattern seen in early modern human tibiae. As a right tibia, it is illustrated in approximately anterior, posterior and lateral views (fig. 79), and aligned with a recent human right tibia to illustrate its preservation and morphology (fig. 80). It cannot be determined to what degree the available views follow normal anatomical planes, but they appear to be relatively close to those planes.

Morphology

The interosseus line is prominent from the middle of the proximal metaphyseal area to approximately midshaft, where it approaches the posterolateral margin but remains clearly on the lateral side. This is the normal arrangement. The interosseus line then becomes less pronounced but still evident through the mid-distal third of the diaphysis, to become prominent again as it approaches the distal metaphysis.

The rugosity for the distal tibiofibular ligaments is evident distally, and it is likely that the distal break is close to the talar trochlear facet margin. The region up to the tibial tuberosity appears to have been largely intact. There is no prominence of the tuberosity in lateral view, but the anterior view indicates that the distal end of the tuberosity was present but eroded at the anteroproximal break. The posterior bulge of the bone just below the remaining metaphysis suggests that there was some posterior displacement of the tibial plateau, but the extent of that projection cannot be assessed.

There is a prominent sulcus on the anterolateral diaphysis surface along the interosseus line or crest, which extends from the tibial tuberosity to slightly distal of midshaft. There is a smaller sulcus posterior of the interosseus line proximally, but it fades out near the prominent nutrient foramen on the proximal posterolateral surface. In this configuration, it closely resembles the tibial diaphyses of Upper Paleolithic early modern humans and contrasts with those of archaic *Homo*.

Figure 79 - Anterior (Ant), posterior (Post) and lateral (Lat) views of the Muierii 1 tibia. No scale is available. Photos: Institutul de Antropologie "Fr.J. Rainer."

Figure 80 - Lateral view of the Muierii 1 tibia, aligned alongside of a recent human tibia for orientation. No scale is available. Muierii tibia photo: Institutul de Antropologie "Fr.J. Rainer."

	Robusticity Index[2]	Cnemic Index	Midshaft Index
Muierii 1[1]	((13.5))	((146.0))	((139.5))
Neandertals	16.7 ± 0.8 (8)	145.4 ± 13.0 (8)	145.7 ± 9.4 (8)
Mid Paleo Mod Hum	14.6 ± 1.5 (4)	153.3 ± 11.6 (6)	143.3 ± 11.4 (8)
Mid Upper Paleolithic	14.3 ± 1.4 (21)	160.8 ± 16.0 (26)	147.9 ± 14.9 (25)
Kruskal-Wallis P	0.001	0.039	0.780

[1] The Muierii 1 values are estimated from preserved photographs, and the maximum length is estimated from landmarks on the preserved diaphysis estimated on the photographs. Given that the indices are ratios, the absolute values of the measurements are not important. The values are nonetheless placed in double parentheses.
[2] Index = ((midshaft AP + midshaft ML) / maximum length) x 100.

Table 40 - Estimated tibial indices of the Muierii 1 tibia and Late Pleistocene comparative samples.

The anterior crest appears to have been slightly rounded although prominent along the mid-proximal diaphysis. It becomes more rounded distally. The anterior crest also had a distinct "S" curve proximodistally, being convex medially proximally and then convex laterally further distally.

On the posterior surface, the soleal line is moderately well-marked, extending from the proximolateral break to close to midshaft on the medial side. At the middle of the soleal line, just medial of the tibial pilaster, there is an irregularity of the line, with what appears to be a small area of resorption below the line. This is the area of the origin of flexor digitorum longus, and it is possible that the irregularity is related to the attachment of the proximal end of that muscle. There is a vertical line in the preserved photograph extending distally from the soleal line in this area, which may be related to the muscle attachment. The flexor line between tibialis posterior and flexor digitorum longus runs along the tibial pilaster, and it does not appear to have been prominent.

In lateral view, there is a moderately prominent tibial pilaster at the level of the nutrient foramen. There is then an anteriorly prominent curvature of the diaphysis through the middle and mid-distal diaphysis, giving the bone a slight "S" curve in lateral view. This is an exaggeration of the normal curve of the bone found in many recent human tibiae, including the one in figure 80.

Diaphyseal Robusticity

The bone appears to have been rather linear. As a crude quantification of its diaphyseal proportions, five measurements were taken from the unscaled photographs (all at the same scale given the maximum length of the preserved portion. The anteroposterior and mediolateral diaphyseal diameters were measured at midshaft and the proximal diaphyseal diameters were measured at the maximum development of the tibial pilaster, at the level of the nutrient foramen. In each case, the almost identical values from the anterior and posterior views were averaged.

The length from the proximal capsular area to the distal tibiofibular facet margin was measured, and then its maximum length estimated using a least squares regression combining 24 recent human and four Pleistocene human tibiae ($r^2 = 0.892$). The resultant measures provide an index of midshaft anteroposterior to mediolateral diameter index of ~139.5, a proximal anteroposterior to mediolateral diameter (cnemic) index of ~146.0, and midshaft robusticity (summed diameters to maximum length) index of ~13.5. Despite the uncertainties in the measurements, the values should approximate the original proportions.

The midshaft diaphyseal shape index is below the means of the comparative samples, but it is well within their ranges of variation, which are indistinguishable from each other (tabl. 40). The cnemic index is close to the Neandertal mean, yet it is well within the ranges of variation of the early modern human samples. The Muierii 1 estimated robusticity index, despite uncertainty in the original length of the bone and the crudeness of the measure compared to cross-sectional analyses, suggests a "gracile" tibia. It is within the ranges of variation of the early modern human samples, but it is four standard deviations from the Neandertal mean. Even given uncertainty from the estimation of the Muierii 1 values, it is unlikely to have been within an expected range of variation of the Neandertal sample.

The one sufficiently complete Early Upper Paleolithic modern human to provide a robusticity index, Tianyuan 1, has an index of ~15.5. This value is in between the Neandertal and early modern human means, and it is affected by both its apparently large body mass to height proportions and its moderately high crural index (Shang & Trinkaus 2010).

Given these considerations, the Muierii 1 tibia appears to approximate the level of diaphyseal expansion characteristic of European and southwest Asian early modern human tibiae, and to contrast with the stockier tibiae of the Neandertals. However, this tells us *nothing* about its robusticity, that is its strength appropriately scaled to bone length and body mass (cf., Ruff *et al.* 1993; Trinkaus & Ruff 2000). As has been shown (e.g., Trinkaus *et al.* 1999b; Trinkaus and Ruff 1999; Trinkaus 2006d, 2009), there is no significant difference across these samples in tibial midshaft cross-sectional robusticity once they are appropriately scaled to bone length times estimated body mass. What these differences in this index reflect are differential body proportions, or the more linear body proportions of the early modern humans in contrast to the stockier Neandertals (Holliday 1997, 2000). Assuming that these metric assessments are reasonably close to the original bone, they indicate that the Muierii 1 tibia joins the slightly older Mladeč 27 femur (Trinkaus *et al.* 2006b) and the modestly younger Paviland and Cro-Magnon tibiae in indicating distinctly linear body proportions for these early modern humans in Europe.

Summary

Despite the disappearance of the original Muierii 1 tibia, it is possible to infer that it resembles those of other early modern humans in Europe in terms of its cross-sectional shape and its diaphysis to length proportions. The latter inference supports the previous inference of linear body proportions of these early modern humans from the diaphyseal proportions of the Mladeč 27 femur.

The Muierii 2 Left Temporal Bone

Along with the Muierii 1 cranial and postcranial remains in the Galeria Musteriană, the 1952 excavations found a largely complete human left temporal bone, missing principally the squamous portion and the zygomatic arch (see above). Although the temporal bone was originally considered to be part of the Muierii 1 cranium, it does not appear to belong to the same individual based on a general, mirror-image assessment of its likely fit with the right parietal and occipital bones of Muierii 1 near asterion and the differences in sexually dimorphic features of both bones. It is therefore described separately here as Muierii 2. Should this bone be deemed in the future to be part of the Muierii 1 cranium, that will affect only the sexual diagnosis of the individual, as well as reducing the number of individuals providing radiocarbon and stable isotope data.

The bone, given the completeness of the regions of the temporomandibular articulation, the auditory porous, the mastoid process, and the petrous portion, provides considerable information on this taxonomically diagnostic bone (fig. 81 and 82). It also provides information on its semicircular canals, or labyrinthine morphology.

Late Pleistocene Temporal Bone Morphomic Considerations

The human temporal bone is a complex mix of different developmental, functional and spatial constraints. It develops from three principal portions, the squamous, petromastoid and tympanic parts, plus the styloid process. It serves and/or houses a multitude of functions, including the inferolateral neurocranial wall, the temporomandibular articulation, portions of the origins of major masticatory muscles, the special senses for balance and hearing, the transmission of major blood vessels to the brain as well as cranial nerves from the brain, plus the basicranial attachments of various pharyngeal and mandibular muscles and ligaments. Although it is possible to consider all of these aspects in a multivariate shape context, it is the relative shapes and sizes of the different elements, as well as their relative positions that determine the overall morphology of the temporal bone; such multivariate assessments (e.g., Harvati 2003) are therefore biologically meaningless. The separate elements are therefore considered here.

In this context, long term analyses of Neandertal temporal morphology in particular (e.g., Vallois 1969; see also Weidenreich 1943; Elyaqtine 1995; Trinkaus 1983, 2002) have shown several general aspects as well as detailed features of the temporal bone to contrast between the Neandertals and modern humans. Some of these "Neandertal" features are apparently ancestral for the genus *Homo* (Weidenreich 1943; Elyaqtine 1995), but others are likely to be derived for the Neandertals (Vallois 1969; Elyaqtine 1995).

With reference to the portions preserved on Muierii 2, these include the vertical position of the zygomatic root relative to the auditory porous, the relative development of the post-glenoid process, the orientation of the long axis of the auditory porous (if ellipsoid), the inferior projection of the mastoid process (but not necessarily the vertical dimension from the Frankfurt horizontal), the laterally bulbous nature of the mastoid process (as opposed to one that curves inferomedially), the size of the juxtamastoid eminence, the position of the occipitomastoid suture, the position of the stylomastoid foramen relative to the digastric sulcus, and the general orientation of the petrous portion. Additional features are evident internally in the petrous portion (Spoor *et al.* 2003). Although many of these features can be individually quantified, they are principally described qualitatively here.

The Zygomatic Arch

Only the posterior root of the zygomatic arch remains. It occupies a straight line above the auditory porous, independent of how the bone is oriented. Even with the portion of the zygomatic root made horizontal above the glenoid fossa, the anterior end where it is broken off curves slightly superiorly. There is a modest sulcus ~14 mm wide at the anterior end of its base. The arch, at the broken anterior end, is 8.3 mm high

Figure 81 - Lateral (above) and medial (below) views of the Muierii 2 temporal bone. Scale bar is 5 centimeters.

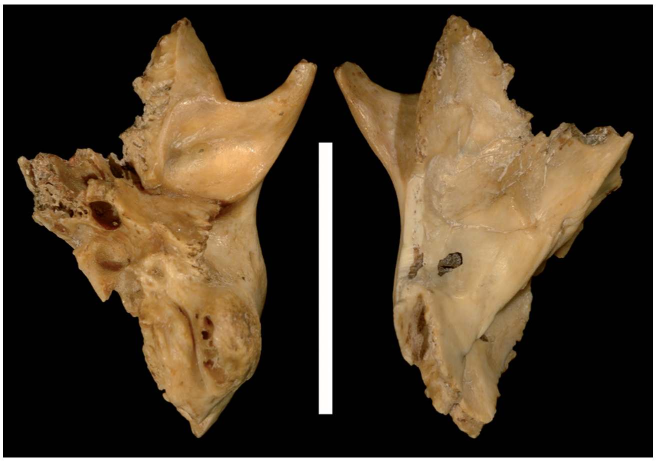

Figure 82 - Inferior (left) and superior (right) views of the Muierii 2 temporal bone. Scale bar is 5 centimeters.

and 3.5 mm wide at the break. Neandertals have the zygomatic arch in line with the auditory porous, whereas early and recent modern humans (as well as at least some earlier archaic *Homo*), have the porous situated below the plane of the arch. Muierii 2 fits the modern human pattern.

The Temporomandibular Articulation

There is a smooth and continuous parasagittal S-curve around the middle of the articular eminence and through the glenoid fossa to the post-glenoid process, which is evident in lateral view. The posterior face of the articular eminence, or the anterior portion of the glenoid fossa, makes an angle of 35° to 40° with the horizontal plane defined by the root of the zygomatic arch immediately above the temporomandibular articulation. There is a modest hollowing of the anterosuperior glenoid fossa along its full width. The subchondral bone of the fossa is completely temporal (no sphenoid contribution). There is a small inferiorly projecting spine at its medial end, adjacent to the sphenoidal spine. The mediolateral breadth of the glenoid fossa is ~22 mm; the lateral edge is rounded and therefore the margin is indistinct.

The post-glenoid process projects ~6.5 mm below the level of the most superior point of the lateral glenoid fossa, or approximately one-third of the height of the auditory porous. In general, post-glenoid processes are smaller among modern humans, including Middle Paleolithic ones, but there is considerable variation in their degrees of development.

The Auditory Porous, Tympanic Bone and Petrous Portion

The auditory porous, the opening at the lateral end of the meatus, is large and ovoid. Using the root of the zygomatic arch for a horizontal reference plane, the long axis of the porous is ~65° from the horizontal. It is oriented anterosuperior to posteroinferior, the more common orientation among modern humans. Neandertals frequently, but not universally, have ovoid openings, but when ovoid their long axes are oriented posterosuperior to anteroinferior, or the opposite of what is found in Muierii 2 and other early modern humans. The lateral diameters of the porous are 12.8 mm (maximum) and 9.0 mm (perpendicular to the maximum).

The tympanic bone forms an even curve from the post-glenoid process to the anterior surface of the mastoid process. There is no thickening of the lateral margin, which is 2.1 to 2.3 mm thick, depending on proximity to the tympanic crest. There is no foramen of Huschke. The tympanic bone is fully fused to the mastoid process posteriorly and has a partially fused fissure between it and the post-glenoid process.

There is no evidence of degenerative processes within the auditory meatus or at the porous edge. The internal bone, as evident, is smooth without any formation of the auditory exostoses (or auditory tori) common in Late Pleistocene (especially) older individuals.

Inferiorly there is a relatively prominent tympanic crest from the posterior portion of the lateral tympanic bone to the middle of the tympanic bone next to the carotid canal. The crest makes an angle of ~50° with the mediolateral coronal plane defined by the anterior glenoid fossa. However, the glenoid fossa is normally oriented anterolateral to posteromedial, so that this angle only provides a relative measure of petrous and tympanic angulation and not one tied into the anatomical planes of the whole cranium. Moreover, most previous assessments of petrous or tympanic orientation (e.g., Vallois 1969) are mostly inconclusive, since few Late Pleistocene temporal bones retain sufficient amounts of the medial process to provide meaningful angular measurements (see Trinkaus 2002).

The carotid canal is small and ovoid in cross-section at its inferior opening (4.7 mm anteroposterior and 6.7 mm mediolateral). The posterosuperior margin of the petrous portion shows little or no evidence for the superior petrosal sinus, unlike the distinct sulcus frequently found on Neandertal petrous portions (Grimaud-Hervé 1997; Verna 2006).

The Mastoid Process and Adjacent Crests

Muierii 2, as indicated with respect to its sex diagnosis, has a large and protruding mastoid process. It is laterally and posteriorly rugose, but there is no anterior mastoid tubercle. The anterior and posteroinferior sides are almost straight (minimally convex) in lateral view, and the inferior tip is rounded. The middle of the process is laterally bulbous.

Superiorly it is 21.7 mm anteroposterior, and its height from the Frankfurt horizontal is 28.5 ± 1.0 mm; the uncertainty derives from the difficulty in orienting an isolated temporal bone to an anterior cranial reference plane. There are few sufficiently complete and similarly measured early modern human mastoid processes, but Howells (1973) provided a range of means for 17 recent human samples of 25.9 ± 2.4 to 30.2 ± 3.1 mm for males and of 21.6 ± 3.9 to 26.3 ± 2.8 mm for females, with overall male and female means of 28.6 ± 3.0 and 24.8 ± 2.9 mm. The Muierii 2 value is on the overall male mean, although it is within the female range of variation. The Muierii 2 mastoid process is similar in size to the large ones present on the probably male Cioclovina 1 and Mladeč 5 crania (Frayer *et al.* 2006; Soficaru *et* *al.* 2007), although the presumably female Mladeč 1 and 2 crania also have relatively large ones (Wolpoff *et al.* 2006). Oase 2, in contrast to these other Early Upper Paleolithic specimens and to its facial size, has a relatively small mastoid process (Rougier *et al.* 2007). Neandertal mastoid processes, although tapering and often dwarfed by their large juxtamastoid eminences, have similar absolute heights from the Frankfurt horizontal (Trinkaus 1983).

The Muierii 2 mastoid process does not have a real sulcus on its posterior margin; it slopes inward and is slightly irregular to the adjacent occipitomastoid suture. There is a shallow sulcus on the medial side of the process.

Superiorly on the lateral side there is a gentle sulcus above the convex process, and then a very modest swelling extending posteriorly from the zygomatic root, the homologue to a supramastoid crest.

The juxtamastoid area has three small, rounded crests between the digastric sulcus and the occipitomastoid suture. The most lateral of the three is the most prominent, but all of them are minimally projecting and remain completely behind the projecting mastoid process. The stylomastoid foramen is located just medial of the midline through the digastric sulcus.

The Region of Asterion

Asterion is indicated by a clear angle between the parietomastoid and occipitomastoid sutures. There is no evidence of a notch for an absent sutural bone, so as with the Muierii 1 cranium, if a sutural bone was present, it was located into the adjacent vault bones. The sigmoid sinus, as with Muierii 1, extended fully onto the posteroinferior endocranial parietal bone, crossed the parietomastoid suture surface of the temporal bone, and hence remained above the mastooccipital suture.

The parietomastoid suture slopes markedly anterosuperior to posteroinferior, at an angle of ~40° with respect to the horizontal plane inferred from the zygomatic arch root. As noted with respect to Muierii 1, a sloping parietomastoid suture is present in both late archaic and early modern humans, but it is more commonly present among the latter. The edge for the parietomastoid suture, however, appears relatively thick. It is 7.0 mm thick at the parietal notch, 4.1 mm at the sigmoid sinus, and then 6.4 mm at asterion.

The Labyrinthine Morphology (Marcia Ponce de León & Christoph P.E. Zollikofer)

Computed Tomography (CT) scans of the left temporal bone of Muierii 2 were performed at relatively low spatial and contrast resolutions (data acquisition with 2 mm slice thickness, image reconstruction with soft tissue kernel, and 2 mm interslice distance), so it is difficult to derive detailed information regarding the morphology of the cavity system of the inner ear. However, the CT data are of sufficient quality to derive standard linear measurements from the three well-preserved semicircular canals (tabl. 41) and to compare the labyrinthine morphology of Muierii 2 with that of modern humans and Neandertals. The internal otic morphology of both modern humans and Neandertals exhibits remarkable variability, and there is great overlap between the samples in linear labyrinthine dimensions (Spoor *et al.* 2003). Nevertheless, there is one relevant morphometric feature, in which the two groups differ with high statistical significance. In Neandertals, the posterior semicircular canal is at a low position relative to the lateral canal (Spoor *et al.* 2003; Bouchneb & Crevecoeur 2009), whereas in early and recent modern humans the posterior canal is at a middle position relative to the lateral canal (tabl. 42). This pattern is indicated by the sagittal labyrinthine index [the ratio of the distances from the plane of the lateral semicircular canal to the inferior and superior middles of the posterior semicircular canal, in which a high index indicates a low position of the posterior semicircular canal (Spoor *et al.* 2003)]. The few Middle Pleistocene *Homo* providing data are similar to modern humans in this respect (SLI 41.6 ± 8.9), with the exception that the posterior canal tends to be smaller in diameter (Spoor *et al.* 2003). In Muierii 2, the labyrinthine index is 51.7 (tabl. 42), which is close to the mean of Holocene humans, similar to those of the early modern humans, and below the range of variation found among the Neandertals.

Summary

The Muierii 2 temporal bone therefore exhibits a suite of features that align it principally with early, and more recent, modern humans (Table 43). These include the high position of the zygomatic arch relative to the porous, the small post-glenoid process, the anterosuperior to posteroinferior orientation of the porous long axis, the laterally bulbous nature of the mastoid

superior canal width (ASCw)	6.4
superior canal height (ASCh)	6.3
lateral canal width (LSCw)	4.7
lateral canal height (LSCh)	4.9
posterior canal width (PSCw)	6.0
posterior canal height: superior portion (SLIs)	2.9
posterior canal height: inferior portion (SLIi)	3.1
posterior canal height (PSCh)	6.5

Table 41 - Dimensions of the Muierii 2 labyrinth, in millimeters; variable definitions from Spoor *et al.* (2003).

Muierii 2	51.7
Neandertals	62.6 ± 8.0 (24)
MPMH	53.0 ± 6.2 (11)
EUP	41.5, 55.1
MUP	47.3 ± 8.4 (4)
Holocene humans	50.7 ± 7.1 (134)

Table 42 - Sagittal labyrinthine indices (SLI) for Muierii 2 and comparative samples [SLI = (SLIi / (SLIi+SLIs)) x 100]. Comparative data from Spoor *et al.* (2002, 2003), Bouchneb & Crevecoeur (2009), and Ponce de León & Zollikofer (n.d.). Note that a high index expresses a low position of the posterior canal.

Trait	Configuration
Zygomatic arch to porous	above
Glenoid fossa	temporal
Post-glenoid process	small
Auditory porous	ovoid
Porous orientation	anterosuperior – posteroinferior
Foramen of Huschke	absent
Auditory extostoses	absent
Superior petrosal sinus sulcus	absent
Lateral mastoid process	bulbous
Anterior mastoid tubercle	absent
Juxtamastoid eminence	small
Stylomastoid foramen	medial of digastric sulcus axis
Sigmoid sinus	parietomastoid
Parietomastoid suture	sloping
Posterior semicircular canal	high

Table 43 - Configurations of discrete aspects of the Muierii 2 temporal bone.

process, the diminutive size of the juxtamastoid eminence(s), the labyrinthine morphology (especially the position of the posterior semicircular canal), and (to a lesser extent) the sloping parietomastoid suture. There is little to suggest archaic human, or Neandertal, affinities.

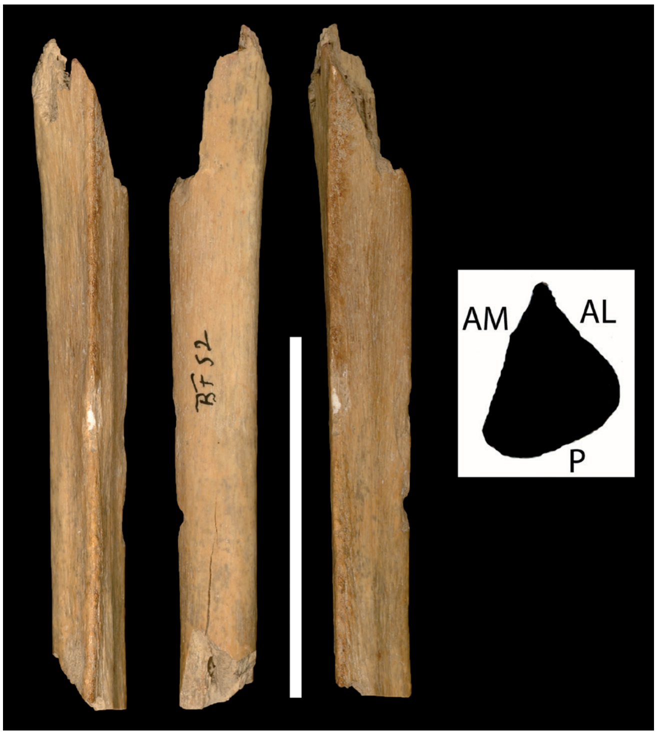

Figure 83 - Views of the Muierii 3 left fibula, plus its cross-sectional contour near midshaft. The photos from left to right are anterior, posterior and medial respectively; scale bar equals 5 centimeters. For the cross section, AM: anteromedial or medial; AL: anterolateral or lateral; P: posterior. The cross section is enlarged relative to the photos.

The Muierii 3 Left Fibula

The Muierii 3 fibula (fig. 83) is difficult to evaluate. As noted above, it is not known whether it was associated *in situ* with any of the other human remains from the site, or from which time horizon it may derive. Based on general bone preservation, it contrasts with the non-mineralized human remains from the Holocene levels of the cave, but it could derive from either one of the earlier Upper Paleolithic or the Middle Paleolithic levels in either gallery. The bone is labeled only "BF 52."

Late Pleistocene Fibular Morphology

Late archaic and early modern human fibulae have received relatively little attention, other than to document that their general muscle crest patterns fit with those of recent humans (e.g., Heim 1982) or as a means of estimating tibial length from more complete fibulae (e.g., Trinkaus 1983). It has, however, become apparent that there is a shift, at least in a distributional sense, between late archaic and early modern human fibulae in the degree of formation of longitudinal sulci between the crests. Although both samples have fibular diaphyseal cross-sectional shapes that fall with recent human ranges of variation (Sprecher 1932), late archaic humans tend to have shallow sulci or flat surfaces between the crests (Heim 1982; Trinkaus 1983; Radovčić *et al.* 1988), whereas those of early modern humans tend to have distinct longitudinal sulci, frequently pronounced ones (Mateigka 1938; McCown & Keith 1939; Kolovskaya & Mednikova 2000; Trinkaus 2006d). It appears (Trinkaus 2006a) that the late archaic human pattern is the ancestral one for the genus *Homo*.

The Muierii 3 Fibular Diaphysis

The Muierii 3 shaft (fig. 83) has a sharp interosseus crest along its preserved length, forming an angle of ~58° between the medial and lateral adjacent surfaces. There is minimal rugosity of the edges of the interosseus crest and the bone immediately alongside of it. Near the middle of the piece, which should be near midshaft, the posterior contour is largely flat, with rounded posteromedial and posterolateral corners. The medial surface is overall flat in a posteromedial to anterior direction, but there is a low muscle ridge running down the middle of it. The ridge represents one of the muscle lines in the area, but it is not clear whether it derives from tibialis posterior, peroneus brevis or extensor hallucis longus. This ridge results in two very shallow longitudinal sulci, the more posterior one of which is minimally deeper. On the lateral surface, there is a single shallow sulcus running the length of the bone, deeper proximally and flatter distally.

This fibular cross section contrasts with the strongly grooved fibular diaphyses of some Mid Upper Paleolithic humans, but it is closer to the cross sections seen in some of the Middle Paleolithic modern human fibulae. At the same time, it does not have the more flattened appearance with multiple flat planes seen in at least the La Ferrassie, Krapina and Shanidar fibulae. Yet, it is not particularly distinct from the partial fibula from La Chapelle-aux-Saints 1. Unfortunately, sufficient cross-sectional data on enough relevant fibulae are not available to be more precise.

Consequently, if the Muierii 3 fibula derives from the same time horizon as the Muierii 1 and 2 remains, hence Early Upper Paleolithic, it could represent an early modern human with affinities close to the Middle Paleolithic humans, especially late archaic ones. If it derives from a deeper Middle Paleolithic horizon, it could be viewed as further data on Neandertal fibular variation, but still close to the previously documented range for that sample.

Stable Isotopes of the Muierii Human Remains

In addition to the stable isotopes generated for the faunal remains through radiocarbon dating (Chapter 4), it has been possible to obtain carbon and nitrogen stable isotope values ($\delta^{13}C$ and $\delta^{15}N$) from the radiocarbon dating of the Muierii 1 zygomatic bone and the Muierii 2 temporal bone (Chapter 2).

Comparative Considerations

As with the discussion of the cave bear stable isotopes in Chapter 4, ideally one would compare the Muierii human isotopic profiles to a range of values from species of known dietary preferences. For Muierii, this means only the data of the cave lion is relevant, since there are no data available for herbivores from the site. If, however, one accepts the cave bear data as accurately reflecting the dietary preferences of the species, from partially vegetarian through omnivory based on other data (Richards *et al.* 2008a; Figueirido *et al.* 2009; Peigné *et al.* 2009), then the limited, albeit older, faunal data from Muierii provides a general framework for interpreting the human isotopic data.

In addition, the past decade has seen a steady accumulation of Eurasian Late Pleistocene human isotopic data (tabl. 44), much of it generated in the context of the direct radiocarbon dating of late Neandertal and early modern human remains. Many, but not all, of these comparative values can be compared to faunal data from the same sites, but others stand alone as the only values from the site in question. Yet, they are consistent within the groups, giving some confidence in their reliability.

Muierii Human Stable Isotopes

The $\delta^{13}C$ values for the two Muierii specimens are similar to the *Panthera spelaea* from the site, and moderately above (less negative than) those for the *Ursus spelaeus* specimens (tabl. 10 and 44). At the same time, the Muierii $\delta^{13}C$ values (–19.3‰ and –19.1‰) are well within the ranges of variation of all of the Late Pleistocene human samples, even through they are more positive than those of most of the Neandertals. The Muierii values are slightly more negative than the mean early modern human value (–18.5‰ ± 0.8‰, N = 8) but still well with that range of variation. If the relatively high values for Arene Candide and Paviland are deleted, given their exploitation of maritime resources (Richards & Trinkaus 2009), the early modern human values decrease minimally to –18.7‰ ± 0.8‰ (N = 6), slightly closer to the Muierii 1 and 2 values.

At the same time, the Muierii 1 and 2 $\delta^{15}N$ values of 12.3‰ and 12.4‰ are well above the value of 8.2‰ for the cave lion, further above the values of 6.0‰ and 7.3‰ for the more omnivorous of the Muierii cave bears, indicating a highly carnivorous diet for these individuals, or at least an almost purely carnivorous source for the individuals' protein. Yet, these values for Muierii 1 and 2 are well within the range of variation of European early modern humans and only slightly above the mean for that sample (11.9‰ ± 1.0‰, N = 8). They are below the very high value for Oase 1, below the value for Cioclovina 1, and close to those for Arene Candide IP, Brno-Francouzská 2 and Dolní Věstonice 35. Interestingly, despite having clearly "carnivorous" or high trophic level $\delta^{15}N$ values, the Neandertals (from both the Middle Paleolithic and the Initial Upper Paleolithic, have slightly lower values (10.7‰ ± 1.2‰, N = 12). The two samples are modestly significantly different (Wilcoxon P = 0.049), and they become more so if the Muierii specimens are added to the early modern human sample (P = 0.013).

Discussion

Therefore, all of these Late Pleistocene humans, Neandertals, Early Upper Paleolithic humans and Mid Upper Paleolithic humans, have rather high $\delta^{15}N$ values. For all of them, the high $\delta^{15}N$ values should reflect a high level of carnivory (but see Hardy 2010). Surprisingly, however, many of their $\delta^{15}N$ values, as with the Muierii ones relative to the cave lion from the same site, are substantially higher than those of dedicated carnivores from the same or similar sites. This applies to all of these Late Pleistocene humans, but it applies in particular to the earlier Upper Paleolithic modern humans.

As has been suggested (Richards *et al.* 2001; Richards & Trinkaus 2009), these high early modern human $\delta^{15}N$ values may reflect a substantial consumption of aquatic resources. Aquatic ecosystems tend to have longer food chains than terrestrial ones and hence higher apparent trophic levels for the carnivores at the tops of those food chains (Richards *et al.* 2001). In fact, at the other end of the Eurasia, the early modern human from Tianyuandong, slightly older than the Muierii remains, provides carbon, nitrogen and sulfur isotopic data which indicates that at least that individual had a substantial freshwater component to its diet (Hu *et al.* 2009).

If these data indicate that there was a substantial increase in aquatic resource consumption among at least some of these early modern humans, including the Muierii ones, relative to the Neandertals, it need not imply improved subsistence abilities, at least in the Early Upper Paleolithic. As suggested (Richards & Trinkaus 2009), it may only reflect greater population pressure and the increased need to exploit resources that are otherwise difficult to acquire.

Summary and Discussion

The human skeletal remains from the Galeria Musteriană therefore provide considerable evidence on the morphology and paleobiology of these individuals. The four elements of Muierii 1 (cranium, mandible, scapula and tibia) represent a probably female, moderately aged (fourth or fifth decade) adult. The temporal bone that is Muierii 2 appears to be a young adult male. The Muierii 3 fibula is apparently adult.

	$\delta^{13}C$	$\delta^{15}N$	Source
Muierii 1, Romania	–19.3‰	12.3‰	Trinkaus *et al.* 2009
Muierii 2, Romania	–19.1‰	12.4‰	Trinkaus *et al.* 2009
Middle Paleolithic Neandertals			
Feldhofer 1, Germany	–21.6‰	7.9‰	Richards & Schmitz 2008
Feldhofer 2, Germany	–21.5‰	9.0‰	Richards & Schmitz 2008
Jonzac 1, France (premolar)	–20.7‰	10.6‰	Richards *et al.* 2008b
Les Pradelles 64801, France	–19.1‰	11.6‰	Bocherens *et al.* 2005
Les Pradelles M300, France	–19.1‰	11.5‰	Bocherens *et al.* 2005
Les Pradelles M400, France	–19.5‰	11.4‰	Bocherens *et al.* 2005
Rochers-de-Villeneuve 1, France	–19.0‰	11.6‰	Beauval *et al.* 2006
Scladina 1B, Belgium	–21.2‰	11.8‰	Bocherens *et al.* 2001
Initial Upper Paleolithic Neandertals			
Saint-Césaire 1, France	–19.8‰	11.4‰	Bocherens *et al.* 2005
Spy 572a, Belgium	–19.8‰	11.0‰	Bocherens *et al.* 2001
Vindija 207, Croatia	–20.5‰	10.8‰	Richards *et al.* 2001
Vindija 208, Croatia	–20.2‰	10.3‰	Higham *et al.* 2006a
Early Upper Paleolithic Modern Humans			
Cioclovina 1, Romania	–19.6‰	12.7‰	Trinkaus *et al.* 2009
Oase 1, Romania	–18.8‰	14.2‰	Trinkaus *et al.* 2009
Mid Upper Paleolithic Modern Humans			
Arene Candide 1, Italy	–17.6‰	12.4‰	Pettitt *et al.* 2003
Brno-Francouzská 2, Czech Rep.	–19.0‰	12.3‰	Richards *et al.* 2001
Dolní Věstonice 35, Czech Rep.	–18.8‰	12.3‰	Richards *et al.* 2001
Eel Point 1, UK	–19.0‰	10.9‰	Schulting *et al.* 2005
Paviland 1, UK	–18.2‰	10.4‰	Jacobi & Higham 2008
La Rochette 1, France	–17.1‰	11.2‰	Orschiedt, 2002 pers. comm.

Table 44 - Comparative Middle Paleolithic and Initial Upper Paleolithic Neandertal and Early and Mid Upper Paleolithic modern human carbon and nitrogen stable isotope data from Eurasia. Values are per mil.

From a morphological perspective, in the context of being one of a modest number of Early Upper Paleolithic modern humans in Europe, the Muierii human remains follow a pattern evident in the pooled sample of other human fossils of this group.

Their overwhelming morphological pattern is that of "anatomically modern humans" (cf., Trinkaus 2006a). With respect to this designation, the Muierii 1 remains exhibit the absence of a supraorbital torus, relatively high and rounded midsagittal neurocranial vault, prominent parietal eminences, parietomastoid sigmoid sinus, reduced facial prognathism with anteriorly positioned zygomatic bones, subrectangular orbits, distinct canine fossae, a narrow nasal aperture, relatively small anterior dentition, as well as its meningeal groove and nasal aperture crest patterns and (to a lesser extent) its parietomastoid suture inclination. Its tibia also has the distinct longitudinal sulci and crests of modern humans.

These features are joined by a suite of aspects of the Muierii 2 temporal bone which align it completely with recent humans, including the configurations and relative positions of its auditory porus and zygomatic arch, small post-glenoid process, laterally bulbous mastoid process, small juxtamastoid eminence, sloping parietomastoid suture, parietomastoid sigmoid sinus, and labyrinthine configuration. Although all of these features exhibit variation among early and recent modern humans, and many of them have ranges of variation which overlap those of the Neandertals and other archaic humans, together they establish the modern human morphological affinities of these Muierii Pleistocene human remains.

The nasal aperture configuration and the implied linear body proportions from the tibia reinforce a pattern evident in the Mladeč and Oase remains. Both of these features imply affinities to lower latitude populations, either archaic or early modern.

At the same time, the Muierii 1 fossils possess several features that are unusual for an Early Upper Paleolithic modern human and especially for an earlier Middle Paleolithic modern human. The prominent occipital bun is shared with Mladeč 5 and the moderately more recent Cro-Magnon 3, but it contrasts with all Middle Paleolithic modern humans and aligns it with the Neandertals. The configuration of the iniac, suprainiac and superior nuchal line region appears as an incipient (or reduced) form of the pattern ubiquitous among the Neandertals. On the mandible, the markedly asymmetrical mandibular notch with a high coronoid process is found among the Neandertals, and then among MIS 2 modern humans, but it is absent from MIS 6 to 3 modern humans. Earlier Middle Pleistocene archaic *Homo* frequently have asymmetrical notches, but they lack the high coronoid process of the Neandertals and Muierii 1. The relatively medial position of the mandibular notch crest on the condyle is a feature known exclusively among the Neandertals during MIS 6 to 3, and it is absent from earlier *Homo*.

To this list of cranial and mandibular features might be added the scapular glenoid fossa. The narrow glanoid fossa of Muierii 1 appears to be ancestral for the genus *Homo*, and it is found among the Neandertals but not among more recent MIS 3 modern humans. However, it is not known whether Middle Paleolithic modern humans also possessed such a glenoid configuration. Therefore, it is probably best to consider the narrow glenoid fossa of Muierii 1 in a functional perspective. The primarily bisulcate pattern of its scapular axillary border provides affinities with all of the Late Pleistocene comparative samples.

From these lists of features, it is apparent that the Muierii Pleistocene human remains have their morphological affinities principally with other Early Upper Paleolithic modern humans. Yet, as with other members of this sample, it exhibits a minority of features that align it with the Neandertals and/or with archaic *Homo* generally to the exclusion of early modern humans. These comments raise the issue that was present from the beginning of the reassessment of the Muierii Pleistocene human remains (*cf.*, Soficaru *et al.* 2006; Trinkaus 2007; Chapter 1), namely the nature of the population processes that were involved in the dispersal and establishment of early modern humans in Europe.

In the discussion of modern human emergence in Europe, the issue has been, and remains, the degree to which early modern human populations absorbed, or assimilated, local populations of late archaic humans (Neandertals) into their populations. It is now apparent that the earliest modern humans emerged from late archaic humans in (probably eastern) Africa in the late Middle Pleistocene, and they expanded into Europe only sometime after 50,000 BP but certainly by the 40,000 BP age of the early modern humans from the Peştera cu Oase. Scenarios in which there was largely regional continuity from the Neandertals to early modern humans or total replacement of those Neandertal populations by early modern humans can no longer be maintained. The remaining population issues are therefore how much assimilation took place, in what geographical, temporal and cultural contexts.

The simple fact that the available human remains from the Early Upper Paleolithic of Europe, including the specimens from Peştera Muierii, are universally attributed to "early modern humans" means that the overwhelming morphological pattern of these fossil remains is that of more recent "anatomically modern humans." This observation implies that the majority of the ancestry of these "early modern humans" is to be found among earlier modern humans from outside of Europe and not among the Neandertals. Yet, a series of analyses (e.g., Trinkaus *et al.* 2003a; Smith *et al.* 2005; Frayer *et al.* 2006; Wolpoff *et al.* 2006; Rougier *et al.* 2007; Soficaru *et al.* 2007; Trinkaus 2007; Ramirez Rossi *et al.* 2009) have noted the presence of features in these remains (and those of subsequent Mid Upper Paleolithic humans) that are either distinctive of the Neandertals, generally archaic for the genus *Homo* but lost in the earliest non-European modern humans, or unusual for all of those potentially ancestral groups.

In this context, the Muierii 1 and 2 remains are clearly, by any criteria, those of anatomically modern humans. They exhibit a suite of features, especially of the cranium, mandible, and tibia, which are either uniquely derived for early and recent modern humans and/or are found in markedly higher frequencies among modern humans than among any samples of archaic *Homo* (including the Neandertals). Yet, Muierii 1 in particular exhibits features that are reminiscent of the Neandertals in an MIS 3 context. The most obvious of these features are aspects of the mandibular ramus, but its prominent occipital bun can be included among them. The narrow scapular glenoid fossa could also be included among these traits, although it is apparently characteristic of archaic *Homo* generally and may have been present among the Middle Paleolithic modern humans.

As such, the Muierii Early Upper Paleolithic human remains join the other relevant European fossils, from the Early Upper Paleolithic and the Mid Upper Paleolithic, in documenting what should be the null hypothesis, that the in-dispersing modern human populations did what is normal within a syngameon (Holliday 2006) and for widely dispersed Pleistocene foraging populations; they intermingled and produced the subsequent generations of MIS 3 human populations. If the null hypothesis were the opposite, one of total replacement of the Neandertals with no admixture, the morphological mosaics of the Muierii and other European earlier Upper Paleolithic fossils are sufficient to reject it.