
Plio–Pleistocene hominid discoveries in Hadar, Ethiopia

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The International Afar Research Expedition has now recovered remains of twelve hominid individuals from geological deposits estimated to be ~ 3.0 Myr in Hadar, Ethiopia. A partial skeleton represents the most complete hominid known from this period. The collection suggests that Homo and Australopithecus coexisted as early as 3.0 Myr ago.

FOLLOWING a short reconnaissance expedition in 1972 (ref. 1) to the central Afar, one of us (M.T.) organised the International Afar Research Expedition. We have now codirected two field campaigns (September–December, 1973 and 1974 (refs 2 and 3)) in the area known as Hadar (see Fig. 1).

Although a number of other excellent fossil sites are known from the central Afar¹, Hadar was selected for intensive exploration for a number of reasons: first, the fossil vertebrate assemblage suggested a considerable antiquity (~ 3–4 Myr); second, the area is extremely rich in splendidly preserved fossils, deposited in low energy environments; third, the deposits are heavily dissected and characterised by clear marker-horizons which are laterally continuous; and fourth, the thick series of lake sediments contains a number of volcanic horizons available for absolute radiometric age determinations.

The Hadar site is located in the Afar depression in the west central Afar sedimentary basin² at 11°N and 40°30'E. It now encompasses ~ 42 km², but extension of study into

adjacent, previously unexplored regions will substantially increase the area.

Preliminary palaeontological investigations, particularly of the suids and the elephants, have suggested a biostratigraphic correlation of the Hadar Formation with the Usno and the lower portion of the Shungura Formations^{3,6}. Two radiometric K–Ar age determinations for a basalt support this with an age estimate of 3.0 ± 0.2 Myr (ref. 5).

All hominid fossils (Table 1), and most of the vertebrate material, were surface finds, although some small scale excavation and sieving operations were undertaken. A painted marker was placed at each palaeontological locality, each located on a map and the geological section carefully examined to determine the horizon yielding fossil material (see Fig. 2). At each hominid locality, a topographical map and detailed stratigraphical sections were drawn. Samples of matrix adhering to fossil hominid specimens are undergoing mineralogical and sedimentological analyses for comparison with sediment samples taken at their collection points. Their completeness and lack of anataxic abrasion⁷ virtually precludes the possibility that the specimens were moved over great distances.

1973 hominid discoveries

The first discovery of fossil hominid remains in the Hadar region occurred on October 30, 1973, when four associated leg bone fragments (AI. 128, 129) were collected from a mudstone horizon. These consist of fragmentary right and left proximal femora associated with a right proximal tibia

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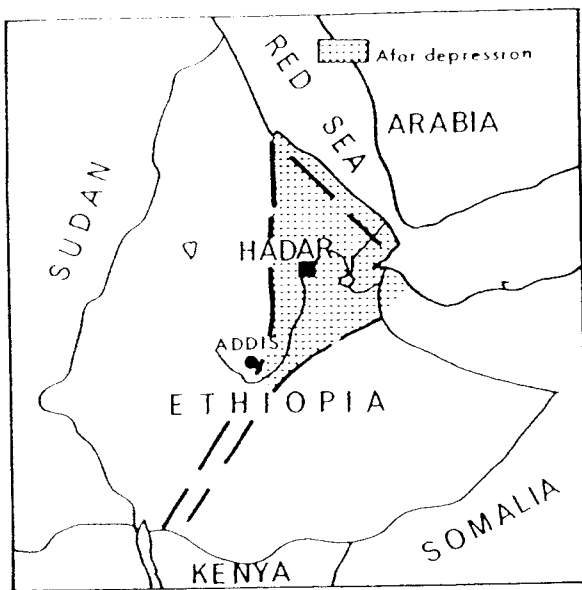


Fig. 1 Location of Hadar.

and distal femur. Their proximity to one another, as well as the morphological and size similarities of the proximal femora, strongly suggest that they represent a single individual. This provides a complete knee which will greatly enhance our understanding of the biomechanics of this important joint in early hominids (see Fig. 3).

Both proximal femora lack heads and necks. The left is best preserved with the shaft broken ~ 38.0 mm below the lesser trochanter. From the remaining portions of the femora it is clear that the neck is flattened anteroposteriorly and that its cross section is oval. There is an indication of trochanteric flare, the trochanteric fossa is well marked, a quadrate tubercle is clearly discernible, muscle markings are prominent on the greater trochanter, the spiral line is pronounced and the lesser trochanter is visible from the anterior aspect. Both fragments, particularly the right, exhibit some degree of predepositional crushing, which is

suggestive of carnivore activity.

The distal femur is undistorted, and both condyles are complete and intact. It is small, with the lateral condyle measuring 39.0 mm anteroposteriorly and 18.9 mm medio-laterally. This fragment demonstrates a number of anatomical details which are intimately related to bipedal locomotion^{2,3}: the bicondylar angle is rather high, the lateral lip of the patellar groove is raised and the lateral condyle flattened and elongated.

The associated proximal tibia is intact except for some slight abrasion around the periphery of the superior articular surface. It also is small, the total preserved articular surface measuring 50.7 mm mediolaterally and 33.0 mm

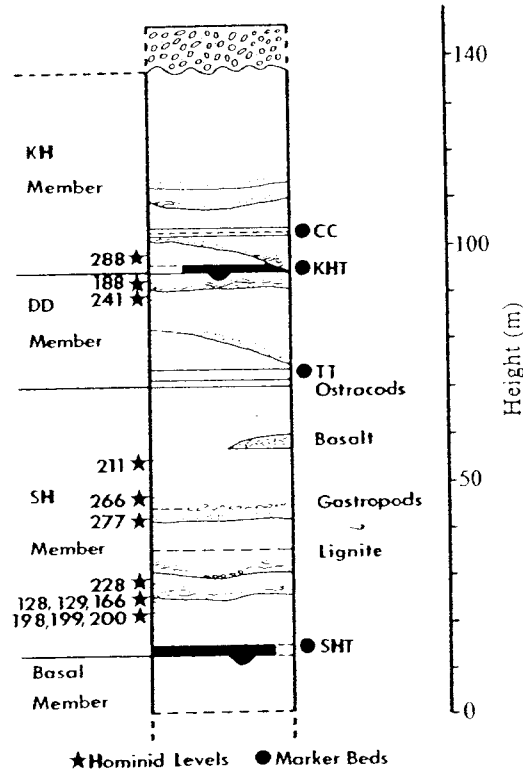


Fig. 2 Stratigraphic positions of Hominid Horizons. ★, Hominid levels; ●, marker beds.

Table 1 Fossil hominid specimens from Hadar

Afar locality (AL)	Date of discovery	Description
1973		
178-1	30 October	Left proximal femur fragment
178-1a	30 October	Right distal femur
129-1b	30 October	Right proximal tibia
129-1c	30 October	Right proximal femur fragment
166-9	11 December	Left temporal fragment
1974		
188-1	16 October	Right mandibular corpus; M ₂ -M ₃
198-1	18 October	Left mandibular corpus; C-P ₄ , dm, M ₁ -M ₂
198-17a,b	5 December	Left I ¹ and I ²
198-18	5 December	Right I ₂
199-1	17 October	Right maxilla; C-M ³
200-1a,b	17 October	Complete maxilla; 16 teeth. Right M ₁
211-1	20 October	Right proximal femur fragment
228-1	27 October	Diaphysis of right femur
241-14	22 December	Left lower molar
206-1	16 November	Mandibular corpus; left P ₃ -M ₁ , right P ₃ -M ₃
277-1	19 November	Left mandibular corpus; C-M ₂
288-1	24 November	Partial skeleton; occipital and parietal fragments; mandibular corpus with left P ₃ , M ₃ , right P ₃ -M ₃ , mandibular condyles; right scapula fragment; right humerus; proximal and distal left humerus; proximal and distal right and left ulnae; proximal and distal right radius; distal left radius; left capitate; 2 phalanges; 6 thoracic vertebrae and fragments; 1 lumbar vertebra; sacrum; left innominate; left femur; proximal and distal right tibia; right talus right distal fibula; numerous rib fragments

anteroposteriorly. The tibial tuberosity is pronounced and is limited proximally by the transverse groove; the soleal line is distinct on the posterior surface of the shaft and the interosseous membrane attachment is indicated by a roughened line on the medial aspect of the shaft; the head is slightly retroflexed with only minor tibial torsion; and the intercondyloid eminence is prominent with well developed intercondyloid fossae.

A heavily eroded temporal fragment (AL 166-9) constitutes the only other hominid discovery from the 1973 field season. The specimen derives from a sandstone horizon a few metres stratigraphically above the level of the postcranial material. The temporal has been extensively eroded, with most of the petrous portion broken away, and extensive pneumatization is exposed in the mastoid and zygomatic regions. The mandibular fossa is broad and flat, bordered by a postglenoid process, but open anteriorly with only a slight articular tubercle. There is a prominent entoglenoid process on the medial wall which is broken exposing a large pneumatization. The mastoid is large and globular. The external auditory meatus is oval in section with a thick tympanic plate.

1974 hominid discoveries

Our sample of the Hominidae has been greatly augmented with additional field work. The 1974 investigations yielded

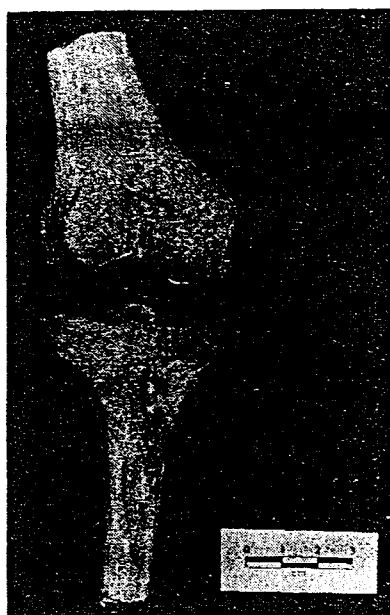


Fig. 3 Anterior view of AL 129-1a and 1c

remains of 10 additional individuals represented by dental, cranial and postcranial elements, including a remarkably intact partial skeleton.

Stratigraphically just below the 1973 hominid discoveries, one complete (AL 200-1) and one half maxilla (AL 199-1) (see Fig. 4) were recovered by Ato Alemayehu Asfaw within 15 m of one another and from the same mudstone horizon.

The AL 200 specimen is an undistorted palate with full dentition and an associated right M₁. The general pattern of dental wear is interesting, in that the incisors exhibit extensive 'ribbon like' wear and dentine exposure relative to the postcanine teeth. In addition, the canines and the P³'s have suffered antemortem enamel chippage on their buccal surfaces during the specimen's lifetime. The tooth rows of AL 200 are subparallel and the arch is relatively long. The anterior portion of the arch is broad to accommodate the large central incisors and marked diastemata occur between the lateral incisors and the canines. The palate is shallow, becoming somewhat deeper posteriorly.

In lateral view this specimen exhibits pronounced alveolar prognathism. The zygomatic root is situated above the first molar, the maxillary sinuses are large and the lower nasal margin is guttered.

The right half maxilla is smaller in size and is less complete, with C-M³, as well as both incisor sockets and the

I² root. The dentition is smaller than that of AL 200 (Table 2), but the similarity in morphological detail is striking. Although the incisors are lacking, it is apparent from the root sockets that the anterior portion of the arch was broad and somewhat squared-off as in AL 200. The specimen is broken close to the midline exposing the incisive canal. The palate is shallow and the greater palatine foramen is present. The inferior nasal margin is not sharp and in lateral view alveolar prognathism is well developed. The maxillary sinus is large and the zygomatic root is situated above the distal portion of the first molar.

A partial mandible (AL 266-1) was located in a horizon of sandy clay, ~ 10 m stratigraphically below the basalt flow². This specimen includes the complete right corpus with P₃-M₃, the symphysis with canine and incisor roots, and a portion of the left corpus with P₃-M₁ (Table 3). The dentition is moderately worn with the third molar having just come into occlusion and showing only minor wear facets. The anterior portion of the dental arch is rounded and the dental rows are straight and slightly divergent posteriorly. The post-incisive planum is only moderately developed and the corpus in the region of M₁ is 21.7 mm thick and 31.0 mm deep.

A right mandibular fragment (AL 188-1) containing M₂-M₃ and roots of P₃-M₁, was collected from a sandstone horizon immediately below KHT. The molars are heavily worn. The mandible exhibits some wind abrasion, but it is possible to estimate a thickness of 20.7 mm and a depth of ~ 32.0 mm in the region of M₁.

AL 277-1, a fragmentary left mandible containing C-M₂ and sockets for I₁-I₃, is derived from a sandstone horizon. It is broken just to the right of the midline and distal to M₂. The occlusal wear is heavy with the canine worn flat. Anteriorly the fragment gives the impression of being deep, measuring ~ 41.0 mm just distal to P₃. A prominent post-incisive planum is present, as well as a slight inferior mandibular torus. The inferior surface of the symphysis is flattened and has distinct mental spines. The corpus exhibits slight eversion.

An interesting left half mandible (AL 198-1) was recovered from a mudstone horizon, stratigraphically equivalent to AL 199 and AL 200. The specimen is broken near the midline with the I₁ socket and the root for I₂ preserved. The C-P₁ and M₁-M₂ are present, with a retained deciduous molar located distal to the P₁. The deciduous nature of this tooth is confirmed by a radiograph demonstrating a widely divergent root system. Substantial occlusal wear is evident on P₁-M₂. The corpus is broken just distal to M₂, exposing a portion of the mesial root of M₃ immediately superior to the mandibular canal. The mandible is lightly built, being 16.0 mm thick and 31.9 mm deep at M₁.

Fig. 4 Occlusal views of AL 200-1a and AL 199-1

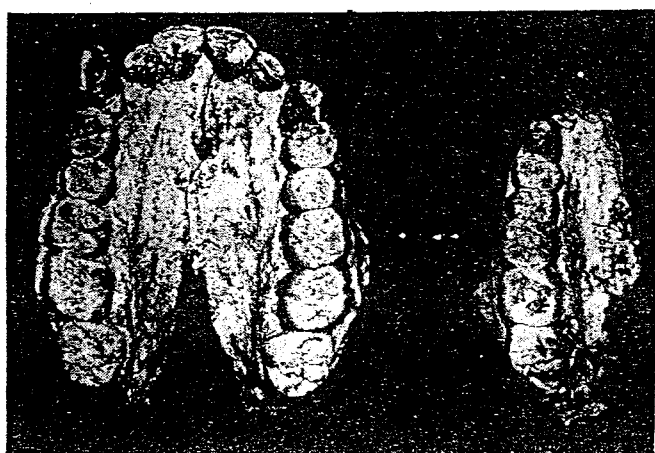


Table 2 Dental measurements of AL 200-1a and AL 199-1 (mm)

AL 200-1a	Left		Right	
	Mesio-distal	Bucco-lingual	Mesio-distal	Bucco-lingual
I ¹	10.8	8.3	10.9	8.5
I ²	7.4	7.1	7.3	7.0
C	9.4	10.9	9.4	11.0
P ³	9.0	12.2	8.9	12.2
P ⁴	8.5	12.2	8.5	12.1
M ¹	11.8	13.1	11.8	13.2
M ²	13.8	14.8	13.7	15.0
M ³	14.2	15.0	14.3	15.0
AL 199-1				
C			8.7	9.3
P ³			7.3	11.2
P ⁴			7.1	11.2
M ¹			10.1	12.0
M ²			11.7	13.5
M ³			11.3	(12.7)

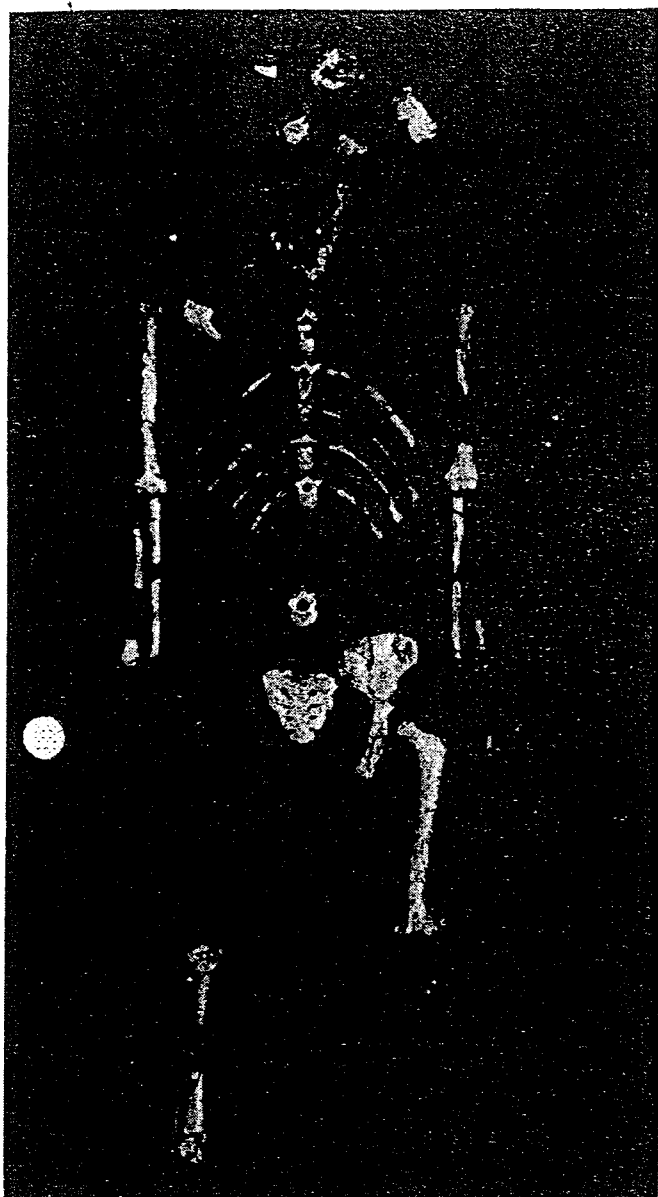


Fig. 5 Partial skeleton (AL 288-1) from Hadar

It exhibits some modelling and the inferior margin is thin and not bulbous.

During screening operations, three additional teeth were located at this locality: a right I¹ (AL 198-18), a left I² (AL 198-17a) and a left P¹ (AL 198-17b). The interproximal facets on the upper incisors match perfectly, suggesting that they are from the same individual. Because of the close association of these teeth with the AL 198 mandible, we tentatively assign them to the same individual.

Stratigraphically just below the basalt flow a fragmentary right proximal femur (AL 211-1) was collected. The specimen is somewhat abraded with the head and neck missing and most of the greater trochanter. The neck is very flattened, no trochanteric flare is present, the intertrochanteric line is weakly expressed, the spiral line is well developed and the lesser trochanter is not visible from the anterior aspect. The specimen is quite large and fairly robust.

AL 228-1 is a distal portion of a femoral diaphysis recovered from a sandstone. It is not large, but exhibits strong development of the linea aspera. It is smaller than AL 129-1A.

The partial skeleton

The discovery on November 24 of a partial skeleton (AL 288-1, see Fig. 5) eroding from sand represents the most

outstanding hominid specimen collected during the 1974 field season. The stratigraphic horizon yielding the skeleton is situated just above the KHT, which has not yet been dated. Fossil preservation at this locality is excellent, remains of delicate items such as crocodile and turtle eggs and crab claws being found. It is obvious that this discovery provides us with a unique opportunity for reconstructing the anatomy of an early hominid in far more detail than has been previously possible. Extensive descriptive and comparative studies are projected for the AL 288 partial skeleton and will provide us with details of stature, limb proportions, articulations and biomechanical aspects. Three weeks were devoted to intensive collecting and screening to ensure the recovery of all bone fragments from the site. Laboratory preparation and analysis has only just begun, and in this report it is possible to mention only a few salient points.

The mandible is not heavily built; it is 30.0 mm deep and 19.0 mm thick in the region of M₁. The M₃s are fully erupted and occlusal wear facets are just appearing. The symphysis is intact with a slight post-incisive planum. Although the incisor crowns are absent, it is apparent that this region was quite small. The remaining dentition is small and not very worn. The P₃s are interesting with a sloping buccal surface and almost no development of a metaconid. The form of the dental arch as well as the body of the mandible is distinctly V-shaped.

The cranium is not sufficiently complete to estimate cranial capacity. The cranial bones are thin, exhibit no sutures (internally or externally) and no marked development of nuchal or temporal musculature is present.

The left innominate is complete, although it is somewhat distorted in the pubic region and particularly in the area of sacral articulation. In size the specimen resembles Sterkfontein (Sts) 14; the ilium, however, gives the appearance of being higher, and the anterior border is relatively straight. A strongly developed anterior inferior spine is apparent. The acetabulum is shallow when compared with modern man and with Sts 14. The sciatic notch is broad, the subpubic angle obtuse and the pubis exhibits a pronounced ventral arc, all of which suggests the skeleton belonged to a female. When viewed from the superior aspect, the base of the sacrum is divided into thirds, with the diameter of the sacral body equal to each of the alae. This again suggests that AL 288 was female.

A complete left femur is associated with the innominate, but the distal portion is badly crushed. Its total length has been estimated at 280 mm but may be slightly revised when the distal end is reconstructed. The femur has minimal trochanteric flare, the neck is anteroposteriorly flattened, an intertrochanteric line is present and the lesser trochanter is not visible from the anterior aspect.

The proximal right tibia is nearly identical in size and morphology to AL 129-1b. The distal tibia is associated, and articulates with a talus and a distal fibula.

The right humerus is complete with some crushing of the proximal end. Its total length is estimated at ~ 235 mm giving a value of 83.9 for the humeral-femoral index. The distal end possesses a marked ridge separating the capitulum and trochlea.

Significance of the Hadar hominids

Detailed studies of the Hadar hominids have just recently been initiated and definitive interpretations are not yet possible. Because of the geological antiquity, and in some instances the completeness of the specimens, however, we proffer a number of preliminary impressions concerning their phyletic affinities and resemblances to other specimens.

The partial skeleton exhibits a number of similarities to the Sterkfontein sample. Specifically, the size of the pelvis and to some degree its morphology are reminiscent of Sts 14. The shallow acetabulum and relatively high ilium, how-

Table 3 Dental measurements of AL 266-1(mm)

AL 266-1	Left		Right	
	Mesio-distal	Bucco-lingual	Mesio-distal	Bucco-lingual
P ₃	9.1	10.1	9.2	10.1
P ₄	8.9	11.0	9.4	10.8
M ₁	12.1	11.9	12.1	12.0
M ₂			13.3	14.0
M ₃			15.3	13.7

ever, demonstrate certain divergences from the Sterkfontein specimen and possibly reflect a somewhat more primitive status for the AL 288 specimen. The associated V-shaped mandible is noteworthy. Leakey¹⁰ has drawn attention to mandibular shape and has suggested that KNM-ER 1482 (Kenya National Museum, East Rudolf), and Omo 18 should be considered primitive because of their V-shaped contours. Should this prove to be a diagnostic character, it is possible that AL 288 retains more primitive features than *Australopithecus africanus*, recognised from Sterkfontein.

Previously the 1973 postcranial material has not been assigned to a taxon. It is now clear that it should probably be included in the same category as the AL 288 specimen because of the striking similarity of the proximal tibial fragments in size and morphology as well as the preserved femoral fragments. This is important because: there is now evidence of at least two individuals of a very small hominid in Hadar, and the AL 128 and 129 specimens are situated stratigraphically 80 m below the partial skeleton (Fig. 2).

The presence of another taxon is suggested by two other specimens in the Hadar hominid collection. AL 211-1 resembles very closely Olduvai Hominid (OH) 20 (ref. 11) as well as the two proximal femora from Swartkrans (SK 82 and SK 97). Similarities are not only in size but also in morphological detail; stout shafts, flattened necks, a lack of trochanteric flare and posteriorly facing lesser trochanters not visible in anterior view.

The temporal fragment (AL 166-9) resembles material from Swartkrans and East Rudolf which has also been assigned to a large *Australopithecus* pattern, particularly in the large bulbous mastoid process and heavy pneumatization, as well as the broad temporal shelf. It is, however, less typical of this pattern in the broad, flat mandibular fossa and absence of a strong articular tubercle.

The close association of AL 199-1 and AL 200-1, as well as their stratigraphic equivalence, is important because

of the high probability that they sample the same taxon. Except for size differences, these two specimens are remarkably similar, and suggest variation within a single taxon. The complete maxilla has large canines, broad central incisors and large posterior dentition. These characters as well as other details suggest resemblances with some *Homo erectus* material, particularly *Pithecanthropus* IV. This dental pattern is also seen in KNM-ER 1590 from East Rudolf, a specimen with large cranial capacity assigned to the genus *Homo*^{10,12}. It must be recognised that other aspects of the AL 200 maxilla are 'primitive', such as the guttered nasal margin and the alveolar prognathism.

The AL 266-1 and AL 277-1 mandibles resemble, in details of the dentition and mandibular morphology, other specimens assigned to *Homo*, such as OH 7 (ref. 13) and KNM-ER 1802 (ref. 10).

On the basis of the present hominid collection from Hadar it is tentatively suggested that some specimens show affinities with *A. robustus*, some with *A. africanus* (*sensu stricto*), and others with fossils previously referred to *Homo*.

The understanding of Plio-Pleistocene hominid remains is undergoing intensive revision and re-evaluation, and we stress that our identifications and phylogenetic interpretations such as the guttered nasal margin and the alveolar prognathism. With continued collection of specimens from the three million year-old time range in Hadar and elsewhere, and with additional detailed studies and comparisons, our attempts to interpret the earliest hominids should become more clear.

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