

## Further details concerning fossils attributed to *Sahelanthropus tchadensis* (Toumaï)

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The fossils attributed to *Sahelanthropus tchadensis* from the Late Miocene of Chad are of great scientific and cultural importance, and are the subject of debate as to whether they represent a hominid or an ape. It is therefore necessary to provide full and accurate details of the fossil collection. We demonstrate that the third lower molar of the right mandible illustrated in the *Nature* article<sup>1</sup> that announced the discovery is in reality a left M<sub>3</sub>, and an incisor collected at the site did not feature in the paper. These particulars affect the interpretation of the fossils, including estimates of the minimum number of individuals involved and the associations between the various specimens.

### Introduction

The discovery and announcement of fossils attributed to *Sahelanthropus tchadensis*<sup>1</sup> has confirmed the importance of the Late Miocene of Africa as a period of major interest for the study of hominid origins. The interpretation of *Sahelanthropus* as an early hominid (possibly even a bipedal one) is the subject of debate, with some authors claiming that it was probably a quadrupedal ape.<sup>2</sup> Brunet<sup>3</sup> has maintained his view that *Sahelanthropus* was a hominid. Because of the nature of this debate, and its implications for palaeoecology and human origins, it is necessary to provide further particulars regarding the hypodigm and anatomy of *Sahelanthropus*. The aim of this contribution therefore is to record geomorphological details about site TM 266 (and its environs), which yielded the *Sahelanthropus* fossils, and also to describe the events surrounding the discoveries themselves, as it seems there is some confusion about the fossil associations, and even about the total number of hominid specimens recovered from the site. Given the great value of the discovery in terms of human heritage and its scientific importance, we deem it necessary to provide information about the context of the findings, as well as particulars of the fossils themselves.

The first author led the field trip that resulted in the original discovery of the

skull popularly known as Toumaï<sup>4</sup> as well as the later expeditions that recovered the mandible fragments and the isolated teeth attributed to *Sahelanthropus*. He was thus intimately involved with the events as they unfolded.

### Geological context

Toros-Menalla is the name given by palaeontologists to an extensive region about 150 km long in the west of the Djourab erg, Chad. A notable feature in the centre of this zone is a low scarp generally about 10 m high and about 40 km long (Fig. 1). This escarpment, facing east, is clearly indicated on the topographic map IGN NE-33-VI at a scale of 1:200 000 over a distance of more than 25 km (from 16°20'N, 17°15'E to 16°15'N, 17°28'E). This relief possibly represents an ancient fault which became reactivated as a result of tectonic forces related to Tibesti volcanism. Emi Koussi (a large volcanic cone 80 km in diameter, culminating at an altitude of 3415 m, that was built up from the end of the Tertiary, Late Miocene to sub-Recent times) is only 400 km away. Today, evidence of tectonic activity is closer to the Djourab, such as the northern margin of the Chad basin where the Angamma cliffs attest to an underlying flexure.

It is unfortunate that the area has been described as 'a desolate plain, the monotony of which is interrupted only by the modern dunes',<sup>4</sup> which gives a distorted impression of the potential of the area

both for stratigraphy and palaeontology. A similar restricted impression is given by the stratigraphic section published by Vignaud *et al.*,<sup>5</sup> which shows 6-m-thick sediments comprised of only two stratigraphic units. It should be pointed out that this section was measured at TM 266, but that, along the 40-km length of the scarp, the succession is really thicker and more complex than this (Fig. 1), with lacustrine, peri-lacustrine, sub-aerial, fluvial and aeolian deposits.

The scarp forms either a unique escarpment, or a succession of lower terrace-like steps (Fig. 1), sometimes separated from each other by several hundred metres. Even though it is levelled off at its two extremities, in the central part a combination of corrasion and deflation by the wind has in places uncovered a well-defined scarp or series of structural flats and bluffs (Fig. 1). There, the uppermost part is rich in geomorphological and archaeological evidence indicating the shores of the last phase of Lake Mega-Chad. However, the sediments in the lower parts of the scarp are considerably older, dating from the Late Miocene on the basis of mammalian biochronology, and are not related to the Pleistocene to Recent history of Lake Chad, but rather to a much older precursor.

To give an idea of the palaeontological richness of the area, it suffices to point out that from the first reconnaissance of the scarp from July 2001 to March 2002, 59 fossiliferous localities were mapped, which together yielded 1627 fossils. These represent 20% of all the fossils that have been stocklisted since 1994 by the scientific project. Among these fossils, new taxa of Giraffidae, Hippopotamidae and Anthracotheriidae as well as *Sahelanthropus* were discovered. The collection also contains an abundance of microfauna and other vertebrates, both aquatic and terrestrial, such as *Deinotherium*, *Anancus* and fish. Of



Fig. 1. View of the east-facing scarp in the Toros-Menalla (site TM 039) region of the Djourab Desert, Chad, showing the Miocene deposits cropping out as small bluffs (usually composed of sandstones or other resistant layers such as diatomites), overlain by modern sand dunes. The erosion in this area is largely due to wind deflation, but it is thought that the scarp owes its origin to the presence of a fault line, which is obscured under sands on the downslope side of the scarp. Note that the total thickness of Miocene strata in the region greatly exceeds 10 metres. Despite the possibility of reinterpreting the fossils, the mammalian assemblages collected appear to comprise exclusively Late Miocene taxa.

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these localities, it is TM 266 with its 691 fossils (in March 2002) that accounts for the richest assemblage. The fossiliferous potential of this area is still important, notably for finding small fossils and in relation to the entire surface that is covered with a thin layer of sand or dunes that the wind may sweep away.

### Palaeoanthropology

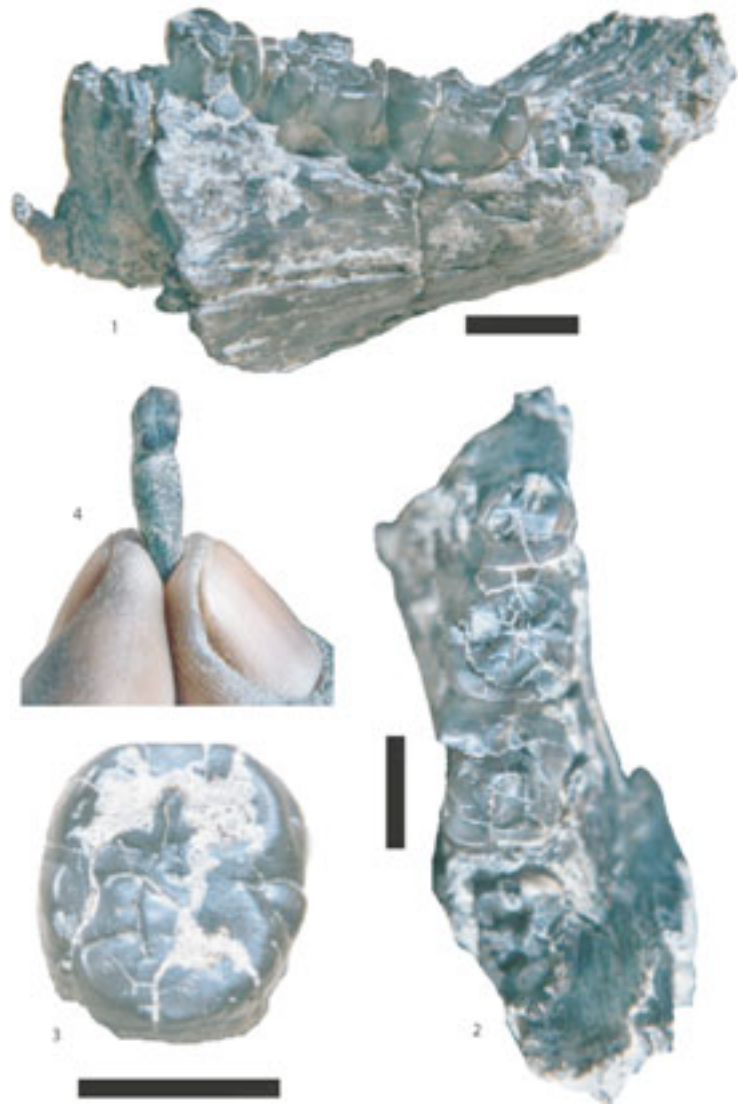
#### *Hypodigm of Sahelanthropus tchadensis*

There are some differences between the list of fossils attributed to *Sahelanthropus tchadensis* in the article in *Nature*<sup>1</sup> and the one that was published on the Internet<sup>6</sup> based on specimens that were collected in the field by the first author and by his Chadian colleagues and Laurent Viriot, itself based on the field catalogue made at the time of the discoveries.<sup>7</sup> The following account deals with the fossils in the chronological order of their discovery. The catalogue numbers comprise four parts: the first, TM 266, refers to the locality; the second indicates the year of discovery; the third is the catalogue number of the specimen in the order of discovery; and the fourth (if present) denotes different elements of a single fossil.

TM 266-01-060-1 (the skull) was simultaneously discovered next to TM 266-01-060-2 (a symphysis fragment with incisor and canine alveoli) on 19 July 2001, by Ahounta Djimdoumbaye. From the same place, an unpublished incisor was found on 21 December 2001 at N'Djaména by Laurent Viriot, while picking through screening residues. The latter specimen comprises half an incisor, split vertically from the apex of the crown to the tip of the root [Fig. 2(4)]. This tooth differs from the upper incisor (TM 266-01-448) that was illustrated in *Nature* (ref. 1, fig. 2a).

It should be pointed out that it has been the practice of the Mission Paléoanthropologique Franco-Tchadienne not to write numbers on fossil hominid specimens, a policy that has been enforced since the discovery of the mandible of *Australopithecus bahrelghazali*.<sup>8</sup> The catalogue numbers of specimens TM 266-01-447 (molar in ref. 1) and 448 appeared for the first time in the CD database of fossils established at the University of Poitiers and for the second time in the *Nature* article in July 2002. We are unaware of specimen TM 266-01-447 and the exact sites and circumstances of the discovery of fossils TM 266-01-447 and 448.

On 1 November 2001, the complete



**Fig. 2.** Fossils attributed to *Sahelanthropus tchadensis*, from site TM 266, Toros-Menalla, Chad. Scale: 10 mm. (1) TM 266-02-154-1, oblique lingual view of right hemi-mandible showing the specimen in the condition that it was found, lacking the  $M_3$  crown, and exposing the roots of the  $P_3$ . (2) TM 266-02-154-1, occlusal view of right hemi-mandible made soon after discovery, showing the roots of  $M_3$ . (3) TM 266-02-154-3, occlusal view of left  $M_3$  made soon after discovery, and before the specimen was cleaned (mesial at the top). (4) TM 266-01-448 ?, unpublished damaged incisor found near the holotype skull of *Sahelanthropus tchadensis*.

right upper canine belonging to TM 266-01-060-1 was found, exactly where the skull was located, as a result of screening by Fanoné Gongdibé. The tooth consisted of two fragments which fitted perfectly onto the right canine root.

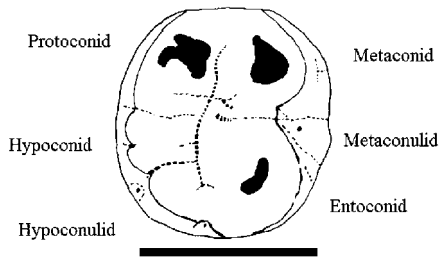
TM 266-02-154-1 (right hemi-mandible with  $P_4$ - $M_2$  and roots of  $P_3$  and  $M_3$ ) and TM 266-02-154-3 (crown of left  $M_3$ ) were recovered on 20 January 2002, about 105 m to the north-northeast of the Toumaï skull site. This lower jaw was the subject of two photographs in the *Nature* paper (ref. 1, fig. 2b,c) one in occlusal view, the other in the form of an axial CT scan.

TM 266-02-154-2 (lower canine; ref. 1, fig. 2d,e) was first recognized on 30 January 2002, at N'Djaména, in screening residues from the spot where the mandible and  $M_3$  were found. It was

completely encrusted with sand and could not be photographed at the time of discovery. Finally, TM 266-02-203 (mandibular symphysis with premolar, canine roots and incisive alveoli) was discovered on 12 March 2002, a dozen metres south of the mandible and  $M_3$ .

### Anatomy

The photograph in *Nature* of the right hemi-mandible, TM 266-02-154-1 (ref. 1, fig. 2b,c), shows the complete tooth row from  $P_4$  to  $M_3$ . In occlusal view, the  $M_3$  appears as a well-preserved tooth, whereas the three other teeth are heavily worn and damaged. In contrast, in the tomographic section, the roots of the  $M_3$  appear to be damaged, the two roots being broken. In fact, the  $M_3$  molar illustrated, of which only the crown is



**Fig. 3.** Interpretation of TM 266-02-154-3, left  $M_3$ . The disposition of the protoconid, hypoconid, hypoconulid, metaconid and entoconid reveals unequivocally that this lower molar is from the left side. Scale: 10 mm.

preserved, was found isolated several decimetres from the hemi-mandible. It is here catalogued by the first author as TM 266-02-154-3. It was given the suffix 3, following 1 (mandible) and 2 (canine) of the other pieces attributed to TM 266-02-154, the only indication in the field catalogue. This  $M_3$  was later fixed onto the lower jaw in the laboratory at the University of Poitiers.

Figure 2(1–2) shows the mandible as it was on the day of its discovery. Note that the right  $M_3$  crown is missing. The roots of the  $P_3$  are clearly visible in anterior oblique view [Fig. 2(1)], extending deeply into the corpus of the mandible and curving distally as they do so. The extremely buccal position of the mesial root (on the left in the figure) indicates that the canine root was probably large and that its apex was positioned appreciably further distally than its cervix. The inferred large size of the canine root indicates that this mandible probably belonged to a male individual.

The occlusal outline of the tooth TM 266-02-154-3 immediately evokes a hominoid lower molar [Fig. 2(3)], being pentacuspitate with the mesio-distal diameter of the occlusal surface greater than its bucco-lingual one, and the mesial margin [at the top in Fig. 2(3)] broader than the distal one, which is also more convex indicating that it is most likely an  $M_3$ . The protoconid is larger than the hypoconid and the hypoconulid but is smaller in area than the entoconid (Fig. 3). The metaconid is slightly mesio-distally shorter than the protoconid but is bucco-lingually slightly broader. There is a prominent mesio-distal groove separating the buccal cusps from the lingual ones, located slightly buccally to the midline of the crown; despite the wear on the tooth, the transverse grooves between the protoconid and the hypoconid on the one hand and the hypoconid and the hypoconulid on the other are clearly visible. The transverse groove separating the metaconid and entoconid is worn

away except at its lingual and buccal extremities. In Fig. 2(3) the mesial fovea is obscured under a sandy concretion, but the distal fovea is discernible. In the *Nature* article (ref. 1, fig. 2b), the concretion has been removed, but the mesial fovea is difficult to discern, probably because it may have been worn away. A remarkable feature of this tooth is the presence of a large metaconulid positioned disto-lingually to the metaconid (sometimes known as the 'sixth' cuspid). Such cuspids are rare in extant humans, occurring in 7% of  $M_1$ 's (tooth 36 in dentist's terminology) and about 2% of  $M_3$ 's (tooth 38). Sixth cuspids also occur in samples of *Pan* and *Gorilla* lower molars. Given that the protoconid, hypoconid and hypoconulid are on the left of this tooth, this indicates that the specimen is a left lower molar, meaning that a left  $M_3$  has been mistakenly glued into a right mandible.

We provisionally estimate that there is a minimum of three individuals in the TM 266 hominoid hypodigm: one represented by the type specimen, skull TM 266-01-060-1; a second by the hemi-mandible TM 266-02-154-1, the teeth of which are more worn than those in the type specimen; and a third by the mandibular symphysis, TM 266-02-203, which shares parts in common with the right lower jaw. It remains to be determined whether the third symphyseal fragment with incisor and canine alveoli (TM 266-01-060-2 in ref. 1) and the isolated teeth from the site represent the same individuals as these three.

Two more hominoid specimens were recovered in the neighbourhood, an edentulous hemi-mandible (TM 247-01-02), found by Mahamat Adoum on 15 July 2001, and a symphysis broken into four fragments (TM 292-02-01 with left  $C$ ,  $P_4$ – $M_1$ , right  $P_3$ ,  $M_1$ – $M_2$ ) collected by the first author and two of his colleagues on 15, 16 and 17 January 2002. These fossils probably represent two additional individuals of *Sahelanthropus*.

#### Palaeoecological implications

After the discovery of *Australopithecus bahrelghazali* ('Abel') on 23 January 1995 in Chad Sahara, the unearthing of *Sahelanthropus* ('Toumaï') on 19 July 2001 confirms the existence of a Lake Chad Story, countering the prediction made by Coppens of an East Side Story.<sup>9</sup> And yet, if Toumaï is not a hominid,<sup>2</sup> its discovery could be used to support the hypothesis of the East Side Story.

Other mammals found in the same levels, such as anthracotheres, which are abundant in Chad but have not been reported

from the richly fossiliferous deposits of the same age in East Africa,<sup>10</sup> reveal that there was indeed marked provincialism in the Late Miocene faunas of Africa and show also that the known environmental conditions of the Chad basin could have supported the emergence of human species.

The present analysis, based on some *Sahelanthropus* paratypes, is only one element of the discussion about this genus. It does not modify the basis of the debate concerning the systematic position and palaeoecology of *Sahelanthropus*.

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