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Faunal dating of the Taung hominid fossil deposit

Although the Taung skull was once thought to be the oldest representative of *Australopithecus africanus*, more recent attempts to date the Taung site have ranged from 2·3 m.y.a. based on cercopithecid biochronology to as recent as 1 m.y.a. based on radiometric techniques. Recent work by Vogel has shown that the latter date can be disregarded. Our excavations of Taung deposits from 1988 to 1992, under the direction of P. V. Tobias, have revealed more fauna and geological information with which we can make a more accurate assessment of the faunal age than was possible with cercopithecids alone. On the basis of historical records and newly exposed fossil deposits deeper within the cave-riddled Thabaseek tufa, it seems likely that the Taung hominid predates the Hrdlička deposits from which most of the fauna have been derived. Thus a faunal date derived from the combined samples can serve only as a *terminus ad quem* for the age of the hominid deposits. The Hrdlička fauna falls within a time range close to that of Sterkfontein Member 4, ca. 2·4 to 2·6 m.y.a., whereas the hominid deposit could be somewhat older, in the probable range of 2·6 to 2·8 m.y.a.

Introduction

Dating of the southern African hominid fossil sites has been a largely intractable problem because the cave sites are not amenable to absolute geological dating techniques. Since the 1924 discovery of the type specimen of *Australopithecus africanus* (Dart, 1925), the fauna presumed to be associated with the Taung hominid skull, and particularly the abundant baboons, have played a key role in assessing the relative age of the cave deposits. But a consensus on the age of the Taung hominid deposit has still not been reached, despite the critical role that accurate ageing must play in discerning the evolutionary position of the early hominids represented by the Taung skull.

Early notions of the age of the Taung caves were formulated before the discovery of the hominid. Fossil fauna from the Buxton Limeworks at Taung have been known and reported since 1919. Wybergh (1920) noted the recovery of fossil lion, jackal, baboon, tortoise, and other animals by the quarry workers who had found them in the cavern fills of the calcareous tufa deposits. Haughton described an extinct species of baboon, now known as *Parapapio antiquus*, at a meeting of the Royal Society of South Africa in 1920, but only later published the description (Haughton, 1925). The presence of the extinct baboons, along with the observation of a dry ravine that had cut through the tufa deposits, led Wybergh (1920:118) to speculate that "the formation is of relatively great age and hardly to be classed as 'Recent' ".

Dart's announcement of the Taung skull, in which he placed it as a representative of "an extinct race of apes intermediate between living anthropoids and man" (Dart, 1925:195), led Sir Arthur Keith (1925a) to hail the discovery as a "missing link". This initial enthusiasm came with an important reservation: "To have any claim to stand near the human line of descent it must be able to claim an early Miocene date at least", whereas he speculated that "these caves may not be older than the Pliocene or earlier Pleistocene" (Keith, 1925a:326). This proviso, along with G. Elliot Smith's (1925) comment on the need for geological evidence of the age, set the stage for the initial and subsequent rejections of the Taung *A. africanus* as a representative of the human lineage.

In the ensuing two decades, Robert Broom played a decisive role in the faunal assessments of the age of Taung. His initial statement that Haughton's baboons from Taung were not strikingly different from those of the modern day led him to suggest a recent Pleistocene age for Taung, within the human period (Broom, 1925a,b). Whereas this early predilection, along with that of Schwartz (1925), fuelled Keith's (1925c,d) rejection of *A. africanus* as a human ancestor, Broom (1925a:570) remained undeterred in his support of Dart, stating that the age "no way interferes with its being a true 'missing link' ". Dart (1926, 1929), however, noting now a second extinct species of baboon from Taung (*Papio izodi* Gear, 1926) and Young's (1925) notes on the ancient dry ravine cutting through the tufa, held to a more remote, Tertiary age of the deposits. Broom (1929) reassessed his earlier position, and suggested a Pliocene or even Miocene age for Taung, more in line with Keith's requirement for a human ancestor.

Conceptions of Taung's geological age subsequently rested largely on analysis of the fauna. Along with the extinct baboons already known from the site, Broom extracted and named a number of extinct species from matrix of the Taung deposits. These led to assignments of the site to the Pliocene (Broom, 1930, 1945, 1946) or Early Pleistocene (Broom, 1934, 1938, 1943; Cooke, 1940). By 1948, Broom (1948a,b) had recognized 17 species from Taung, including *A. africanus*. Because all of the Taung species were extinct, and none are found at the more recently discovered early hominid sites of Kromdraai and Sterkfontein, Taung was inferred to be the oldest of the southern African hominids (Broom 1946, 1948a). However, as noted in part by Tobias (1978), of the 17 species then known from Taung, 14 had been named and described by Broom himself; some species were identified on very fragmentary evidence, and of those, seven are still unique to Taung.

After the University of California African Expedition of 1947–1948 (Camp, 1948; Peabody, 1954), knowledge of the Taung fauna and its context grew. Furthermore, *Australopithecus* and a wealth of associated fauna became known from Makapansgat and Sterkfontein as well as a distinct hominid and associated fauna from Kromdraai and Swartkrans. Ewer (1956, 1957) suggested that the Taung faunal assemblage, especially with the inclusion of *A. africanus* and *Cercopithecoides williamsi*, was most closely linked with Sterkfontein and Makapansgat, as opposed to Swartkrans and Kromdraai, and Cooke (1963) concurred. These faunal divisions were formalized by Ewer & Cooke (1964) as the Sterkfontein Faunal Stage, including Taung, Sterkfontein, and Makapansgat, and the Swartkrans Faunal Stage, comprising Swartkrans and Kromdraai. [The term "Stage" was later replaced by "Span" (Cooke, 1967).]

The studies of Ewer & Cooke as well as Sampson (1971) each noted, quite appropriately, that the unique environmental conditions at Taung made temporal correlations of the fauna with other sites extremely difficult. The apparently dry climate represented by the Taung fauna differed markedly from that of the Transvaal cave sites. It was the drier environment of Taung that led Oakley (1954) to place Taung between Makapansgat and Sterkfontein in time, as it was seen to represent a period of reduced rainfall. On the other hand, the geographical position of Taung, the southern-most *Australopithecus* site at what is now the edge of the Kalahari desert, made environmental correlations somewhat suspect.

Ewer and Cooke did not sequence the sites within the Sterkfontein Faunal Span, but Broom's notion that Taung was the oldest apparently persisted (e.g. de Graaff, 1960). A distinct change in thinking came with Wells' (1967, 1969) suggestion and Taung was the most recent of the *A. africanus* sites. His argument rested largely on the baboons, in particular a species named *Papio wellsi* (Freedman, 1961) which Wells saw as being very similar to the

sample from Swartkrans. The perception that the Taung fauna suggests an age younger than that of Sterkfontein and Makapansgat persists in more recent faunal correlations based on cercopithecids (Delson, 1974, 1975, 1984, 1988; Szalay & Delson, 1979) and on the "scant evidence" of the bovids (Vrba, 1982:727). Alternatively, the Taung hominid may be considered undated (White *et al.*, 1981).

Geological context of the Taung fossils

Dating of the Taung hominid has been further complicated by the lack of knowledge about its immediate geological context. The Taung skull was a product of quarry operations through tufa riddled with a "series" of caves (Gordon, 1926:xxxviii), unlike the extensive caverns found in the dolomite of the Transvaal. After the skull was recovered by Mr De Bruyn (Tobias, 1984), no detailed records were kept, no spot was marked. Young (1925), Dart (1926), and Broom (1925*b*) all published photographs of the putative discovery site, but their accounts do not match, and Broom's photo is distinctly different from that of the others.

The majority of the faunal material came from what is now known as the Hrdlička deposits (Figures 1 and 2). This locality is probably where Aleš Hrdlička, the first anthropologist to visit the site after the Taung skull discovery, recovered some fossil baboons from "the pinkish fillings of *another* tunnel" near the *Australopithecus* cave (Hrdlička, 1925:386, italics mine). Only five species could presumably have been directly associated with the *Australopithecus* deposit (see below), having been derived "from the floor of the same cave" (Broom, 1934: 480). Broom (1946) inferred that the rest were roughly contemporaneous, mostly from the nearby Hrdlička deposits, but also including *Mylomygale spiersi*, which came from a small cave about one half mile to the north of the *Australopithecus* deposit (Broom, 1948*a*).

Of pivotal importance in the interpretation of the Taung caves at Buxton was the first detailed geological analysis, conducted by Peabody (1954). He described and named four distinct tufa accretions (Figure 1). On the basis of the historical record and interviews with people who worked at the quarry in 1924, Peabody found that the *Australopithecus* cave was in the most southerly tufa, inferred to be the earliest, known as the Thabaseek. He felt that the Hrdlička and *Australopithecus* deposits were part of a continuous cave system which filled at the end of the phase of Thabaseek tufa formation. However, most of the fossil fauna was deemed to be from an earlier "dry phase" of cave fill, whereas the *Australopithecus* deposit formed in a later "wet phase". This interpretation meant that ages derived from the fossil fauna must represent a *terminus post quem* for the hominid, and Peabody (1954) suggested that the Taung skull was no older than the Early Pleistocene and possibly even Middle Pleistocene.

Partridge's (1973) geomorphological dating of Taung and Transvaal cave sites, based on the cave openings suggested by erosional nickpoint migrations, yielded an age for the Taung caves under 0·87 million years. Although the underlying assumptions of his interpretation were thoroughly discredited (Butzer, 1974; de Swardt, 1974), the notion of a late age for Taung seemed to be somewhat consistent with Wells' (1967, 1969) faunal age of Taung. In an independent and more convincing analysis by Butzer (1974, 1980), building on Peabody's work, an Early Pleistocene age for Taung no older than Swartkrans or Kromdraai became accepted as being even more probable. Although inconsistencies in the analysis were noted by Butzer *et al.* (1978) and Partridge (1982), many researchers still viewed Taung as the most recent *A. africanus* site.
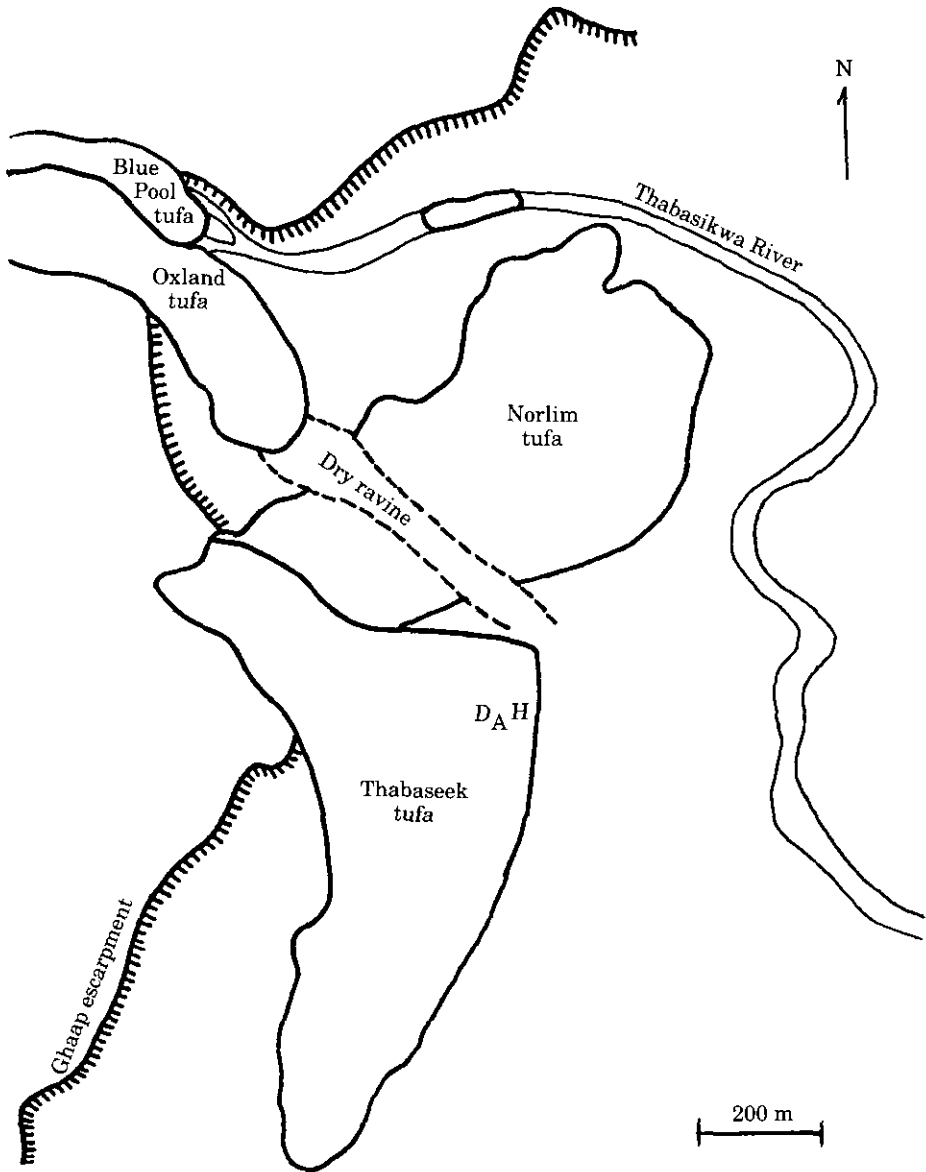
Figure 1. Tufa deposits reconstructed by Peabody (1954): the Thabaseek tufa, containing the Taung hominid, was inferred to be the oldest, followed by the subsequent deposition of the Norlim tufa. In a third phase, the source water of the tufa deposition shifted further north, forming the Oxland tufa, and cutting the "dry ravine" that had been noted by Wyberg (1920) and Young (1925). The Blue Pool tufa, the most recent, formed on the current course of the Thabasikwa river. Modified from Peabody (1954), Partridge (1985), and McKee (1992a). D represents the Dart deposits, A is at the position of the Taung monument, and H indicates the locaton of the Hrdlička deposits (see Figure 2).

Research by Butzer (1974, 1980) led to the inference that the Taung hominid cave was a solution cavity which formed after the completion of the Thabaseek tufa, during deposition of the subsequent Norlim tufa (Figure 1). Alternatively, Peabody (1954) had felt that the cave,
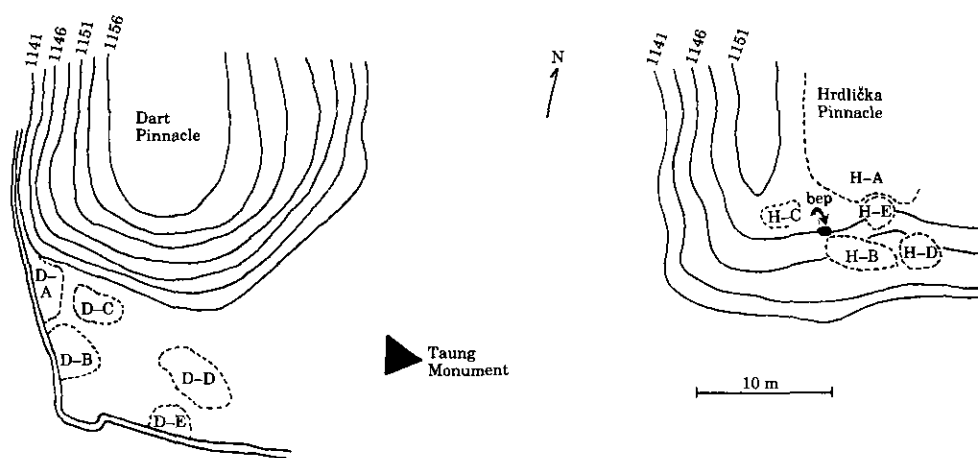
Figure 2. Diagram of known fossil deposits in the Thabaseek tufa near the type locality of *Australopithecus africanus*. The "Hrdlička deposits", denoted with an H prefix, are found on the south face of the Hrdlička pinnacle, and are intersected by a more recent solution cavity known as the "Black Earth Pipe" (bep). The Taung Monument stands at the approximate spot which Peabody (1954) reconstructed as the site from which the Taung skull was quarried. The "Dart deposits" (D-A to D-E) were found in the quarry floor below the area of the probable Type Site as reconstructed by McKee (1993a), and are inferred to be part of the same cave system.

albeit a solution cavity, filled near the terminal phases of Thabaseek deposition. In either case, any absolute age for the Thabaseek tufa would provide a *terminus pro quem* for the fossil deposits. Vogel & Partridge (1983) made a preliminary attempt at ionium dating of the tufa and derived an age of 942,000 B.P., or at most 1·2 million years. Thermoluminescence provided results that were consistent with the ionium dating (Vogel, 1985). This left Taung to be less than half the age of the other *A. africanus* sites.

Opinions on the phylogenetic position of the Taung hominid were sometimes profoundly influenced by the putative late age of the fossil site. Tobias (1973, 1975, 1978), provisionally accepting Partridge's initial geological dating with the support of Wells' faunal dating, suggested two possibilities: the Taung hominid represented a "relict population" of *A. africanus* or, given its inclusion of robust features, may have been closer to *A.* cf. *robustus*. Wolpoff (1974) also proposed the above possibilities in response to Butzer (1974). Partridge (1985) suggested further that the notion of a relict population must also apply to the baboon fauna, and later went so far as to propose that the springs at Taung provided a local refugium for isolated fauna to persist in the area while many of the species went extinct in the rest of southern Africa.

Frameworks for the geochronological position of the Taung hominid have resulted in widely vacillating interpretations of its role in human evolution. It has gone from the late Pleistocene to the Miocene, and although consensus has not been reached on its age, many researchers place Taung as the most recent representative of *A. africanus*, having been deposited sometime toward the end of the Pliocene. Consequently, the species the Taung skull represents has been alternatively placed within and without human ancestry. That its temporal position still affects some scholars' views of Taung's place in the human lineage is illustrated by Tobias's (1991a,b) suggestion that the skull represents "derived" *A. africanus*.

Perspectives on the temporal status of the Taung hominid must be reconsidered as some recent developments in studies of the Taung caves may be leading to a new interpretation.

First, the assumptions underlying Vogel's ionium dating of the tufa have been falsified (Tobias *et al.*, 1994). Secondly, Cooke (1990) has analysed Taung fauna from the University of California collections and has added significantly to the list of known Taung species. Thirdly, continuing excavations started in 1988 (McKee & Tobias, 1990) are adding new species to the faunal list and providing much better contextual detail that may alter our understanding of the site (McKee, 1993a; Tobias *et al.*, 1994). In this paper I assess the implications of the updated faunal list within the context of the depositional sequences revealed by the Taung excavation.

The Taung fauna and its context

Hypotheses on the age of the Taung fauna can be generated from comparisons with the complete and revised list of mammal species identified from the hominid deposit and associated deposits, as found in Table 1. This list is largely based on Cooke's (1990) compilation, but some species must be dropped from previous lists because they are not clearly associated with the hominid deposit. *Mylomygale spiersi* has been excluded because Broom (1948) noted that it came from a half-mile north of the *Australopithecus* site, and thus was derived from a separate tufa flow (Figure 1) and certainly cannot be temporally associated with the hominid site. Likewise, *Vulpes pattisoni* cannot be associated securely with the hominid deposit, as its origin was left unstated by Broom (1946, 1948a) and the brownish-grey matrix that adheres to the specimen is quite different in colour from any of the red or pink breccias so far known from the Dart and Hrdlička deposits.

Inclusion of *Cercopithecoides williamsi* in the Taung species list has been questioned by Delson (1984). Instead he has opted for the presence of cf. *Cercocebus*, on the basis of three partial maxillae from the Transvaal Museum collection (Delson, 1988). My own analysis of the same collection has revealed no *Cercocebus*, as all but one specimen fall within the morphological range of *Parapapio antiquus* or *Papio izodi*. The exception is a partial maxilla (T15), which is indistinguishable in tooth size and morphology as well as facial characteristics from *Cercopithecoides williamsi* of Makapansgat and Bolt's Farm. The identification of *Cercocebus vs. Cercopithecoides* makes little difference in terms of faunal dating, but may eventually play a role in ecological analyses of Taung.

List additions include *Gazella* sp., identified by Vrba (1982). Newly discovered species from our excavations include *Parapapio broomi* from deposit D-D. Post-cranial bones of *Panthera* cf. *pardus* have been identified from deposit H-E (Figure 2).

Limitations must be placed on biochronological interpretations of the Taung fauna, for very few species can be associated directly with *A. africanus*. The species that Broom (1934) claimed came from the same cave were *Procavia antiqua*, *Gypsorhychus darti*, *Pedetes gracilis*, *Palaeotragiscus longiceps*, and *Cephalophus parvus*. Our own excavations have opened up a new series of *in situ* deposits, dubbed the "Dart deposits" after Broom's (1946) "Dart Cave" with which there is an apparent association. On the basis of the historical record (Hrdlička, 1925; Young, 1925; Cipriani, 1928; Peabody, 1954), the Dart deposits are much closer to the hominid type site and probably are part of the same cave system (McKee, 1993a). Most of the material from the Dart deposits cannot be identified to species, but does include the mandible attributable to *Parapapio broomi* and a fine specimen of *Procavia antiqua*. Deposit D-A (Figure 2) also contains sparsely distributed egg shells and tortoise carapace pieces, as did the hominid deposit.

Table 1 **List of identified fauna from Taung. Species possibly associated with the Taung type site [as determined by Broom (1934) and McKee (1993a)] are indicated with an asterisk. Species initial codes used in Figure 3 follow the species name in parentheses; those species without initials are unique to Taung**

Small mammals		Large mammals	
Chiroptera		Artiodactyla	
Rhinolophidae	*Rhinolophus* cf. *darlingi* (*Rd*)	Bovidae	**Cephalophus parvus*
			Gazella sp.
Insectivora			*Oreotragus major* (*Om*)
Soricidae	*Crocidura taungensis* (*Ct*)		**Palaeotragiscus longiceps*
	Crocidura cf. *bicolor* (*Cb*)		*Syncerus* cf. *acoelotus* (*Sa*)
	Suncus varilla (*Sv*)		*Tragelaphus* cf. *angasi* (*Ta*)
Rodentia		Suidae	*Notochoerus* cf. *capensis* (*Nc*)
Bathyergidae	*Cryptomys robertsi* (*Cr*)		
	*Gypsorhychus darti	Carnivora	
	*Gypsorhychus minor	Canidae	*Canis* cf. *mesomelas* (*Cm*)
Cricetidae	*Mystromys antiquus* (*Ma*)	Felidae	*Panthera* cf. *pardus* (*Pp*)
	Proodontomys cookei (*Pc*)		
	Desmodillus auriculatus (*Da*)	Viverridae	*Herpestes* sp.
Hystricidae	*Hystrix africaeaustralis* (*Ha*)	Hyracoidea	
		Procaviidae	**Procavia antiqua* (*Pa*)
Muridae	*Acomys* cf. *cahirinus* (*Ac*)		**Procavia transvaalensis* (*Pt*)
	Dasymys sp.nov.		
	Dendromus sp.	Primates	
	Malacothrix cf. *typica* (*Mt*)	Cercopithecidae	*Cercopithecoides williamsi* (*Cw*)
	Mastomys cf. *natalensis* (*Mn*)		*Papio izodi* (*Pi*)
	Otomys gracilis (*Og*)		*Parapapio antiquus*
	Prototomys campbelli		**Parapapio broomi* (*Pb*)
	cf. *Rhabdomys* sp.		
	Tatera cf. *brantsii* (*Tb*)	Hominidae	**Australopithecus africanus* (*Aa*)
	Thallomys debruyni (*Td*)		
Pedetidae	*Pedetes gracilis*		
Petromyidae	*Petromus minor*		
Macroscelidea			
Macroscelididae	*Elephantulus* sp.		
	Elephantulus antiquus (*Ea*)		
	Macroscelides proboscideus (*Mp*)		

Implications of the stratigraphic sequences of the Taung fossils are coming into focus with the continuing excavation. Peabody's notion of a "dry phase" of red sandy breccia predating a "wet phase" with pink breccia within the Hrdlička deposits can be shown to be invalid, as the respective breccia types are interfingered (Partridge *et al.*, 1991). Moreover, many fossils extend through both the red and pink breccias. Furthermore, it is now clear that the Hrdlička deposits were primary caves that formed with the accretion of the tufa, and not secondary solution cavities that could have formed during subsequent times (McKee, 1993a).

Palaeontological and geological analysis of the Hrdlička pinnacle has revealed chronologically distinct deposits (Figure 2). Most of the fauna previously described can be associated with the deposits marked H-B and H-D [noted as 5a and 5b by Cooke (1990)]. Our

excavations have revealed *Parapapio antiquus* as the sole papionin from H-B, but it is clear that *Papio izodi* must have been included in either H-B or H-D (Freedman, 1965; Cooke, 1990; F. E. Peabody's field notes). Deposit H-E, discovered in 1989, is a later overlying deposit rich in *Papio izodi* fossils, but no *Parapapio*. Although there is an obvious sequence of deposition, the time separation of the deposits may not be of a geologically significant interval. The other Hrdlička deposits have not yielded specifically identifiable fossils.

Vertical stratigraphy within the Hrdlička pinnacle is not nearly as important as the horizontal stratigraphy revealed in the Thabaseek tufa; tufa deposition proceeded roughly from east to west with successive primary caves forming at the edges of the accreted lime layers. The nature of the fossils in the more easterly Dart deposits is consistent with the records of Hrdlička (1925) and Cipriani (1928), being sparsely distributed and including tortoise carapaces and egg shells. The cave system represented by these deposits certainly formed long before the Hrdlička deposits, and there, fillings most likely predate most of the fauna in the Hrdlička deposits (McKee, 1993a). On the other hand, the sedimentological evidence (Partridge *et al.*, 1991; Tobias *et al.*, 1994) may hint at an interpretation of contemporaneity of the fills, so one must keep an open mind on the issue of the temporal disassociation of the Dart and Hrdlička deposits.

Taung thus has a series of fossiliferous deposits that may represent distinct periods of time. Because of the lingering doubts as to whether or not the hominid predates most of the recognised Taung fauna, the subsequent faunal dating analysis initially combines the total sample listed in Table 1. However, the derived faunal age must be seen as a *terminus ad quem* for the *Australopithecus* type site and Dart deposits (McKee, 1993a; Tobias *et al.*, 1994).

Faunal age of the Taung deposits

Occurrences of Taung species at other southern African Plio–Pleistocene cave sites provide useful biochronological reference points. Thus a data base of identified species from well sampled southern African sites was compiled. Two types of analysis were conducted with the use of the specially written SAFAUNA computer program. In the first analysis, identified species and genera are compared with key early hominid sites of southern Africa, similar to the methods used by Ewer (1956, 1957), Ewer & Cooke (1964), and Cooke (1978, 1990). In the second, known time ranges of species and genera, based on inferred ages of a more complete sample of southern African fossil sites, were used to determine the most likely age of deposition of the Taung fossils.

Basic comparisons based on the numbers of shared species and genera between Taung and other southern African sites are listed in Table 2. In terms of all species, Taung has its greatest affiliations with Sterkfontein Member 4, Makapansgat Member 3, and Gladysvale, in that order. There is a lesser association of Taung with Makapansgat Member 4, from which the the fauna is not well sampled, and the presumably later sites of the Swartkrans Faunal Span. As many of the extant species known from Taung fossil deposits are widely ranging in time (Figure 3), it can be useful to look at just those identified as extinct species. With extinct species alone a very similar pattern emerges, and Taung has its strongest ties to the fauna of Sterkfontein Member 4.

Identified genera shared among the fossil sites provide a somewhat more robust picture. Using all of the genera, Taung has strong affiliations with Sterkfontein Member 4, Gladysvale, and Makapansgat Member 3, but there is an even greater association with Kromdraai B and Swartkrans Member 1. Most of the shared genera are extant taxa of microfauna. This may

Table 2 **Numbers of Taung species and genera compared with fauna from other southern African fossil sites (Makapansgat Member 3, Makapansgat Member 4, Sterkfontein Member 4, Gladysvale, Sterkfontein Member 5, Kromdraai B, Kromdraai A, Swartkrans Members 1, 2, and 3)**

	Taung	Mak 3	Mak 4	Sts 4	Glv	Sts 5	Kro B	Kro A	Swt 1	Swt 2	Swt 3
All species	38	16	9	20	15	10	13	10	14	6	5
Extinct species	25	10	6	12	10	4	7	6	8	2	2
All genera	38	20	16	23	23	20	28	19	24	10	11
Extinct genera	9	7	3	4	4	0	2	2	5	2	2

Faunal lists were compiled from Berger (1993), Brain (1981), Brain & Watson (1992), Collings *et al.* (1976), Cooke (1990), Hendey (1981), de Graaf (1988), McKee (1991, 1993*b*), Pocock (1987), Szalay & Delson (1979), Vrba (1981, 1987).
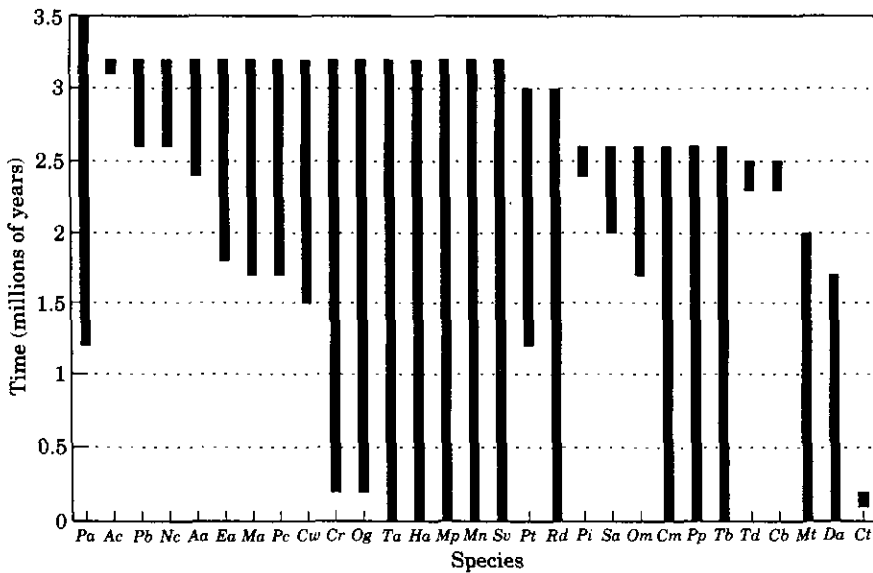

Figure 3. Time ranges of identified species from Taung as determined from other southern African sites. Species names indicated by initials can be found in Table 1. (Dates used for other sites: Langebaanweg >3·5, Makapansgat Member 3—3·1, Member 4—3·0, Sterkfontein Member 4—2·6, Member 5—2·0, Gladysvale—2·4–2·5, Kromdraai A—1·8, B—2·0, Swartkrans Member 1—1·7, Member 2—1·5, Member 3—1·2, Cave of Hearths—0·2)

indicate either environmental or taphonomic similarities among sites where microfauna is well sampled, whereas the age of the site may be of secondary importance in such correlations (McKee, 1991). If this is true, then the numbers of species in common between sites may also be complicated by taphonomic and environmental factors.

Associations of the extinct Taung genera are instructive because Makapansgat Member 3 emerges as the site most similar to Taung. This association is especially interesting given the different inferred environments and condition of deposition between the two sites. Makapansgat fauna seem to indicate a wetter, more wooded environment whereas the Taung fauna are more characteristic of a dry savannah. Likewise, Makapansgat is an exceptionally large dolomitic cave in contrast to the tufa caves at Taung which appear to be among

the smallest of the caves in question. Among the extinct genera is *Gypsorhychus*, a specialized form of rodent mole with continuously growing teeth (Broom, 1934, 1939, 1948*b*), which is unique to Taung and Makapansgat (Pocock, 1987). *Notochoerus capensis*, a suid tentatively identified from Taung by Cooke (1990), has been found in southern Africa only at Makapansgat and the Older Vaal River Gravels, implying an age older than Sterkfontein.

Synthesis of these data could lead one to suggest that Taung is roughly contemporaneous with Sterkfontein Member 4, or perhaps slightly older as the genera and species unique to Taung and Makapansgat may indicate. However, the data must be viewed with at least three important reservations. First, as noted above and as has long been recognized [e.g. Ewer (1957, 1958), Cooke (1963), Ewer & Cooke (1964) Sampson (1971), McKee (1991)], environmental and taphonomic factors complicate simple site comparisons, and age cannot be assumed as the primary factor determining site similarities. Secondly, there is a possibility of a temporally mixed fauna attributed to Sterkfontein Member 4, and likewise the voluminous Gladysvale fauna (Berger, 1993) almost certainly spans distinct time periods. Thirdly, Cooke (1990) noted that only some of the sites have been examined by the same taxonomists, and this may lead to species identifications with taxonomic biases. Thus there may be varied inherent biases in this type of biochronological analysis that could skew the results in favour of some sites over others due to sampling problems and taxonomic predilections.

Whereas direct site comparisons are instructive, alternative types of analysis are possible with the data base of identified fauna from most of the southern African fossil sites. Using approximate ages for the fossil sites at which Taung species occur, it is possible to construct a graph of provisional time ranges for Taung species (Figure 3). Although the sequence of sites is that most commonly accepted, the dates are to be seen as tentative and are derived from a synthesis of the following references: Berger (1993), Brain & Watson (1992), Brock, McFadden & Partridge (1977), Delson (1984, 1988), Harris & White (1979), Hendey (1981), McFadden, Brock & Partridge (1979), McKee (1991), and Vrba (1981, 1982).

Indications from nearly all the species, with only one exception, suggest a minimum age for Taung at least as old or older than Swartkrans Member 1, ca. 1·7 million years. The exception is *Crocidura taungensis* (*Ct* in Figure 3), a species of shrew named and described by Broom (1948*a*) on the basis of a partial skull from the Hrdlička deposits, but also recognized from the Cave of Hearths (de Graaff, 1960). De Graaff (1988) suggested that this species may indicate an environmental similarity between the sites, and as the genus *Crocidura* is widespread in time, this anomaly should not detract from the conclusion of a Pliocene age for Taung.

The majority of the species indicate an age for Taung between approximately 2·4 and 2·6 million years, roughly contemporaneous with Sterkfontein Member 4. Some species, in particular *Malacothrix typica* (*Mt*) and *Desmodillus auriculatus* (*Da*), suggest a later age, whereas others such as *Notochorerus capensis* (*Nc*) may imply an earlier age. The notion of an earlier age is furthered by the presence of the genus *Gypsorhychus*, known only from Taung and Makapansgat. Certainly the Taung site fits best within the Sterkfontein Faunal Span, represented by Sterkfontein Member 4, Makapansgat, and perhaps the older fauna from Gladysvale. Thus *Australopithecus africanus* from Taung cannot be seen as a representative of a late relict population.

Discussion and conclusions

Hominid fossil sites in southern Africa have yielded a wide spectrum of associated fossil species. A circumspect view of the fauna recognized from Taung deposits in relation to these

sites provides a strong indication of an estimated age of deposition between 2·4 and 2·6 million years. Certainly Taung falls within the general time period of Sterkfontein and Makapansgat. However, previous suggestions that the fauna point to a younger age, as well as questions arising from the new stratigraphic evidence, must be addressed.

Taung's abundant baboon fossils have long played a key role in the faunal dating of the site. The notion of a late age for Taung arose from Wells' (1967, 1969) suggestion that *Papio wellsi* was similar to the baboons of Swartkrans. Since that time *Papio wellsi* has been synonomized with *Papio izodi* (Szalay and Delson, 1979), and *Papio izodi* has been identified in Sterkfontein Member 4 (Eisenhart, 1974; Szalay and Delson, 1979; McKee, 1992, 1993*b*). Nevertheless it was still the relative abundance of *Papio* at Taung that led Delson (1988) to propose an age for Taung around 2·3 m.y.a., and Cooke (1990) to suggest that Taung fell in time between Makapansgat/Sterkfontein and Swartkrans.

Hypotheses concerning the evolutionary relationships of these early baboons shed light on their biochronological significance. Recent excavations at Taung have yielded a larger sample of *P. izodi*, allowing a better understanding of its morphology as well as its context. *P. izodi* is morphologically quite distinct from later *Papio* and is most similar to *Parapapio broomi*, suggesting a close evolutionary relationship (McKee, 1992, 1993*b*). There can be no doubt that the Taung and Sterkfontein *Papio izodi* represent the oldest and most primitive members of the genus in southern Africa, and thus do not necessarily suggest a later age.

Analysis of the context of the Taung *P. izodi* demonstrates that the species only becomes prevalent in the later phases of deposition in the Hrdlička pinnacle caves (Deposit H-E, Figure 2). In the earlier depositional phase (Deposit H-B), *Parapapio antiquus* was the more abundant if not the only cercopithecid (depending on its relationship to Peabody's deposit 5a). The Dart deposits, which can be seen as the earliest of the sequence and most closely associated with the hominid remains (McKee, 1993*a*), have so far yielded only *P. broomi*, a species known from Sterkfontein Member 4, Makapansgat and Bolt's farm. One must conclude that the context of *Papio izodi*, as with its morphology, cannot be used to suggest a date for Taung any later than Sterkfontein Member 4.

Nearly all of the chronologically significant species from Taung, like *P. izodi*, come from the Hrdlička pinnacle deposits. Under my interpretation of the Taung site (McKee, 1993*a*), there are only seven species that can be assumed to be directly associated with *Australopithecus africanus*, and these are indicated in Table 1. Four of these species are unique to Taung, and two are also known from the Hrdlička deposits. This leaves only *Parapapio broomi* and *A. africanus* itself, the removal of which does not significantly alter the conclusions of the faunal analysis (as the relative site similarities stay the same). Thus it is the Hrdlička fauna that yields on age of 2·4 to 2·6 million years. If further excavations confirm the notion that the Dart deposits were deposited at an earlier time than most of the Taung fauna and that they are most closely associated with the hominid, then it may lead to a still earlier proposed age for the Taung *Australopithecus*, perhaps on the order of 2·6 to 2·8 million years (based on the time necessary for tufa deposition between the two sets of deposits).

Knowledge of an early date for Taung implies that the hominid can no longer be viewed as a representative of a relict population, or even as a late "derived *Australopithecus africanus*". This is consistent with Grine's (1985) conclusion that the Taung hominid's dental characteristics show a closer relationship to *A. africanus* from Sterkfontein and Makapansgat than to later hominids. If the Taung skull does contain "robust australopithecine" features (Broom, 1946; Tobias, 1973, 1975, 1978), then the chronology proposed here suggests that perhaps these traits are representative of a primitive rather than a derived form. It would then be no

coincidence that Tobias (1967, 1973) and Aguirre (1970) recognised robust characters in the Makapansgat hominid sample and Clarke (1988) saw robust elements in some Sterkfontein hominids. It may be that the early *Australopithecus* in southern Africa was a somewhat robust form, similar to the model suggested by Robinson (1963), or at least that the divergence between *A. robustus* and *A. africanus* was very early, leaving many shared characteristics between the two species. In other words, the evolution of *A. africanus* may have involved a long process of gracilization toward *Homo* features. Clearly there is more to be learned from the southern African hominids and their respective chronological and environmental contexts.

Systematic analysis of the Taung fauna and its context have returned us to a view of the antiquity of the site that was common before 1967. It can be concluded that the fauna from Taung indicates a *terminus ad quem* of 2·4 to 2·6 million years. Some of the fauna, and in particular *A. africanus*, may be somewhat older for which I offer a tentative estimate of 2·6 to 2·8 million years. The Taung hominid certainly falls within the general time range of *A. africanus* from Sterkfontein and Makapansgat.

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References

Aguirre, E. (1970). Identificacion de '*Paranthropus*' en Makapansgat. *Cron. del XI Congresso Nac. Arqueologia*, 98–124.

Berger, L. R. (1993). The age of the Gladysvale australopithecine site in relation to other southern African early hominid-associated sites based on the macro-mammalian faunas. *Palaeont. afr.* **29**, in press.

Brain, C. K. (1981). *The Hunters or the Hunted?* Chicago: University of Chicago Press.

Brain, C. K. & Watson, V. (1992). A guide to the Swartkrans early hominid cave site. *Ann. Transv. Mus.* **35**, 343–365.

Brock, A., McFadden, P. L. & Partridge, T. C. (1977). Preliminary palaeomagnetic results from Makapansgat and Swartkrans. *Nature* **266**, 249–250.

Broom, R. (1925a). Some notes on the Taung skull. *Nature* **115**, 569–571.

Broom, R. (1925b). On the newly discovered South African man-ape. *Nat. Hist.* **25**, 409–418.

Broom, R. (1929). Note on the milk dentition of *Australopithecus*. *Proc. Zool. Soc. Lond.*, 85–88.

Broom, R. (1930). The age of *Australopithecus*. *Nature* **125**, 814.

Broom, R. (1934). On the fossil remains associated with *Australopithecus africanus*. *S. Afr. J. Sci.* **31**, 471–480.

Broom, R. (1938). The Pleistocene anthropoid apes of South Africa. *Nature* **142**, 377–379.

Broom, R. (1939). The fossil rodents of the limestone cave at Taungs. *Ann. Transv. Mus.* **19**, 315–317.

Broom, R. (1943). South Africa's part in the solution of the problem of the origin of man. *S. Afr. J. Sci.* **40**, 68–80.

Broom, R. (1945). Age of the South African ape-man. *Nature* **155**, 389–390.

Broom, R. (1946). The occurrence and general structure of the South African ape-men. *Transv. Mus. Mem.* **2**, 7–153.

Broom, R. (1948a). Some South African Pliocene and Pleistocene Mammals. *Ann. Transv. Mus.* **21**, 1–38.

Broom, R. (1948b). The giant rodent mole, *Gypsorhychus*. *Ann. Transv. Mus.* **21**, 47–49.

Butzer, K. (1974). Palaeoecology of South African Australopithecines: Taung Revisited. *Curr. Anthrop.* **15**, 367–426.

Butzer, K. (1980). The Taung australopithecine contextual evidence. *Palaeont. afr.* **23**, 59–60.

Butzer, K., Stuckenrath, R., Bruzeqicz, A. J. & Helgren, D. M. (1978). Late Cenozoic paleoclimates of the Gaap escarpment, Kalahari margin, South Africa. *Quat. Res.* **10**, 310–339.

Camp, C. L. (1948). University of Californian African Expedition—Southern Section. *Science* **108**, 550–552.

Cipriani, L. (1928). Sull "*Australopithecus africanus*", Dart. *Arch. Anthrop. Etnol.* **LVII**, 1–29.

Clarke, R. J. (1988). A new *Australopithecus* cranium from Sterkfontein and its bearing on the ancestry of *Paranthropus*. In (F. E. Grine, Ed.) *Evolutionary History of the "Robust" Australopithecines*, pp. 317–324. New York: Aldine de Gruyter.

Collings, G. E., Cruikshank, A. R. I., Maguire, J. M. & Randall, R. M. (1976). Recent faunal studies at Makapansgat Limeworks, Transvaal, South Africa. *Ann. S. Afr. Mus.* **71,** 153–165.

Cooke, H. B. S. (1940). A preliminary survey of the Quaternary Period in southern Africa. *Bureau of Archaeology, Archaeological Series* **4,** 7–59.

Cooke, H. B. S. (1963). Pleistocene mammal faunas of Africa, with particular reference to southern Africa. In (F. C. Howell and F. Bourliere, Eds) *African Ecology and Human Evolution*, pp. 65–112. London: Methuen.

Cooke, H. B. S. (1967). The Pleistocene sequence in South Africa and problems of correlations. In (W. W. Bishop & J. D. Clark, Eds), *Background to Evolution in Africa*, pp. 175–184. Chicago: University of Chicago Press.

Cooke, H. B. S. (1990). Taung fossils in the University of California collections. In (G. H. Sperber, Ed.), *From Apes to Angels*, pp. 119–134. New York: Wiley-Liss.

Dart, R. A. (1925). *Australopithecus africanus*: the man-ape of South Africa. *Nature* **115,** 195–199.

Dart, R. A. (1926). Taungs and its significance. *Nat. Hist.* **26,** 315–327.

Dart, R. A. (1929). A note on the Taungs skull. *S. Afr. J. Sci.* **26,** 648–658.

De Graaff, G. (1960). A preliminary investigation of the mammalian microfauna in Pleistocene deposits of caves in the Transvaal system. *Palaeont. afr.* **7,** 59–118.

De Graaff, G. (1988). The smaller mammals of the Cave of Hearths. In (R. J. Mason, Ed.), *Cave of Hearths, Makapansgat Transvaal*, pp. 535–548. Johannesburg: Archaeological Research Unit, Occasional Paper No. 21.

De Swardt, A. M. J. (1974). Geomorphological dating of cave openings in South Africa. *Nature* **250,** 683.

Delson, E. (1974). CA* comments on Butzer and Tuttle articles. *Curr. Anthropol.* **15,** 403–404.

Delson, E. (1975). Palaeoecology and zoogeography of the Old World monkeys. In (R. Tuttle, Ed.), *Primate Functional Morphology and Evolution*, pp. 37–64. The Hague: Mouton.

Delson, E. (1984). Cercopithecid biochronology of the African Plio-Pleistocene: Correlation among eastern and southern hominid-bearing localities. *Cour. Forsch. Inst. Senckenberg* **69,** 199–218.

Delson, E. (1988). Chronology of South African australopith site units. In (F. E. Grine, Ed.) *Evolutionary History of the "Robust" Australopithecines*, pp. 317–324. New York: Aldine de Gruyter.

Ewer, R. F. (1956). The dating of the Australopithecinae: faunal evidence. *S. Afr. Arch. Bull.* **11,** 41–45.

Ewer, R. F. (1957). Faunal evidence on the dating of the Australopithecinae. In (J. D. Clark & S. Cole, Eds.) *Proceedings of the Third Pan-African Congress on Prehistory*, 1955, pp. 135–142.

Ewer, R. F. & Cooke, H. B. S. (1964). The Pleistocene mammals of southern Africa. In (D. H. S. Davies, Ed.) *Background to Evolution in Africa*, pp. 35–48. The Hague: Junk.

Freedman, L. (1957). The fossil Cercopithecoidea of South Africa. *Ann. Transv. Mus.* **23,** 122–262.

Freedman, L. (1961). New cercopithecoid fossils, including a new species, from Taung, Cape Province, South Africa. *Ann. S. Afr. Mus.* **46,** 1–14.

Freedman, L. (1965). Fossil and subfossil primates from the limestone deposits at Taung, Bolt's Farm, and Witkrans, South Africa. *Palaeont. afr.* **9,** 19–48.

Gear, J. H. S. (1926). Preliminary account of the baboon remains from Taungs. *S. Afr. J. Sci.* **23,** 731–747.

Gordon, G. B. (1926). Discussion on Calcareous Tufa Deposits of the Campbell Rand. *Proc. Geol. Soc. S. Afr.* **28,** xxxvii–xxxix.

Harris, J. M. & White, T. D. (1979). Evolution of the Plio-Pleistocene African Suidae. *Trans. Am. Phil. Soc.* **69,** 1–128.

Haughton, S. H. (1925). Note on the occurrence of a species of baboon in limestone deposits near Taungs. *Trans. Roy. Soc. S. Afr.* **12,** 68.

Hendey, Q. B. (1981). Palaeoecology of the Late Tertiary fossil occurrences in 'E' quarry, Langebaanweg, South Africa, and a reinterpretation of their geological context. *Ann. S. Afr. Mus.* **84,** 1–104.

Hrdlička, A. (1925). The Taungs Ape. *Am. J. phys. Anthropol.* **8,** 379–392.

Keith, A. (1925a). The new missing link. *Br. med. J.* February 14, 325–326.

Keith, A. (1925b). The fossil anthropoid ape from Taungs. *Nature* **115,** 234–235.

Keith, A. (1925c). The Taungs skull. *Nature* **116,** 11.

Keith, A. (1925d). The Taungs skull. *Nature* **116,** 462–463.

McFadden, P. L., Brock, A. & Partridge, T. C. (1979). Palaeomagnetism and the age of the Makapansgat hominid site. *Earth Plant. Sci. Let.* **44,** 373–382.

McKee, J. K. (1991). Palaeo-ecology of the Sterkfontein hominids: A review and synthesis. *Palaeont. afr.* **28,** 41–51.

McKee, J. K. (1992). The southern African origin of the genus *Papio. S. Afr. Med. J.* **82,** 193.

McKee, J. K. (1993a). Formation and geomorphology of caves in calcareous tufas and implications for the study of the Taung fossil deposits. *Trans. Roy. Soc. S. Afr.* **48,** in press.

McKee, J. K. (1993b). Taxonomic and evolutionary affinities of *Papio izodi* fossils from Taung and Sterkfontein. *Palaeont. afr.* **29,** in press.

McKee, J. K. & Tobias, P. V. (1990). New fieldwork at the Taung hominid site: 1988–1989. *Am. J. phys. Anthrop.* **81,** 266–267.

Oakley, K. P. (1954). Dating of the Australopithecinae of Africa. *Am. J. phys. Anthrop.* **12,** 9–27.

Partridge, T. C. (1973). Geomorphological dating of cave opening at Makapansgat, Sterkfontein, Swartkrans and Taung. *Nature* **246,** 75–79.

Partridge, T. C. (1982). The chronological positions of the fossil hominids of southern Africa. *Proc. Cong. Int. de Pal. Humaine, Nice* **2,** 617–675.

Partridge, T. C. (1985). Spring Flow and Tufa Accretion at Taung. In (P. V. Tobias, Ed.) *Hominid Evolution: Past, Present and Future,* pp. 171–187. New York: Alan R. Liss.

Partridge, T. C., Bollen, J., Tobias, P. V. & McKee, J. K. (1991). New light on the provenance of the Taung skull. *S. Afr. J. Sci.* **87.** 80–83.

Peabody, F. E. (1954). Travertines and cave deposits of the Kaap escarpment of South Africa, and the type locality of *Australopithecus africanus* Dart. *Bull. Geol. Soc. Am.* **65,** 671–706.

Pocock, T. N. (1987). Plio-Pleistocene fossil mammalian microfauna of southern Africa. *Palaeont. afr.* **26,** 69–91.

Robinson, J. T. (1963). Adaptive radiation in the australopithecines and the origin of man. In (F. C. Howell & F. Bourliere, Eds.) *African Ecology and Human Evolution,* pp. 385–416. London: Methuen & Co.

Sampson, C. G. (1971). Sequential dating of the South Africa australopithecine-bearing breccias. Paper presented to the 70th Annual Meeting of the American Anthropological Association (unpublished).

Schwartz, E. H. L. (1925). Letter to *Nature. Nature* **116,** 22.

Szalay, F. S. & Delson, E. (1979). *Evolutionary History of the Primates.* New York: Academic Press.

Tobias, P. V. (1973). Implications of the new age estimates of the early South African hominids. *Nature* **252,** 85–86.

Tobias, P. V. (1975). New African evidence on the dating and the phylogeny of Plio-Pleistocene Hominidae. In (R. P. Suggate & M. M. Cresswell, Eds.) *Quaternary Studies,* pp. 289–296. Wellington: Royal Society of New Zealand.

Tobias, P. V. (1978). The Southern African australopithecines in time and hominid phylogeny, with special reference to the dating and affinities of the Taung skull. In (C. J. Jolly, Ed.) *Early Hominids of Africa,* pp. 45–84. London: Duckworth.

Tobias, P. V. (1984). *Dart, Taung and the 'Missing Link'.* Johannesburg: Witwatersrand University Press.

Tobias, P. V. (1991a). Nouvelles hypotheses sur l'apparition de l'hominide dans un environment Africain instable. *L'Anthropol.* **95,** 379–390.

Tobias, P. V. (1991b). *Olduvai Gorge, Volume 4: The Skulls, Endocasts and Teeth of Homo habilis.* Cambridge: Cambridge University Press.

Tobias, P. V., Vogel, J. C., Oschadleus, D., Partridge, T. C. & McKee, J. K. (1994) New isotopic and sedimentological measurements on the Thabaseek deposits and their bearing on the dating of the Taung hominid. *Quat. Res.,* in press.

Vogel, J. C. (1985). Further attempts at dating the Taung tufas. In (P. V. Tobias, Ed.) *Hominid Evolution: Past, Present and Future,* pp. 189–194. New York: Alan R. Liss.

Vogel, J. C. & Partridge, T. C. (1983). Preliminary radiometric ages for the Taung Tufas. In (J. C. Vogel, Ed.) *Late Cainozoic: Palaeoclimates of the Southern Hemisphere,* pp. 507–514. Rotterdam: A. A. Balkema.

Vrba, E. S. (1981). The Kromdraai Australopithecine site revisited in 1980: recent investigations and results. *Ann. Transv. Mus.* **33,** 17–60.

Vrba, E. S. (1982). Biostratigraphy and chronology, based particularly on Bovidae, of southern hominid-associated assemblages: Makapansgat, Sterkfontein, Taung, Kromdraai, Swartkrans; also Elandsfontein (Saldanha), Broken Hill (now Kabwe) and Cave of Hearths. *Proc. Cong. Int. de Pal. Humaine, Nice* **2,** 707–752.

Vrba, E. S. (1987). A revision of the Bovini (Bovidae) and a preliminary revised checklist of Bovidae from Makapansgat. *Palaeont. afr.* **26,** 33–46.

Wells, L. H. (1967). Antelopes in the Pleistocene of southern Africa. In (W. W. Bishop & J. D. Clark, Eds) *Background to Evolution in Africa,* pp. 99–107. Chicago: University of Chicago Press.

Wells, L. H. (1969). Faunal subdivision of the Quaternary in southern Africa. *S. Afr. Arch. Bull.* **24,** 93–95.

White, T. D., Johanson, D. C. & Kimbel, W. H. (1981). *Australopithecus africanus:* its phyletic position reconsidered. *S. Afr. J. Sci.* **77,** 445–470.

Wolpoff, M. H. (1975). CA* comments on Butzer. *Curr. Anthropol.* **15,** 412–413.

Wybergh, W. (1920). The limestone resources of the Union, Vol. II, The limestones of Natal, Cape, and Orange Free State Provinces. *Geol. Surv. Mem.* (South Africa) **11.**

Young, R. B. (1925). The Calcareous Tufa Deposits of the Campbell Rand, from Boetsap to Taungs Native Reserve. *Trans. Geol. Soc. S. Afr.* **28,** 55–67.