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Invited Contribution

The new hominid skeleton from Sterkfontein, South Africa: age and preliminary assessment

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ABSTRACT: A new hominid skeleton from Sterkfontein Member 2 attaches to foot bones recovered from loose blocks during the 1980s and first described in 1995. Several flowstone horizons are present above and below the skeleton and have given clear palaeomagnetic signatures. Five changes in magnetic polarity have been identified; when constrained by the available biostratigraphy, this sequence can be placed confidently between 3.22 and 3.58 Ma. Interpolation of sedimentation rates over the small intervals between reversals allows this range to be reduced to 3.30–3.33 Ma. The skeleton is thus the oldest yet discovered and is considered to belong to a species of *Australopithecus* other than *africanus*. Copyright © 1999 John Wiley & Sons, Ltd.

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KEYWORDS: hominid; *Australopithecus*; palaeomagnetic stratigraphy; Sterkfontein.

Introduction

Four *Australopithecus* foot bones from Sterkfontein, South Africa (Fig. 1) discovered by R. J. Clarke in 1994, were of great significance because apparently they were derived from underground deposits older than the Member 4 breccia that has yielded many *Australopithecus africanus* fossils previously (Clarke and Tobias, 1995). The specimens, representing the left talus, navicular, medial cuneiform and first metatarsal, were the first discovery of such a series of bones of an *Australopithecus* foot and indicated a mixture of human and ape characters. In 1997, Clarke discovered eight more misidentified foot bones as well as tibia and fibula fragments of the same *Australopithecus* individual in other boxes; these convinced him that the rest of the skeleton must still be embedded in the cave breccia from which the 12 bones were blasted by lime miners in the 1920s or early 1930s. Accordingly, he asked members of his field staff Stepthen Motsumi and Nkwane Molefe to search the underground breccia surface for an exposed cross-section of tibia to which the sheared-off right distal bone fragment would attach. On 3 July 1997, after one and a half days of searching, they found the exposed tibia shaft, to which the fragment joined perfectly. Subsequent excavation by Clarke, Motsumi and Molefe revealed more of the skeleton and a complete skull (Clarke, 1998) (Figs 2 and 3), with every indication that the whole skeleton is present in the breccia.

This is the first ever discovery of such a complete *Australopithecus* skull and skeleton, and Clarke's preliminary assessment is that the anatomy of the skull and radius suggest a species other than *Australopithecus africanus*. The age of the skeleton, which we give here, places it as a contemporary of *Australopithecus afarensis* from East Africa, but until more of the skull is uncovered and studied it is not possible to say whether it belongs to *A. afarensis* or to another species of *Australopithecus*.

Stratigraphical setting

At the time of the first announcement of the discovery of foot bones from the new hominid skeleton in 1995 the stratigraphical derivation of these remains was not known precisely. It was assumed from the position of the loose block from which they were extracted, and its apparent

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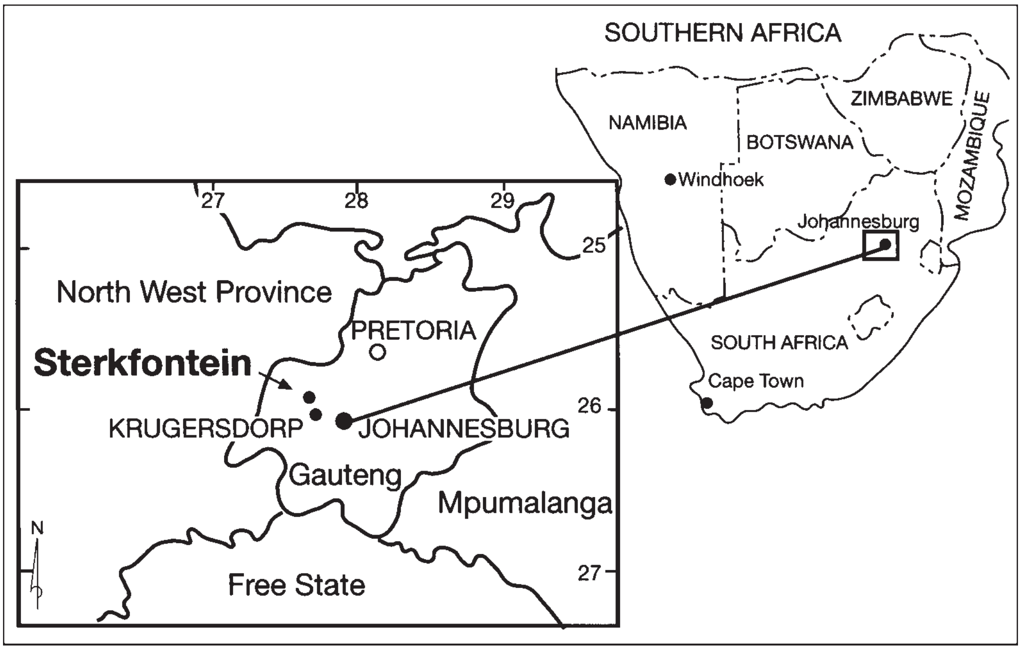

Figure 1 Locality map.

similarity to strata exposed in the underground chamber known as the Silberberg Grotto, that they came from Member 2 of the Sterkfontein Formation (Partridge, 1978). Lime mining during the 1920s and 1930s had removed a large boss of calcitic flowstone from the Silberberg Grotto (Fig. 4), and a number of blocks of the adjoining silty cave fill were detached in the process. The discovery of what is apparently most of the remainder of the skeleton confirms that it belongs in Member 2.

The specimen is preserved on the flank of a calcified debris cone. This was covered by the boss extracted during mining, and is situated almost vertically below strata in the surface excavations (Member 4) that have yielded almost all of the australopithecine specimens from Sterkfontein. The minimum vertical separation of Member 4 from the new specimen is 10 m on the basis of information from cores, one of which was extracted from a borehole no more than 5 m from it (Fig. 4). The intervening Member 3 is bone bearing, but its fossil content has not yet been investigated as it is exposed only as a rather inaccessible, vertical face in the Silberberg Grotto.

No accepted technique of absolute dating has yet been found applicable to the Sterkfontein cave fill. First appearance datums (FADs) and last appearance datums (LADs) of bovid taxa from well-dated sites in East Africa have been used as a basis for palaeontological comparisons, and have led Vrba (1995) to assign the bovids of Member 4 an age of about 2.5 Ma. McKee (1993) has used a wider range of fauna and recalibrated palaeomagnetic results from East Africa to infer an age range for Member 4 of 2.6–2.8 Ma. These estimates, and the considerable thickness of deposit that separates Member 2 from Member 4, led Partridge (in Clarke and Tobias, 1995) to propose an age range for the 1995 hominid foot bones of 3.0–3.5 Ma.

Member 2 has so far yielded mainly primate and carnivore remains, but few bovids; this fauna has, with a single exception, been of little indicative value with respect to age. The one specimen examined recently that points to Member 2 being substantially older than Member 4 has been assigned by Turner (1997) to *Chasmaporthetes nitidula*; Turner has drawn attention to primitive characteristics in this specimen that are reminiscent of those in *C. australis* from the 5.0 Ma site of Langebaanweg in the Western Cape.

Magnetostratigraphy

Previous palaeomagnetic measurements on continuous core samples from Sterkfontein have shown that the cemented cave fill (or breccia) does not preserve a stable magnetic signal. This probably is a result either of the high-energy environment of deposition or of the presence of detrital magnetite grains, transported from a known source in older rocks within the sedimentary catchment of the cave. The sequence of strata in the immediate vicinity of the new hominid skeleton differs from that elsewhere, in the presence of four thin, but locally continuous, flowstone (stalagmite) bands, which are interbedded conformably within the clastic deposits that consitute the bulk of the debris slope. Two of these flowstones are above the skeleton, and two below it; a thicker flowstone band, some 4 m higher in the succession, comprises Unit A of Member 3 (Fig. 4). As these flowstones contain some discolouration owing to the presence of organic complexes and dust, but are free of detrital contamination, attention was focused on them as a more promising source of palaeomagnetic information. In accordance with the broad palaeontological age indications discussed above, the extreme upper and lower limits of this sequence were set at 2.7 Ma and 4.0 Ma.

Nine orientated hand-samples were collected from the five discrete flowstone strata for palaeomagnetic analysis. Each block was drilled to provide a series of 1-inch (2.5 cm) oriented cores. These were measured on a FIT SQUID magnetometer in a Magnetic Measurements low field cage. The determined intensity of natural remanent magnetisation (NRM) was found to be low throughout the section, with a minimum value of 7.6×10^{-9} A m^2 kg^{-1} in block 5 and a maximum intensity of 2.2×10^{-6} A m^2 kg^{-1} for block 9 (see Fig. 6 for position of sample blocks). Measured sample NRMs were found to contain only a weak secondary viscous

Figure 2 StW 573 skeleton as exposed so far. Bottom centre is cast of left tibia and fibula with foot pointing into breccia. Right centre is the right tibia with cast of distal end attached. Visible part of shaft is 19 cm long. Top centre are right and left distal femora in reversed positions. Top right is the left radius.

magnetisation (VRM). For the majority of the samples alternating field (AF) demagnetisation to 10 mT removed the weak secondary viscous magnetisation. Stepwise AF demagnetisation to 50–60 mT identified a single stable primary component of magnetisation (Fig. 5a). Demagnetisation vectors were evaluated using principle component analysis (Kirschvink, 1980) (Fig. 5b and Table 1). A total of five polarity reversals were identified within the Sterkfontein section (Fig. 6). The polarities preserved in the flowstone record three distinct periods of geomagnetic behaviour.

1 Reversed polarity is observed in Member 2 at the base of the section studied (samples 8, 7 and 6).
2 The middle portion of Member 2 contains a record of rapid changes in polarity. From the base of this sequence to the top, the observed polarity transitions are *reverse* to *normal* (samples 6 and 5), *normal* to *reverse* (samples 5 and 4), *reverse* to *intermediate* to *normal* (sample 4), *normal* to *reverse* (samples 4 and 3) and finally *reverse* to *normal* (samples 3 and 2).
3 Normal polarity from the upper strata of Member 2 into the base of Member 3 (samples 2, 1 and 9).

Table 1 Fisher mean direction (Fisher, 1953) determined for each of the individual sample blocks throughout the Sterkfontein section

Sample block	Flowstone	Inclination (°)	Declination (°)	Polarity
9	3	−55.5	25.7	N
1	2D	−57.4	354.7	N
2	2D	−62.2	357.2	N
3	2C	49.6	189	R
4 (top)	2C	−50.7	37.8	N
4 (middle)	2C	2.1	36.5	I
4 (base)	2C	48.1	143.8	R
5	2B	−49	12.5	N
6	2B	56.8	213.3	R
7	2A	35.4	187	R
8	2A	39.6	171.3	R
Normal mean	2	−56.6	8.3	
Reverse mean	2	46.2	188.2	

Figure 3 StW 573 skull and left humerus.

From the base to the top of the section the polarity changes recorded in the flowstones match the geomagnetic polarity time-scale (Cande and Kent, 1995) within the expected age range (2.7–4.0 Ma):

Flowstone	*Sample*	*Polarity Interval*
2A	8	Cochiti subchron termination → Gilbert (C3n.In → C2Ar)
2A	7	Gilbert chron (C2Ar)
2B	6	Gilbert chron (C2Ar)
2B	5	Gauss chron (C2An.3n)
2C	4 (base)	Mammoth subchron (C2An.2r)
2C	4 (middle)	Mammoth subchron termination → Gauss (C2An.2r → C2An.2n)
2C	4 (top)	Gauss chron (C2An.2n)
2C	3	Kaena subchron (C2An.1r)
2D	2,1	Gauss chron (C2An.1n)
3	9	Gauss/Matuyama boundary (C2An.1n → C2r.2r)

The hominid bearing stratum is located between palaeomagnetic samples 4 and 5. The stratigraphical correlation therefore places the specimen within an age interval between the Gauss–Gilbert reversal boundary and the termination of the Mammoth subchron. By comparison with the geomagnetic time-scale of Cande and Kent (1995) the Sterkfontein

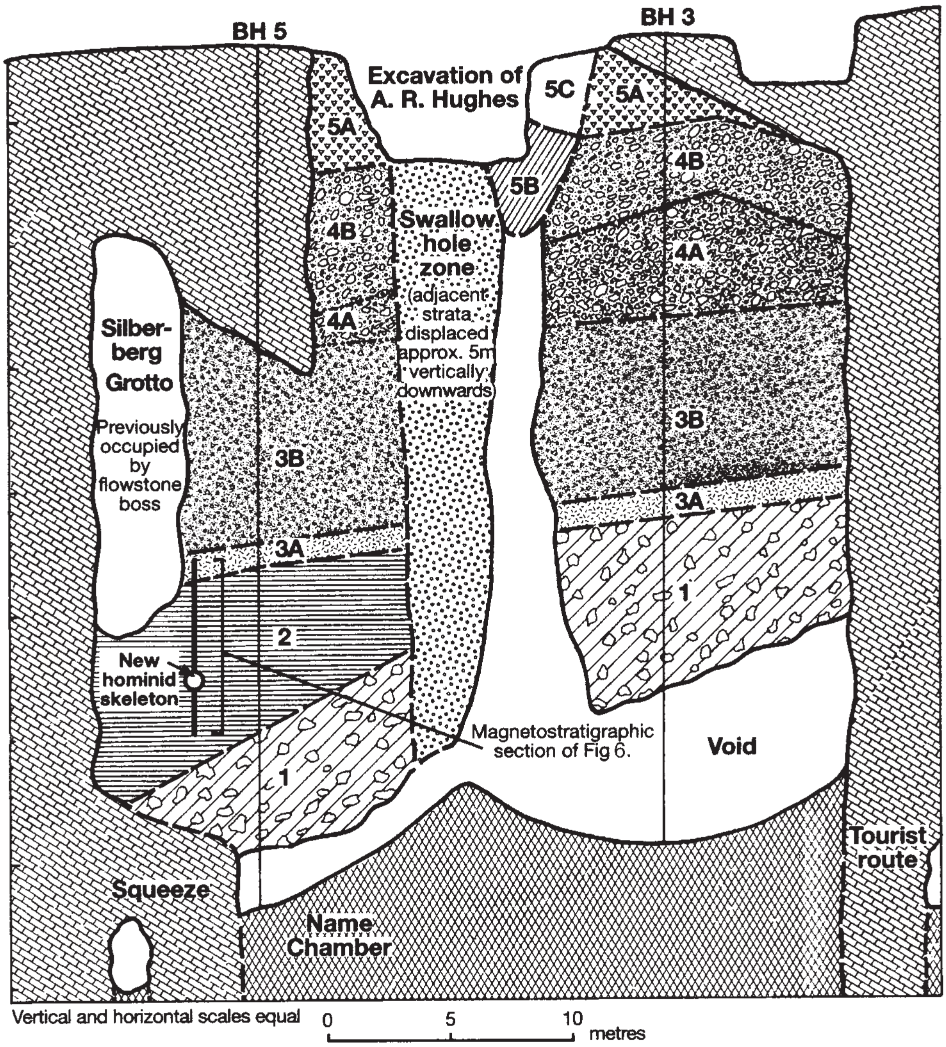

Figure 4 Section through Sterkfontein Formation close to position of new hominid skeleton showing sequence of strata and magnetostratigraphical section of Fig. 6 (adapted from Partridge and Watt, 1991).

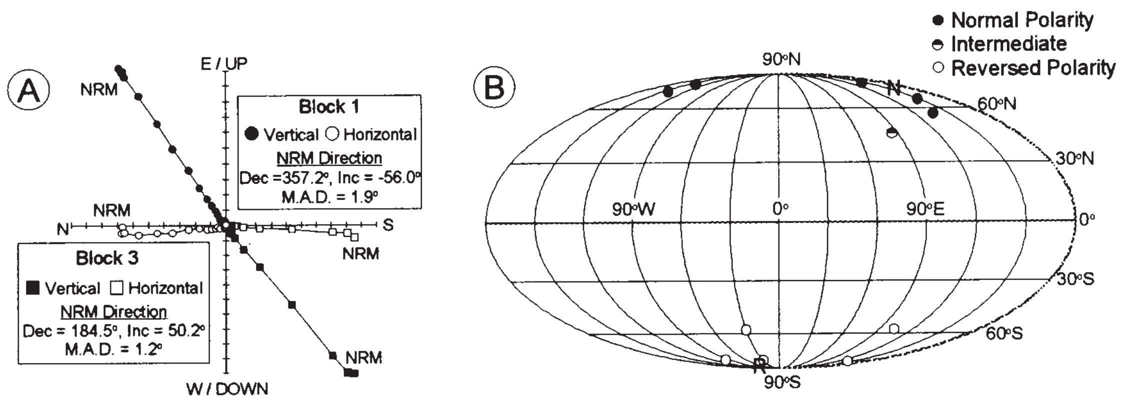

Figure 5 (A) Combined Zijderfeld plot for palaeomagnetic subsamples from block 1 (normal) and block 3 (reversed). Both subsamples contain a small VRM component that is readily removed with low AF demagnetisation. Progressive demagnetisation produces linear vectors into the origin of the plot. For each sample the observed linear vectors were isolated and recorded as the characteristic remanent magnetisation. (B) Projection of the virtual geomagnetic poles (VGP) calculated from the mean primary remanence direction of each of the palaeomagnetic block samples (see Table 1). Additionally, mean VGP positions are shown for each of the *normal* and *reversed* populations (marked N and R respectively). Because of its intermediate direction, sample block 4 (middle) was not included in the calculation of the population means.

hominid can be assigned a clear palaeomagnetic age of between 3.220 and 3.580 Ma.

Assuming a uniform deposition rate for flowstones 2B and 2C it is possible to refine the palaeomagnetic date. Fortunately the Mammoth–Gauss and Gauss–Kaena reversals are within flowstone 2C. The Mammoth–Gauss boundary (3.220 Ma) is well defined at 9.2 cm above the base of flowstone 2C. The Gauss–Kaena boundary (3.110 Ma) is less

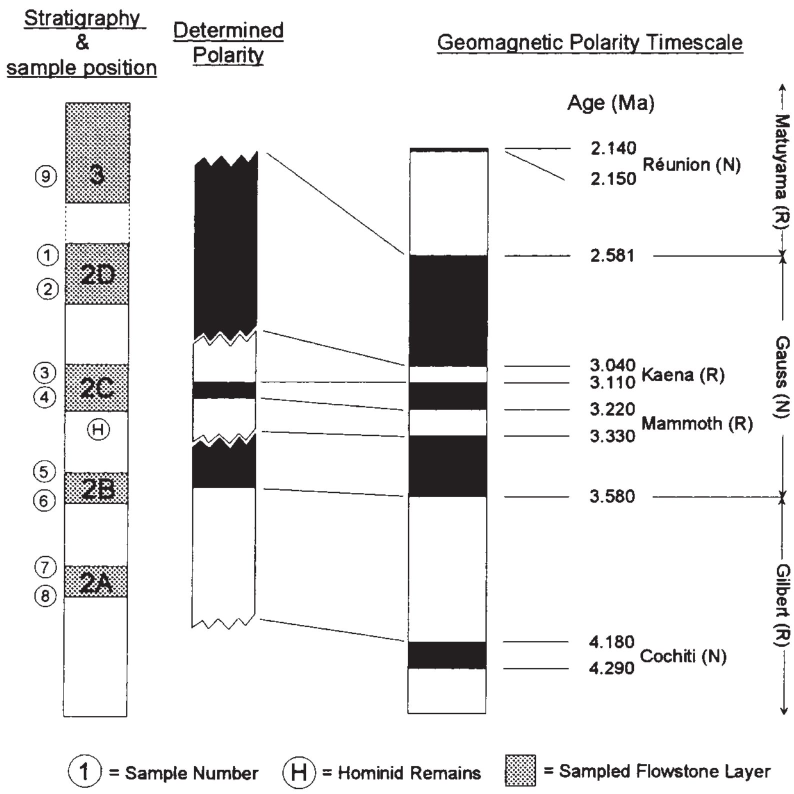

Figure 6 Correlation of the determined Sterkfontein magnetostratigraphy to the geomagnetic polarity time-scale (Cande and Kent, 1995). Breaks in the Sterkfontein polarity scale indicate the positions of reversals that lie between discrete samples and the absolute position of each is therefore unknown.

well defined, being between 16.2 and 21.7 cm above the base of 2C. Using the extreme positions of this boundary it is possible to calculate the maximum and minimum rate of deposition of flowstone 2C and extrapolate to determine a maximum and minimum age of the base of 2C. Similarly the Gilbert–Gauss boundary can be placed between 15.2 and 25.2 cm below the top of flowstone 2B and, assuming the same deposition rate as for flowstone 2C, the age of the top of 2B can be calculated. The hominid remains are 40 cm above the top of 2B and 10 cm below the base of 2A. From the ages calculated for these boundaries, and assuming uniform deposition between flowstones 2B and 2A, the best estimate for the age of the hominid skeleton is 3.30 to 3.33 Ma.

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