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THE STRATIGRAPHY OF THE STERKFONTEIN HOMINID DEPOSIT AND ITS RELATIONSHIP TO THE UNDERGROUND CAVE SYSTEM

by

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ABSTRACT

A programme of orientated core drilling was carried out during 1989 to elucidate stratigraphic relationships within the Sterkfontein Formation and to obtain a representative suite of samples for palaeomagnetic analysis. The cores have revealed that the hominid-bearing cave deposits occur as a continuous succession comprising 6 Members and extending to a maximum depth of about 30 m below present surface. Of these Member 1 (comprising a sterile, residual fill) and Member 3 are the most extensive. This sequence has been displaced vertically downwards within a zone of decalcification coinciding with the central part of the deposit. This zone has been the focus of recent deep excavations at the site.

The results of the drilling, in conjunction with recent surveys of the underground cave system, confirm that a dolomite floor existed at an average depth of about 20 m at the time of first cave filling. Subsequent cavern development down to depths in excess of 50 m caused the local collapse of some lower units of the Sterkfontein Formation and, as new openings developed to the surface, permitted the ingress of younger fills below the base of the hominid-bearing succession.

INTRODUCTION

The three-dimensional stratigraphy of the Sterkfontein hominid deposit has, until recently, been largely a matter of speculation owing to poor exposure, particularly of its lower units. During May and June 1989 five cored boreholes were sunk through the deposit into underlying dolomite bedrock under the direction of T.C. Partridge. The drilling sites were positioned so as to provide maximum information on stratigraphic relationships; orientation of the cores has also permitted their use in a new programme of palaeomagnetic analysis, the results of which will be reported elsewhere.

PREVIOUS INTERPRETATIONS OF THE STERKFONTEIN STRATIGRAPHY

The Sterkfontein deposit has become world-famous as a result of the discovery, from 1936 onwards, of hominid remains in excavations carried out near the summuit of a hill underlain by dolomite of the Monte Christo Formation (Transvaal Sequence). Since that time more than 600 hominid specimens and several hundreds of thousands of faunal remains have been recovered from the calcified filling of an ancient cave system which has become deroofed and exposed at the surface by erosion. Until the commencement of the current programme of excavation of the University of the Witwatersrand in 1966, an appreciation of the stratigraphy of these hominid-bearing deposits was based largely on the exposures provided by the surface excavations initiated during lime quarrying operations and subsequently extended by Drs. Robert Broom and John Robinson of the Transvaal Museum (Brain 1958; Robinson 1962). In the early 1970's the possibility was raised that calcified cave fills exposed at depths of 20 m and more below surface in the cave system beneath the Sterkfontein hill were continuous with those of the surface excavations (Wilkinson 1973). Surveys carried out by I.B. Watt confirmed the superposition of the two sets of deposits and indicated a minimum vertical separation of some 7,5 m between the relevant exposures. On the assumption that continuity did, in fact, exist and using the data from *in situ* observations and sedimentological analyses carried out on a large suite of samples, Partridge (1978) subsumed the hominid-bearing deposits within a Sterkfontein Formation comprising 6 members. The vertical extent and distribution of these members was further elucidated in Stiles and Partridge (1979).

In subsequent papers on the morphology of the Sterkfontein cave system Wilkinson (1983, 1985) claimed that the fossiliferous deposits have a continuous vertical extent of more than 50 m and are likely to span a period of some six million years. These claims contradicted the earlier findings of Partridge (1978) that the base of the Sterkfontein Formation was nowhere located more than about 30 m below present ground surface.

In order to resolve these differences and to provide definitive information on the three-dimensional stratigraphy of the Sterkfontein Formation, as well as to recover samples for palaeomagnetic analysis, a programme of orientated core drilling was carried out at the site during

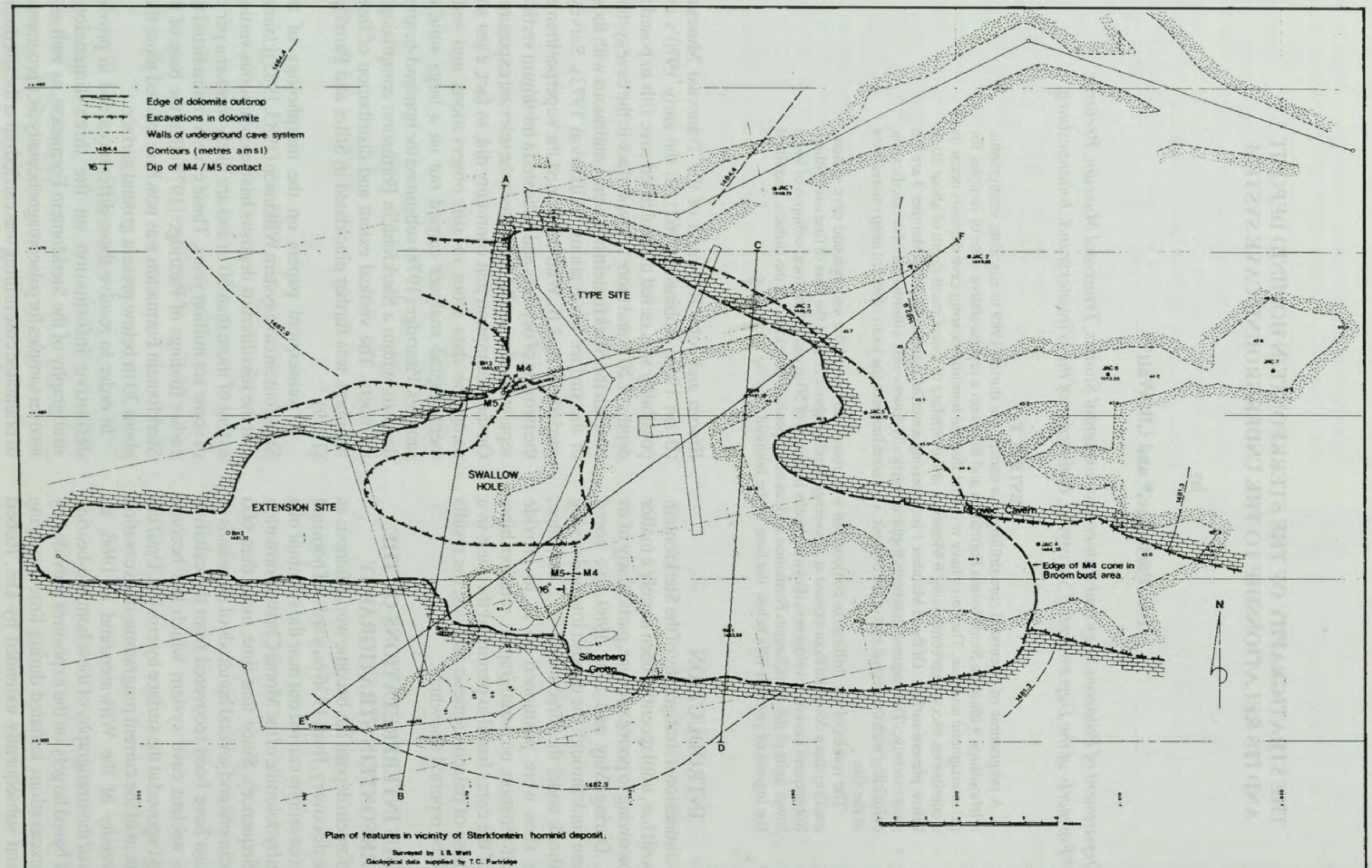


Figure 1: Plan showing surface extent of the calcified cave fill comprising the Sterkfontein Formation and underlying portions of the underground cave system.

May and June 1989. This programme involved the sinking of 5 cored boreholes using diamond-crowned bits with an internal diameter of 58,7mm. A total of 139,45m of core was recovered, and orientation with respect to true north was achieved over more than 90% of the core length using the impression method. The findings of this programme are discussed below.

RESULTS OF THE 1989 CORE DRILLING PROGRAMME

The positions of the 5 cored boreholes are shown in Figure 1; this figure, which is based on surveys carried out by I.B. Watt, also shows the extent of the surface outcrop of the Sterkfontein Formation and key elements of the underground cave system. Within the cores the vertical thickness of the Sterkfontein Formation ranges from 12,0m to 29,75m, averaging approximately 20m. Where possible (i.e. where the borehole did not terminate in a large cavity) each hole was continued at least 5m into the dolomite floor to confirm that the base of the deposit had been reached.

The vertical extent of the Sterkfontein Formation is thus in accord with the earlier estimates of Partridge (Partridge 1978; Stiles and Partridge 1979). The six-member subdivision of the Sterkfontein Formation proposed in these papers is likewise confirmed. The drilling results have, in addition, been used, in conjunction with the underground survey data, to construct a number of stratigraphic sections, which are presented in Figures 2 - 4. These sections demonstrate that, over substantial areas, the base of the Sterkfontein Formation is formed by a dolomite floor which, *contra* Wilkinson (1983, 1985), separates this older depository from deeper, but more recent chambers which extend down to the water table at depths of up to 55m below surface. Over part of its area the Sterkfontein Formation terminates above a cavern formed by the subsidence of this floor into lower-lying cavities belonging to the younger cave system. These lower-lying caverns contain both collapsed debris derived from lower members of the Sterkfontein Formation and younger debris cones which have accumulated beneath avens (or slots) to the surface, through which colluvium from the hillside has been washed. In several instances roof drip has calcified the upper layers of these debris accumulations to form hard carapaces; where further subsidence has occurred, remnants of such younger carapaces have been left as hanging remnants adhering to the dolomite walls and roofs of these deep chambers. Our recent drilling and surveying programmes have demonstrated a clear separation between the Sterkfontein Formation and these deeper (but younger) fills.

As has been pointed out previously (Partridge 1978) the surface excavations carried out to date have sampled only the upper members of the Sterkfontein Formation, despite the fact that excavations carried out by Alun Hughes in the area between the Type and Extension sites since 1983 have now reached a depth in excess of 12 m below the original surface of the cave fill. These new excavations have been restricted almost exclusively to a partially decalcified zone within the deposit in which progress is considerably more rapid than in adjacent well cemented fills, whose consistency approaches that of concrete. In the course of these excavations it became apparent that an almost vertical contact separates the older Member 4 deposits to the east from the younger Member 5 deposits to the west; this contact has previously been claimed to form a dividing line between the occurrence of australopithecine remains and that of specimens of *Homo habilis* in association with an Early Acheulian stone industry (Clarke 1985, 1988; Partridge *et al.* 1991). Since the westward declivity of this contact, as revealed over a much wider area sampled by the borehole cores, does not exceed 20°, its extreme steepness within the decalcified zone is clearly a local phenomenon. In fact, all evidence points to the occurrence in this area, some time after deposition, of vertical movements totalling about 5 m. Although some disturbance and mixing inevitably take place during such movements, the general stratigraphic sequence is commonly preserved; this has resulted in Member 5 within the swallow hole zone being brought into juxtaposition with Member 4 in the unaffected cave fill along an almost vertical plane of separation. Swallow hole translocations of this type are common in partically cemented cave fills, either as a result of ongoing solutional activity below poorly calcified materials or as a result of early deroofing and decalcification in zones underlain at depth by cavities. The latter seems more probable in the present instance. The associated vertical movements account for the failure of the deep excavations carried out to date to penetrate Member 3, which occurs at shallower depth on either side of the decalcified zone. This interpretation, made possible by the results of the drilling programme, is contrary to earlier views that the steepness of the M4/M5 contact in the excavation zone is the result of substantial erosion of the flank of the debris cone of Member 4 prior to the accumulation of Member 5.

The implications of the existence of this swallow hole zone within the Sterkfontein cave fill for the correlation of its lithostratigraphic units with hominid remains are considerable. As was the case in analogous fills in the Cave of Hearths (Partridge 1982), the movements associated with the development of the swallow hole do not appear to have disrupted completely the overall stratigraphic sequence within the displaced block; however, within the swallow hole zone the general positions of the contacts between members, particularly between M4 and M5, remain to be determined before the extent of the vertical displacement can be better estimated. There are thus reasonable prospects that it will be possible to relate most hominid specimens from this zone to individual stratigraphic units, as has been possible elsewhere in the deposit. It seems worthwhile, also, to emphasise the distinction between swallow hole development and the formation of *makondos* or solution pits (Brink and Partridge 1980). The latter are common within the eroded surfaces of Members 4 and 5, and one

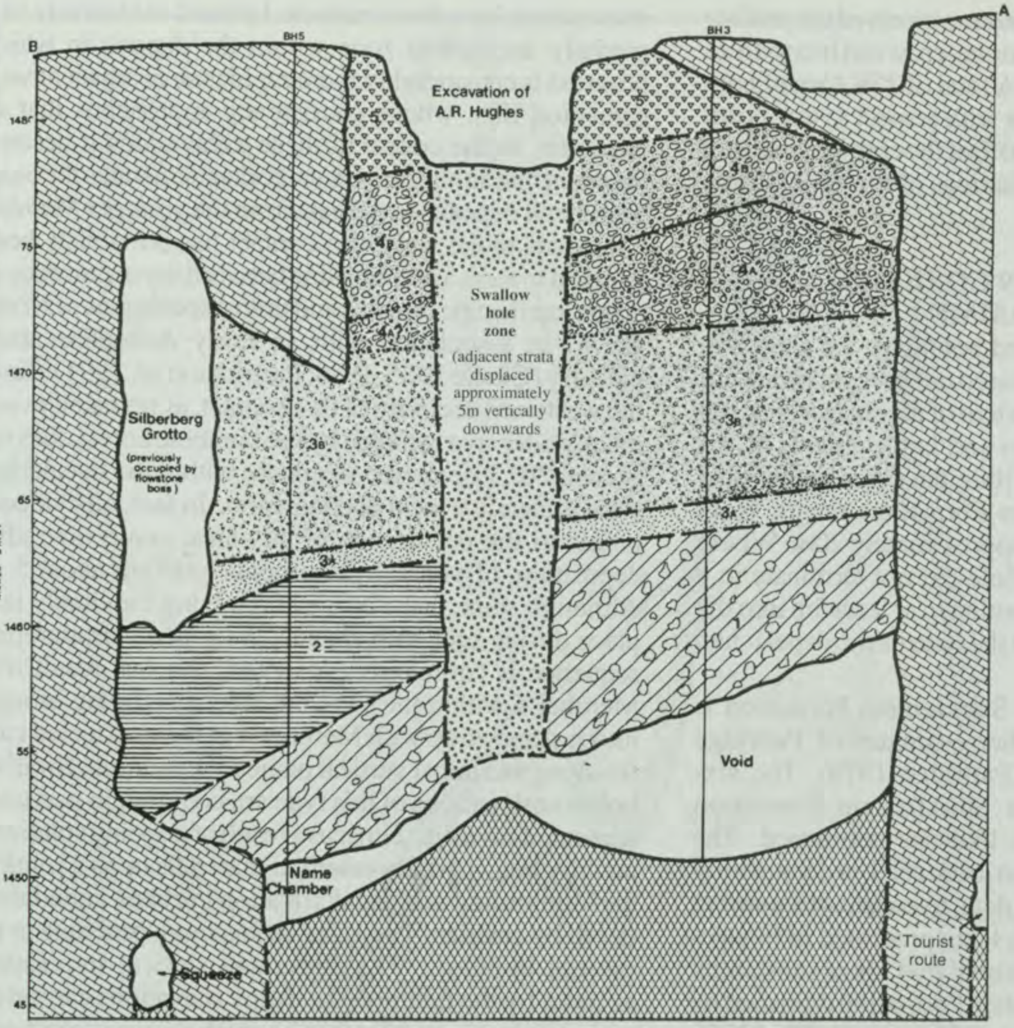


Figure 2

SUMMARY DESCRIPTION OF UNITS OF THE STERKFONTEIN FORMATION

Member 6: (Absent in sections). Basal calcite flowstone followed by dark reddish brown, moderately calcified, clastic fill. Middle Pleistocene fauna.

Member 5: Reddish brown, generally well calcified, clastic fill with abundant rock debris. *Homo habilis*, Early Pleistocene fauna and Early Acheulian stone industry.

Member 4: Bed D - localised banded calcite (pool deposits)
Bed C - Reddish brown, generally well calcified clastic fill with scattered large dolomite/chert blocks.
Bed B - Reddish brown, well calcified, clastic fill with abundant rock debris.
Bed A - Dolomite/chert roof-fall debris cemented by calcite.
All beds contain *Australopithecus africanus* and a Late Pliocene fauna, but no stone artefacts.

Member 3: Bed B - Reddish brown clastic fill with sparse rock debris and some bone.
Bed A - Basal calcite flowstone.

Member 2: Pale brown and red, well bedded, clastic fill with sparse rock debris and locally abundant bone.

Member 1: Dark brown, manganiferous, residual clastic fill with clay pellets, large dolomite/chert blocks and interbedded calcite layers.

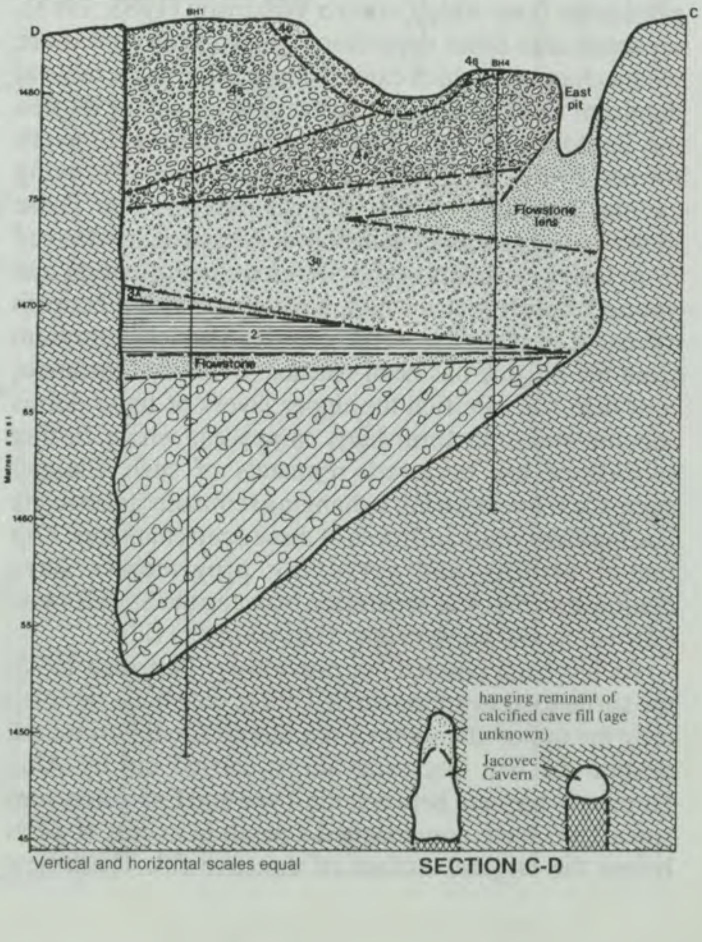


Figure 3

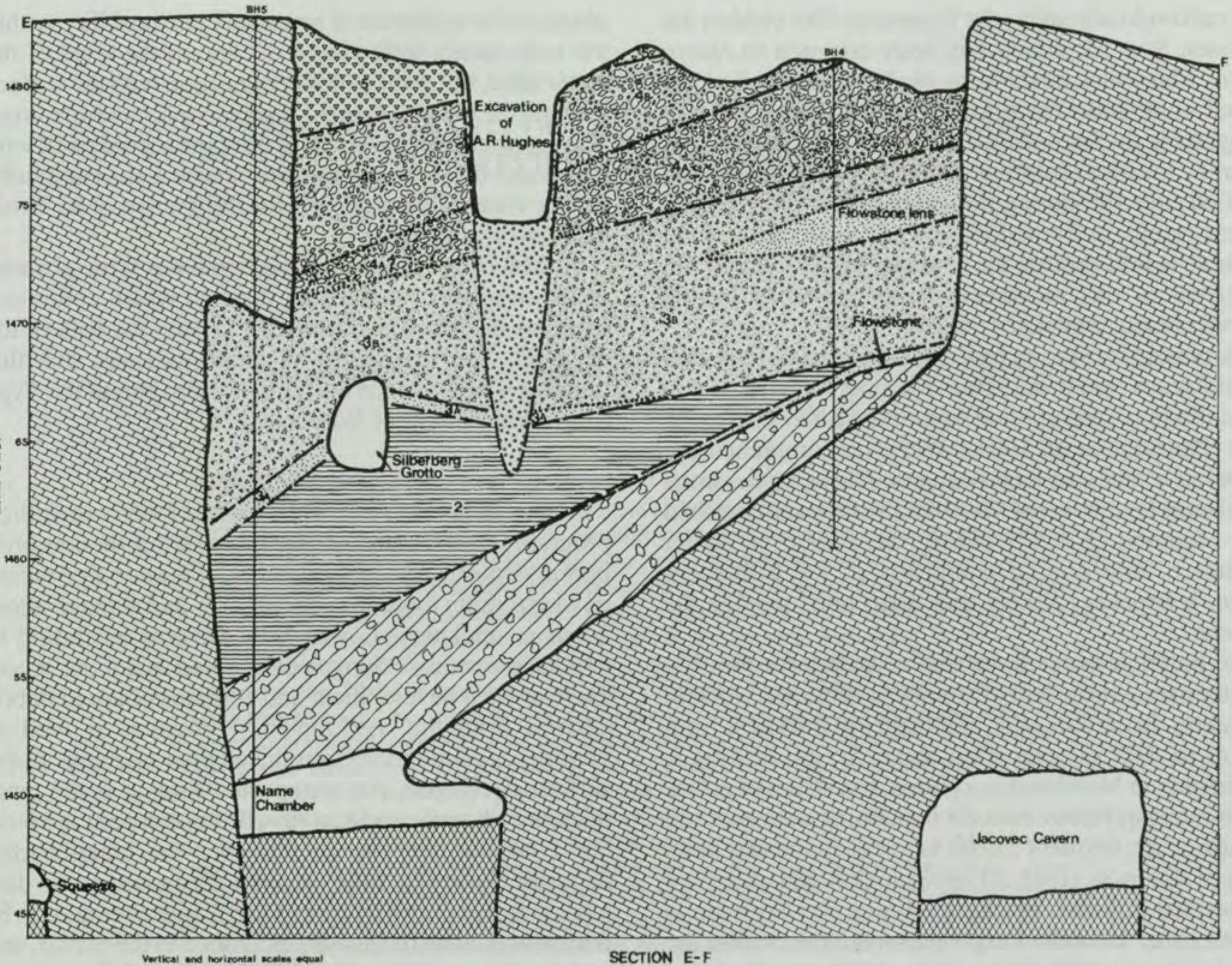
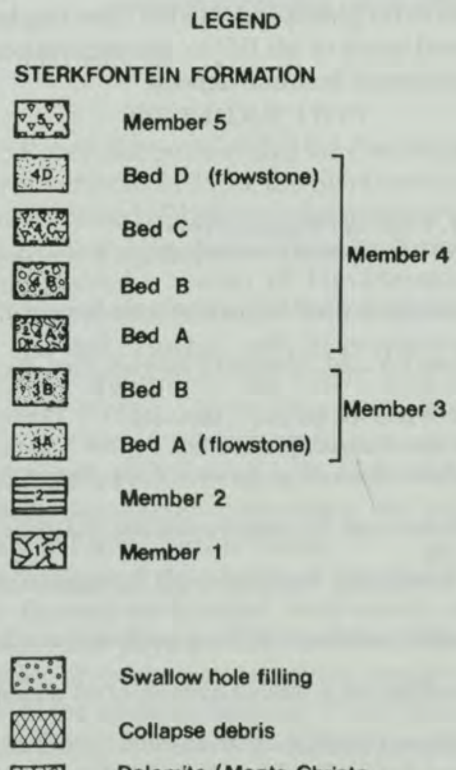


Figure 4



Figures 2 - 4: Sections through the Sterkfontein Formation drawn up from borehole data and surface and underground exposures. Positions of the section lines are shown in Figure 1. Legend and summary description of lithostratigraphic units accompanies Figure 2.

Note: although no stratigraphy is shown within the swallow hole zone, there is evidence that the general stratigraphic sequence was maintained within the slumped block.

such makondo adjoining the Extension Site yielded the specimen Stw 53, which has been assigned to *Homo habilis*. Makondos differ from swallow holes in lacking a basal void, subsidence into which displaces the full stratigraphic thickness of the deposits. They are formed, rather, by localised solution within the upper zone of the calcified cave fill; during this process loss of carbonate cement results in limited downward movement of the insoluble residue within the confines of the solution pit, the extent of this movement being governed by the original cement content of the fill.

The present consensus, based on the faunal and hominid material recovered to date from Members 4 and 5, is that these units may span a period from about 2,8 to 1,5 million years (Partridge *et al.* 1991). While no comprehensive comparative analyses have been possible using the small faunal samples recovered from blocks of deposit detached from Members 2 and 3 during the course of earlier subsurface lime mining operations in the Silberberg Grotto, it appears unlikely that these units predate the Pliocene.

The borehole cores have also revealed, for the first time, the nature and extent of Member 1 of the Sterkfontein Formation. In the cores this unit ranges in thickness from 2,51 m to 8,03 m, averaging about 5,5 m, making it second only to Member 3 in volume. It consists of a dark brown manganiferous clay-silt containing pellets of red unctuous clay, frequent calcite veinlets, numerous large clasts of dolomite (roof collapse blocks) and extensive interbedded horizons of calcite flowstone. No bone is evident either in limited exposures available within the cave system or within the cores, but bone fragments are cemented into its uppermost few centimetres in the Silberberg Grotto. The bulk of this member thus appears to have accumulated within deep phreatic chambers of the cave system subsequent to their drainage and aeration (through the existence of secondary permeability within the rock mass), following a decline in the level of the water table, but prior to their connection with the surface through the development of macroscopic cave openings. The occurrence of basal fills of this type accords well with the model of cave development under a spasmodically falling water table proposed for the Transvaal by Brink and Partridge (1965).

A final issue resolved by the boreholes is the position of the original cave opening through which colluvium from the hillside was introduced to form the bulk of the cave fill. The disposition of strata indicates that this opening was located in the north-eastern part of the Type Site in the vicinity of Borehole 4.

CONCLUSIONS

The evidence now available from the 1989 core drilling programme at Sterkfontein has revealed that the hominid-bering deposits comprising the Sterkfontein Formation nowhere attain more than about 30 m and average about 20 m in thickness. Lower-lying caverns extending to depths in excess of 50 m were formed in a more recent cycle of cave development and contain collapsed debris derived from the Sterkfontein Formation as well as younger accumulations introduced after openings to the surface developed. An unexpected finding is the great thickness of sterile, residual cave filling comprising Member 1, which everywhere underlies the bone-bearing deposits. Since scientific excavations carried out to date have sampled only Members 4 and 5, much remains to be done to elucidate the history entombed in the earlier, and even more extensive, units of the Sterkfontein Formation. For the progress already achieved towards this goal the scientific world is greatly indebted to Alun Hughes, who has dedicated much of his life to the excavation of this uniquely important hominid deposit.

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