
The Formation and Sedimentary Infilling of the Cave of Hearths and Historic Cave Complex, Makapansgat, South Africa

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The archaeology of caves is best served by including a study of natural effects prior to and during anthropogenic input. This is especially true for the Cave of Hearths because not only has erosion determined the area of occupation, but also subsequent undermining has caused collapse of some of the rearward parts of the site during Early Stone Age (Acheulian) and later times; and this had a major impact on excavation. The key to understanding the nature of the collapsed layers was the rediscovery of a lower part of the cavern below the whole site. This lower cavern is no longer accessible, but the evidence for it was revealed in a swallow hole by R.J. Mason, and in archived material at the Department of Archaeology, University of Witwatersrand. The creation and dissolution of dolomite fragments in the upper layers has resulted in the formation of thick, carbonate-cemented breccia that has preserved underlying layers and prevented further collapse. We agree with Mason that further archaeological and hominid finds await excavation under the proximate Historical Cave west entrance. This area has the potential for archaeological and palaeoanthropological material that predates the layers in the Cave of Hearths. © 2004 Wiley Periodicals, Inc.

INTRODUCTION

The Cave of Hearths is situated high up on the left flank of the Makapansgat Valley near Potgietersrus (now Mokopane), Northern Province, South Africa (Figure 1). The cave was so named by C. (Piet) van Riet Lowe in 1937 after blackened patches and “ash” in Early Stone Age (ESA) layers were revealed in a miner’s horizontal cutting (adit) of a partially unroofed cave. Although the claim for early hearths was contentious, less ambiguous evidence for hearths was later uncovered in Middle Stone Age (MSA) and Later Stone Age (LSA) horizons under excavations by van Riet Lowe, the Kitching brothers, and later by Revil Mason (Mason, 1988). The Cave of Hearths lies parallel to the side of the valley and is part of the fossil cave remnant also comprising, up-valley, Historic Cave and, down-valley, Hyena (Mandible) Cave. The occupation of the Cave of Hearths occurred at the same time as the system continued to erode, and the erosion and partial collapse of some sediments into underlying voids determined to a great extent where areas of occupation were to be concentrated. Hence, the archaeological site is heavily influ-

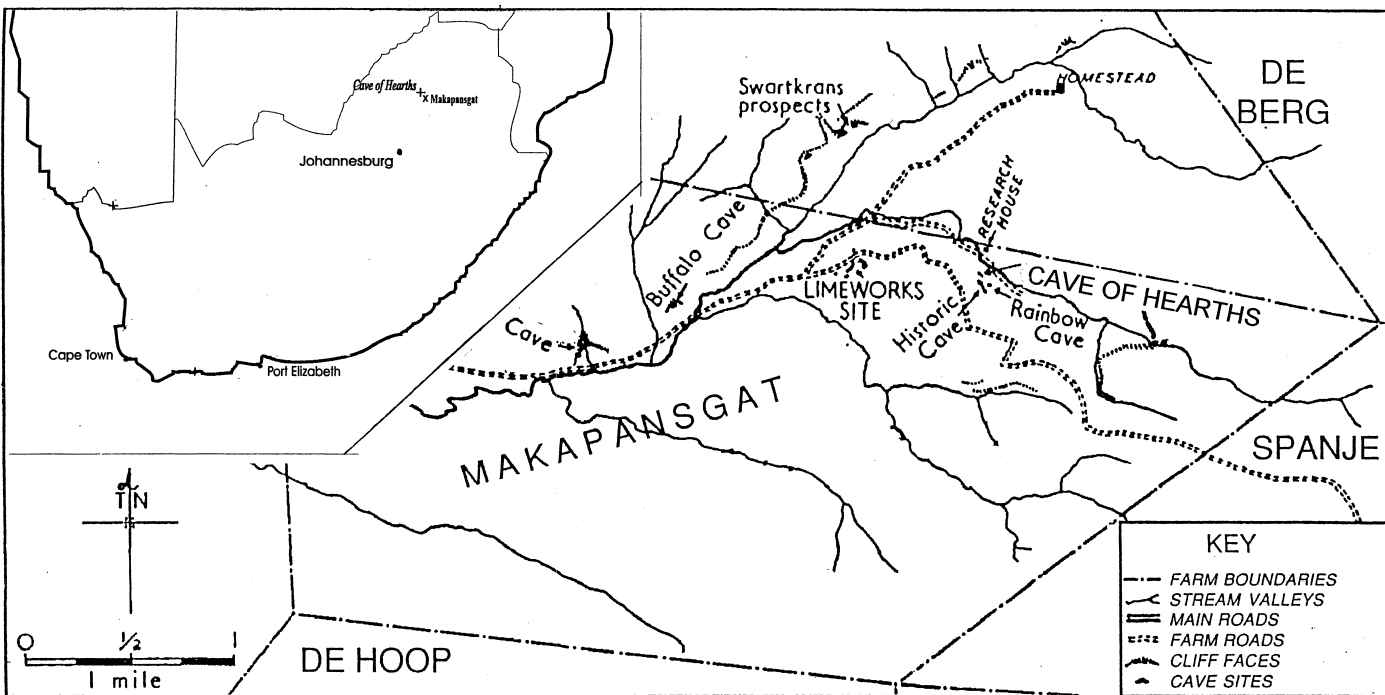


Figure 1. Map showing the location of the Cave of Hearths, Makapansgat. The map also shows the position of the Limeworks Australopithecine site.

enced by the predisposition of the cave and its sediments and by its further natural development during occupation. The miner's remnant known as Rainbow Cave, which intersects the opposite entrance of the complex, also contains ash-like layers and MSA lithics. Here also the archaeological layers, though not excavated and hence not revealed in entirety, occur above, with, and below various types of natural sediments. It follows that the sites, and any original hearths, will probably have been affected by groundwater filtering through the overlying layers as the cave continued to unroof. It is the aim of this paper to present an updated survey of the cave complex, to present a likely synopsis of cave development, and to suggest how this development might have influenced the occupation and its subsequent appearance.

The speleogenesis of the Cave of Hearths–Historic Cave complex is presented also because of the strong likelihood that it formed part of a much longer system that culminated in the well-known Australopithecine site, the Limeworks Cave. The development of that cave together with its sediments is given in separate papers (Latham et al., 1999; Latham et al., 2003). This paper forms part of the reappraisal of the archaeology of the Cave of Hearths and related external sites that we call the Makapanskat Middle Pleistocene Research Project (MMPRP), directed by A. Sinclair (University of Liverpool) and J. McNabb (University of Southampton); a report for this is now in preparation.

THE CAVE OF HEARTH: ARCHAEOLOGICAL HISTORY

After the lime workers had removed speleothem from Hyena Cave, they removed speleothem in a drive along the inside of the dolomite barrier (Figure 2). It was this adit that was investigated by van Riet Lowe in January 1937, and where he discovered a wall of bone-bearing breccia and a layer of “fine, loosely consolidated and ash-like appearance” several inches thick and exposed over six feet (Mason, 1988). The idea of purpose-built hearths was questioned at the time by H.B.S. Cooke and M.D.W. Jeffreys (in Mason, 1988) and since by Oakley (1954). A lightning strike onto guano was suggested to account for the possible ash. As most of the hearth sites here and at Rainbow Cave were largely unprotected by the retreating cave brow, it is almost certain that any hearths would have been altered by infiltration of groundwater. We are currently studying these sites using a combination of magnetic susceptibility methods and Fourier Transform Infra Red spectrometry (FTIR).

The archaeological material of CoH was excavated and examined by van Riet Lowe, the Kitching brothers, Mason, Tobias, and others (Mason, 1988). The subsequent intensive excavations of Mason, from 1953 to 1954, involved blasting techniques on the calcite-hardened breccia and dolomite blocks. Approximately 1800 tons of cave fill were removed, revealing a 7-m-deep section containing cultural layers, making the CoH a special site for the ESA to MSA cultures of Southern Africa (Figures 3 and 4). The limited fossil hominid remains, including a radius (Pearson and Grine, 1997) and a mandible (Mason, 1988) found near the remnant of an outer cave wall (“dolomite barrier” of Mason [1988]) of the CoH, appear to



Figure 2. Photograph showing the start of excavations in 1947. Ben Kitching is in the foreground. The two workers at the top are sitting immediately in front of the Historic Cave West Entrance. In the foreground is the miner's cut lying inside the dolomite barrier (after Figure 5 of Mason [1988], with permission, University of Witwatersrand, Department of Archaeology).

show traits representative of both ancient *H. heidelbergensis* and more anatomically modern *Homo*. The stratigraphy at CoH was straightforward except for an area near the inner wall, where slumps occurred into a “swallow hole” during MSA occupation times. A lateral continuation of the deposits into a large boulder breccia near the entrance to the proximate Historic Cave has not been excavated, though Mason recognized that it probably contained more archaeological material. To the southwest, the continuation into Hyena Cave represents part of the same original cave, except that the speleothem and any faunal remains are probably much older than the archaeological deposits.

Mason cut through the barrier wall in order to install rails and cocopan tubs connecting the excavation to the sorting dumps on the valley side (Figure 5). The backfill from the excavations now lies about 3.5 m below the top of the dolomite barrier, and inward drafts under the floor and next to the barrier confirm that there must be a lower opening out into the valley side. This suggests that the remnant of this outer barrier is, in part, a dolomite bridge.

Historic Cave and Cave of Hearths

Makapansgat Valley, Potgietersrus, Northern Province,
South Africa.

Surveyed using Suunto clinometer and compass, A. Latham and
A. Herries. Drawn by A. Latham, 2001. Brit. Cave Res. Assoc. Gd4.

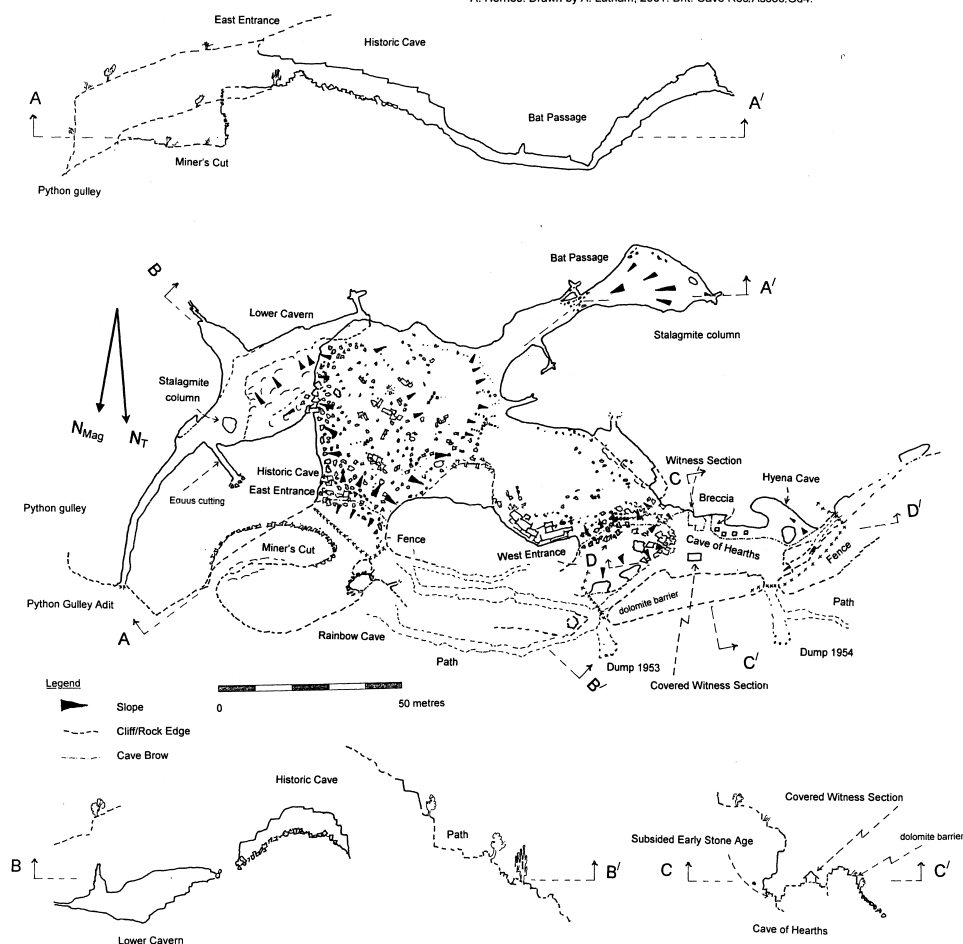


Figure 3. Plan map and cross-section of the Historic Cave–Cave of Hearths complex. The survey also includes Hyena Cave, the continuation of the Cave of Hearths, and the MSA site of Rainbow Cave. For sections on CC' and DD', see Figure 11.

A lowering of the roof at a dolomite “septum” marks the boundary between the CoH and Hyena Cave. The lime workers left behind a flowstone roof column as support for the breccia, and layers within it show sediment contamination; in effect, an entrance existed as the flowstone layers were being laid down. A hyena mandible was found in a dark pink-brown breccia layer partway through the sequence. On the outer floor of Hyena Cave is a large fallen dolomite block that was originally



Figure 4. Photograph of the Cave of Hearths at the close of excavations in 1954. Archaeological levels are painted on the wall at the rear of the cave. The retaining wall has yet to be built, but the slope of the flowstone resting on dolomite can be clearly seen. Block collapse of ESA layers up to layer 3 occurred because of the lack of support of that part of the flowstone lying on soft sediment rather than on dolomite. The two legs of the ramp are resting on part of this collapsed flowstone (after Figure 12b of Mason [1988], with permission, University of Witwatersrand, Department of Archaeology).

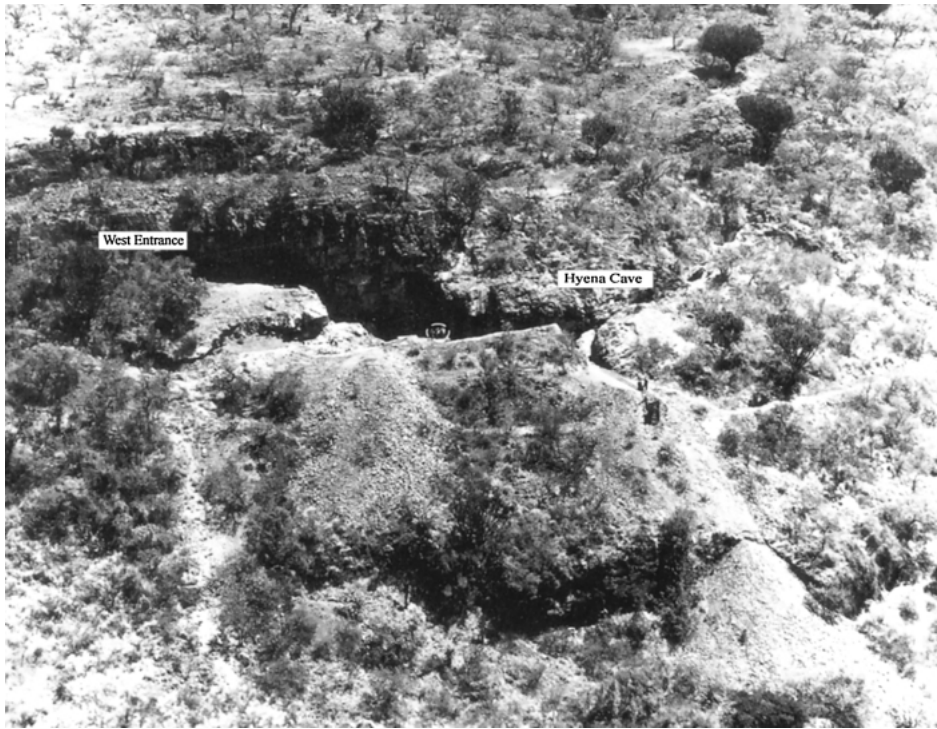


Figure 5. View across the valley at the 1953–1954 excavations of Mason, showing the debris in front of the West Entrance, the dolomite barrier (with three individuals circled), Hyena Cave (to the right), the cocopan rails, and the excavation rubble heaps. The negative marks left in the breccia by a large columnar stalagmite are visible immediately to the right of the three individuals (after Figure 12 of Mason [1988], with permission, University of Witwatersrand, Department of Archaeology).

covered in flowstone. The lime workers excavated remnants of the cave for a further 200 m along the side of the valley, but no archaeological material is known from their workings.

THE SPELEOGENESIS OF CAVES IN CARBONATE ROCKS

Wherever they are formed in the world, most limestone caves experience a life history that consists of a subaqueous (phreatic) phase, a partially air-filled (vadose) phase, phases of sedimentary infilling and breakdown, and a phase of unroofing and erosion (see, for example, Bögli [1980] or Ford and Williams [1989]). Some of these phases overlap, and details may vary even within a single cave system. A useful distinction can be made between caves formed in low-relief areas, where underground water may be thought of as approximating a water table, and mountain caves, where streams sink at altitude to emerge at springs in an adjacent valley.

In discussing the formation of caves of anthropologically important sites of Southern Africa, the model most frequently assumed is of a cavern formed by solution below a water table as, for example, at Sterkfontein and Swartkrans (Brain, 1993). It is likely, however, that, because of the setting, the Cave of Hearths–Historic Cave (CoH-HC) complex and the Lineworks Cave (LC) were formed under conditions of high relief.

Phreatic, vadose, and breakdown elements are recognizable in the CoH-HC complex. So far, it has not been possible to identify any water-lain deposits that might relate to the period when a river ran through the cave passages. If such deposits do exist, then they may be buried under other, later, sediments. The extant deposits in these cave remnants relate rather to late phase deposition of speleothem, and to slope wash from overlying surfaces that was contingent upon erosion and mechanical breakdown of the passages.

The cave remnants were mined for rich speleothem deposits mainly in the 1920s and 1930s, and the miner's excavations cut through a variety of deposits to the dolomite bedrock in many places. There is, therefore, a good sampling of stratigraphic sequences, though stratigraphic correlations between some areas at the same site have been obscured.

DESCRIPTION AND SURVEY

The Cave of Hearths–Historic Cave complex consists of a main large fossil passage that is truncated by erosion in several places (Figure 3). On the up-valley side of the complex, the Historic Cave East Entrance lies over massive blockfall. The cave is actually truncated by the downcutting of Python Gulley over a long period. Erosion has exposed the subaerially deposited, breccia-filled, lower part of the passage that is known as Python Gulley Cutting (Miner's Cut; Figure 3). This was mined for speleothem to within about 10 m of the brow of Historic Cave, leaving a sloping buttress on the valley side (southwest side) of the cutting, and vertical exposures of solid and loose breccia on the northern wall and on the back of the cut. The buttress represents all that remains of the original right cave wall, and its approximate height from the base of the cutting to the Historic Cave roof is about 25 m. We estimate that the height of the solutional cave passage, before blocks began to fall from the roof (technically called stoping, which is roof fall that results mainly from brittle fracture of rock to relieve stress), was about 15–20 m in this area. The negative impression of hardened breccia and remnants of speleothem suggest this miner's cut once contained large stalagmitic bosses or columns, probably over 10 m high, as well as wall-draped flowstones of varying thickness. The speleothem would have been partly eroded before mining extraction.

From the valley side, a second miners cut pierced about 3 m of the lower part of the dolomite buttress and intersected a layer of flowstone up to about 75 cm thick. The truncation of some of the flowstone layers clearly shows that they were weathered, fractured, and eroded before and, possibly, during the deposition of the superposed sediment. This is Rainbow Cave, so called because the cutting has

revealed an alternation of sloping colored bands resembling burned sandy sediments. These silty-sands have yielded MSA flakes (Mason, 1988; Tobias, 1997).

From the East Entrance, the outer right wall of the passage appears to be intact for about 60 m to within about 20 m of the lower West Entrance. Here mining excavations have revealed breccia and flowstone that points to the position of truncation by weathering of the downstream end of Historic Cave. In fact, truncation has occurred over the 60 m width of the lower mouth of Historic Cave to the Cave of Hearths and out to Hyena Cave on the downstream side. In the interior northwest cave wall of Historic Cave there are deep cracks, drafting downwards, descending to about 20 m or more that suggest that the original lower opening into the valley lies 10 m below the present externally mined floor. Natural stoping, mining debris, and talus have obscured the shape and depth of the original truncated passage cross section.

At the downstream end of the cave, the West Entrance turns 30° left to enter the Cave of Hearths (Figure 6). Unlike the interior roof where blockfall along bedding partings is ubiquitous, the lower inside corner to the CoH has not suffered rock fall and shows the original rounded phreatic solutional forms.

The outer dolomite barrier (Figures 3 and 7) of CoH is a > 50-m-long, 4-m-wide, 3–4-m-high platform parallel to the valley. It is mostly eroded naturally, though parts of it were also probably removed by the lime workers (Figure 5).

The original depth of Historic Cave is revealed by a lower cavern that is reached by going down a steep boulder climb on the outside of the true left bend from the main upper passage (Figure 3). It is an irregularly shaped cavern that appears to represent the outer part of the left bend of the original solutional passage. At its northerly end, the miners cut a 40-m-long adit to Python Gulley in order to transport massive speleothem from the center of the cavern. The miners left a 15-m-high, 3-m-diameter column as a roof support. On the east wall are remnants of hardened, winnowed, fine-grained sediment containing some bone fragments. Although the miner's excavations have obscured the stratigraphic relationship between the sediments and the speleothem, it seems likely that the sediment is the later deposit. There is a very small amount of modern speleothem deposition in the form of ribbonlike curtains on the underside of the roof and there are small modern gours. The cave ends in a crawl under breakdown from the overlying main passage.

Near the column is Equus Cutting, a 15-m-long adit made to intersect the continuation of the Python Gulley Cutting on its inner wall. The speleothem occurs only as a 2-cm-thick veneer on the dolomite and so the cut was abandoned. A piece of a horse mandible, found in the loose silty sands among dolomite clasts (P. Quinney, personal communication, 1999), was identified as probably belonging to hipparion. If the identification is confirmed, it places a minimum age for the infill of Python Valley (Miner's) cutting at 500 ka, the last appearance date of this species (Churcher and Watson, 1993). The intersected wall is overhanging and the floor falls away showing that the adit intersected the cutting some way above the floor of the latter.

On the outside of the left bend, from the upper entrance to Historic Cave to its lower entrance, are two other passages. The smaller is a 1–2-m-wide passage that

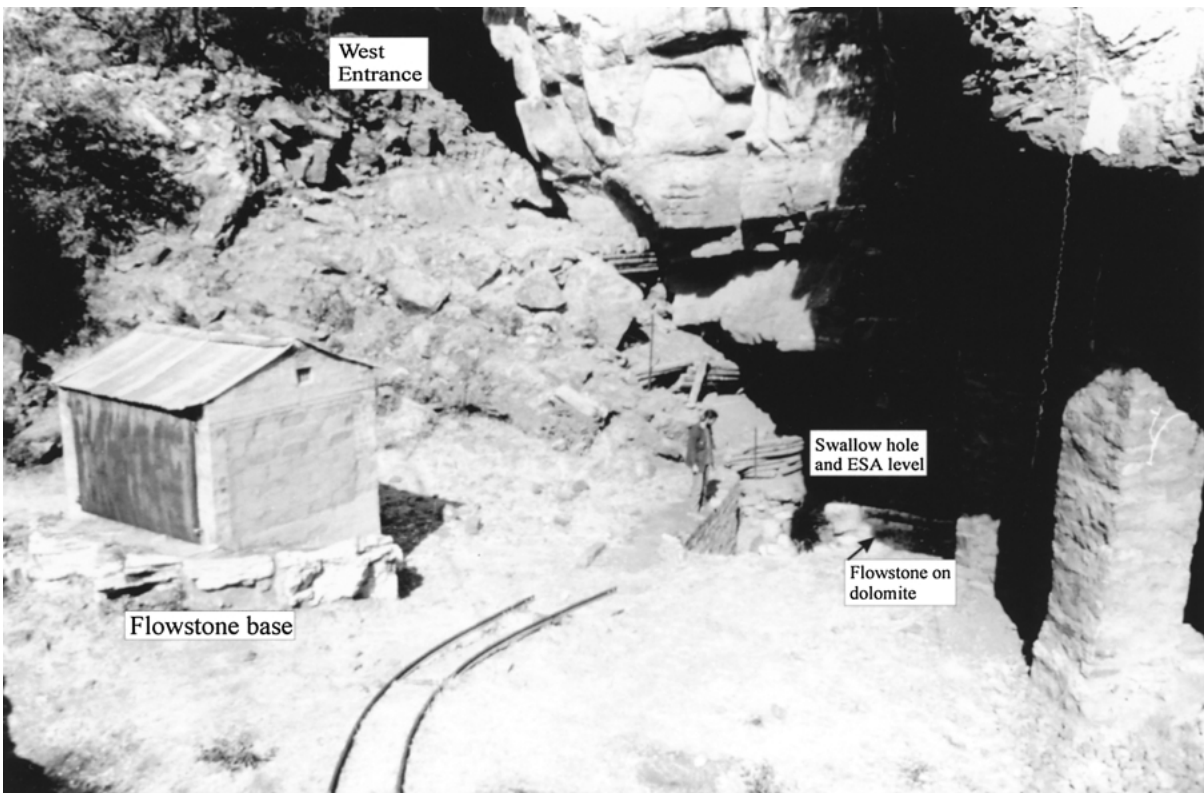


Figure 6. The junction of Historic Cave West Entrance with the Cave of Hearths. The witness section is inside the hut and lies on top of a >1 m-thick remnant of flowstones. A continuation of the flowstones, resting on dolomite, can be seen behind the second pillar above the pit. The large, blocky breccia under the West Entrance is unexcavated, but certainly has considerable archaeological potential.

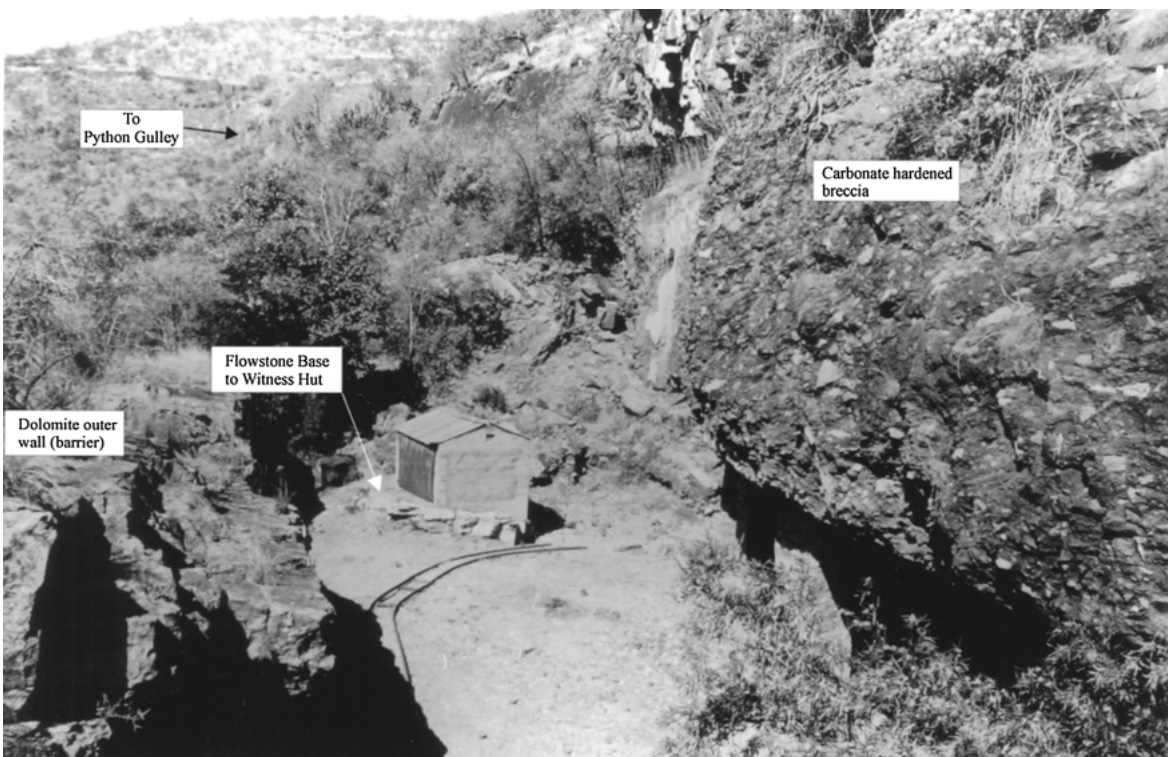


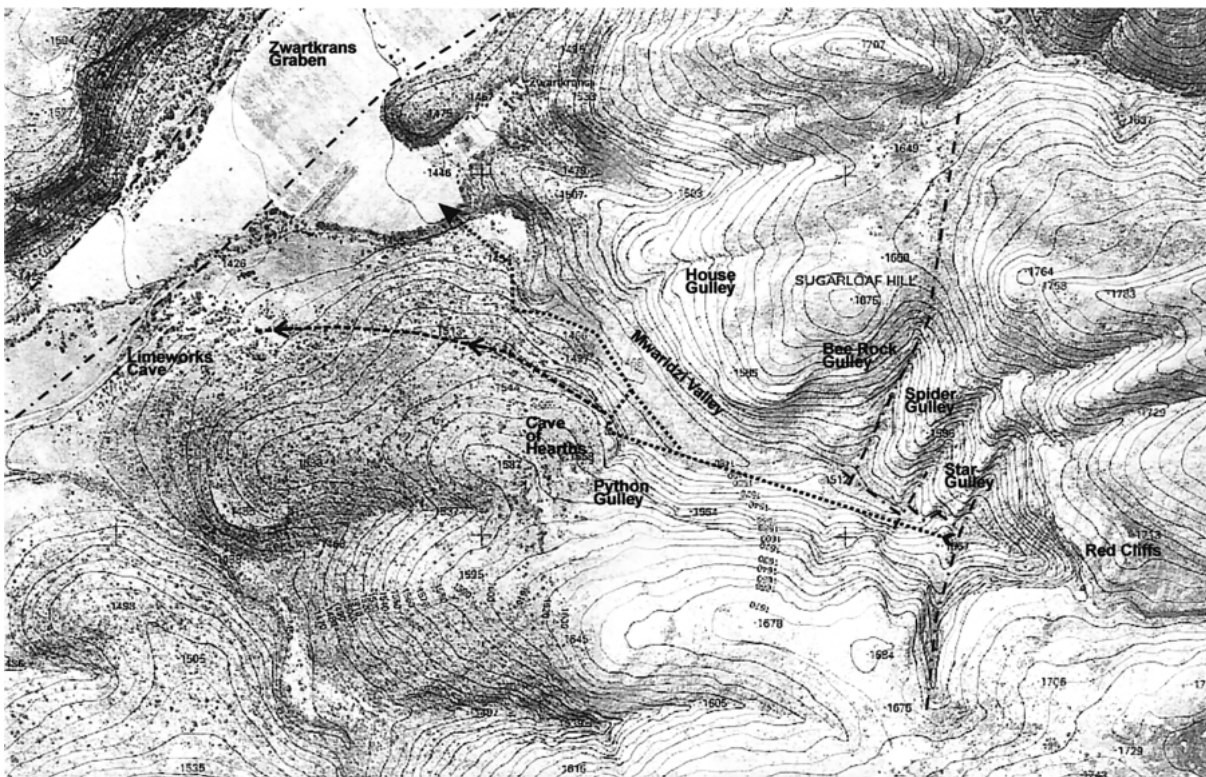
Figure 7. Photograph of the Cave of Hearths looking up-valley into Python Gulley. At the position of the arrowhead are the remains of a stalagmite column that preceded the flowstone; a piece of this column lies at the back of the hut. The floor is largely debris from the mining and excavations and lies approximately at a level that divides the upper from the lower, now hidden cavern.

barely goes 3 m to a short climb. It was formed by phreatic solution along joints, and it connects back into the second passage. The second, much larger passage, known as Bat Passage, begins as a 4-m-wide opening that, further in, contains an increasing number of small dolomite blocks. After 15 m it rises steeply up a long slope of slippery bat guano to a cavern on a cross joint. The dolomite and the chert ledges are rotting away because of the conditions created by bat feces and urine, and this has resulted in crumbly, dark gray, shale-like sediment. At the top, the cavern is about 30 m wide, 8 m high, and ends abruptly in an overhanging back wall. At the very top of the slope, a short recess at the back descends again, but is choked by flowstone, rotted dolomite, and chert debris. The size and configuration of this passage suggests that it continues on the other side of the blockage. Also at the top is a 3-m-high, 1.5-m-wide, irregularly shaped stalagmitic column that has tree roots hanging down. We observed that between yearly visits these roots have grown and multiplied considerably. New growth is evident in fresh root shoots of up to several meters long that have now reached the guano substrate. Evidently the speleothem and a tree above occur here because of a joint in the overlying dolomite. We draw attention to this feature as it is certainly analogous for several of the passage remnants seen elsewhere both in the Cave of Hearths and at the Limeworks Cave.

THE MAKAPANGSAT RIVER CAVE HYPOTHESIS

The large sizes of the Cave of Hearths–Historic Cave complex and of the Limeworks Cave, and the proximity of the caves to each other, suggest that they are remnants of a former river-cave system that occupied what is now the lower Makapansgat (Mwaridzi) valley. Figure 8 is an area map showing the position of the caves, the valleys, and some of the main local geological features, and Figure 9 is a cross-section of the Malmani dolomite from Maguire (1998). About 1 km up-valley from CoH-HC, Nettle Gulley on the south side defines a fault that has thrown down the dolomites against the Black Reef Quartzite by several hundred meters. Small streams on either side of the main valley have used the faulted zone to form gulleys. The 100-m-high nick point of the Mwaridzi stream, known as the Red Cliffs, is about 350 m up-valley from the fault. The juxtaposition of the Black Reef quartzite against the stratigraphically higher Malmani dolomite would have allowed, at sometime in the past, first contact of the Makapansgat stream with the dolomite and so initiated cave formation. It seems likely that the cave was initiated when the quartzites and shales overlying the dolomite were first breached, perhaps during middle to late Miocene times, that is, before 5.1 Ma. The Nettle Gulley has offsets and complementary faults visible on the sides of the streambed below; they account for the abrupt turns of the miniature gorges leading to the lower pools (Maiden's Pool). The fault appears to die out at the back of Sugar Loaf Hill, though the asymmetric saddle between the dolomite on Sugar Loaf Hill and the Black Reef quartzite suggests that it might continue, possibly as a flexure, into the next valley.

The existence of a Makapansgat river cave is also suggested by the gorgelike



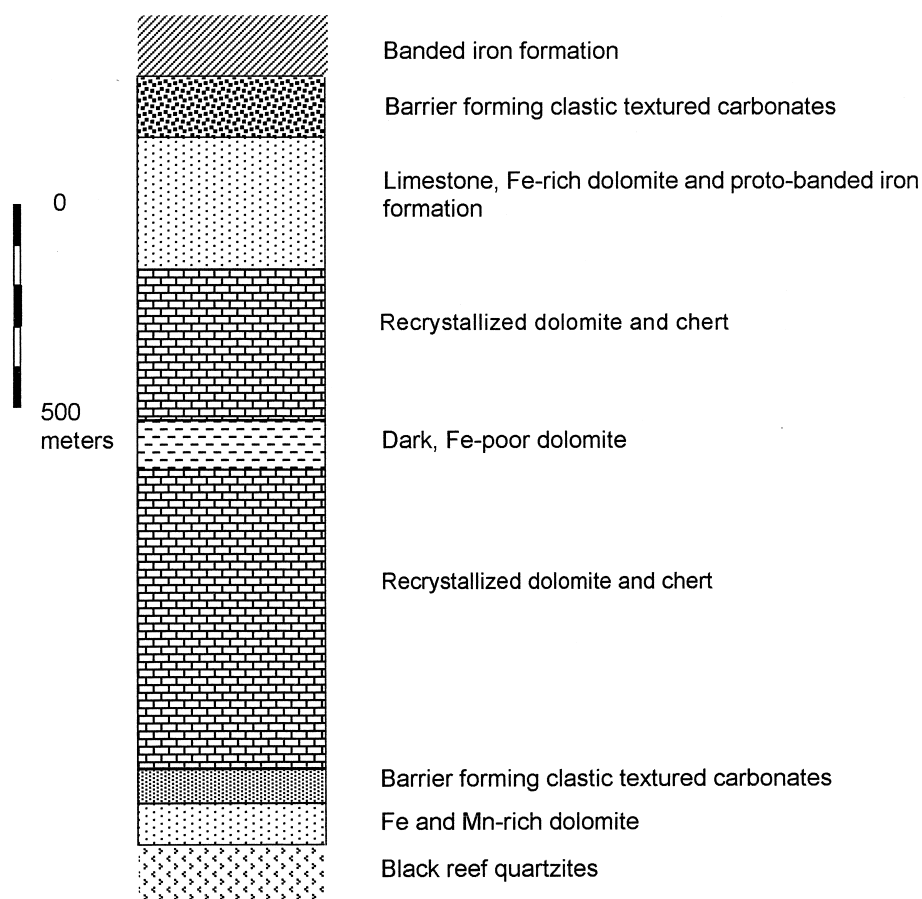


Figure 9. Stratigraphic cross-section of the Malmani dolomites and adjacent layers. The cave systems are thought to lie near the top of the lower, recrystallized dolomite band (after Eriksson et al. [1976]).

appearance of the valley. The steep sides would have formed by the collapse of most, if not all, of the former cave passage. The CoH-HC complex probably represents an abandoned oxbow to the system, and the Limeworks Cave almost certainly functioned as the approximate site of an upwelling of the cave river into the Zwartkrans valley drainage. Smaller flank streams, such as that now occupying Spider Gulley on the northeast side and Python Gulley next to HC, may have been smaller underground feeders into the system.

CAVERN SHAPE, STRATIGRAPHY, AND SEDIMENTATION PHASES

Brain (1988) suggested that hominid habitation of the CoH became possible via an opening that is now lower than the Historic Cave West Entrance. The direction

of flowstone dip in the area of Hyena Cave is into the hill and toward CoH, and, because of the depth and cover of the early flowstone coming from Hyena Cave, it would not have been possible for hominids to enter the CoH from the Hyena Cave direction. We are uncertain when carbonate layers ceased to be laid down in this area, but a U-Pb age estimate of a sample from an upper flowstone layer from Hyena Cave suggests an age between 1 and 1.5 Ma (R.A. Cliff, personal communication, 1999).

A layer of thick flowstone once formed the floor of the Cave of Hearths. The brick pillars were built on a 30-cm-thick part of the flowstone in order to prop up the breccia (Figure 10). Also, there is a gently dipping remnant acting as a platform for the witness layers and the hut, and there is a trace of the flowstone on the dolomite barrier coming down at a high angle next to the hut. Sedimentation from slope wash, later rockfall, and occupation occurred on top of this flowstone. The witness section clearly shows the disposition of this last flowstone layer as being higher at Hyena Cave than at CoH (Figure 10). The miner's drive on the inside of the rock barrier that was started from Hyena Cave shows that as soon as the miners broke through flowstone, stratigraphically from below, and into the archaeological

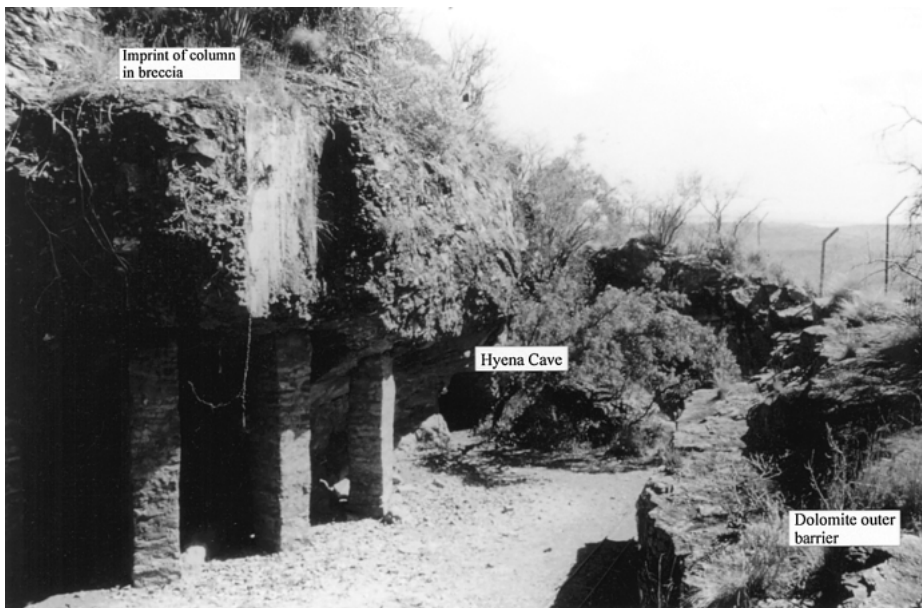


Figure 10. Photograph of the Cave of Hearths looking down valley. The brick pillars support the breccia, which itself bears the imprint of a former large stalagmite column. The top of the stalagmite flow girds the roof and is part of the column support. At the far corner on the left is the excavation into the stalagmite flows of Hyena Cave. The cocopan rails are situated approximately above the rift (neck) that leads down to the blocked-off lower cavern.

layers and breccia, they ceased extraction. The lowest layer that covers the flowstone at the outer wall is deemed by Mason to have been bat guano ("Basal Guano Beds"). It was on this flowstone that the brick hut was built as a means of preserving it and the "ash" layers. Acheulean bed 1 in Mason's notation lies on top of the guano.

The miners also broke through the flowstone layer where it dipped toward the inner wall. A negative impression in the overlying breccia (northwest breccia in the notation of Mason) clearly shows that large stalagmitic columns once formed here along the axis of the cave (that is, parallel to the walls, Figure 10). As the roof was eroding, sediment, and then dolomite clasts, accumulated on the flowstone floor, and some material has rolled down where the flowstone had sufficient dip. The inner-wall witness section shows that fine-grained sediments either flowed by creep processes or were winnowed from between the breccia flakes onto lateral extensions of the dipping flowstone.

The witness section shows that at some later time, carbonate-rich water from runoff cemented the sediments into a hardened reddish breccia (see Figures 7 and 10). The underlying 3 m of sediments are not as indurated, and they retain the color of a grey-brown, organic-rich soil. This suggests that the hardening process was related to weathering in the open, and that the upper indurated zone prevented carbonate-rich water from infiltrating the underlying sediments. The same process of calcite induration acted on the breccia in front of Historic Cave.

Bat guano was identified as the basal deposit on the flowstone next to the dolomite barrier (Mason, 1988). The existence of a bat roost at the end of the Bat Passage and deep inside other local caves shows that bats could have gained entrance to the Cave of Hearths via the East Entrance, before the creation of the present West Entrance. Owls, however, do not usually roost out of the range of light, and so the evidence of owl pellets and rodent bones in the hut witness section (de Graaf, 1988), overlying the guano, indicate that an opening had been created in the area of the East Entrance by that time. After that, the archaeological excavations show that ESA hominids began to occupy the area from the outer wall to the rear wall of CoH. Mason makes the point that the area of occupation from one level to the next higher one seems to have been determined by the position of the retreating drip line of the cave brow. The retreat of the line of occupation also occurred probably because of the danger of rock fall.

The Lower Half-Cavern

On what was the main CoH flowstones deposited? At the inner northerly witness section they were undoubtedly deposited onto the dolomite bedrock floor that partly separated the upper part of the cave from a lower half-cavern (Figure 11a and 11b). A sketch on an archived drawing in the Archaeology Department at the University of the Witwatersrand indicates that, at about the place where the copan rails run parallel to the dolomite barrier, there was a lower half to the cavern separated from the upper part by a narrow cleft. Brain (1988) noted that a part of this chimney was blocked off prior to Mason's excavations.

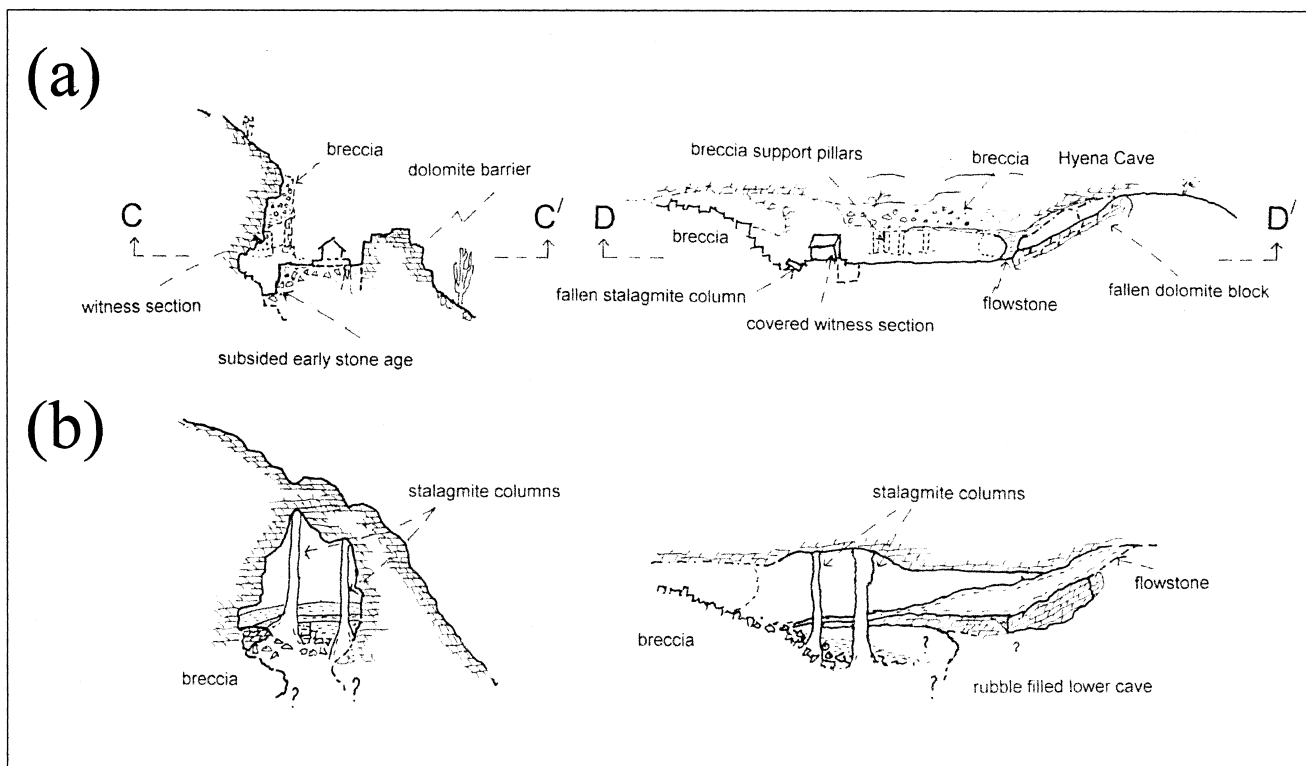


Figure 11. (a) Cross-sections taken at the eastern end of the Cave of Hearths on CC' and DD' of Figure 3, based on existing exposures. (b) Reconstruction of the same sections before the cavity was opened up to occupation by fauna and hominids (see text). Note that information is missing for the space now filled by breccia under the Western Entrance of Historic Cave (unexcavated) and the space below the Witness section to Hyena Cave section (backfilled and unrecorded).

According to Mason's (1988) account, there were already hollows under the flowstone floor and they caused collapse of the sediment, particularly near the rear wall. One normal fault was recognized in the flowstone, and it extends along the side of the flowstone on which the witness hut now stands. According to Mason's illustration and description, the archaeological sediments (ESA beds 1–3) on top of the flowstone actually dropped as a more or less intact block. A set of steps currently leads down 3 m into what remains of this "swallow hole." During Mason's excavation, further slumping occurred (Figure 4), so he felt that it was necessary to stabilize the pit by constructing a right-angled wall. It is possible to crawl behind the wall between jumbled dolomite blocks and underneath a dolomite buttress for about 3 m and to glimpse part of the backfilled lower half of the cavern.

At the hut, the flowstone is secondary to some stalagmitic columns having curtain-form sides. A piece of one of these columns lies partly buried between the hut and the breccia slope to Historic Cave. Abutment relationships between the columns and the flowstone floor, just under the grill of the hut, clearly show that the columns preceded the flowstone and, therefore, must have helped to support the latter. One or two dolomite blocks among the back-fill also have thin calcite flows running down them; hence these blocks must have preceded the flowstone.

In 1999, P. Quinney dug a shallow test pit next to the hut and adjacent to the massive block breccia below the West Entrance. This revealed (1) dolomite blocks and some original undisturbed layered sediment, (2) as mentioned above, a 2 m section of a large fallen speleothem column, and (3) the underside of the flowstone floor now filled with rubble and with an inward draft. In the area of the test pit, this flowstone floor is about 1 m thick and, as far as one can reach by arm, lacks its original substrate. The underside of the flow is smooth, and it may be inferred that, here, the flow originally lay on soft sediment that has slumped out, or has been washed out. Nearby, a fallen block of dolomite is encased in the flowstone. Unlike the rearward area, the flowstone was sufficiently thick that it did not collapse.

Based on these observations, it is clear that a considerable depth of the original cave still underlies CoH. Much of it is filled with blockfall and sediment that predates the flowstone layer, and then with the backfill from excavations.

Mason's description and diagrams show that rearward collapse of beds occurred partway through to bed 3 because of the juxtaposition of adjacent archaeological beds of different ages. The collapse meant that artefacts and bones up to MSA times were to some extent intermixed. The outer area between the dolomite barrier and a point near the inner edge of the hut remained intact, though after ESA times, there was increasing roof fall. Occupation during the MSA and later times was, therefore, confined more to the rear of the cave.

To summarize, it is apparent that the massive flowstone was deposited not only on available solid, dolomite floor rock, but also on fallen blocks and, in various places, especially toward the rear and east of the cave, onto soft sediment. It is possible that when holes appeared in the valley side underneath the dolomite barrier this unconsolidated sediment was somehow removed to leave spaces under the unsupported areas of the flowstone. The original fine-grained sediment under-

lying the flowstone probably came from the direction of Historic cave, and it appears not to have been calcified into a hard substrate.

CONCLUSIONS

The Cave of Hearths retains considerable archaeological interest because (1) there is evidence for early construction of hearths, though some of this has been contested, (2) the hominid remains are associated with *Homo heidelbergensis*, and (3) it has figured in discussions on the use of caves as a home base. This last point was the main impetus to re-examine the archaeology of the Cave of Hearths in the context of Middle Pleistocene foraging, stone tool use, and occupation behavior, and this study of site formation forms part of that reexamination.

Based on the unpublished archaeological evidence, the area of occupation of the Cave of Hearths, from the ESA to LSA, became restricted to the rear of the site. The chief excavator, Reviel Mason, and others suggested that this was consistent with a retreating cave brow. In addition, Mason found that the occupation layers had been disrupted by collapse into void space below. Clearly, therefore, these natural processes, and others, were major factors in determining both the mode of occupation and subsequent site formation. In this paper, in preparation for a new appraisal of the archaeology of this important Southern African site, we have looked at site formation as it has been impacted by cave formation, and make the following points:

1. The cave and its adjoining Historic Cave (the Cave of Hearths–Historic Cave Complex) had formed much earlier as part of a large cave system that probably included the well-known Limeworks Cave. A comprehensive cave survey was completed to accompany the discussion of the speleogenesis of the complex.
2. The subsequent development of these caves has been dominated by erosion of the roof by collapse and dissolution, infilling by surficial sediments, and the induration of breccias and sediments by carbonate cement.
3. Unpublished archives, and evidence from the so-called swallow hole of the Cave of Hearths, show that the second half of the cavern lies underneath the archaeological site, and that the two parts were partially separated by a narrow cleft and by a layer of flowstone that thinned towards what is now the proximal Historic Cave entrance.
4. During occupation in MSA times, layers at the rear of the site collapsed into the underlying cavern. The reasons for collapse are (1) the flowstone was thinnest in this area, (2) it had formed on sediment that subsequently got washed out into the lower cavern, and (3) it could not support the accumulating burden of sediment and block fall from the cave brow.
5. We concur with Reviel Mason that a substantial amount of archaeology lies buried under the Historic Cave Entrance that may include layers earlier than the Acheulian of the Cave of Hearths. As we know from the Australopithecine Limeworks site, hominids have lived in the environs for a long time. The somewhat larger area of the Historic Cave entrance may thus have the potential

for layers predating tool use. However, it would be a logistical challenge to deal with this area because it is dominated by large blockfall.

This interim report, which forms the geological background to the archaeology, will be expanded in the volume(s) of the Makapansgat Middle Pleistocene Research Project (MMPRP) edited by J. McNabb and A. Sinclair, which is currently in preparation. We acknowledge support by the MMPRP funded by the British Arts and Humanities Research Board (AHRB) to Dr. Anthony Sinclair, Liverpool University. Andy Herries acknowledges AHRB support via a studentship (1998–2002). Permission to sample was given by South African Heritage (SAHRA). The Department of Archaeology, Witwatersrand University, is thanked for permission to publish photographs from the Mason (1988) volume. We thank Revil Mason, Judy Maguire, Patrick Quinney, Anthony Sinclair, John McNabb, and Annabel Field for help and useful discussions.

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