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The archaeology of Swartkrans cave, Gauteng, South Africa: new excavations of members 1 and 4

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Declaration

I declare that this thesis is my own unaided work. It is being submitted for the degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other university.

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(Signature of candidate)

_____

Date

Abstract

Swartrkrans Cave, famous for abundant hominin fossils of *P. robustus* and the site where the first evidence of the co-existence of two hominin species was recovered, has yielded a wealth of information on early hominin behaviour. In 2005 a new program of research and excavation began at the site, and its results form the central part of this thesis.

This study has focused on the early Pleistocene Member 1 deposits which include an Earlier Stone Age industry and the late Pleistocene Member 4 Middle Stone Age deposits. The thesis has four areas of focus. First the new work has resulted in clarification and new interpretations for the formation of the hominin rich Hanging Remnant deposit of Member 1, which lacks stone tools. This extensive calcified conglomerate which spans most of the north wall of the cave is now seen as a non-homogenous unit that represents material entering from at least four avens. However, this study also established that the newly exposed central portion of the Hanging Remnant and the hominin fossil-rich northwest corner infill worked by Robert Broom in the 1940s derived from the same depositional episode. Secondly, the new excavations in the Lower Bank of Member 1 have resulted in an enlargement of the previously ambiguous Earlier Stone Age assemblage. Analysis of this new assemblage, in conjunction with recently released dating results, has now confirmed that the artefacts belong to the Oldowan Industrial Complex.

Thirdly, new excavations in the Member 4 deposit have resulted in the recovery of over 3,200 Middle Stone Age (MSA) stone tools and a clearer understanding of their context. The stone tool-bearing deposits of Member 4 are now understood to derive from a surface colluvium, rather than a cave infill. This MSA assemblage consists of a high number of retouched pieces that are dominated by steep-sided scrapers and denticulated scrapers with a near-absence of points. The technology of a variety of core types suggests a superior understanding of raw material flaking qualities by the tool makers. The limited types of formal tools suggest that the site was used for one or more specific activities, rather than for a range of activities by the tool makers. Fourthly, excavation of the deposits underlying the Member 4 colluvium has resulted in the discovery of two previously unknown hominin-bearing deposits. It is now established that what was originally called Member 4 is composed of three distinct deposits. The lowest of these is an east extension of the Member 1 Lower Bank (LB East Extension), which has yielded *P. robustus* fossils. This is overlain by a large talus cone (TCD), which also has yielded *P. robustus* fossils. The latter is capped by flowstone dated to ~110,000 years, followed by the MSA-tool bearing colluvium.

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The Archaeology of Swartkrans Cave, Gauteng, South Africa: new excavations of Members 1 and 4

by

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Chapter 1
Introduction

1.1 Introduction

Swartkrans Cave, located approximately 40km northwest of Johannesburg, South Africa (Figure 1), coordinates 26" 01' 02S, 27" 43' 24E, is one of the most important palaeo-anthropological sites in Africa. Swartkrans is situated within the Cradle of Humankind World Heritage Site (COHWHS). The area was established as a World Heritage Site based on three key historical sites, of which Swartkrans is one. However, there is a total of sixteen sites within the COHWHS that have yielded Plio-Pleistocene period fossils. Swartkrans has yielded the second largest hominin fossil assemblage and the largest collection of *Paranthropus (Australopithecus) robustus* fossils in the world. Swartkrans is the location where the first evidence of the coexistence of two hominin species (*P. robustus* and early *Homo*) was recovered. C.K. Brain's (e.g., 1970, 1981, 1993; Brain et al., 1988) work at the site from 1965 until 1986 resulted in the recovery of large fossil and archaeological samples which, because they were collected with acute regard for stratigraphy and taphonomy, provide essential context for those extinct hominins. The significance of Brain's results are revealed in the wealth of evidence reflecting hominin interaction with the environment, including: (1) the recognition that many of the hominins were collected in the cave as the prey of large carnivores (Brain, 1981, 1993b); (2) the identification of bone tools used by hominins for digging activities (Brain and Shipman, 1993); (3) the identification of burned bones from

Member 3, indicating some of the earliest known control of fire by hominins at c. 1.0 Ma (Brain and Sillen, 1988); (4) the recovery of an Oldowan artefact industry representing the second largest collection of the earliest preserved human technologies in southern Africa (presented in this thesis), followed by slightly more advanced Early Acheulean assemblages (Clark, 1993; Field, 1999), as well as younger Middle Stone Age stone tools; and (5) the most behaviorally informative collections of large mammal remains butchered by Earlier Stone Age (ESA) hominins in the subregion (Brain, 1993b; Pickering et al., 2004, 2005, 2007, 2008).

During Brain's period of research at Swartkrans much focus was directed at interpreting the cave formation and depositional processes. Because of the multifaceted formation of karst caves and the complex depositional processes present in the dolomitic limestone caves of the area, Brain's interpretations (Brain, 1958, 1976, see Brain 1993 for an evolution of the interpretation) evolved during his years of excavation at Swartkrans. Following the Member system used by Partridge (1978, 1979) for Sterkfontein and Makapansgat, the current stratigraphic sequence is divided into six depositional units. Oldest to youngest, these units are the Lower Bank (LB) of Member 1, the Hanging Remnant (HR) of Member 1, Member 2, Member 3, Member 4, and Member 5. Members 1-3 occupy the main excavated area of the site and have yielded a large faunal assemblage as well as hominin fossils of both *P. robustus* and early *Homo*. Member 4, located in the northeast corner of the site, was not excavated but a test trench through the deposit yielded several hundred Middle Stone Age (MSA) stone artefacts (Brain, 1993). Member 5 represents a much later (C^{14} dated to 11,000 years ago) deposit that contains no cultural material but has a fossil assemblage composed primarily of the extinct springbok *Antidorcas bondi* (Brain, 1993). Adding to the complexity of the

Swartkrans formation is the lack of material (such as volcanic tuffs for potassium/argon dating) for direct dating.

Chronological sorting of the depositional infills has proved difficult (Balter *et al*., 2008; Curnoe *et al*., 2001). The best accepted dates are based on biostratigraphic evidence, which, on balance, places Members 1-3 between c. 1.8–1.0 Ma. Parsing of the bovid and equid data leads some (e.g., Vrba, 1985; Churcher and Watson, 1993) to assign dates more specifically, with Member 1 at 1.7 Ma, Member 2 at 1.5 Ma, and Member 3 at 1.0 Ma. Brain (1993) provides comprehensive justification for the assigned chronological order of successive infillings at Swartkrans and corroborating evidence of their discrete natures.

Due to the methodical, detailed approach to excavation of the site by C. K. Brain, the Swartkrans assemblages continue to provide data for researchers seeking answers to questions regarding early hominin behaviour. In 1986 Brain ceased excavations at Swartkrans and since that time no field work had been conducted at the site. However, in 1993 C.K. Brain summed up his interpretation of site formation at Swartkrans with a prescient statement: "The process of discovery is by no means over and I am convinced that as further work is done there in the future, new surprises will surface, with the result that revisions of the interpretation presented here will be needed" (Brain, 1993c: 23).

1.2 Research goals

In 2005, the Swartkrans Paleoanthropological Research Project (SPRP), a new program of research at Swartkrans, was initiated. The SPRP has focused on the Member 1 and Member 4 deposits. As the research team archaeologist and the site excavation supervisor this thesis is the result of this author's work on the SPRP excavations from 2005-2009. Within the scope of the research questions of the SPRP, two objectives are the focus of this thesis:

1) Member 1: excavation of the Member 1 Lower Bank deposits with a goal of expanding the sample size of the current fossil and lithic assemblages, conduct an analysis on the newly recovered material from the earliest member of the site providing a more informed determination of the lithic industry; a re-examination of the formation processes and the relationships of the two primary components, the Lower Bank and the Hanging Remnant; and an attempt to elucidate the dates for the formation of Member 1.

2) Member 4: excavation and analysis of Member 4, with Middle Stone Age artefacts and no fauna, with a focus on: a) the analysis of site formation issues detailing the relationship of the MSA deposit to the older fauna-bearing Member 1-3 deposits; b) a typological and technological analysis of the stone tools; and c) an attempt to determine the age of the MSA industry.

The previous archaeological work at Swartkrans was always focused on the older deposits of Member 1, 2, and 3 and provided knowledge on hominin behaviour between 1.8 and 1.0 million years ago. Member 4, which Brain initially identified during his third or final 7-

year phase of work at the site, was never fully explored, as the Middle Stone Age was not the focus of Brain's research at Swartkrans. As very limited research has been conducted on the Middle Stone Age in the Cradle of Humankind region overall (eg., Reynolds *et al.* 2007; de Ruiter *et al.* 2008) this has left the area without information on a significant period in human development.

Both Members 1 and 4 are included in this work because these are the two deposits with the most critical archaeological questions. The Member 1 stratigraphy and the relationship of the two components (Hanging Remnant and Lower Bank) are unresolved. Additionally, the lithic assemblage and its designation to an industry is important on a broader scale. Does the assemblage represent only the second confirmed Oldowan assemblage in southern Africa or one of the earliest Acheulean industries on the continent? The younger Member 4 MSA deposit has previously yielded a large assemblage of MSA stone tools that prior to this work were unanalyzed. Placement of this assemblage within the broader technological context of the variable Middle Stone Age can provide insight into the capabilities of early modern humans in the area.

Members 1 and 4 represent very distinct time periods and research issues, so within this thesis the two deposits are treated independently. The excavation of the two deposits and analysis methods on the recovered material are the similar. However, the research questions are very different and thus the results are discussed separately in different chapters.

1.3 Structure of the thesis

Chapter 2 provides a review of the historical work at Swartkrans, covering from 1948 through to the recent past. The review places the work at the site in the broader context of anthropological and archaeological questions at the time. As more fossils and artefacts begin to be recovered in both South Africa and East Africa, the research questions evolved and Swartkrans played a large role in a variety of developing fields.

Chapter 3 describes the geology of the area explaining the cave formation and site formation processes. The geological formation is similar throughout the COHWHS and thus cave development followed a similar pattern at the other sites. However, site formation processes, composed of deposition, erosion, calcification and decalcification are unique for each site. Thus the focus on site formation in this work is related to Swartkrans only.

Chapter 4 covers the results of excavations and analysis of the early Pleistocene material from Member 1. This includes the stratigraphic analysis of the calcified conglomerates of the Hanging Remnant, as well as the results of the dating of the speleothem material within the deposit. This chapter also includes the results of analysis of the expanded stone artefact assemblage. It begins with a background review of the issues surrounding the early stone tool industries, the Oldowan and Early Acheulean, and then places the Swartkrans material in the correct industry. The hominin fossils recovered during the excavations are also presented and described, but it is the archaeology which is the focus of this thesis.

Chapter 5 covers the results of excavations and analysis of the Middle Stone Age material from Member 4. This includes the discovery of two previously unknown deposits underlying the MSA layer of Member 4. Also described are the stone artefacts recovered from the deposit. A review of the relevant research issues within the MSA is discussed and that is followed by the results of a technological analysis of the stone tools.

Chapter 6 is the summary and conclusions of this work. It summarises the excavations and and lithic and hominin analysis of the recovered material. This chapter also discusses future research issues related to this work.

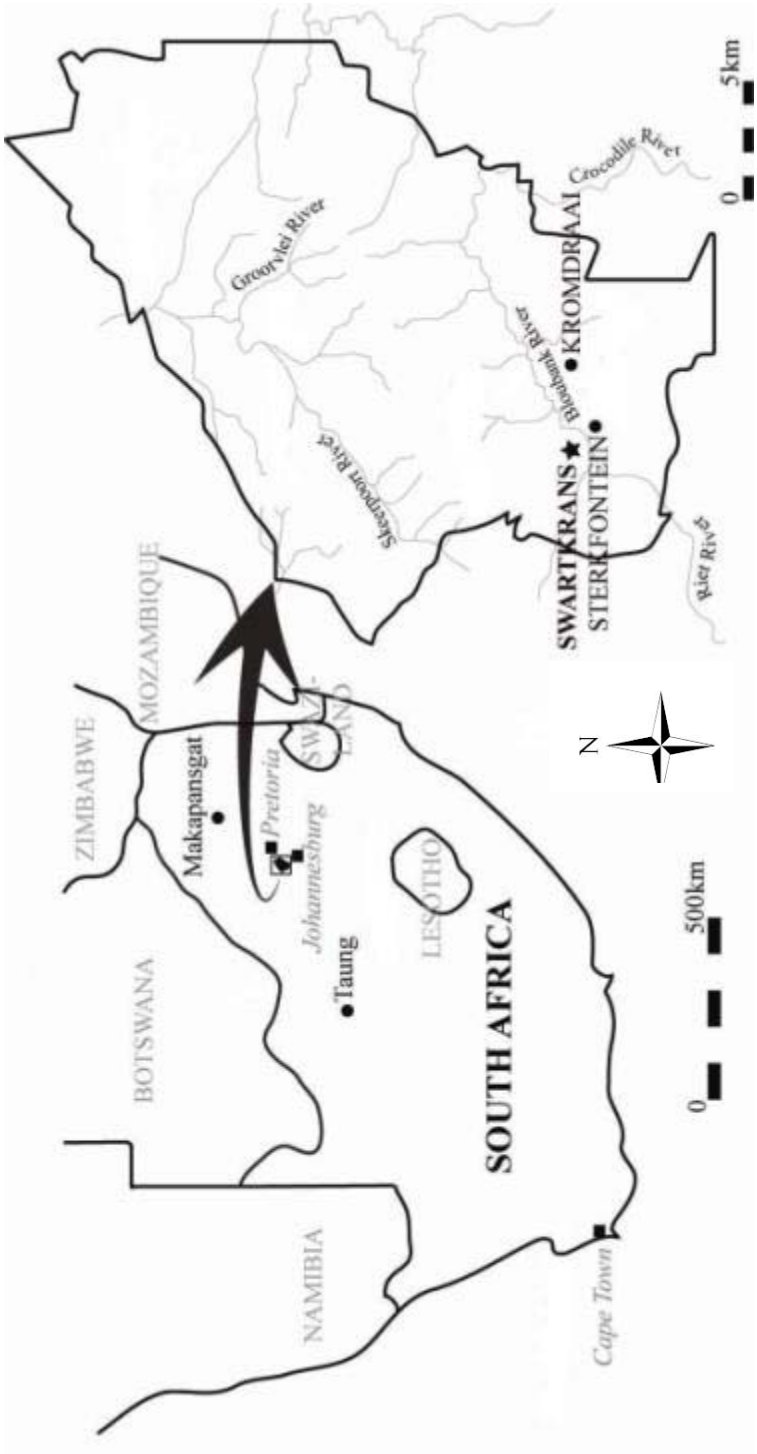


Figure 1. Map of South Africa with detail of the Cradle of Humankind and location of Swartkrans. Modified from Sutton *et al*. 2009

Chapter 2

Swartkrans, a review of the history of research

2.1 Swartkrans' contribution to our evolving interpretations of early hominins and their behaviour

The search for the fossils and artefacts that represent our human origins has engrossed mankind for centuries. The search has covered several continents and included a host of famous and infamous people and discoveries. The research into our origins crosses many disciplines and many points of view. This has led to an uneven and sometimes contentious path. Swartkrans has been central to many key discoveries and significant research since the late 1940's. The site has also contributed much evidence that has led to ongoing debates within the many disciplines. But most importantly, Swartkrans has played a vital role in helping us better understand and interpret the appearance and behaviours of two early hominins, *Paranthropus* and early *Homo*.

2.2 Broom and Robinson and the early fossil finds

2.2.1 *Paranthropus robustus*

In April 1948, with funding and impetus from the University of California's African expedition, Robert Broom and John Robinson, who had been working for over a decade at Sterkfontein, crossed the Bloubank River to the opposite side of the valley and begin

excavating the exposed hilltop cave known as Swartkrans (Brain 1981). After only a few days the project was rewarded with the recovery of a mandible (SK6) of what Broom recognized as a new species as it was more derived than *Paranthropus robustus* found at Kromdraai B also near to Sterkfontein (Broom 1938, 1949). The robust mandible, with thick enameled teeth, was clearly different from *Australopithecus africanus* recovered from Sterkfontein and, Broom believed, also different from the Kromdraai *Paranthropus* fossils due to its larger size (Broom 1949; Broom and Robinson 1952). Broom and Robinson would eventually recover a significant number of fossils that would be the basis for debates regarding separate species, but today these fossils are generally all referred to *P. robustus*.

Although there were more advanced hominins discovered earlier, the first early hominin discoveries were made in Indonesia by Eugene Dubois' in 1891--*Pithecanthropus erectus* (Java man) now referred to *Homo erectus.* Additional *Homo erectus* fossils were found in China in the 1920s. These events had many researchers looking to Asia for the origins of humans. But the fossils recovered in South Africa would shift the spotlight to the African continent. Raymond Dart's discovery of the Taung Child fossil (Dart 1925) at the Buxton Lime Works in Taung in central South Africa was the first very early hominin fossil recovered in the country. Dart would later follow that with many other fossils recovered from Makapansgat in northern South Africa. Broom, intrigued by Dart's discovery of the Taung child in 1924, was a supporter of the belief that this find stood "somewhere between the chimpanzee and man" and represented a link in the human evolution chain (Broom 1925: 414). He began his own quest for an adult missing link at Sterkfontein in

1936, resulting in dozens of fossils recovered from there, as well as at Kromdraai and Swartkrans.

The South African focus for the African continent would soon change with Louis and Mary Leakey's work in East Africa. Louis Leakey began expeditions to Olduvai Gorge, Tanzania in 1931. This endeavor would finally have rewards with the recovery of the robust hominin fossil (OH 5) in 1959. Initially believing it was distinct from the South African fossils, Leakey applied a new genus and species name, *Zinjanthropus boisei* (Leakey 1958, 1959) to the specimen. Early on there was much disagreement regarding the placement and names for the robust ape-man fossils. By the mid- 1960's it was clear that *Zinjanthropus boisei* was just a hyper-robust variant of the South African *Paranthropus robustus* fossils. Tobias' (1967) persuasive argument that Zinj was not a separate genus resulted in *Zinjanthropus* becoming *P. boisei.* Subsequently even earlier fossils were recovered from Omo (Arambourg and Coppens 1968) and were eventually classified as *A. aethiopicus*. Later more fossils were recovered from Koobi Fora in Kenya and grouped with *A. boisei*, and from West Turkana, also in Kenya, and grouped with *A. aethiopicus* (Walker 1973; Walker *et al.* 1986; Leakey and Walker, 1988) further complicating the robust relationships.

This would lead to decades long debates regarding the status of *robustus*. Some researchers (Howell 1978; Grine 1981, 1982, 1988, 1993) agreed with Broom on a distinction between the Swartkrans and Kromdraai fossils and viewed them as separate species. Grine (1993, p.107) in a re-examination of the craniodental material concluded

"the morphological and metrical differences between the Kromdraai and Swartkrans dental samples suggest that a species level distinction should be retained for *P. robustus* and *P. crassidens*". Others (Washburn and Patterson 1951; Le Gros Clark 1955; Tobias 1967) suggested the robust fossils of both Swartkrans and Kromdraai belonged in the *Australopithecus* genus. Still others (Wood and Chamberlain 1987; Wood 1988, 1992a) viewed the Swartkrans and Kromdraai specimens as belonging to the same group but distinct from *Australopithecus*. More recently, Constantino and Wood (2004) argue the southern and East African taxa of *Paranthropus* should be maintained and place the robust specimens within three taxa, *P. aethiopicus* and *P. boisei,* for the east African material and *P. robustus* for the southern African material.

The basis for the debate centered on the most distinct characteristic of *Paranthropus*, the dental remains and cranial architecture. Robinson maintained the *Paranthropus* taxon and in an extensive examination of the dentition of the fossils placed the differences on dietary adaptations. Robinson (1956, 1963, 1967) positioned *Paranthropus* as a specialized vegetarian with a diet consisting of grasses and other grinding requisite foods. Robinson's hypothesis was based on the massive, flat premolars and molars and the small anterior teeth, as well as the wear on the teeth and the architecture of the skull, which makes *Paranthropus* most suited for this type of dietary preference. These features were very different from the more gracile *Australopithecus africanus* fossils which were viewed as more generalized feeders. This separate dietary profile of the two species allowed each to fill a niche within a changing ecological landscape. The morphological characteristics of *Paranthropus* permitted it to exploit extensive vegetation present in the

Bloubank Valley during humid periods. Robinson's premise incorporated the existing view, from C. K. Brain's (1958, 1967a) work, which related the depositional processes within the caves to periods of dry and wet or glacial and interglacial cycles (discussed in Chapter 3). Robinson's theory had widespread acceptance with researchers comparing the fossil dentition with other primates and arriving at the same conclusions (Jolly 1970; Wallace 1975). (See page 35 for more recent studies that counter these conclusions.)

2.2.2 Early *Homo*

While the robust hominin debate carried on, Swartkrans was to provide evidence for another early hominin species and the emergence of a new debate regarding early *Homo*. In April 1949, one year after first beginning work at Swartkrans, John Robinson recovered a mandible (SK15) of a hominin that clearly was distinct from what had previously been found. The mandible was less robust and narrower than those belonging to *Paranthropus* but more *Homo sapiens*-like than *Australopithecus africanus*. Broom and Robinson named this new hominin *Telanthropus capensis* (Broom and Robinson 1949, 1950a) (Figure 2). Recovered from the same breccia as several of the *Paranthropus* specimens, this proved to be the first evidence of the coexistence of two hominin species. Later in that same year other fossils, two teeth (SK18a, SK43) and a radius (SK18b), were recovered which Broom felt belonged to the same species. Then in 1950 more fossils, a partial mandible with two teeth (SK45) and a maxilla (SK80) were recovered (Broom and Robinson 1950b). Though not initially called *Telanthropus*, Robinson's re-evaluation in

1953 resulted in the specimens being placed in this taxon (Robinson 1953). As with *robustus* before, the *Telanthropus* fossils would spark debate regarding their placement on the hominin tree. Not everyone agreed these new discoveries belonged in a new genus and species. Dart (1955) maintained the fossils were smaller and more gracile because they represented female *Paranthropus*. Le Gros Clark (1964, 1967) and Pilbeam (1970) argued for placement

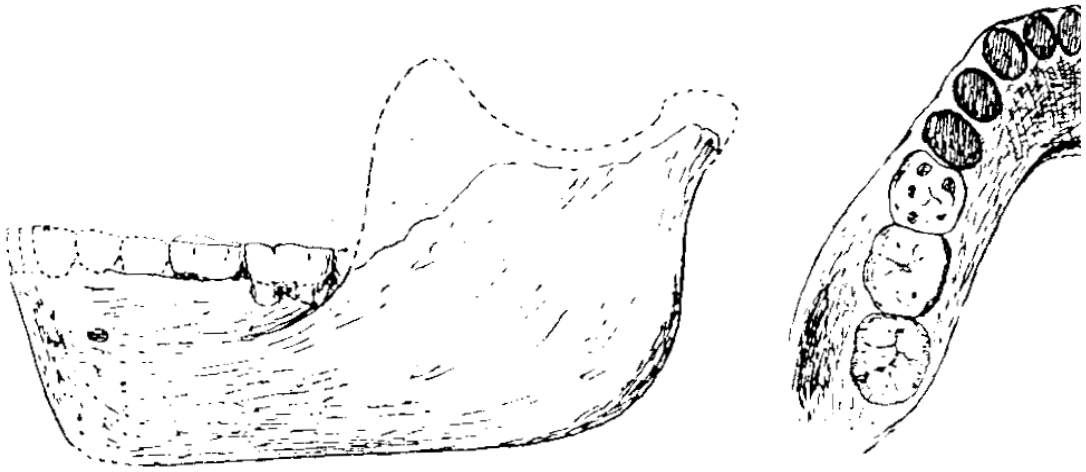


Figure 2. Side view of mandible (L) and occlusal view of teeth (R) of *Telanthropus*. (not scaled). From Broom and Robinson, 1949.

within *Australopithecus,* seeing little difference in the new fossils and existing *africanus* specimens. Later Robinson (1961) would discard the *Telanthropus* designation and assign the fossils to *Homo erectus.* Others (Howell 1967; Leakey 1963) agreed with Robinson also assigning the fossils to *Homo erectus*.

Adding substance to this debate was the continued recovery of fossils from east Africa. Fifteen years after the announcement of *Telanthropus* at Swartkrans in 1949 by Broom

and Robinson, Leakey and others proposed a new species of *Homo* for fossils recovered from Olduvai Gorge (Leakey *et al*. 1964). Fossils such as OH7 and others were placed in a new taxon, *Homo habilis*. The Leakey team felt the fossils were distinct from *Australopithecus* but with a smaller brain and smaller teeth than *Homo erectus* (*ibid*). As with most early hominin fossils, this proposal was not widely accepted. Le Gros Clark (1964, and see Wood 1992a) and Holloway (1965) argued the fossils were Australopithecines. Robinson (1965, 1966) argued that some of the fossils were *Australopithecus* but others were early *Homo* and should be placed within the *Homo erectus* taxon. Howell (1978) accepted *habilis* but stated that not all of the fossils belonged with the *habilis* species.

Then in 1969, in a remarkable piece of investigative work, R. J. Clarke while analyzing Swartkrans material at the then Transvaal Museum in Pretoria recognized SK847 as being distinct from other *Paranthropus* fossils with which it had been classified. While comparing SK847 with SK80 Clarke was able to conjoin the two, establishing that the two separate fossils were in fact part of one individual (Figure 3). Clarke *et al.* (1970) argued this now more

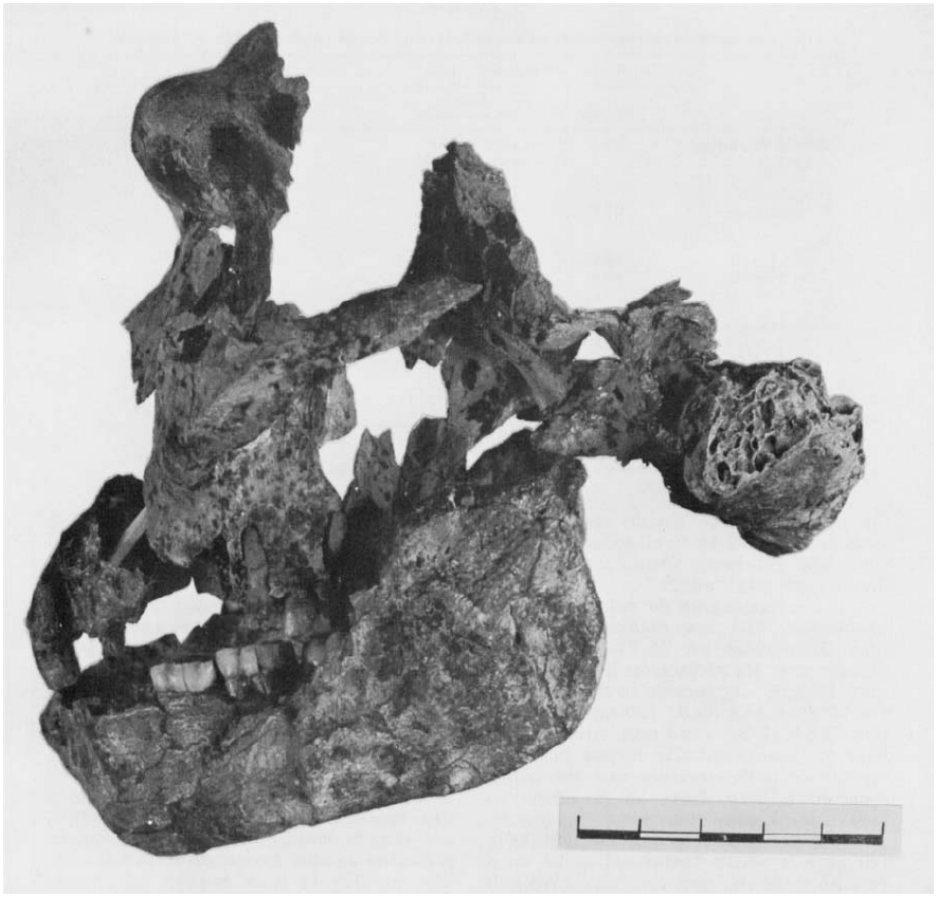


Figure 3. Lateral view of SK847 and the mandible SK15. From Clarke and Howell, 1972.

complete cranial material was early *Homo*. Although they felt the fossil, now known as SK847, was early *Homo*, they preferred leaving the species indeterminate rather than placing it within the *Homo erectus* taxon. Although it was clear the fossils did represent one individual, not everyone was in agreement that the individual was part of the *Homo* family. Wolpoff (1970, 1971) argued the fossils represented an australopithecine or small adult *Paranthropus*. Wolpoff's basis for this argument was his contention that only one species existed at Swartkrans. Clarke, along with F. C. Howell, countered these arguments (Clarke and Howell 1972), easily discounting Wolpoff's assertions, many of which were

based on photographs and measurements from those photos (*ibid*). Then Clarke provided a more detailed analysis in his dissertation (Clarke, 1977) that convinced most researchers the fossils were early *Homo*. Olsen (1978) accepted the early *Homo* classification but placed the fossils and others (SK99, SK1587, SK1588) under *Homo africanus*, which was actually the taxon into which Robinson (1972) placed *Australopithecus africanus.* Later, Howell (1978) placed SK847 with other *Homo habilis* fossils*.* After the recovery of *Homo erectus* fossils from Koobi Fora in Kenya, Walker (1981) argued SK847 was similar enough to those fossils that it must also be *Homo erectus*. Wood (1985) supported the Koobi Fora fossils as being early *Homo.* Groves and Mazak (1975) created the species *Homo ergaster* for some of the Koobi Fora fossils and Wood (1991) agreed with the placement for these specimens. Thus, many researchers today recognize SK847 as *Homo ergaster* (e.g., Clarke 1994). However, Grine and others (Grine *et al*. 1993) argue SK847 should be placed with *Homo habilis*. The problem that exists is the lack of a clear, consistent and consensus definition for early *Homo*, including *Homo habilis* and *Homo ergaster*. Both Wood (1992a) and Grine (1993) have noted this problem and attempted to establish a tenet for separating the early *Homo* taxa.

Broom and Robinson's work at Swartkrans resulted in a significantly large assemblage (n=3,600) of fossils. Though their work at Swartkrans proved to be productive, it was short-lived due to several reasons. The first year of funding was provided by the University of California, but none was provided the following year. The Transvaal Museum filled the funding gap in 1949, but by the end of the year that had run out as well (Brain 1981). More detrimental to the project, was the exposure, during the 1948-

1949 excavations, of a large limestone flowstone which had formed in a cavity beneath the north wall. During December of 1949 lime miners set up operations at Swartkrans and began removing the large flowstone. As the property was privately owned, Broom and Robinson were reduced to sorting through the breccia dumps created by the mining operator. This process was frustrating but successful as several more hominin fossils (SK48, SK23) were recovered (Brain 1981). However, Broom died in early 1951 and it was only later that year that Robinson resumed work at the site. The work continued into 1953, but most of what Robinson called the "pink breccia" had been removed so the work focused on the "brown breccia" which had a much lower density of bone. The brown breccia yielded very few fossils and in 1953 Robinson returned to full-time work at Sterkfontein, thus ending the first period of palaeo-anthropological work at Swartkrans.

2.3 C. K. Brain

In 1965 C. K. (Bob) Brain began a new period of work at Swartkrans. Brain understood the importance of properly interpreting the stratigraphy and formation processes. This attention to detail which Brain applied to the excavations ensured a more comprehensive understanding of the cave. But it also allowed him and many later researchers to reach conclusions on a host of questions regarding early hominin behaviour. Brain's pioneering and seminal research over an almost thirty year period on the Swartkrans deposits would provide a significant basis for a variety of related fields, including taphonomy, paleontology, paleoanthropology and paleoecology.

Brain's first contact with the site began in 1953 when, at the suggestion of John Robinson, he undertook a geological analysis of the Swartkrans Formation (Brain and Robinson 1953). Brain expanded his geological work to include Sterkfontein, Kromdraai and Makapansgat for his PhD thesis (Brain 1958). This work was the first comprehensive analysis on the formation and depositional processes of these hominin-bearing caves. Prior to Brain's work the only geological analysis conducted on the hominin fossil yielding caves was Lester King's (1951) research. King argued the calcite accumulations within the caves were the result of calcite dust via a recrystallisation process (*ibid*). However Brain was able to show that the speleothem formations were the result of calcium carbonate rich water percolating through the dolomite (Brain 1958) (see chapter 3 for a discussion on the cave formation processes). Employment took Brain elsewhere for a few years but he was able to return to Swartkrans after his appointment to the Transvaal Museum in Pretoria, in 1965. It was at this time that Brain began the Swartkrans Paleontological Research Project.

2.3.1 Challenging the Osteodontokeratic Culture

Brain (1981, 1993a) states one of the primary reasons for his desire to conduct excavations and research at Swartkrans was Raymond Dart's "Osteodontokeratic Culture" concept (1957). Though first published in 1957, Dart's ideas about predatory australopithecines began in the late 1940's and were included in numerous publications over an almost two decade period. The Osteodontokeratic (ODK) concept attempted to

explain the accumulating agents, skeletal part percentages and damage patterns within the fauna assemblages Dart was recovering from the Taung and Makapansgat sites. Dart felt the assemblages could not be explained by typical animal predators or scavengers. Instead he interpreted the assemblages as hominin accumulations. Dart argued the *australopithecines* were predatory implement users, occupying the caves and collecting the bones for tools and weapons. Dart first found several inward depressed fractured cranial remains of baboons and australopithecines. In searching for an answer to the possible accumulator of these bones, Dart surmised the australopithecines must have been hunters of baboons and other australopithecines. Dart eventually recovered over 7,000 bones from Makapansgat, consisting primarily of bovids, but only certain skeletal elements were represented. Dart saw this bias in preservation as a selective assemblage collected by the australopithecines. The abundance of broken bovid long bone shafts indicated to Dart that a crack and twist technique was used to create a spiral fracture that could then be used as a tool. This pointed shaft could be used for cutting, scooping, or scraping but it also provided a key component as a composite tool as a handle into which other tools (bones) could be inserted (Brain 1981). Dart's Osteodontokeratic Culture sparked much debate. Additionally, it helped to serve as an impetus for the budding field of taphonomy. A term defined by Efremov (1940, p.85) as "the study of the transition (in all its details) of animal remains from the biosphere into the lithosphere, i.e. the study of a process in the upshot of which organisms pass out of the different parts of the biosphere and, being fossilized, become part of the lithosphere". Some researchers agreed with Dart. Le Gros Clark (1957) felt Dart had sufficiently established the possible

accumulators of the Makapansgat assemblage. But he stopped short of agreeing that Dart had correctly interpreted the use of the possible bone tools. Robinson (1967) supported Dart's view that australopithecines were tool users, probably both bone and stone. Robinson (1959) furthered argued a bone tool recovered from Sterkfontein provided additional support of Dart's ODK. Wolberg (1970) in an extensive review of the ODK defended Dart. He countered the arguments presented against the ODK by Dart's detractors and then used Kitching's (1963) work at Pin Hole Cave, a Mousterian site in England, as an example of the ODK. He saw this as additional evidence that confirmed the ODK existed and in places other than Makapansgat.

Those researchers that disagreed with Dart's ODK built a large body of evidence against it. Washburn's (1957) study of modern carnivore activity at the Wankie Game Reserve (now the Hwange Game Reserve, Zimbabwe) showed that their predation and scavenging of animals results in a very selective assemblage, with skeletal representation very similar to the Makapansgat material. Klein (1975) showed a hyaena accumulated assemblage reflected the same skeletal percentages as recovered at Makapansgat. His analysis on the material from the Swartklip site in the Western Cape of South Africa established the primary accumulating agent as hyaenas. The site lacked any cultural remains, indicating no activity by humans. Instead there existed numerous burrows and hyaena coprolites throughout the cave, and yet the skeletal element percentages of the assemblage were very similar to the Makapansgat material recovered by Dart (Klein, 1975). But it was Brain's work that would provide the deathblow for the ODK. After establishing the Swartkrans Palaeontological Research Project Brain began a pioneering approach to

answering the questions regarding not only Dart's ODK but how it related to the Swartkrans assemblage. His detailed, methodological approach and extensive actualistic research would provide new insight into faunal assemblage interpretations. Brain's excavations at Swartkrans led to the recovery of over of 5,500 macrovertebrates (Brain 1983) which, along with the Broom and Robinson assemblage, he then compared to Dart's Makapansgat material. But Brain was prepared to do the necessary "background research on cave bone-accumulating agencies in African caves" (Brain 1983, p.3). In a number of publications (Brain 1967b, 1968, 1970, 1980) he showed that these element and fracture patterns could be found in non-hominin accumulated circumstances. Brain amassed his large body of evidence in *The Hunters or the Hunted? An Introduction to African Cave Taphonomy* (Brain 1983). Here he presented research reflecting a more holistic approach to finding the answer to both the accumulating agents as well as the possible source of the fractures.

Brain included evidence from bone assemblages observed and collected from hunter-gatherer groups in Namibia. As the groups' meat diet consisted primarily of goats it was easy to determine element part representation. Here he established that after human activity (butchering) followed by scavenger activity (in this case dogs, though sometimes birds and gerbils) and the natural weathering processes only the more resistant denser parts of the skeleton remain. Thus he reported the survival, in descending order, of mandibles, distal humeri, distal tibia, proximal radius and ulna and proximal metatarsals, followed by a lesser presence of other skeletal elements. Brain then did extensive research on modern carnivore dens, including hyaenas and leopards. He was able to

show that not only do these predators accumulate bones but their destructive force also results in many of the fracture patterns attributed to the ODK process, especially the "crack and twist" breakage patterns seen by Dart as a solely hominin phenomenon. The hyena evidence consisted of many limb bone shafts fractured spirally. Brain also recorded data on porcupines, eagles and owls all of which exhibit activity that can result in bone accumulations in caves. Brain's exhaustive research was able to establish that the hominins recovered from Makapansgat and the (then) Transvaal area caves (Swartkrans, Sterkfontein and Kromdraai) were not only not the accumulators, but they were part of the assemblage due to predation by carnivores. One of the most compelling pieces of fossil evidence Brain recovered from Swartkrans is fossil SK54. This partial cranium of an adolescent *Paranthropus* has two round holes in the occipital region in each parietal bone which are clearly punctured from the outside inwards. The spacing and hole diameter of these two puncture marks match the lower canines of a leopard, which is well represented in the Swartkrans deposits. Brain has suggested a scenario in which the damage was caused to the child while being transported after the consequence of leopard predation (Brain 1969).

This work and the expanding taphonomic analysis of other researchers (Binford 1981; Sutcliffe 1970, 1973; Hill 1976, 1980; Shipman and Phillips-Conroy 1976, 1977) resulted in a paradigm shift in the interpretations of early hominin behaviour. Dart's ODK concept influenced from the 1950's into the 1970's how most people viewed australopithecine behaviour. Brain's African cave research showed the impression was incorrect and the australopithecines were, in fact, prey rather than predator.

2.3.2. Fire Use

During excavations in 1984 Brain and his team recovered bone that appeared to have been burned. As the excavations continued, Brain would eventually recover 270 pieces of burned bone. The bones were recovered from numerous levels throughout almost six meters of deposit excavated from what is termed Member 3 (see chapter 3 for a discussion on cave formation). Additionally, these burnt bones were present in 23 successive 10cm levels, indicating repeated fire use (Brain 1993).

Prior to Brain's recovery of burned bone at Swartkrans, which he argued represented controlled use of fire at the site, there was dispute regarding the oldest evidence of human fire use. The best known and most accepted evidence had been the burned bones and stone artefacts, ash and hearths from Locality 1, Zhoukoudian, in China (Oakley 1954; Zhang 1985). The site also yielded *Homo erectus* fossils and was dated to between 500k and 200k years ago (Grun *et al.* 1997), although recent cosmogenic burial dating using $^{25}Al/^{10}Be$ has now indicated the lower deposits date to 770K years ago (Shen *et al*. 2009). For many decades Zhoukoudian has been noted as clear evidence of fire use by *Homo erectus.* However there has since been debate concerning the relationship between the burned material and the hominin fossils. Binford and others (Binford and Ho 1985; Binford and Stone 1986) have argued there were no actual hearths in the deposits and the bone was blackened due to manganese staining rather than being burned. More recently Weiner *et al.* (1998) have shown there was, in fact, burned bone present. But

their analysis concludes the material was primarily deposited by fluvial action and no ash was present. They state (Weiner *et al.* 1998, p.252), “Infrared spectra as well as elemental analyses showed that the clays are secondarily silicified, and the aggregates are possibly a product of the silicification process. We thus infer from the above that the carbonated apatite present in the upper part of Layer 10 is not derived from ash, and that there is no evidence for the presence of woodash in Layer 10”. The conclusion on the Zhoukoudian evidence is that the burned material cannot be shown to be in association with the hominin fossils.

In 1981 Gowlett and others (Gowlett *et al*. 1981) announced the recovery of evidence of hominin fire use at the Chesowanja site, near Lake Baringo in Kenya. The deposits contained burned clay which had been heated to several hundred degrees and was found in association with stone tools and fauna remains. Dated to 1.4 million years ago this represented the oldest evidence of hominin fire use. However this claim was also controversial. Isaac (1982) argued that red clay patches exist throughout the area and most are the result of recent grass fires. Additionally, he argued that the site formation was the result of colluvial action and thus association of the burned clay with the other material is indirect. Clark and Harris (1985) countered this assertion by arguing a lack of size sorting among the material indicates very little colluvial action. James and others (James *et al.* 1989), in a comprehensive review of hominin fire use evidence, attributes the material to natural fires or volcanic activity, noting the presence of a basalt layer less than 200m from the Chesowanja site (James *et al*. 1989, p.4). Gowlett (James 1989 in reply) argues the basalt layer is 50m higher in the stratigraphic sequence and thus could

not be responsible for the heating of the clay sediments within the site, although he does not rule out the possibility of non-cultural actions being responsible for the fires.

A second east African site also claimed to be the oldest evidence of hominin controlled fire use. Koobi Fora (site FxJj2oE) on the east side of Lake Turkana in Kenya yielded oxidised deposits that extended 10-15 cm in depth (Clark and Harris 1985). As grass fires are typically low temperature and oxidise soil only a few centimeters below the surface, the indications are that the sediments must have been heated to a higher degree. Indeed, paleomagnetic and thermoluminescence analysis conducted on the sediments suggest they were heated to temperatures of several hundred degrees. Clark and Harris (1985) propose hominins were maintaining campfires at the lake shore over 1.5 million years ago. However, when Barbetti (1986) conducted paleomagnetic analysis on two sets of samples only one set reflected magnetization readings that differed from natural heating, and he stated that no definite conclusions could be reached regarding hominin fire use at the site.

Thus it was into this on-going debate that Brain introduced evidence from the Member 3 deposits of Swartkrans (Brain and Sillen 1988). Brain conducted comprehensive replication experiments which involved burning bone at a series of temperatures and observing the surfaces, as well as microscopically analyzing cross-sections. Brain established that the recovered fossils burned condition was the result of being heated to temperatures over 300^0 Celsius. Additional work by Sillen and Hoering (1993) also supports this high temperature for the burned bone. They focused on the char content

and associated temperatures needed to reach that content percentage, and estimated a range of between 300^0 and 500^0 Celsius for the Swartkrans material. The high temperatures necessary for this condition excludes the possibility of lightening induced natural veld fires or burning trees, both of which burn at much lower heat. Additionally, as the burned fossils were recovered through 6 meters of deposit this would have required repeated high temperature fires over thousands of years.

The behavioural implications, as suggested by Brain and Sillen (1988), are that early hominins were controlling fire by one million years ago at Swartkrans. Brain (1993d) further hypothesized that the hominins were using an entrance or overhang of the cave system as shelter and were tending fires in the area. This is supported by the presence of cutmarked fauna and bone tools in the deposits along with the burned bone. Though some researchers argue the incomplete nature of the lithic assemblage in Member 3 argues against hominins sheltering within a cave overhang or entrance (K. Kuman, *pers. comm. 2007*). Brain stopped short of suggesting intentional burning or cooking of the faunal remains and instead believed the burned material inadvertently came in contact with camp fires. Brain's body of supporting evidence for the cause of the burned bone from Member 3 makes it the strongest case for the earliest human-controlled use of fire.

2.3.3 Bone tools

Brain's excavations also recovered other suggestions of hominin interaction with the surrounding environment. During the 1979 to 1986 excavations, Brian recovered 68 fossil

bones that had been used as tools. Brain recognized the appearance of the bones (polished ends that had been worn to a point) as being very similar to the large metal screwdrivers used as excavation tools in the slightly de-calcified Member 1 deposits (Brain and Shipman 1993, p.195). Again using actualistic experiments Brain was able to show these bones had been used as digging implements. Using fractured long bone shafts, Brain's team performed a series of digging tests, extracting several *Hypoxis* plants from the rocky Swartkrans hillside. Microscopic analysis of the tips of the experimental bones reflected wear patterns and scratching similar to the fossils. Additionally, the medial portions of the fractured shafts showed very little modification indicting the friction existed on the distal ends (Brain and Shipman 1993). Again, a behavioural model drawn from Brain's work suggests the hominins were using bone as digging tools, probably extracting underground plants, tubers and other underground storage organs (USOs) as part of their diet. Brain also noted the incidence of recovered bone tools was much higher in Member 3, the younger one million years old deposit, than in Members 1 and 2, suggesting a change in behaviour by early *Homo* at one million years ago.

The debates regarding bone tool use go back to Dart's ODK. It has been well known and accepted that taphonomic processes influence bone and often leave culturally similar modifications on bone surfaces (Behrensmeyer 1978; Myers and Corner 1980; Binford 1981; Bonnichsen and Sorg 1989). Additionally, it is suggested that cave depositional processes and re-working can be abrasive enough to also modify bone surfaces (K. Kuman, *pers comm.* 2009). With this understanding some researchers question the validity of hominin modified bone tools in the early Pleistocene cave sites of South Africa.

2.3.4 Stone tools

The stone artefacts from Swartkrans have received less focus than the fossil bone, but the stone tool analysis is critical in reaching a comprehensive understanding of early hominin behaviour. Brain recovered stone tools from four of the five identified Members of the Swartkrans Formation, only Member 5 has not yielded any cultural material. Member 4 yielded several hundred MSA tools which have not been analyzed until this study; the material is discussed in Chapter 5. The stone artefacts from the early Pleistocene deposits of Member 1-3 have been analyzed and placed in the Early Stone Age.

In the late 1960's, artefacts from the Early Stone Age (ESA) were still only loosely defined. It was then generally accepted that two main technological industries were present in the ESA (Inskeep 1969). The first was the Acheulean industry, found widely on both the African and European continents, and was identified by the presence of handaxes, picks and cleavers. Though the industry was typified by characteristic heavy-duty tool types, many researchers saw local variations within the Acheulean and thus different nomenclature existed. But the most common subdivisions were the Earlier, Middle and Later Acheulean (Mason 1961). The second major technological industry was often called the pre-Acheulean (Inskeep 1969) as it was clear stone tool production existed prior to the manufacture of handaxes. The definitive work by Mary Leakey on the stone artefacts of Olduvai Gorge Beds I and II (Leakey 1967, 1971, 1975) would have such a significant

and lasting impact that the pre-Acheulean became known as the Oldowan. Leakey classified the oldest deposits at Olduvai (Bed I and Lower Bed II) as Oldowan. This industry was defined by its heavy duty tools, which were choppers and other core tools, as well as some light-duty tools which were flakes that Leakey labeled scrapers, awls and burins. The lower and middle levels of Bed II were identified as Developed Oldowan A due to the presence of more bifacial working, but the primary tool types identified were awls and laterally trimmed flakes. Leakey (1971) originally saw this industry as the output of a different hominin but later suggested it could be the various adaptations of a single cultural group (Leakey 1975). The middle and upper levels of Bed II yielded true bifaces that Leakey characterized as a higher quality of biface production than the previous levels but still somewhat poorly made. Thus she saw this as the beginning of an industry that reflected the tools of a hominin with a more advanced cognitive ability than that which existed during the Oldowan. She labeled this industry Developed Oldowan B (Leakey 1971). This was not without controversy since the Acheulean was defined by the presence of 40% or more bifaces among the formal tools, which were largely core-tools in Leakey's classification scheme. Mason (1976) disagreed with Leakey's Developed Oldowan B. He analyzed the Sterkfontein Member 5 material and argued that even though it was comparable to the Middle and Upper bed II at Olduvai, the Sterkfontein deposits were not in primary context in contrast to those at Olduvai. Mason understood that the many variables influencing an artefact assemblage impacts upon tool type frequencies present within that assemblage. Stiles (1979) argued that the term Developed Oldowan should not exist as the assemblages are instead an example of early

Acheulean. Stiles (Stiles and Partridge 1979; Stiles 1980) analyzed the Sterkfontein material and, comparing it to the Olduvai assemblages, concluded that there existed little difference between the Acheulean levels and the Developed Oldowan levels. The difference that did exist was attributed to raw material rather than technological capabilities. Jones (1979) was able to show that raw material procurement had a large impact on stone tool production and could affect the end product, and later Jones (1994) showed through experimental work that curation also played a major role in typological percentages. Davis (1980) supported Leakey's classification and argued that Stiles excluded material from some of the assemblages resulting in a selective analysis sample. Additionally, Davis (1980) notes the Developed Oldowan B material has a similar range of tool types as Developed Oldowan A suggesting the biface tools were not an important behavioural change but just part of the tool kit. Gowlett (1988) found no basis for a Developed Oldowan at the Kilombe site, which he characterized as Acheulean, but stopped short of proclaiming the Developed Oldowan did not exist and instead noted that many variables influence archaeological sites. Even with the questions surrounding the Oldowan and Acheulean boundary, Leakey's classification system was generally accepted.

The Swartkrans stone tools were described by Leakey (1970) who analyzed 30 artefacts collected from the breccias dumps surrounding the main site. Leakey classified them according to her typology as belonging to the Developed Oldowan B industry. She saw similarity with the Swartkrans material, along with the Sterkfontein Member 5 artefacts, and the artefacts from Beds I and II at Olduvai. The Swartkrans dump collection did

include three handaxes, a cleaver and a pick-like tool indicating substantial bifacial working of the material. Together with the flakes, the collection did appear more like Leakey's Developed Oldowan B assemblage.

But the examination of the Oldowan would change based on the influence of Glynn Issac. Issac (1977) took a more holistic approach to interpreting early hominin behaviour from archaeological sites and encouraged others (primarily his students-- Bunn *et al*. 1980; Schick 1986; Toth 1985) to do the same. Toth (1985) would establish that flake production was the primary goal of the Oldowan knappers. The flakes were the tools and the cores and choppers were the by-product waste from flake manufacture. Many of Leakey's classifications continued to be used but the heavy–duty component (choppers/chopper cores) was no longer seen as an end-use product.

With an enhanced understanding of Oldowan technology but using Leakey's classifications, Clark (Brain *et al*. 1988; Clark 1991, 1993) conducted a more comprehensive analysis of the Swartkrans material. Brain's additional 14 years of excavations at the site had resulted in several hundred additional artefacts being recovered. Additionally, there was now a more detailed understanding of the formation processes and the relationship of the different deposits. Due to Brain's meticulous methods, Clark was able to analyze the material from each of the three Members separately (Table 1). Clark (1991, p.140) begins by stating "no difference could be discerned in the flaking methods used to produce the assemblages from each of the three Members". But he did conclude that each Member assemblage did display distinguishing

characteristics. Member 1 has a smaller range of core and flake sizes than Members 2 and 3 and an absence of bifaces. Member 2 has more evidence of bifacial flaking and has similarities with Member 3. Member 3 represents an Acheulean industry with the presence of a large diabase flake from a proto-Levallois core and a quartz spheroid. Additionally, three handaxes, a cleaver and a pick were recovered from the un-provenanced dumps, indicating the presence of an Acheulean industry at the site. Based on this and the presumed dates of the deposits, Clark (1991) placed Member 1 with Oldvuai Bed I and concluded it represented an Oldowan assemblage. But later Clark (1993) was more ambiguous in assigning Member 1 to the Oldowan. Member 2 represented a Developed Oldowan/Early Acheulean industry and Member 3 a later Acheulean industry (Clark 1991, 1993).

Artefact type	Member 1 Lower Bank	Member 2	Member 3	Total
Retouched/Modified				
Heavy-duty:				
Double side-scraper/?cleaver	__	__	1	1
core/chopper-- end	1	5	2	8
side	__	2	1	3
side & end	__	__	3	3
Polyhedrom	3	10	1	14
Sub-spheroid	__	2	1	3
Spheroid	__	__	1	1
Light-duty				
Scraper- side	1	4	__	5
end	1	2	__	3
borer	__	3	__	3
Bec	1	__	__	1
Burin (technical)	__	1	__	1
Total Retouched/modified	7	29	10	46
Modified/edge-damaged				
Flake	1	3	__	4
Flake fragment	6	__	__	6
Angular chunk	2	1	__	13
Total Modified/edge-damaged	9	14	__	23
Core: Unmodified waste				
Cores: Casual ---cobble	7	4	__	11
angular chunk	6	__	4	10
Bipolar	__	6	1	7
Disc	__	2	1	3
Biconical	__	2	1	3
Single Platform-- cobble	__	2	__	2
angular chunk	__	7	1	8
Two-platform	__	2	__	2
Three Platform	__	1	1	2
Total cores	13	26	9	48
Flakes-- end struck	15	23	10	48
side struck	6	7	4	17
fragments	226	61	12	299
Angular chunk	114	221	27	362
Cobbles	10	22	__	32
Fire-fractured	2	__	__	2
Total Cores/unmodified waste	386	360	62	808
Grand total	402	403	72	877

Table 1. Summary table of Clark's classification for the stone artefacts from Members 1-3. From Clark, 1993.

2.4 Post Brain period

In 1986 Brain ceased excavations at Swartkrans and no fieldwork was conducted at the site until the new SPRP began in 2005. But during that fieldwork hiatus, Swartkrans

continued to provide evidence and data for research into early hominin behaviour. Many of the early debates still continue and because of the rigorous excavation methods applied by Brain, many of the questions can now be answered. Additionally, due to advances in techniques, many new questions can be asked and the Swartkrans assemblages often provide the material to pursue new lines of research.

2.4.1 Dietary preference

One of the first early hominin behaviours to be challenged by scientific advances was Robinson's dietary preference hypothesis for *P. robustus*. Due to its unique dentition, Robinson and others saw *robustus* as a species filling a niche separate from *A. africanus* and early *Homo*. The later two species are seen as omnivores with a strong reliance on meat.

Sillen (1992) conducted isotope studies measuring the strontium-calcium (Sr/Ca) ratios present in *robustus* fossil bone from Swartkrans samples. In comparisons with other animals, including leopards (carnivores), baboons (omnivores—with small amounts of meat) and kudus (herbivores) the *robustus* samples fell midway between the leopards and baboons suggesting a more varied omnivorous diet than previously thought. Lee-Thorp *et al*. (1994) conducted a similar study measuring the staple carbon isotopes in tooth enamel in *robustus* samples from Swartkrans. With an understanding that the C^4 process of grasses results in higher levels of ^{13}C and the C^3 processes of trees and shrubs

favors higher levels of ^{12}C, they measured the ratios of $^{12}C/^{13}C$ in the tooth enamel. These results also reflected a more omnivorous diet for *P. robustus*.

Expanding this line of research Lee-Thorp *et al*. (2000) tested the Hunters or Hunted theme. Using the premise of dietary niche for the hominins and assuming that early *Homo* at Swartkrans was hunting, they measured the $^{12}C/^{13}C$ ratios of both early *Homo* and *robustus* fossils along with other animals. All the primates had a predominately C^3 diet, but both hominins (*homo and robustus*) differed from the other primates by showing C^4 signatures in the range of one quarter of their diet. As sedges and grass seeds (possible sources of C^4) were likely not an important component of the hominin diet, the authors surmise that grass eating vertebrates and insects provided the C^4 signature. Surprisingly, the two hominins did not differ in their ratio of C^3/C^4 indicating early *Homo* was not exploiting the environment at a higher degree than *robustus* despite the belief that *Homo* was the tool maker.

2.4.2 Behaviour

For many years the primary view of early hominins, in regards to resource procurement, was seen as similar to modern hunter-gathers (Shipman 1986). Early hominins were thought to have hunted, at least by the time (2.5-2.0 mya) of the production of stone tools. However, that observation changed in the mid-1980s. The Olduvai material from east Africa was shown by Shipman (1983, 1984, 1986) to be atypical of modern hunter-gatherer assemblages. In a through analysis of bovid limb bone shafts from Bed I at

Olduvai, Shipman (1986) established, based on the position and distribution of cut marks on the bone, that the early hominins were scavenging the carcasses. After Brain's work at Swartkrans, the view of the Swartkrans hominins had also been one of passive scavenging (Brain 1993b). The hominins were perceived as accessing meat sources after the primary predators had either moved on and/or discarded the carcasses. This was supported by taphonomic studies (Brain 1993b; Vrba 1975) showing the primary accumulating agents for the Swartkrans fauna were carnivores.

However research by Pickering *et al*. (2004) on faunal material recovered by Brain from Swartkrans Member 3 revealed a different scenario. The Member 3 deposit, dated to ~1.0 mya, may reflect a change in early hominin behaviour from the activities revealed from the older Member 1 and 2 deposits (Newman 1993). Pickering *et al*. (2004) re-analyzed the Member 3 fossil assemblage with the goal of identifying cut and percussion marks. They recognized an additional 163 bones with surface damage indicating hominin butchery activity. Also looking at position and distribution of the cut and percussion marks they showed a high percentage of the surface damage occurred along the mid-shaft of the long limb bones suggesting there was ample meat in these areas. The implications were stated: "if hominins were denied access to large mammal carcasses until after abandonment by the predators and primary consumers of those carcasses (that is, large carnivores), as the passive scavenger model of early hominin foraging implies, then the midshafts of upper and intermediate limb bones would already be defleshed at the time of the delayed access by hominins" (Pickering *et al*. 2004: 218) This

research established that, at least by 1.0 mya, hominins at Swartkrans were active hunters.

Another line of research reflecting behaviour involves attempts to interpret hominin social behaviours from an ecological approach (Vrba 1980, 1985; Foley 1984, 1994; de Heinzelin 1999). Foley and Lee (1989) proposed that evolutionary pathways were influenced by social behaviours. Dean (1987), examining dental growth patterns, showed a rapid early development for *P. robustus*. This is seen as a characteristic of environmental pressures and high fertility rates. Foley and Lee (1989) suggested that *robustus* operated in a competitive multi-male social structure. Thus *P*. *robustus*, with a high degree of sexual dimorphism and somewhat specialized diet, was categorized as living in large groups. This was based on the assumption that their primary food sources occur over larger areas and thus a higher group size reduces predation risk. "The resulting large group would consist of reproductive units with unrelated females in stable associations with a single male, but with both male and female kin present. Related males would be available for group defense against other coalitions of conspecifics, while the advantages of kin coalitions for females, reproductive assistance, and enhanced feeding opportunities, would be less immediate since these female kin would not be in close associations and thus less available for supportive interactions" (Foley and Lee 1989: 905).

Later Lockwood *et al*. (2007) analyzed *P*. *robustus* dental fossils and, based on a ranking of the dental wear stages present, suggested that the *P*. *robustus* fossils reflect a

predominance of young adult males in the Swartkrans and Drimolen assemblages. They concluded that there was a high ratio of young males among the hominins because of predation, reflecting behavioural activites similar to gorillas. This behaviour is described as young males being forced out of their natal group and needing to find their place within another group, usually by forming their own dominance over females and other males. Because of this separation activity, young males are more likely to have an extended period of time when they would be without the protection of a group (kin or otherwise). As such, they are more likely to face predation risks than older males. This hypothesis is argued for the fossil record at both Swartkrans and Drimolen, evident in a higher percentage of young males than either females or older males.

A counter to this interpretation is presented by Copland *et al*. (2010, 2011). The researchers measured strontium isotope levels of tooth enamel of Swartkrans *P. robustus* and Sterkfontein *A. africanus* fossils with a view to interpreting landscape use patterns. Strontium in tooth enamel reflects the direct levels of strontium in the food source of that animal. Using laser ablation MC-ICP-MS they measured the $^{86}Sr/^{87}Sr$ ratios of the teeth and then compared those to $^{86}Sr/^{87}Sr$ ratios present in different geological formations in the Bloubank River Valley area. The sites rest on Malmani dolomites (see chapter 3 for a geological description of the area); however due to geological formation processes several other formations developed over the dolomite within 2km of Swartkrans and Sterkfontein. The research measured the $^{86}Sr/^{87}Sr$ ratios of the dolomite as well as formations both north and south of the dolomite. The results show a marked difference in ratios for the “non-local” (off the dolomite) and the “local” (on the

dolomite) samples (Copland *et al.* 2011). When measurements were compared with the fossil tooth enamel samples the results show differential behaviour, not among the young and old males, but between the males and females. The females show movement out of the area during early growth periods while the males do not show movement. The author's conclusions infer that early hominins were exhibiting social behaviour unlike gorillas but also unlike other primate groups as well. The results suggest females were moving away from residential groups rather than males.

2.4.3 Burned bone

Brain's (1993d) work on the histology of burned bone to determine human influences was further tested by Hanson (2005). She studied fossilised burned bone from Cave of Hearths and subfossilised burned bone from Sibudu Cave, both South African sites, to test if histology could be used as a method for identifying bone burned at higher than natural temperatures. Natural brush/grass fires burn at low temperatures while controlled fires (campfires) have a higher central heat, though experimental campfire research has shown variability in temperature levels (Brain 1993d; Nicholson 1993; Hanson 2005). Thus evidence of higher temperature exposure and extended burning times suggest cultural activity, Hanson's goal was to determine if histological evidence can be used to confirm burning in recovered fossils. A key component of this study was a comparative analysis of both modern and fossil bones that had no evidence of burning with those that did. The conclusions were positive in that histology is a valid tool for identifying burning

of bone. However there are cautions due to the many variables affecting the identification of the causes of burned bone. Additionally, it is difficult to determine bone that has been burned at low temperatures for long periods of time and bone burned at high temperatures for short periods of time. A further histological analysis of burned bone from Sibudu Cave (Hanson and Cain 2007) supports using this method to identify cultural activity in the archaeological record. This line of research has shown that Brain's original work on the Member 3 material from Swartkrans is valid and suggests that the site has yielded some of the earliest evidence for controlled use of fire.

2.4.4 Bone tools

Brain and Shipman's (1993) claim of bone tool use by the Swartkrans hominins was tested by Backwell and d' Errico (2001) and d' Errico *et al.* (2001), who re-examined the modified bone specimens. Backwell and d' Errico believed the study did not consider the "contextual data (species, type of bone used, fracturing patterns, degree of weathering, bone flake morphometry, spatial distribution)" of the bones to support the tool use hypothesis (d' Errico and Backwell 2003:1560). Additionally, they saw the original study deficient in testing alternative uses or functions for the purported bone tools as well as the influence of natural processes that mimic anthropic alterations. Using scanning electron microscopy to view molds made of the bone tools, they recorded measurements of the striations and wear patterns on the surfaces. This was then compared to a reference collection which included bones altered by animals (primarily carnivores) and

natural elements. An additional data set was used to experimentally dig up tubers, scrape and pierce animal hides and dig into termite mounds (Backwell and d' Errico 2001). They argued that the results showed that the distinctive wear patterns on the Swartkrans bones recovered by Brain were replicated on the experimental bones used for digging into termite mounds. Backwell and d' Errico (2001) concluded that the Swartkrans fossil bones were modified by hominins digging into termite mounds and extracting termites. They suggested that the Swartkrans hominins supplemented their diets with the protein rich termites on the hillside.

In the course of the above study by Backwell and d' Errico identified a horncore and one bone that appeared to be, not just used but also modified by hominins. In a further study (d' Errico and Backwell 2003) involving horncores from Sterkfontein, Makapansgat and Gondolin as comparative material and including archaeological material (arrow points, awls and other items shaped by grinding), they proposed that the facet damage on the horncores and those on the bone had, most probably, been modified by hominins.

2.4.5 Stone tools

In 1999 the stone artefacts from Members 1-3 were re-examined by Field (1999). The Swartkrans material was then compared to Sterkfontein and Kromdraai artefacts. Field's research included experimental knapping of the local raw materials, allowing better interpretation of the end products found in the deposits.

Field's conclusions differed from Clark's (1993) with regards to the technological industries for the three members. Field assigned Members 2 and 3 to the Developed Oldowan/Early Acheulean based on the larger flake sizes present and the lack of *in situ* Acheulean handaxes. Member 1 was considered too ambiguous to classify and thus left as indeterminate. This has left uncertainty regarding the Member 1 assemblage and reflects a need to increase the sample size to determine if artefacts more diagnostic of the Acheulean are indeed absent, and thus to verify which industry is present in the Member Lower Bank deposits. This study will be discussed in more detail in Chapter 4 in comparison with the recovered material from the current project.

2.4.6 Dating of the deposits

Of particular interest to the new SPRP have been the attempts to determine the age of the different deposits using radiometric methods. Blackwell (1994) used ESR on tooth enamel from fossils from the Member 3 deposits. However, the results showed an age range of between >3.0 mya and 360 kya. This wide margin led her to conclude the fossils represented a mixed deposit. Younger material had become incorporated into the older deposits resulting in assemblage representing material over long expansive of time. Curnoe *et al.* (2001) used ESR on tooth enamel from three samples from the Hanging Remnant of Member 1. The results also fell within a wide age range of 2.065 mya $\pm$365 ka and 1.152 mya $\pm$213ka.

Balter *et al*. (2008) used U_Pb (Uranium/Lead) dating on tooth enamel from samples from Members 1-3. Using a method that accounts for the loss and uptake of nuclides of ^{238}U, ^{234}U, and ^{230}Th they showed that an adjustment can be made so that a more accurate date could be obtained for the age of the fossil. The advantage of this method is that it allows for direct dating of the fossils which takes environmental factors into account. Their results reflected a problematic age of 1.83±1.38 Ma for Member 1, 1.36±0.29 Ma for Member 2, and 0.83±0.21 Ma for Member 3 (Balter et al. 2008: 245).

Because enamel is an open isotopic system with the potential for diagenetic gain and loss of U and Pb, there are inherent problems with dating of tooth enamel. The results often have high margins of errors associated with the age calculations. This was especially the case in the Balter *et al.* (2008) research, where the Member 1 deposit has an acceptable age but an error margin of over 60% of that age.

Herries *et al*. (2009) applied a seriation method to dates for the Bloubank Valley sites. Looking at multiple forms of dating methods including biochronological, archaeological, palaeomagnetic, electron spin resonance (ESR) and uranium series techniques, they placed Swartkrans Member 1 at ~2.0 mya, Member 2 with a much wider range of 1.7 – 1.1 mya, and Member 3 at ~1.0 – 0.6 mya.

2.5 Conclusion

The importance of Swartkrans is multi-faceted in that it: 1) contains deposits that represent a time span that correlates with diversity in the hominin evolution sequence, 2) contains two of those hominin species which co-existed on the Swartkrans landscape for over one million years, 3) is the only hominin site in South Africa's Cradle of Humankind with good evidence of interaction with the environment—in the form of stone tools, bone tools, cut and percussion marked bone and burned bone, and 4) continues to provide answers to a wide spectrum of researchers because of the archaeological methods used for the excavation of the material.

Chapter 3

Geology and Cave Formation

3.1 Introduction

There is a need to understand the cave structure, as it relates to both Member 1 and Member 4 research issues. The development of the caves is directly related to the geological formation in the area. The geology is similar throughout the COHWHS and thus the formation of the many caves in the area is alike. Thus a general overview of the geology is discussed because it relates to the processes that occurred at all the sites. However, the depositional processes are unique for each site, as the caves have experienced periods of deposition and erosion and calcification and decalcification differentially. Thus, discussions of the site formation processes at Swartkrans Cave are unique for the site and do not necessarily describe the processes at other sites.

3.2 Geological setting

Swartkrans Cave formed in the Malmani dolomites of the Chuniespoort Group (Malmani Subgroup) of the Transvaal Supergroup. The Transvaal Supergroup is palaeoproterozoic and originated between 2658±1 Mya and 2224±21 Mya (Eriksson and Reczko 1995; Eriksson *et al*., 2001). The dolomite mineral is typically rich in Fe and Mn (up to 3% combined) (Martini *et al*. 2003: 49). Obbes (2000) estimates the carbonate sequence was

deposited between 2643 and 2520 Mya. The Chuniespoort Group is intruded with many diabase sills and dykes. The Malmani Subgroup is characterized by stromatolithic dolomite with chert interbeds. The Malmani Subgroup is subdivided into five formations: the Oaktree, Monte Christo, Lyttelton, Eccles and Frisco formations (SACA, 1980). Swartkrans, as well as the sites on the south side of the Bloubank River (Sterkfontein (partially), Kromdraai and Coopers), occur within the Monte Christo formation. The Monte Christo is the thickest of the subgroups reaching up to 700 meters. Lithologically the dolomite is light colored, recrystallised and chert -rich (Buttrick 1993). The chert-rich dolomite has experienced more karstification due to the fragmented chert horizons “being accessed by deeper penetrating fractures and fissures" (Holland 2009: 514).

3.3 Environmental setting

The landscape over the dolomite is similar to the landscape at the time sediments began entering the Swartkrans cave system. The environment today is semi -arid open grassland. Tree cover exists in close proximity to the river and tributaries creating a more riverine woodland environment in these areas. Trees also grow in the loose sediments around the avens. The loamy soil cover is very thin (<0.5m) on the hill crests and steeper slopes and only thickens to approximately 1.0m as the gradient flattens. The climate is warm, sub-humid with a mean annual rainfall of between 600-700 mm per annum (DWAF 1992). This precipitation occurs during afternoon thunderstorms in the rainy

season, which are the summer months (November – February). For the remainder of the year the area experiences no rain.

The Bloubank is little more than a stream at present. However, it was responsible for the incision of the valley that exists between Swartkrans and Sterkfontein indicating a much more prominent role in the environmental picture 2.0 million years ago. Currently, during the wet season the Bloubank is at its most active, but is still little more than ~4m across. It splits at the base of Swartkrans hill into two channels that merge approximately 50 meters downstream of Swartkrans hill. During heavy rains the river often floods it banks and provides a water source for the valley floor area. The flood plain today extends approximately 30 meters on either side of the river.

Swartkrans is located <300m north of the Bloubank River at an elevation of 1480m. The site is exposed on the south facing slope ~15 meters below the crest of the hill. The south side of Swartkrans hill has a slope of approximately 30^0. Along the southern portion of the east side of the hill are exposed vertical cliffs of manganese stained dolomite. It is from this area that the site derives its' name—black cliffs. The northern portion of the hillside has a more typical slope of between 30-40 degrees.

3.4 Cave formation

Cave formation in the area is a karst process or system. "Karst is commonly considered to be the result of the solution of carbonate rocks (referred to as "karstification"). When

infiltrating rainwater is in equilibrium with the carbon dioxide in the atmosphere (~0.035%) and the soil zone (up to a few %), it forms a weak carbonic acid (H2CO3). This weakly acidic water causes the dissolution of the carbonate minerals while circulating through a dolomitic succession. The final result is the development of open cavities and caves" (Leyland 2008: 5).

The caves of the area are the result of tens of millions of years of process. The dissolution of calcite ($CACO_3$) from the dolomite first occurred in a phreatic environment leading to breakdown within the dolomite. Eventually, caverns are formed by breakdown of roof material. Tectonic uplift, decrease in the water table, climatic changes, valley incision by rivers and possible other factors leave these closed caverns above the waterline but still closed to the surface. During this vadose zone period the dissolution continues, via rainwater, leaking through fissures or joint planes in the dolomite. The high content carbon dioxide surface runoff not only continues the dissolution process but also results in the formation of stalactites and stalagmites. Additionally, these formations often continue to the extent that larger speleothems are formed in cavities, resulting in flowstone material that can extend several meters in thickness. Eventually, the breakdown continues upwards along enlarged vertical joints to reach the surface. These openings, avens, represent the first exposure to the surface. Surface detritus then enters the aven, via erosion, resulting in the infilling process. Surface bones and artefacts enter the cave system in this manner and are deposited on the cave floor. Calcite rich water, dripping from the cave roof and from stalactites, then cements the cave floor material

(including bones and artefacts) into a calcified conglomerate (bone and/or artefact-bearing cave breccia)*.

3.5 Swartkrans formation

The interpretations of the formation and deposition processes at Swartkrans have changed as more of the cave became exposed. The initial interpretations focused on the northeastern corner of the cave as this was the area that Broom and Robinson worked as well as the starting point for Brain's excavations.

Robinson's belief was that the cave deposits contained one conglomerate (bone-bearing cave breccia) which he referred to as the "pink breccia" and a much smaller pocket infill of "chocolate breccia" (Robinson 1952). The pink breccia yielded the substantial hominin assemblage recovered by Broom and Robinson, *sans* SK15, which is the early *homo* fossil recovered from the chocolate breccia. Brain was later to identify these two deposits as the Hanging Remnant of Member 1 (pink breccia) and Member 2 (chocolate breccia). But before that became apparent Brain (1958) interpreted the formation as representing three chambers or areas that were separated by a large roof spall block that had

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*Note: *Several terms have been used for the description of the calcified cave sediments in the area. The author accepts "calcified conglomerate" as the best descriptive term and that term will be used throughout this thesis. However as breccia or fossiliferous cave breccia is most often used by researchers when referring to the calcified sediments, the use of "breccia" is obligatory. Thus in this thesis "calcified conglomerate" and "breccia" are synonymous and refer to calcified cave sediments often containing bones and artefacts.*

subsided in the northeast corner of the formation; these were the Outer Cave which was filled with pink breccia, the Inner Cave which contained the brown breccia and the Lower Cave. As Brain's work progressed and more of the cave was exposed by the clearing of miners rubble it became evident the Inner Cave and Lower Cave were, in fact, connected and formed one large area. It was also evident an immeasurable amount of erosion had taken place through the Lower Cave. Brain described it as serving "as a space through which water has passed on its way from the surface to subterranean reservoirs" (Brain 1993c: 24).

Later Butzer (1976) conducted an analysis of the deposits from a lithostratigraphic perspective and identified two separate deposits he termed Members I (1) and II (2). Member 1 was determined to be one depositional unit but was divided by Butzer into separate lithostratigraphic facies based on the matrix. These separate facies, comprising one unit, represent the natural sedimentary sorting processes that occur as surface detritus moves through the cave system. Butzer's (1976) divisions for Member 1 are:

IA is the 2m thick speleothem that formed over the large detached roof block.

IB1 is slightly stratified, clayey sand-silt material containing small to medium size clasts of surface derived dolomite. This facies represents the first surface material to enter the cave and appears to become more sorted toward the distal end of the talus.

IB2 is slightly stratified, clayey sand –slit grading toward sandy silt. It contains very small to small clasts of dolomite. The matrix is interspersed with several thin speleothem

formations, suggesting either periods of slow or non-deposition or more likely channels eroded through the matrix. Butzer suggested this bed reflected a slower deposition rate.

IC is slightly stratified sandy clay silt with very small to small sub-angular to sub-rounded dolomite. This material is overlain by the 15-40cm thick flowstone that caps Member 1 (Hanging Remnant) and serves as the base on which Member 2 rests.

While is it evident the Member 1 deposit represents one unit, the long period of deposition (possibly 10k-40k) and the distance the distal talus material traveled from the aven has resulted in lenses that are clearly distinguishable. While Butzer's "beds" within Member 1 are not necessarily recognized today they appear to represent the complexities of the formation process. Additionally, the facies correlate with the recent work by this author on the Hanging Remnant along the central portion of the north wall (see Chapter 4).

The recognition of Members 1 and 2 by Butzer and Brains' continued excavations through 1974 led to a new interpretation, by Brain (1976), of the formation process. The original aven allowed the entry of material that would fill the Outer Cave and Lower Cave (Member 1). An erosion period results in part of the Outer Cave material being eroded into a lower, still unidentified, portion of the cave. Then a later, subsequent aven allows the entry of material that forms Member 2, filling the Inner Cave and the eroded space in the Outer Cave. Thus the Outer Cave contained both Member 1 and Member 2 deposits. Additionally, it was evident that the Member 2 (brown breccia) material extended into

the Inner Cave and represented a large deposit that covered the entire central and primary portion of the site.

The identification of the Hanging Remnant portion of Member 1 clinging to the north wall of the cave and the realization that erosion episodes had created a large cavity beneath it that was filled by Member 2 led Brain to search for a counterpart to the Hanging Remnant on the floor of the cave. Subsequent excavations revealed this deposit, which was termed the Lower Bank of Member 1. The Lower Bank was primarily overlain by younger Member 2 material. This lowest deposit represented the earliest depositional period at Swartkrans, but was incomplete as portions of the deposit had been eroded away.

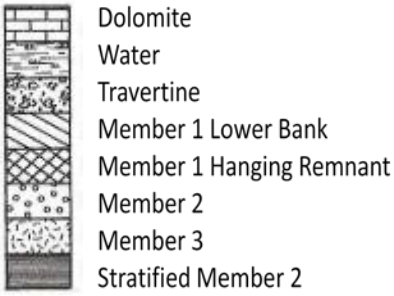
3.5.1 Current interpretation of the Swartkrans formation

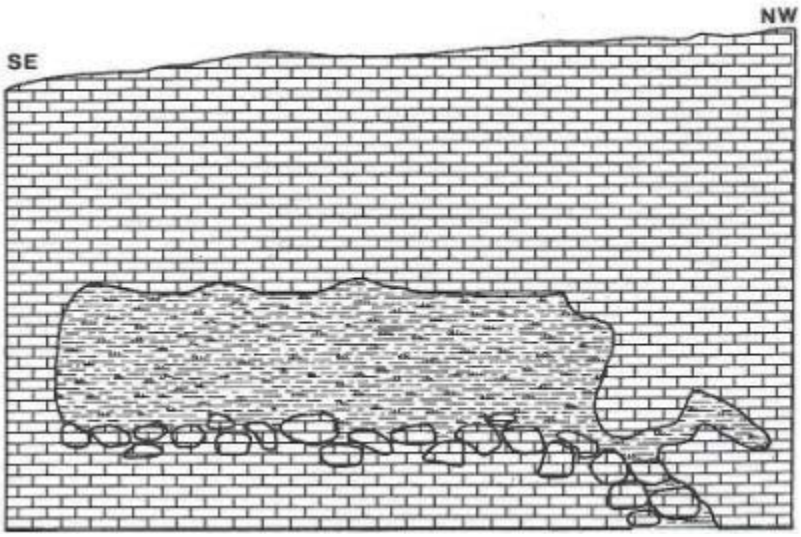
Brain's excavations continued through 1986, further elucidating the processes that formed the cave system as well as the erosion and depositional episodes that resulted in the infilling of the cave. This work led to the current interpretation of the sequence of stages for the formation of the deposits.

The following are the stages of formation of Swartkrans Cave as described by Brain. This schematic representation refers to the northeast corner of the cave and describes the formation of the cavern that Brain originally termed the Outer, Inner and Lower Cave, but later identified as the deposits of Member 1 (including the Hanging Remnant breccia

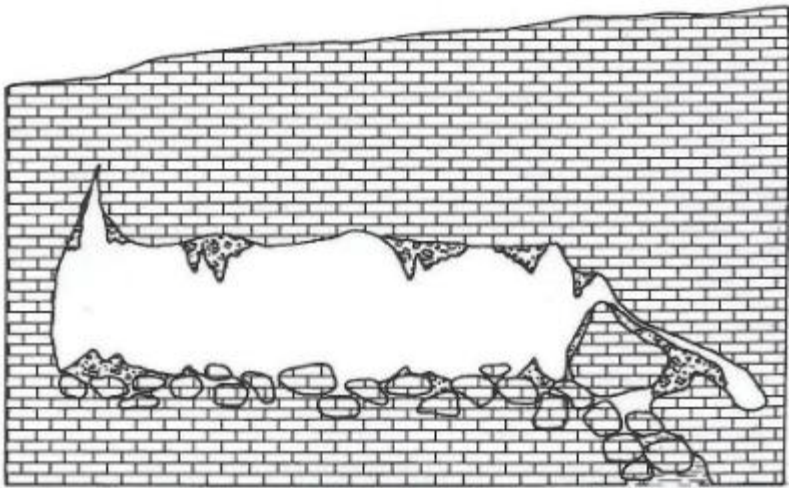
and the Lower Bank de-calcified deposits) and Member 2. Member 3, infilling much later (~1 my) is also represented in Stages 8 and 9 below.

Figure 4. Stages in the formation of the Swartkrans Cave and its geological Members, modified from Brain 1993c.

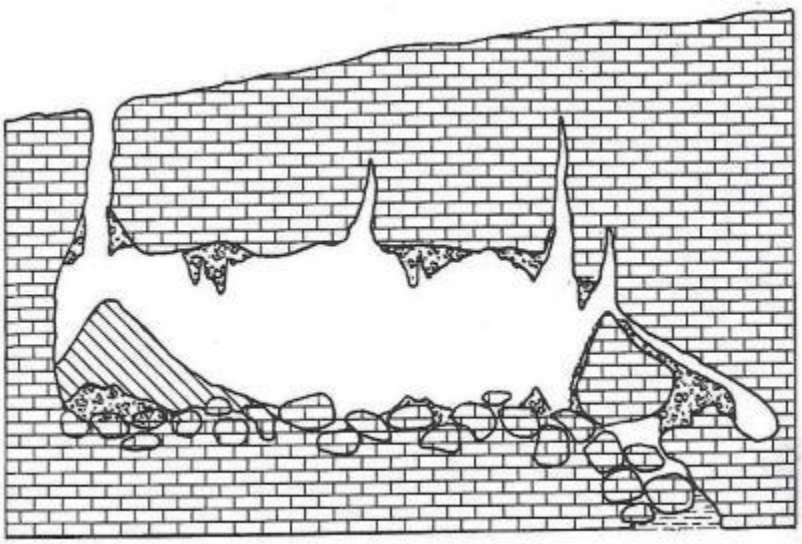




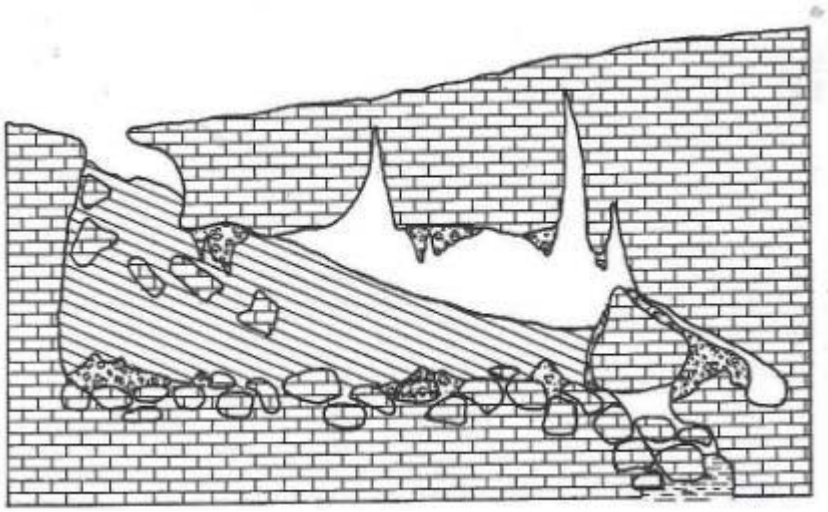
Stage 1. Probably during the Miocene, a cavern is dissolved in the dolomite well below the surface in the phreatic zone. The weak fissures or joint planes determine the extent of the breakdown of the dolomite.



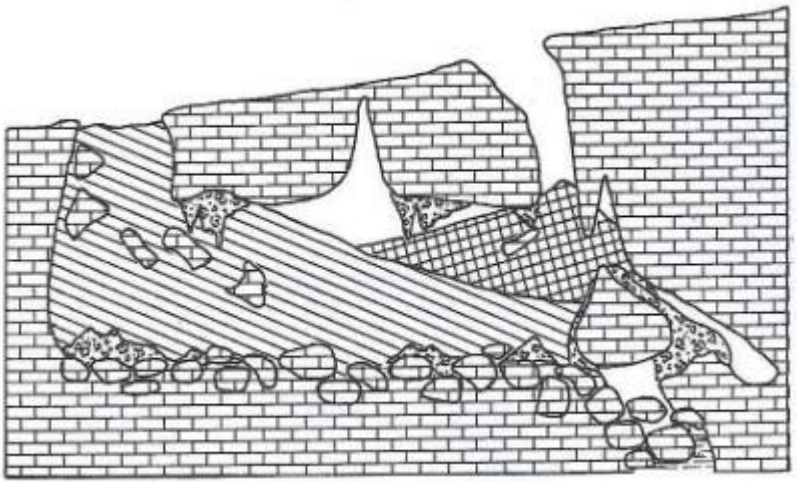
Stage 2. Uplift and valley incision lower the water table leaving the cavern in a vadose zone. A large dolomite block detaches from the roof in the northeast corner of the cavern. A prolonged period of dissolution results in the formation of stalactites and stalagmites, as well as a large speleothem which covers the roof spall block.



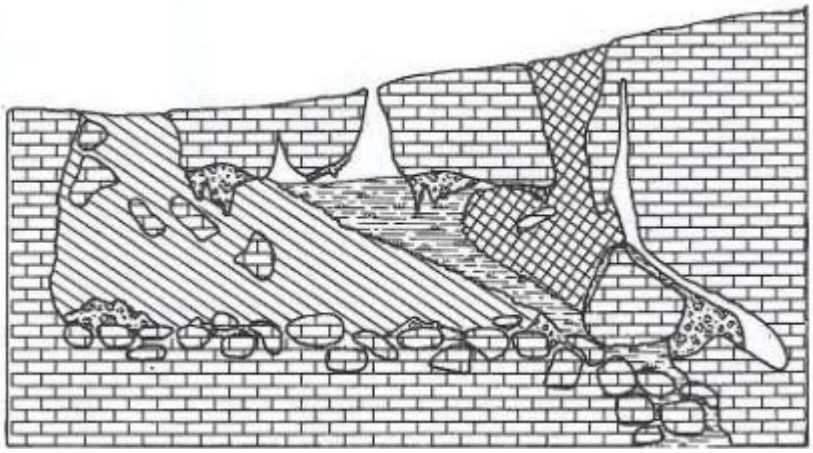
Stage 3. Dissolution along the joint planes results in an aven opening to the surface. This allows the first surface derived material to enter the cave and is identified as Member 1 Lower Bank (LB). Calcite rich water dripping onto the cave floor begins calcifying the Lower Bank sediments.



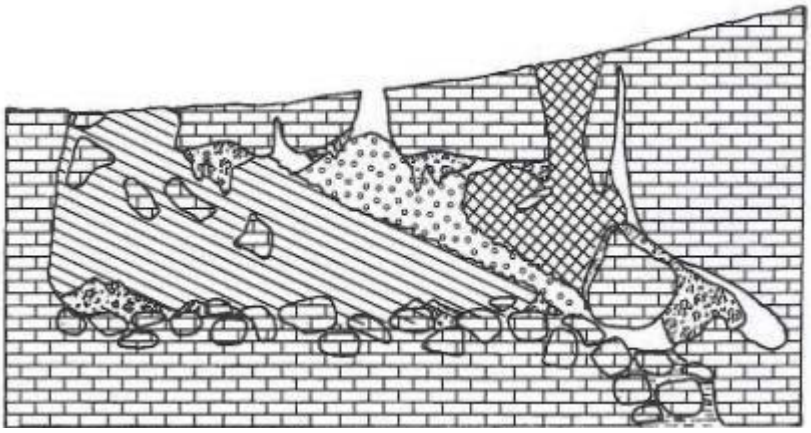
Stage 4. Lower Bank material eventually fills the aven shaft. The LB deposit remains only slightly calcified. Continued dissolution along joint planes and fissures leads to other shafts forming in the dolomite roof of the cavern.



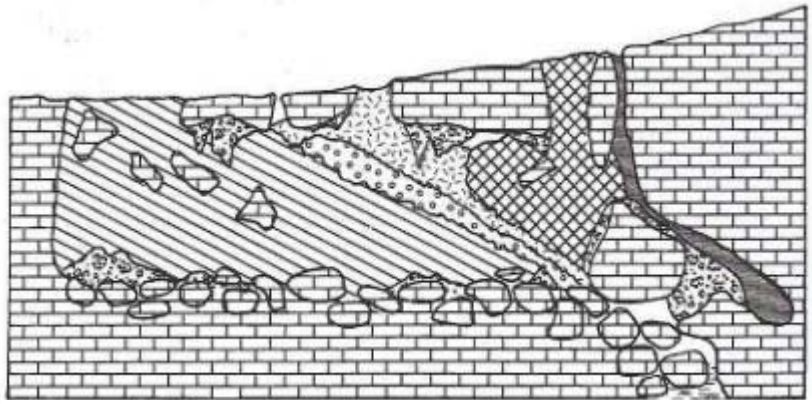
Stage 5. A second aven opens and allows surface detritus to enter the cave. This material is identified as Member 1 Hanging Remnant (HR). The HR differs from the LB in that it is heavily calcified. Additionally, the HR has a higher density of bone and greater concentration of hominin fossils, indicating increased hominin activity during the deposition of the HR.



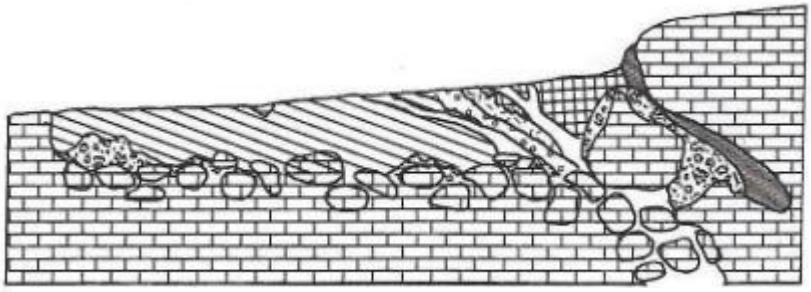
Stage 6. Other avens open and a period of erosion begins. Channels are cut into the Lower Bank deposit resulting in a gap several meters wide between the LB and HR. The eroded material filters into lower, still unidentified, caverns.



Stage 7. Approximately 1.5 mya a new period of deposition begins and surface material enters the cavity that developed between the LB and the HR. This deposit, termed Member 2, is also rich in fauna and hominin remains.



Stage 8. In addition to the primary Member 2 material covering the central portion of the site, a contemporaneous shaft collects stratified Member 2 deposits along the wall in the northeast corner of the cave. Later, another erosion episode removes some Member 1 LB and Member 2 material creating a channel near the west wall. At ~1.0 mya this channel is filled with Member 3 material.



Stage 9. Continued erosion of the dolomite lowers the hillside, eventually leading to breakdown in the cave roof resulting in the majority of Swartkrans now being exposed to the surface.

In addition to Members 1-3 which occupy the central and northwestern portion of the site two other younger deposits are contained in the cave system. Member 4 is a colluvial deposit in the northeast corner of the cave which formed on the surface rather than as an infilling, and Member 5 is an early Holocene deposit that has filled a solution pocket near the center of the site. Member 4 contains MSA artefacts but no bone and is now understood to be less than 110k years old (see Chapter 5). Member 5 has yielded no

cultural material but instead a large assemblage of fauna composed primarily of fossils of *Antidorcas bondi* which have been radiocarbon dated to 11,000 years ago (Brain 1993: 33).

Brain has stated (1993) that the depositional and erosional episodes at Swartkrans probably occurred more than the five times (Members) which are identified. However the evidence for these episodes is no longer present today. The currently reconised erosion episodes indicate material traveling to, what is today, the lowest portion of the cave and continuing to lower levels through a small (30cm) opening at the base of the north wall. This small size of the fissure does not permit exploration but it serves as the most plausible receptacle for the eroded material including the site's oldest deposits.

Besides the natural processes that formed the cave, as described above, the site was further altered through two mining episodes, the first in the early 1930's and the second after Broom and Robinson exposed the large speleothem in the northwest corner in 1948-1949. The complicated formation process was thus compounded by human intervention constraining the resolution necessary to clearly re-construct the natural and cultural activities at Swartkrans.

Chapter 4

Member 1

4.1 Introduction

The Swartkrans Paleoanthropological Research Project (SPRP) began in 2005. This multi-disciplinary, long-term project seeks to answer a series of questions relating to Swartkrans. Included among those research issues are clarifying stratigraphic interpretation concerns related to the Hanging Remnant and Lower Bank deposits of Member 1 (Figure 5) as well as resolving the chrononlogical/dating problems for the Hanging Remnant. The HR has yielded early *Homo* fossils, which in East Africa appears ~1.8 mya (Wood 1991). Resolving the stratigraphic and chronological issues of Member 1 at Swartkrans should provide valuable data for interpreting the appearance and spread of early *Homo* species in southern Africa. In addition the SPRP seeks to expand on the hominin, fauna and artefact assemblages of the Lower Bank to provide a more complete interpretation on the behaviour of these early hominins.



Figure 5. Plan view of Swartkrans Cave with detail of the Member 1 Lower Bank and Hanging Remnant deposits.

4.2 Hanging Remnant

The Hanging Remnant of Member 1 has yielded the largest hominin assemblage at Swartkrans and the largest *P. robustus* assemblage in the world. The greatest proportion of the collection was recovered by Broom and Robinson from 1948-1951. However the Broom and Robinson collection has a hominin bias as they were searching for hominins and gave lesser attention to the other fauna present. Only easily identifiable bone and elements with articulated ends were retained. One of the goals of the SPRP is to provide the palaeoecological and taphonomic contexts for this large hominin assemblage. This stated goal correlated well with a mandate recommended by the Cradle Management Authority and the permitting authority, the South African

Heritage Resources Agency. Both of the agencies mandated the removal of a large dolomite block that was positioned precariously above a 3-5cm wide fissure extending east/west across the central portion of the Hanging Remnant wall (Figure 6).

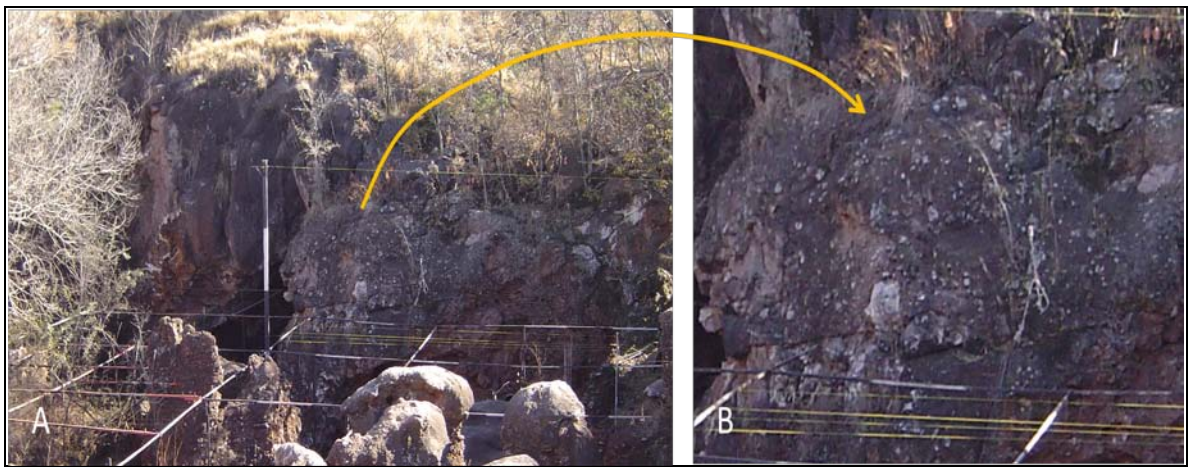


Figure 6. View of central portion of North wall (A) showing the Hanging Remnant and detail (B) of section that was removed.

In January, 2006 under the direction of John Cruise and overseen by Dusty van Rooyen both of John Cruise Mining Consultants the large block was removed. In a series of three controlled blasts of the heavily calcified sediments, several tons of dolomite and calcified conglomerate were removed from the north wall of the cave. The outsized blocks were then reduced into manageable sizes with jackhammers and hand-held tools. These blocks were sorted and then entered into an acetic acid preparation process to dissolve the calcite and extract the encased fossils. This process was first conducted at the Sterkfontein lab (2006-2008) and is now being carried out by the Ditsong Museum, Pretoria. This material will be analyzed by Travis Pickering of the University of Wisconsin and is not part of this thesis.

4.2.1 New Interpretation of Hanging Remnant formation

The removal of the large dolomite block and adhering calcified conglomerate revealed a much more complex development process for the HR than was previously understood. The exposed section is composed of several distinguishable strata of calcified conglomerate as well as two speleothem layers (Figure 7). The stratification suggests the conglomerates are not entrance talus material but instead are sediments which have been transported by water through the cave system (White 2007).

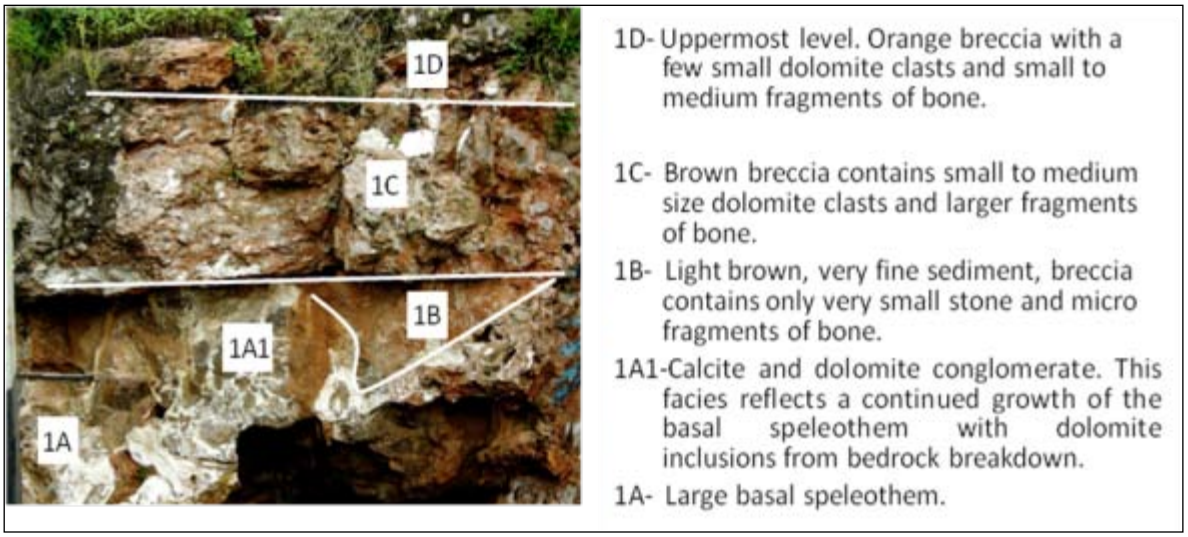


Figure 7. Exposed section of HR wall showing the different facies or layers of calcified conglomerate.

Facies 1A is a basal speleothem.

Facies 1A1 is a breccia of calcite and dolomite form internally from roof breakdown. This facies is a continuation of 1A but includes breakdown material incased in the calcium carbonate flowstone. This facies does not include surface material, indicating

composition prior to the opening in this area. Capping this facies is 10cm thick layer of speolothem that is void of breakdown material.

Facies 1B consists of only fine-grained sediments and appears to have formed as a result of slackwater action (White 2007). When stream water reaches pockets or niches it pools and as a result suspended sediments settle out of the water and form a sediment layer. This facies may also represent a period of slow alluvial action. This facies overlies an approximately 10cm thick speolothem that formed a basal layer before surface material entered the system in this area.

Facies 1C is a non-stratified, brown calcified conglomerate that contains small to medium clasts of sub-angular dolomite and larger size fragments of fossil bone.

Facies 1D is a non-stratified, light red-orange breccia composed of only small clasts of subangular dolomite and smaller fragments of fossil bone.

Facies 1C and 1D are distinct and are differentially sorted and may represent a channel type facies (i.e. sorted by transport along a channel). As they are only partially sorted and clast size disparity is only slightly divergent, they are more likely to have progressed through varying forces of movement as well as experiencing different levels of obstruction due to blockages and breakdown. Combined this section of the HR does reflect cave sorting and indicates transport of the sediments beyond the entrance talus. This formation represents material that is a distance from the aven.

If this newly exposed section is compared to the adjacent calcified conglomerate the complexity of the HR formation becomes more evident. The calcified material east of the exposed section suggests close proximity to the aven. It contains large, angular, surface weathered dolomite blocks randomly spaced in a “curtain” (Jennings 1985: 162) growth of speleothem attached to the north wall (Figure 8). This material must have entered the cave from directly above this section of the north wall, filling a wall pocket created by the de-calcification of the Lower Bank breccia. De-calcified material has less volume than calcified conglomerate and this results in pockets or gaps along the walls. Thus the central section of the HR contains material that represents infills from two different openings or avens.

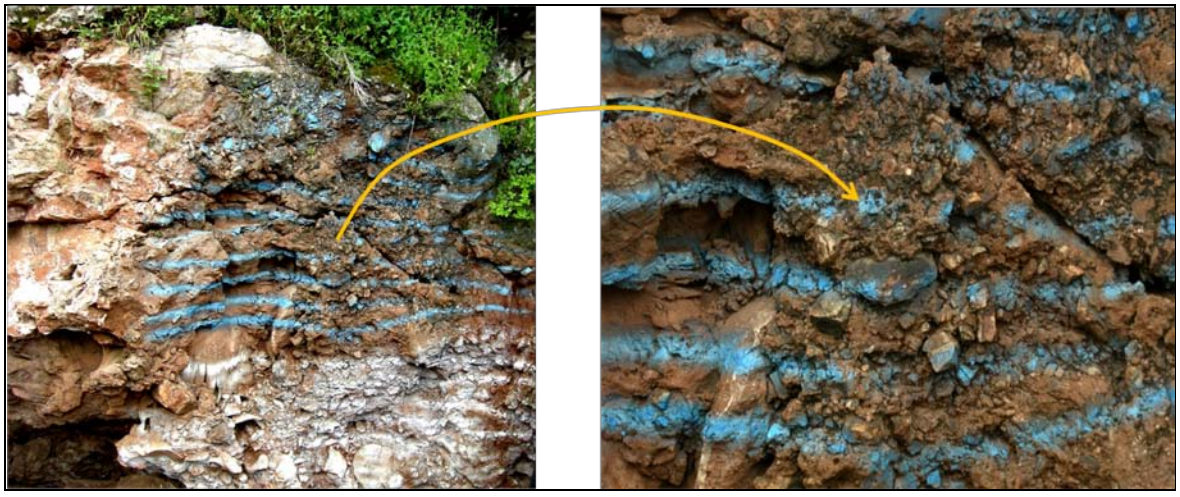


Figure 8. View of HR calcified conglomerate adjacent and east of newly exposed section (seen on far left).

An examination of the entire remaining Hanging Remnant along the north and west wall of the cave reveals two other areas where calcified conglomerate adhering to the wall

of the cave reflects entrance material (Figure 9). This type of material signifies close proximity to an aven (Figure 10) that would have existed in the now eroded cave roof.

Each of these possible avens allowed surface detritus to enter pockets that existed near the cave wall and do not seem to have extended further into the cave. The material along the west wall is similar to the conglomerates adjacent and east of the exposed section. It is composed of large angular, surface weathered dolomite blocks randomly spaced in the curtain speleothem.



Figure 9. Photos of two areas [(A) along the west wall and (B) near the northeast corner] of the HR calcified conglomerate that entered the cave system from separate entrances than the primary material that yielded the large hominin assemblage.

However, the material near the northeast corner of the cave, while representing a separate facies is clearly an isolated, localized infill. In this area there is enough evidence to re-create the sequence of events leading to the formation. The cavern was created by the dissolution of the calcium carbonate as described in chapter 3. Post this process a large dolomite block detached from the cave roof and collapsed into this lower cavern. Following this, a period of heavy dissolution resulted in the formation of a

large speleothem on top of the roof spall dolomite block. This action essentially sealed the lower cavern from the surface. However surface detritus enters above the speleothem and becomes calcified, resulting in bone-bearing breccia forming above the block. This natural process was then altered even more during the first mining operation in the 1930's. Lime miners removed the speleothem leaving a cavity beneath the calcified conglomerate clinging to the upper part of the wall. The effect of these activities left the HR section in this area resembling the west wall material, resulting in a homologous appearance for the entire north wall of the cave.

In addition to the separate formation process for the material in the northeast corner, the conglomerate is also distinguishable by facies. The acid-prepared samples demonstrate a conglomerate that has a higher degree of calcification, is more consolidated and contains less bone than the other conglomerates.

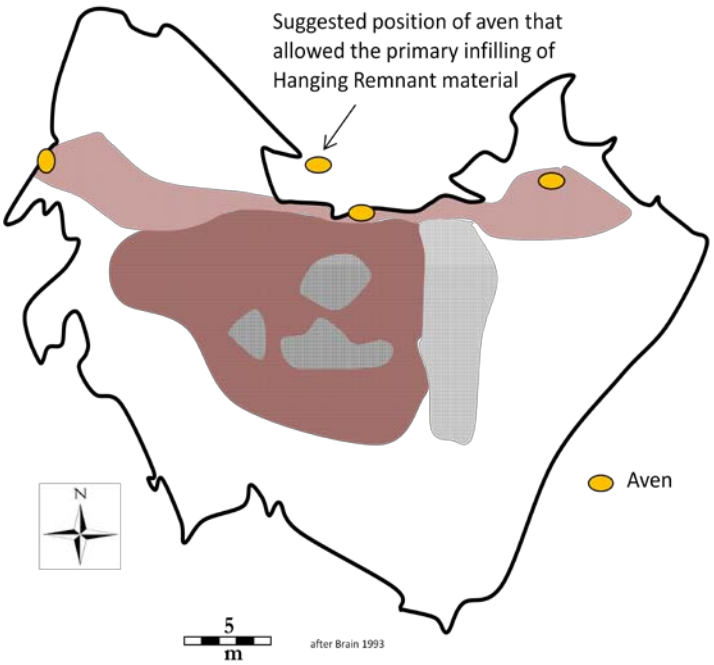


Figure 10. Plan view of Swartkrans showing the probable locations of avens for the Hanging Remnant breccias along the north and west walls. The distinguishing breccias indicate the existing HR material is not one homogenous unit.

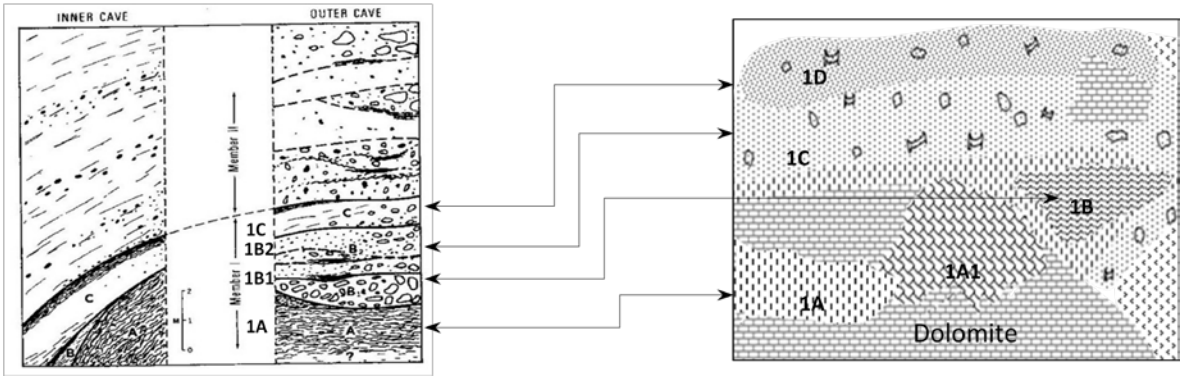
4.2.2 Implications of the new interpretations

The identification of multiple facies and conglomerate types within the Hanging Remnant formation establishes the HR is not a single unit and is instead composed of material that represents at least four different avens or entrances into the cave system. As the HR is not a single infill, this creates an untenable position on the SPRP to address one of its' primary questions related to the HR deposits. The SPRP goal, with the HR material removed from the north wall, was to establish a valid *in situ* taphonomic subset of fauna to supplement the large hominin assemblage. This hominin assemblage was recovered from the northwest corner by Broom and Robinson but except for a small (3m x 2m) section clinging to the west wall all the material was removed by the miners. This left a void between the central section of the HR and the Broom and Robinson section and there is now no clear lateral connection between the two. This discontinuity has been overlooked due to the belief the HR unit represented a single infill. The new interpretation now establishes that the HR is not a single infill. Thus the newly processed material from the block removed along the central north wall may not be related to the material that yielded the hominin assemblage, making any faunal comparison invalid. To address this problem two additional lines of analysis have been initiated for this study; a comparison of the stratigraphic profiles and radiometric dating of speleothems from each area.

4.2.3 Stratigraphic comparison of northwest corner and central section of the HR

Butzer (1976) conducted a lithostratigraphic analysis of the Swartkrans deposits after Brain's excavations had cleared the central portion of the site. Butzer's analysis was focused on the northwest corner of the cave and included Members 1 and 2. The view at the time was an inner and outer cave and he made some distinction between them, but the primary focus was on the outer cave material of Members 1 and 2. Butzer's stratigraphic profile (see chapter 3) included four "beds" or separate facies of material; a basal speleothem and three calcified conglomerates. Each of them was described in detail with distinctions being made based on the composition of the matrix material. A comparison of Butzer's profile with the current interpretation is seen in figure 11. The basal speleothem (1A) exists in both sections. Butzer's 1B1 and the current 1B are disparate. Butzer suggested 1B1 represented a period of rapid accumulation while 1B represents a pooling of water that suggests slow colluvial action. However Butzer's suggestion of rapid accumulation was based on the absence of flowstone interlaminations, which is tenuous. Secondly, rapid water flowing through channels in the northwest corner could result in side or niche channels accumulating pooling water. 1B certainly represents slackwater accumulation; however this can often result from a rapid flooding of primary channels. The flow is pushed into secondary areas which pool as the primary channels clear. Facies 1B is positioned >1m higher in the cave than the area of 1B1, which would also explain water pooling in the central portion of the cave. As the primary channel erodes through the lower northwest corner, slackwater is trapped in the higher area of 1B resulting in the accumulated sediments. Additional

evidence that reinforces the association of the two facies is that 1) both represent the first entry of surface material that formed the HR deposit, and 2) both are overlain by a 5-10cm wide lateral flowstone. Thus, though the two facies are not characteristically analogous they most likely represent the same depositional episode.



Butzer 1976 northwest corner | **Sutton 2012 central section**

1C	Light reddish poorly sorted sandy-clay-slit subangular to subrounded detrutus with abundant microbone. Grades to sand near the top	**1D**	10R 5/6 light red, poorly sorted, sandy silt subangular to subrounded dolomite and chert small fragments of fossil bone
1B2	Reddish brown poorly sorted sandy silt angular granule-to-gravel dolomite debris with bone fragments.	**1C**	5YR 5/4 reddish brown, poorly sorted, sandy silt angular to subangular very small to small dolomite and chert clasts with small bone fragments
1B1	Reddish brown poorly sorted sandy silt mass of angular gravel-to cobble dolomite rubble occasional bone	**1B**	5YR 5/4 reddish brown silty sand with only very small clasts of rock and micro fragments of fossil bone
1A	Basal travertine in excess of 2m thickness.	**1A, 1A1**	Basal speleothem, upper portion includes dolomite breakdown forming true breccia.

Figure 11. Hanging Remnant facies comparison showing the strong correlation between the northwest corner (Butzer 1976) and the central portion of the north wall (current study).

Facies 1C and 1D of the current interpretation provide further support for the lateral association of the two areas. Facies 1C and facies 1B2 from the northwest corner are

both reddish brown, poorly sorted, sandy silt and contain/contained small to medium clasts of dolomite and chert interspersed with interbedded recrystallized flowstone material. Facies 1D and facies 1C from the northwest corner are both light red, poorly sorted, sandy silt with subangular to subrounded very small to medium dolomite and chert. Additionally, both contain a high percentage of microfauna.

Though the hominin fossil bearing material of the Hanging Remnant from the northwest corner no longer exists, the methodical excavation processes maintained by Brain and the detailed analysis by Butzer provide the current study with enough data to make a comparison with the central portion deposits. The result of this comparison of the two profiles indicates a strong correlation between the material that yielded the large hominin assemblage and the newly exposed central portion of the HR.

4.2.4 Dating of the speleothem material

A program of radiometric dating was initiated by the SPRP in 2009. The program has two primary goals; 1) to assist in determining the relationship of the two areas of the Hanging Remnant along the north wall and 2) to clarify the age of the Member 1 deposits. The first stage of this program involved Uranium series disequilibrium dating.

Due to the regional absence of Plio-Pleistocene volcanic activity it is not possible to provide absolute radioisotopic ages using methods such as K-Ar and Ar- Ar; as is done at East African hominin sites (Sarnawojcick 1985). Thus, in the past Swartkrans researchers

relied primarily on faunal comparisons with absolutely dated stratigraphic layers from East African sites. Those faunal comparisons generally placed Members 1 – 3 of the Swartkrans Formation between 1.8 – 1.0 Mya, with some specific research on bovids and equids (e.g., Vrba, 1985; Churcher and Watson, 1993) assigning more exact estimates of 1.7/1.8 Mya for Member 1, 1.5 Mya for Member 2 and 1.0 Mya for Member 3. As noted in Chapter 2 attempts have been made to apply radiometric dating methods to the Swartkrans deposits using tooth enamel (Blackwell 1994; Curnoe *et al* 2001). But these resulted in, at best, only limited success.

In contrast to enamel, inorganic carbonates, such as speleothems, behave as closed systems and thus provide much more reliable dates. The U_series decay process has long been known as a dating technique, first on sediments (Smith and Farquhar 1989) and later on calcite material (Kenneth 1992; Ludwig *et al*. 1992, Richards *et al*. 1998). The decay of ^{238}U to ^{206}Pb allows for dating of material millions of years old. However, Richards *et al*. (1998), using speleothem material, demonstrated the method can be accurate at much younger ages (less than a few million years) and can be a valuable tool in dating Plio-Pleistocene and early Pleistocene deposits. SPRP member Robyn Pickering of the Institute for Geological Sciences, University of Bern has shown success using this method on speleothem material from Cradle sites (R. Pickering *et al.* 2007, 2010). She conducted the uranium–lead (U–Pb) dating lab work for the Swartkrans samples.

During exploratory work, this author recovered a sample of the distal end of the large speleothem that occupied the cavity in the northwest corner. This is the large flowstone

that was mined out, after being exposed by Broom and Robinson, in the early 1950's. This speleothem underlies both the Lower Bank and Hanging Remnant of Member 1 and thus represents the maximum age limit for the deposits at Swartkrans. A second flowstone along the west wall caps the Member 1 deposits and separates it from the slightly younger Member 2 infill. Thus these two flowstones bracket the Member 1 deposits (Figure 12). To meet the two goals of the SPRP regarding the dating of Member 1, samples were also collected from the central section of the HR. After analysis of the newly exposed section of the HR, the speleothem samples were collected from the basal unit (1A). A second sample was collected from the flowstone near the top of the sequence. The flowstone is interspersed in facies 1D and continues through a solution pocket into the upper level of 1C (Figure 12).

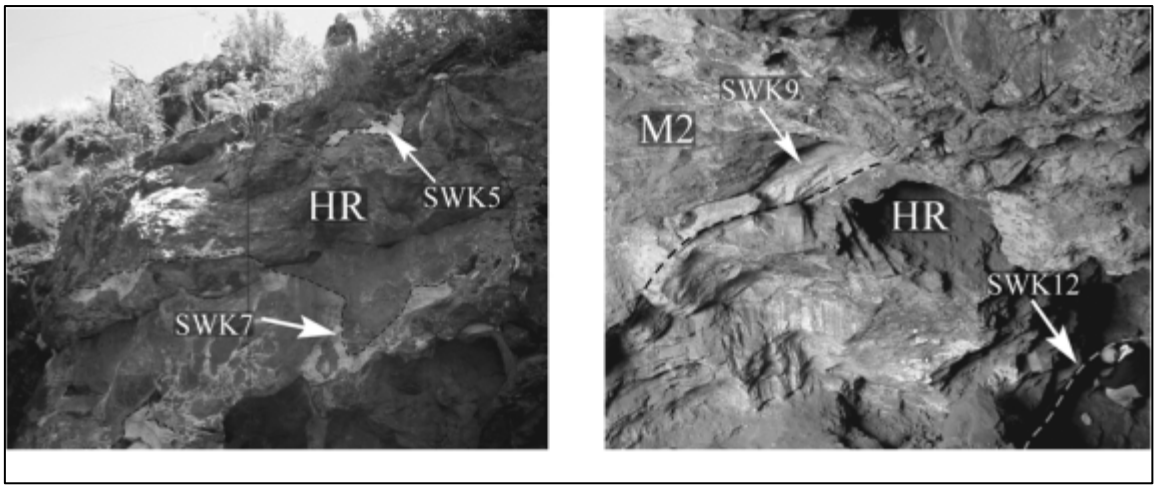


Figure 12. Photos showing the position of the flowstones and the locations from which the dating samples were taken. The left photo is the newly exposed central portion of the HR. SWK 7 was taken from the base of the deposit. SWK 5 was taken from near the top of the deposit. The right photo is the HR along the west wall in the northwest corner of the cave. Sample SWK 12 was taken from the distal portion of the large speleothem removed by the miners. SWK 9 was taken from the flowstone at the top of the HR where it is overlain by Member 2. Photo on left taken by R. Pickering.

Sampling from both the northwest corner and the central section provided a redundant test of the results as well as served to correlate the two areas (Figure 13).

Samples taken from the speleothems that bracket the HR in the northwest corner.

- SKW 12 provided a date of 2.249 ± 0.077 Ma below the HR
- SKW 9 provided a date of 1.706 ± 0.069 Ma above the HR

Samples taken from the speleothems that bracket the HR in the central portion of the north wall

- SKW 7 provided a date of 2.248 ± 0.052 Ma below the HR
- SKW 5 provided a date of 1.800 ± 0.005 Ma above the HR

Thus the HR is bracketed between dates of around 2.25 and 1.7 Ma. The correlation between basal flowstones (samples 7 and 12) is exceptionally strong with a mean variation of less than .001k years. The flowstones in the two areas represent the same speleothem formation event and most probably represent the same large speleothem.

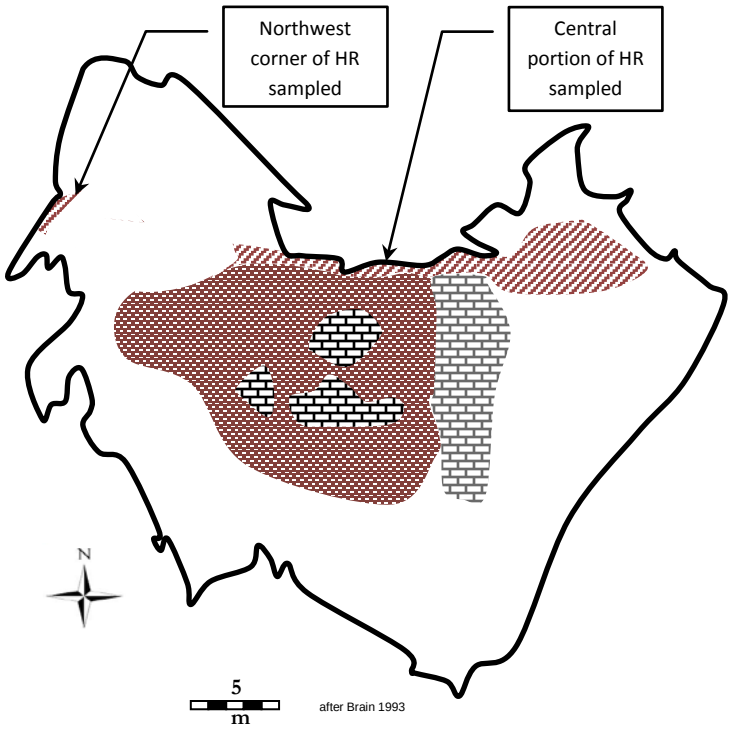


Figure 13. Plan view of Swartkrans showing the Member 1 deposits. This view reflects the current span of area covered by the HR. Note the break in continuity from the central portion to the west wall.

While the overlying flowstones (samples 5 and 9) are not within error of each other they are closely associated (less than 100k years) and probably represent an extended period of speleothem formation from 1.8-1.7 mya.

4.2.5 Conclusions

The results of the U-Pb radiometric dating show the underlying flowstones from the two areas are contemporaneous. The overlying flowstones, formed over a longer period, (100kya) also represent a single period of formation. Thus the calcified conglomerates of the HR from the two areas that are bracketed by the flowstones must also represent a contemporary depositional period. However the coincident depositional process of

this part of the HR could still signify separate entrances. It is accepted that the caves of the Cradle area can have multiple concurrent avens. The Sterkfontein Cave system has approximately 25 entrances today (Martini *et al*. 2003). Though human activity has altered several and created a few it provides a good example of the formation processes at work in a karst system. While it is possible the Member 1 HR deposits entered from separate openings the strong facies comparison of the two areas supports a single infill senerio.

This study has shown the Hanging Remnant is composed of material from multiple openings. However, the northwest corner breccias and the newly exposed portion of the central section breccias represent infill material from the same aven. The radiometric dating (U-Pb) establishes the simultaneous deposition of both areas and the facies comparison reflects parallel stratigraphy. Thus it can be conclusively stated that the HR material in the newly exposed central section along the north wall is the same depositional material which yielded the Broom and Robinson hominin assemblage near the northwest corner of the cave.

4.3 Lower Bank

Concurrent with the work on the Hanging Remnant, excavations have also been conducted on the Lower Bank deposits. The Lower Bank (LB) deposits are only lightly calcified, either having de-calcified during exposure after the erosion of the cave roof or possibly, as the lowest deposits of Member 1, never fully calcified. The fabric of the deposit indicates a flow direction toward the north wall with an inclination of 30^0 (Brain 1993d). This suggested to Brain the aven for the Lower Bank infill was above the southeast wall of the cavern. The Lower Bank deposit occupied the entire central portion of the cave system as well as extending under the north wall, filling what Brain originally called the inner cave. The talus also continues laterally ~50m toward the east until it reaches the east wall of the cave (Sutton *et al*. 2009). The passage through which this eastward extension of the LB traveled was very narrow due to the extreme thickness of the cave's roof near its north wall; this narrow channel between the roof and floor of the cave leveled the deposit near the east wall. This eastward extension was only discovered in 2009 and is now referred to as the LB East Extension deposit (Sutton *et al.* 2009). The Lower Bank is considered to be chronologically earlier than the Hanging Remnant. The newly established date of the HR is 2.248±0.052 - 1.800±0.005 mya (Pickering *et al.* 2011). However there exists the possibility the LB is older than the HR (results of cosmogenic nuclide dates are expected late 2011). Stratigraphically it would appear the central HR material entered from a aven directly above the north wall and rested, originally, on the upper surface of the Lower Bank (Brain 1993: 256). However that contact zone was

eroded away and the channel filled by Member 2, so the evidence is tenuous. Brain (1993) has stated that it is possible the HR entered first and the erosion cycle removed the base of the HR which was subsequently filled by the LB infill. From a formation perspective the first scenario is more plausible.

There is some palaeontological evidence to support the HR being older than the LB. *Parapapio jonesi,* a small baboon, is present in the HR and not the LB, it is also present in Sterkfontein Member 4 but is absent from Member 2 (1.5 mya) and other younger deposits at Swartkrans and Sterkfontein. The implication is that the presence in the HR and not in the LB suggests the HR is older and *jonesi* is extinct by the time the LB begins entering the cave system. This same pattern is also seen in two other species present in the Swartkrans formation. Both *Dinofelis sp.,* a false sabre-toothed cat, and *Makapania sp*., an ox-like ovibovine, have been recovered in the HR deposits but not in the LB or subsequent younger deposits (Brain 1993). These three species presence or absence could be due to a number of factors (e.g. sampling, natural accumulation bias, or preservation) and thus only provide for the possibility that the HR may be older than the LB. It can be said that regardless of the chronological order the two deposits do not differ that greatly in age. Additionally, the U-Pb dating conducted on the basal flowstone, which underlies both the HR and the LB, constrains the range of the two deposits. Thus, the Member 1 deposit combined (HR and LB) are placed within the 2.31 – 1.64 mya time window (Pickering *et al.* 2011).

4.3.1 Stone tools

Brain's excavations in the Lower Bank of Member 1 resulted in the recovery of 298 stone artefacts. These were analyzed by Clark (1993) and Field (1999), but due to the small sample and the lack of clearly diagnostic pieces, the ascribed industry was ambiguous. Field (1999) classified the Member 1 material as indeterminate but Clark (1993) suggested the assemblage could be Oldowan due to the age of the deposits and absence of larger pieces. The age of the Lower Bank deposits are estimated to be 1.7/1.8 mya (Vrba 1985; Churcher and Watson 1993) and this correlated with the Oldowan from Olduvai Gorge. However Acheulean artefacts have been recovered from deposits dated to 1.76 mya at Koleslei in east Africa (Lepre *et al*. 2011). And in South Africa the Acheulean is dated to an average of 1.6 mya in the Vaal basin but could as old as 1.7 mya (Gibbon *et al.* 2009). Thus chronologically the assemblage could be Oldowan or early Acheulean. One of the primary research goals for the SPRP was to increase the sample size of the Member 1 Lower Bank assemblage and determine whether the material represents late Oldowan or some of the earliest Acheulean in southern Africa.

4.3.1.1 Defining and interpreting the Oldowan

The earliest evidence of human cultural activity is found in stone tools. These earliest expressions of human production capabilities are referred to as Oldowan, a term first used by Louis Leakey (1934, 1936) for the artefacts recovered from Olduvai Gorge,

Tanzania. As stated in Chapter 2, it was the work of Mary Leakey (1971) on the stone artefacts from Bed I and Lower Bed II at Olduvai Gorge that established the Oldowan stone tool technology. Leakey saw the cores and large flakes as the primary heavy-duty tools and from the Olduvai assemblages defined the characteristics of an Oldowan assemblage. This included:

Core forms	**Retouched forms**
Choppers	Heavy-duty scrapers
Spheroids and sub-spheroids	Light-duty scrapers
Polyhedrons	Awls
Discoids	Burins

The Oldowan assemblage was divided into heavy-duty tools, light-duty tools and utilized pieces. The Oldowan tool makers were seen as producing core tools with the un-retouched flakes being the debris from this knapping process. Leakey's approach to early stone tools was strictly typological with artefacts classified based on tool type. This approach was the norm at the time (Clark and Kleindienst 1974) and followed on the work of Bordes (1961) on European Paleolithic assemblages, with site comparisons based on tool type frequencies.

Issac's (1977) early work at Olorgesailie expanded the range and understanding of the Oldowan stone tool industry but the focus was still from a typological perspective. However, Issac began to extend the research focus with the creation of the Koobi Fora Research Project. Still in the Rift Valley but north of Olduvai, the Koobi Fora site complex

in Kenya provided Issac with an area that was contemporaneous with Olduvai. But because the Koobi Fora artefacts were over a vast landscape, Issac developed research models that incorporated the geological and geomorphological features. An example of this landscape approach was the "scatters and patches analysis" (Issac 1981: 142) whereby information was also collected in the areas between the sites. The data was interpreted based on an overall distribution rather than just site distribution. Issac and Harris' (1980) work on the "scatter between the patches" focused on observable differences in assemblage structure between high and low density assemblages.

Issac's model-building theoretical approach to the study of Oldowan sites helped to broaden the research focus of the Oldowan Industrial Complex (Issac 1984). Other researchers followed this lead. Foley (1981) developed an "off-site" archaeological approach, looking at regional scale records in the context of behaviour and geomorphologic properties. Kroll (1994) expanded on the regional scale distribution approach by evaluating the material within a hominin activity or behavioural hypothesis. She compared Olduvai and Koobi Fora assemblages, stressing the significance of anthropological influenced distributions for the lithics and fauna. Other models added the temporality of the landscape to capture variability across time in a landscape context (Potts 1986; Bunn 1982, 1986; Bunn and Kroll 1986). Stern (1993) attempted to identify hominin behaviour by considering the amount of time represented by each component of the archaeological record separately. She concluded it is not possible to establish precise contemporaneity or non-comtemporaneity of different sets of archaeological debris

because geographically separate sections accumulate during different time intervals and at different rates. Bunn and Kroll (1993), accepting that hominin activity does leave patterns, took issue with Stern's negative view of approaches that regard patterned associations of material remains. Others (Haynes 1993; McBrearty 1993; Sept 1993) believed Stern's call for a new theoretical approach, while commendable, needed to be better defined.

These new approaches were termed "middle range theory," and the processual paradigm that shifted archaeological research and resulted in the middle range theory in Oldowan site studies also influenced the investigation of the artefacts. The most important revision during this period was Toth's (1982, 1985) seminal re-assessment of the Oldowan tool industry. Toth analyzed the artefacts from the perspective of function rather than type. He established that rather than working toward premeditated forms such as choppers, the tool-makers' primary goal was flakes. Through extensive actualistic experiments Toth demonstrated that flakes were much more effective as tools (for butchering and skinning) than the heavy-duty cores. Flake production resulted in the abundance of cores in the assemblage. Many of those cores were waste, having been abandoned once flake production was exhausted. Toth also concluded that Oldowan tool makers exhibited simple technology, but more complex raw material selection and management than originally thought (Toth 1986). The focus of Oldowan stone tool analysis was now more directed at the end products--the flakes--but the frameworks for the research were still within a typological context.

Over the past two decades this approach has changed and the primary focus of Oldowan stone tool research is now technological (Hovers and Braun 2009). This technological approach looks at the chain of operation or *chaine operatoire.* By focusing on the reduction methods employed by the early knappers, researchers can better interpret behavioural capabilities and intentions. Studies (Stout *et al*. 2010, Delanges and Roche 2005) have shown that the earliest knappers exhibited advanced skill in the reduction process, as well as knowledgeable selectivity in regard to raw material selection.

4.3.1.2 Oldowan summary

The Oldowan is characterized by simple technology that includes non-standardized cores and the flakes and flake fragments produced from the cores (Toth 1985). Core tool also sometimes form a limited heavy-duty component (choppers, heavy-duty scrapers) of an assemblage. The flakes and flake fragments, the primary end-products, are sometimes modified (retouched) for use, but more often the flakes are used without secondary modification. Typologically, Leakey's (1971) classification system is still used as a basis to describe an assemblage, but most research today also focuses on patterns of reduction. Intra-site comparisons have shown variability within the Oldowan; however this variability is often the result of raw material forms and availability, functionality of the end-products and disparity within the different populations of tool makers as well as differences in skill levels within those populations.

The earliest Oldowan stone tools date to ~2.6 mya at Gona, Ethiopia and this industrial complex lasted for almost one million years. Although there is variability among Oldowan assemblages the technological aspects are the same until around 1.7 mya when the Acheulean Industrial Complex appears in the archaeological record.

4.3.1.3 Acheulean Industry

The Acheulean or Mode 2 technology is defined by the appearance of Large Cutting Tools (LCTs) often bifacially shaped. Included in this heavy-duty bifacal tool kit are handaxes, cleavers and picks. The earliest Acheulean is dated to 1.76 mya at Kokiselei at Lake Turkana in Kenya (Lepre *et al.* 2011). Although the Acheulean is characterized by large cutting tools (LCTs), it includes a small flake component as well. As noted by de la Torre (2008) most early Acheulean sites (eg., Olorgesailie (Isaac, 1977), Olduvai (de la Torre and Mora, 2005), Isenya (Texier and Roche, 1995) and Peninj (de la Torre *et al*. 2008)) are represented by two chaine operatoires. One is the production of LCTs and the second focuses on small flakes. The small flake production is often distinguished by a discoidal bifacial reduction process.

Acheulean sites are found in more varied environments than Oldowan sites. While this could be a reflection of site preservation for the younger Acheulean, it is more accepted that Acheulean tool makers occupied and thrived in many different habitats (Rogers *et al*. 1994). The oldest Acheulean is found in east and southern Africa but the technology

spread throughout most of the Old World into the Levant by 1.4 mya, Europe by 1.0 mya and parts of Asia by 800k years ago. Acheulean technology lasts until 300k-250k years ago when it was replaced by flake and blade industries (Middle Stone Age). Thus for over a million years Acheulean technology, characterized by LCTs, dominated the toolkits of *Homo* throughout many parts of the world.

Because of the long and widespread existence of the Acheulean, most research focuses on two primary areas: *Homo* dispersal and cognitive development. Many researchers (Bar-Yosef and Belfer-Cohen 2001, Carbonell et al. 1999, Goren-Inbar 2000, Lycett and von Cramon-Taubadel 2008) have looked at the spread of Acheulean technology for insights into routes of dispersal and phases of movements of early *Homo* out of Africa.

Lycett and Cramon-Taubadel (2008) used a model approach comparing morphometric measurements of handaxes and geographical locations to show that there was dispersal out of Africa, but concluded it was punctuated due to population bottlenecks. These bottlenecks resulted in the presence of Mode 1 or Oldowan technology persisting for longer periods of time in some areas due to severe reduction in population size for some colonizing groups. Additionally, as *Homo* dispersed into new areas, environmental or other pressures depleted the population to such an extent that Mode 2 technologies were not maintained. The result of these bottlenecks is an archaeological record that in some areas reflects Mode 1 technologies lasting long after the appearance of Mode 2 technologies.

While the model based approach to interpreting dispersal patterns for early *Homo* is a valid approach, different models can result in different interpretations. For example, Mithen's (1994) model explains the co-occurrence of Mode 1 and Mode 2 tools in Britain as based on the relationship of group size to environmental conditions. He sees Mode 2 technologies being used in more open environments which would support larger group sizes and thus allow more transmission of cultural traditions. Yet other researchers (McNabb and Ashton 1995; White 2000) have noted that Acheulean sites also exist in many closed environments.

Because the perceived maker of Acheulean tools is *H. ergaster* and later, in Europe, *H. heidelbergensis,* both considered advanced species of early *Homo*, much research (McNabb *et al*. 2004; McPherron 2000; Mithen 1996, 1999; Wynn 1995, 2002) has focused on the cognitive abilities and the social aspects of transmission of cultural traditions present in Acheulean tool production. McNabb *et al*. (2004) analyzed Acheulean material from South African sites and concluded the symmetry present in handaxe production is a result of continued exposure of the knapper to others within the group producing handaxes. Thus the standardization is from memory which is termed "conceptual standardization," and the variability seen in an assemblage is the result of individual variation, either through skill or perceived desired outcome. In this explanation the authors see minimal or weak transfer related to social learning or social context; rather the reproductions were the result of a knappers' uptake from his/her

surroundings. This lack of social constraint on Acheulean LCT production places the standardization and/or variability back on either function or raw material.

A technological perspective for analysis of Acheulean artefacts not only provides an understanding of reduction strategies but can also contribute to the interpretation of an industry. For example, de la Torre *et al*. (2008) have shown that, technologically, even sites without handaxes represent an Acheulean industry. At Peninij in the early Acheulean levels "large cutting tools resemble massive crude scrapers rather than bifaces of any kind. ….knappers do not seek to obtain symmetrical shapes or bifacial distribution of volume in artefacts, but simply to obtain heavy duty tools with massive tips and blunt edges" (de la Torre 2008:262). The desired end-product during the early Acheulean is LCTs and these large cutting tools are most often made from large blanks. The early stages of Acheulean technology is still anchored in bifacial reduction but can, at times, have an absence of signature bifacial handaxes, cleavers, and picks, and some assemblages are even dominated by unifacial handaxes.

4.3.1.4 Acheulean summary

The Acheulean or Mode 2 technology is characterized by the consistent appearance of larger shaped tools. These LCTs are often referred to as handaxes, cleavers and picks and are often on large flake blanks. This allows for more standardization within the tools but also results in more diversity in tool types. This heavy-duty tool production results in

larger flake debitage during the reduction process. But the early Acheulean also includes a smaller discoidal reduction scheme for the production of smaller flakes as end-products. The earliest Acheulean bifaces were crudely produced but the skill and, most probably, the cognitive abilities of Acheulean hominins increased through time. This resulted in what many see as an Early Acheulean, Middle Acheulean and Later Acheulean. The basis is a refinement in the production of bifaces through time. The middle and later periods of the Acheulean reflect this increased skill level with very finely crafted handaxes.

4.3.1.5 Developed Oldowan

Compounding difficulties answering the question of which industry is present in the Member 1 LB at Swartkrans is the possibility of the existence of the Developed Oldowan. The Developed Oldowan was first identified by Leakey (1971) from the Olduvai Gorge material. She proposed three stages of Developed Oldowan (A, B, and C) and saw these industries as distinct from the Oldowan and the Acheulean. In the Olduvai sequence Lower and Middle Bed II, dated to ~1.7-1.53 mya (Walter *et al*. 1991; Tamrat *et al*. 1995) , was said to have Developed Oldowan A (Kimura 2002) which resembled Oldowan but included many spheroids and sub-spheriods as well as what Leakey termed protobifaces. Middle to Upper Bed II (1.53-1.4 mya) and Bed III (1.2 mya) contained Developed Oldowan B, which was characterized by crudely worked bifaces made from cobbles as well as larger, well- made bifaces produced from large flakes (Kimura 2002). This

increased occurrence of well-made bifaces was seen as technologically advanced to the Oldowan tool kit and Leakey saw this change as possibly a reflection of a different cultural group or hominin species entering and occupying the area (Leakey 1971). Developed Oldowan C is used to type the material from Bed IV (1.2- 0.6 mya) and was seen as a refinement in biface production over the Developed Oldowan B material.

As mentioned in Chapter 2 the Developed Oldowan concept was accepted as a transition between the Oldowan and Acheulean industrial complexes and was identified at other sites (Chavaillon *et al*. 1979; Clark and Kurashina 1979). But as more Oldowan sites were discovered not all researchers agreed that the Developed Oldowan existed as a separate industry. Some (Stiles 1979b; 1981) saw little distinction between the Acheulean and Developed Oldowan. Others (Gowlett 1988, Davis 1980) accepted the Developed Oldowan in part but not all three divisions (A, B, and C) proposed by Leakey. But more recently, with a focus on the technological aspects of the early Acheulean assemblages, the Developed Oldowan industry has been put to rest. De la Torre and Mora (2005) have shown that the technology involved in the bifacial reduction process for the production of handaxes is evident in the earliest stages of the Acheulean. Semaw *et al.* (2009) in a review and re-examination of the Oldowan material also present a strong case for the technological change that occurs for the production of bifaces. They see the Developed Oldowan A as belonging to the Oldowan as it is not technologically different to the Oldowan material. The protobifaces are seen as exhaustively reduced cores that are bifacially worked. The goal of the reduction process is to generate flakes, not the

exhausted core. The Developed Oldowan B, characterized by bifaces, is seen as belonging to the Acheulean (Semaw *et al*. 2009). The technology is focused on obvious handaxe production and, though at times crude, this technology is an innovation over the Oldowan industry. They argue that the hominins had developed, by this time, the technological ability to produce large bifacial cutting tools. This cognitive move is clearly the advancement that marks the appearance of the Acheulean industry. Thus, if the tool makers possess the ability and are producing the bifacial tools, then this material should be classified as Acheulean. This author agrees with this assessment and does not recognize the Developed Oldowan. Once the leap in technological advancement occurred—which is seen archaeologically by the bifacial production of LCTs—then we should recognize such an assemblage as belonging to the Acheulean Industrial Complex.

4.3.2 Approach to the Lower Bank Assemblage

The question regarding the Lower Bank artefacts which motivated this research is whether the assemblage represents only the second evidence for the Oldowan in southern Africa or rather an early Acheulean technology like that found in East Africa.

Because the Oldowan is a simple Mode 1 industry that lacks diagnostic types it is difficult to define, and both the technological and typological characteristics of the industry can be found in later industries. However, there are attributes that can distinguish an Oldowan assemblage. Barsky (2009) has used the dominance of smaller flakes in

assemblages to describe Oldowan industries. The average flake size of later industries, such as LCT- dominated assemblages, would be larger than classic Oldowan assemblages. Another key characteristic of Oldowan assemblages is the simple reduction processes, despite the variability that has been shown to exist within the Oldowan (Delagnes 1995; Delagnes and Roche 2005). The third key characteristic that will be addressed in this analysis is raw material selection as rock procurement becomes more varied through time. Selectivity of a greater variety of raw material types and the distances traveled for those raw materials also increase through time. Conversely, selection of localized material is most often a reflection of expedient activity of the early tool makers, although this attribute has also been shown to be variable (Braun *et al*. 2009). Lastly, comparing the Swartkrans assemblage to the Oldowan and Acheulean assemblages of Sterkfontein can assist in assigning the Lower Bank artefacts to the appropriate industry. This also provides an opportunity to reflect on an important component of the early tool industries—variability. A comparison of the Swartkrans artefacts to a known Oldowan assemblage at Sterkfontein provides an opportunity to consider variability in southern Africa.

4.3.3 Excavation methods

Excavations have taken place in the northeastern portion of the Lower Bank. This is the primary deposit and represents the remaining, largest section of the LB. An EDM laser

theodolite (Nikon DPM 320) was used to establish a grid of 1m x 1m squares. This data was recorded from Brain's original datum point so the excavated meter squares are correctly tied to Brain's grid system. Thus all the excavated meter squares and recovered material can be correlated with the Brain assemblage. Sixteen 1 x 1 meter squares have been excavated to varying depths (Figures 14 and 15). Each square was excavated by quadrant (50 cm x 50 cm) in 5 cm or 10 cm spits. Each quadrant level was excavated separately and then sieved using a 5 mm mesh over a 2 mm mesh screen. The material from the 5 mm mesh was then wet sieved. The 2 – 5 mm fraction material was collected to ensure the recovery of small bone fragments of macrovertebrates, microfaunal remains and stone artefact chips.

The new Lower Bank excavations have resulted in the recovery of 1,058 stone artefacts (≥ 2cm) and 13 hominin fossils. The stone artefacts and hominin fossils have been analyzed and are discussed in detail in the following sections. The excavations have also resulted in the recovery of a large faunal assemblage that is to be analyzed by Travis Pickering and does not form part of this thesis.

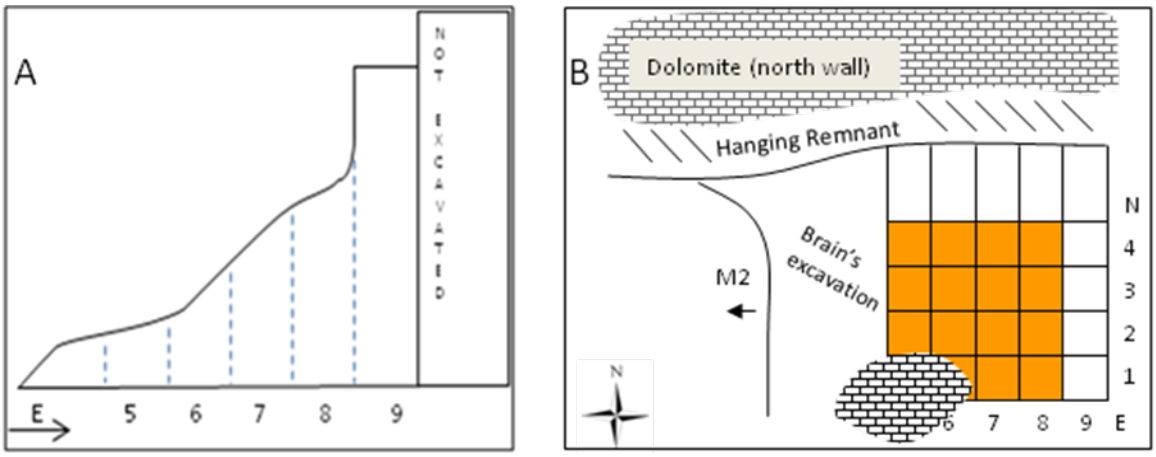


Figure 14. (A) Profile of the Lower Bank excavation slope. Of the original excavations by Brain, only row 9E was still clearly stepped down to row 8E. 9E had been excavated ~1.5m below the surface. The remaining East rows had eroded to such an extent that they were no longer stepped. Because of the steepness of the infill the squares were excavated to varying depths. (B) Plan view of Lower Bank excavation area. Sixteen one meter squares have been excavated to either 1.5m to 2m each along the slope of the deposit.



Figure 15. Photos of Lower Bank, (A) showing position of LB in relation to the HR, looking east and (B) detailed view of excavations—rows 5 and 6.

The terms and methods used in this analysis are explained in the Appendix.

4.3.3 Stone Tool Discussion

4.3.3.1 Raw Material

The artefacts from the Lower Bank are composed of three primary raw materials: 1) Quartz, 2) Chert, and 3) Quartzite. Additionally, there is a small number of artefacts (13/ ~1%) produced from igneous rocks (Table 2, Figure 16). Cortex on the artefacts reflects that both outcrop rock and river cobbles were used by the Swartkrans Earlier Stone Age knappers. Outcrops of all four raw materials occur within a radius of <10km of Swartkrans (Leyland *et al.* 2008).

	Quartz	Chert	Quartzite	Igneous
All Other	524	397	38	13
Cores	34	11	27	
Manuports	3		11	
Total	561	408	76	13
% of Total	53	38.6	7.2	1.2

Table 2. ≥20mm pieces by raw material.

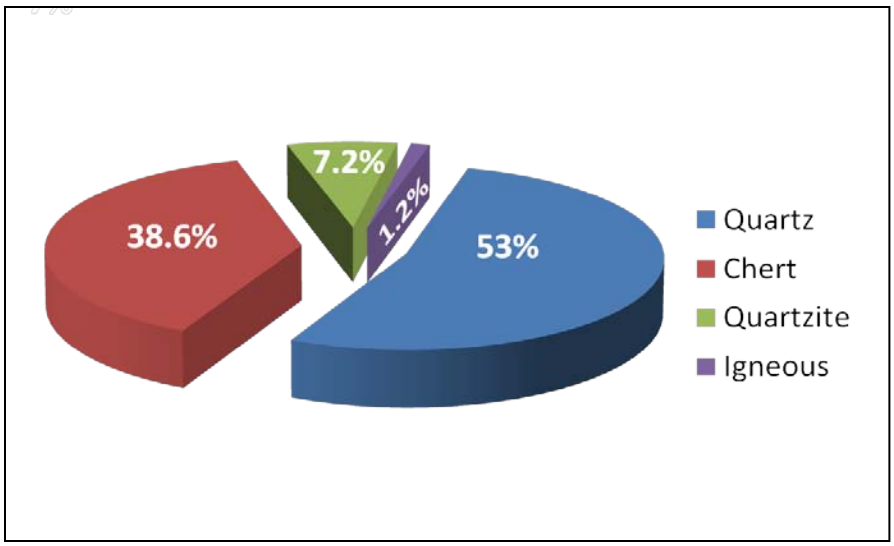


Figure 16. ≥20mm by percentage of raw material.

Additionally, outcrops of all four raw materials occur upstream of the Bloubank River and thus could have easily been transported downstream past the site. This would have made raw material procurement readily available near the site. Also, chert occurs within the dolomite throughout the area, while the quartz is present in bands or seams in most of the host rocks in the area.

Quartz. 1221 (57.4%) of the artefacts of the complete (including the <20mm SFD) assemblage are quartz. Both outcrop and river cobbles were used. Though quartz occurs within the dolomite throughout the area, no quartz vein has been identified on the Swartkrans hill, but several outcrops exist south of the Bloubank River. One lies between the Sterkfontein and Coopers sites within 1.5km of Swartkrans. A second large (>100m across) outcrop (Figure 17) is located within 3km south of Swartkrans. Samples from this outcrop are equivalent to some of the quartz artefacts recovered from the Lower Bank.

But the quartz river cobbles were just as commonly used as raw material. The quartz flakes reflect a range of material types, from milky white in appearance to almost translucence quartz. The quality of quartz material also varies from lower quality rock with many crystal interface fractures to very fine high quality rock with very few crystal interface fractures.



Figure 17. Large quartz outcrop <3km from Swartkrans hill. The exposed outcrop contains quartz rock that compares to several of the artefacts in the Swartkrans Lower Bank assemblage. L. Pollarolo for scale.

Chert. 783 (36.8%) (including <20mm SFD) of artefacts are on crypto-crystalline or chert. The chert is a sedimentary rock formed in association with the dolomitic sediments and is interbedded in the dolomite. Chert exists in several bands in the Swartkrans formation. It

is a fine-grained siliceous rock but has abundant internal fracture planes and is most useful in the production of small flakes, with larger flakes being difficult to produce even with larger blocks of chert. Both river cobbles and chert from hillside rocks were used as raw material, though knapping experiments show the river cobbles produce better flakes (Field 1999).

Quartzite. 91 (4.3%) (including <20mm SFD) of the artefacts are on quartzite. Quartzite outcrops are present within 10km of Swartkrans but would have been readily available as river cobbles in the Bloubank gravels. Both outcrop and river cobbles were used by the knappers, but the majority of cores in the assemblage are on river cobbles. The quartzite weathers out in block form and even the river cobbles are very angular, though they often have rounded edges. Because of the large, angular shape of the river cobbles the quartzite allows for larger flakes to be produced. Much like the quartz material, the quartzite artefacts also reflect a range of quality from fine grained pieces to a few that have very large grains with loose consolidation. These pieces grade only a little better than sandstone for knapping quality.

Igneous/Diabase. Only 33 (1.5%) (including <20mm SFD) of the artefacts are on igneous rock, primarily on diabase. Like quartzite, diabase does not occur on Swartkrans hill. But diabase does occur in dikes and sills within several of the geological formations in the area. The closest diabase outcrop today is ~10km from Swartkrans (Leyland *et al.* 2008). However the diabase and other igneous rock were most probably procured from the river gravels beneath the site. The lack of proximity to the site, which also means fewer

cobbles available in the river, could explain the small number of igneous pieces present in the assemblage, rather than solely a selection preference by the LB knappers. The fine-grained igneous rocks are excellent for knapping and result in larger flakes. Butchering experiments conducted with students at both Swartkrans and Sterkfontein have shown that diabase flakes have sharp edges and undergo less breakage during use than quartz flakes. The diabase is softer (3 on Moh's scale) than the other rock and is more susceptible to oxidation in wet conditions. Thus most of the material in the assemblage is degraded, making it difficult to identify attributes.

The Swartkrans assemblage is predominantly quartz (53%) and chert (38.5%) both of which are present in the cave dolomite. The other raw materials were procured from the river. Though this source was within 300m of the site it appears the Swartkrans tool makers primarily chose the easier, expedient option of using raw material from the hillside.

4.3.3.2 Assemblage size profile

Of the 2128 artefacts recovered in the current excavations, 355 are less than 10mm and 715 pieces are 11mm to 20mm (Figure 18). This small flaking debris (SFD) category accounts for 50.1% of the overall total. This is slightly less than the expected experimental published values of 60-80% SFD component (Schick 1984; Field 1999; Kuman and Field 2009) of a complete assemblage, especially given the predominance of quartz. Quartz has

high fracturing qualities, resulting in a higher quantity of small debris during the knapping process. The under representation of <10mm pieces suggests there is some winnowing of the smallest size material from the deposit. However the >50% SFD component is significant in that it does indicate a high degree of assemblage capture. Quartz reduction, both bipolar and free hand - hard hammer, results in a larger portion of <10mm fraction than 10-19mm material (Field 1999 and *pers. experiments*). The small ratio of <10mm quartz in the LB assemblage indicates a portion of the smallest material was lost from the deposit before capture, probably through slope wash.

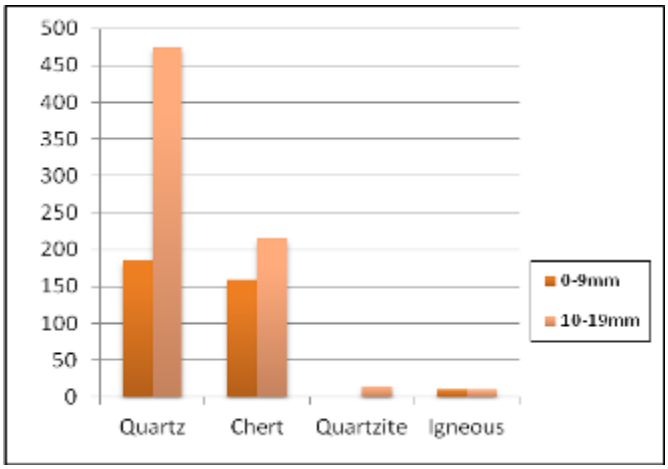


Figure 18. Graph showing small flaking debris (SFD) size profile; 50.1 % of the assemblage is <20mm.

Length	Quartz	Chert	Quartzite	Igneous
0-9mm	185	160		10
10-19mm	475	215	15	10

Table 3. Numeric representation of SFD by size and raw material.

The predominant quartz and chert have a mean length of 30.3mm ± 10.0 and 34.3mm ± 11.9 respectively. Since quartz and chert account for >90% of the material present, this

results in the assemblage having a small mean size (Figure 19). The largest quartz flake is 93.3mm and the largest chert flake is only 79.8mm. The assemblage does not contain any larger flakes (>10cm) which are found in LCT industries. The expedient nature of raw material selection by the Swartkrans knappers and the smaller flake sizes suggest an Oldowan-type approach to stone usage. Like at Sterkfontein, the assemblage is dominated by materials that are present on the hillside or at the river less than 300m away. Quartz was the preferred raw material and was available both in veins in the bedrock (dolomite) and in river cobbles along the banks of the Bloubank. Both sources provide

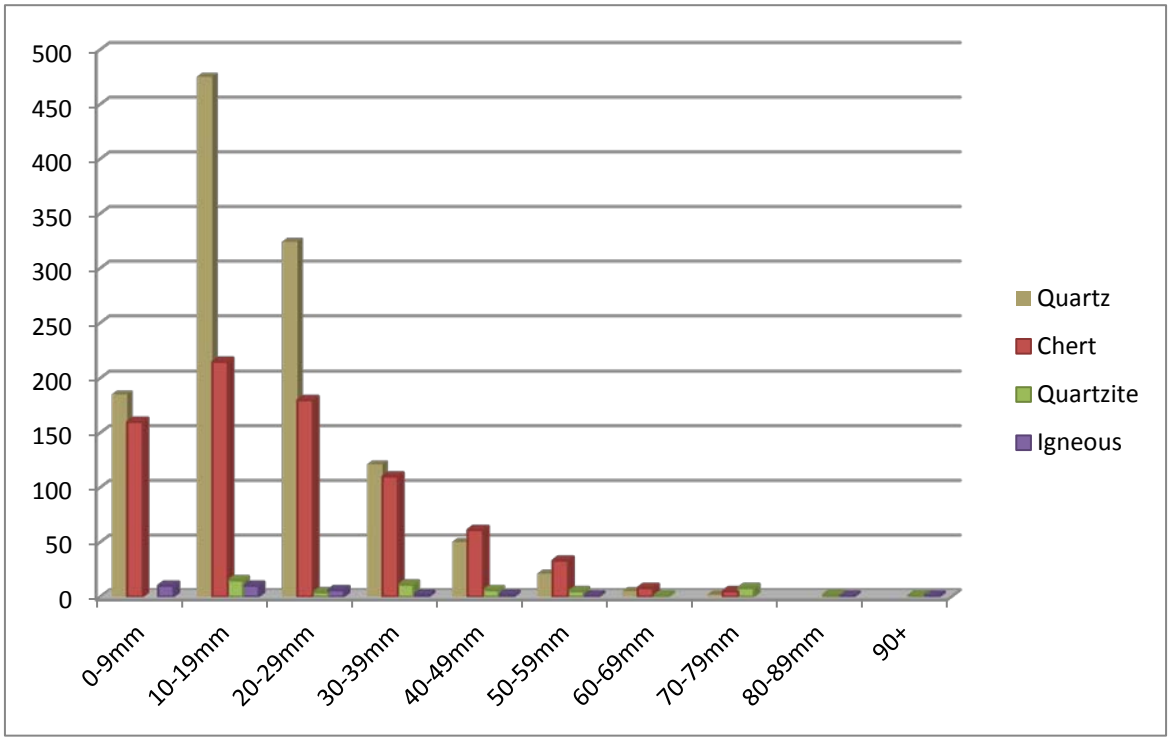


Figure 19. Maximum length of the newly excavated LB assemblage, excluding cores and manuports. The collection is dominated by small pieces but has a full range of debitage indicating a near complete assemblage.

Length	Quartz	Chert	Quartzite	Igneous	Total	%
0-9mm	185	160		10	355	17.40
10-19mm	475	215	15	10	715	35.00
20-29mm	324	180	4	6	514	25.20
30-39mm	121	110	11	2	244	11.95
40-49mm	50	61	6	2	119	5.82
50-59mm	21	33	5	1	60	2.95
60-69mm	5	8	1		14	0.70
70-79mm	2	5	8		15	0.73
80-89mm			2	1	3	0.15
90+			1	1	2	0.10
Total	1183	772	53	33	2041	100%

Table 4. Maximum length, by raw material, of the newly excavated LB material, excluding cores and manuports.

cores that trend toward smaller sizes. The quartz blocks weathering out of the exposed outcrops generally range in sizes from about 45cm. Likewise the quartz river cobbles, having originated from the same source, have the same size range. The same can be said for the chert artefacts. The chert cores used were in the small size range resulting in smaller flakes. Additionally, the most common reduction method for the quartz cores was bipolar flaking, which produces many flakes, but the majority of them will be small. This quartz and chert preference resulted in a smaller flake size range for the Swartkrans assemblage.

This is in contrast to the quartzite material which occurs in large cobbles (manuport length average = 98mm) and can produce much larger flakes. Additionally, the quartzite outcrops provide a source for large cores or flake blanks for the production of bifacial

tools or LCTs. The Lower Bank tool producers did not utilize raw material not in close proximity to the site.

4.3.3.3 Cores

Quartz. A total of 34 quartz cores has been recovered. Bipolar flaking dominates the quartz reduction process, but a number of cores in the assemblage reflects hard hammer percussion techniques. Many of these cores have multiple flaking surfaces and are best described as polyhedral. However, radial reduction was also used (Figure 20). The average size of the quartz cores is 69mm but several are less than 50mm and show small <30mm flake scars. The majority of the quartz cores have been extensively flaked and have limited options for further reduction, indicating an exhaustive process in relation to the quartz core flaking. Three of the cores, SWT 376, SWT 392 and SWT 771 (Figure 21), do still present flaking options but both have many internal fracture planes that would result in broken flakes. This reflects clear understanding of the local rock properties by the LB knappers. Three manuports are quartz rock and all three are river cobbles. Additionally, a total of five large blocks of quartz were recovered that could have been flaked, but were not. These five pieces have to be considered natural as they could have weathered out of the vein quartz present in the dolomite.

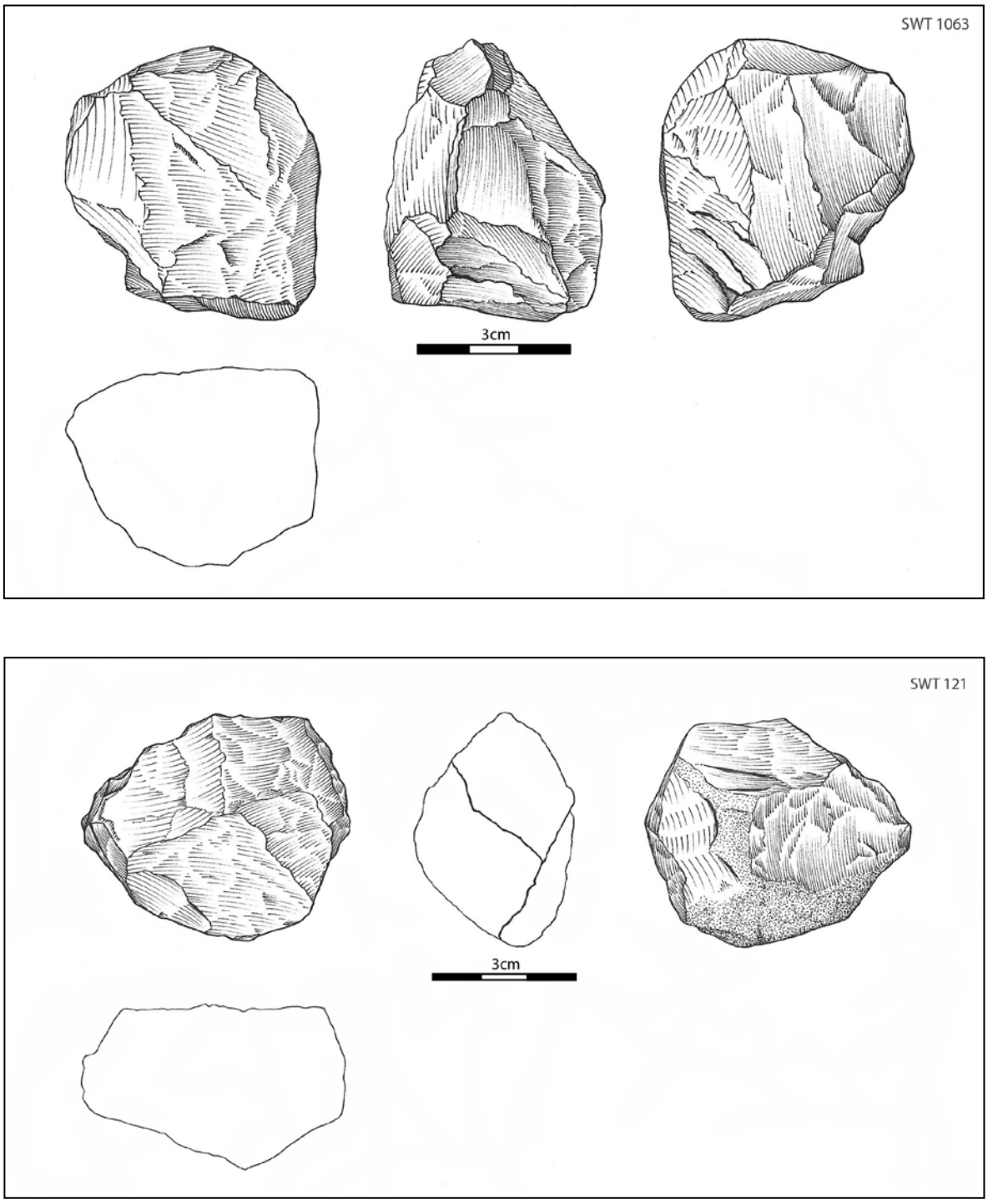


Figure 20. SWT 1063 (top) and SWT 121 (bottom) are examples of quartz cores with radial reduction. From the Lower Bank of Member 1. Drawn by A. Sumner.

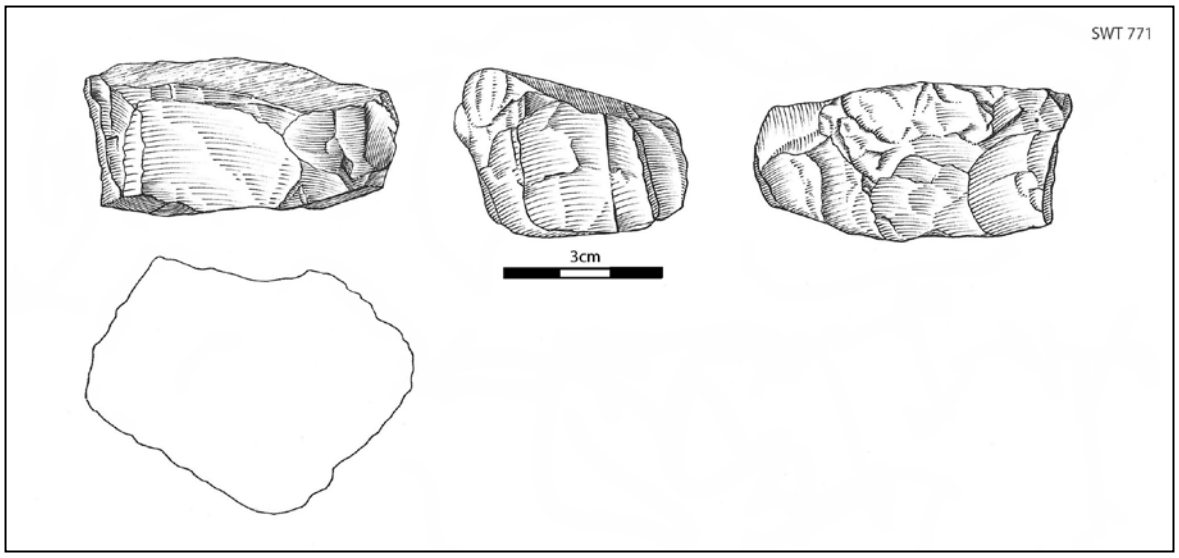


Figure 21. SWT 771, a quartz core from the Lower Bank of Member 1 with only two removals. Flaking angles still exist but the many fracture planes in the raw material (e. g., see middle view) make it poor quality and thus it was abandoned, reflecting understanding of the raw material properties by the tool makers. Drawn by A. Sumner.

Chert. Eleven chert cores have been recovered. Unlike the quartz, the chert material was primarily hard hammer flaked with little evidence of bipolar technique. The average size (69.8mm) of the chert cores is similar to the quartz. The majority of the chert cores are polyhedrals. Also like the quartz most of the chert cores are exhausted, though SWT 643 (Figure 22) is another example of a core with remaining flaking options. Core STW 543 has been bifacially flaked and would easily be classified as a chopper in Leakey's typological configuration. No chert manuports were recovered, but the majority of the chert material was procured from the cave rock.

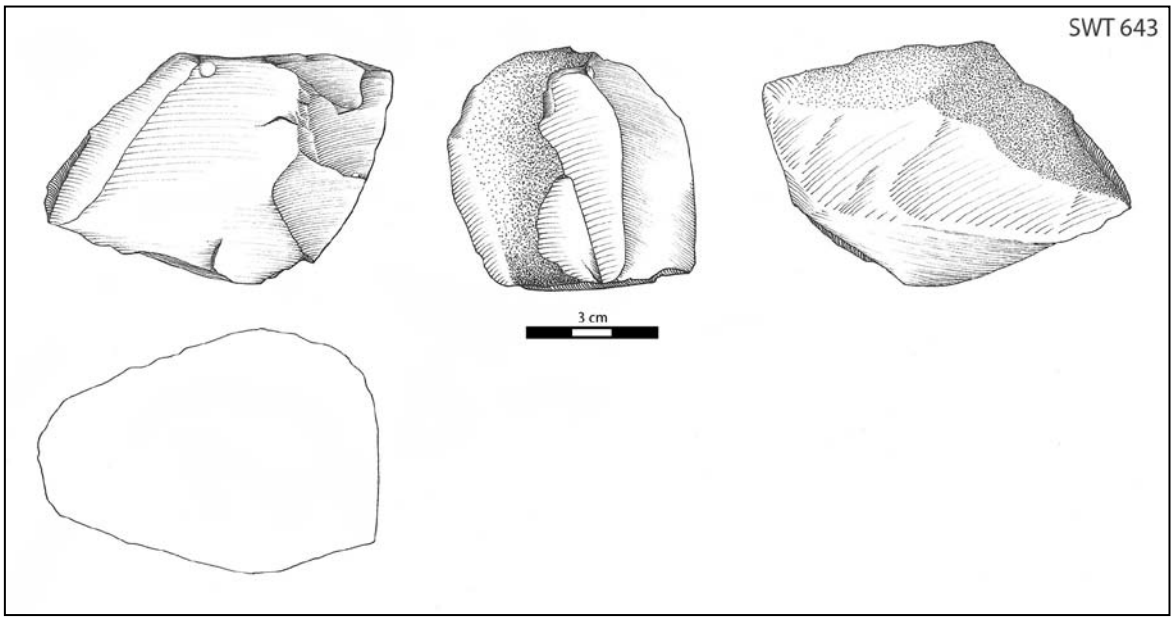


Figure 22. SWT 643, a chert casual or tested core from the Lower Bank of Member 1 with only one removal and associated breakage. Drawn by A. Sumner.

Quartzite. Even though quartzite accounts for only 12.2% of the entire assemblage, it comprises 33% or 27 of the cores. The quartzite cores include multi-directional reduction, but several have uni- or bi-directional flaking only. Bipolar, while not common does occur (Figure 23). Cores STW 699 and STW 373 are single platform cores. Both SWT 1025 and SWT 709 are polyhedrals (Figure 24) that have been exhaustively flaked. But, unlike the quartz and chert cores, several of the quartzite cores have remaining reduction options. STW 527 still has flaking options but has been bifacially flaked to create an edge and would be classified as a chopper in Leakey's typological configuration. Overall the quartzite cores are larger and have been less extensively flaked than either the quartz or chert material. There are 11 manuports in the assemblage, more than any other raw material. Additionally, all are river cobbles collected and brought up to the site. Though

the quartzite provided better flaking-quality raw material, it was not so utilized as the quartz and chert rock.

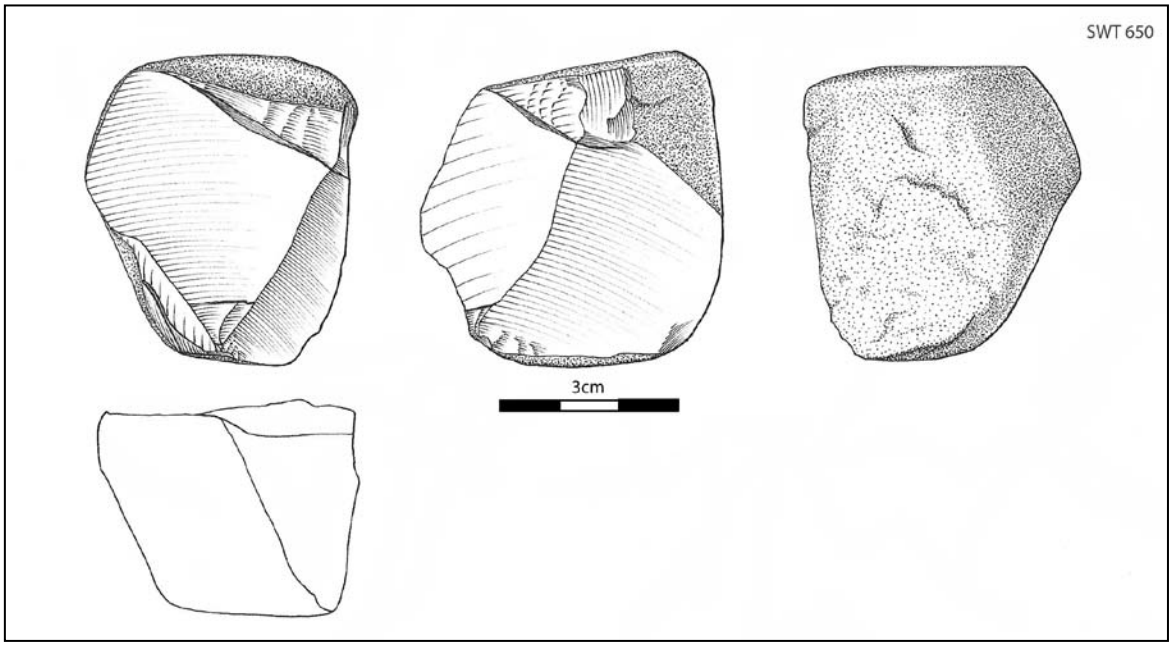


Figure 23. SWT 650 a quartzite core, from the Lower Bank of Member 1, reflecting a bipolar opening stage but no other removals though there are existing flaking angles. Drawn by A. Sumner.

Igneous. No igneous cores or manuports were recovered during the current excavations, but some are noted from earlier excavations (Field 1999).

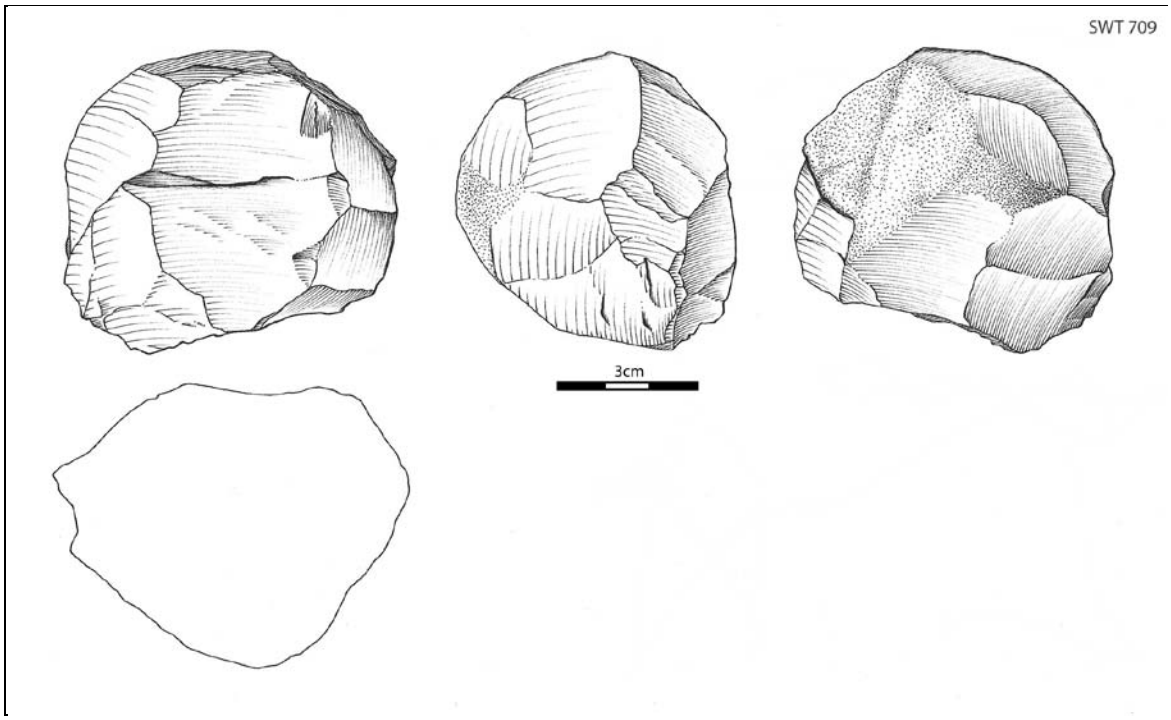


Figure 24 . SWT 709, an example of a quartzite polyhedral core from the Lower Bank of Member 1. Drawn by A. Sumner.

4.3.3.4 Comparison with Sterkfontein Oldowan assemblage

The Swartkrans assemblage compares well with the Oldowan from Sterkfontein which is also predominantly quartz (Figure 25). However, the Swartkrans assemblage does contain a higher percentage of chert. This is a reflection of the geological formation on the north side of

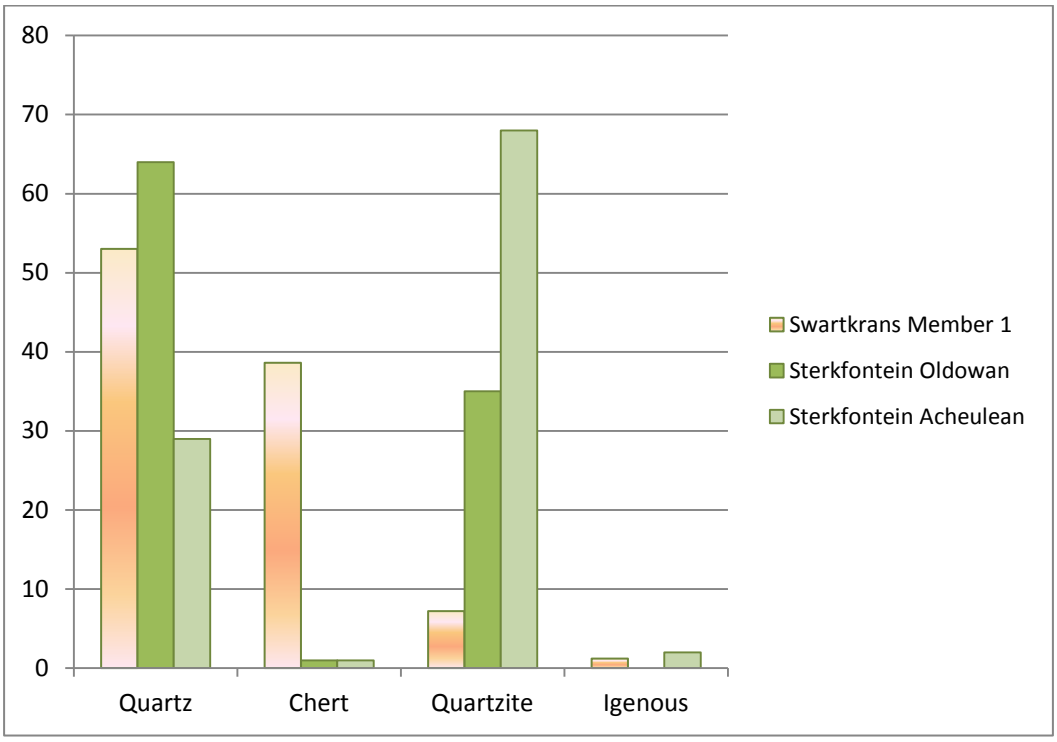


Figure 25. Graph of raw material usage comparing Swartkrans M1 and with both the Sterkfontein Oldowan and Acheulean. Y axis represents the absolute numbers of artefacts.

the Bloubank River. The dolomite on Swartkrans hill has a higher chert or silica content than at Sterkfontein, making chert clasts readily available at the site. Quartzite (68%) becomes the preferred raw material in the Acheulean at Sterkfontein (Field 1999). Quartzite also becomes much more prominent (32%) in the Member 2 Acheulean deposit at Swartkrans. The mean lengths of the artefacts in the two Oldowan assemblages, at Sterkfontein and Swartkrans, are also similar for all three raw materials (quartz, chert and quartzite). The Sterkfontein Oldowan has a higher percentage of SFD than the Swartkrans LB assemblage, but that could be a reflection of the predominance of quartz in the Sterkfontein assemblage or better site capture at Sterkfontein. Like Sterkfontein the smallest SFD material (<10mm) is underrepresented in the assemblage. It is now evident

the smallest material in the Sterkfontein assemblage eroded into the underlying Name Chamber (Stratford 2008; Kuman and Field 2009) as that assemblage is dominated by small debris. Likewise, at Swartkrans it is most likely a portion of the smallest material was eroded away into a lower, undiscovered, cavern in the cave formation or, more likely, was winnowed from the surface before deposition in the cave. The formation process for Members 1 and 2, as detailed by Brain (1993), reflect an erosion episode wherein the middle section of the Member 1 deposit eroded away leaving a solution area that was subsequently filled by Member 2 sediments. This pattern of deposition and erosion, which exists within the dolomitic limestone caves of the area, may be reflected in the site capture properties of the Swartkrans Member 1 LB assemblage.

The reduction process is also the same for the two assemblages. The Sterkfontein Oldowan primarily comprises polyhedrals or casual cores (58%). The Swartkrans LB cores also predominate multi-directional or casually flaked. No discoidal cores are present in the Swartkrans assemblage while Sterkfontein has only one. Kuman and Field (2009) have noted, from their experiments, that continued or exhaustive reduction of a discoid often results in a core with a polyhedral shape. That appears to be the case in both the Sterkfontein and Swartkrans assemblages. Only the quartzite cores are not exhaustively reduced in both assemblages. While both assemblages have a high percentage of quartz flakes produced by bipolar flaking, both also have few bipolar cores: three from Sterkfontein and two from Swartkrans. Thus the two assemblages have similar raw material procurement and usage, similar flake size profiles and similar core reduction

methods. This strong correlation supports an Oldowan designation for the Swartkrans M1 LB assemblage; rather than the presence of an early Acheulean industry.

4.3.3.5 Summary

The oldest Swartkrans stone tool assemblage now contains over 3,000 artefacts here assigned to the Oldowan industry. The collection is a large enough sample to, not only analyze, but also to compare with the only other southern African Oldowan assemblage--Sterkfontein. The Swartkrans LB assemblage which includes over 1,000 pieces ≥20mm, does not contain any LCTs (handaxes, cleavers and picks). Nor does the assemblage contain any large flake blanks or flaking debris indicative of LCT production. The assemblage, instead, includes primarily small flakes and flake fragments. Additionally, the Swartkrans LB assemblage possesses expedient, casual reduction processes rather than organized flaking. However, the knappers show the good skill typical of other Oldowan assemblages selecting easily procured material from the hillside as well as cobbles from the Bloubank river. While the reduction processes (bipolar and multi-directional) seem simplistic, they do reflect an acute understanding of the raw material properties and the most effective methods for flake production.

The previous studies on the Member 1 artefact assemblage (Clark 1993; Field 1999) were based primarily on typological classification of the artefacts. The results were ambiguous and the researchers were noncommittal in assigning the assemblage to an industry. But this analysis of the characteristics of the assemblage has resulted in establishing which

industry is present. The Swartkrans assemblage has all the characteristics of an Oldowan assemblage: lack of LCTs, lack of large flakes or flake blanks, predominance of small flakes, simple reduction methods for flake production and expedient use of localized raw materials. Additionally, the Swartkrans LB deposit was overlain by the younger Member 2 infill that includes larger flakes and two LCTs recovered from miners' breccia dumps, reflecting the change to Acheulean technology by the Swartkrans hominins at ~1.5 mya. So like Sterkfontein, the Swartkrans Oldowan is followed by a clear technological change toward Acheulean LCT production, all of which is absent in the Member 1 LB deposit. Additionally, new preliminary results of cosmogenic nuclide dating on quartz artefacts from the deposit reflect a date of ~2.0 mya for the Lower Bank (Granger and Gibbons *pers. comm*. 2010). This older date is well within the age of other Oldowan assemblages and >220k years before the first known appearance of the Acheulean. Thus, with the now larger sample of Member 1 LB artefacts, it can conclusively be stated that the oldest deposit at Swartkrans is an Oldowan industry.

4.4 Who were the earliest tool-makers?

An important question in the study of early stone artefacts is, of course, who made them. The ability to produce tools is often seen as the rubicon skill that separates *Homo sapiens* from the rest of the animal kingdom. But many other animals also use tools and some also make alterations to an item (*e.g*. removing leaves from a twig) before using it. Wild

primate populations are known to use a variety of plant material as tools (Teleki 1974, Boesch and Boesch 1990). There is also clear evidence of stone tool use by both captive and wild monkeys (Visalberghi *et al*. 2007, Ottoni and Izar 2008). Capuchins, known to use a hammer and anvil technique for nut cracking, have also been documented transporting hammerstones for use at a site (*ibid*). Chimpanzees are also known to exhibit this behaviour (Whiten, *et al*. 1999). Chimpanzees also use tools for accessing and retrieving underground storage organs (Hernandez-Aguilar, *et al.* 2007). Macaques have been observed cracking mollusks and crabs with stones (Malaivijitnond 2007). Thus stone use and tool production cannot be attributed solely to hominins. This has led to studies comparing ape archaeology with early Oldowan assemblages (Mercader *et al.* 2002). A chimpanzee site in the Cote d'Ivoire was excavated and Mercader *et al.* (2002) have argued that the nut cracking activity of the chimpanzees mimic Oldowan assemblages recovered from hominin sites. However this has not been widely accepted (de la Torre 2004, Schick *et al.* 1999) and many feel there is a clear distinction between the "incidental, unintentional by-product of nut cracking" (Schick and Toth 2006: 24) by chimpanzees and the complex actions necessary for the procurement, manufacture and use of Oldowan tools by early hominins.

The actual rubicon skill may be the production of complex tools. Certainly no other animal has exhibited the ability to make complex composite tools. That lies only with *Homo*. But the earliest stone tools, the Oldowan industry, are often simple conchoidal fractured

flakes. So another question that must first be answered is what gave/gives hominins the ability to manufacture stone tools.

- **Hand anatomy**. Hominins possessed a longer thumb length that provided greater dexterity. A larger pad area on the thumb allowed for a precision grip. Additionally, the wrist bones and the ability to cup the hand provided a range of power grips. (Christel 1993, Marzke and Wullstein 1995).

- **Expanded hominin brain**. This allowed for the development of abstract conceptualization and planning capabilities. The reduction process requires a sequential plan (Inizian *et al*. 1999, Pelegrin 2000, Wynn 1988) and the ability to perform subroutines (Bruner 1970, Elliott and Connolly 1974) or hierarchical organization. A larger brain, especially the expanded frontal cortex, increased cognitive ability.
- **Expanded neurobiological capacity for motor skills**. Hominins exhibited the ability for timed adjustment and coordination of different movements. An important key in knapping is the ability to deliver powerful blows accurately (Inizian *et al*. 1999) and to make the necessary wrist adjustment at the point of impact. Stone tool production also requires bi-manual role differentiation (Byrne 2004:7) wherein the two hands perform different actions in a complimentary technique.

While the above traits are often used to differentiate hominins from the primates, these same traits are sometimes used by primatologists to show hominins were not the only primate with the capability for tool production (Byrne 2004).

4.4.1 Fossil evidence

With the recovery of OH5 (*Zinjanthropus boisei*) at Olduvai Gorge, Leakey (1958, 1959) believed he had discovered the maker of Oldowan tools from the FLK site. However, less than a year later another hominin was discovered in Lower Bed 1 at Olduvai. OH7 (*Homo habilis*) with a larger brain (>600cc) and in the same stratigraphic level as the FLK tools then became the first tool maker (Leakey 1960, Leakey *et al*. 1964, Tobias 1991, Wood 1992b). Remarkably, OH7 was recovered with a set of associated hand bones and Napier (1962) showed that *Homo habilis* had the ability to perform a precision grip, an important skill for stone tool production. Thus, early *Homo* was considered the only hominin that, because of its large brain and hand morphology, was capable of making stone tools (Robinson 1962; Leakey *et al*. 1964; Tobias 1965). But Susman (1988a, 1988b) showed that *Homo* was not the only hominin capable of producing stone tools. Analyzing hand bones of *Paranthropus robustus* from Swartkrans Member 1, Susman argued that, based on the size and shape of the thumb as well as the breath of the finger pads, these hominins would also have been capable of making the necessary hand manipulations

needed for stone tool production. Ricklan (1987), analyzing *Australopithecus africanus* hand bones from Sterkfontein Member 4, presented evidence suggesting Australopithecines also had the dexterity for stone tool production. Others have disagreed with these assessments. Marzke (1997) presented a new set of morphological features to use in identifying precision grip capabilities and concluded that the pre-*Homo* hominins anatomical structure did not different, significantly, from other primates. Trinkaus and Long (1990) argued that Susman's identifications of the Swartkrans hand bones as *Paranthropus* and early *Homo* was not possible as they are not distinguishable. However Susman (1991) has argued that the fact the fossils are so similar supports his view that both could have produced stone tools. Wood (1997) has argued that *Paranthropus* is most likely the maker of Oldowan tools rather than *Homo*, arguing that because the stasis in *Paranthropus* morphology correlates with the stasis in Oldowan technology from 2.6 to 1.7 mya. It is more probable that *Homo* was not the only hominin tool maker.

This view is supported by the archaeological evidence as Oldowan tools are being recovered at sites that predate the earliest appearance of *Homo.* The Olduvai deposits were dated to ~1.7 mya (Leakey 1971, Ludwig and Harris 1998), but Oldowan tools are also found at older sites. The oldest recovered stone tools date to ~2.6 mya at Gona, Afar in Ethiopia (Semaw *et al*. 1997). Several other sites also date beyond the Olduvai Gorge deposits, including Omo in Ethiopia dated to 2.42 mya (Howell *et al.* 1987), Lokalalei in Kenya at 2.34 mya (Kibunjia *et al*. 1992; Kibunjia 1994), Hadar in Ethiopia at 2.33 mya

(Kimbel *et al*. 1996; Hoovers *et al*. 2002) and Kanjera in Kenya at 2.2 mya (Ditchfield *et al*. 1999; Plummer *et al.* 1999). The oldest *Homo* fossils have been recovered from Hadar in Ethiopia at 2.33 mya. While *Homo* was most likely the maker of the Hadar tools the association does not establish the maker of the tools at older sites. Thus either the oldest *Homo* fossil has not yet been found or, more likely, other hominins were also producing stone tools.

Evidence points to at least two other possible candidates as the producers of the earliest stone tools. At Bouri in Middle Awash, Ethiopia cut-marked and percussion-marked bone has been recovered from ~2.5 mya deposits. While no stone tools have yet been recovered from the site, the fossil evidence reflects stone tool use. In the same stratigraphic levels, approximately 275 meters away from the butchered bone, hominin fossils of *Australopithecus garhi* were recovered. Though the hominin fossils are only indirectly associated with the cut-marked bone, the recovery of the fossils in the same layer supports the contemporarily of the two. *Paranthropus aethiopicus* fossils have been recovered from deposits contemporary with stone tools from Omo on the Ethiopian side of Lake Turkana and stone tools from Lokalalei on the Kenyan side of the lake. This makes *P. aethiopicus* a strong candidate for the possible maker of the tools at the two sites. As both *P. aethiopicus* and *A. garhi* date to beyond 2.5 mya they would have been on the landscape when the earliest stone tools were produced at Gona. Although both have brain cases smaller than early *Homo* (410cc for *P. aethiopicus* and 450cc for *A. garhi*) and

no hand bones have been recovered for anatomical reference, it is possible that either could have been tool producers.

While the makers of the earliest stone tools are not conclusive, the shift to Acheulean tools appears to be synchronic with the appearance of *Homo ergaster. H. ergaster* with a cranial capacity of 880cc (Johanson and Edgar 1996) had the capability for more complex cognitive behaviours. The almost simultaneous appearance of Acheulean tools and *H. ergaster* at ~1.7 mya suggests the new hominin was making more advanced stone tools. Additionally, at Sterkfontein there is direct association of Acheulean tools and *H. ergaster* fossils (Kuman and Clarke 2000). The more complex biface manufacture required an abstract thought process to "see" the final product and the course of reduction necessary to achieve it (Wynn 1988; Gowlett 1984). This new hominin and new technology correlation also coincided with an expansion of hominins into more varied environments. *H. ergaster* had a tall skeletal frame that was suited for long distance walking (Walker and Leakey 1993), possibly facilitating habitat expansion as well as providing a wider range for resource procurement. Archaeologically, many Acheulean sites contain artefacts on raw materials that reflect transport from greater distances.

While there are other *Homo* species (*habilis, rudolfensis and erectus*) that could have been responsible for this change in technology, the most likely maker of Acheulean tools is *H. ergaster*.

It can conclusively be stated that *Homo* was/is a tool maker. At least during the length of time *Homo* has walked the earth, stone tools have been made and used. And, certainly, long after all other hominin species had become extinct *Homo* was still producing stone tools. But it cannot be stated clearly if, before the extinction of the other species, *Homo* was the only stone tool producer.

4.4.2 Lower Bank Hominins

Which species made the Oldowan tools at Swartkrans? Although this question cannot be positively answered, the continued excavations of the SPRP has resulted in the recovery of additional hominin fossils and could eventually clarify the stone tool and hominin association in the Lower Bank deposit. Certainly the additional fossils enlarge the database of hominin remains from Swartkrans and can assist in elucidating the depositional accumulation processes of the Lower Bank deposits.

Brain's excavations resulted in the recovery of 36 hominin fossils from the Lower Bank of Member 1 (Brain 1993). Of the total, 20 specimens are craniodental remains and 16 are composed of postcranial material. Nineteen of the 20 craniodental specimens have been assigned to *Paranthropus* and one to *Homo sp* (Grine 1989, 1993). All 16 of the postcranial specimens are assigned to *Paranthropus* (Susman 1993).

The new SPRP excavations have resulted in the recovery of an additional 13 hominin fossils from the LB of Member 1 (Table 5).

The ratio of P. robustus to Homo is similar to Brain's assemblage with 9 of the specimens classified as P. robustus and 1 Homo. Three other specimens (SWT LB-4, LB-6 and LB-8) are indeterminate to genus and species. The following descriptions of and taxonomic allocations for the fossils are from Pickering *et al.* 2012.

Specimen	Taxonomic attribution	Element	Excavation coordinates	
			Square	Depth below surface
SWT1/LB-2	cf. *Paranthropus*	Right femur	1N 6E	4.4 m
SWT1/LB-3	*Paranthropus robustus*	Left dm_2 (?)	3N 6E	4.5 m
SWT1/LB-4	Hominidae gen. et sp. indet.	Postcanine tooth	3N 6E	4.7 m
SWT1/LB-5	cf. *Homo*	Molar	3N 6E	3.4 m
SWT1/LB-6	Hominidae gen. et sp. indet.	Upper molar	1N 8E	4.5 m
SWT1/LB-8	Hominidae gen. et sp. indet.	Left C	1N 6E	3.4 m
SWT1/LB-10	*Paranthropus robustus*	Left M^1	2N 5E	5.4 m
SWT1/LB-11	*Paranthropus robustus*	Left upper molar	2N 6E	5.5 m
SWT1/LB-12	*Paranthropus robustus*	Right P^3	2N 7E	5.6 m
SWT1/LB-13	*Paranthropus robustus*	Left I^1	1N 7E	5.8 m
SWT1/LB-14	*Paranthropus robustus*	Left P^4	2N 7E	6.0 m
SWT1/LB-15	*Paranthropus robustus*	Right di^1	3N 7E	6.3 m
SWT1/LB-16	*Paranthropus robustus*	Right I^1	4N 6E	6.5 m

Table 5. List of new hominin fossils recovered from Member 1 Lower Bank

Upper central incisors (Figure 26)

One deciduous (SWT1/LB-15) and two permanent (SWT1/LB-13 and SWT1/LB-16) upper central incisors were recovered from the LB; each derives from a separate hominid individual. All three specimens are attributed to *P. robustus.*

SWT1/LB-15 is a right di^1 with a complete crown and root that is nearly complete except for its chipped apex. The thick but short form of the root is typical of *P. robustus* central incisors. Upper central deciduous incisors are rare in the *P. robustus* hypodigm, but SWT1/LB-15 conforms metrically and morphologically to the other fairly complete and moderately worn Swartkrans *P. robustus* di^1, SKX 16060, with a short, thick root and squat crown bulging from it (Grine 1989, 2004).

SWT1/LB-13 is a complete crown, with an attached root fragment, of a left I^1. Metrically and morphologically the tooth is similar to previously described *P. robustus* homologues from Swartkrans (Robinson 1956; Grine 1989, 2004).

SWT1/LB-16 is a right I^1 with a complete crown and root that is only missing the very tip of its root. This robust root form is typical of *P. robustus* permanent upper incisors (Robinson 1956).

SWT1/LB-13 is a complete crown, with an attached root fragment, of a left I^1. Metrically and morphologically the tooth is similar to previously described *P. robustus* homologues from Swartkrans (Robinson 1956; Grine 1989, 2004).

SWT1/LB-16 is a right I^1 with a complete crown and root that is only missing the very tip of its root. This robust root form is typical of *P. robustus* permanent upper incisors (Robinson 1956).

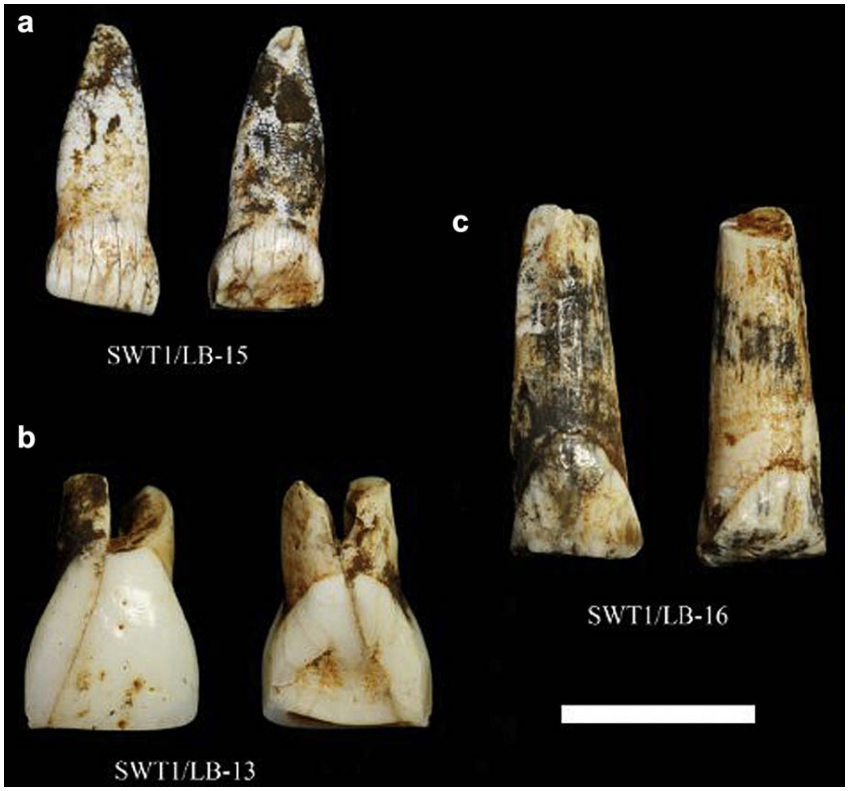


Figure 26. *Paranthropus robustus* upper central incisor fossils from the Lower Bank of Swartkrans Member 1. SWT1/LB-15 is a right deciduous (a), SWT1/LB-13 is a left permanent (b) and SWT1/LB-16 is a right permanent (c). Bar scale ¼ 1 cm. From Pickering *et al.* 2012.

Upper canines (Figure 27)

One upper canine has been recovered. SWT1/LB-8 is a mesial enamel fragment of a left C, with moderate occlusal wear. Meaningful measurements are not possible. The specimen is allocated to Hominidae gen. et sp. indent.



Figure 27. Hominin upper canine fossil from the Lower Bank of Swartkrans Member 1. SWT1/LB-8, a mesial enamel fragment of a left permanent, is shown in mesial view (left of pair) and the right image of the specimen is a distal view of the tooth's internal surface along a natural fracture plane (a). Bar scale ¼ 1 cm. Modified from Pickering *et al.* 2012.

Upper third premolar (Figure 28)

SWT1/LB-12 is an upper third premolar and is a relatively uninformative specimen, recovered from the LB and attributed to *P. robustus* because its projected occlusal outline is roughly oval and because it possesses a prominent cingulum bulge (Pickering *et al in press*). The crown feature relationships accord with characteristic occlusal morphology of *P. robustus* P^3s (Robinson 1956).

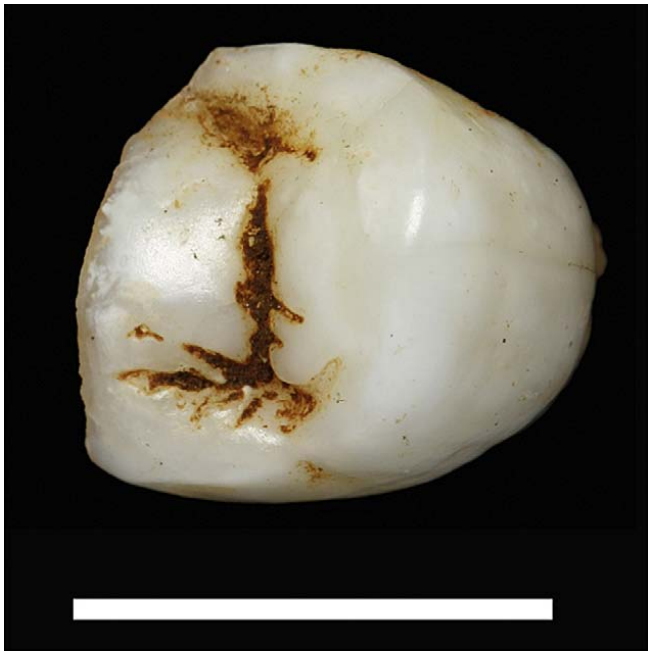


Figure 28. SWT1/LB-12 (occlusal view), a lingual crown fragment of a *Paranthropus robustus* right upper third premolar (missing its buccal ridge) from the Lower Bank of Swartkrans Member 1. Bar scale ¼ 1 cm. From Pickering *et al.* 2012.

Upper fourth premolar *(*Figure 29)

SWT1/LB-14 is a fragment of an upper fourth premolar. The tooth is unworn and was unerupted when the individual from whom it derives died. Morphologically, it compares favorably to the previously described Swartkrans *P. robustus* P^4 specimen SK 825 (Robinson 1956).



Figure 29. SWT1/LB-14 (occlusal view), a nearly complete crown of a *Paranthropus robustus* left upper fourth premolar (missing much of its buccal ridge) from the Lower Bank of Swartkrans Member 1. Bar scale ¼ 1 cm. From Pickering *et al.* 2012.

Upper first molar (Figure 30)

SWT1/LB-10 is a buccal fragment of enamel of an erupted left M^1. As is typical of *P. robustus* M^1s, the buccal crown margin slopes gently inward, toward the occlusal margin, the cusps are low the cuspal wear pattern is flat (Robinson 1956). No meaningful measurements are possible.



Figure 30. SWT1/LB-10 (occlusal view), a buccal crown fragment (with preserved paracone and metacone, buccal groove and partial central groove) of a *Paranthropus robustus* left upper first molar from the Lower Bank of Swartkrans Member 1. Bar scale ¼ 1 cm. From Pickering *et al*. 2012.

Upper molar (Figure 31)

SWT1/LB-11 is an unerupted left upper molar with a complete crown and three partially formed roots. Morphologically and metrically, SWT1/LB-11 compares very favorably to the erupted left M^2 of the Swartkrans *P. robustus* partial cranium SK 47 (MD diameter = 14.0; BL diameter = 14.2); Robinson 1956). Ronald Clarke is of the opinion that rather than being an M^2, SWT1/LB-11 is possibly the unerupted left M^3 of that very cranium from the HR. More cleaning of SK 47 is required to expose its partially erupted right M^3 so that SWT1/LB-11 can be compared to it in order to confirm or falsify this hypothesis (Pickering *et al*. 2012)

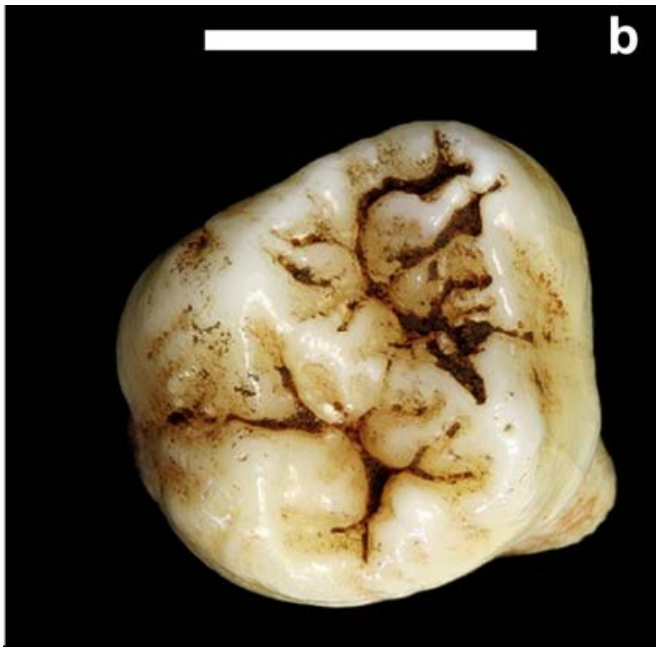


Figure 31. SWT1/LB-11 (occlusal view), unerupted left upper molar of *Paranthropus robustus* from the Lower Bank of Swartkrans Member 1. Bar scale ¼ 1 cm. From Pickering *et al*. 2012.

Lower second deciduous molar

SWT1/LB-3 is a segment of a crown of a left dm_2. No meaningful measurements are possible.

Indeterminate postcanine teeth fragments

Three dental fossils from the LB cannot be attributed to any specific tooth, but all are definitively hominid and all derive from postcanine teeth. SWT1/LB-4, an indeterminate postcanine tooth in two fragments, and SWT1/LB-6, an upper molar fragment, can only be assigned to Hominidae gen. et sp. indet. The most interesting aspect of this small sample is that it contains SWT1/LB-5, a molar fragment, which is diagnosed as cf. *Homo*. None of the specimens is amenable to measurement.

SWT1/LB-6 is a fragment of the crown and attached root of an upper molar. No meaningful measurements of the specimens are possible.

SWT1/LB-5 is an occlusally well-worn fragment of enamel. Pickering, *et al.* (2012) have tentatively assigned this specimen to *Homo* due to a sharply defined margin between the occlusal surface and the side, which is more Homo-like. Secondly, the occlusal surface is worn in an undulating pattern, as is typical of *Homo*, rather than worn flat, as is typical of *Paranthropus*.

Femur (Figure 32)

SWT1/LB-2 is a fragment of right proximal femur recovered in two pieces (reconstructed by Ronald Clarke), one composed of the head and neck and the other a portion of the extreme proximal diaphysis (truncated just inferior to the largely missing greater trochanter), with a good contact between the two sections. The fossil is allocated to *P. robustus* (Pickering *et al*. 2012).



Figure 32. SWT1/LB-2 (anterior view), hominin proximal femur from the Lower Bank of Swartkrans Member 1. Bar scale ¼ 1 cm. From Pickering *et al.* 2012.

4.4.3 Hominin summary

The new SPRP has expanded the hominin fossil collection from Swartkrans and makes an important contribution to the hominin fossil record. Archaeologically, the hominin fossils, *Homo* and *Paranthropus*, are associated with stone tool production, but it cannot be determined which hominin species (*Homo or Paranthropus*) was the maker of stone tools or if both made tools. Association with tools does not necessary indicate the maker. It is clear that both early *homo* and *P. robustus* occupied the same landscape from 2.0 to 1.0 mya but in all three deposits (Members 1-3) at Swartkrans the two are differentially represented. Member 3 at Swartkrans has stone tools and only *Paranthropus* remains. However, the suggested accumulation process for Member 3 is that *P. robustus* is present due to predation and the absence of *Homo* is indicative of its ability to avoid predation (Brain 1981, 1993). This lack of predation for *Homo* is thought to be possible due to the use of stone tools and controlled fire and greater intelligence. This is easily accepted, as the *Homo* present at the time was *Homo ergaster*. The same can be argued for Member 2 which is dated to ~1.5 mya. Based on the age it is assumed the Member 2 *Homo* fossils represent *H. ergaster* and this evolved hominin produced stone tools and was thus better positioned to confront other predators. However the older deposits of the Lower Bank of Member 1 do not easily fit this scenario as it may date to ~2.0 mya and is beyond the earliest evidence of *H. ergaster*. Additionally, it is now apparent the deposit contains Oldowan tools rather than Acheulean artefacts. Oldowan artefacts are generally recognized as being the product of *Homo habilis*. But the recovered hominin fossils from

the Lower Bank do suggest a similar scenario of accumulation with the deposits of Members 2 and 3. The percentage of *P. robustus* to *Homo* (97% from Brain's assemblage, 82% from the new excavations—89.5% overall) may indicate that even during the Member 1 depositional phase there was a divergent dynamic wherein *P. robustus* was more heavily preyed upon than early *Homo*. One possible explanation for this could be that *Homo* had stone tools and *P. robustus* did not**.** Member 1 contains Oldowan stone tool technology and possibly *H. habilis* rather than *H. ergaster* (R. J. Clarke *pers. comm*. 2012), but it appears the accumulating processes for the deposits are the same as the other two members**.** Thus the most mitigating factor influencing the differential representation of the two hominins present at Swartkrans may be the production of stone tools by early *Homo*.

Chapter 5

Member 4

5.1 Introduction

Member 4 is a colluvial deposit in the north-east corner of the cave system which contains Middle Stone Age artefacts (Figure 33). It occupies an area of ~62^2 on the surface above the cave. The Member 4 colluvium extends down into the cave as the outer layer of a talus cone. The cone is at least 12 m in vertical depth, with a 38^o slope and a base of 19m across its north face. During the 1980−1981 excavations, Brain dug an east-west archaeological test trench (~7m x ~3m x ~1 m) within an existing lime miners' trench and through the surface of the Member 4 deposit. Brain's goal with this test trenching was to determine the relationship of Member 4 with the rest of the cave system (Brain *Pers. comm.* 2005). More than 1700 stone artefacts, many of them diagnostically Middle Stone Age (MSA), were recovered from the Member 4 test trench dug by Brain. As Brain's research focused on the much older deposits of Members 1-3 he stopped the excavations upon reaching the east wall and suspended work in the Member 4 deposit. The artefacts were boxed and stored in the Transvaal Museum (now the Ditsong Museum).

In the last two and a half decades, the Middle Stone Age has become a critical time period in the debates surrounding modern *Homo sapiens*. Much of this renewed interest in the MSA has, more recently, been focused on the South African archaeological record. Several South African sites, primarily those on the southern cape coast, have yielded

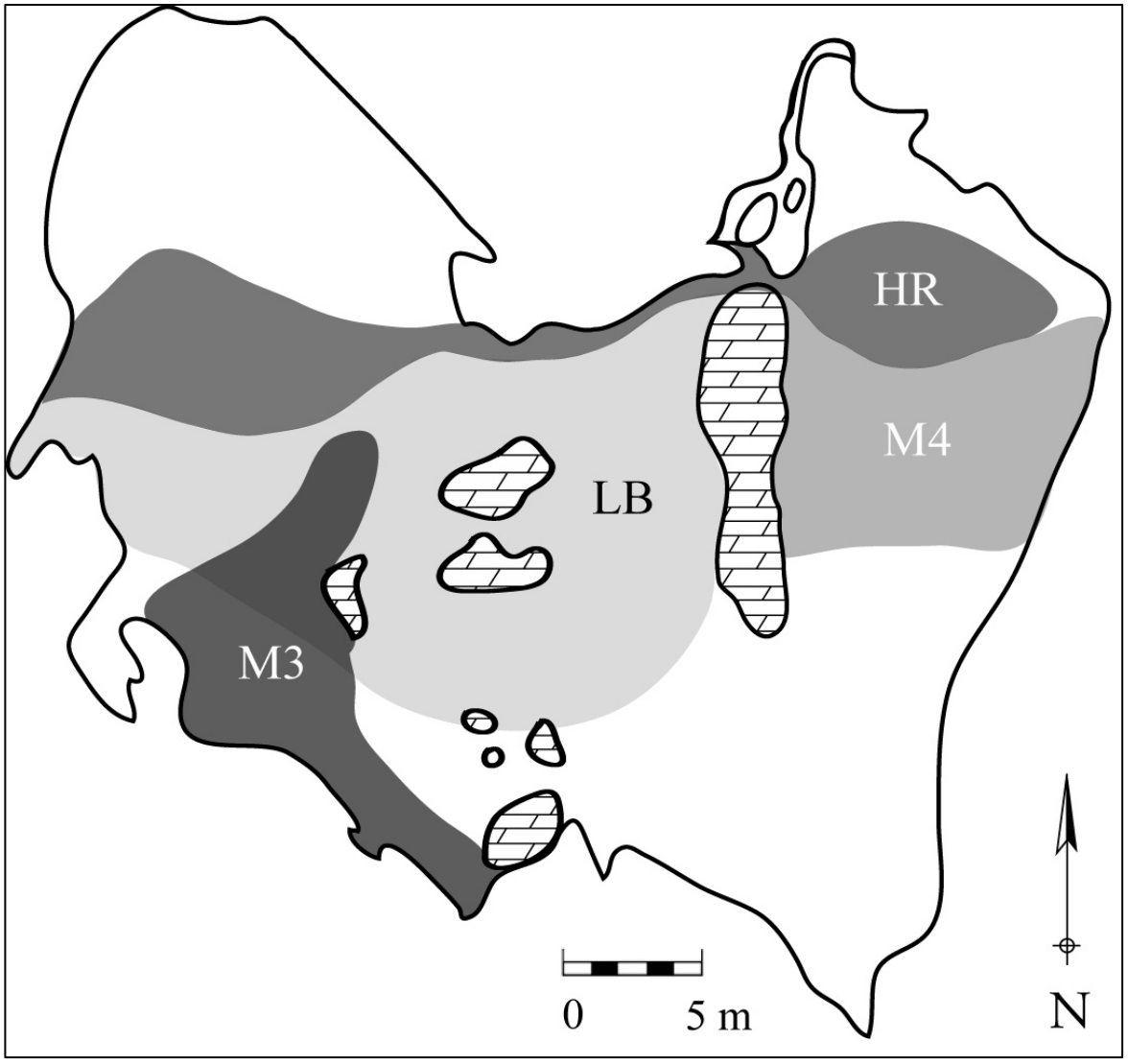


Figure 33. Plan view of Swartkrans reflecting the area of the Member 4 surface deposit and its association with the older Members 1-3 deposits.

remarkably preserved archaeological material from 50k-100k years ago. While sites in the interior of the country have not exhibited the same preservation from this time period, there exists a limited record of stone artefacts. Thus the Member 4 MSA deposit at Swartkrans can contribute to the on-going research debates regarding the MSA. Additionally, while much research in the Cradle area has been focused on the Plio-Pleistocene and early Pleistocene periods and a great amount of information is known

about early hominins and their behaviour, little is known about the earliest modern humans who inhabited the area.

5.2 Middle Stone Age

The Middle Stone Age follows the Earlier Stone Age, appearing around 300k years ago and continuing until ~40/30k years ago (McBrearty and Brooks 2000). The MSA is characterised by a change in stone tool types. Handaxes and cleavers, which had been part of the Earlier Stone Age tool kit for well over a million years, are replaced with lighter, more standardised flake and blade industries, largely driven by the development of hafting technology. Additionally, prepared core reduction techniques become common in the MSA. In addition to technological changes occurring in the MSA, the period is also important for two other significant archaeological attributes. The MSA represents the first appearance of anatomically modern *Homo sapiens* and, arguably, the first appearance of modern human behaviour.

5.2.1 Origins of Modern Humans

There exist two opposing hypotheses for the origins of *Homo sapiens*: the "Multi-regional" hypothesis and the "Out of Africa" hypothesis. The first hypothesis suggests that modern humans evolved independently in different parts of the world resulting in regional variations in the world's population. In this scenario Neanderthals in Europe and

Homo erectus in Asia did not make a genetic contribution to the modern *Homo sapiens* population, and instead they were replaced by moderns from Africa. The second hypothesis suggests that modern humans evolved on the African continent and spread to the other parts of the world, replacing the existing "archaic" populations and ultimately resulting in a single modern human population.

The multi-regional hypothesis was first proposed by Franz Weidenreich (1943, 1949) who argued that the *Homo erectus* fossils of China (Peking Man fossils) gave rise to the modern Chinese population and the *Homo erectus* fossils from Indonesia (Java Man fossils) gave rise to Neanderthals, ultimately leading to modern Europeans. The more recent multi-regional model proponents see gene flow occurring between the archaic and the modern species of humans, leading to a regionally diverse modern population today (Wolpoff *et al*. 1984, 2001; Wolpoff 1989; Wolpoff and Caspari 1997). Anatomical features developed in response to regional environmental conditions and those regional variations remain today. More recent arguments for this model accept a more intermediate view. There is more support for arguments that some gene mixing occurred between the modern humans from Africa and those regional human populations in other parts of the world (Pearson 2004)

Genetic studies seem to support the "Out of Africa" model. Mitochondrial DNA and Y-chromosome DNA research of modern Africa groups indicates the greatest time depth of any modern human population (Cann *et al*. 1987; Vigilant *et al*. 1991; Harpending *et al.* 1998; Blum and Jakobsson 2011; Henn *et al.* 2011; Veeramah *et al*. 2012). Other

researchers place the dispersal of modern humans out of Africa and replacement of archaic populations at a later period, around 50k-60k years ago (Richards and Macaulay 2000; Semino *et al.* 2000; Ingman *et al.* 2000; Underhill *et al.* 2001; Stringer 2002; Caramelli *et al.* 2003; Forster 2004; Serre *et al*. 2004). However there is still debate among researchers regarding the genetic evidence. Eswaran (2002) suggests that the genetic data may reflect a gradual diffusion of modern genes through the existing archaic population. Relethford and Harpending (1995) and Relethford (2001) have shown that some genes have older lineages in, not Africa, but other parts of the world. Still others have argued that the rate of change or evolution in DNA is not completely understood leading to a misinterpretation of the data (Clark and Lindly 1989). The most recent research suggests there was, in fact, some genetic contribution from Neanderthals to modern human DNA (Green *et al.* 2010). Green and colleagues found 1-4% of Neanderthal contribution to the gene pool of modern humans living outside of Africa.

In addition to the genetic evidence the fossil evidence also supports an African origin for modern *Homo sapiens*. The discovery of the earliest *Homo sapiens* goes back to 1967 when a team lead by Richard Leakey recovered a near complete skull (Omo II) in the Omo Valley of south-west Ethiopia (Leakey *et al*. 1969). Three fossils were recovered but it was Omo II with a large cranial vault, high forehead and gracile features that clearly placed it as *Homo sapiens*. Originally dated to 130k years ago, the formation has recently been re-dated and determined to be 196k years old (McDougall *et al.* 2005) making it the oldest *Homo sapiens* fossil yet to be found. The next oldest *Homo sapiens* material was recovered in the early 21st century from Herto, Ethiopia, dated to 160k years ago (Clark *et*

al. 2003, White *et al*. 2003). Southern Africa has also yielded early *Homo sapiens* fossils though the sites do not date as old as the east African material. These include Border Cave (Beaumont *et al*. 1978; Beaumont 1980; Pfeiffer and Zehr 1996; Sillen and Morris 1996), Die Kelders (Grine 1998, 2000), Klasies River Mouth (Singer and Wymer 1982; Rightmire and Deacon 1991; Grine *et al*. 1998) and Pinnacle Point (Marean *et al*. 2004). The southern African material has proved to be difficult to date but is accepted as being 50k-100k years old. In contrast, the oldest anatomically modern human fossil found in Europe comes from Pestera cu Oase in Romania and is only dated to 32k to 40k years ago (Trinkaus 2003, Rougier *et al.* 2007).

Thus, currently the "Out of Africa" model carries more evidence, both archaeologically and genetically, and is more widely accepted than the "Multi-regional" model.

5.2.2 Origins of Modern Human Behaviour

Perhaps more important than the appearance of anatomically modern humans is the first appearance of behaviorally modern humans, for it seems that it is our behaviour, our social structure and cognitive abilities, that more appropriately define us. But the origin of modernity is still a much debated topic as well. Some (Klein 1995, 2000, 2001; Ambrose 2001; Coolidge and Wynn 2009) still see the Upper Paleolithic of Western Europe as reflecting the first clear evidence of modern behaviour at around 35-40k years ago. The Upper Paleolithic humans produced cave paintings, carved figurines and engraved bone; all examples of art and a reflection of symbolic behaviour. Thus the transition from the

Middle to the Upper Paleolithic appears to have been very rapid and represented the first appearance of a host of behavioural traits that signaled the emergence of modernity. This model is often referred to as the "Revolution Model". Its origins can be traced back to the late 1980s with the publication of two books which were the result of a conference on the origins of modernity. *The Human Revolution: behavioural and biological perspectives on the origins of modern Humans* (Mellars and Stringer 1989) and *The emergence of modern humans: an archaeological perspective* (Mellars 1990), a collection of essays by researchers who proposed that the transition from the Middle Paleolithic to the Upper Paleolithic represents change in human behaviour manifesting in what today is seen as modernity. In addition to the modern behaviour witnessed in artistic expression, proponents of this model also postulate that Upper Paleolithic humans developed advanced techniques in the production of stone tools. An example of this is the development of single platform blade cores. This technique allows for multiple removals of similar blades or "blanks" that then can be converted into a wide variety of tool types. This production-line reduction process is seen as a major advancement in tool making by the Upper Paleolithic humans. Additionally, hafting of tools promoted more standardization of many of the tool types. Thus the early Upper Paleolithic is seen as having the "complete package" and is characterised by many innovations, such as improved blade and bladelet technology, new tool forms (including microlithics, complex bone and antler tools) and personal ornaments, sculptures, cave paintings, musical instruments, rapid changes in technological patterns, an increase in population densities and highly structured occupation sites (Klein 1995, 2000, 2001; Ambrose 2001; Coolidge

and Wynn 2009). Stringer and Gamble (1993) have labeled the sudden appearance of this host of modern behaviours as a creative explosion. Similarly, Bar-Yosef (1998, 2002) applied the term “revolution” to the abrupt change seen in the archaeological record at the beginning of the Upper Paleolithic. Some researchers (Klein 1999; Coolidge and Wynn 2009) argue that this rapid appearance of the complete set of modern behaviours was the result of a genetic change in the Upper Paleolithic humans. These first modern humans were the recipients of an additive genetic mutation that served as a basis for brain organization leading to modern thinking.

The “Revolution Model” does reflect the appearance in the archaeological record of what appears to constitute the remains of a people exhibiting modern behaviour. But it is based on evidence from sites that are chronologically narrow (25k-40k years ago) and spatially constrained (Southwestern Europe). Thus the “package" of traits that is evident in the Upper Paleolithic only reflects that time period and that area.

On the other side of this debate are those that see an African origin for modernity. McBrearty and Brooks (2000) countered the Human Revolution hypothesis with a detailed and comprehensive review of the African Middle Stone Age archaeological record. They were able to show that the components of the early Upper Paleolithic assemblages are found in the African MSA tens of thousands of years earlier. They argued that because of the long temporal span and large geographic coverage of the African MSA elements of social, economic and subsistence strategies changed at different rates and appeared at different times and places. This rebuttal to the Human Revolution model was

supported with multiple lines of evidence. Cylindrical or single platform blade cores were recovered from Kapthurin in Kenya from levels dated to almost 280k years ago. Expertly crafted bone points have been recovered from Katanda in the Democratic Republic of Congo with secure dates in excess of 90k years ago (Brooks *et al.* 1996; Yellen *et al*. 1995; Yellen 1998). Complex marine resource procurement was present as evidenced by fish fossils recovered from White Paintings Shelter in Botswana dated to between 50k-70k years ago (Robbins *et al*. 1994; Robbins and Murphy 1998) and mollusks fossils from Haua Fteah in Libya (Klein and Scott 1986) and invertebrate fossils near Massawa on the coast of Eritrea in levels dated to 125k years ago (Walter *et al*. 2000). Symbolic behaviour, the cornerstone of the Human Revolution model, is also found in Africa earlier than in Europe. Symbolism in the archaeological record is often described in expressions of art or ornaments. Ostrich eggshell beads have been recovered from MSA levels at Cave of Hearths (Mason 1962, Mason *et al*. 1988), Bushman Rock Shelter (Plug 1982) and Blombos (Henshilwood *et al.* 2004) in South Africa and from Mumba Rock Shelter in Tanzania (Mehlman 1989). Incised or engraved pieces of ochre were recovered from Blombos in South Africa (Henshilwood and Sealey 1997, Henshilwood *et al*. 2002) and Border Cave in Swaziland (Beaumont *et al*. 1978). Notched bone pieces have been recovered from Klasies River Mouth in South Africa (Singer and Wymer 1982) and from Apollo 11 in Namibia (Wendt 1972).

McBrearty and Brooks (2000) presented a strong argument for an African origin of modern human behaviour. More recently even more evidence has emerged from African MSA sites that indicates modern behaviour (Lombard 2012). The ochre processing toolkit

recovered from Blombos strongly suggests the use of the material for skin decoration or protection (Henshilwood and Dubreuil 2011; Henshilwood *et al.* 2011). Ochre, which has also been recovered from Klasies River (d'Errico *et al.* 2012) and Sibudu (Wadley 2009) may have been used symbolically either as body decoration or in rituals; but could also have served a more functional use. Marine shell beads, which must represent ornaments, have been recovered from sites in North Africa (Bouzouggar 2007) date beyond 80k years ago. Technological complexity, on the other hand, is more difficult to establish as an indicator of modern thought, but Ambrose (2010) suggests increased technological complexity, such as composite tools, require greater memory use and thus represent the expressions of modern brains. One clear example of the use of composite tools in Africa is the recently established early date for the bow and arrow (Lombard and Phillipson 2010).

However there is a weakness in using a shopping list of traits to determine behavioural intent as there exists a tenuous connection between artefacts and behaviour interpretation. Henshilwood and Marean (2003) have attempted to address this weakness by focusing on a symbolically mediated approach to determining modernity. They argue that the African continent involved different environments and different strategic approaches than what existed in Western Europe. They see the need for a paradigm shift that will bring a more African perspective to the issue. This new perspective can be used in developing models that can better describe the actions or behaviours of African MSA humans. Wurz (2008) has argued that "traits" that or considered to represent modern human behaviour may extend back to the ancestors of modern humans and thus may not be the marker that establishes our uniqueness. As

these behaviours may have followed a long and gradual evolutionary line it is difficult to distinguish the origins within a fractured and incomplete record, but some (d'Errico and Stringer 2010) argue that it is essential to understanding the rise of modern humans.

Africanist archaeologists have recovered a wealth of evidence that establishes the origins for this change in behaviour that appears in the Upper Paleolithic as coming from Africa. The African MSA clearly exhibits, in the archaeological record, people expressing themselves in symbolic ways and demonstrating a vast and complex understanding of their surrounding environment.

5.2.3 MSA Stone Tool Technology

The Swartkrans assemblage lacks symbolic artefacts that attest to the origins of modern behaviour, but it does contain MSA stone tools. Thus, it can make a contribution to a better understanding of the technological changes/adaptations in MSA stone tool production. More importantly, as inland or interior sites in South Africa are infrequent, the Swartkrans assemblage can provide information on MSA technologies in alternative habitats.

The MSA was first described by Goodwin (1928) as being intermediate between the Earlier Stone Age and the Later Stone Age. It was characterised by the absence of large, bifacially flaked cutting tools (handaxes and cleavers or LCTs), which represented the Earlier Stone Age, and microlithic tools, which represented the Later Stone Age (Goodwin

1928). Goodwin and Van Riet Lowe (1929) further defined MSA technology as a flake industry produced from predominately prepared cores. Importantly, they recognised variability within the MSA. In contrast, later researchers (Klein 1992, 1998; Clark 1999; Noble and Davidson 1996; Mithen 1996) actually did not see this and most often declared the MSA as static and without the variation seen in the Later Stone Age and the Upper Paleolithic.

Currently the MSA is loosely defined as the absence of LCTs with an emphasis on a flake and blade industry. The flake component is most often produced from prepared and/or radial core reduction processes. An important part of this flake industry is the production of points. A second significance is the increased reliance on blade production which allowed for a greater variety of tool types than what was previously obtainable. A third significant technological advancement during the MSA was the hafting of tools (Lombard 2006a, 2006b; Wadley 2005).

Earlier MSA research in southern Africa has been focused around typological analyses (Volman 1984). The resulting terminology and the research focus have often been divergent from Middle Paleolithic research. However the typological analysis conducted in South Africa did provide a solid basis for understanding the industries within the MSA. More recently, researchers have used a technological approach when analyzing assemblages, looking at core reduction (Wurz 2002), blade production (Soriano 2007) and hafted points (Villa and Lenoir 2006).

Cave of Hearths in the Limpopo Province of northern South Africa provided one of the earliest examples of an application of a cultural-stratigraphic approach to sequencing excavating levels. Cave of Hearths was first reported on by Van Riet Lowe (1938, 1943) who provided brief descriptions of the Stone Age tools present there. However, it was Mason's (1962, 1988) excavations over many years that exposed the rich and long Stone Age sequence of Cave of Hearths. The site yielded an Acheulian complex overlain by an extensive sequence of MSA material, which itself was overlaid by several Later Stone Age levels. Mason's divided the MSA levels (Beds 4-15) into an Earlier, Middle and Later Pietersburg. He described the earliest deposits (Bed 4) as Earlier Pietersburg characterized by large flake-blades and large points, with little formal retouched material present. There were only a few denticulates noted. This changed during the Middle Pietersburg (Bed 5), which had an increase in retouch and a decrease in flake and blade sizes. The Later Pietersburg (Bed 6) is characterized by large numbers of scrapers, retouched points and many points with modified platforms (suggesting hafting). The uppermost levels contain some backed tools or segments that are similar to the Howiesons Poort industry (Mason 1971). The Cave of Hearths assemblage was also placed into a cultural-stratigraphic sequence by Sampson (1974) and Volman (1984) as parts of larger reviews of the South African MSA. Though the three researchers used slightly different nomenclature for the industries and noted different stratigraphic levels for those industries, they agreed on certain trends that existed through the sequence: 1) decrease in size of blades and flakes, 2) increase in percentage of retouched pieces, 3) increase in variety of raw materials utilized, 4) increase in unifacial and bifacial points and,

5) the presence of backed tools or segments in the upper levels. More recently Sinclair (2009) analyzed the Cave of Hearths material and while accepting the above classifications he described the assemblage as having little variation and patterning. He saw greater modifications to blanks in the upper levels than in the lower levels and greater lengths to the blades in the lower levels.

Volman (1984) expanded his Cape analysis (Volman 1981) to include most of the known MSA sites at the time. His sequence began with early MSA which was described as having very little formal retouch and small, broad flakes with few faceted platforms dated to around MIS stage 6. Few retouched scrapers and no retouched points occur. MSA 1 is characterized by large, narrow flakes and flake-blades. MSA 2 sees the appearance of more retouched pieces and unifacial and bifacial points. He divided MSA 2 into an older 2a and younger 2b. Both the retouch and retouched points increase from 2a to 2b. Both the retouch and retouched points increase from 2a to 2b. The MSA 2 is followed by the Howieson's Poort industry. This industry is characterized by backed tools, usually made on blades smaller than those present in previous industries. The Howieson's Poort lacks points and it has been suggested the points, used as hafted tools, were replaced by the backed pieces as hafted tips (Lombard 2008). The Howieson's Poort is unusual in that the technology is short lived and after ~15k years the tool kit resembles the MSA 2. After Howieson's Poort is MSA 3, which is characterized by its similarity to MSA 2 and noted by Volman as "not readily distinguished as a group from MSA 2 assemblages" (1984: 207).

Singer and Wymer (1982) also used a cultural-stratigraphic approach in sequencing the layers at Klasies River, in the southern cape of South Africa. Their work, though involving only one site, made an important contribution to understanding change in the southern African MSA. They developed five cultural-stratigraphic stages for the Klasies River sequence—MSA I, MSA II, Howiesons Poort, MSA III, and MSA IV. As the Klasies River formation is not as old as some other sites, the first cultural-stratigraphic designation (MSA I) does not include the early MSA assemblages >110k years ago. MSA I was described as having little selection of non-local raw materials, very little retouch and more emphasis placed on the production of long, narrow flakes or blades. Denticulates dominate the retouch material. MSA II contained a higher percentage of pointed flake blades and a lower percentage of worked points. These were slightly smaller in size than those found in MSA I. The most common specialized tools were denticulates and scrapers. There was an increase in standardised cores. The Howiesons Poort is characterised by backed pieces with geometric shapes, made from a greater variety of non-local raw materials. Typical blades decrease as the focus shifted to backed micro-blades. Then in MSA III the assemblage reverts to similar tool types as found in MSA II, with unifacial points and blades with retouch dominate. In MSA IV the emphasis is on pointed and convergent flake blades. Blades are not backed but range in size similar to Howiesons Poort pieces.

All of the above analyses were based primarily on typology. This typological approach was common and the standard for stone tool analysis in southern Africa. However this helped create a disconnection between Middle Paleolithic research and Middle Stone Age

research. Several decades ago Middle Paleolithic researchers begin approaching lithic analysis from a technological perspective rather than just typological. Middle Stone Age researchers have only been conducting these methods in the last 10-15 years. Thus there has been a lag in technological studies regarding the African MSA. Additionally, this separate approach and separate terminology has resulted in difficulty in making cross comparisons between Middle Paleolithic sites and Middle Stone Age sites. This gap is rapidly narrowing as more researchers include a technological approach to MSA assemblages and make comparisons to the Middle Paleolithic (Villa *et al*. 2005; Villa, and Lenoir 2006; Soriano *et al.* 2007).

A good example of a more technological approach is the work of Wurz (2002). She incorporated facets of both approaches in a re-assessment of the Klasies River main site. She studied the stone tools from each of the technological sub-stages established by Singer and Wymer (1982), looking at blade production through the core reduction process. Wurz was able to show that even though there were typological similarities between the divisions there were definite differences in technological approaches by the tool makers. The research reinforced the divisions established by Singer and Wymer, but Wurz proposed different names for the stages—Klasies River, Mossel Bay, Howiesons Poort, Post-Howiesons Poort.

The Klasies River sequence has been dated by several techniques, including Uranium series (Vogel 2001) and Luminescence (Feathers 2002). The lowest levels of the Klasies River sequence (Singer and Wymer- MSA I; Volman- MSA 2b; Wurz- Klasies River) date to

~110k years ago. MSA II dates are varied but cluster around 60-80k years ago. The Howieson's Poort levels are ~50-60K years old and the MSA III or post-Howieson's Poort is dated to 45-50k years ago.

More recently, Jacobs *et al.* (2008) have dated the Still Bay and Howieson's Poort industries across a number of sites in southern Africa, including Klasies River and other costal sites in South Africa. The Still Bay and Howieson's Poort industries, due to their innovativeness, are considered important possible markers for modern human behaviour. Jacobs *et al.* (2008) place the Still Bay appearing around 72k years ago and lasting only ~4-5k years. The Howieson's Poort appeared 64.8k years ago (± 3.2k years) and disappeared 59.5k years ago (± 3.1k years).

The dating of MSA sites has resulted in a variable span of time for the appearance of different technological industries. Part of this variability may lie with the different dating methods used or different labs/researchers performing the tests. But more likely, the variability is a reflection of the elasticity of humans. The technological changes found in the archaeological record are a result of the adaptability and innovation of people. The pressures for adaptive changes fluctuate both spatially (different regions) and chronologically (different times). Additionally, innovation does not follow a linear progression. Thus, it would be expected to have irregularity in the appearance and disappearance of technology in the archaeological record. However, patterns within the record do represent behaviour and dating of sites, and more specifically, dating technological changes can assist in discerning that behaviour.

5.3 Member 4 Excavations

The Member 4 excavations began in 2005 in the trench originally dug by Brain (Figure 34). A fortuitous formation process exists where the lower part of the Member 4 talus cone is accessible beneath a large cave roof block 10 meters below the surface. This allowed the author to excavate both the surface deposit and the sediments 10m below the surface without removing 10m of soil. One of the original goals of the Member 4 excavations for this



Figure 34. The author and C. K. (Bob) Brain standing in Brain's Member 4 test trench at the beginning of the 2005 excavations.

project was to recover stone tools from the surface excavation as well as inside the cave. As the recovered material would be separated by ~10m of deposit, and possibly tens of thousands of years in time this could have provided an opportunity to distinguish technological change, chronologically, in the Swartkrans Formation. However, as with many archaeological excavations, the original goals and objectives had to be adjusted as the work progressed. It is now clear the MSA at Swartkrans is contained in a colluvium that overlies a much older talus cone that extends into the cave. Additionally, this talus cone itself overlies a separate deposit that appears to be an extension of the Lower Bank which is the oldest deposit in the cave system (Sutton *et al.* 2009 and see results section for a more complete explanation of the Member 4 formation).

5.3.2 Excavation Methods

An EDM laser theodolite was used to establish a square meter grid over the floor of Brain's original 1980−1981 test trench on the surface of Member4. The Member 4 grid is now part of Brain's overall grid system, with the meter coordinates used in the current excavation corresponding to each square's position within the cave system (Figure 35). Each square was excavated by quadrant (50 cm x 50 cm) at 5 cm and 10 cm (after reaching sterile levels) depths. Six squares, 2N 21E, 2N 22E, 3N 21E, 3N 22E, 4N 21E, and 4N 22E, were excavated. The first four squares occur within Brain's 1980−1981 trench. Squares 4N 21E and 4N 22E were opened to provide a sample from the original surface of the deposit since their north halves are beyond the north wall of the trench. This is due to

erosion of the trench walls in the 25 years since the original excavation. The original 3m wide trench is now ~3.5m wide.

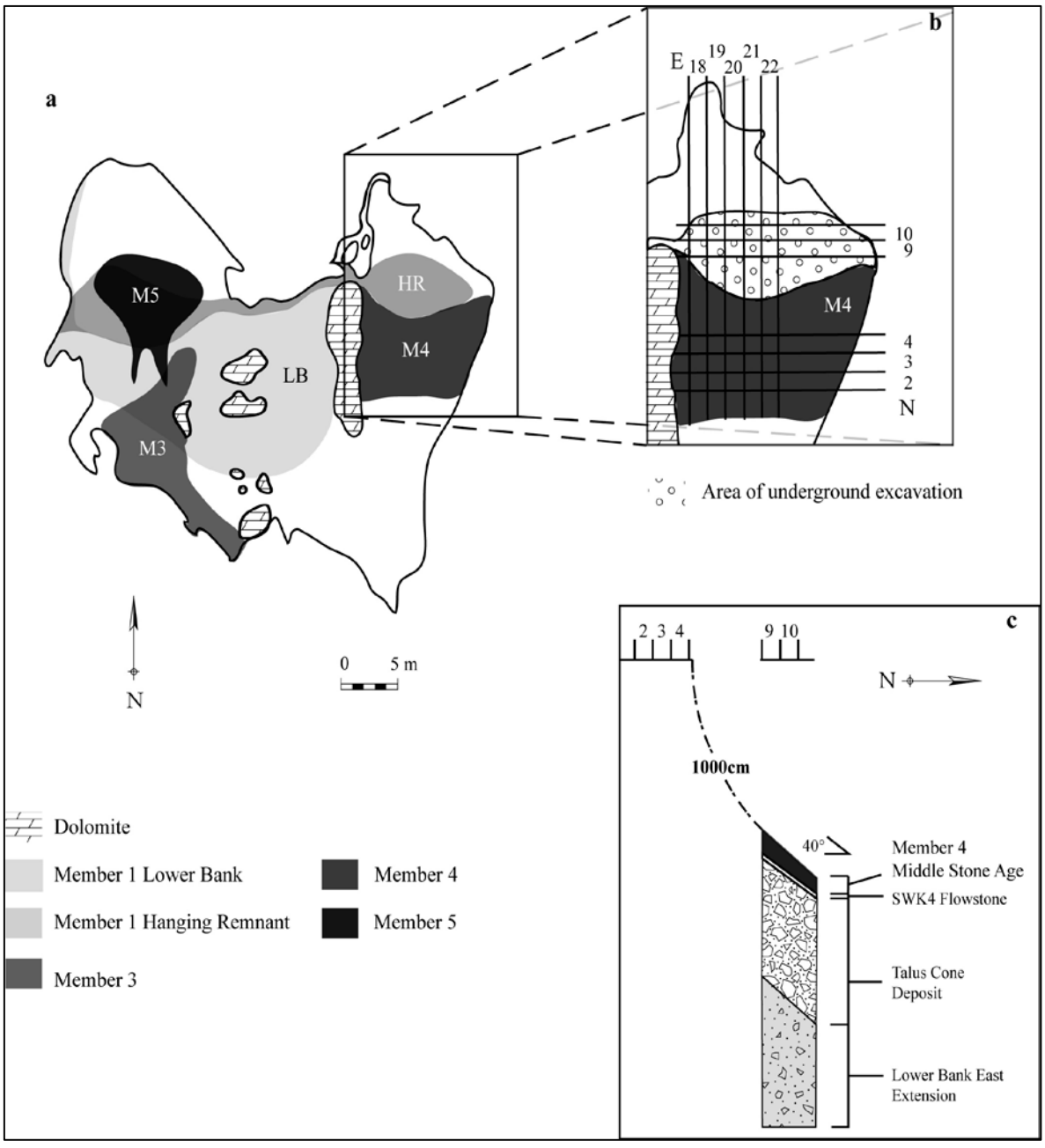


Figure 35. Plan view of Swartkrans Cave showing the relationship of Member 4 to the other areas of the site. (b) Detail of the Member 4 area, with the excavation grid superimposed. The Member 4 area includes the MSA surface excavation (shaded) and the underlying Talus Cone Deposit and Lower Bank East Extension deposit, exposed in our excavations to the north (open circles) of the surface excavation. (c) The Member 4 area stratigraphy is shown schematically in profile. Drawn by Jason Heaton.

All artefacts ≥20mm in length were recorded by position with the EDM before removal. Each quadrant level was excavated separately and then sieved using a 5 mm mesh over a 2 mm mesh screen. The material from the 5 mm mesh was then wet sieved. The 2−5mm fraction material was sorted to ensure the collection of stone artefact chips, small bone fragments and microfaunal remains.

5.4 Excavation Results

The excavation on the floor of Brain's 1980-1981 test trench (squares 2N 21E, 2N 22E, 3N 21E, 3N 22E, Figure 36) immediately yielded stone artefacts. Approximately 40 artefacts per 5 cm level were recovered in the upper levels (40 cm) of square 2N 21E. However, beyond these depths only a few artefact flake fragments per level were recovered, and eventually at ~60 cm below the floor of Brain's original test trench the deposit became archaeologically sterile. A similar pattern existed in the upper levels of 2N 22E, 3N 21E, and 3N 22E, and it was decided to halt excavations of these squares and continue down in 2N 21E to determine the natural contour of the deposits. Artefact density parallels a change in the matrix. The floor and walls of the test trench are composed of a reddish brown (5YR 3/3), slightly organic, silty sand. Then, at ~40 cm, a more consolidated, dark reddish (2.5YR 3/6) silty sand was exposed. This relatively consolidated layer continues to a depth of 130 cm, at which point excavation on 2N 21E was discontinued. Squares 4N 21E and 4N 22E, which began at the original surface above Brain's trench, also yielded dense artefact levels until reaching the matrix change or underlying deposit. It is evident the MSA artefacts exist in the upper 110 cm (from original untrenched surface) layer,

which overlies a larger Talus Cone Deposit (TCD). Brain's original trenching was stopped when he reached a slight change in the sediment and he considered this was the proper deposit (Brain *pers. comm*. 2005). It appears that he stopped at the base of the colluvium and the top of the underlying talus cone. In the ensuing 25 years the trench walls eroded onto the floor of the trench. Thus the upper levels (0-40cm) of the squares 2N 21E, 2N 22E, 3N 21E, 3N 22E in the new excavations actually included eroded trench wall material. Once through this layer the underlying talus was reached, which did not contain any MSA artefacts. Thus what was known as the Member 4 MSA deposit actually consists of 110-120cm of colluvial sediments which are underlain by an older talus cone.

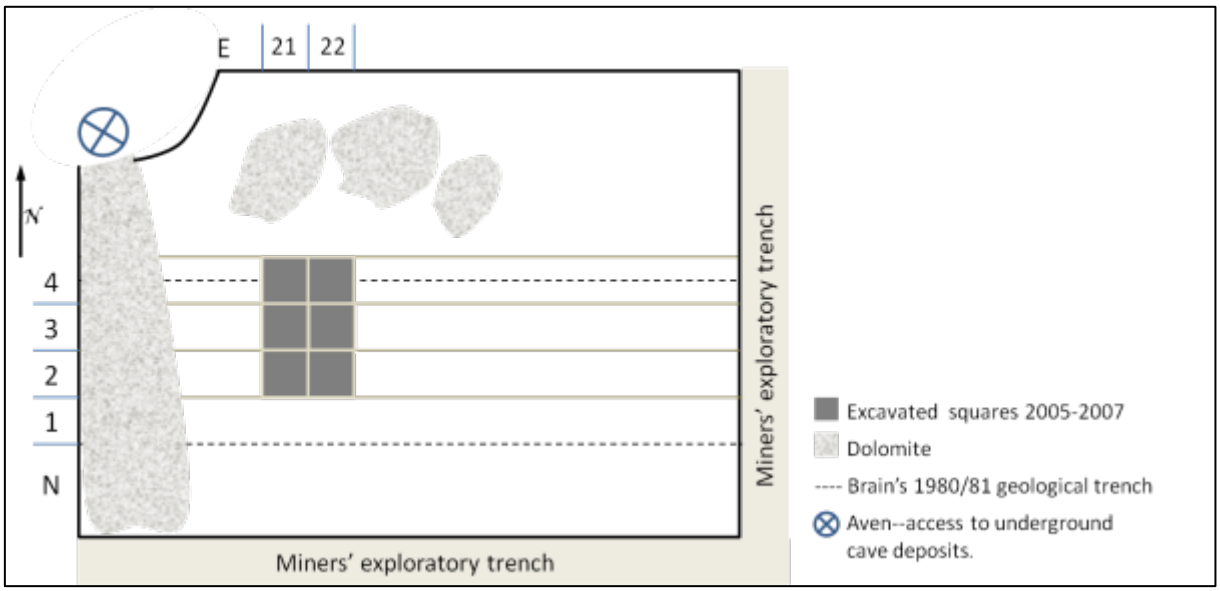


Figure 36. Plan view of the Member 4 surface deposit showing Brain's test trench and the newly excavated squares.

Approximately 3200 artefacts have been recovered from the surface excavations. No cultural material other than stone artefacts has been recovered from the MSA colluvium.

The absence of bone or fossil remains is in stark contrast to the other deposits of the Swartkrans Formation. There is no evidence of diagenetically altered bone to suggest the dissolution of fossils in the deposit (see Karkanas *et al*., 2000) to explain their absence. Rather the lack of fossils suggests the absence of a cave roof overhanging the area now occupied by Member 4 during the period when MSA sediments and artefacts were deposited. Bone preservation within dolomitic limestone caves is due largely to its encasement in calcified conglomerates (i.e., sedimentary breccia), and bone breccia formation in a cave is typically dependent on an overhanging roof from which water bearing calcium carbonate drips onto the floor and calcifies sediments and the bones and stone clasts within them (Brain, 1958, 1981; Latham, 1999). Alternatively, bones may have never been deposited in the area during the MSA. However along the northern edge of the deposit rests several large dolomite blocks that represent roof spall that resulted from a collapse of the cave roof in that portion of the cave. As these blocks are both overlying and surrounded by the Member 4 deposit it suggests the collapse occurred during or after the MSA people were in the area. This may imply that an overhang of the roof existed during the MSA and this could have been part of the attraction to the tool makers.

Four square meters were excavated underground to a depth of 175 cm, on the north side of the Member 4 talus (9N 18E, 9N 19E, 10N 18E, and 10N 19E). The same excavation methods as the surface excavation were used inside the cave. As the excavations were into the north face of a large talus cone, the levels (10cm) were sloped to maintain the 38^0 slope of the talus (Figure 37). The limestone miners had originally cut into the talus

cone approximately 1.5m in search of limestone material. Thus, my excavations begin in that cutting, in square 9N 19E. Stone artefacts, in the form of flakes and flake fragments,



Figure 37. Photo of underground deposits showing (a) in profile, the flowstone with the MSA overburden and (b) in plan, the exposed flowstone capping square 10N 18E. (c) Two underground stratified deposits, TCD overlying the LB East Extension. Note the large dolomite roof spall blocks in the corners of the photo representing the roof collapse above that allowed the TCD material to enter the cave .

were recovered from the outer 18cm of the underground Talus Cone Deposit (TCD) material in squares 9N 18E and 9N 19E. The recovered artefacts included a large quartz scraper and a denticulated blade, but within the same layer I also recovered a partial plastic container that appears to be a modern AA battery package. The implication was

that the level had experienced recent mixing. What became apparent was the outer layer of the TCD contained surface material from the overlying colluvium. A small number of stone artefacts with clear MSA attributes were also recovered from 10N 18E and 10N 19E. The artefacts recovered from the cave deposits are included in the technological analysis. In square 10N 18E, I also uncovered a 2-3cm thick flowstone at a depth of ~18cm (Figure 25). Once I removed this flowstone I recovered a few non-diagnostic flake fragments, but more significantly, almost immediately I recovered fossilized bone, including hominin specimens of *P. robustus* (see hominin section below). As the last dated appearance of *P. robustus* is from Swartkrans Member 3 (900k years ago), it became apparent the talus cone was a much older deposit. The calcite flowstone was a capping stone formed over the underlying TCD and separated it from the overlying MSA artefact bearing colluvium. Further inspection of the exposed profile of the wall in squares 9N 18E and 9N 19E revealed other remnants of this capping flowstone. However, because these squares are further within the talus cone and at this point the dolomite cave roof angles sharply vertically, the flowstone had the full weight of 10m of talus cone sediment above it. Thus the flowstone was broken up and mixed into the talus sediments in this area. As the excavations continued in all four squares to a depth of 110cm from the original entry point into the cone, a clear unconformity between the TCD and an underlying stratified deposit was reached (Figure 37c). This contact point is ~10m below the surface (the depth varies from 9.8 – 10.3). This lowest deposit contains fossils, but no stone artefacts have yet been recovered. The deposit is also distinct sedimentologically from the overlying TCD. The TCD is dark reddish (Munsell 2.5YR 3/6) sediment, that is very loosely

consolidated with large to small clasts of dolomite. The lower deposit is a more consolidated, largely decalcified yellowish-red (Munsell 5YR 4/6), sandy silt sediment that contains fossils, with only occasional very small to small clasts of subangular dolomite. Additionally, the lower deposit has areas of remaining calcification. The color, consistency and content of the matrix appear to be identical to the Lower Bank of Member 1.

5.4.1 Fabric Analysis

In order to better understand the formation processes of the two underground deposits, a preliminary fabric analysis was conducted on the sedimentary clasts included in the sediments. Fabric analysis involves the measurements of angle and direction of elongated stone clasts in a stratum to clarify the origin or flow direction and dynamics of the accumulation. "The term ''fabric'' refers to the spatial attitude of objects such as clasts and lithic or bone artefacts lying within a geological layer. This attitude is quantified by the measurement of the strike and dip of a suitable aspect of the objects, i.e. the long axis (a) or the plane of maximum projection (ab)" (Bertran and Texier 1995: 522). Data collection followed the methods suggested by Bertran and Texier (1995) and Lenoble and Bertran (2004). A Brunton® GEO Transit instrument was used to measure inclination and orientation on all stones >2cm in length with an elongation ratio (length/width; Drake 1974) of >1.6. Elongated pieces of stone with a ratio of 1: 1.6 or higher will, in most cases, orientate themselves in the direction of flow, whether in a fluvial (i. e. stream bed) or colluvial (i. e. slope wash into a cave) environment. The analysis on the two underground

deposits is considered preliminary due to the sample size. Lenoble and Bertran (2004) recommend a sample size of 40-50 measured pieces to ensure a stable Vector Magnitude. Because the Swartkrans dolomite weathers predominantly into cube-shaped blocks, elongated pieces >2 cm in the underground excavations are rare and only 10 pieces per deposit were suitable for measurement. Thus, even though our fabric data were collected from several excavated levels, the overall samples still fall short of the recommended sample size. However, there were clear distinctions between the two underground deposits (Figure 38). Stones measured from the lower deposit were oriented east-northeast, reflecting a sediment flow direction from the west side of the cave. This is the area occupied by the Lower Bank of Member 1.

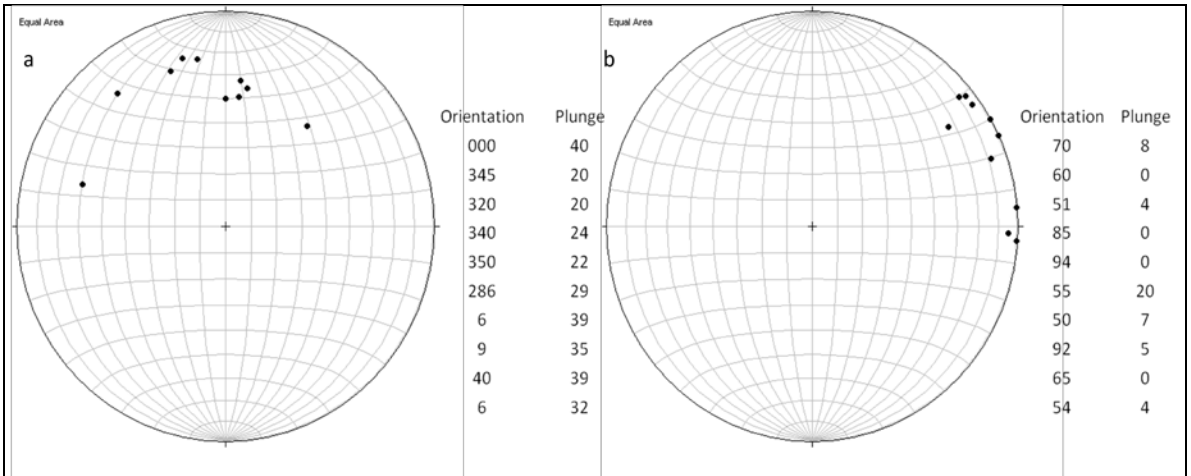


Figure 38. Stereographic presentation of fabric reflecting plotted orientation and plunge of elongated stone, (a) from overlying talus cone (TCD) and (b) from the lower deposit, (LBEE). The talus cone pieces have a northerly orientation and a plunge range of between 20^0 and 40^0 (mean 30.5^0) analogous to the 40^0 slope of the north side of the talus. The LB East Extension pieces are oriented ENE and are relatively flat (plunge range of 0^0 to 20^0 with a mean 4^0) indicative of the east distal end of the Lower Bank infill. Fabric analysis data were plotted with Stereonet software developed by Richard W. Allmendinger.

Additionally, the inclination of the recorded stones from the lower deposit are relatively flat with a plunge range of $0^0 – 20^0$ with a mean of 4^0**.** This relatively flat angle suggests the slope infill flattened as it moved toward the east wall, continuing under the low hanging cave roof beneath the M4 area. Thus the inference is that this lower deposit is an extension of the Lower Bank and is now designated as the LB East Extension (Sutton *et al*. 2009). In contrast, the TCD pieces are oriented north, with their inclination (plunge range $20^0–40^0$; with a mean of 30.5^0) clustered around the overall slope angle of the talus cone which is 38^0. This is what is predicted for stones filtering down the outside edge of the north face of the talus cone from the overlying MSA deposit.

5.4.2 Speleothem Dating

A sample (SWK 4) of the capping flowstone of calcite underlying the Member 4 MSA unit was extracted for Uranium Thorium (U-Th) dating. The sample was removed from the *in situ* formation in square 10N 19E. This block was subsampled three times (SWK 4-1, 4-4, 4-5) by Robyn Pickering of the Institute for Geological Sciences, University of Bern, Switzerland. Uranium and thorium isotopes were measured separately on a Nu Instruments® multicollector ICP-Mass spectrometer. Table 6 summarizes U-Th disequilibrium dating results on the SWK 4 subsamples, with a mean age of 110,330 ± 1,980 years old for the flowstone layer (Sutton *et al.* 2009). This establishes the maximum age for the overlying MSA stone tool assemblage.

Sample	U ppb	Th ppb	(234U/238U)b	±	(230Th/234Th)c	±	(230Th/232Th)	±	Age (ka)	±	(234U/238U)d	±
SWK4-1	59.9	0.8	1.201	0.005	0.642	0.004	178.5	1	109.29	2.24	1.274	0.013
SWK4-4	59.3	1.3	1.176	0.002	0.655	0.004	107.9	0.7	111.24	2.14	1.257	0.004
SWK4-5	58.4	0.9	1.188	0.001	0.652	0.003	146.6	0.7	110.47	1.57	1.257	0.004
							Mean	**Age**	**110.33**	**1.98**		

Table 6. Table showing the results of U-Th dating on the flowstone sample underlying the MSA deposit. Multicollector ICP-Mass spectrometer uranium series data for sample SWK 4a. The mean age of the samples is 110.33k years ago, establishing the maximum age for the overlying MSA assemblage. From Sutton *et al*. 2009.

5.5 Discussion: New Stratigraphic Interpretations

The new excavations in the Member 4 deposits at Swartkrans have exposed a much more complex formation process than what was originally thought. It is now clear that the northeast corner of the cave system that has been designated the Member 4 deposit is actually composed of four distinct stratigraphic divisions. In summary, following the order of discovery (youngest to oldest), these are:

(1) The uppermost layer is the MSA tool-bearing deposit, to a depth of 110 - 120 cm and composed of dark reddish-brown (Munsell 5YR 3/3), loose, non-calcified silty sand, with abundant small to large clasts of angular dolomite that are heavily stained with manganese. Unlike the MSA infill at nearby Sterkfontein, where some diagnostic artefacts co-occur with reworked ESA materials (Reynolds *et al*. 2007), the Swartkrans MSA artefact assemblage does not show any incorporation of older, reworked artefacts, and its large size renders it more informative of MSA hominin behavior and technology. A probably younger (88,700 ± 1,600−62,900 ± 1,300 years old) MSA artefact assemblage

from Plover's Lake, only ~6 km northeast of Swartkrans, has not yet been published in detail (de Ruiter *et al*., 2008).

(2) The MSA stratum overlies a now-fragmented speleothem, with a mean U-Th age of 110,000 ± 1,980 years old, which sets the maximum age for the MSA and serves as a capstone for two underlying strata that necessarily must be older than c. 110k years old.

(3) Immediately beneath the dated flowstone is the large TCD, >12 m thick. The TCD, a dark red (2.5YR 3/6) decalcified silty sand, with small to medium sized (10−25 cm) clasts of angular and subangular dolomite, contains an abundance of fossils but no MSA stone artefacts deeper than its outer 20 cm. The presence of *P. robustus* fossils in the TCD indicates that it is of much greater (late Pliocene or early Pleistocene) age than the overlying flowstone and MSA units.

(4) The lowest sedimentary unit is a yellowish-red (Munsell 5YR 4/6), sandy silt, with only occasional very small to small clasts of subangular dolomite. It contains fossils and is termed the Lower Bank (LB) East Extension. The LB East Extension is largely decalcified, but it has areas of remaining calcification. The matrix of the LB East Extension is consistent with that of the LB of Member 1 from Brain's original excavation area on the cave's surface and we infer that the former is an eastward extension of the latter (Sutton *et al.* 2009: 695).

In combination with Brain's (1993c) previous interpretation of the formation of the Swartkrans Cave deposits the new revised reconstruction for the northeast corner area is as follows:

(1) Sometime probably in excess of 1.7 Ma, joints in the roof of an underground cavern that was to become Swartkrans Cave opened between the ground surface and the cavern. This shaft began to admit surface-derived soil materials, which formed a talus slope below the shaft and extended toward the northwest corner of the cave; this deposit is now referred to as the LB of Member 1 (Brain, 1993c). This project now shows that the infilling also continued laterally toward the east for ~50m until it reached the east wall of the cave. The passage through which this eastward extension of the LB traveled was very narrow due to the extreme thickness of the cave's roof near its north wall; this narrow channel between the roof and floor of the cave leveled the LB East Extension deposit, as reflected in fabric orientation (ENE) in that portion of the cave. Eventually, but still in the early Pleistocene (c. 1.8−1.0 Ma) based on the faunal dates for the contiguous surface LB of Member 1, the eastern part of the cave became choked with LB East Extension sediments.

(2) More recently in the Pleistocene, the continued dissolution of dolomite by groundwater resulted in a partial collapse of a section of cave roof in the Member 4 area. The resulting aven allowed the infilling of the Member 4 area TCD, as evidenced by the large roof spall in the contact zone of the LB East Extension and the overlying TCD and by the presence of surface dolomite rubble in the lower portions of the TCD. Fabric orientation reflects the steep northward advance of the talus formation. The talus cone eventually filled the opening, once again choking off the area from further infill.

(3) A flowstone layer was deposited over the TCD in the late Pleistocene, c. 110k years ago, indicating that the cave was partially closed during this time and that its roof was relatively intact.

(4) A MSA deposit covered the top of the talus cone in the Member 4 area, with some material filtering down the north surface of the cone. The density of stone tools and absence of bone suggest deposition of MSA materials after the dissolution and collapse of the cave roof, or, alternatively, that the materials were deposited just beyond the protection of an existing roof (Sutton *et al.* 2009: 695). There are several large dolomite blocks lying in the north edge of the surface deposit. These blocks appear to be large spall blocks from the dolomite cave roof. As the blocks lie both within the deposit and over the base of the colluvium, it suggests that during the deposition of the MSA deposit there might have existed an overhang or partial intact cave roof along the northern boundary of Member 4 (Figure 23). Additionally, as will be discussed in the stone tool section, the great majority of the artefacts are in fresh condition with little or no edge damage, indicating very little movement of the colluvium. A large dolomite block along the western boundary of the deposit limits the path of slope wash down the hillside and has most likely eased abrasive forces. Artefact condition thus supports a conclusion that the MSA assemblage may be in near-primary context. This area of the Swartkrans site could have been an attractive locality to Middle Stone humans, providing shelter/protection during their activities on the hill.

5.5 Hominin fossils

Hominin fossils have been recovered from the underground deposits. Analysis of the hominin fossils from the lowest deposit (LB East Extension) have not been conducted and are not part of this thesis. Three hominin dental fossils have been recovered from the TCD (Table 7, Figure 27; Sutton *et al.* 2009). All three specimens have been attributed to *P. robustus*.

Specimen SWT/TC-2 is a partial crown of a right upper molar with the root missing. It is broken mesiodistally through the buccal cusps but the remaining crown is well preserved with very little wear.

Specimen SWT/TC-3 is a fragment of either a premolar or molar with heavy wear as well as a series of wear scratches. SWT/TC-4 is a complete upper central incisor with heavy wear and possible damage during life (Sutton *et al*. 2009).

In addition to adding to the overall hominin fossil collection from Swartkrans, the dental specimens from the TCD are significant as they were recovered from a previously unknown deposit at the site. The above research has established the TCD as a wholly distinct infill which now represents the fourth hominin bearing deposit in the Swartkrans Cave formation.

Specimen	Element	Excavation Coordinates	
		Square	Level below Datum of 100
SWT/TC-2	RM[1]	9N 18E	90.400- 90.300
SWT/TC-3	Premolar or Molar Fragment	9N 18E	90.400- 90.300
SWT/TC-4	LI[1]	9N 19E	90.300- 90.200

Table 7. Hominin dental fossils recovered from the TCD of Member 4.

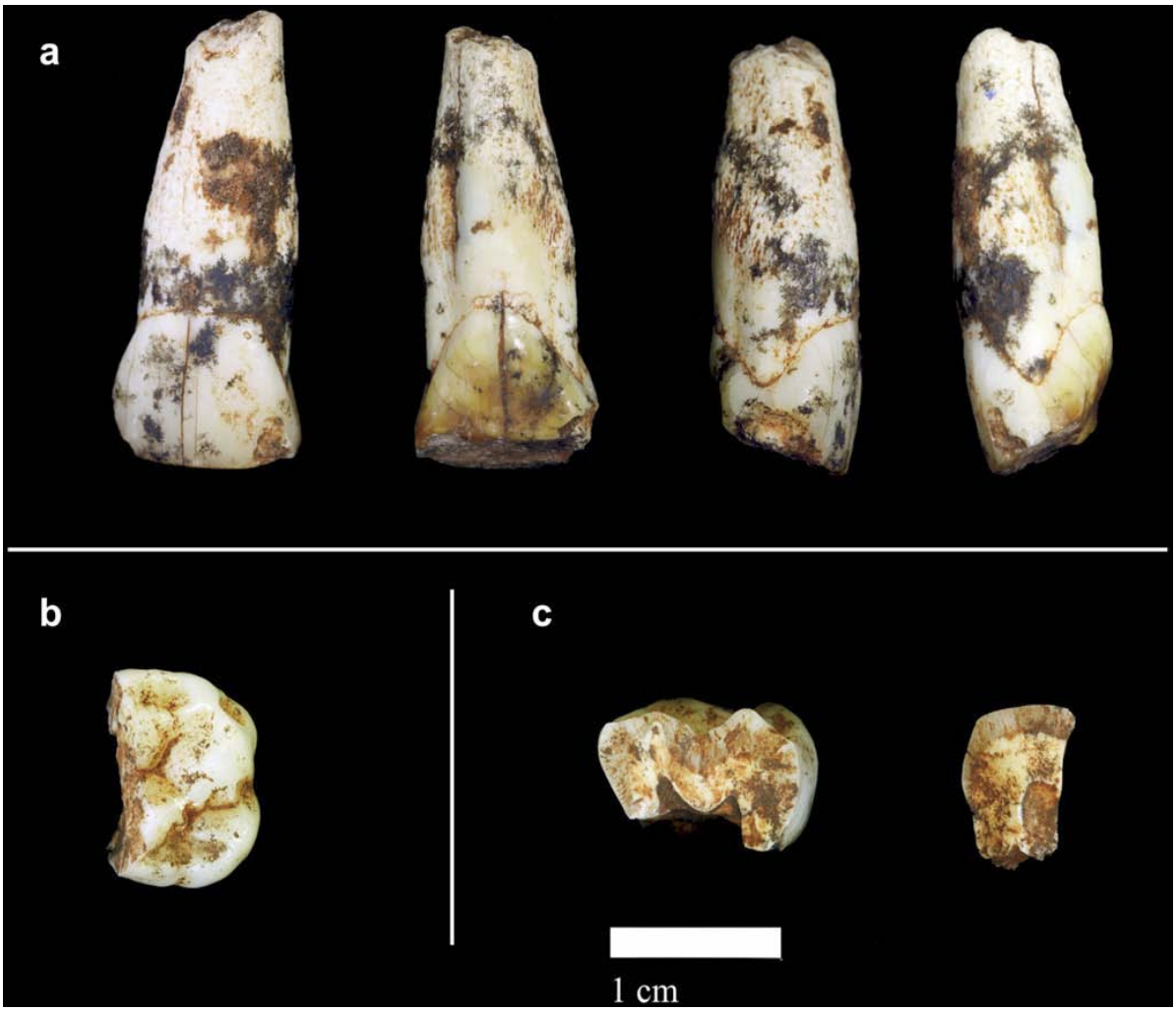


Figure 39. Photo of the *P. robustus* dental fossils recovered from the TCD. (a) SWT/TC-4 is a left upper central incisor, (b) SWT/TC- 2 a right upper molar and (c) SWT/TC-3, a premolar or molar. Photograph by Jason Heaton.

5.6 Stone Tools

Brain's 1980/81 test trench through the M4 deposit resulted in the recovery of 1781 stone artefacts. The 2005-2007 excavations resulted in the recovery of 3226 additional stone artefacts. For analysis purposes it was decided to set a cut-off point at a maximum length of 2cm, and thus all pieces <2cm are classified as small flaking debris (SFD). The 1980/81 excavations only included two pieces less than 2cm. However, the 2005-2007 excavations recovered many more SFD pieces (N= 2227) (see section 5.6.1). The combined >2cm pieces analyzed are N= 2778 (Table 7 and 8).

5.6.1 Comparisons of the 2005-2007 and the 1980-1981 assemblages

The large discrepancy between the SFD numbers of the two excavations must be regarded as collection bias. Brain's methods for sieving were consistent with work elsewhere in the site, using gradient sieves down to 2mm in size. Brain (*pers. comm*. 2007) has affirmed that these methods were used during the test trenching of Member 4. In the other Members (1-3) there are high frequencies of microfauna confirming recovery of small material. However the near absence of stone artefacts <2cm suggests the collection and recognition process for small artefacts must have been biased. There are no <10mm pieces and only two 11-20mm pieces, whereas the 2005-2007 excavations recovered 2227 pieces <20mm. Thus discussion in this thesis regarding site capture and

small flaking debris (SFD) percentages is based on the new excavations and does not include the 1980-1981 material.

Table 8. Artefacts from 1980/81 excavations categorized by raw material and debitage type

	QUARTZ				QUARTZITE				DIABASE				CHERT			TOTAL
		COMPLETE FLAKES	261			COMPLETE FLAKES	20			COMPLETE FLAKES	4			COMPLETE FLAKES	4	289
		FLAKE FRAGMENTS	324			FLAKE FRAGMENTS	8			FLAKE FRAGMENTS	15			FLAKE FRAGMENTS		347
		INCOMPLETE FLAKES	274			INCOMPLETE FLAKES	26			INCOMPLETE FLAKES	8			INCOMPLETE FLAKES	1	309
										INDETERMINATE	178					178
		SPLIT FLAKES	10			SPLIT FLAKES	3									13
		CHUNKS	330			CHUNKS	3			CHUNKS				CHUNKS		333
		FORMAL TOOLS	152			FORMAL TOOLS	24			FORMAL TOOLS	3			FORMAL TOOLS	1	180
		CORES	52			CORES	4			CORES	2			CORE	1	59
		CORE MAINTENANCE				CORE MAINTENANCE								CORE MAINTENANCE		
		TRIMMING	7			TRIMMING	1							TRIMMING	1	9
		REJU				REJU								REJU		
		CORE FRAGMENTS	31			CORE FRAGMENTS										31
						HAMMERSTONE	1									1
			1			MANUPORT	3			MANUPORT	1					5
		BLADES	2			BLADES	6			BLADES	6			BLADES	1	15
		RETOUCHED	5			RETOUCHED				RETOUCHED	1					6
		BLADE FRAGMENT	2			BLADE FRAGMENTS	1				1					4
Totals			1451				100				219				9	1779
		SMALL FLAKING DEBRIS														
		<10mm														
		10-19mm	2													2
														TOTAL		1781

Table 9. Artefacts from 2005-2007 excavations categorized by raw material and debitage type

			N												
	QUARTZ				QUARTZITE				DIABASE				CHERT			TOTAL
		COMPLETE FLAKES	126			COMPLETE FLAKES	54			COMPLETE FLAKES	17			COMPLETE FLAKES	15	212
		FLAKE FRAGMENTS	214			FLAKE FRAGMENTS	38			FLAKE FRAGMENTS	16			FLAKE FRAGMENTS	8	276
		INCOMPLETE FLAKES	146			IMCOMPLETE FLAKES	55			INCOMPLETE FLAKES	7			INCOMPLETE FLAKES	20	228
										INDETERMINATE	6					6
		SPLIT FLAKES	4			SPLIT FLAKES	8									12
		CHUNKS	96			CHUNKS	6			CHUNKS	3			CHUNKS	1	106
		FORMAL TOOLS	52			FORMAL TOOLS	31			FORMAL TOOLS	1			FORMAL TOOLS	2	86
		CORES	9			CORES	4			CORES	2					15
		CORE MAINTENANCE														
		TRIMMING	3													3
		REJU	1													1
		CORE FRAGMENTS	9			CORE FRAGMENTS										9
						HAMMERSTONE	1									1
						MANUPORT	4									4
		BLADES	15							BLADES	20			BLADES	2	37
										RETOUCHED	3					3
Totals			675				201				75				48	999
		SMALL FLAKING DEBRIS														
		<10MM	695				17				11				21	744
		10-19MM	1294				86				25				78	1483
																2227
														TOTAL		3326

Another clear distinction between the two excavations involves the percentage of diabase material. Brain's excavation recovered N=219 diabase artefacts > 20mm which represents 12.3% of the total pieces recovered. This high percentage makes diabase the second most abundant raw material present after quartz. The 2005-2007 excavations recovered only N=75 diabase artefacts ≥20mm which represents 7.5% of the total pieces recovered. This is much less than both quartz and quartzite pieces. Unfortunately, the majority (81.3%) of the diabase material from the 1980-1981 excavations is too degraded to be analyzed and is placed in the indeterminate category. The quantity discrepancy is difficult to explain but one possibility could relate to formation processes. Notes on the museum boxes holding the material suggest the majority (N=201/92%) of the diabase material came from the eastern end of the test trench. The 2005-2007 excavations were concentrated in the central portion of the trench. Thus the higher percentage of diabase artefacts could be from one portion of the excavation area. However as the deposit is a colluvium it seems unlikely that a bias would exist in separate portions of the excavation area. Additionally, a small portion of the 1980-1981 material had been partially sorted; some retouched quartz pieces had been placed in paper bags and a few other pieces were placed in smaller boxes within the museum boxes. As the material has been in the museum since the original excavation 28 years ago, it may be that the concentration of diabase pieces into boxes noted as the eastern end of the trench could be related to post excavation storage error.

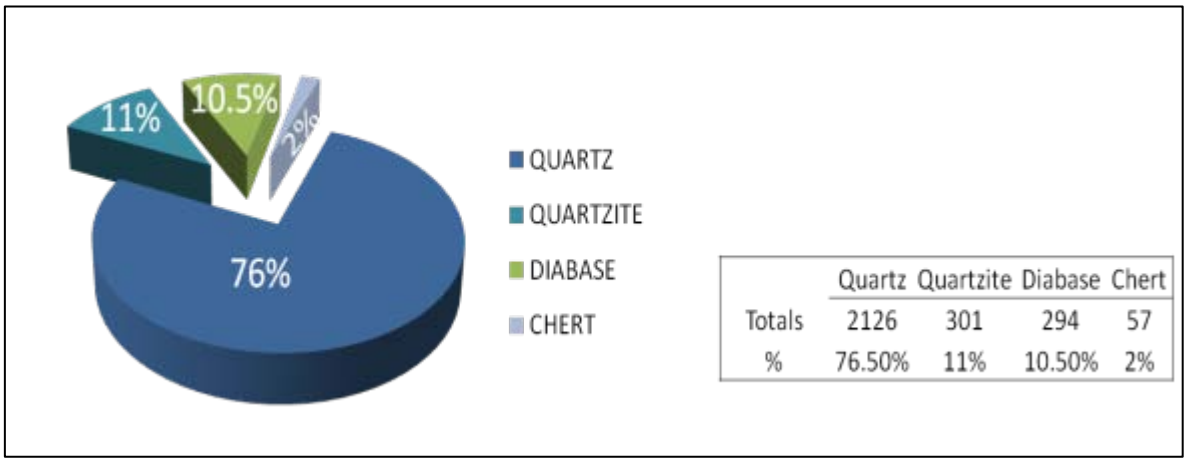
The issue is pertinent as sampling an archaeological site or excavating only a portion of a site (a prudent behaviour that respects possible future excavations) can result in a bias. Any analysis conducted on the assemblage in regard to percentages and the relationship

of percentages as well as the interpretation of those numbers may very well be skewed due to the sampling bias.

The remainders of the two assemblages are similar in raw material percentages, retouched percentages, flake size profiles and range of tool types. Thus discussion concerning the raw material, tools and sizes include the combined assemblage of both excavations.

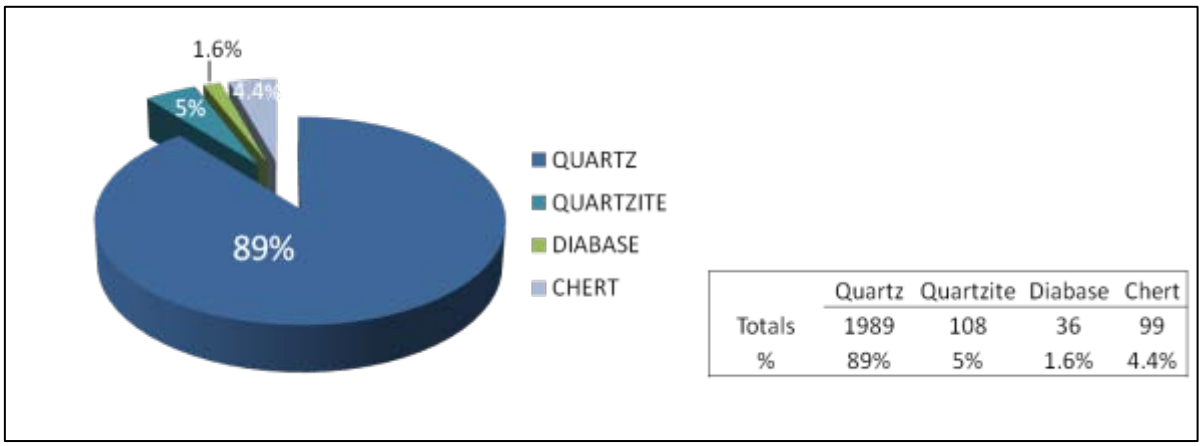
5.6.2 Raw Material

The assemblage is composed of four raw material types: quartz (76.5%) quartzite (11%), diabase/dolorite (10.5.%), which is a crystalline igneous rock and the cryptocrystalline silicate chert (2%) (Figure 40).



	Quartz	Quartzite	Diabase	Chert
Totals	2126	301	294	57
%	76.50%	11%	10.50%	2%

Figure 40. Raw material percentages .≥2cm pieces.



	Quartz	Quartzite	Diabase	Chert
Totals	1989	108	36	99
%	89%	5%	1.6%	4.4%

Figure 40a. Raw material percentages <2cm Small Flaking Debris (SFD) pieces from new excavations.

Raw material discussion, including the <2cm SFD.

Quartz N= 4115 (82.2%) of the total assemblage. This percentage is considerably lower if the Small Flaking Debris is subtracted; only 76%. The fracture qualities of the quartz and the high incidence of bipolar flaking among the tools makers resulted in a higher proportion of quartz SFD. River pebbles and cobbles with fluvial transport surfaces as well as alluvial surfaces from nearby outcrops are reflected in the cortex of the quartz pieces. Quartz seams are common in the dolomite of the area. No quartz seams have been found on Swartkrans hill, but several outcrops exist south of the Bloubank River. One lies between the Sterkfontein and Coopers sites within 1.5km of Swartkrans. A second large (>100m across) outcrop is located within 3km of Swartkrans. Like with the Member 1 Lower Bank material the samples from this outcrop are equivalent to some of the quartz artefacts recovered from Member 4. Also like the Member 1 material, the quartz flakes reflect a range of material and quality types.

Quartzite N= 404 (8.1%). Both gravel and outcrop cortex is present on the quartzite pieces indicating both sources were utilized. The quartzite weathers out in block form and even the river cobbles are very angular, though they often have rounded edges. Because of the large, angular river cobbles the quartzite material allows for larger flakes to be produced. The material ranges from light grey to reddish brown. Much like the quartz material, the quartzite artefacts also reflect a range of quality from the fine grained pieces to a few that have very large grains with loose consolidation. The assemblage contains at least three blocks that were likely used as grinding and/or pounding stones. These pieces have flat sides with unnatural worn indentations in the center.

Diabase N= 330 (6.6%). Like quartzite, diabase does not occur on Swartkrans hill. But diabase does occur in dykes and sills within several of the geological formations in the area. The closest diabase outcrop today is ~10km from Swartkrans. However the diabase was most probably procured from the river gravels beneath the site. The fine-grained igneous rocks are excellent for knapping and result in larger flakes. The diabase is softer (3 on Moh's scale) than the other rock and is more susceptible to oxidation in wet conditions which is believed to have existed at some point since deposition. The majority of the dolomite rocks in the colluvium are heavily stained with manganese and many (N= 184, 63%) of the diabase pieces in the assemblage are degraded to such an extent it is impossible to identify attributes.

Chert N= 156, 3.1%. Chert occurs both in the gravels and in seams within the dolomite throughout the area. Chert seams have been identified on Swartkrans hill. The exposed

seams weather out in tabular form creating easily knapped blocks. The blocks range from very light to dark grey. Due to the exfoliating–like process of breakdown, the cortex is difficult to identify on chert stones. Thus it is not possible to determine if river cobbles or outcrop material was selected. However, both are readily available near the site.

5.6.3 Size and condition of artefacts

A full range of flake sizes is present in the assemblage (Figure 41). Additionally, 69% of the newly excavated material consists of SFD <20mm (Figure 42). The <10mm material is underrepresented, falling in the low range of what would be expected for on-site knapping (Schick 1987; Kuman and Field 2009). However, this suggests a high degree of site capture with little winnowing of artefact size classes except for the smallest size category. Raw material plays a strong role in the assemblage profile. Quartz has higher fracture properties than most other rocks so a quartz dominated assemblage would be expected to reflect a high percentage of SFD. Additionally, bipolar was a common reduction method used on the quartz raw material. This method also results in a higher percentage of debitage. If only quartz is factored in the size ratio, the percentage of SFD to the larger material is only 34% (N= 1989/675) indicating either a loss of the small fraction sizes of quartz or that a proportion of the quartz knapping was conducted off-site. The quartzite and diabase artefacts have a higher proportion of larger flakes and blades. This is a reflection of raw material selection. Both the quartzite and diabase raw

material weather out in medium size (10-15cm) angular blocks, allowing for larger removals by the knappers.

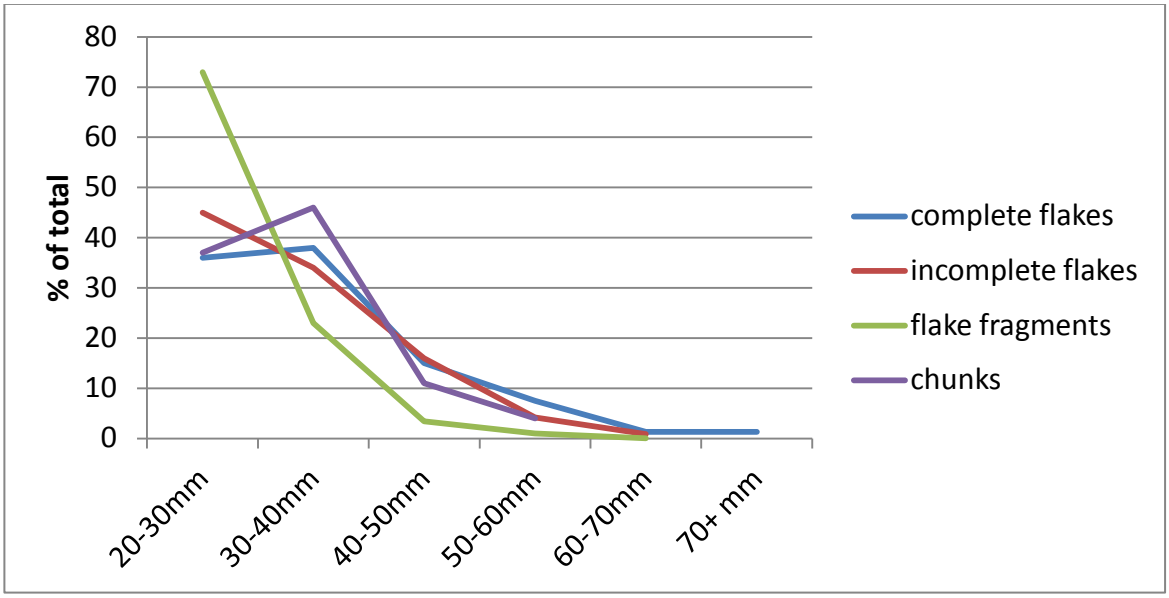


Figure 41. The assemblage contains a range of sizes from 20mm up to over 70mm, though weighted toward the less than 40mm size. This complete range, combined with the SFD (Figure 30), indicates a high degree of site capture though the smallest sizes fall within the low range of what is expected. N=1779.

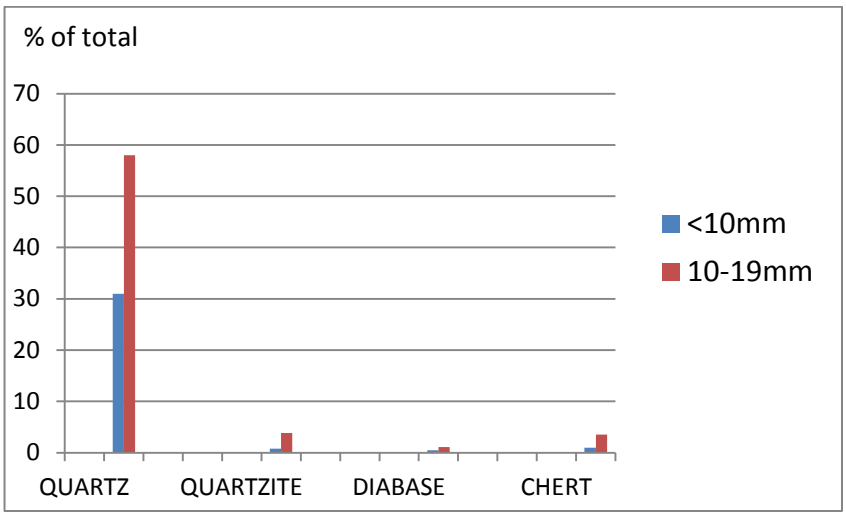


Figure 42. SFD percentages by size category. N=2227

The artefacts were classified according to their surface condition of the surfaces of the stones. The weathering conditions were placed into three classifications: fresh, slight weathering or weathered (see Appendix for a description of the categories). The assemblage is predominately in fresh condition with little weathering. Only 20% of the assemblage is weathered. Sixty-one percent of the pieces have fresh surfaces, while another 19% has only slightly weathered surfaces (Figure 43, Table 10). Additionally, separately noted was the condition of the edges of the artefacts and very few of the pieces have any edge damage. The implications of these two observations suggest the assemblage was rapidly buried and the colluvium underwent little movement. This also suggests the assemblage, while in a colluvium, may be in near-primary context.

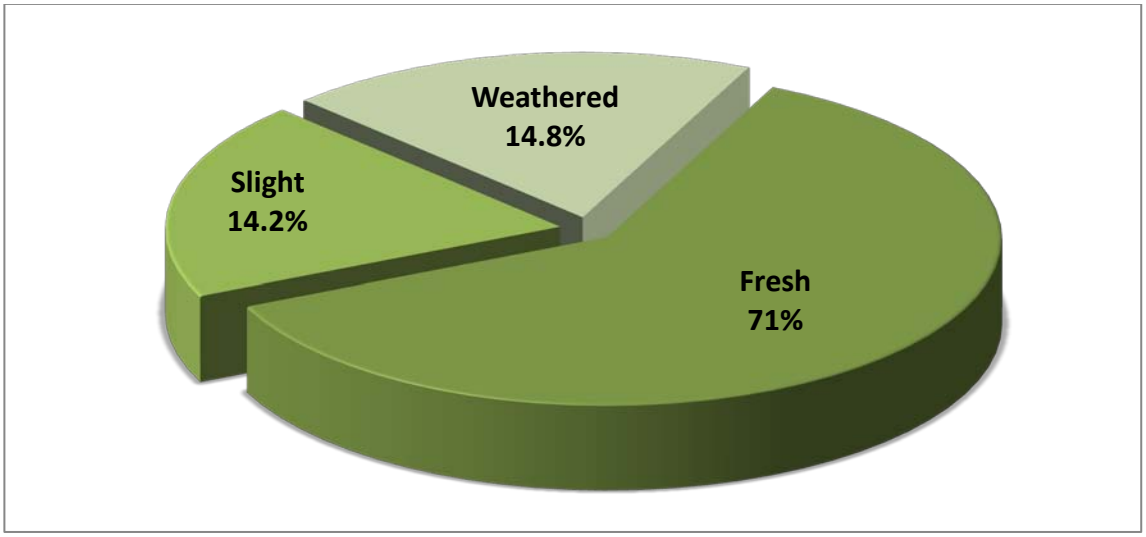


Figure 43. The assemblage is predominately fresh with only 14.8% of the pieces classified as weathered. This fresh state along with the lack of edge damage on the artefacts suggest a rapid burial and very little movement of the colluvium.

	QUARTZ	QUARTZITE	DIABASE	CHERT	TOTAL	%
Fresh	1775	113	1	34	1923	71
Slight	205	146	5	26	382	14.2
Weathered	57	46	295	2	400	14.8

Table 10. Weathering states by raw material of the combined assemblages ≥2cm.

5.6.4 Cores

Eighty-two cores have been recovered from the Member 4 deposit (Table 11). There are eight different cores types present. The variety of core types indicates the variable reduction processes used by the tool makers.

Quartz cores are present in seven of the core types. Quartz cores (N= 58) are 71% of the overall total, with the most common method of reduction being discoidal or radial. These

CORE TYPE	**QUARTZ**	**QUARTZITE**	**DIABASE**	**CHERT**	**TOTALS**
RADIAL	21	2			**23**
MULTI-PLATFORM	15		1	1	**17**
CASUAL	9	8	1		**18**
OPPOSING-PLATFORM	4				**4**
SINGLE PLATFORM	6	2	2		**10**
POLYHEDRAL	1		1		**2**
BIPOLAR	2				**2**
PREPARED		6			**6**
TOTALS	**58**	**18**	**5**	**1**	**82**
CORE FRAGMENTS	**60**	**6**		**3**	**69**

Table 11. Cores by raw material and core type.

cores appear to have been worked extensively. The quartz debitage totals indicate bipolar was also a very common method used by the tool makers; 137 of the pieces are byproducts of bipolar reduction. While radial and bipolar reduction methods are considered informal and not as technologically advanced as Levallois or preferential methods (Delagnes 1995; Demidenko and Usik 1995; Lenior and Turg 1995), they do show understanding of the properties of the raw materials by the tool makers. The large number of flakes from the quartz material suggests bipolar and radial reductions are efficient and expedient flake production processes. Additionally, two of the quartz radial cores may have been used to remove preferential flakes. Two of the single platform quartz cores are blade cores producing small parallel blades.

The quartzite cores (Figures 44, 45, 46, 47) include several (N= 8) casual or tested cores. These are cores with only one or two removals. These are often considered tested cores but could also result from an abundance of available raw material. The quartzite reduction method is dominated by preferential flake production. There are 6 prepared cores. One of the cores clearly meets the criterion for recurrent centripetal Levallois reduction (Figure 44(a) and 45). The others cores are centripetal cores that have a radial flaking surface for preferential removals. The two radial cores are asymmetrical and thus may have been prepared cores in an earlier production stage. Two of the quartzite cores are blade cores. The quartzite debitage reflects this focus on preferential flakes and blades. Unlike the quartz material the quartzite allowed the tool makers to apply greater technological control over the production of flakes and blades.

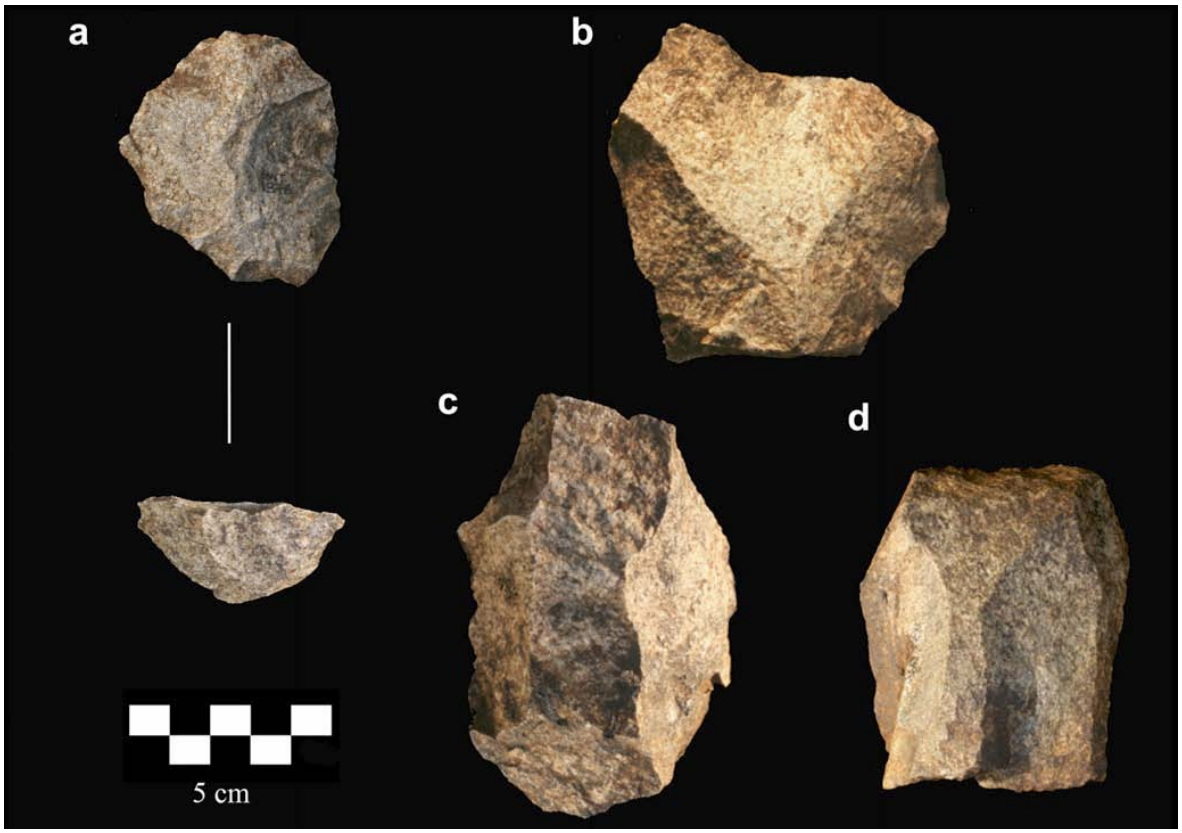


Figure 44. Quartzite cores, a) Levallois, b) preferential and c) and d) blade cores. From Sutton *et al*. 2009.

The diabase cores are primarily blade cores. Again this is a reflection of the ability of the tool makers to produce end products based on the properties of the raw material. The finer grained diabase allows from removals along the length of the core. Additionally, the diabase, like the quartzite, is present in larger blocks in the river gravels. One of the diabase cores is a polyhedron with multiple platforms. Though it is slightly oxidized and rounded, making it difficult to view the reduction sequence, it appears to have a couple of hinge terminations.

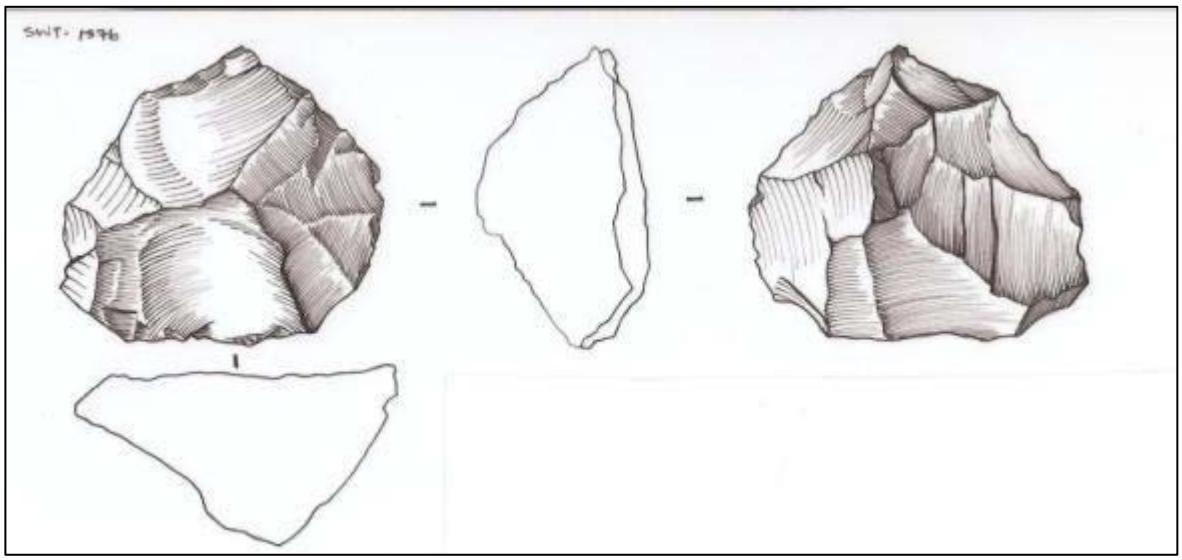


Figure 45. Quartzite Levallois core. Image in figure 32 (a). Drawn by A. Sumner

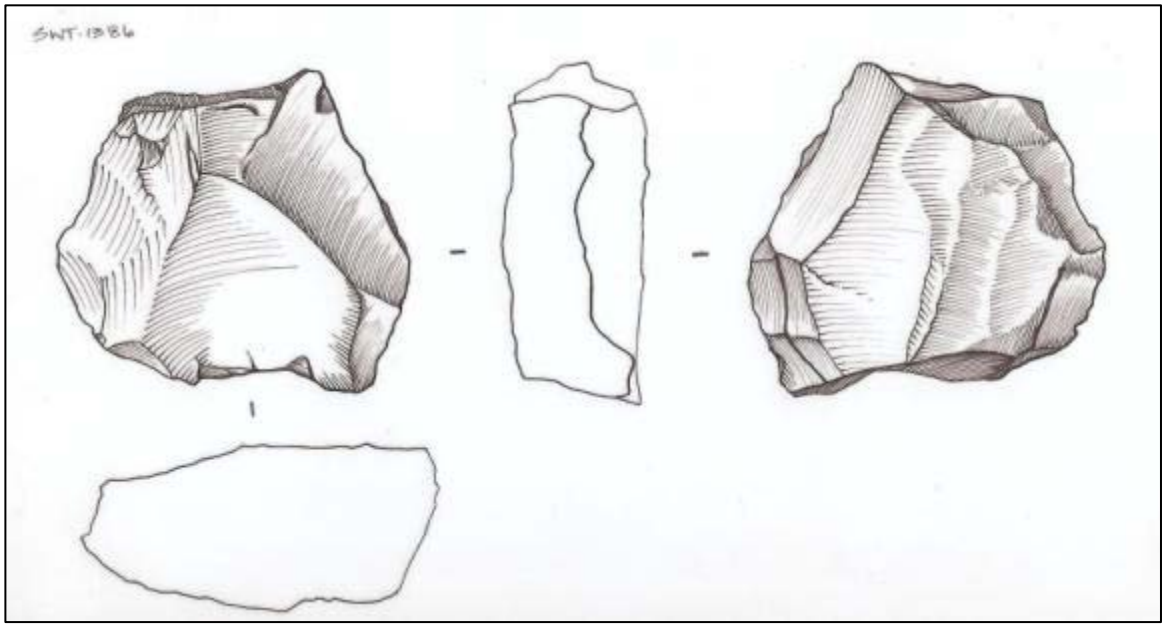


Figure 46. Quartzite prepared core. Image in figure 32 (b). Drawn by A. Sumner.

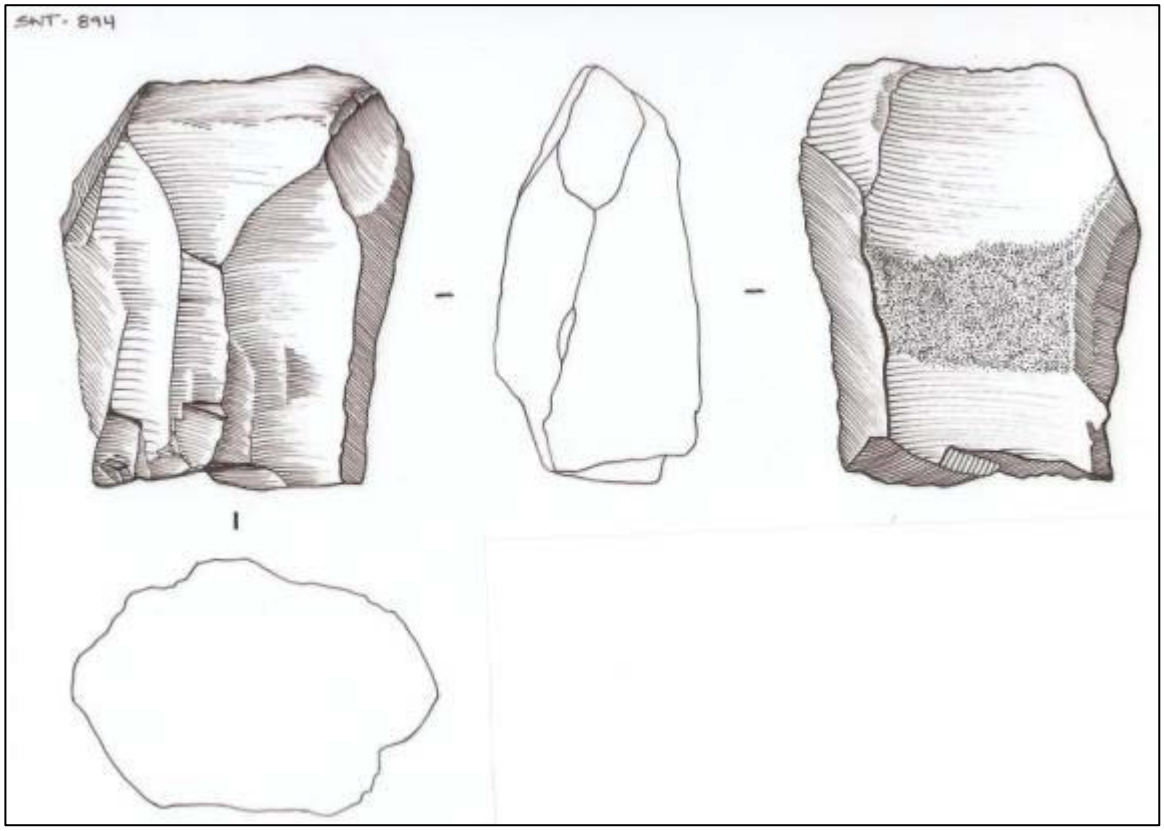


Figure 47. Quartzite blade core. Image in figure 32 (d). Drawn by A. Sumner.

The single chert core is less standardized than the quartzite and diabase cores and is more like the quartz cores. It has multiple platforms and does not reflect uniform reduction processes. However there are several convergent chert flakes in the assemblage suggesting the chert reduction methods were similar to those used on the quartzite and diabase raw materials.

5.6.5 Formal tools

Approximately 10% of the material ≥20mm in size has been retouched. The formal retouched material appears to be a typical and generic form of MSA, without any time-diagnostic types. The basal flowstone beneath the deposit has an age of 110K years ago, indicating the overlying MSA is younger. While no minimal age is available, the assemblage does not contain those MSA industries representing stages such as Howieson's Poort (with geometric backed pieces) and Still Bay (with lanceolates and other well retouched points). The assemblage is dominated by scrapers and denticulated scrapers (Figures 36 and 37). Most of the formal tools can be classified as scrapers, denticulates or denticulated-notched-scrapers. For purposes of analysis the retouched pieces were classified according to extent of retouch. The retouch was recorded as either unifacial or bifacial and either on one or two lateral edges of the artefact (Table 11).

The most interesting characteristic of the retouched pieces is the type of retouch. The majority of the retouched scrapers and denticulates have steep-sided retouch (greater than 30^0, Figures 50 and 51) as opposed to flat retouch. This scraper trait rather than a cutting edge accounts for over 70% of the retouched pieces.

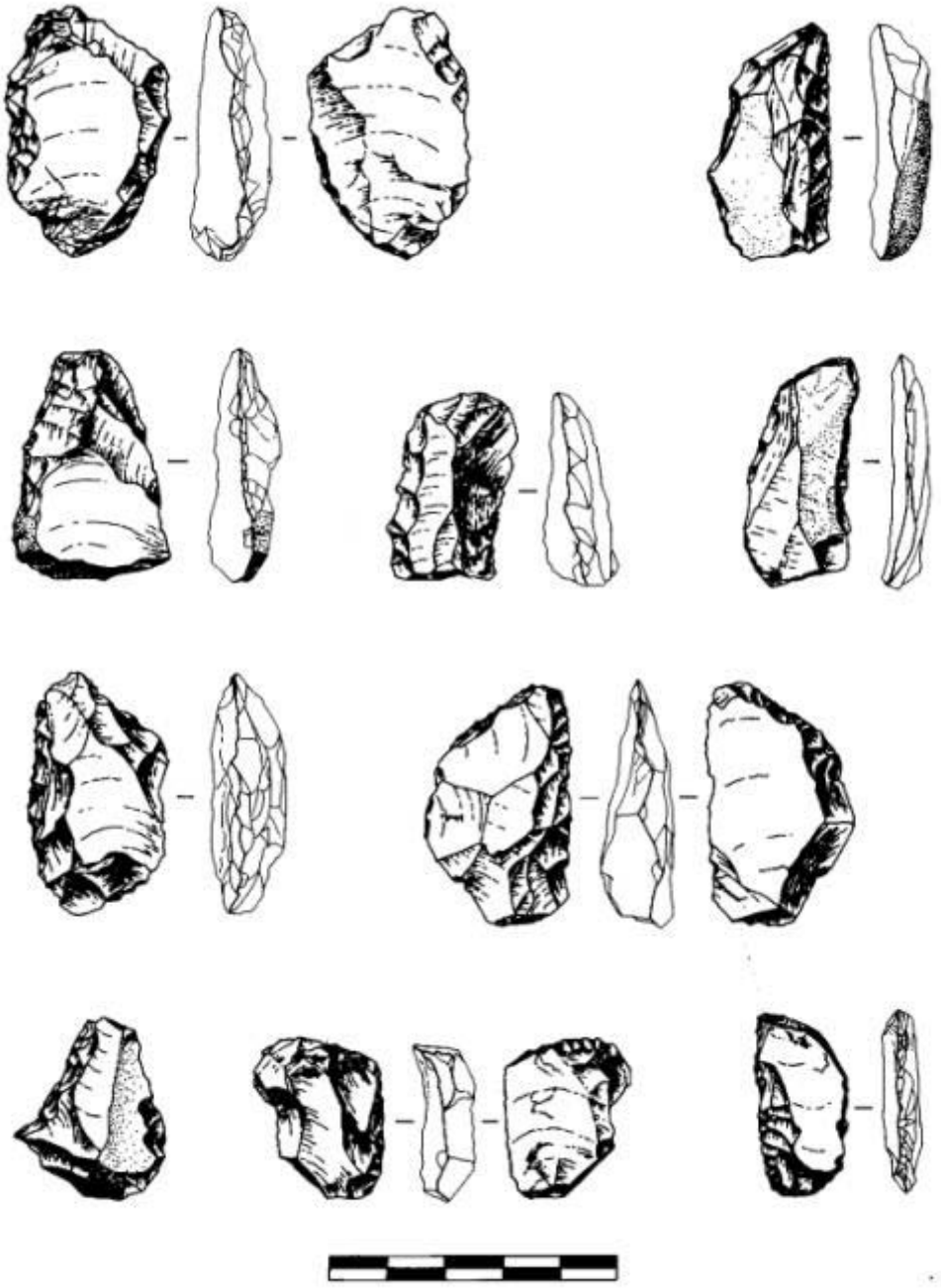


Figure 48. Quartz retouched pieces from the Member 4 MSA deposit. Drawn by W. Voorvelt.

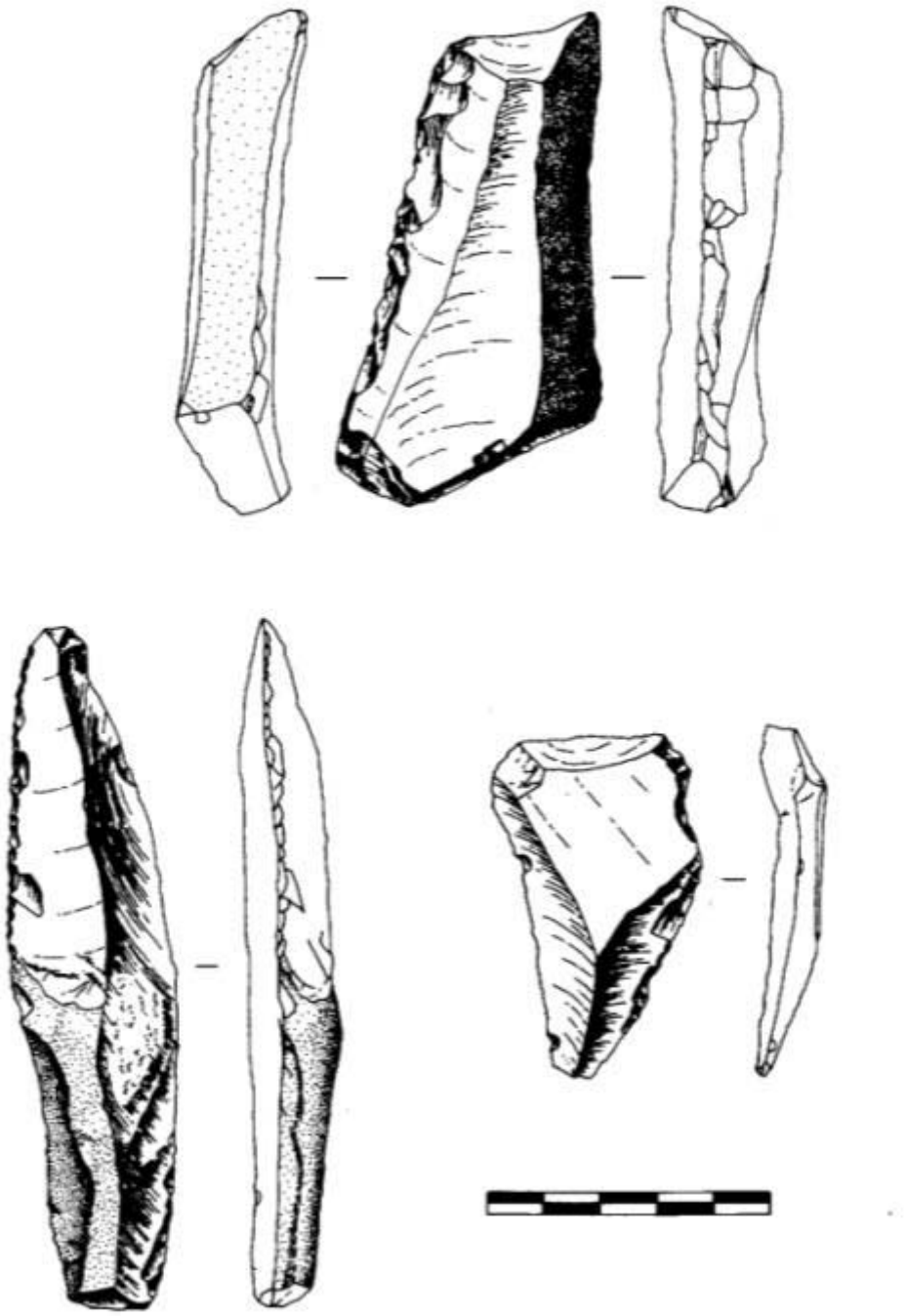


Figure 49. Quartzite retouched pieces from the Member 4 MSA deposit. Drawn by W. Voorvelt.

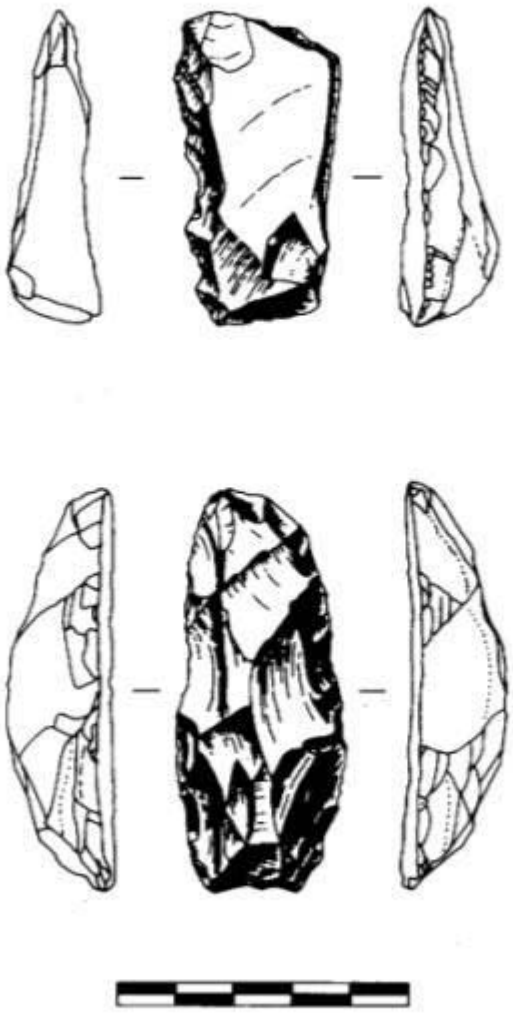


Figure 50. Quartzite scrapers. Example of steep sided retouch that is the most common form of retouch present in the assemblage. Drawn by W. Voorvelt.

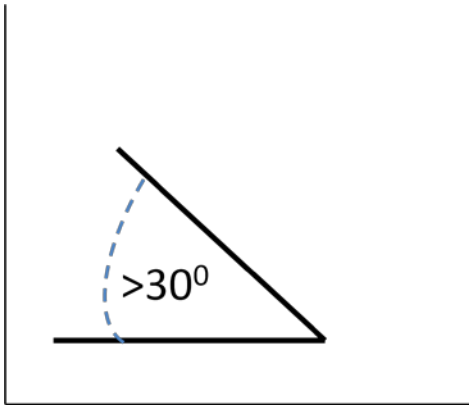


Figure 51. The greatest percentage of retouched pieces have steep-sided retouched scraper edges as opposed to flat cutting edges.

While there are only two points in the assemblage, there are a number of convergent flakes with steep retouch. However, only the two quartz points have retouch along the tip which is defined as a true point. Additionally, there is one quartz broken point tip that has been bifacially retouched. Two diabase pointed flakes have unifacial retouch along one lateral edge of the piece. The overall purpose of the retouch on the convergent flakes falls within the realm of scrapers.

	Single edge		Double edge		
	Unifacial	Bifacial	Unifacial	Bifacial	Total
Quartz	168	1	27	3	199
Quartzite	49	2	8	1	60
Diabase	14		5	4	23
Chert	2		1		3
Total	233	3	41	8	285

Table 12. Retouched pieces categorised by location of retouch.

5.7 Summary

The stone tool assemblage contains a high percentage (10%) of retouched pieces, however the majority of these formal tools are steep-sided scrapers rather than a variety of tool types and points are virtually absent. This focus on steep-sided scrapers and denticulates suggests the assemblage is dominated by a specific activity practiced at the site, rather than general use by the MSA humans. It is unlikely the cave on Swartkrans hill was actually used by MSA humans. Instead the anthropogenic activity probably occurred outside on the hillside near the cave entrance. Evidence, in the form of large roof spall blocks both within and overlying the MSA deposit, suggests there was a roof overhang in the northeast portion of the cave system during the Middle Stone Age. The tool makers probably used this area for one or more specific activities, and subsequent slopewash and gravitation then transported the sediment and its included artefacts down the hillside where it was contained by dolomite blocks. The fresh condition and lack of edge damage of the assemblage suggest the colluvium did not move very far before being blocked by the dolomite. The assemblage has a high degree of steep retouch, a relatively high percentage of SFD, a high frequency of cores, and a complete range of flake sizes representing multiple stages within the reduction process. This suggests the MSA humans both manufactured and used the tools in proximity to the Member 4 area.

The new excavations in the Member 4 deposits have resulted in what is now the largest assemblage of MSA tools in the Cradle of Humankind area. Additionally, the assemblage

has the best context of any MSA period deposits in COHWHS (e.g., Reynolds *et al.* 2007; de Ruiter *et al.* 2008). The Swartkrans MSA is the only comprehensive assemblage that has been analyzed in the north eastern part of South Africa. The nearest published material is from Cave of Hearths in Limpopo Province (Mason 1962, 1988; Sinclair 2009) and Florisbad in the Free State Province (Kuman *et al*. 1999). Swartkrans therefore is an important site in addressing the limited information on the MSA in the northeastern part of South Africa.

Chapter 6

Summary and Conclusions

6.1 Introduction

The previous work at Swartkrans contributed to a greater understanding of early hominin behaviour. The site yielded the first evidence of the coexistence of two hominin species with the discovery of *P. robustus* and early *Homo* in the Hanging Remnant of Member 1 by Robert Broom and John Robinson. But it was the seminal work of C. K. (Bob) Brain that resulted in the large fossil and archaeological samples that reflected the even greater importance of the site. Brain's 30 plus years of research on the Swartkrans material further established the great significance the site occupies in palaeoanthropology.

Brain's précis on his interpretation of the site formation at Swartkrans ends with the following, ''The process of discovery is by no means over and I am convinced that as further work is done there in the future, new surprises will surface, with the result that revisions of the interpretation presented here will be needed'' (Brain, 1993c: 23). His words could not have been more prophetic.

Brain's work at the site ceased in the 1990s and for more than 20 years no formal excavations had taken place at Swartkrans. Then in 2005 the Swartkrans Paleoanthropological Research Project was formed. While the goals and objectives of the SPRP are varied, a major component was this author's thesis research on the Member 1 and Member 4 deposits. This was focused

on interpretations of the formation processes and the enlargement and analysis of the stone artefact assemblages. As with any excavation project the objectives and goals evolved as the excavations progressed.

6.2 Member 1

The Member 1 work began with the mandated removal of a large block of dolomite in the central portion of the Hanging Remnant of Member 1 and led to two important revelations. The first was that the Hanging Remnant was not a single homogenous unit but instead consisted of surface derived material that entered the cave system from at least four different avens. This discovery shed new light on the depositional processes of the Hanging Remnant material. Previously considered one infill, based on Brain's earlier interpretation, the HR must now be seen as separate depositional episodes. One of the goals of the SPRP was to recover a valid taphomonic fauna sample from the newly removed breccias blocks to complement the significant hominin fossil collection recovered by first Broom and Robinson and later by Brain from HR calcium carbonate cemented blocks. Since the area where the large hominin collection was recovered was subsequently blasted out of the cave by limestone miners there is no *in situ* material remaining in this area. However, the new findings meant the goal of recovering a valid fauna sample to compliment the hominin assemblage was not possible. But as this author's work progressed the second revelation resolved the issue. The newly exposed central portion of the HR has now been compared to the original stratigraphic analysis conducted by Butzer on the northwest corner portion of the HR and the two are analogous. Additional supporting

evidence is provided by the U-Pb dating of flowstone material from both the central portion and the west wall of the HR. The northwest corner, where the hominin collection was recovered, is bracketed by flowstones with a basal date of 2.249 ± 0.077 mya and a capping date of 1.706 ± 0.069 mya. The central portion of the HR north wall is bracketed by flowstones with a basal date of 2.248 ± 0.052 mya and a capping date of 1.800 ± 0.005 mya. The stratigraphic analysis and dating results both support the conclusion of this thesis; that the two, now separate, areas of the HR are part of the same infill.

The Lower Bank of Member 1 was the focus of another component of this thesis. The research question revolved around the stone tool assemblage and its industrial designation. Brain's previous excavations resulted in the recovery of 298 stone tools, but due to a lack of diagnostic features the assemblage was never classified to an industry. The previously accepted faunal date (1.7/1.8 mya) of the deposit had placed it on the boundary of the oldest stone tool industry, the Oldowan, and the slightly more advanced Acheulean industry. My goal was to expand the sample size, via excavation, and analyze the artefacts to determine which industry was present in the Lower Bank deposit. The new excavations resulted in the recovery of 1058 stone artefacts providing a large enough sample to analyze. The results of the analysis conducted for this thesis indicates the stone tools represent an Oldowan industry. The technology, size range and raw material selection all suggest the Lower Bank hominins were producing Oldowan type tools rather than Acheulean tools. Additionally, further evidence is provided from a comparison with the nearby Sterkfontein Oldowan assemblage. The Swartkrans assemblage compares well with the Sterkfontein Oldowan.

6.3 Member 4

The third part of this thesis was focused on the Member 4 Middle Stone Age deposits. Brain's previous excavations had resulted in the recovery of 1781 stone tools, many with MSA attributes. However no analysis was ever conducted on the stone tools. The Member 4 deposit has a depth of at least 12 meters and the lower part of this deposit is exposed within the cave under an overhang of the cave roof. This provided an opportunity to excavate material from the surface and from 10 meters below the surface. As the deposition of 10 meters of cave deposit could take thousands of years the Member 4 talus could represent a long period of MSA activity. The goal was to recover stone tools from both the surface and inside the cave and compare change through time. However, as with the Member 1 excavations, the complexity of the depositional processes became more evident as the excavations progressed. The Member 4 surface excavations resulted in an additional 3226 artefacts and the realization that the MSA material was contained within a colluvium that comprised the upper 110-120cm levels of the deposit. A complete size range of tools and the largely fresh condition with no edge damage suggests a high degree of site capture with little winnowing of the material and a rapid burial with little movement within the colluvium. The stone artefacts from the MSA deposit appear to represent one or more specific oriented activities rather than general use by the tool makers. The assemblage has a high number of pieces with steep retouch, the formal types are dominated by steep-sided scrapers and denticulated scrapers and a near absence of points. A variety of core types suggests a superior understanding of raw material flaking qualities by the tool makers. U-Th dating of a basal flowstone to ~110K years old establishes a maximum age for the MSA assemblage placing it in the middle to late MSA.

The underground Member 4 excavations resulted in the discovery of two additional, previously unknown deposits within the Swartkrans Formation. Both of these deposits have now yielded hominin fossils representing *P. robustus*. Fabric analysis and matrix inclusions show the two underground deposits are distinct and entered the cave system from different openings. The lowest deposit entered from the west and traveled to the east wall. The research for this project establishes this lowest deposit as being an eastern extension of the Lower Bank of Member 1 (LB East Extension). The second overlying talus cone, also distinct, is now referred to as the Talus Cone Deposit (TCD) and entered the cave from an opening in the Member 4 area. Then much later the MSA colluvium covered the top of the talus cone material and it's capping flowstone. The conclusion is that the northeastern deposit, which was previously known as Member 4 MSA deposit at Swartkrans, is in fact, three separate deposits. Included is an MSA colluvium overlying the large hominin bearing Talus Cone Deposit which itself overlies the Lower Bank East Extension.

6.4 Future Research

While this work has established a clearer stratigraphic picture of the Member 1 Hanging Remnant calcified conglomerates and resulted in the discovery of two additional deposits in the Member 4 area, there still exist many questions regarding the two deposits.

The new speleothem dating results confirm the antiquity of the HR as greater than 1.7 mya. However the upper limit is as great as 2.4 mya, leaving a wide age range for the Member 1 deposits. Additionally, the cosmogenic burial date for the Lower Bank of Member 1 is

preliminary, as it was determined from one sample. Thus future research will focus on 1) alternative dating methods of these deposits such as paleomagnetic and 2) expanding the sample base to ensure accurate results.

Another area of research for Member 1 is a comparison of the HR fossil assemblage with the LB material. As it is confirmed these deposits represent two separate infills, it is important to compare and contrast the faunal assemblages. Also important is a review of the hominin fossils in the historical collections, as well as the newly excavated specimens with a goal of confirming which *Homo* species are present. *Homo habilis* is most probably represented by SK27 and *Homo ergaster* by several of the other early *Homo* fossils, including SK847. It may very well be confirmed that the oldest Swartkrans deposits include three different hominin species.

The lithic assemblage, now established as Oldowan, should be compared to the East African material. There exists significant variability between the two South African assemblages (Swartkrans and Sterkfontein), and thus it would be essential to look at variability across Africa. This type of comparison will assist in identifying factors influencing the variability, such as the environment, raw materials, and possibly the hominin species responsible for the production of the tools.

The Member 4 lithic assemblage is somewhat unique among general MSA assemblages due to the lack of pointed pieces, the high percentage of retouch and the dominance of steep-sided retouch, all of which suggests a specific activity taking place on Swartkrans hill. This is being explored with microscopic use wear analysis of the formal tools. Analyzing the formal retouched tool edges for damage will allow interpretation of the function of the tools from the

Swartkrans assemblage. This type of microwear analysis is also being planned for the Oldowan assemblage from the Lower of Bank of Member 1.

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Appendix I

Descriptions of typological terms used in the analysis

Complete Flakes. These are ≥2cm whole removals that has not been broken. The pieces include a striking platform and a complete termination. The maximum length is measures from one end along the maximum distance to the other end.

Incomplete Flakes. These are ≥2cm flakes that have been broken distally. The striking platform is present but part of the distal end is missing.

Flake Fragments. These are ≥2cm incomplete flakes that are broken proximally, missing the proximal the striking platform.

Chunks. There are angular pieces ≥2cm but have no clear flake attributes. These pieces are most often created from shatter during the knapping process.

Small Flaking Debris (SFD). These are <2cm pieces that are either knapping debris, broken flakes or core fragments. These pieces sometimes exhibit clear flake attributes, but often do not include all flake features. However some aspect of the knapping process must be visible on the piece to separate it from natural stone.

Platforms. This is the striking platform where the flake was struck when being detached from the core. I recorded the facets present on the platform as an indication of core preparation before flake removal.

> Broken Platforms indicate some portion of the platform is missing.
>
> Shattered Platforms indicate the complete absence of the platform but the overall length of the flake has not been reduced.
>
> Facets. Sections on the platform surface with clear ridges as separation. This is most often an indication of core preparation and suggestion preferential flake production.

Cortex. The outer rind of the stone. The cortex was categorized according to the percent present. 0, 1-25%, 26-50%, 51-75%, 76-100%

Cortex Type. Two types are noted. Outcrop or vein cortex is weathered from an ourcrop source and collected by the tool makers. River or fluvial cortex reflects rolling in a water environment.

Weathering. Three types are noted. Fresh has not visible deterioration to the outer surface. Slight has some degree of weathering but is still somewhat fresh. Weathered has clear deterioration of the outer surface.

Cores. These are the pieces that have flaked and have clear flake removal scars on their surface. Cores were divided into categories based on number and direction of platforms as well as the reduction sequence.

Single Platform. Cores with removals from only one direction or platform.

Opposing Platform. Cores with removals from two opposing directions or platforms.

Multiple Platform. Cores with multiple removals from more than two directions or platforms. These differ from polyhedreal cores in that they appear to have more organized reduction patterns.

Radial. Cores that have been flaked from the edge to the center in a circular fashion.

Polyhedral. Cores with multiple platforms that exhibit no organization to the reduction process .

Bipolar. Cores that have been struck between an hammer and anvil and results in flakes removed with impact points on both ends.

Prepared. Cores that have been prepared for the removal of one or more flakes of a predetermined shape and size. These cores are asymmetrical and the flakes are removed parallel to the plane of intersection of the two halves.

Casual. Often called tested core material. Cores that have only one or two removals. The few removals are stage one opening process after which the cores is abandoned.

Retouched Types

Miscellaneous retouched pieces. Pieces with minimal and discontinuous retouch.

Denticulated/notched scrapers. Pieces that have one or more steep-sided edges and one of those has a notched working area.

Denticulates. Pieces with extensive and continuous retouch that produces a serrated edge.

Scrapers. Pieces with steep-sided retouch along the edge. These can be end or side scrapers.

Methods of measurements

Stone artefacts

All the stone artefacts were washed with water and lightly brushed to remove all adhering sediments. All artefacts 20mm and larger were numbered and entered into the database. All <20mm material was classified as Small Flaking Debris (SFD) and recorded only in relation to provenience (square meter, quadrant and level).

Raw material. As only a few raw material types are present in the assemblage it is relatively easy to distinguish types. Nevertheless, each artefact was viewed under 10x and 20x magnification to determine the raw material type.

Artefact Type is based on typical typological categories. See above.

Artefact Condition was recorded based on two criteria.

1) Weathering-- overall weathered condition of the piece
2) Edge damage. This could include broken edges from post-depositional activity (trampling, rolling, etc) or from possible use.

Platform type. See above. This was recorded to determine the degree of platform preparation before flake removals.

Termination of Complete flakes. This is used to describe the distal end of complete flakes. Feathered, Hinged, Stepped, Retouched.

Maximum length. The measurement of the longest axis on a flake. Measured from one end to the other along the axis plane. This measurement was taken using electronic calipers.

Edge angle. For retouched pieces only. The measurement of the degree of angle on a retouched edge. This measurement was taken using goniometer.

Hominin Fossils

This was performed by T. R. Pickering and J. L. Heaton. Each dental specimen was examined using a low-power binocular microscope and, when possible, measurements were taken with a Paleo-Tech Concepts Hillsone-Fitzgerald dental caliper. Standard gross tooth crown measurements were taken to the nearest tenth of a millimeter. When possible, the cervico-occlusal (CO) height (measured in the vertical plane) and labio/buccolingual interproximal (L/BL) breadth (measured in the horizontal plane) of interproximal facets were measured on the dental fossils. See Pickering *et al.* 2012 for additional analysis information regarding the hominin fossils.