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Lithic raw material procurement through time at Swartkrans: Earlier to Middle Stone Age

Nicole Leoni Sherwood

A dissertation submitted to the School of Geography, Archaeology and Environmental Studies, Faculty of Science University of the Witwatersrand, Johannesburg for the degree of Master of Science.

Johannesburg 2013

DECLARATION

I declare that this Dissertation is my own, unaided work. It is being submitted for the Degree of Master of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

(Signature of candidate)

2 May 2013

Johannesburg

ABSTRACT

Tool manufacturing played a major role in the development and evolution of our species, and by studying the tools left behind by our ancestors we gain valuable insight into their development and behaviours through time. This study was conducted on the Swartkrans Oldowan (2.2 - 1.7 Ma), early Acheulean (1.5 - 1 Ma), and Middle Stone Age (<110 ka) assemblages to determine the degree of lithic raw material selectivity for making stone tools, and if they practiced ever increasing selection towards better quality stone over time. The presence of quality selection was determined by comparing the various Swartkrans assemblages with experimentally created lithic tools from rock types found in the study area. Three main characteristics that determine selection of rock types were isolated: flaking predictability, durability and sharpness. Analysis of the data provided further evidence that our early stone tool making ancestors had the ability to understand how different rock types behave when knapped and tended to select rocks that had a high flaking predictability, high durability and could produce fairly sharp edges. It was also apparent that they could identify features that diminish the above mentioned characteristics. Variables such as the impurity encounter rate, fracture encounter rate, weathering, grain size and homogeneity were semi-quantitatively recorded for the three techno-complexes at Swartkrans and compared to each other to help identify the degree of selectivity that was practiced over time. The data revealed that selection for quality of lithic raw materials was practiced to some extent during the Oldowan and improved slightly in the early Acheulean. The most marked selection for quality was seen for the Middle Stone Age when modern humans used the site. These results indicate that as time progressed in the Sterkfontein valley, and the stone tool technologies became more complex, so too did the selective pressures and thus an increase in selection for quality lithic raw materials over the course of time.

To my parents

David and Leoni Sherwood

Thank you for all your guidance, help and support.

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CHAPTER 1 INTRODUCTION

"The most beautiful thing we can experience is the mysterious. It is the source of all true art and all science. He to whom this emotion is a stranger, who can no longer pause to wonder and stand rapt in awe, is as good as dead: his eyes are closed".

Albert Einstein

True are these words, for it is the wonder of the mysterious that triggers the sweltering passion to seek answers to the unexplained. It is apparent even from the earliest evidence of human self-awareness that our leading search is to find the origin of our being, which comes as no surprise, since this has always been the greatest mystery.

Important discoveries in the last century, in various fields of science, have revealed a great deal of information about the origin of life and the universe in which it resides. Among these are advances in the biological sciences and the discoveries of various fossil hominid remains, which have given us much insight into the origin and development of our species. We have also been searching for evidence to help us understand the cognitive complexity of our closest ancestors through the course of their evolution, and how their behaviours eventually led to our evolution. This is however a daunting task, as we do not even fully understand the complexity of the modern human mind, and fossil remains can only give us so much information about the complexity of a species' mind. For that reason it is best to assess objects that our ancestors made, modified and left behind. Although not all such artefacts preserve, fortunately stone tools do, and they appear in East Africa for the first time around 2.6 Ma, indicating a behavioural change in early hominids that may very well have led to their success and continued evolution. Even though the species responsible for the creation of these tools are no longer around, we can gain valuable information from the tools they left behind by analysing all aspects surrounding them. A number of studies has been conducted on the technologies of the various tool assemblages, which indicate a general increase in sophistication over the course of time. Furthermore, by studying the intricacy of selection for the lithic raw materials they utilised, we can refine our understanding of the complexity of their thought. Quality selection of rock has been assessed to some extent in East Africa for

the earliest assemblages (Semaw *et al*. 2003; Stout *et al*. 2005; Goldman-Neuman and Hovers 2012; Braun *et al*. 2009). These studies revealed that hominids responsible for the earliest stone tools practiced selection for certain rock types and were already capable of quality selection but it was not quantitatively determined to what extent these early hominids practiced such selectivity. Little comprehensive research has been done on quality selection for the Acheulean. Conversely, a good deal of research on rock selection for the Middle Stone Age (MSA) has been conducted, specifically with regards to the procurement of "exotic" rock (eg. McBrearty 1988; Ambrose & Lorenz 1990; Mehlman, 1991; Ambrose 2006; Negash and Shackley 2006). According to Ambrose (2006) a rock is considered "exotic" if it comes from a distance greater than 40km from the site. Additionally, research has been conducted on quality of lithic raw material during the MSA (Singer and Wymer 1982; Villa *et al*. 2010; Wadley and Kempson 2011), however, no research has been done on the changes of quality selection between techno-complexes. As a result, little is known about the changes in complexity of lithic raw material acquisition from the inception of stone tool manufacture (Oldowan) to the appearance of *Homo sapiens* (MSA). I intend to access the degree of lithic raw material selection for three techno-complexes (Oldowan, Acheulean and MSA) at Swartkrans cave site, and to determine the degree of change over time.

1.1 Research goals

This project aims to quantitatively and semi-quantitatively determine if early hominids living in southern Africa selected rocks for tool creation at random or practiced selection for high quality lithic raw materials. Most importantly it aims to uncover if there was an improvement in quality selection over time. This will be determined by analysing the quality of the rocks that were used to create the various tools from each techno-complex and by isolating any differences between the Oldowan and the Acheulean, and the Acheulean and the MSA.

A lithic raw material is considered of low quality when it exhibits multiple flaws which hinder the knapping process (these are explained in greater detail in Chapter 4), and of high quality if these flaws are absent. A rock is also considered to restrict the knapping process if it is coarse grained and substantially weathered. This dissertation examines the geology of the study area and creates experimental examples of stone tools from the rock types found in the study area, this has helped isolate the flaws that restrain the creation of stone tools and aided in the creation of a set of variables for analysis (Chapter 4).

Hominids were already capable of identifying and selecting certain rock types and had sufficient understanding that certain features could diminish the effectiveness of a rock to produce effective tools (Semaw *et al*. 2003; Stout *et al*. 2005; Goldman-Neuman and Hovers 2012; Braun *et al*. 2009), but the degree of this is not certain.

I hypothesise that:

- The early ESA hominids at Swartkrans did occasionally select for the quality of a lithic raw material, but it was not a stringent practice.
- There was a noticeable improvement from the Oldowan to the Acheulean, in that hominids became more selective for quality.
- There was a substantial improvement from the Acheulean to the MSA, in that MSA people were highly selective towards the quality of a rock type.

1.2 Organisation of the thesis

Chapter Two opens with a description and location of Swartkrans cave and describes the archaeology of the site. This is followed by a brief overview of approaches that have been undertaken in the past to help understand earlier hominid behaviours with regard to the creation of lithic tools, and a discussion of the research that has been conducted with regards to quality selection of rock for stone tool manufacture during the Earlier Stone Age (ESA) and the MSA. In order to determine aspects of lithic raw material procurement in the study area, the surface geology and geological features surrounding the cave site had to be assessed and documented. A detailed description of the surface geology is provided in Chapter Three. This is followed by the methodological steps upon which this project is based in Chapter Four. The results are given in Chapter Five and discussed in greater detail in Chapter Six, in which the final conclusions are drawn.

CHAPTER 2 LITERATURE REVIEW AND BACKGROUND

2.1 Swartkrans

Swartkrans cave is located in the Cradle of Humankind World Heritage Site, South Africa and is situated approximately one kilometre northwest of the Sterkfontein caves (Figure 2.1). This site possesses a rich history and has produced many animal and hominid fossils, as well as bone and stone artefacts, in the last sixty five years. The site is also believed to demonstrate some of the earliest evidence for the use of fire (Brain 1993). As mentioned previously, it has assemblages present from the Oldowan, the Acheulean and the MSA. The rock types utilised in all three techno-complexes are the same and no mixing is evident between these assemblages. This presented a unique opportunity, as this site is ideal, not only for analysing quality lithic raw material selection for each techno-complex, but also to assess the change over time.

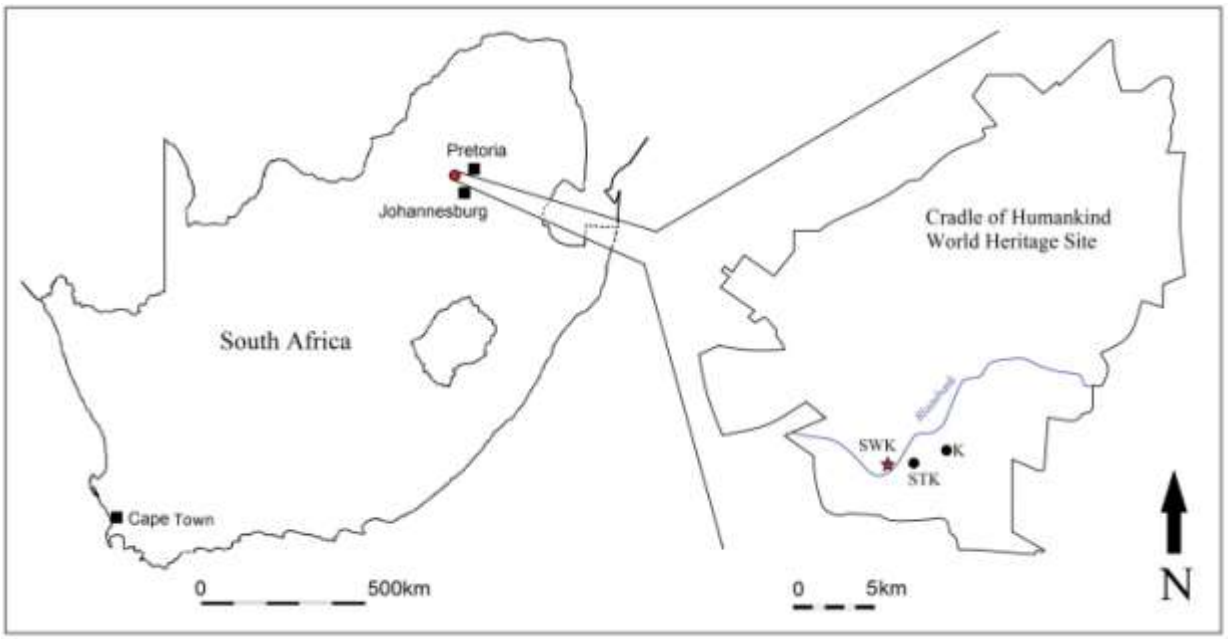

Fig. 2.1: The location of the Cradle of Humankind World Heritage Site showing Swartkrans. (SWK), Sterkfontein (STK) and Kromdraai (K).

Five stratigraphic units have been identified within the cave (Brain 1993), of which Members 1-3 are the oldest and have been estimated via biostratigraphy to fall between 1.7 – 1Ma (Vrba 1985). Brain *et al.* (1988) places Member 1 (which consists of two units, the Lower

Bank and the Hanging Remnant) at roughly 1.8 – 1.5 Ma. More recent dating was done by Balter *et al*. (2008) by making use of U-Pb dating on bovid tooth enamel, and they obtained an age of 1.83 ± 1.38 Ma for Member 1. However, according to Sutton *et al*. (2009) U-Pb dating on enamel is problematic as uranium and lead can move in and out of the enamel through diagenesis, which is likely why such a large error range was obtained for Member 1. Pickering *et al*. (2011) also performed U-Pb dating, but on two flowstones capping and underlying Member 1. From this they determined two age ranges for Member 1, which are both within error of each other and thus an age range of 2.25 - 1.8 Ma for Member 1. Faunal data narrows this date to between 1.9 - 1.8 Ma (Pickering *et al.* 2011). Furthermore, Brain *et al.* (1988) places Members 2 and 3 between 1.5 – 1 Ma based on faunal dates and the U-Pb dating done by Balter *et al*. (2008) on bovid tooth enamel, indicated a range of 1.36 ± 0.29 Ma for Member 2, and 0.83 ± 0.21 Ma for Member 3, which are close to the faunal ages.

The first stone tools excavated at Swartkrans belong to Members 1-3 and were originally described as Developed Oldowan, based on their age and that some heavy duty tools identified from the mine dumps at the site (Leakey 1970). The Developed Oldowan was seen as a transitional industry between the Oldowan and the Early Acheulean, and was divided into three stages by Mary Leakey, labelled as the Developed Oldowan (DO) A, B and C (Leakey 1971). An assemblage is said to belong to the DOA if spheroids, subspheroids, protobifaces, burins and awls make their appearance (Leakey 1971; Semaw *et al.* 2009). The DOB and DOC are similar in composition, but with the addition of bifaces, however in lesser quantity than assemblages attributed to the Early Acheulean (Semaw *et al.* 2009). Today few researchers accept the Developed Oldowan, since many of the differences attributed to the three industries can be explained by multiple factors (Semaw *et al.* 2009), such as lithic raw material availability (Stiles 1979; Clark 1987; Gowlett 1988; Semaw *et al.* 2009), adaptation to local environments (Leakey 1975) or simply by the re-working of Acheulean bifaces (Jones 1994). Semaw *et al.* (2009) argue that the DOA be included in the Oldowan, and that the DOB and DOC be assigned to the Early Acheulean, as hominids were already capable of creating bifaces. This is in agreement with Kuman (1998), who argues that if an assemblage has any bifaces present it should be considered Acheulean. Brain *et al.* (1988) and Clark (1991) accepted Leakey's classification, and since they could not identify any significant difference between the technologies of Members 1-3, they classed all three as representative of a Developed Oldowan culture. The authors did not differentiate between the DOA, B or C, because the sample sizes were too small to determine this. Clark (1993) re-evaluated the

Swartkrans assemblages and suggested that Member 3 is much more likely to belong to the Acheulean based on its age range, and that the Member 2 tool types has more similarities with Member 3 than Member 1 and thus is also more likely to belong to the Early Acheulean. Field (1999) agreed with Clark (1993) and classified Member 1 into the Developed Oldowan and Members 2 and 3 as part of the Early Acheulean. Additionally, Field (1999) argues that flake sizes should be considered an additional marker of the Acheulean, meaning that assemblages which include multiple flakes that were larger than ten centimetres (in addition to bifaces) is more likely to belong to the early Acheulean. She noted that flakes larger than ten centimetres are present in Member 2, but not in Member 1, and therefore she classified only Members 2 and 3 as Early Acheulean. Field (1999) classified Member 1 as Developed Oldowan rather than Oldowan due to its age, and because the sample size was too small to classify it unmistakably as Oldowan. Recent excavations of the Member 1 Lower Bank by Sutton from 2005 - 2010 have enlarged the sample size for Member 1 considerably. This assemblage appears characteristic of the Oldowan industry, as no *in situ* heavy duty tools and large flakes are present (Sutton 2012). Tool types that are characteristic of the DOA such as spheroids, subspheroids, protobifaces, burins and awls are also absent. The absence of bifaces, however, does not necessarily make an assemblage Oldowan as all Oldowan components are present in the Acheulean. Nevertheless, with the larger sample size and a visible difference (Field 1999; and Personal Observation) between this assemblage and those of Member 2 and 3 it has been concluded that lithics from Member 1 are most likely from an Oldowan industry (Sutton 2012).

Of the two remaining members, only Member 4 contains stone tools. Sutton *et al*. (2009) identified these tools as being indicative of the MSA and obtained a maximum age of 110Ka for Member 4 through the use of U-Th dating, which was performed on flowstone directly underlying this Member.

Accordingly, the Swartkrans assemblages to be included in this study are as follows:

- Member 1: *Oldowan* (artefacts excavated by M. Sutton from 2005 -2010)
- Member 2: *Early Acheulean* (artefacts excavated by C.K. Brain from 1965 - 1986)
- Member 3: *Early Acheulean* (artefacts excavated by C.K. Brain from 1965 - 1986)
- Member 4: *Middle Stone Age* (artefacts excavated by M. Sutton from 2005 - 2010)

Lithic raw material has been assessed for Swartkrans with regards to the rock types that were utilised (Field 1999; Sutton 2012). These authors determined that four rock types were favoured for the production of lithics at Swartkrans. These are quartz, quartzite, chert and igneous rock. The frequencies of these rock types vary with each techno-complex, indicating that not only was there selection for certain rock types, but also a change between techno-complexes. The degree of selection with regards to the quality of the individual rock types has not yet been examined in this area.

2.2 Other lithic raw material studies

Various studies have been conducted on lithics to investigate how complex the mind of early hominids might have been (e.g. Wynn 1979; Singer & Wymer 1982; Toth 1985; Ambrose & Lorenz 1990; Schick & Toth 1994; Kuman 1996; Isaac *et al.* 1997; Ludwig & Harris 1998; Field 1999; Plummer *et al.* 1999; Ambrose 2002; Semaw *et al.* 2003; Stout *et al*. 2005; Ambrose 2006; Braun *et al*. 2008; Braun *et al.* 2009; Harmand 2009; Villa *et al*. 2010; Wadley & Kempson 2011; Goldman-Neuman & Hovers 2012). Some researchers have tried determining if early hominids practised highly organised flaking by studying the complexity of lithic technology (Wynn 1979; Plummer *et al.* 1999). However, the lack of highly organised flaking does not necessarily indicate a low level of cognition (Toth 1985). Other researchers have focused on rock selection for insight into hominid behaviour. Some have focused on transport (Hay 1976; Ambrose & Lorenz 1990; Ambrose 2006; Braun *et al*. 2008; Harmand 2009), whereas others have considered selection of lithic raw material types (Toth 1985; Kuman 1996, Isaac *et al.* 1997; Ludwig & Harris 1998; Field 1999; Semaw *et al.* 2003; Stout *et al*. 2005; Harmand 2009; Wadley and Kempson 2011; Goldman-Neuman & Hovers 2012; Sutton 2012), rock sizes and shapes (Toth 1985; Clark 1991, 1993; Schick & Toth 1994; Kuman 1996; Field 1999; Harmand 2009; Goldman-Neuman & Hovers 2012) and others, rock quality (Singer & Wymer 1982; Brantingham *et al*. 2000; Stout *et al*. 2005; Braun *et al.* 2009; Villa *et al*. 2010; Wadley & Kempson 2011; Goldman-Neuman & Hovers 2012). Additionally, many different approaches have been undertaken to help identify any behaviour that could indicate the cognitive complexity of these early hominids. This has been done with experimental (Toth 1985; Schick & Toth 1994; Kuman 1996; Ludwig & Harris 1998; Field 1999; Harmand 2009), qualitative (Goldman-Neuman & Hovers 2012) as well as

semi-quantitative methods (Brantingham *et al.* 2000; Stout *et al*. 2005; Braun *et al*. 2009; Wadley and Kempson 2011).

Stout *et al*. (2005) examined lithic raw material selectivity in some of the earliest tool assemblages to determine if hominids had the cognitive capacity to identify and select better quality rock at the inception of stone tool making. Six sites from Gona were studied of which five date between 2.6 and 2.5 Ma, whilst one site dates between 2.58 and 2.27Ma (Stout *et al*. 2005). The authors semi-quantitatively examined rock type, percentage of phenocrysts (area occupied by large crystals embedded in a fine grained matrix were estimated for an area on one large, relatively flat, surface), average size of phenocrysts, and groundmass texture (the size of the grains surrounding the phenocrysts). These variables were recorded for the artefacts from each site and compared to local rock samples collected from the conglomerates present at each site (Stout *et al*. 2005). This study showed that selection of rock by late Pliocene hominids was indeed present in Gona as they tended to select rocks with properties of superior quality, such as fine grained rocks with smaller and fewer crystal inclusions (Stout *et al*. 2005).

In addition to size and shape, the same variables used by Stout *et al*. (2005) were assessed by Goldman-Neuman & Hovers (2012) for the Oldowan in the Makaamitalu Basin, Hadar, Ethiopia. Two sites were assessed, both roughly 2.36 Ma, one being slightly younger. Selection for rock type was examined semi-quantitatively in the same way as by Stout *et al.* (2005), whilst other variables were assessed more qualitatively and classed into ordinal groups (for example: "small/ medium /large" for phenocryst size, and "no/ few/ many" for phenocrysts percentage). Goldman-Neuman & Hovers (2012) developed a qualitative scaling system designed to group the artefacts according to quality. Six groups were constructed by combining phenocryst size and abundance, as well as the presence of voids and bands and their abundances (Stout *et al.* 2005). Selection at the older of the two sites was mainly against basalt and selection at the younger site was towards quality material with less inherent flaws (Goldman-Neuman & Hovers 2012).

Braun *et al*. (2009) assessed rock quality for the Oldowan in Kanjera South, Kenya, which dates to between 2.3 - 1.95 Ma (Plummer 2004). The aim of their study was to test if certain engineering techniques would be sufficient to determine and explain hominid rock selection. The authors did so by applying these methods to edge durability and fracture predictability, and correlating these with their own experimental results. Edge durability was assessed

through the experimental use of flakes from the various rock types. The percentage of area lost on flakes during use was calculated for each rock type and correlated with an American standard abrasion hardness test (ASTM C241), applied to the local rocks. For fracture predictability Braun *et al*. (2009) made use of the method set out in Brantingham *et al.* (2000) by recording the encounter rate of impurities on artefacts (see later discussion). From an engineering perspective, fracture predictability was determined with the use of a rebound hammer (Schmidt hammer) which impacts a material and tests the ability of a rock to absorb energy. This test was done on rock types that were available from their study area and not on the artefacts themselves. The materials were cut into $10cm^3$ blocks and impacted multiple times to obtain an average. According to the authors, this method is ideal for archaeological studies as it is non-destructive to artefacts and can be used on objects of similar size to stone artefacts such as the $10cm^3$ blocks (Braun *et al*. 2009). However, a rock's ability to absorb energy is too broad an analysis to determine a rock's precise flaking predictability as many interrelated features should be considered. Nonetheless, both the experimental fracture predictability and edge durability tests exhibited a high correlation with the results produced by the engineering techniques, and the authors concluded that certain engineering techniques could be useful to help determine the degree of selectivity practiced by hominids. The results indicated that hominids at Kanjera South selected material that had durable edges over material with higher fracture predictability, but they preferred rock types that were both durable and predictable.

In some cases, more desirable lithic raw materials may have been transported to early sites. This was assessed for the Oldowan in the Kanjera South Formation, Kenya by Braun *et al*. (2008). The authors made use of both destructive and non-destructive ED-XRF (Energy dispersive X-ray fluorescence) to identify transport in the area. The methods identify specific trace elements in an artefact that could be linked to parent rock. The destructive method however requires that a piece of the artefact be ground up for testing, whereas the non-destructive method determines the trace elements directly from the surface of an artefact. The first method is generally considered to be more reliable, which is why the two methods were compared to indicate if the non-destructive method yields similar results to the destructive method, and could thus be used in future to help identify source locations for lithic raw materials. The destructive method was only used on a few artefacts of each rock type for comparison. The results indicated that the non-destructive method was sufficiently reliable, and could therefore be used on artefacts. However, this technique is also time consuming as

samples have to be placed in an ultrasonic bath to remove contaminants and only artefacts with at least one fresh surface can be used (Braun *et al*. 2008).

No detailed studies have been carried out on procurement of quality lithic raw material for any of the ESA sites in southern Africa. However, selectivity is present as has been demonstrated for the Oldowan at Sterkfontein, South Africa. Kuman (1996) made use of experimental studies to link the characteristics of the assemblage to rock forms available from the surrounding landscape. Selectivity of lithic raw materials in the Oldowan assemblage is shown for certain rock types, as 90.5% of the Oldowan assemblage (including small flaking debris) consists of quartz (Kuman & Field 2009). Additionally, rolled quartz cobbles obtainable from river gravels appear to have been preferred over surface quartz found closer to the site, because of their better homogeneity (Kuman 1996; Kuman & Field 2009). Thus, it seems that selection for quartz, which is not the most common rock type in the gravels, existed in the Oldowan at Sterkfontein, probably because quartz flakes produce sharp cutting edges (*ibid*). Additionally, there is a marked increase towards the use of quartzite in the Early Acheulean (Field 1999), which makes sense as good quality cobbles of quartzite will be more efficient for the making of large formal tools than the more brittle chert and quartz in the area. This indicates that early hominids in the Sterkfontein valley at least understood that different rock types had different properties.

Since most studies on lithic raw material procurement in South Africa have been directed towards MSA assemblages, there is good evidence for selectivity of better rocks, as finer and more "exotic" rocks are an important part of some MSA assemblages (Ambrose & Lorenz 1990). "Exotic" here refers to rocks that are not available near the site and are further than 40km away (Ambrose 2006). This is apparent for the Howieson's Poort Industry at Klasies River Mouth (KRM) as there is a noticeable increase in fine-grained rocks which could be explained by an increase in procurement of better material from further away or through lithic raw material exchange between groups (Ambrose 2002, 2006). Either of these behaviours would indicate a conscious decision for selectivity of specific lithic raw materials. Moreover, silcretes used at KRM were classed into two broad categories by Singer & Wymer (1982) as coarse and fine grained varieties. Later Villa *et al*. (2010) created three categories according to the sorting and sizes of grains. These studies indicated that the finer grained silcrete was selected over the coarser varieties.

Wadley and Kempson (2011) assessed Middle Stone Age lithics from Sibudu, KwaZulu-Natal, South Africa. The study included various semi-quantitative methods done on the two predominant rock types found in the assemblages. Wave dispersive XRF and thin sectioning were used on a few geological samples as well as a few select lithics from Sibudu. This merely helped the authors to indentify the mineralogical composition of certain rock types and their possible source locations, but it was not much use in determining quality factors. The authors therefore tested hardness, surface roughness and fracture toughness of dolerite and hornfels, which were used predominantly by the Sibudu occupants. Hardness tests are used to determine how durable certain raw materials are (Wadley & Kempson 2011). The authors made use of the Vickers Hardness Test, which tests the force a material can withstand before deforming. This method makes use of a pyramid shaped diamond which is pushed onto the surface of a specific raw material with a predetermined force. The area of the indent made by the diamond is then measured to give a Vickers hardness value. The higher this value the softer the material. These tests revealed that people selected harder, more durable dolerite and hornfels. Surface roughness was determined by calculating the average grain size of a particular rock; this test revealed that dolerite has a higher surface roughness (i.e., larger average grain sizes) than hornfels. "The greater the surface roughness of rock types, the less the attrition of tool edges, so roughness is a critical attribute that is likely to influence the rate of wear of a tool" (Wadley & Kempson 2011:100). However, this variable alone is not what causes a rock to be brittle. Therefore, it is also necessary to determine the fracture toughness of a particular raw material; this was done by making use of a low energy Charpy pendulum impact testing machine. This device measures the amount of energy a material absorbs before it fractures. It does so by swinging a pendulum with a specific weight from a particular height onto a piece of material that has been cut to specified dimensions. The device then measures the amount of energy the sample absorbs upon impact. The results indicated that dolerite has much higher fracture toughness than hornfels and is thus much more durable. The study revealed that people occupying Sibudu selected lithic raw materials based on intended use, and often selected harder and more durable materials.

Brantingham *et al.* (2000) assessed rock quality for a Middle Palaeolithic site (Tsagaan Agui cave Lower Grotto) in northeast Asia, Mongolia. They argued that the quality of rock is determined by many different features that can be quantified individually, such as size, shape, purity and mineralogical structure. The authors did not assess the size and shape of the rock types, but rather directed focus towards mineralogical structure and purity. According to

Brantingham *et al.* (2000: 257) a high quality material has "little or no crystalline structure and contains few impurities" which can be quantified by four properties "(1) percent crystallinity (how much of the matrix consists of microscopically visible crystals, as opposed to an amorphous material, which lacks a crystalline structure), (2) average crystal size, (3) range in crystal size, and (4) abundance of impurities, such as fossils, vugs and veins of secondary crystals". The artefacts from the Tsagaan Agui Lower Grotto were all made from banded chert (Brantingham *et al.* 2000). It was determined that the chert was <95% crystalline with an approximate crystal size of 10 µm and exhibited a fairly uniform range in crystal size. Despite the high percentage of crystallinity, the material exhibited an ideal crystalline structure due to the small crystal size and crystal uniformity. However Brantingham *et al.* (2000) found that impurities and voids cause the chert to fracture irregularly, and therefore it was important to assess the impurities found in the rocks in great detail. This was done by determining the impurity encounter rate for each artefact, which was calculated by dividing the number of flake scars on an artefact that exhibited an impurity such as a void or crystalline inclusions greater than 1cm ("ISCAR"), by the total number of flake scars on that artefact ("DSCAR") and multiplying this by 100 to get a percentage (Brantingham *et al.* 2000). It was determined that the majority of artefacts had some impurity present (57% falling between 20-100%) and that half of the artefacts had an impurity encounter rate of 40% and above. That means that for every ten removals at least four encountered an impurity. Despite these flaws the people simply adapted by adjusted their flaking strategies.

I am in agreement with Brantingham *et al.* (2000), in that the presence of flaws, such as impurities and voids, is the largest inhibitor to the knapping process. A rock that restrains or prevents the creation of stone tools is considered of poor quality, and since the presence or absence of flaws is such a key factor, it is paramount to investigation. The method that Brantingham *et al.* (2000) used to determine the impurity encounter rate for artefacts was selected for use in this study, as it proved to be a sufficient way to quantify how flawed a particular lithic piece is. The definition of a "flaw" will depend on the rock type that is being analysed. The Swartkrans assemblages consist predominantly of three rock types, which were sampled from the study area and knapped to determine which characteristics act as flaws in each rock type. These were isolated and used to determine the impurity encounter rates in the analyses (this is discussed in greater detail in Chapter 4).

In addition to the impurity encounter rate I have selected a few other variables to quantify the quality of rock types utilised at Swartkrans. The reason for this is because each rock type has multiple characteristics that are unique to that rock type. For example, quartzite consists of sand grains, whereas quartz and chert does not. Grain size and homogeneity of these grains were thus analysed for quartzite. Furthermore, fractures and crystal faces are visible in both quartz and chert, but not in quartzite, which were analysed separately (fracture encounter rate) and not in the impurity encounter rate. Weathering state was also determined for each rock type since weathering breaks down a rock's mechanical integrity, which stone tool manufacture and use rely on. These variables were isolated by examining the geology of the study area and knapping various lithic raw materials that were obtained.

CHAPTER 3 SURFACE GEOLOGY OF THE STUDY AREA

This chapter will give a brief outline of the geology of the study area and descriptions of the various rock types found from each geological succession. Additionally, these rock types, and described characteristics, will be discussed in a later chapter with regards to the knapping process and whether they encumber or promote this process.

The study area has a rather interesting geological history, having been formed by two separate shallow marine basins, namely, the Witwatersrand Basin and the subsequent Transvaal Basin. Only a small part of the lower Witwatersrand Supergroup is located in the study area, with the rest of geology belonging to the Transvaal Supergroup (See Figure 3.1).

3.1 The Witwatersrand Supergroup

The oldest exposed stratigraphy in the study area belongs to the Witwatersrand Supergroup and falls within the Hospital Hill Subgroup. This group consists primarily of quartzites and shales which are believed to have originated from continental shelf sand bodies (Eriksson *et al*. 1981; Winter and Brink 1991; Beukes and Nelson 1995; McCarthy 2006). Thus, the quartzites are rather mature (orthoquartzite), meaning that 95% or more of the rock consists of quartz grains (Law *et al*. 1990). Additionally, the grains are well-sorted and predominantly medium to fine-grained in the Krugersdorp area (Watchorn 1981:33). According to Watchorn (1981) the quartzites from the Hospital Hill Formation exhibit a greenish colour due to mineral traces of fuchsite, but they tend to be either greyish-white or blue in the Krugersdorp area (study area). This is due to the presence of opalescent blue quartz which is prominent in fresh samples (Watchorn 1981) and tends to weather to a greyish-white colour and eventually brown when extensively weathered (Figure 3.2).

The Hospital Hill Formation also contains slates and shales (Figure 3.3), which were formed from laminae of finer clay particles that settled in the deeper parts of the shallow marine basin where there is less kinetic energy. When shales undergo metamorphism they turn to slate, which takes on unique properties depending on the degree of metamorphism, mineral composition of the parent rock (shale), the surrounding geological composition and geothermal activities.

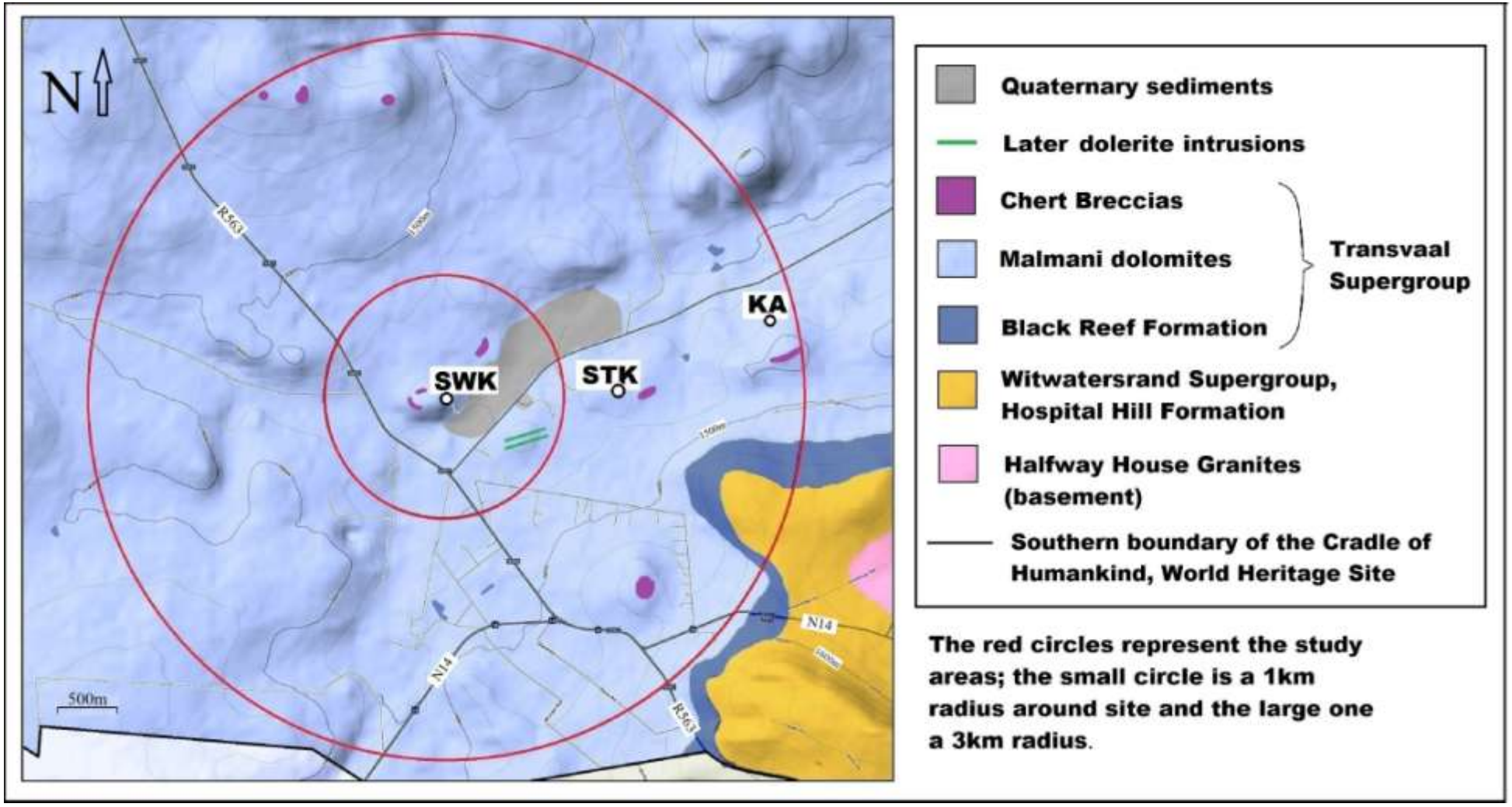

Fig. 3.1: Surface geology of the study area (Leyland *et al*. 2008 and own mapping). SWK, Swartkrans; STK, Sterkfontein and KA, Kromdraai. (Contour map used for background, from Google Earth 2011a).

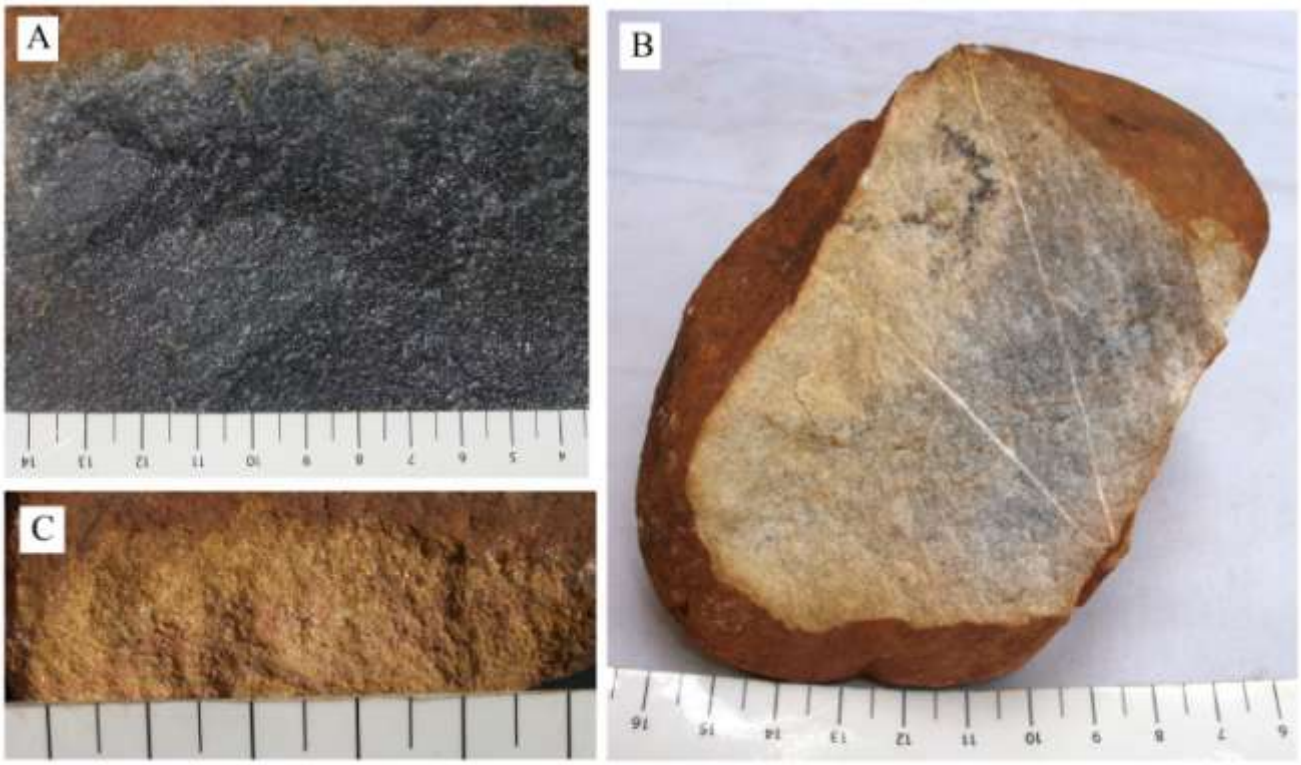

Fig. 3.2: Hospital Hill quartzites. A: fresh, B: slightly weathered, C: extensively weathered.

The shales in the study area are soft and red, indicating the presence of ferrous elements, and thus the slates in this succession are hard, dark and ferruginous (Truswell 1970; 1977). According to McCarthy (2006), because the shales are iron-rich, this resulted in the development of eight magnetite-bearing iron formations of which the most notable is the contorted bed (Truswell 1970; 1977; McCarthy 2006). The contorted bed is in fact banded ironstone with thin alternating magnetite and siliceous bands (Truswell 1970; 1977; McCarthy 2006) (Figure 3.4).

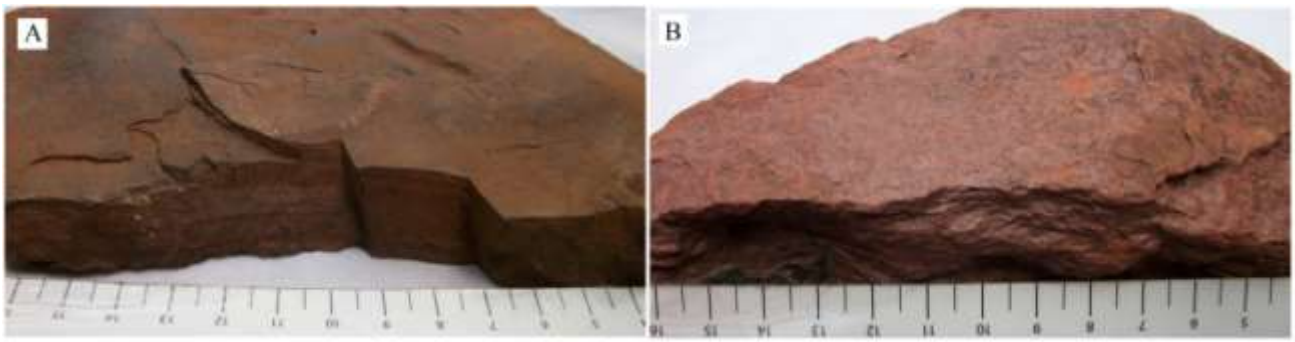

Fig. 3.3: Slate (A) and shale (B) from the Hospital Hill Formation.

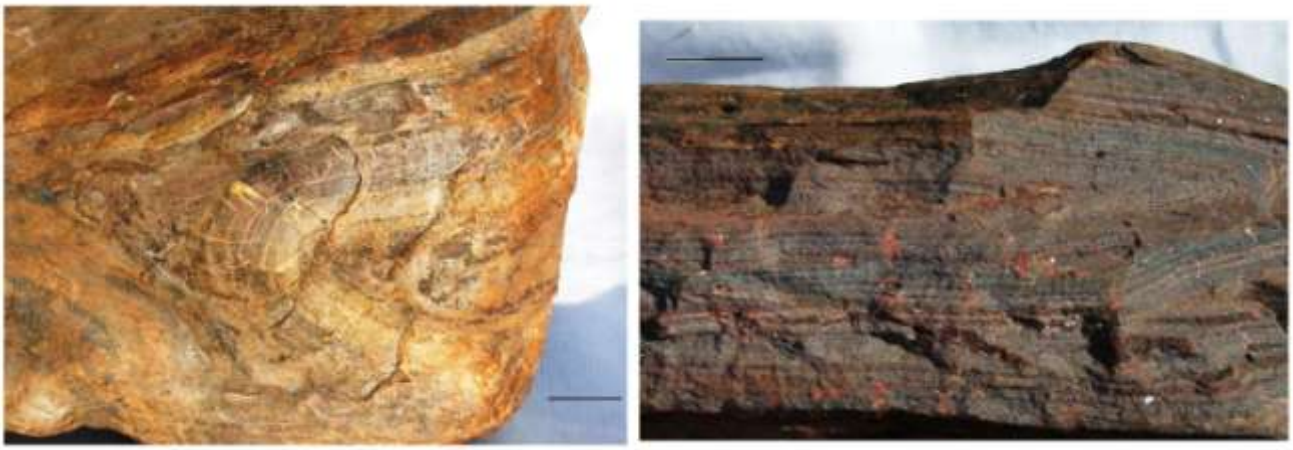

Fig. 3.4: Banded iron formation from the contorted bed. Lateral view of laminae (left) and direct view of laminae (right). (Line is equal to a centimetre).

The deposition of the Witwatersrand Supergroup commenced approximately three billion years ago (Robb and Meyer 1995) and spanned a period of roughly 200 million years (McCarthy 2006). This means that there has been a considerable period of time since deposition for structural changes to occur within the deposits such as metamorphism, fluid movements (Phillips *et al*. 1990) and extensive faulting (Stanistreet *et al*. 1986; Roering and Smit 1987; Stanistreet and McCarthy 1991). These processes are responsible for very strong cleavage in the rocks as well as the intense quartz veining which occurs in the area (Watchorn 1981) (Figure 3.5). These veins are the primary source for quartz in the area and can range from fine lamina to bands that are metres in thickness.



Fig. 3.5: Quartz veins in Hospital Hill quartzites. Line in picture on the right is equal to ten centimetres.

Furthermore, a substantial amount of the Witwatersrand Supergroup was subjected to an intense impact event (Vredefort impact structure), which resulted in the presence of planar deformation features as well as conical structures in the surrounding geology (Reimold 2006; Dankert and Hein 2010). A structure such as this is called a shatter cone and is "a conical surface of weakness, on which striations fan out from the apex" (Bayly 1990: 158) (Figure 3.6). The surface area of the cone acts like a plane of weakness because the cone is covered in a thin layer of glassy particles created from the intense pressure and heat during impact (Gay *et al*. 1978; Bayly 1990).



Fig. 3.6: Shatter cones in slate from the Vredefort dome. Line is equal to ten centimetres.

3.2 Transvaal Supergroup

The majority of the remaining geology in the study area falls under the Transvaal Supergroup, which "encompasses one of the earliest carbonate platform successions" in the world (Eriksson *et al*. 2006: 241). The Black Reef Formation is the basal member of the Transvaal Supergroup and shares a similar depositional setting as the lower Witwatersrand Supergroup, in that it consists of shallow marine shelf sand which was created by the re-

working of sediments from erosion of previous formations, in this case by the Malmani Sea (Button 1973). Like the Hospital Hill Formation, the Black Reef Formation consists of shales, quartz and medium to fine grained quartzites; however, the quartzites are not as extensively metamorphosed as the ones from the Hospital Hill Formation (Truswell 1977; Barton and Hallbauer 1996) and tend to be more sandstone-like. The quartzites are "compositionally mature" (>95% quartz), but contain some "carbonaceous matter and pyritic specks" (Button 1973:92), which can be attributed to microbial mats (Noffke *et al*. 2006). The quartzites therefore exhibit banding which is easily spotted when fresh (See Figure 3.7A). Furthermore, the quartzites alternate in colour, from white to light grey to black, depending on the proportion of carbonaceous matter (Button 1973). However, some are bleached white and some tend to be pinkish, yellowish or even orange inside (Button 1973; Figure 3.7B).

The Black Reef Formation does not outcrop extensively in the study area as it is covered by younger sediments. However, quartzites from this Formation are readily found in the Quaternary sediments (see later).

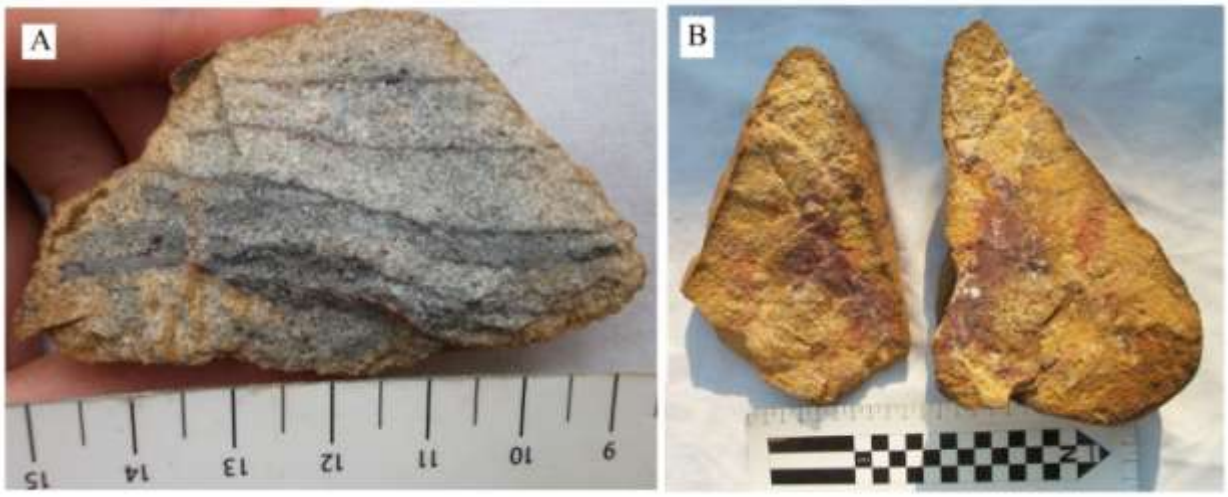

Fig. 3.7: Quartzite from the Black Reef Formation exhibiting banding and colouration.

Overlying the Black Reef Formation is the "Dolomite Series" (Truswell 1970), now referred to as the Malmani Subgroup (Button 1968). The Malmani Subgroup covers the majority of the study area (Figure 3.1) and consists mainly of siliceous dolomitic limestone (from here on referred to as dolomite for simplicity) and chert, but bands of slate and vein quartz have been

observed. This Subgroup is subdivided into five Formations depending on the frequency of chert present as well as the occurrence and sequence of certain structures in the dolomite. This project focuses on the rock types of the Malmani Subgroup as a whole rather than each individual Formation, as structures that are used to define the Formations are present in a number of locations in the study area, although some are more frequent in some areas than others. For example, oolitic dolomite and chert that define the base of the Monte Christo Formation (Button 1973; Eriksson and Clendenin 1990; Eriksson *et al*. 2006) are well exposed near the Sterkfontein caves; however, oolitic dolomite and chert are also found in various locations in the study area as these structures are present in the other Formations, but in lesser quantities or in lenses. Furthermore, the various Formations are exposed in a number of locations due to the topography of the landscape.

There are two main varieties of dolomite in the study area. One is dark grey and weathers to a chocolate brown colour (Button 1973), and the other is blue-grey. However, pink, red and purple varieties occur in small localised areas (Haughton 1969; Figure 3.8).



Fig. 3.8: Dolomite varieties in the study area. Line is equal to a centimetre.

Internal structures of the dolomite include an abundance of stromatolites, oolites, rippled facies and joint planes (Figure 3.9). Stromatolites are created by blue-green algal mats trapping limy sediment and repeatedly growing through this sediment to obtain sunlight (Truswell 1970, 1977). This process can create flat-laminated or dome like structures

depending on the algal species or underlying sedimentary irregularities (Eriksson 1977, Walter *et al.* 1974). Oolites are sedimentary structures composed of rounded grains (ooids) that are approximately two millimetres in diameter (Flügel 2010). The exact formation process of ooids is somewhat uncertain, but it essentially involves the constant precipitation of $CaCO_3$ on and around a nucleus (sand grain, faecal pellet, shell fragment or marine skeletal matter) in agitated shallow marine waters (Flügel 2010).

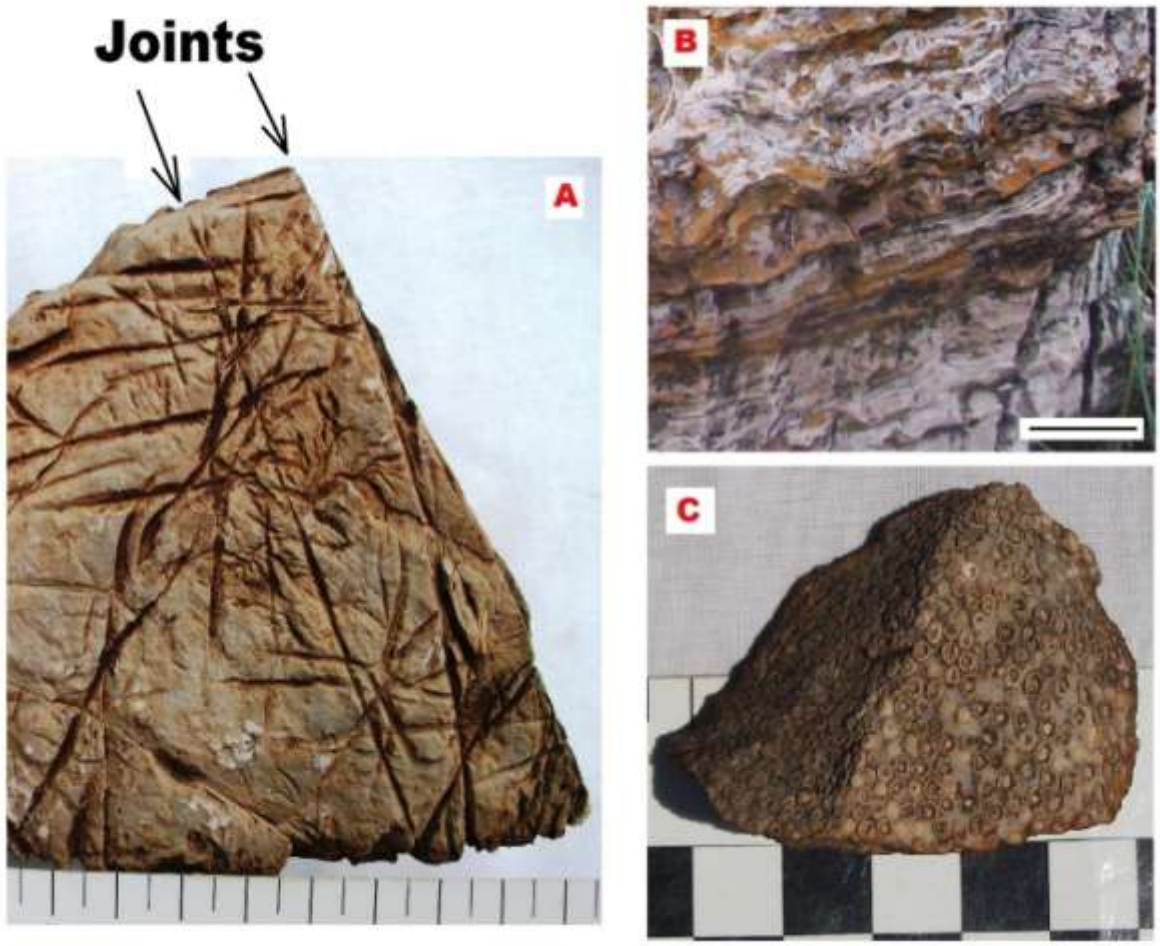

Fig. 3.9: Structures found in the Malmani dolomites. A: joint planes, B: stromatolites and C: oolites. Line in top right picture is equal to ten centimetres.

Chert is abundant in the study area and varies from thin laminae to up to two metres in thickness (Button 1973). The chert is dark grey in colour and weathers to milky white (Button 1973; Figure 3.10). Furthermore, structures that are present in the dolomite are also observed

in the chert, especially stromatolites and oolites, which might have been formed from secondary silicification of dolomite (Haughton 1969; Figure 3.11).



Fig. 3.10: Malmani chert.



Fig. 3.11: Structures found in the Malmani chert. A: stromatolites (flat and domical), B: planar cross-section through stromatolites, C: oolites and D: joint planes.

Slates are also present in the Malmani Subgroup, but tend to be softer and more brittle than the slates from the Hospital Hill Formation (Figure 3.12). Moreover, quartz bands and veins have been observed in the stratigraphy, but they are often only a few centimetres in thickness and exhibit multiple joints, crystal inclusions and cavities (Figure 3.13).



Fig. 3.12: Slate from the Malmani Subgroup.

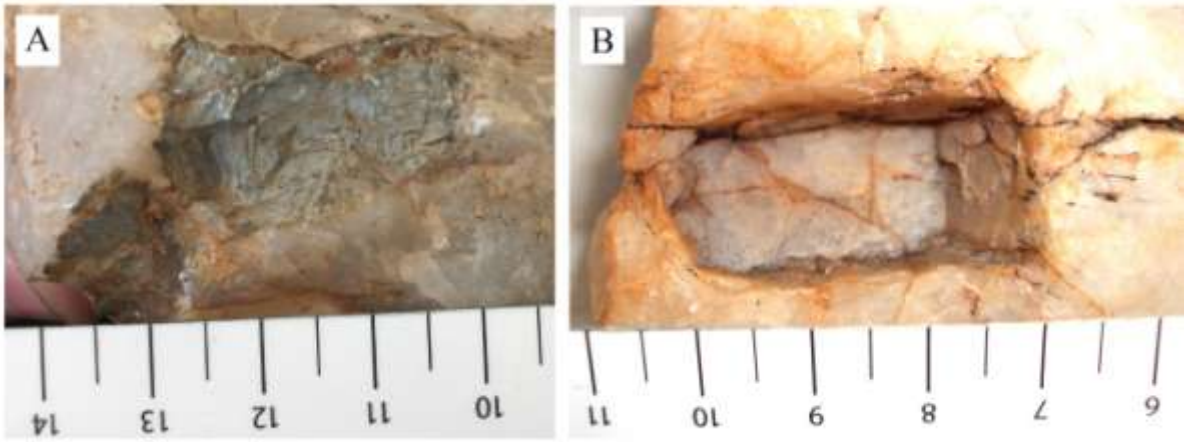

Fig. 3.13: Quartz from the Malmani Subgroup showing mineral inclusions (A) and succeeding cavities (B) created by weathering and removal of such inclusions.

During the Malmani Subgroup's deposition, multiple sea-level transgression and regression cycles occurred (Clendenin 1989; Catuneanu and Eriksson 1999), resulting in surface erosion of the exposed dolomites between cycles, hence multiple erosive breccias are present within the succession (Button 1973; Eriksson and Clendenin 1990; Catuneanu and Eriksson 2002; Eriksson *et al.* 2006).

Furthermore, in the late stage of the Malmani Subgroup's deposition, upliftment of the southern part of the basin lead to erosion of the Malmani dolomites leaving an irregular karst surface in which major *in situ* and alluvial chert breccias and conglomerates accumulated forming the basal members of the Pretoria Group (Eriksson *et al.* 2001; Catuneanu and Eriksson 2002). This breccia is known as the Bevets Member (also termed the Fountains Member or the "Giant Breccia") and consists of large and small angular to sub-angular chert fragments in a silicified matrix (Button 1973). The matrix is generally bleached a whitish grey colour due to weathering (Figure 3.14B, C), but some areas of breccia consist of dark chert fragments in a reddish brown carbonate-bearing ochre (Button 1973; Figure 3.14A).

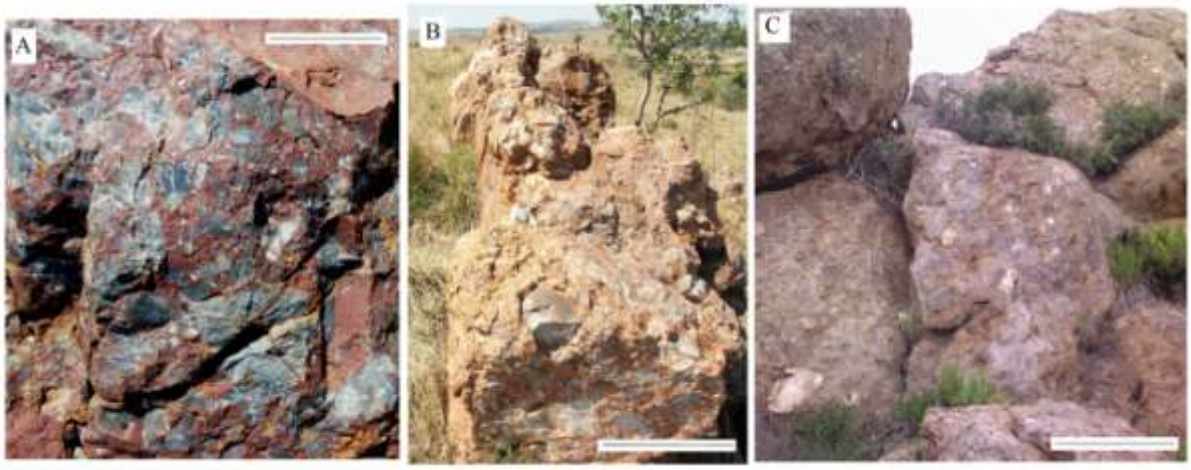

Fig. 3.14: Chert breccias in the study area. A: chert pieces in a reddish brown ochre matrix; B: chert pieces in a chert matrix; and C: chert and quartz pieces in a chert matrix. The scale line in picture A is equal to ten centimetres, and the scale lines in pictures B and C are each equal to half a metre.

The breccias in Figure 3.14 are from the study area and would thus most likely belong to the erosive breccias within the Malmani Subgroup; however, the southern landscape saw approximately 80Ma of erosion (Eriksson and Reczko, 1995) which must have caused an extensively and deeply weathered karst system. Furthermore, weathered and unconsolidated materials often collect in karst features and become silicified over time (Trollip 2006). Thus, it might be possible that certain breccias from the study area are remnants from the Bevets Member that were trapped in karst features within the lower Formations of the Malmani dolomite and are now exposed. In addition Figure 3.14 represents three different types of breccias found in the study area; Figure 3.14 A and B are similar to the descriptions given by Button (1973). Figure 3.14C, however, is a breccia containing a substantial amount of quartz

pieces (see also Figure 3.15), which were not observed in any of the other chert breccias. This is probably due to the *in situ* erosion of a local quartz band in that particular area.



Fig. 3.15: Cherty breccia with quartz fragments.

3.3 Quaternary sediments and other rock types

The study area also includes two parallel dolerite (also referred to as diabase) dykes running close to Swartkrans and Sterkfontein (Figure 3.1). The exact ages of these dykes are not known and will require geochemical and magnetometrical analyses to determine; however, it is likely an intrusion from the Pilanesberg Alkaline Province, which is characterised by multiple northwest dykes of alkaline fine-grained dolerite and syenite (Verwoerd 2006). The dolerite dykes outcropping in the study area tend to be somewhat weathered (Figure 3.16), but might have had some fresh surfaces exposed during hominid occupation 2Ma.

Additionally, flowstone (Figure 3.17) is also present in the study area due to the development of a karst environment and the subsequent precipitation of calcium carbonate within these karst features. However, these rocks might not have been readily exposed or accessible to hominids at all times. Moreover, the landscape is strewn with ferricrete and ferrous nodules which formed in lateritic soils (Figure 3.18). These nodules are most likely hematite and/or magnetite.



Fig. 3.16: Dolerite from the study area exhibiting various degrees of weathering. Slightly weathered (left) to completely weathered (right). Line is equal to a centimetre.



Fig. 3.17: Flowstone from mine workings in the study area. Line is equal to a centimetre.



Fig. 3.18: Ferrous nodules (left) and ferricrete (right) from the study area. Scale line in the picture on the right is equal to ten centimetres.

Finally, Quaternary gravels are well preserved at the foot of the Swartkrans hill and flatlands between Swartkrans and the Sterkfontein caves (Figure 3.1). The gravels exposed run parallel to the existing Blaaubank River and cut southwards into the landscape towards the entrance of Sterkfontein. The modern Blaaubank however is merely a stream with mostly sediment and little gravels present. Conversely, the exposed preserved gravels cover a width of 120 metres in some places, indicating that the Blaaubank River was much larger at some stage. This is supported by faunal studies of Swartkrans assemblages which suggest that during the accumulation of Members 1-3 there was a nearby water source, specifically a large river (Brain *et al.* 1988). Additionally gravels range in varying sizes from massive boulders to pebbles (Figure 3.19).



Fig. 3.19: Gravels next to the Sterkfontein Caves road.

Rock types preserved within the gravels include: quartzite, chert, quartz, chert breccia, slate, banded iron formation, arkose and dolerite (diabase). The majority of the gravels consist of rocks from the various stratigraphic units found within the area, but the odd rock is from successions further to the north, such as arkose, which is more prominent in the later Timeball Hill Formation. The arkose from this area contains a ferromagnesian mineral (Button 1973) and is rich in potassium feldspar, which gives it a red to pinkish appearance (Figure 3.20). This rock type appears similar to quartzite and knaps exactly the same as the quartzite varieties found in the area, and is therefore analysed with quartzite.



Fig. 3.20: Arkose from the Quaternary gravels. Line is equal to a centimetre.

CHAPTER 4 METHODOLOGY

Below is a list of the methodological steps I undertook throughout this project. Each will be explained in detail within this chapter to accentuate the methodological thought process and reasons for this approach.

- Assess artefacts from the Swartkrans assemblages to determine technologies,
- Assess the study area and determine sample points,
- Gather samples,
- Knap samples,
- Determine a set of variables for analyses,
- Build experimental assemblages and
- Collect and analyse data for artefacts and experimental assemblages.

4.1 Assessment of the various technologies at Swartkrans

As already pointed out, Swartkrans contains three major time-related artefact assemblages (Oldowan, Acheulean and MSA). Each of these assemblages has a specific technology, hence it is important for one to familiarise oneself with the technology of each techno-complex. This is especially important if one aims to create experimental assemblages for comparison, as the technology would have to be replicated.

I inspected a variety of artefacts to determine the technology and rock types utilised in the assemblages. The assessment of artefacts for the Oldowan and MSA was done from Swartkrans assemblages, but for the Acheulean, the Sterkfontein assemblages were used as the Swartkrans Acheulean was inaccessible at the time. Also the Sterkfontein site is approximately a kilometre away from Swartkrans (Kuman 1998) and thus shares the same landscape, resources and time interval. The same artefact types are present, except for heavy duty tools, which are absent from the Swartkrans assemblage probably due to small sample size (Field 1999), but have been found in mine dumps, two of which are believed to belong to the Acheulean, based on adhering breccia which resembles that of Member 2 (Brain 1981;

Kuman 2007). Most importantly, the artefacts from both Sterkfontein and Swartkrans are made from the same rock types even though their frequencies differ (Field 1999). However, the frequency differences would not be a problem for the creation of the experimental assemblages as each tool type would be replicated for each rock type and each variety of quality (see experimental assemblages).

The aim of the assessment was not to get the final quality analysis of the Swartkrans assemblages, but to understand the lithic raw material usage and tool types present for each techno-complex in order to replicate similar tools experimentally for comparison. Furthermore, the literature was significantly informative with regards to the above and indicated that the Swartkrans technology was more casually flaked than the Sterkfontein technology (Field 1999), which would have to be considered in the experimental knapping.

4.2 Assess the study area and determine sample points

The next step was to go into the field to familiarise myself with the landscape and the geology. Google Earth (2011b) was utilised to view where major rock outcrops are located and to determine access routes to such areas. A vehicle was used to get close enough to a potential point of interest and with landowner permission the rest was surveyed on foot. From the assessment of the study area, a three kilometre radius around the site was chosen for collection of rock samples, as this would be a sufficient size for a Masters project and would include the available rock types. Furthermore, the assessment also revealed that a substantial variety of rocks was available to hominids within a one kilometre radius due to the presence of preserved gravels from a large river that ran at the foot of the Swartkrans hill. Therefore, sampling was more intensely concentrated in a one kilometre radius of the site. A contour map (Google Earth 2011a) of the area was used for isolating certain points for sample collection. Hill tops were chosen (Figure 4.1) as assessment of the study area revealed that the majority of outcrops is generally on the hills, whereas the low-lying lands were often covered by younger sediments. Hillsides generally expose outcrops of various formations (see geology section) in the area, and an assortment of rocks can be collected from these areas.

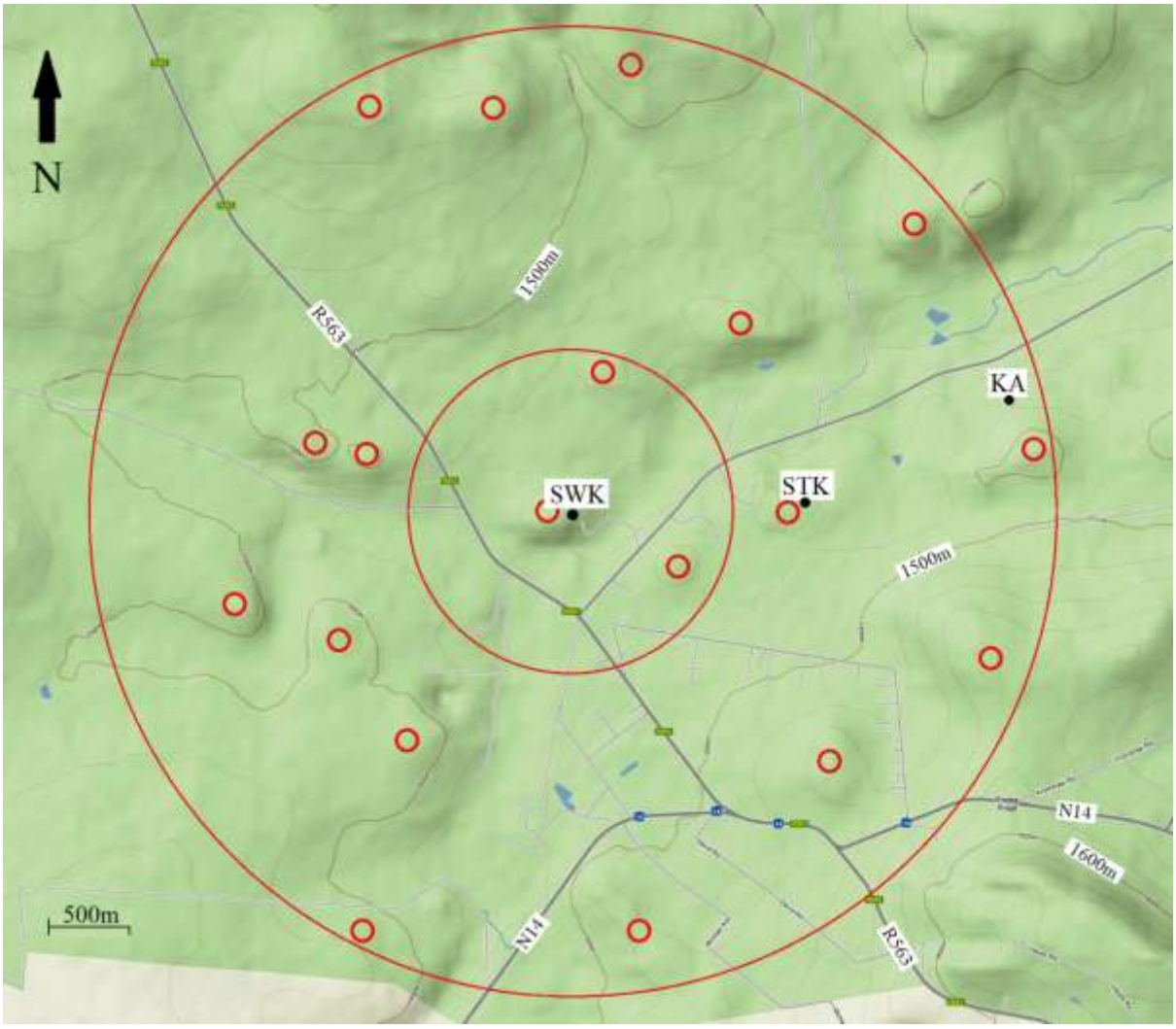

Fig. 4.1: Study area with one kilometre and three kilometre radii around site. Small circles show hilly outcrops for possible sample locations. SWK: Swartkrans, STK: Sterkfontein, KA: Kromdraai A. (Contour map used for background, from Google Earth 2011a).

4.3 Sampling

Samples were taken in a three kilometre radius (Figure 4.2) around Swartkrans cave and were roughly based on Figure 4.1. However, multiple samples were collected in the one kilometre radius because these lithic raw material resources would be the closest to the site. Additionally, focussed sampling was also applied to the areas around the Sterkfontein caves and the Kromdraai site for possible future analyses of these sites (Figure 4.3).

For the remaining outcrops, falling in between the one and three kilometre radii, one major sample was collected for each of the prominent hills and outcrops in the area (Figure 4.2, large closed circles).

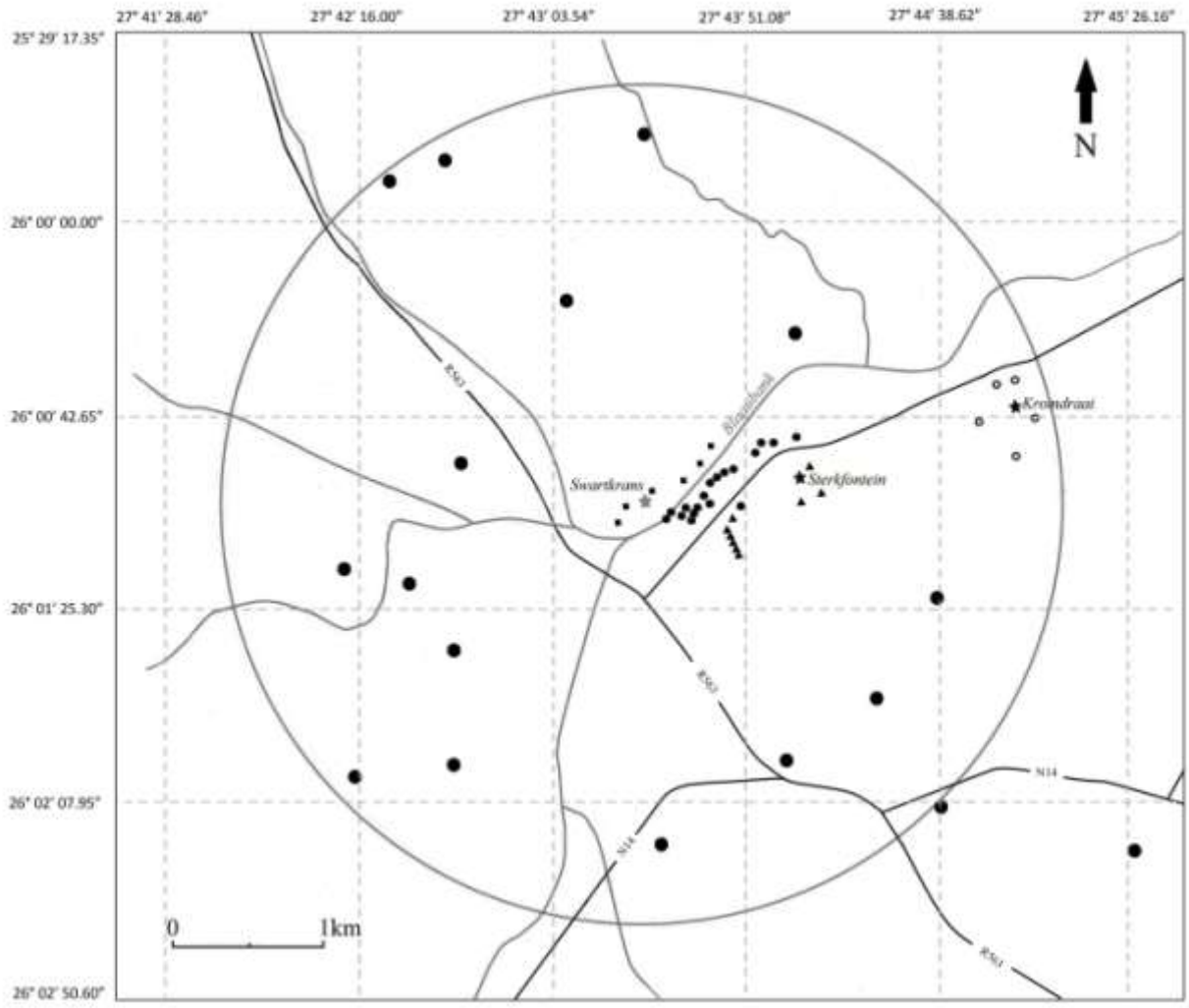

Fig. 4.2: Study area with sample locations. Large closed circles: sample locations outside the 1km radius; open circles: sample locations surrounding Kromdraai; squares: sample locations surrounding Swartkrans; triangles: sample locations surrounding Sterkfontein; and small closed circles: samples from preserved gravels.

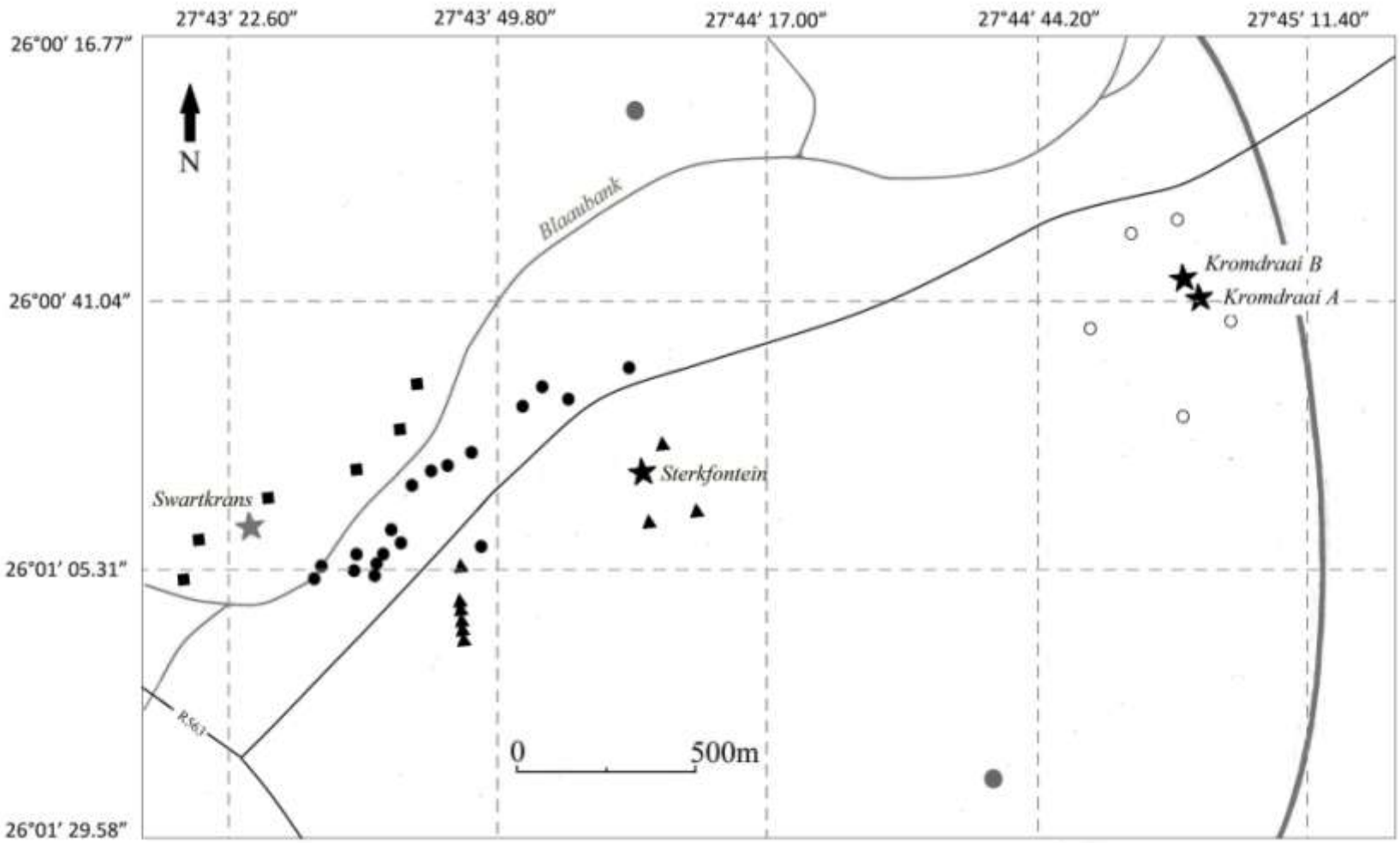

Fig. 4.3: Sample locations near major tool-bearing sites. Large closed circles: sample locations outside the 1km radius; open circles: sample locations surrounding Kromdraai site; squares: sample locations surrounding Swartkrans; triangles: sample locations surrounding Sterkfontein; and small closed circles: samples from preserved gravels.

One sample location lies some distance outside of the study area (large closed circle in southeast corner of Figure 4.2). The reason for the collection of this sample is because there are quartzite formations present of both the Witwatersrand and Transvaal Supergroups (see geology chapter) and the aforementioned sample ensured the sampling of quartzites from both successions. Figure 4.4 shows the location of these quartzite formations in the south-east and indicates that there is a prominent ridge and a spur. The ridge falls within the Hospital Hill Formation (Witwatersrand Supergroup), but at the time of sample collection it was uncertain how much of the spur consisted of the Black Reef Formation (Transvaal Supergroup). Moreover, the Black Reef Formation lies at the base of the Hospital Hill Formation in this area, because this is where the southern edge of the Transvaal strata meets the northern edge of the Witwatersrand outcrop. Since the Transvaal basin's deposition commenced after the deposition of the Witwatersrand Supergroup, some of the quartzites from the Hospital Hill Formation were overlain. Sample locations 36 and 37 might have only sampled the Black Reef Formation, since one was near the base of the northern edge of the Witwatersrand Supergroup and the other on the spur (Figure 4.4). Therefore, sample location 46 was taken on the ridge to ensure that the Witwatersrand quartzites were sampled and to include enough sample points for quartzite outcrops closest to the cave site.

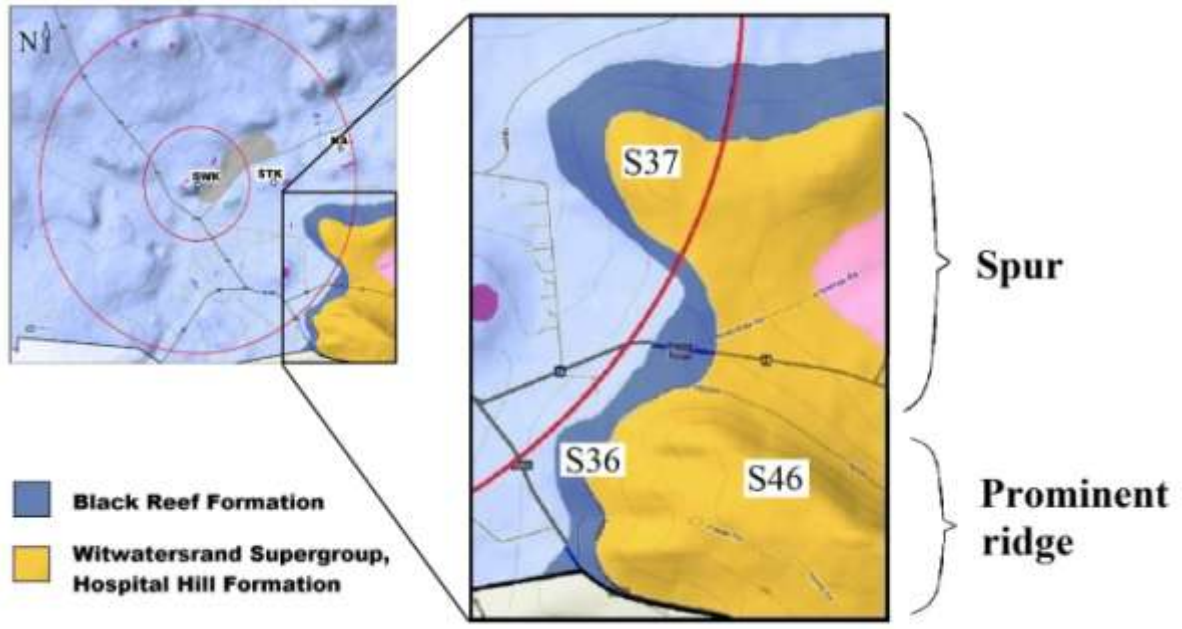

Fig. 4.4: Quartzite outcrops in the study area and samples taken from them. (Contour map used for background from Google Earth 2011a).

A Global Positioning System (Garmin GPS 60) was utilised to obtain coordinates for the sample locations. There were fifty five sample locations in total, with each containing a number of rock samples from that location. These included samples from each rock type found there and all varieties of those types. For example, for quartzite I collected: a fresh piece, a weathered piece, pieces exhibiting different grain sizes, pieces containing joints and pieces containing no joints, *et cetera*. I was not always able to tell the exact condition of an individual rock without a test flake; therefore some were tested on site to determine the state. This is most likely what hominids would also have done, especially if they had to walk a distance to get rocks. Flaked pieces were removed as not to contaminate the archaeological sites. In addition, focus was directed towards collecting varieties of quartz, quartzite and chert, as these were the most predominantly knapped by the hominids; however other rock types were collected for knapping in order to assess the knapping quality of each rock type that was available to the hominids.

Sample sizes from each locality varied depending on how many rock types and how many varieties of each type were present. Thus, the gravel samples have on average more rocks per sample location than the dolomite and chert outcrops, as they preserve almost all rock types found in the area. Moreover, gravels were sampled in many locations as numerous artefacts from the assemblages were made on cobbles, which is apparent from their cortices (Figure 4.5).



Fig. 4.5: Artefacts exhibiting rounded edges and random impact marks, thus showing origin from gravels.

Samples were collected from where hominids would have been able to obtain them. Therefore, the majority of samples came from pieces lying on the surface of the landscape. However, to obtain the freshest sample of chert, it often had to be knocked off from an outcrop. This was done with a geological hammer inflicting as little damage to an outcrop as possible. These would also have been easy for hominids to dislodge with hammerstones. Chert is more resistant to weathering than the surrounding dolomite, therefore chert bands protrude out of the rock face, and they are easy to hammer off with little force. This is illustrated in Figure 4.6.

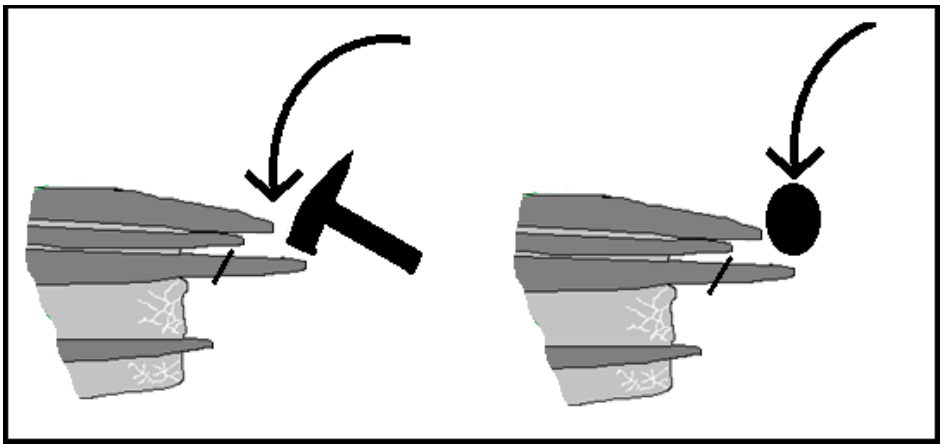

Fig. 4.6: Obtaining chert from an outcrop.

4.4 Knapping

I first had to practice and refine the art of knapping before attempting to knap the collected samples. This was done by replicating the various lithic tool types found in the artefact assemblages from Swartkrans. The Swartkrans tools from all three major techno-complexes were principally made from quartz, chert and quartzite. Therefore, I undertook the knapping preparation on the same rock types, but not all were directly from the study area as some were also from the Jukskei River (mainly quartz and quartzite). After many hours of knapping, I was capable of replicating the technology found in all of the assemblages, including the heavy duty tools. Some examples are shown in Figure 4.7.



Fig. 4.7: Various stone tools created by the author.

Prior to the commencement of the experimental knapping, I first isolated some of the collected rocks for hammerstones, as it is paramount that the same materials found in the study area be used for hammerstones. This is because the materials, shapes and sizes present might limit what can be created. Hammerstones were only chosen from the quartzite cobbles as they were the only material sufficiently hard enough to knap the other materials, including other quartzite tools, without breaking. The cobbles from the gravels are also rounded which make better hammerstones as the impact point on a core is more predictable and controlled. Moreover, cobbles needed to be somewhat fresh as extensively weathered samples crumble upon impact. However, finding such rocks proved to be a little difficult as the majority of the gravels vary in sizes, shapes and states of weathering. Below are the hammerstones that were used for the experimental knapping (Figure 4.8).



Fig. 4.8: Quartzite hammerstones used for the experimental knapping.

Varying sizes of hammerstones were selected because it became clear during the knapping practice that to dislodge large flakes a large and heavy hammerstone was necessary. Conversely, for fine retouch a small hammerstone with a narrow edge was ideal. I also collected a hammer and anvil since the bipolar technique was practiced, which was apparent on some quartz pieces exhibiting impact damage at polar ends. A large, thick, flat and hard piece of ferruginous slate from the gravels was used as the anvil, since this provided a flat stable surface at the base of the percussion giving more control. For the hammer, a large and heavy, sub-rounded quartzite cobble was selected (Figure 4.9A). I made sure that it was large enough to break larger cobbles and applied less force when striking smaller pieces.

It should be noted that there were no hammerstones and anvils found in any of the assemblages, therefore I had no reference points as to what types of materials, shapes and sizes the hominids used. I therefore selected an anvil and hammerstones based on which materials were the best for the job, assuming that hominids would have done more or less the same.

It was apparent from the assessment of the artefact assemblages that three flaking techniques were utilised by the hominids. The most popular technique was the direct hard hammer percussion, followed by the bipolar technique and the occasional thrown core. According to Field (1999), the throwing technique is difficult to determine on artefacts but can be seen by random pitting and bruising over the cortex. She noted from her own experiments that throwing only works for large cobbles, especially if one wishes to expose a natural joint that could be used as a platform. A few of the larger quartzite artefacts exhibited possible signs of throwing, thus this technique was only used on really large cobbles when dislodging large flakes with a hammerstone became troubling (Figure 4.9B), or when it was necessary to break a large cobble along a natural plane to create a flaking platform. Direct hard hammer percussion was used more prominently in the experimental knapping. For this technique the knapper basically holds a hammerstone in one hand and directly impacts the core held in the other hand. This process involves much accuracy and in-depth understanding of materials and how forces affect them. The bipolar technique was mainly utilised on small pieces of quartz, as these pieces were too small to knap with freehand percussion and fractures easily under percussion. It also tends to fracture evenly due to its glassy nature (when of good quality), thus resulting in sharp wedge-like pieces which are suitable for cutting and further retouch.

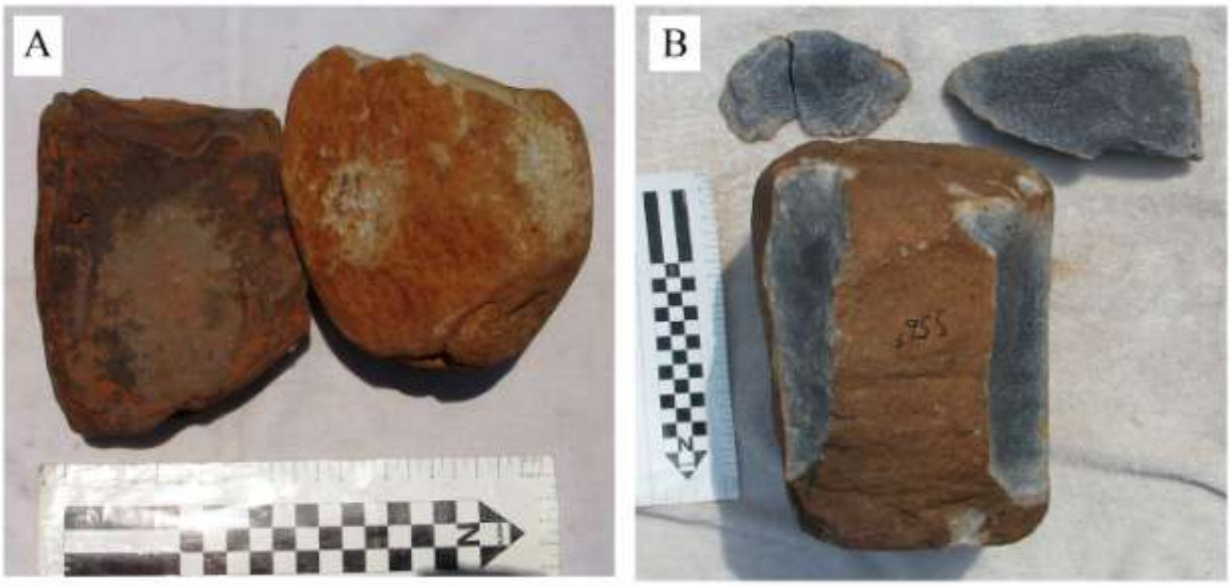

Fig. 4.9: Hammer (A, right) and anvil (A, left) used for the bipolar technique, and a thrown boulder for large flake blanks (B).

All of the rocks obtained from sampling were knapped and I attempted to make all of the tool types available from all of the industries at Swartkrans. Heavy duty tools were also made for a future study of the Sterkfontein and Kromdraai artefacts. However, some materials did not always allow for the creation of every tool type. For example, an extensively weathered piece of quartzite did not allow for the creation of a handaxe or a finely retouched tool, because the material would simply crumble into chunks and grains. This was not a problem for the analysis because if a material would not allow for the creation of a certain tool type it is not likely to feature in the assemblages.

Additionally, knapping was done on a large capture surface, but only pieces that were two centimetres and over were collected and used for the experimental assemblage creation (see experimental assemblage). Furthermore, the experimental knapping allowed for the observation of features each rock type exhibits during the knapping process, and how these features affect the knapping process. The characteristics that either helped or inhibited the process were thus isolated for each rock type and a set of variables was determined for analysis.

4.5 Variables

As pointed out previously, the majority of artefacts from Swartkrans were made from quartz, quartzite and chert. The focus of this project was thus directed towards these three rock types, more specifically, with regards to the selection of the quality of these materials by the artefact creators.

A set of variables was isolated after the exploration of the literature and the experimental knapping (Table 4.1). These variables were used to analyse both the experimentally created lithics as well as the assemblages from Swartkrans.

Table 4.1: Methods for assessing quality of the three most frequently used rock types.

Quartz	**Methods for assessing quality**	**Reasons**
Flaws	Impurity encounter rate (Brantingham *et al.* 2000)	Flaws cause rock to fracture irregularly when impact is driven through these areas.
Crystal structure	Count cracks running into the surface per unit area	The crystal structure in quartz has a direct impact on the way it fractures.
Weathering	Fresh / Intermediate / Complete	Quartz weathers between crystal structures, which make bonds between them weak; this compromises flaking predictability.
Chert		
Flaws	Impurity encounter rate (Brantingham *et al.* 2000)	Flaws cause rock to fracture irregularly when impact is driven through these areas.
Fractures	Count cracks running into the surface per unit area	Force directed through the rock does not run uniformly through the material when fractures are present, often with the result of incomplete flakes and chunks.
Weathering	None / Intermediate / Complete	Weathering weakens the bonds between the tiny silica crystals which can cause flakes to snap and thus makes knapping less predictable.
Quartzite		
Flaws	Impurity encounter rate (Brantingham *et al.* 2000)	Flaws cause rock to fracture irregularly when impact is driven through these areas.
Grain size	Wentworth scale (1922)	The rock will fracture along individual grains; therefore smaller grained rocks will allow for the force to run more uniformly and efficiently.
Homogeneity	Four categories • homogeneous grains and no banding, • inhomogeneous grains and no banding • homogeneous grains with banding, • inhomogeneous grains with banding	The more homogeneous the material the more predictable flaking becomes and vice versa, as the force runs evenly through homogeneous material.
Weathering	Fresh / Intermediate / Complete	Weathering of quartzite compromises the cohesion between individual grains making the material brittle and less predictable.

4.5.1 Flaws

The three above mentioned rock types all exhibit imperfections; however each material has a unique set of imperfections. In order to quantify these flaws it is paramount to first establish what is considered a flaw. From experimental knapping it was determined that flaws, in this study, pertain to any inherent structure that is visible to the naked eye and would compromise the predictability of the knapping process. The flaws that could be identified from the three rock types were: planes, cavities, crystal inclusions, veins and ooids. Crystal faces and irregular fractures are also flaws, however these will be studied separately (see later). Each of the various flaws listed above will be defined and discussed below, followed by an explanation of how these flaws will be quantified for each material.

In geological terminology a plane (joint plane) is defined as "a single fracture in a rock with or without a small amount (<1 cm) of either dilational or shear displacement" (Hoinkes *et al*. 2005: 390). In this study a plane refers to any uniform surface which separates a rock into two pieces. These can be curved as long as they are distinct and penetrate or compromise a part of a lithic. These include joint planes (Figure 4.10A), bedding planes (Fig. 4.10B), shatter cones (Fig. 4.10C) and quartz veins (Fig. 4.10D). Quartz veins are included in this category because in the knapping process they have a similar effect as planes do. However, this only pertains to veins that are no thicker than a few millimetres. Quartz veins observed in artefacts were on average no more than a millimetre in thickness, the largest being just under a centimetre (Figure 4.10 D).

Since shatter cones are conical surfaces of weakness (see geology section); rocks often break along these surfaces, and thus they act much like planes. The majority of rocks found in the study area do not exhibit shatter cones as the area is approximately 120km north of the Vredefort dome centre. Although some of the quartzite cobbles found in the Quaternary gravels do have small conical structures present, these normally are no larger than a few centimetres in diameter (Figure 4.11). These cobbles are most likely from the upstream geology (towards the Vredefort dome). Additionally, Figure 4.11 shows how these conical surfaces can compromise knapping. Notice how the top flake snapped when intersecting these flaws (Figure 4.11). This can also be seen in Figure 4.10C where a hammerstone was compromised by an inherent shatter cone, creating a snapped flake.

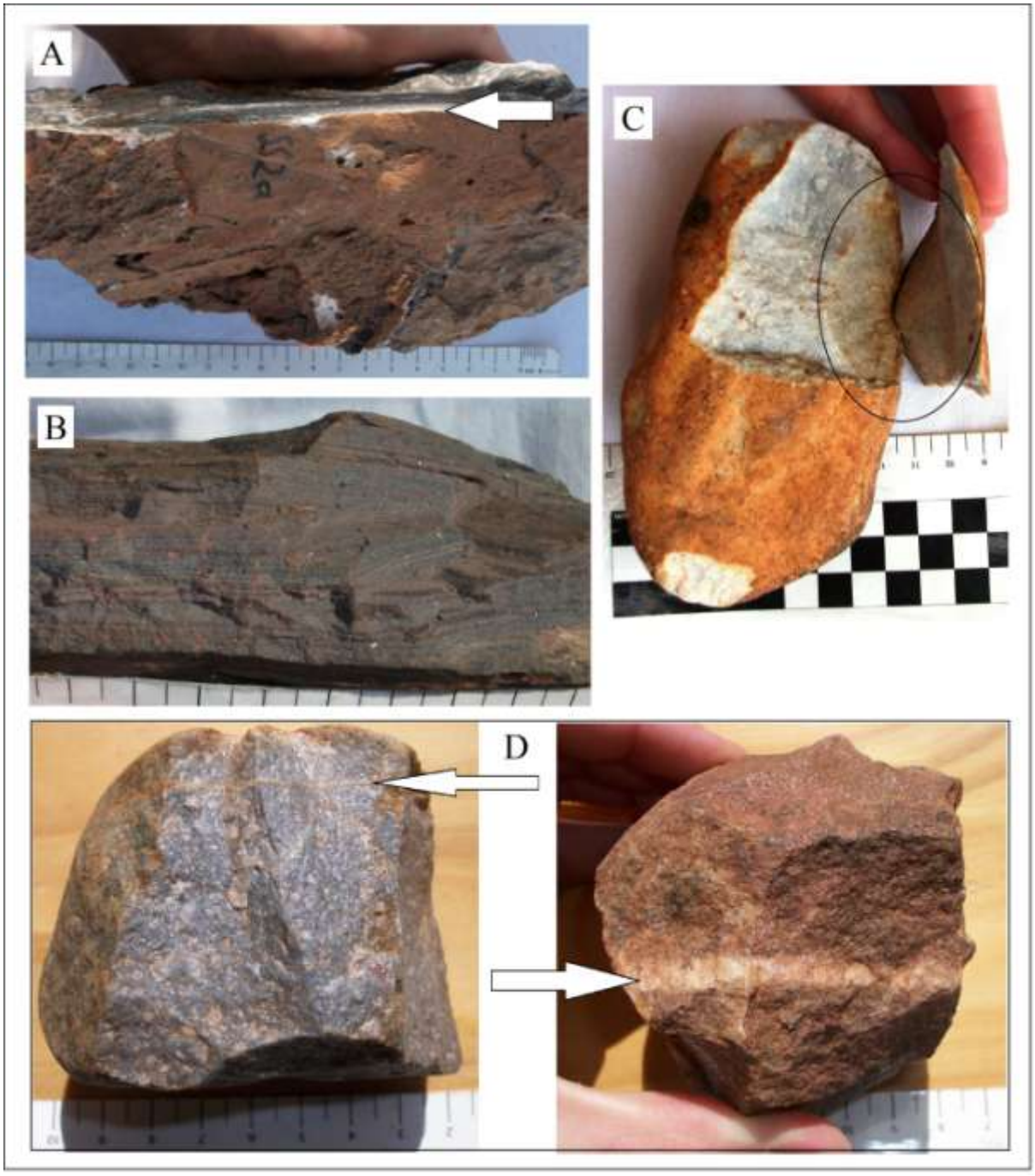

Fig. 4.10: Flaws analysed as planes. A: Joint plane; B: Bedding planes; C: Shatter cone and D: Quartz veins.

Identifying planes on artefacts is rather easy as they tend to be uniform and are often penetrated by fluids which stain the rock in these areas (Phillips 2009). This can be seen in Figure 4.12 where three joint planes intersect and are stained red by ferrous minerals. When seen in cross-section it is normally visible as a fairly uniform line or fracture, often with a colour difference to the rest of the rock due to staining.

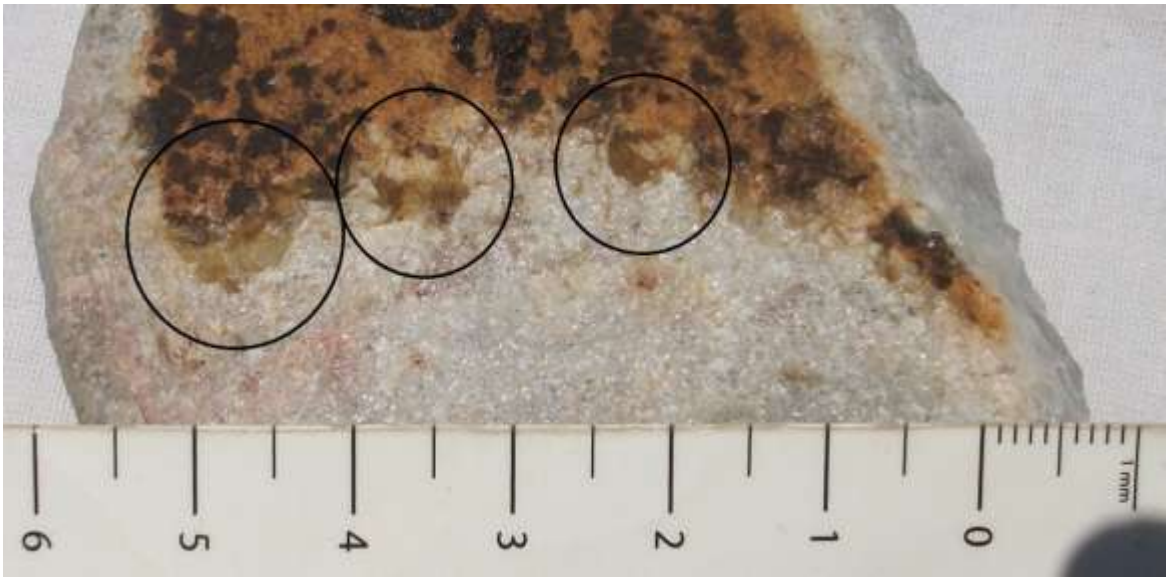

Fig. 4.11: Apices of shattercones in quartzite from the Quaternary gravels.

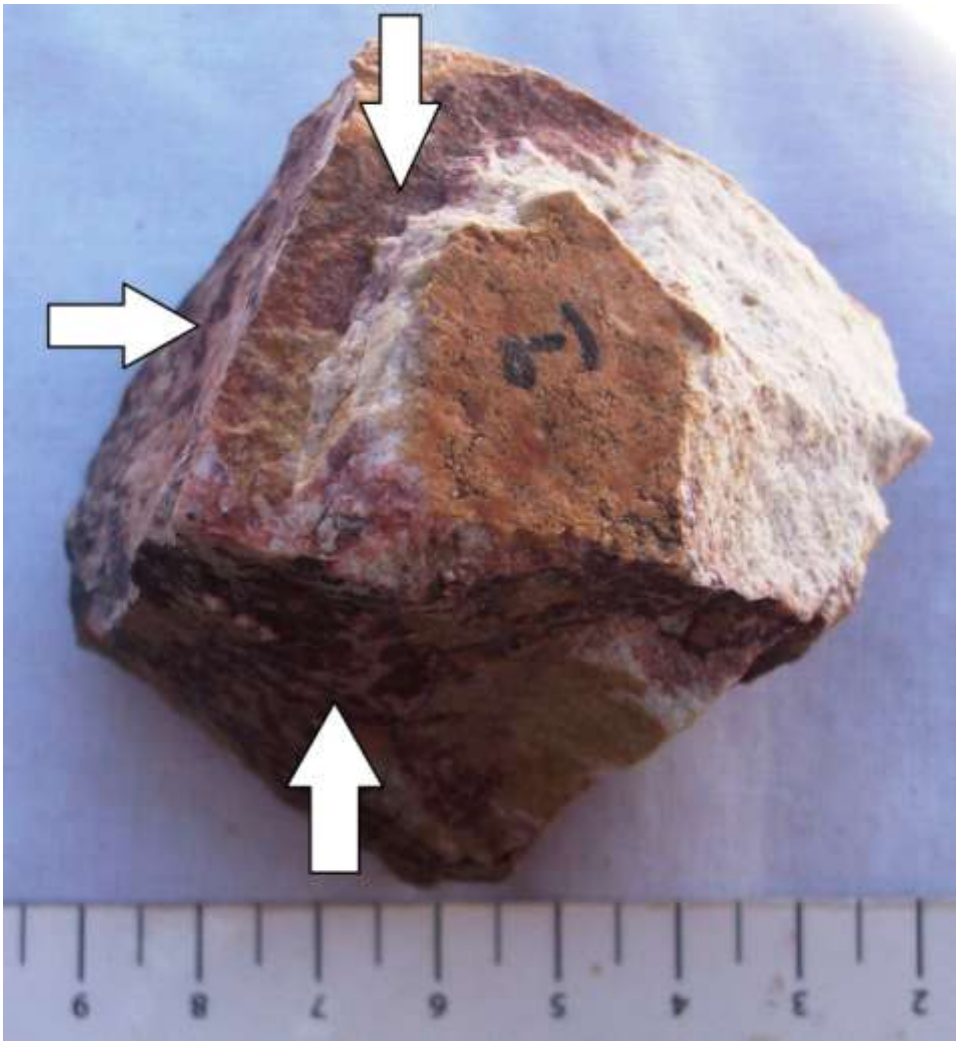

Fig. 4.12: Joint planes in quartzite showing ferrous staining.

Oolites are considered flawed, but only if the ooids actually compromise a lithic. For example, if a flake is incomplete and its broken edge is along ooids the ooids are seen to act as flaws. Of the three rock types only chert contains ooids. Oolites rarely exhibit flaking problems when they are fresh; however when the material is weathered the bonds between matrix and ooids are compromised resulting in irregular fracture (Figure 4.13). Therefore only flakes (and flake scars) that have been compromised by ooids, either because it snapped along an edge where ooids are first encountered or because the material is extensively weathered, will be counted as flawed.

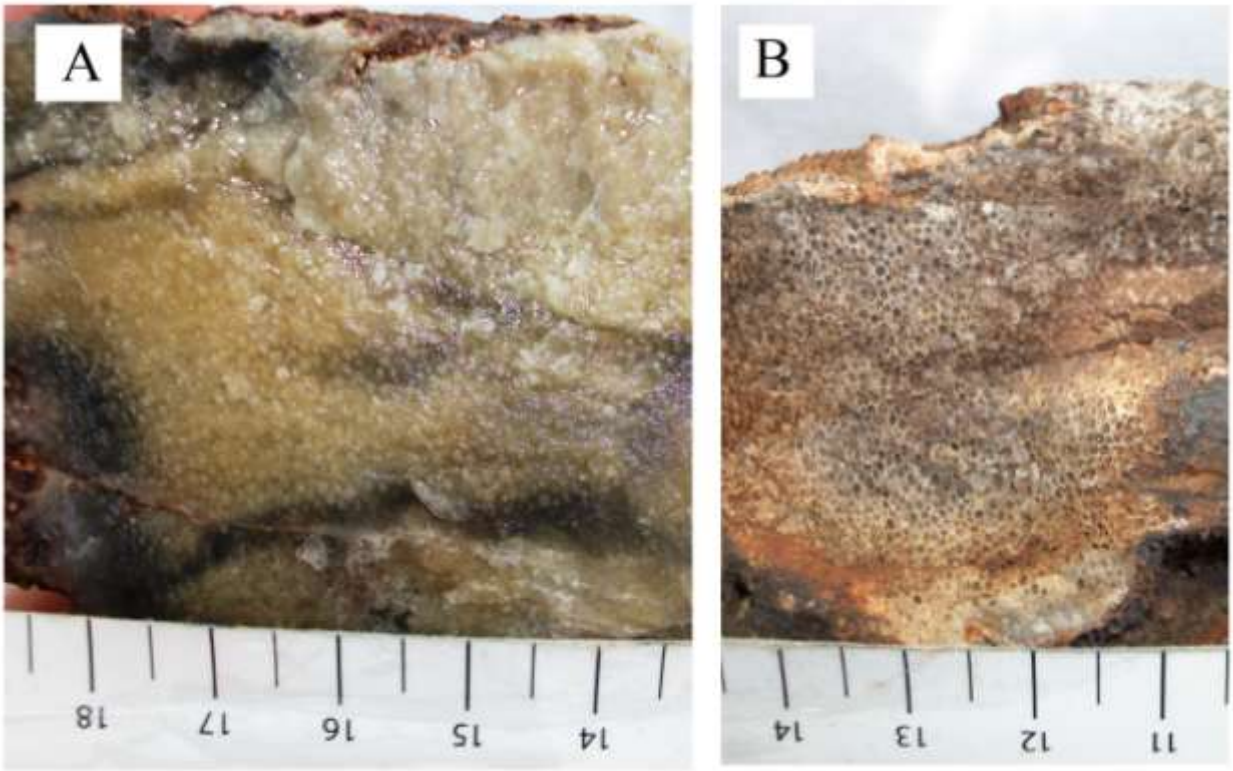

Fig. 4.13: Oolites exhibiting both fresh (A) and extensively weathered (B) surfaces.

In addition, cavities and crystal inclusions (Figure 4.14) are also considered flaws because forces run irregularly through these areas, and thus they often compromise the predictability of the knapping process.

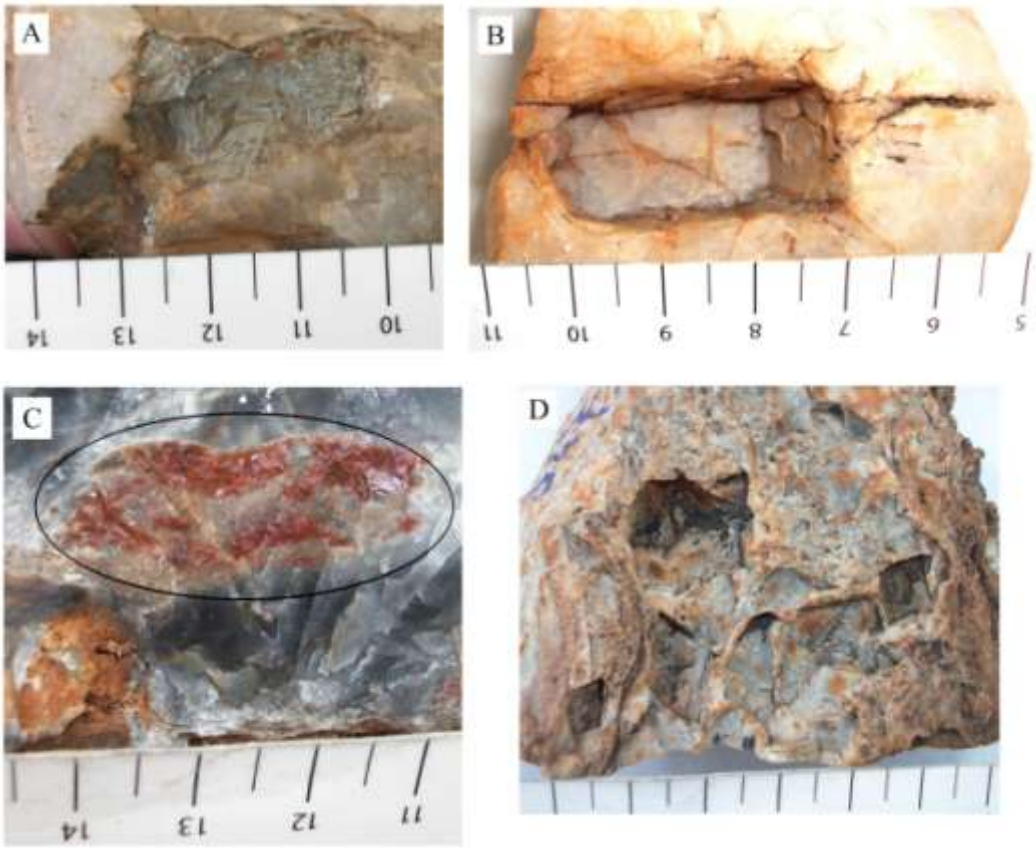

Fig. 4.14: Quartz and chert showing crystal inclusions (A, C) and cavities (B, D).

The method used by Brantingham *et al*. (2000) to quantify the frequency of impurities encountered during primary reduction of a lithic (see literature review), will be used to quantify the above mentioned flaws in our study. Brantingham *et al.* (2000) calculated this rate by dividing the number of flake scars encountered on an artefact that exhibited impurities (ISCAR) by the total number of flakes scars present (DSCAR) and multiplying this by 100 to give a percentage (formula below).

$$impurity\ encounter\ rate\ = \left(\frac{Scars\ with\ impurities}{Total\ no.of\ flake\ scars}\right) \times 100$$

Flake scars here refer to the negative and positive imprints on a lithic where a flake or chunk was removed via the knapping process. Thus, these are any surface on a lithic that has been exposed from the knapping of a rock. Figure 4.15 shows three examples of how the above formula is executed for each lithic. These however only show one side of each lithic as an example, but in the study all the flake scars for each dimension of an artefact are counted.

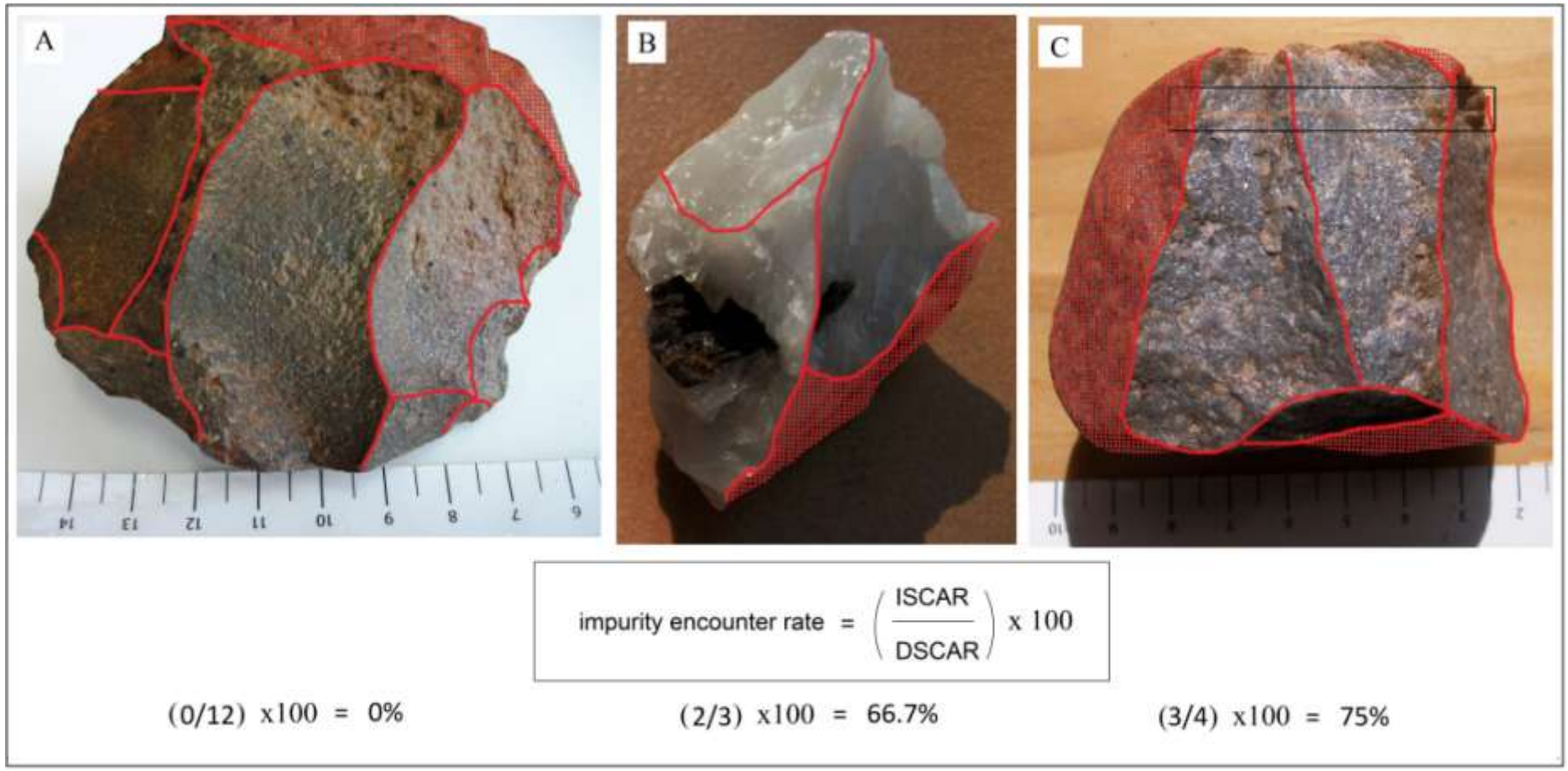

Fig. 4.15: Example of how the flaws were analysed for the various materials. Dots represent where the cortex is located. Formula used as per Brantingham *et al.* (2000). ISCAR: flake scars with an impurity/flaw, DSCAR: Total flake scars.

The lithic in Figure 4.15A has an impurity encounter rate of zero as none of the twelve flake scars exhibited any cavities, crystal inclusions, planes, ooids or veins (black spots are post depositional manganese stains). Figure 4.15B however shows a cavity present, which intersected with two of the three flake scars, thus resulting in an impurity encounter rate of 66.7%. Furthermore, planes often run through multiple flake scars as can be seen in Figure 4.15C, and thus all flake scars that a plane or a quartz vein intersects are counted. Moreover, the experimental knapping revealed that sometimes a plane is exposed through a removal as the forces are directed along the plane. Removals such as these are counted as flake scars and also counted as flawed. This however does present a problem, as the dimensions of an unknapped cobble are sometimes determined by planes as rocks tend to weather and break between these planes of weakness. Therefore, it was important to determine the freshness of such surfaces in order to determine whether they were exposed naturally or through the knapping process. This was easy to establish as flake scars were "fresher' in relation to the cortex, which included cortex formed on planar surfaces. In addition, planes normally exposed from knapping show some staining still present and often an area of damage from hammerstone impact.

4.5.2 Crystal structure / fractures

As mentioned earlier crystal structure and irregular fractures were quantified differently, because these structures were only present in chert (irregular fractures) and quartz (crystal faces and irregular fractures). For each individual artefact a more or less flat area was chosen on one of its faces. The area consisted of a length and a breadth and was chosen to represent what can be seen on all of the artefact's faces. Fractures were then counted in each of these areas, which were then used to determine how many fractures would be present per centimetre squared. This was multiplied by ten to represent the data more clearly and thus gives fractures per ten centimetres squared (formula below and Figures 4.16 and 4.17).

$$fractures\ per\ 10cm^2 = \left(\frac{no.of\ fractures}{(l \times b)}\right) \times 10$$

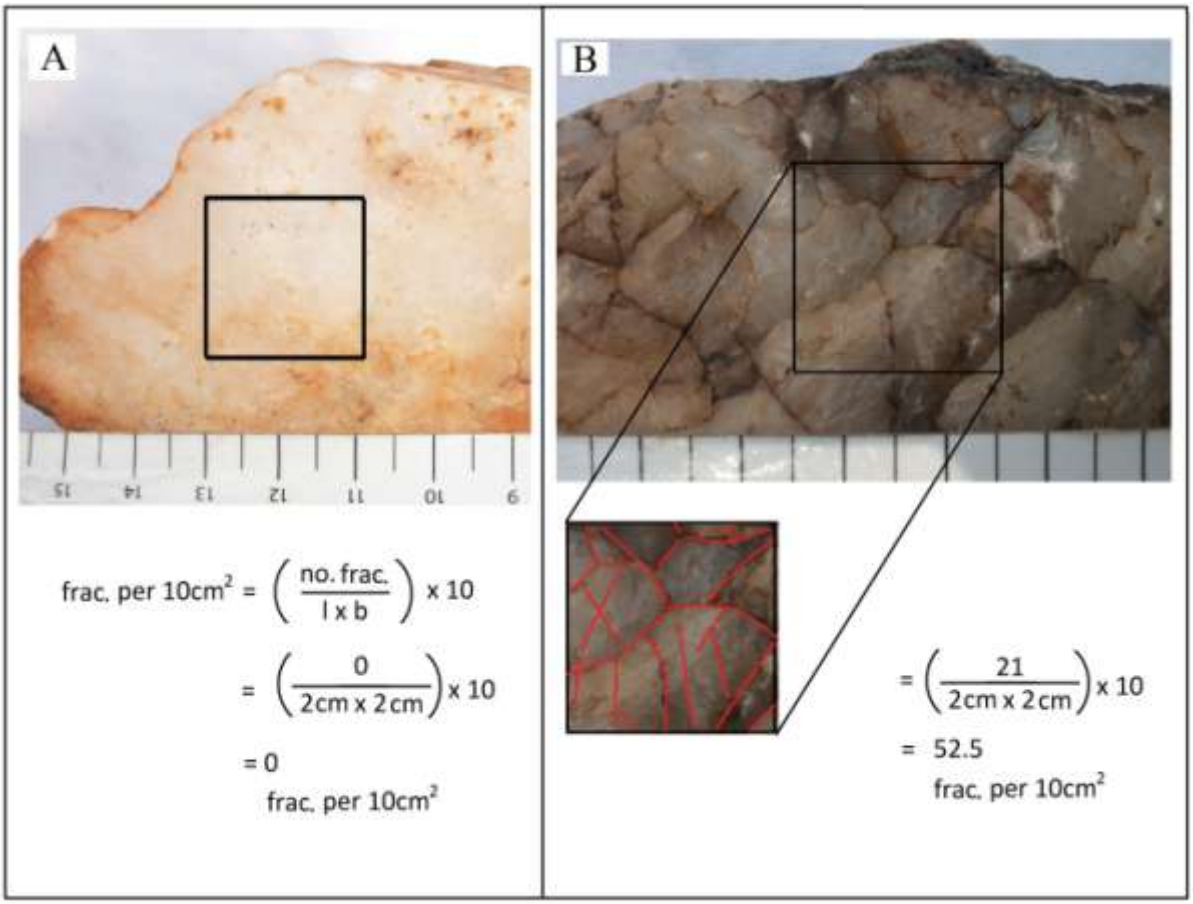

Fig. 4.16: Example of how the crystal structure and fractures for quartz were analysed.

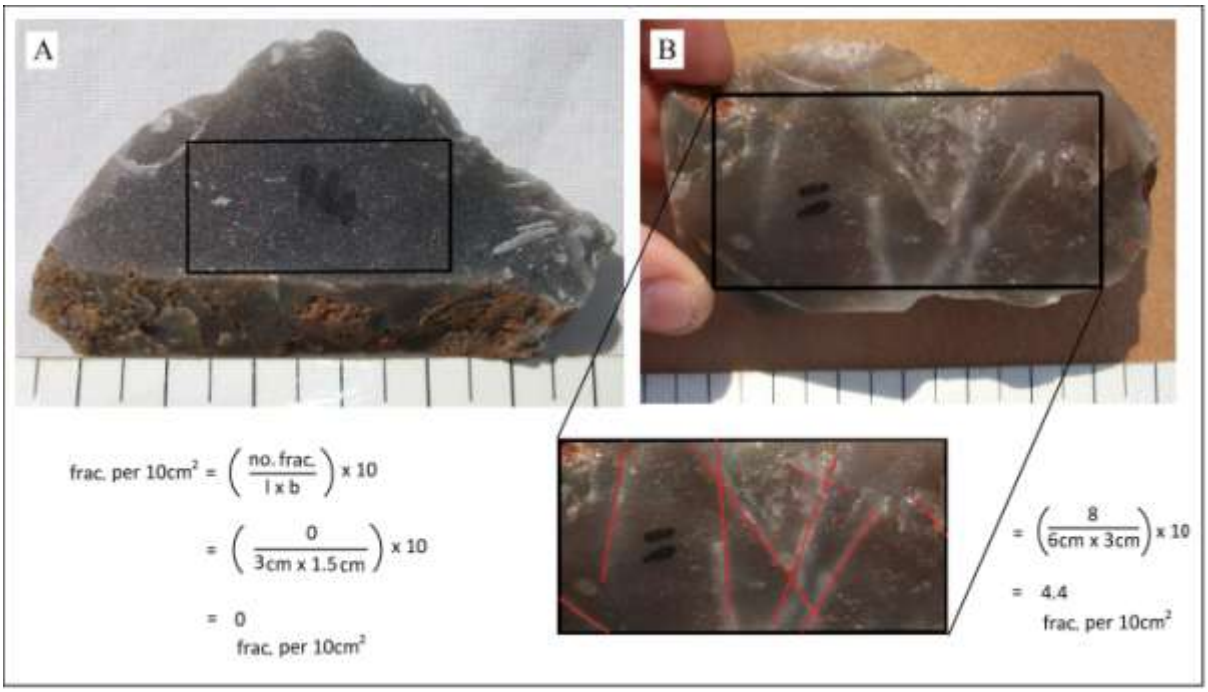

Fig. 4.17: Example of how the fractures in chert were analysed.

In some instances where fracture encounters were high, more than one area was analysed for an individual artefact and the average used. This is also because, for these artefacts, the area was decreased as it would take too long to count a substantial area on artefacts with numerous fractures.

4.5.3 Weathering

All three rock types are silica-based, which happen to be rather resistant to weathering, especially chemical weathering (Tricart 1972; Wray 1997; Sleep and Hessler 2006). However, silica is slightly soluble in water, with some varieties more so than others (Krauskopf 1956; Siever 1962; Wray 1997). Two main categories of silica are found in the three rock types used in this study: the crystalline type (pure quartz) and an amorphous type (silica cement between grains), with the latter being more soluble at lower temperatures than the former (Krauskopf 1956; Siever 1962). All of the three rock types have both crystalline and amorphous silica present, but they also have their own unique structural makeup which allows them to weather slightly differently. This will be discussed below for each rock type.

First, vein quartz is made up of many interlocking macro crystals. The faces between crystals act like planes of weakness (Tallavaara *et al*. 2010) into which water can penetrate and weaken bonds between them by dissolution as well as the precipitation of other minerals. This compromises the flaking predictability when intersecting crystal interfaces.

Secondly, quartzite is a metamorphic rock made up of quartz sand grains in which the sand grains "become cemented and 'welded' together by silica solution that forms during metamorphism" (Cairncross 2004:264). When this material weathers it does so between individual grains. This leads to hydration and solution of the amorphous silica cement between the grains, which eventually lead to the rock breaking down into its original components (Martini 1979; Wray 1997; Doerr 1999; Sleep and Hessler 2006). This happens because the amorphous silica cement holding grains together is more soluble at low temperatures than pure quartz and would therefore weather first (Krauskopf 1956; Siever 1962). The structure of a rock is also important for how dissolution takes place (Sleep and Hessler 2006), as solution in quartzites starts by fluids entering through joints and then proceeds along the boundaries of individual grains (Martini 1979; Wray 1997; Doerr 1999;

Sleep and Hessler 2006). Therefore, quartzites with multiple planes will hamper the flaking predictability of a rock much more, since these boundaries are first to be compromised.

Lastly, chert is made up of silica crystals that are microscopic (cryptocrystalline) (Sleep and Hessler 2006). However, unlike quartzite which is made up of pure quartz grains surrounded by amorphous silica cement, chert can consist of either the more soluble amorphous silica or less soluble microquartz (Siever 1962; Trewin and Fayers 2005). It is more likely that the rocks in our area are made up of the latter due to the recrystallization (Siever 1962; Trewin and Fayers 2005) of amorphous silica, especially since they are 2.5 billion years old (Eriksson *et al*. 2001). This would mean that chert consists of crystal quartz grains surrounded by amorphous silica cement and would thus weather similarly to quartzite, but probably much faster due to its smaller grain size. Weathering makes the material very brittle and eventually powdery. In addition, the weakening of bonds allows for small irregular fractures to occur in the materials which can cause flakes to snap and thus makes knapping less predictable.

Three categories were isolated for all three rock types: fresh, intermediate and complete. Visual representations of these various states are shown for each material in Figure 4.18. Degree of weathering for quartz was determined by the presence of stain marks intersecting flake scars, such as in Figure 4.18A, where a flake scar intersects many crystal interfaces exposing the staining. It was determined whether a piece was intermediately or completely weathered by the cohesion between crystal faces. Cohesion could be determined by how regular a flake scar was. In fresh pieces the forces travel more evenly through the crystal interfaces, whereas it does not in weathered material, thus creating more irregularly shaped flakes. The flake scar in Figure 4.18A exhibits staining and, as the arrow shows, there is a slight downward step where a stained crystal interface was encountered. Quartz that is completely weathered, such as in Figure 4.18B, displays more extensive staining and break between interfaces creating many snapped flakes and chunks. Weathering after discard did not seem to take away staining that was already present. Some pieces did have additional manganese staining between a few of the crystal interfaces, but fresh pieces had no additional yellowish brown staining, whereas pieces that already had weathering present when it was knapped exhibited the yellowish staining underneath the manganese stains.

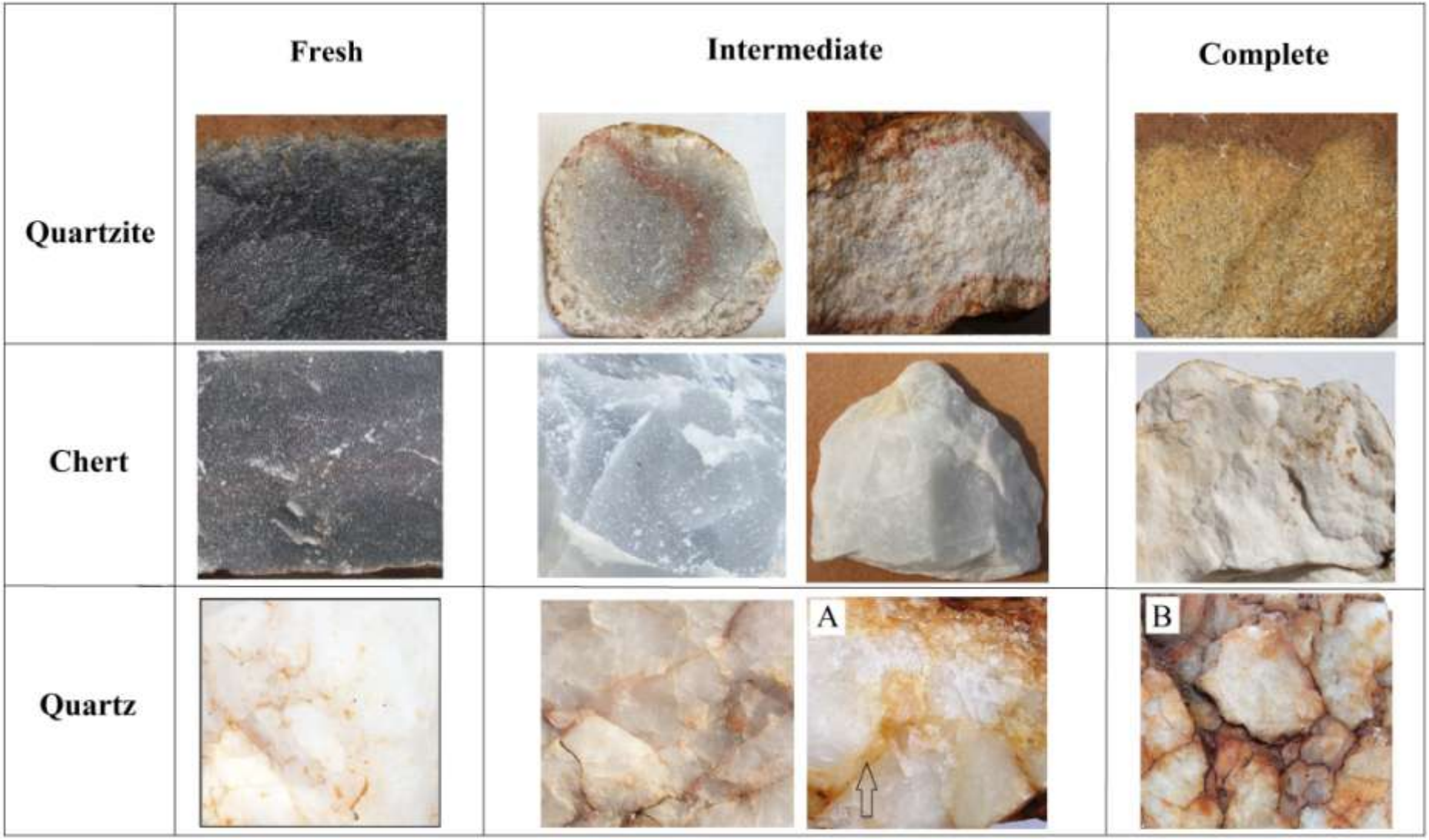

Fig. 4.18: Weathering of quartzite, chert and quartz.

4.5.4 Grain sizes

This variable was applied only to quartzite because it is the only one of the three materials that exhibited a range of grain sizes, whereas vein quartz consists of a solid mass of interlocked crystals varying in sizes, and chert is cryptocrystalline.

This variable is important to assess, because rocks fracture along individual grains; therefore smaller grained rocks will allow for forces to run more uniformly and efficiently. Figure 4.19 shows this more clearly as flake scar margins are more visible and uniform in Figure 4.19D and not very clear or uniform in Figure 4.19A. This is exaggerated when a material is weathered.

The average grain size of an individual artefact was categorised by the Wentworth scale (Wentworth 1922; Table 4.2). Average grain sizes were measured for each artefact by using a Macroscope M25 (Figure 4.20), which could easily measure up to the fine grained sand category in the Wentworth scale (Wentworth 1922).

Table 4.2: Wentworth scale (Wentworth 1922)

Diameter in millimetres	**Wentworth scale**	
256 - 2048mm	Boulders	
64 - 256mm	Cobbles	
4 - 64mm	Pebbles	
2 - 4 mm	Granules	
2 - 1mm 1 - 0.5mm 0.5 - 0.25mm 0.25 - 0.125mm 0.125 - 0.0625mm	Sand	Very coarse Coarse Medium Fine Very fine
0.0625 - 0.0039mm	Silt	
< 0.0039mm	Clay	

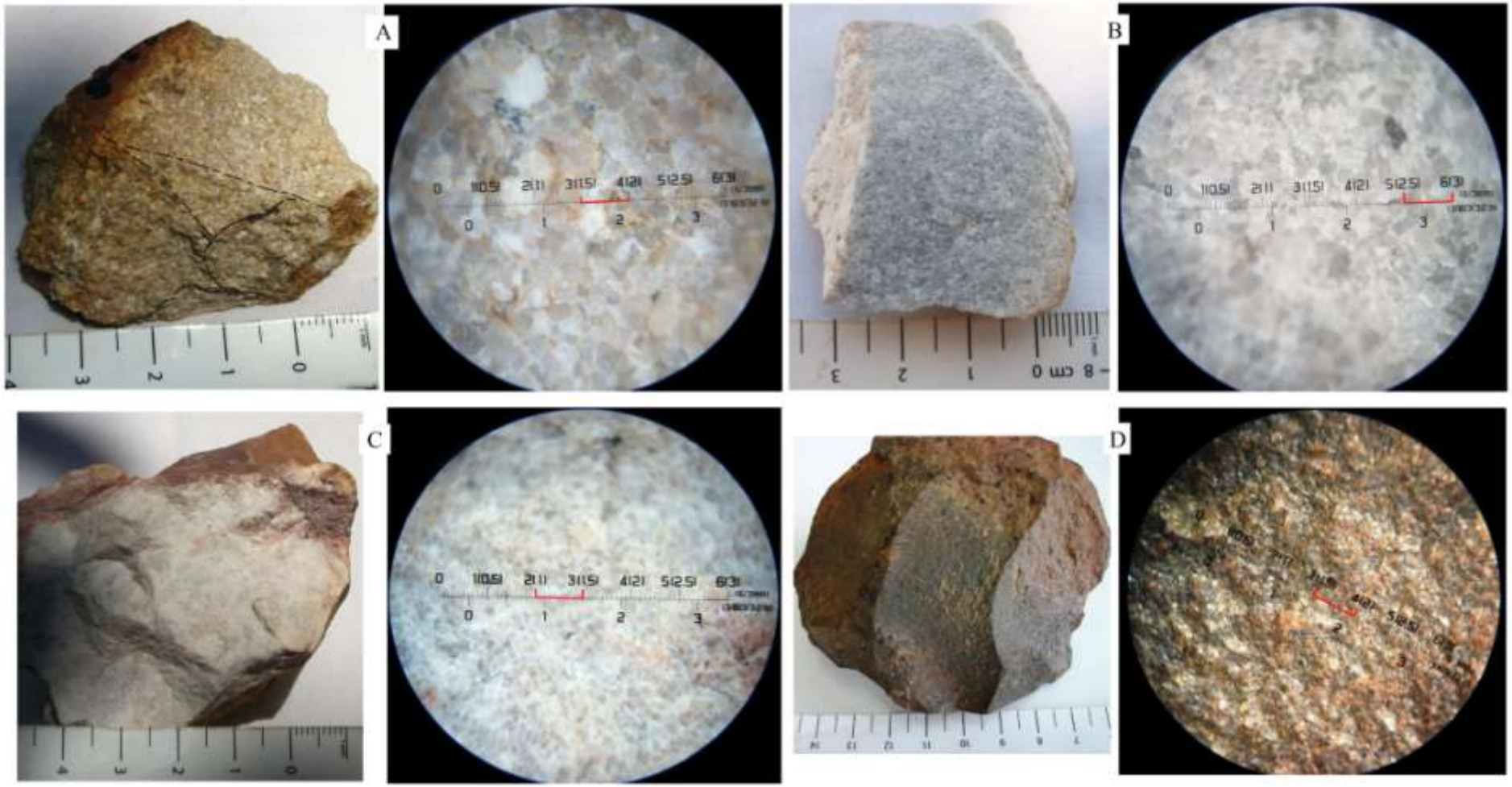

Fig. 4.19: Some quartzite grain sizes. A: Coarse grained, B: Medium grained, C: Fine grained and D: Very fine grained. Circles are the view observed with the Macroscope M25. The red line is included to show the dimension of a millimetre.



Fig. 4.20: Macroscope M25

4.5.5 Homogeneity

The quartzites from the study area were made from continental shelf sand, which tends to be rather well sorted; in other words, grains are roughly the same in size. However, it is possible that some parts of the quartzites are not as well sorted. Specimens such as these have been observed but are not the most frequent. Since quartzite fractures along individual grains, homogeneity is important for allowing forces to run uniformly, making knapping more predictable and thus controllable. Four categories were isolated and recorded for each artefact (Figure 4.21).

Even though banding was measured in the impurity encounter rate, it was also necessary to include it here as banding compromises homogeneity of the material. This is because individual bands / beddings often consist of different average grain sizes or have a slight upward or downward fining, which creates a plane of weakness at the contact between two bands.

The experimental knapping revealed that a rock exhibiting both inhomogeneity of grains as well as banding was the least predictable, followed by homogeneous grains with banding, then inhomogeneous grains with no banding and lastly homogeneous grains with no banding. This is because materials with banding tend to be more unpredictable than materials with no banding. Therefore, these four categories were isolated for analysis of homogeneity with the first category being the most flawed and the last the least flawed. Lithics that exhibit larger grains inside a finer grained matrix were considered homogeneous, but only if larger grains

are spread evenly throughout the material (Figure 4.21A). However, if they are not evenly spread, such as in Figure 4.21B, they were categorised as inhomogeneous.

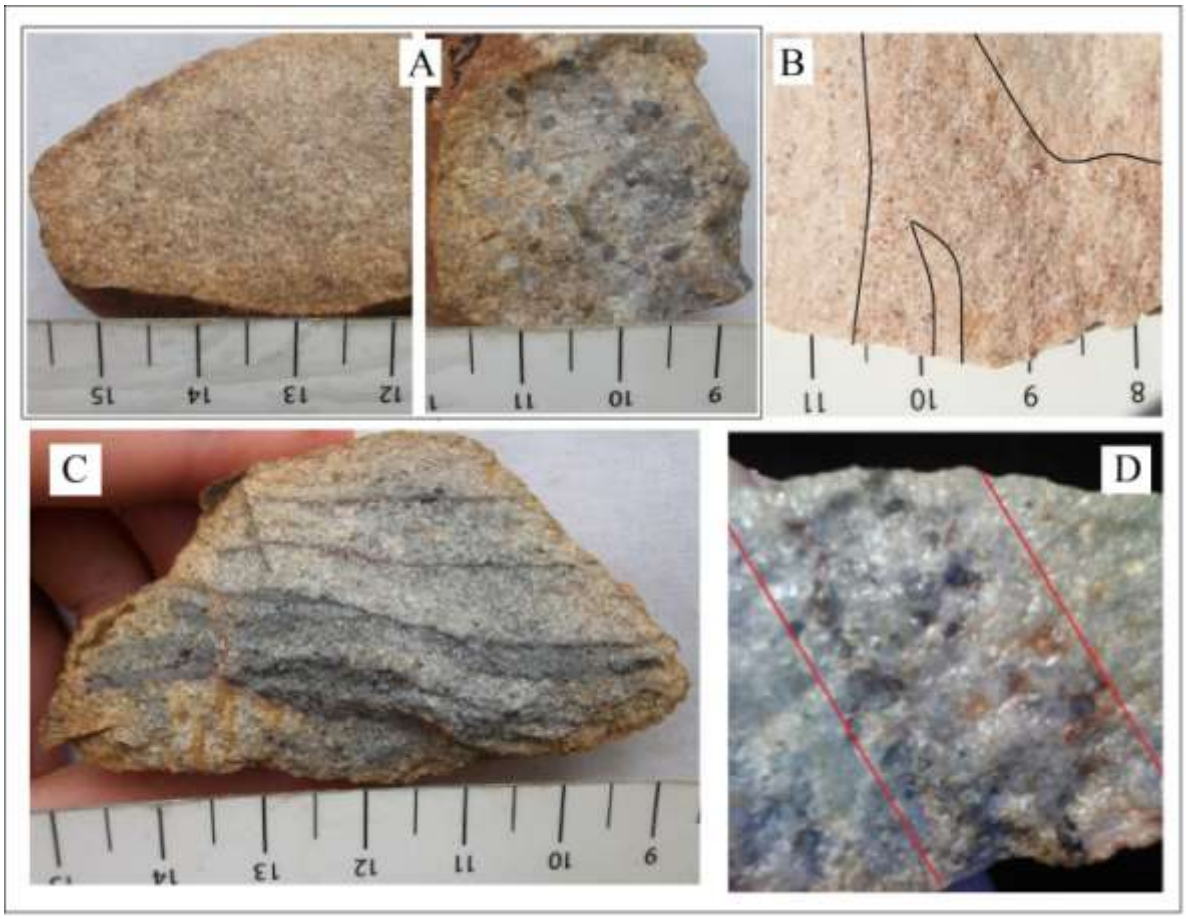

Fig. 4.21: Homogeneity of quartzite. A: grains homogeneous with no bands, B: Grains not homogeneous but no banding, C: Grains homogeneous with banding and D: grains not homogeneous and banding present.

4.6 Experimental assemblage

The experimental assemblage had to be constructed very carefully as it needed to represent all three techno-complexes and present all the different varieties of quality available in the study area. It was decided that creating an experimental assemblage that represented each rock type quality more or less equally would be best, because an exact predominance of each lithic raw material type and qualities thereof was not recorded in detail during fieldwork. Qualities might also vary between the techno-complexes as some of the gravels have undergone weathering during the last two million years; however materials do not seem to be

too compromised, as fresh pieces are available and range in sizes from boulders to fist size pieces. Additionally, the majority of rocks found on the landscape tended to be flawed. Therefore, to avoid having an experimental assemblage that represented mostly flawed material, it was better to represent all qualities equally. That way, if selectivity in artefact assemblages is shown, it would be certain.

Fifty five locales were sampled. However, the two sample locations taken from the modern Blaaubank River were excluded from the analyses as the rocks did not resemble the gravels that were preserved or that were identifiable from the artefact assemblages. Therefore, the experimental assemblage was constructed from 53 sample locations and 391 rocks. The locations within one kilometre of each of the three tool bearing sites were grouped together into one large sample for each of those regions (Figures 4.2, 4.3 and 4.22). These regions were Swartkrans hill (Figure 4.3 squares), Sterkfontein (triangles), and Kromdraai (open circles). Moreover, all sample locations from the preserved gravels (Figure 4.3 small closed circles) were also grouped together. The rest of the samples (large closed circles) were not grouped together as distances between them were too large and geology found on one end of the study area did not necessarily resemble that on the opposite end. For the Swartkrans region six sample locations were combined with 61 rocks in total. Nine sample locations were combined for Sterkfontein with a total of 50 rocks, and for Kromdraai, five sample locations were combined with a total of 45 rocks. The preserved gravels included the most sample locations (sixteen) with a total of 160 rocks, excluding those selected for hammerstones and anvils.

The rocks for each region were knapped and placed into individual bags, which were then subdivided according to rock types (quartz, quartzite, chert and other). These were then further subdivided into specific quality varieties of each rock type (Figure 4.22). For example, all chert rocks that were fresh and exhibited little or no flaws were grouped together. A flake, chunk, two cores (one representing the Oldowan and Acheulean and one representing the MSA), scraper, denticulate, other retouched piece, blade and a heavy duty tool were selected from each of the various quality sets (Figure 4.23). Two of each type were included from the quality sets for Swartkrans, Sterkfontein and the preserved gravel regions, as these samples were in the one kilometre radius and focus was directed towards resources closest to Swartkrans.

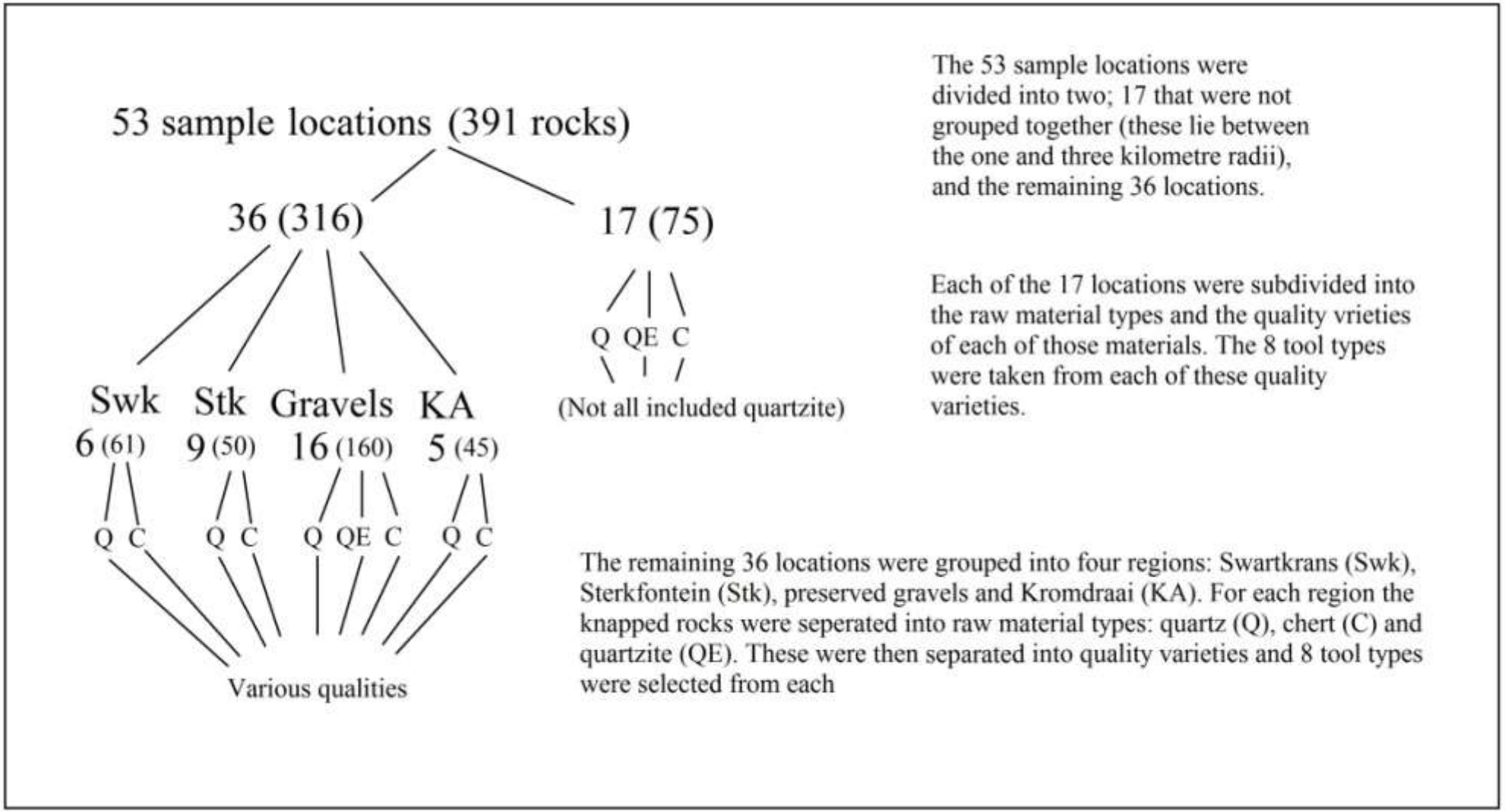

Fig. 4.22: Experimental assemblage construction.



Fig. 4.23: Example of tool types made in the same rock type with the same rock quality category. Shown is fresh quartzite with a joint plane which is present in each artefact.

It was not always possible to get all of the different tool types from a particular rock quality category, as highly flawed rocks did not always permit the creation of every artefact type. However it was possible to obtain at least a flake, a chunk and a retouched piece for each variety. The tool types selected had to be two centimetres or larger as smaller pieces do not always have enough surface area to get accurate data for the chosen variables. The same is true for the artefact assemblages from Swartkrans, in that only artefacts above two centimetres were analysed.

In addition, the tool types for each rock quality category were not selected randomly, because not all the individual pieces knapped from a specific rock represent the quality. For example, a cobble of quartzite might exhibit multiple planes, and when knapped, the majority of knapped pieces will exhibit at least one plane; however there are always one or two pieces that do not. Thus, a random selection was not made in case the one or two artefacts that do not exhibit the flaws were selected. These are normally the much smaller flakes, which is why anything below two centimetres were not studied. Instead all pieces were inspected and one for each tool type was selected that was representative of the majority. All the artefacts

for each rock quality category thus created one large experimental assemblage representing tool types from each techno-complex. All the experimental artefacts were then analysed according to the variables set out earlier.

4.7 Analyses

Data were collected for the variables listed earlier on both the experimental and archaeological assemblages. The experimental assemblage consisted of 1574 (417 quartzite, 289 quartz, 868 chert) pieces which were all analysed. A total of 1951 random pieces was then analysed from the archaeological assemblages. For the Oldowan a total of 614 pieces (41 quartzite, 321 quartz, 252 chert) was analysed, and for the Acheulean, a total of 112 (34 quartzite, 18 quartz, 60 chert), and for the MSA a total of 1225 (142 quartzite, 1023 quartz, 60 chert).

Tool types were classified according to how flake scars were organised on a piece to allow for proper comparison of variables. This is because the data differ by tool type because flaking patterns differ between them. For example, a tool with edge modification has many smaller flake scars along at least one edge, and these flake scars often encounter fewer flaws because they occupy less surface area. This results in tools with edge modification having lower flaw encounters on average than other tool types. For that reason, comparing whole assemblages would require one to construct an experimental assemblage with the exact ratio as the artefact assemblage. This could result in not all quality types being represented, which avoid requiring experimental assemblages to be enormous. In order to compare the experimental assemblage with the various archaeological assemblages, the tool types had to be compared to each other rather than the whole assemblages to each other.

Categories were: cores, flakes, chunks, large cutting tools, blades and pieces with edge modification. Large cutting tools only consisted of choppers as no handaxes or cleavers were present from the Swartkrans Acheulean assemblages. It should be noted that some choppers were classed as chopper cores and were thus analysed in both the core and large cutting tool categories. A piece was placed into the edge modification category when it exhibited at least three small flake scars next to one other along an edge or alternating between two faces but very close together, showing either deliberate modification of the edge or use wear. These pieces included denticulates, scrapers and other pieces exhibiting edge modification. Pieces

that had edge modification due to natural circumstances were not classed into this category. They could be identified by the edge modification scars being fresher than the other flake scars and by the fact that they were usually randomly placed. Blades were not placed into their own category because they only belong to the MSA and not all exhibited retouch.

CHAPTER 5 RESULTS

5.1 Lithic raw material types

Twelve different rock types were identified in the study area (Chapter 3). The most prevalent rock type was dolomite, followed by chert, quartzite and then quartz. If selectivity of certain rock types was not practiced by early hominids then the archaeological assemblages would reflect the same pattern of lithic raw material frequency. Figure 5.1 shows the different occupational time periods and the frequency of rock types in each of the archaeological assemblages. The lithic raw material frequency data for Members 2 and 3 were obtained from Field (1999), and for Members 1 and 4 the data were obtained from Sutton (2012). The data for Member 1 from Field (1999) were not included as these artefacts were not studied and the sample size from Sutton (2012) is much larger. From these data sets the following observations were deduced:

- Of the twelve rock types only four were actively selected for tool making during all three techno-complexes. Quartz was used most predominantly, and since quartz is the fourth most frequent rock exposed in the study area, it can be inferred that hominids did practice selection for rock types, with a preference towards quartz. In addition, dolomite (the most prevalent rock) does not feature in any of the assemblages, except for one piece in the Oldowan.
- Quartz pervasiveness during the Oldowan and Acheulean is more or less constant, but there is a substantial increase in selection for this material during the MSA.
- Chert is rather abundant during the Oldowan, but it decreases in frequency over time, most likely as other materials become more favoured.
- The frequency of quartzite pieces increases during the Acheulean, which makes sense as this techno-complex is known for heavy duty tool types and large flake blanks. Experimental knapping indicated that of the four rock varieties, quartzite was the best material for such tool types.
- There is also an increase in the use of igneous material over time, especially during the MSA. This igneous material (dolerite) is exceptionally durable and sharp but difficult to knap because of its hardness (Wadley & Kempson 2011), which could be why it was not as favoured during the ESA.

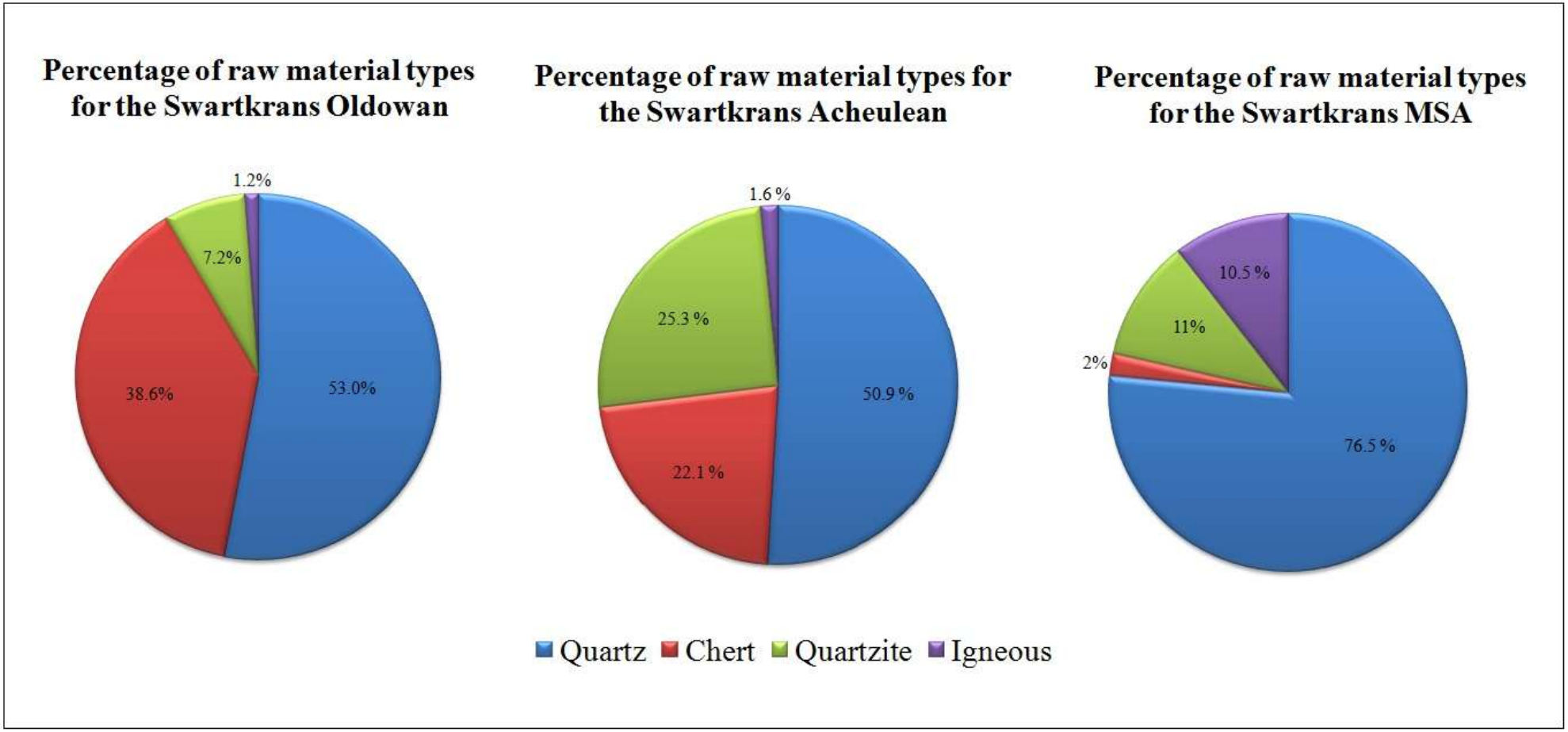

Fig. 5.1: Frequencies of rock types used at Swartkrans for the three techno-complexes. For the Acheulean, Members 2 and 3 were combined to give an overall view of lithic raw material frequencies for this archaeological techno-complex. Lithic raw material frequency data for Members 2 and 3 were obtained from Field (1999) and for the Oldowan and MSA from Sutton (2012). For the Oldowan and MSA only artefacts larger than 2cm are included, but because Members 2 and 3 have a much smaller sample size, pieces under 2cm are included.

5.2 The impurity encounter rate

Only quartz, chert and quartzite were analysed, because dolerite unfortunately weathers too rapidly, even *in situ*, and that makes proper analysis of this material nearly impossible. The impurity encounter rates (IER) for these materials were determined as discussed in Chapter 4 and were analysed for each tool type. This variable determines how flawed a material is by calculating how frequently an impurity is encountered during the knapping process. The higher the percentage, the higher the encounter rate, and thus the more flawed a material is.

5.2.1 Cores

Core samples from the archaeological assemblages were too small to compare each core type separately. Therefore, all core types were combined into a single category. This presented a slight problem for comparing the various assemblages with the experimental cores, since the MSA core types included prepared cores and blade cores along with the cores found in both the Oldowan and the Acheulean. Since the Oldowan and the Acheulean shared similar core types, comparison with the experimental cores was easy, but a separate comparison would have to be done for the MSA. This is because, when blade cores and prepared cores were included into the experimental cores, the average IER decreased slightly for quartz and chert (Table 5.1).

Table 5.1: Impurity encounter rate for cores. A higher percentage indicates more flaws.

	Impurity encounter rate (%) for Quartzite cores	**Impurity encounter rate (%) for Quartz cores**	**Impurity encounter rate (%) for Chert cores**
Experimental cores **excluding** MSA cores	39.6	56.7	60.2
Experimental cores **including** MSA cores.	39.6	54.4	60
Oldowan cores	31.6	33.6	46.7
Acheulean cores	19.4	36.6	50.5
MSA cores	15.3	22.6	12.7

The lower IER for experimental MSA cores is most likely due to the fact that blade and prepared cores are prepared for flaking and thus need better quality material to execute this effectively. Despite the lower IER for experimental cores, none of the average IERs for archaeological cores exceeds the experimental data (Table 5.1). Therefore, all core types were included in Figure 5.2 and 5.8 for representation of data, but MSA cores were excluded when statistical tests were conducted for the Oldowan and Acheulean.

All three techno-complexes have mean IERs below that of the experimental cores (Table 5.1 and Figure 5.2), indicating a strong possibility of quality selection in all three techno-complexes. One tailed Student's t-tests were selected to perform statistical tests between the experimental and archaeological assemblages, and these confirmed that quality selection was present as there was a significant difference at the 95% confidence interval for most of the material, and an 82% confidence interval for Acheulean chert and 87% for Oldowan quartzite pieces. However, the t-tests did not reveal any statistical significance between the Oldowan and the Acheulean, with the exception of chert between the Acheulean and MSA. This could be as a result of the nature of the data set, as sample sizes are sometimes too small. This could also be because artefact assemblages do not always follow a normal distribution (see section 5.8). Therefore, normality tests were performed on the data sets and indicated that the distributions of the data were normal enough to perform t-tests. Student t-tests did reveal that there are significant differences (well beyond the 95% confidence interval) between the three techno-complexes when all lithic raw material types were combined. However, this is mainly due to statistically significant differences between the various materials, which meant a different approach was needed. The Pearson's chi-square test was therefore also performed as an additional statistical test to compare the means directly. For comparing the Swartkrans assemblages with the experimental assemblage, the means for each rock type from the experimental cores were used as the expected values, and the means for the rock type for the artefact assemblages were included as the observed values. All three assemblages indicated a significant difference between the experimental assemblages (beyond the 95% level), further confirming that selection of quality was present in all techno-complexes. For comparing the Oldowan and the Acheulean, the former was used as the expected values, which indicated a significant difference between these two assemblages with a 93% certainty. However, the Acheulean quartz and chert cores exhibit a higher IER than that of the Oldowan as opposed to a lower IER. As a result, there is no support for improved selection from the Oldowan to the Acheulean. However, the chi-square also revealed a significant difference between the Acheulean and MSA (>95%).

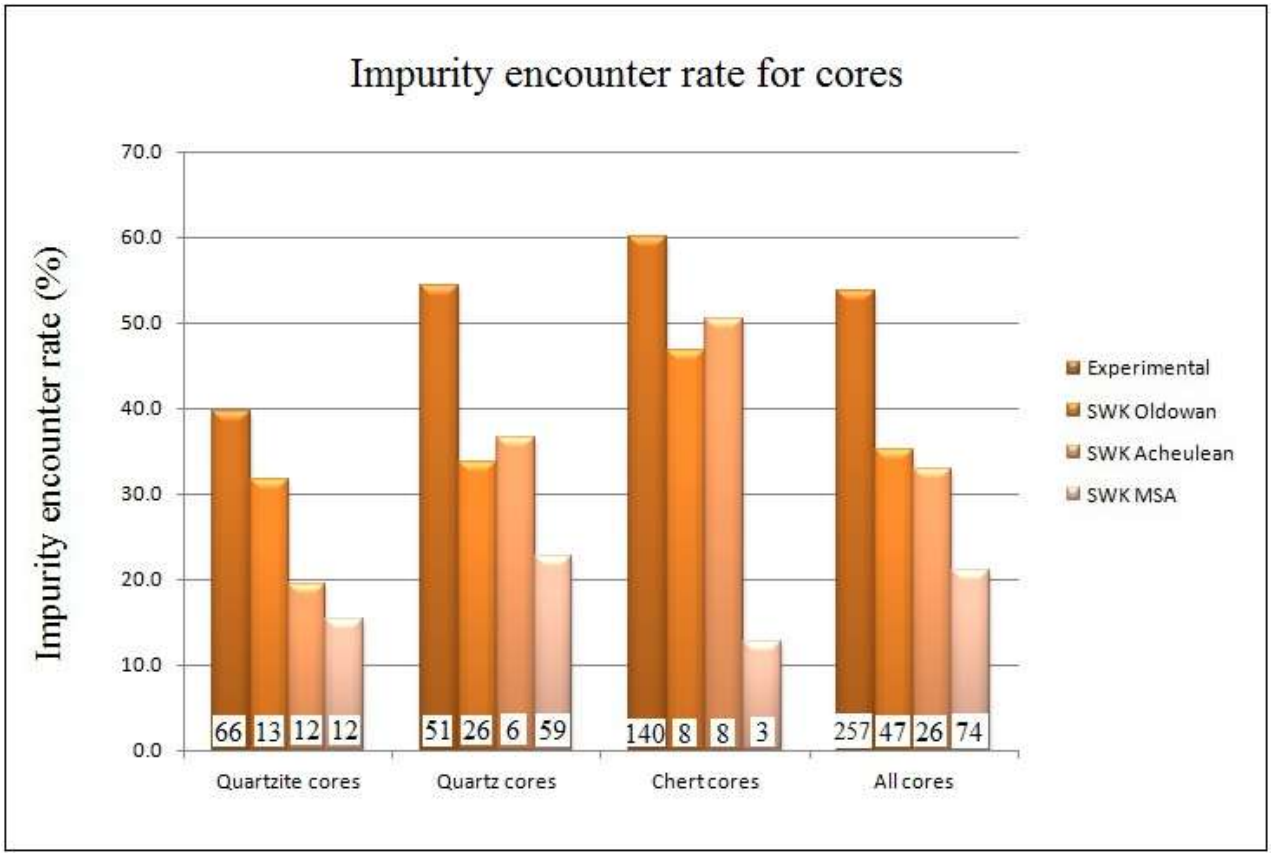

Fig. 5.2: Impurity encounter rate for cores. Blocks with numbers indicate number of pieces analysed for each assemblage.

From the IER data on cores it can only be deduced that there was definite improvement in quality selection in the MSA, but it is uncertain if there was an improvement from the Oldowan to the Acheulean. The fourth category in Figure 5.2 (All cores) was included for representation to show the overall IER for cores for each techno-complex. Even though Student t-tests cannot be performed on the data due to significant differences between lithic raw materials, this is important to present since selection of quality also involves the selection of certain rock types above others. It was apparent from Figure 5.1 that quartzite was more frequently selected during the Acheulean, which is reflected in the core sample, and since the quartzite cores exhibit a low IER, it drops the overall Acheulean IER below the Oldowan for all cores.

5.2.2 Flakes and chunks

Flakes and chunks were combined into a single category. This is due to the fact that the average number of flake scars was the same for both. Sample sizes were also too small to analyse separately. Lithics placed into this category included complete and incomplete flakes and chunks that exhibited no retouch. These artefact types could thus also be lumped together as they are often not the intended end products but are mostly discard from the knapping process.

No flakes or chunks are included in Figure 5.3 for quartzite and quartz from the Acheulean, as only three quartzite flakes were analysed and it exhibited an IER of zero, but these were included when all materials were combined. Figure 5.3 indicates that all IERs from the three t techno-complexes are below the experimental IERs. Chi-square tests indicate that there is a statistically significant difference between both the Oldowan and the experimental assemblage (>95%) and the MSA and the experimental assemblage (>95%). However the tests could not be performed between the Acheulean and the experimental assemblage because there was a zero value for both quartzite and quartz. It is also apparent that chert pieces from the Acheulean are more flawed on average than their Oldowan counterparts.

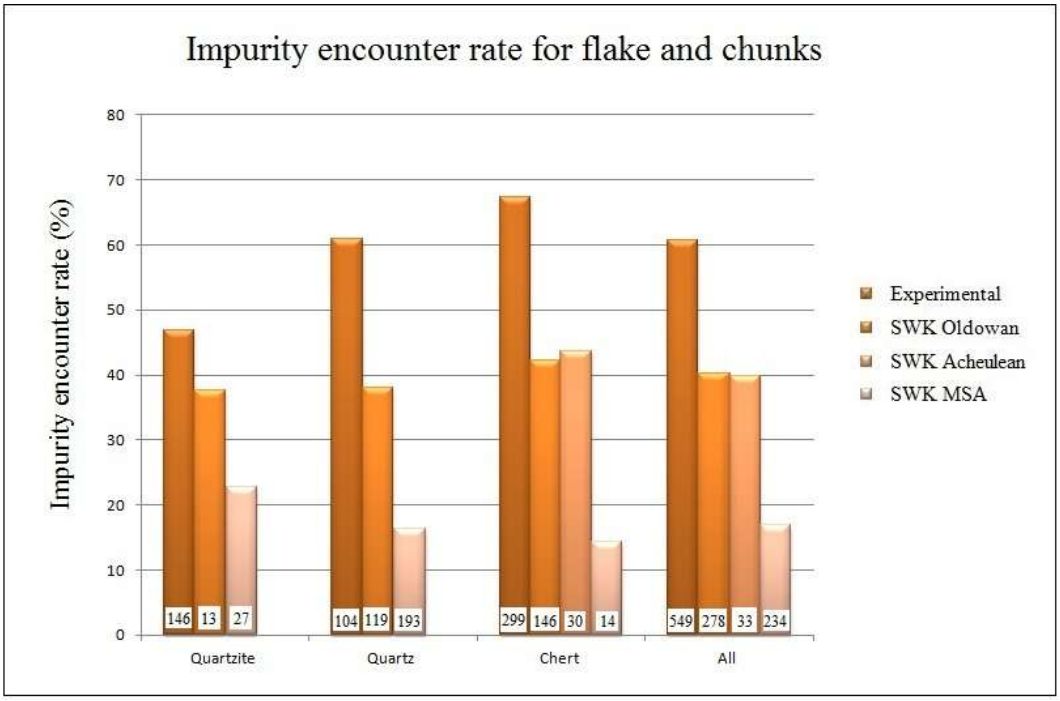

Fig. 5.3: Impurity encounter rate for flakes and chunks. Blocks with numbers indicate number of pieces analysed for each assemblage.

Therefore, as with cores, only meaningful statistical data can be obtained for differences between the Oldowan and the MSA. The chi-square test revealed a significant difference (>95% certainty) between the Oldowan and the MSA, signifying a definite improvement in quality selection in the MSA.

5.2.3 Choppers

Choppers are only present during the Oldowan and the Acheulean. Unfortunately only one chopper featured in the Oldowan assemblage, which does not provide a sufficient sample size for a proper comparison, and is therefore not included.

The Acheulean choppers are less flawed than the experimental choppers (Figure 5.4), indicating selection for quality in all three rock types. Despite the small sample sizes, the t-tests show significance between the experimental and Acheulean choppers for quartzite and chert above the 95% level, and for quartz at the 90% level of confidence.

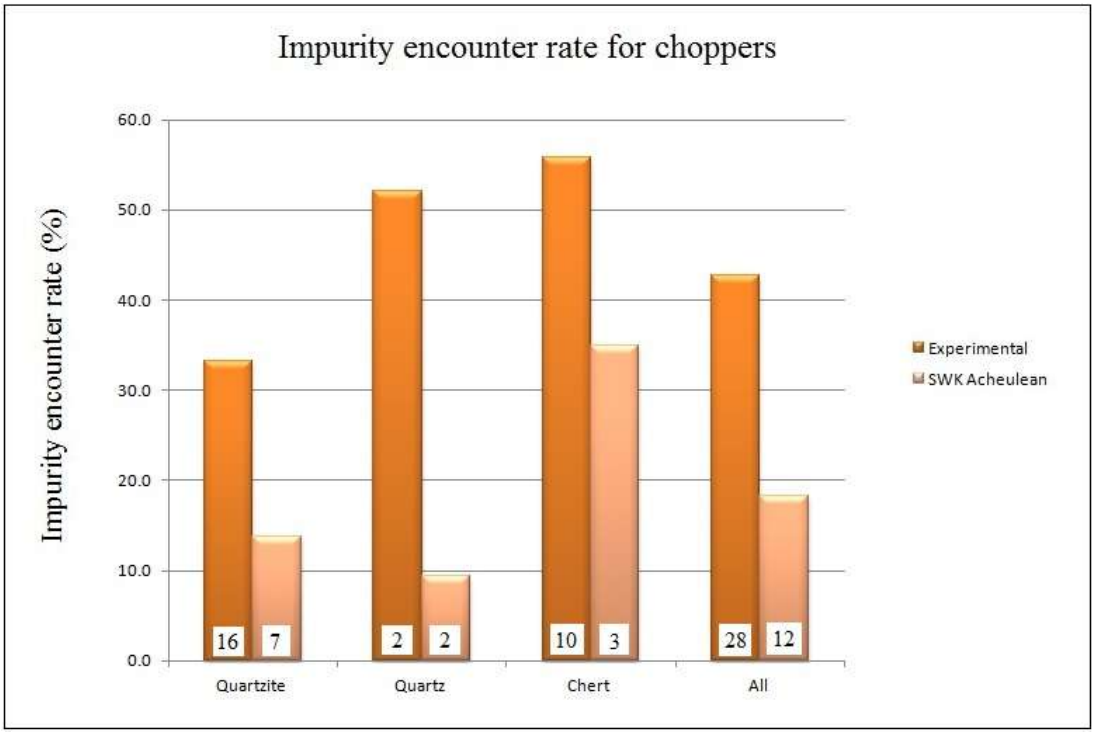

Fig. 5.4: Impurity encounter rate for choppers. Blocks with numbers indicate number of pieces analysed for each assemblage.

5.2.4 Blades

Blades only feature in the MSA most likely because, as experimental knapping revealed, the creation of a blade usually requires a fairly high quality material for the preparation of the core. The blades created by the MSA people indicate a high level of selection for quality material, as the IERs for all materials are below 10% (Figure 5.5), meaning that an impurity is only encountered for every ten or more removals. Student t-tests showed a difference between the experimental and the MSA chert blades beyond 95% certainty, and quartzite with 90% certainty. For quartz the difference between the experimental and archaeological means was too small to obtain significance, but it is apparent that the IER needs to be rather small to create quartz blades, which is only 7.7% on average for the experimental blades and 6.7% for MSA blades.

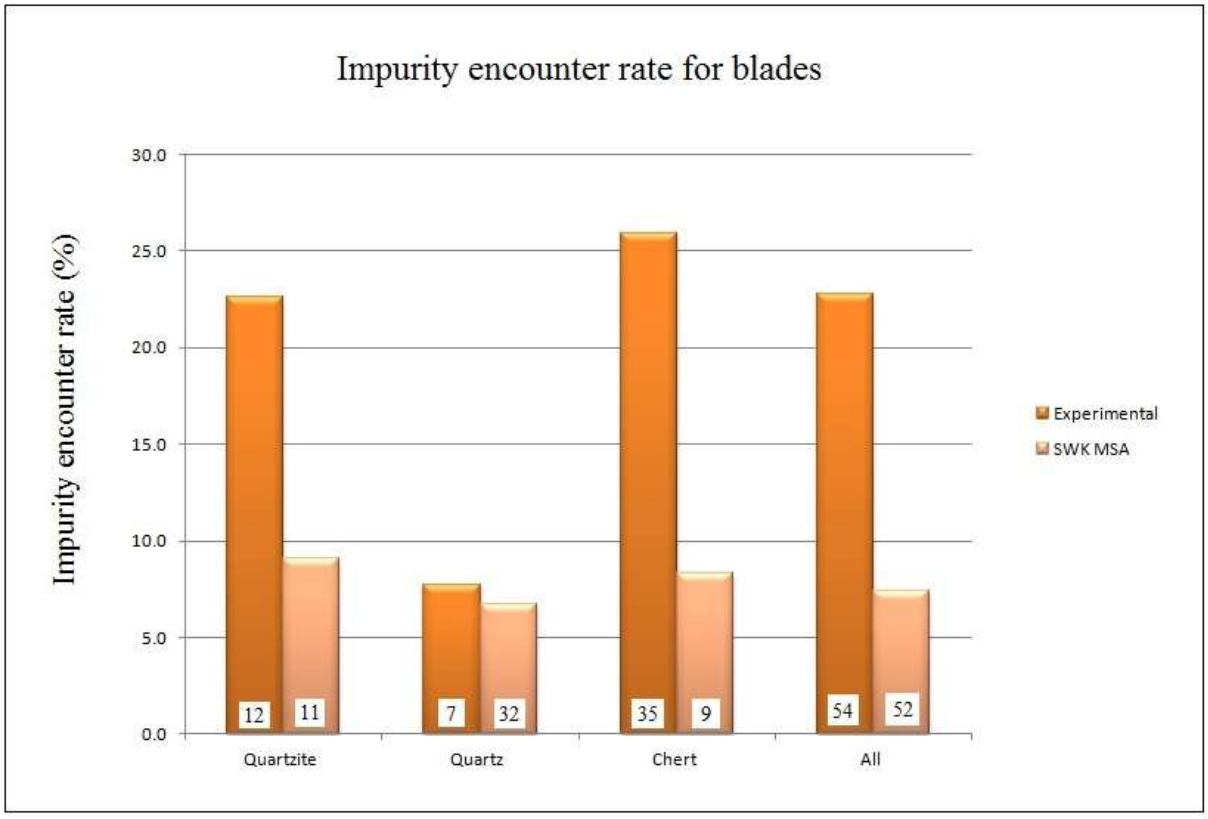

Fig. 5.5: Impurity encounter rate for blades. Blocks with numbers indicate number of pieces analysed for each assemblage.

5.2.5 Pieces with edge modification

Pieces that exhibit edge modification, as described in Chapter 4, were placed into this category, with the exception of blades, which were analysed separately because they feature only in the MSA. From Table 5.2 it is apparent that pieces with edge modification make up the bulk of each Swartkrans industry, and are therefore important for revealing patterns of selection with regards to quality, especially since they might have been the desired end products for use. It should be noted that these pieces might not have been deliberately retouched, and could reflect use wear instead. This is likely why there are so many of these pieces in the Oldowan. They were placed into this category to allow for proper comparison between tool types, since the arrangement of flake scars had an effect on the IER.

Table 5.2: Percentage of tool types analysed for each Swartkrans assemblage**.**

	Oldowan	**%**	**Acheulean**	**%**	**MSA**	**%**
Modified pieces	287	**46.7**	43	**38.4**	865	**70.6**
Cores	47	**7.7**	26	**23.2**	74	**6**
Flakes and chunks	278	**45.3**	33	**29.5**	234	**19.1**
Choppers	1	**0.2**	12	**10.7**	0	**0**
Blades	1	**0.2**	0	**0**	52	**4.2**
Total	614	**100**	112	**102.0***	1225	**100**

**Percentage higher than 100 because chopper cores were included as both cores and choppers.*

Figure 5.6 demonstrates that a distinct pattern emerges for all lithic raw material types. There seems to be a trend towards usage of better quality rock over the course of time, as the IER for each rock type drops for each ensuing techno-complex. Student t-tests confirm that some selection for quality is present in all three techno-complexes, because there is a difference between all archaeological and experimental assemblages well beyond a 95% level of confidence. However, the t-tests only reveal a significant difference between the Oldowan and Acheulean chert pieces (95% certainty). When all the lithic raw material means were compared in the chi-square test there was a difference between the Oldowan and the Acheulean, with 82% certainty, and a difference between the Acheulean and MSA means, but only with 70% certainty.

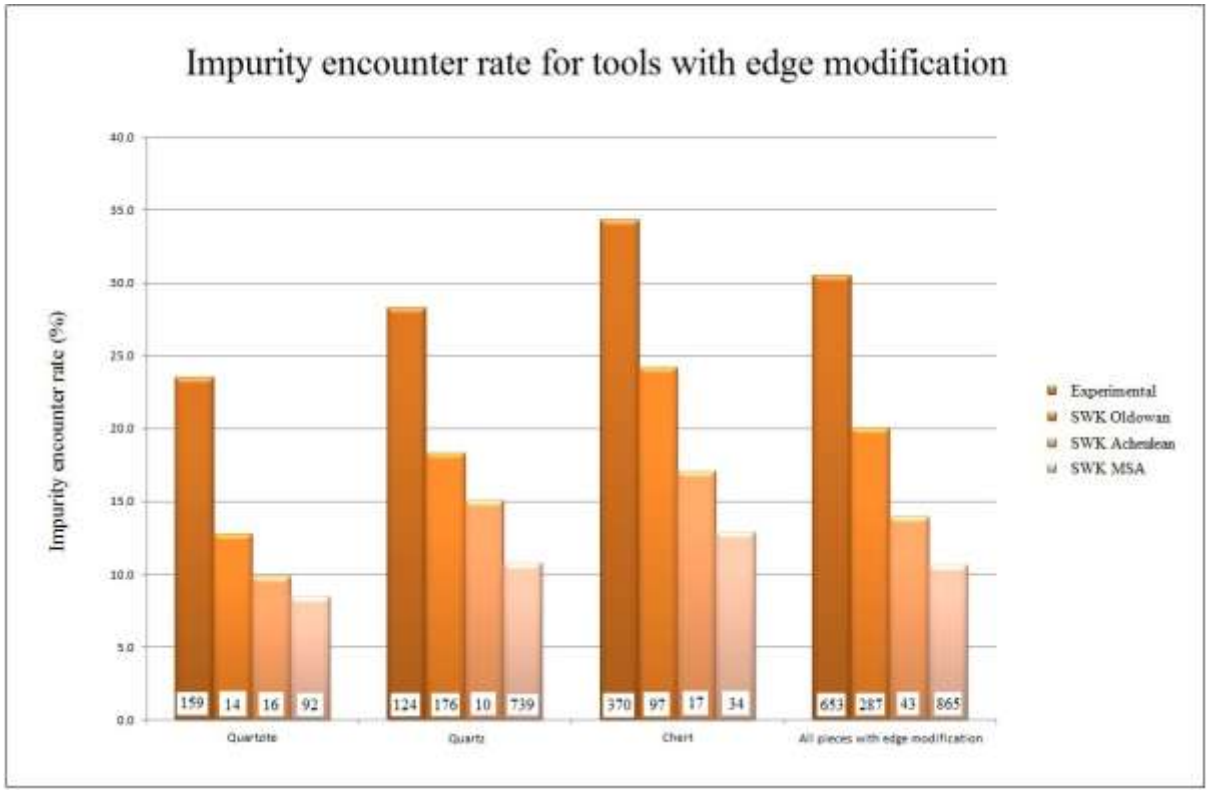

Fig. 5.6: Impurity encounter rate for tools with edge modification. Blocks with numbers indicate number of pieces analysed for each assemblage.

This is somewhat problematic as statistical comparisons between techno-complexes reveal low significance, even though a distinct pattern appears across rock types for the bulk of each assemblage. The overall IERs for lithic raw materials for each assemblage are thus shown in Figure 5.7. It is clear that there is some improvement of selection from the Oldowan to the Acheulean when comparing quartzite and quartz. However, the IER for chert is exactly the same for the Oldowan and the Acheulean. Student's t-tests could not be performed between the assemblages because there was statistical significance between rock types, and since the assemblages all have different frequencies of the various rock types, any significant difference could simply mean that assemblages differ significantly with lithic raw material types. The same is true for tool types. Therefore, chi-square tests were done between the IER means of lithic raw material types for each techno-complex. This indicated a significant difference between the Oldowan and the Acheulean as well as between the Acheulean and the MSA, all beyond the 95% level of confidence.

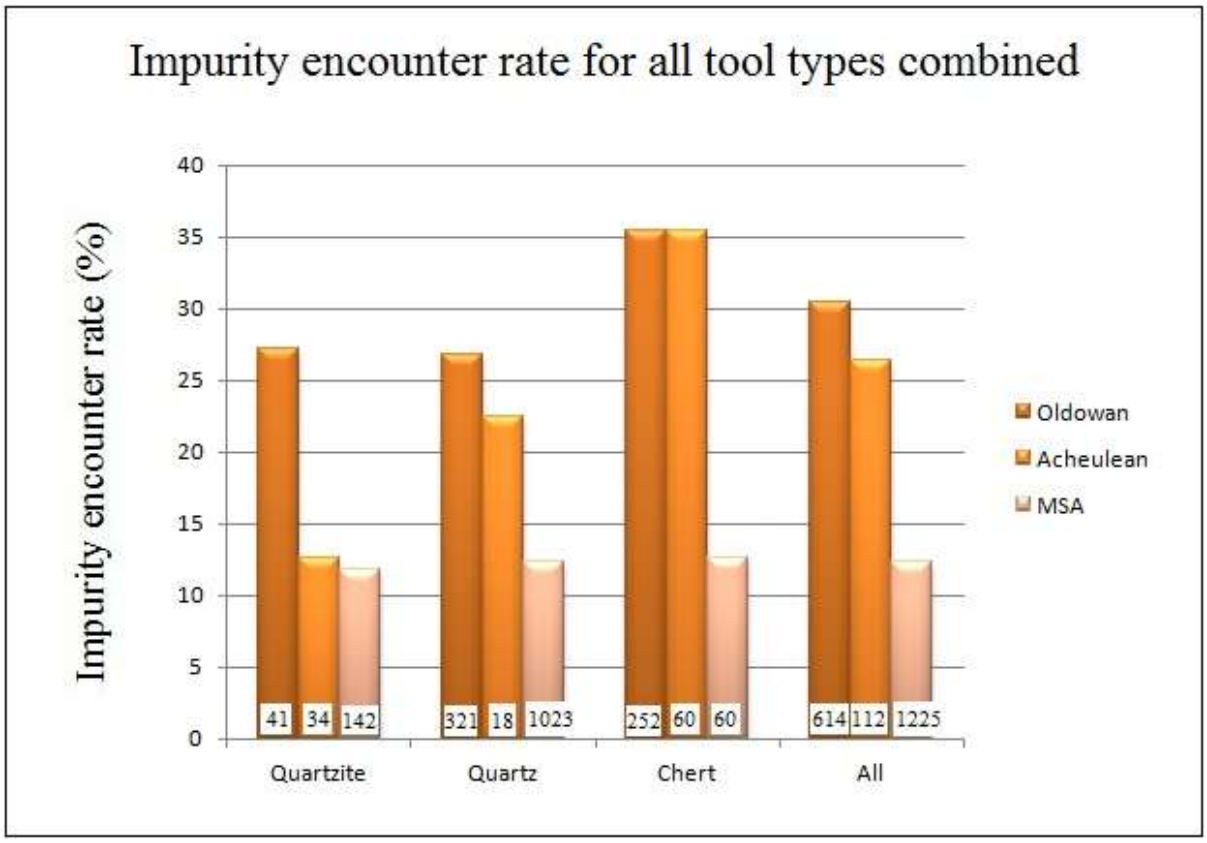

Fig. 5.7: Impurity encounter rate for all tool types combined. Blocks with numbers indicate number of pieces analysed for each assemblage.

Since the significance between the Oldowan and the Acheulean is due to lower mean IER values (except for chert which was the same), it signifies that selection for quality material became a little more frequent during the Acheulean. It should also be noted though that not all pieces from each assemblage were analysed, thus resulting in an over-representation of chert in the Acheulean as opposed to quartz, which was less flawed and more frequently used in this techno-complex (Figure 5.1). This suggests that selection for quality during the Acheulean might have been more intensely practiced than what we can see from the data. Furthermore, all the MSA IER averages are lower than the Acheulean, thus confirming that MSA people were selective towards high quality lithic raw materials.

The increase in selection for rock is clearly seen when we rank the IER data for each techno-complex (Table 5.3). From Table 5.3 it is apparent that 21.7% of the Oldowan artefacts that were analysed had no flaws present. This percentage was slightly higher for the Acheulean (27.7%), and remarkably high for the MSA (52.7%).

The cumulative percentages indicate a similar pattern, signifying that there is relatively more quality material present in the Acheulean than in the Oldowan and that there is a substantial amount of quality material present in the MSA.

Table 5.3: IER data for Swartkrans assemblages ranked according to class, showing the accumulative percentage of data that fall in each category for each techno-complex.

	Oldowan	Acheulean	MSA
IER 0%	21.7%	27.7%	52.7%
IER 0 - 9.9%	28.0%	34.8%	60.6%
IER 0 - 19.9%	42.2%	53.6%	72.1%
IER 0 - 29.9%	60.6%	65.2%	83.8%
IER 0 - 39.9%	69.4%	74.1%	91.0%
IER 0 - 49.9%	74.8%	83.0%	94.9%
IER 0 - 59.9%	84.4%	86.6%	98.0%
IER 0 - 69.9%	89.6%	89.3%	99.1%
IER 0 - 79.9%	91.2%	91.1%	99.3%
IER 0 - 89.9%	92.2%	92.9%	99.6%
IER 0 - 99.9%	92.2%	92.9%	99.6%
IER 0 - 100%	100.0%	100.0%	100.0%
Pieces analysed	614	112	1225
Mean IER	30.4	26.4	12.3

Cumulative percentage of assemblage falling into the various IER categories

5.3 Fracture encounter rate

In addition to the IER, the fracture encounter rate (FER) was also determined for the same lithic pieces analysed above. However, this was only obtained for chert and quartz, as quartzite rarely exhibits small-fractures and crystal interfaces, but instead contains joints, which were also present in quartz and chert but were included in the IER.

5.3.1 Cores

Figure 5.8 demonstrates the FERs for cores and suggests that there was selection for material that exhibited fewer fractures and crystal interfaces than the majority of rocks available in the study area. Student's t-tests between the assemblages and the experimental cores indicate that this is accurate well beyond 95% confidence interval. Unfortunately, as with the IER, t-tests did not show significant differences between the archaeological assemblages. The chi-square test revealed that there was a significant difference between the Oldowan and the Acheulean (95% certainty), but not the Acheulean and the MSA.

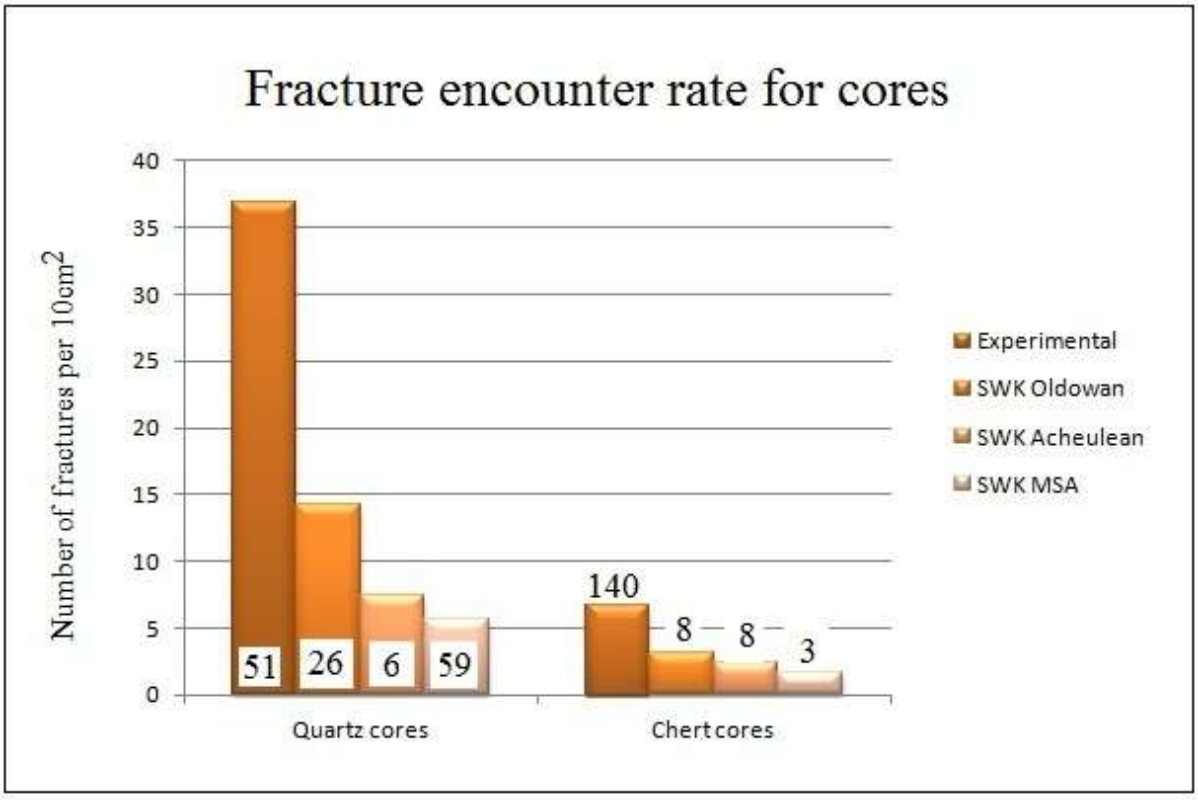

Fig. 5.8: Fracture encounter rate for cores. Blocks with numbers indicate number of pieces analysed for each assemblage.

5.3.2 Flakes and chunks

The Acheulean was only represented by chert pieces as no flakes or chunks were analysed for quartz. This was due to the random selection of the pieces for analyses. It is apparent from Figure 5.9 that these chert pieces exhibited a very high FER, and as a result the Acheulean

FER was not significantly different from that of the experimental tools. Flakes and chunks from the Oldowan and the MSA on the other and were significantly different from the experimental tools (>95% certainty for both the chi-square and t-test). Consequently, we can therefore only really evaluate differences between the Oldowan and MSA, which were significantly different at the 95% confidence interval (chi-square and t-test) for both rock types, confirming that MSA people selected material with fewer fractures than hominids from the Earlier Stone Age.

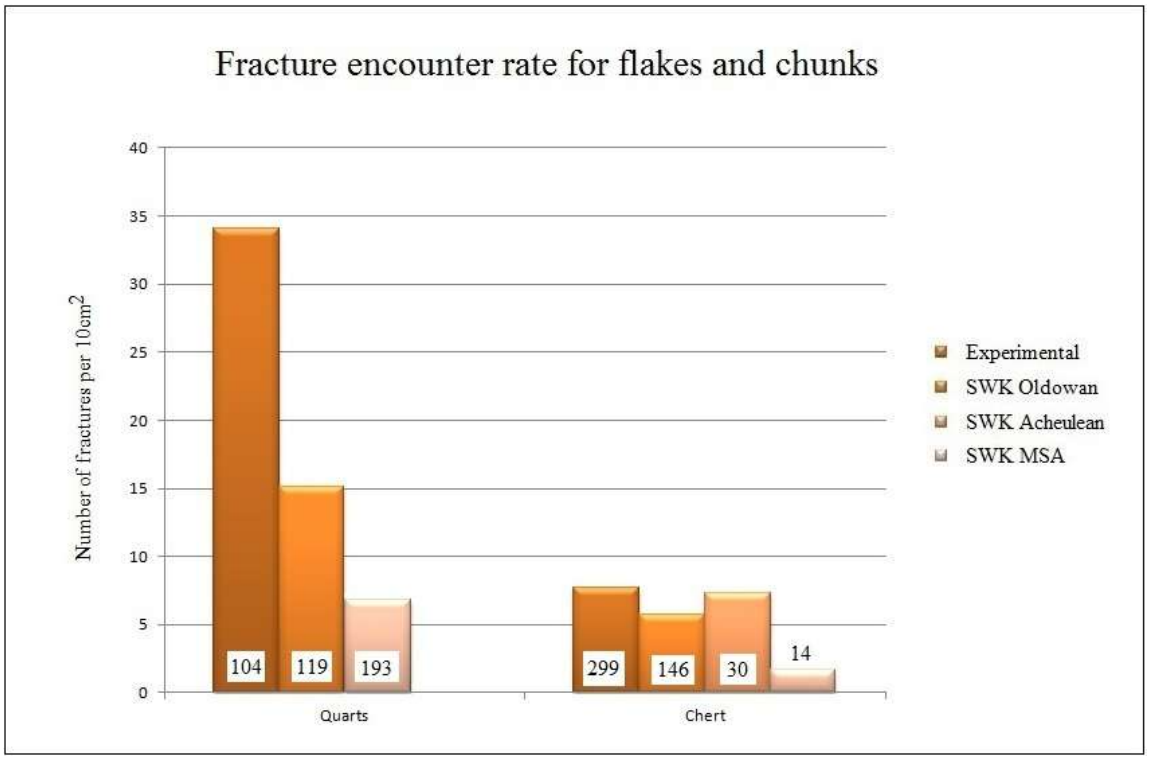

Fig. 5.9: Fracture encounter rate for flakes and chunks. Blocks with numbers indicate number of pieces analysed for each assemblage.

5.3.3 Choppers

There were too few samples to determine any statistically significant differences for this tool type with regards to the FER. However, the means for both materials were below that of the experimental tools (Table 5.4). However, the experimental quartz sample unfortunately also included an outlier which resulted in a drastically high FER.

Table 5.4: FERs for choppers

	Experimental	SWK Acheulean
Quartz	174.5	8.5
No. samples	2	2
Chert	6.1	1.9
No. samples	10	3

5.3.4 Blades

The FERs for MSA blades were on average lower than values for the experimental blades (Figure 5.10). Student's t-tests indicate that the difference for quartz is significant with 80% certainty and for chert more that 95% certain.

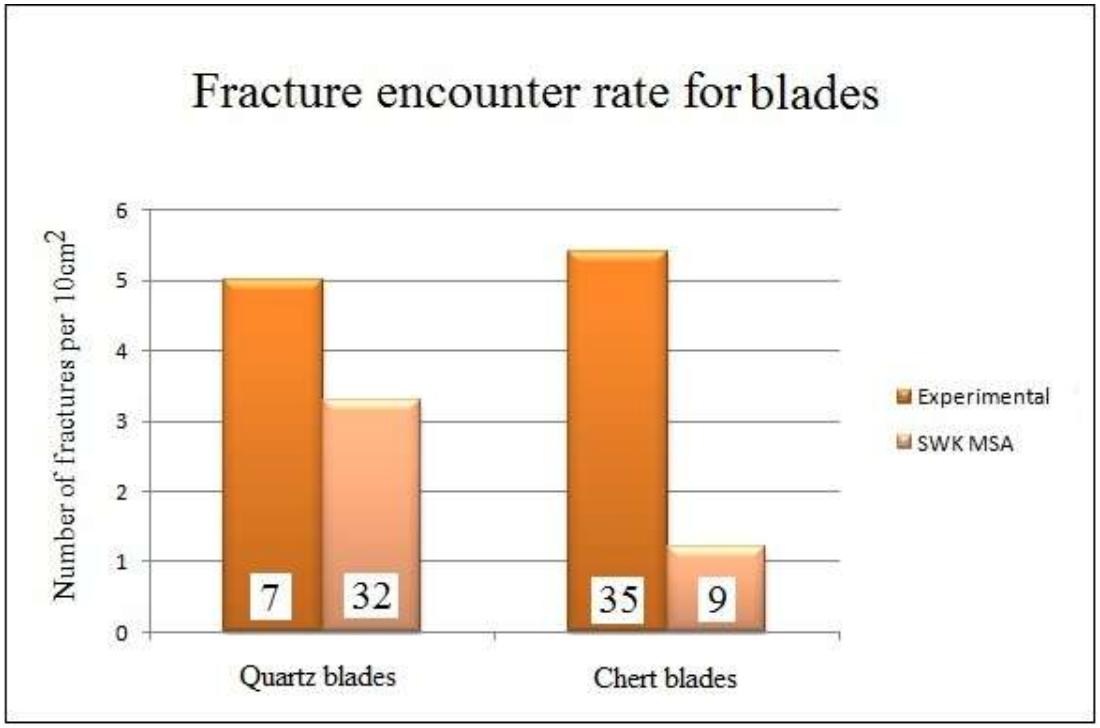

Fig. 5.10: Fracture encounter rate for blades. Blocks with numbers indicate number of pieces analysed for each assemblage.

5.3.5 Pieces with edge modification

Once again there are significant differences between the experimental and archaeological assemblages (>95% on the t-test), except for chert pieces from the Acheulean (Figure 5.11). Consequently, we cannot compare the Acheulean chert pieces to the Oldowan or the MSA, thus meaningful statistical data between the archaeological assemblages can only be obtained from quartz pieces. Student's t-tests conducted on FERs for quartz pieces indicate a difference between the Oldowan and Acheulean, but only at the 85% confidence interval, and a significant difference between the Acheulean and the MSA >95%. Unfortunately a chi-square test would also not be much use on this data set because it determines a significant difference between means, but does not focus as to which side of a mean any difference lies. Since the FER for Acheulean chert pieces exceeds the Oldowan FER, a difference between means is detected and added to the difference between quartz pieces, which had a lower FER than the Oldowan. The chi-square test thus indicates a significant difference between the two assemblages, but this is meaningless for determining overall improvement with regards to selectivity in the Acheulean.

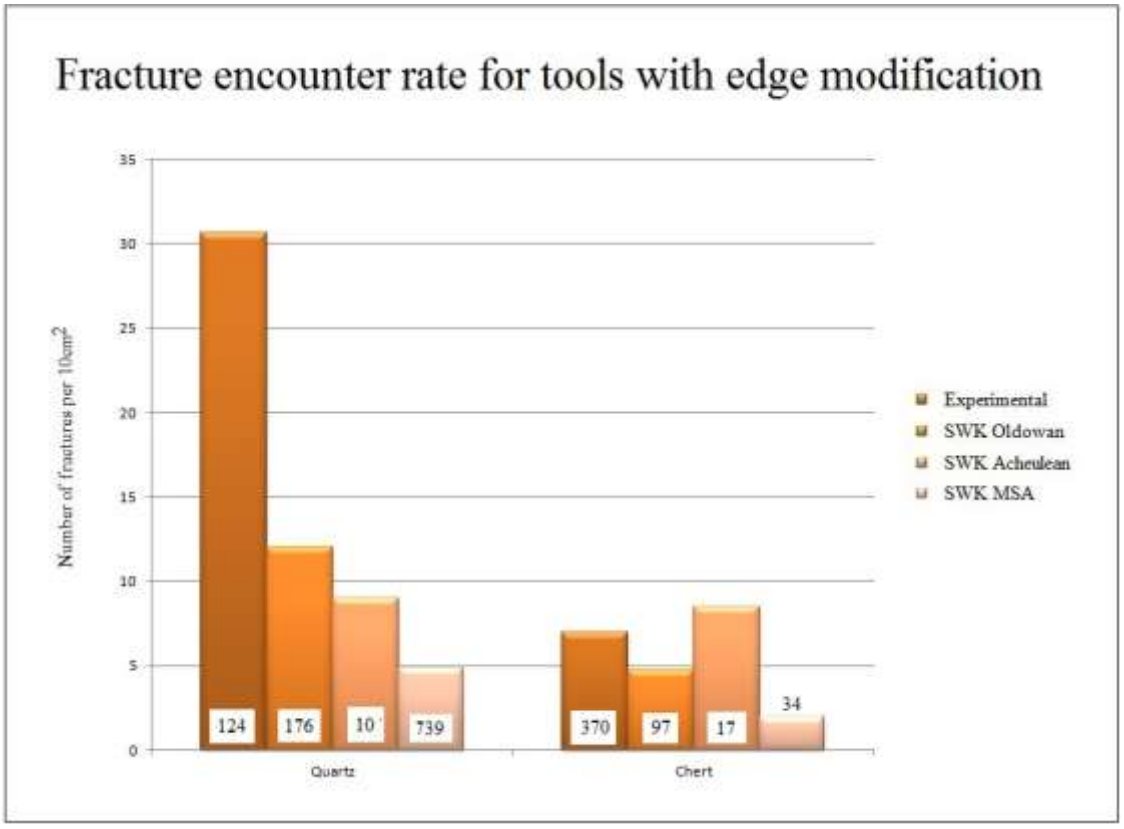

Fig. 5.11: Fracture encounter rate for pieces with edge modification. Blocks with numbers indicate number of pieces analysed for each assemblage.

The tool categories above indicate that both the Oldowan and MSA occupants practiced selection towards materials that exhibited fewer fractures and crystal interfaces than the majority of rocks that were obtainable in the study area. It is to some extent apparent that such selection was also present in the Acheulean, but only for quartz. However, it is yet to be established if there was an improvement from the Oldowan to the Acheulean and from the Acheulean to the MSA.

All tool types were thus combined for each assemblage to determine if any significant differences were apparent. Student's t-tests were not performed on the data as a significant difference would most likely be due to the different frequencies of the various tool and lithic raw material types. Figure 5.12 illustrates the FERs for quartz and chert for each of the Swartkrans assemblages, which makes it apparent that chert pieces from the Acheulean are more flawed on average than those from the Oldowan. Consequently a similar problem will be encountered with the chi-square test as was encountered for tools exhibiting edge modification.

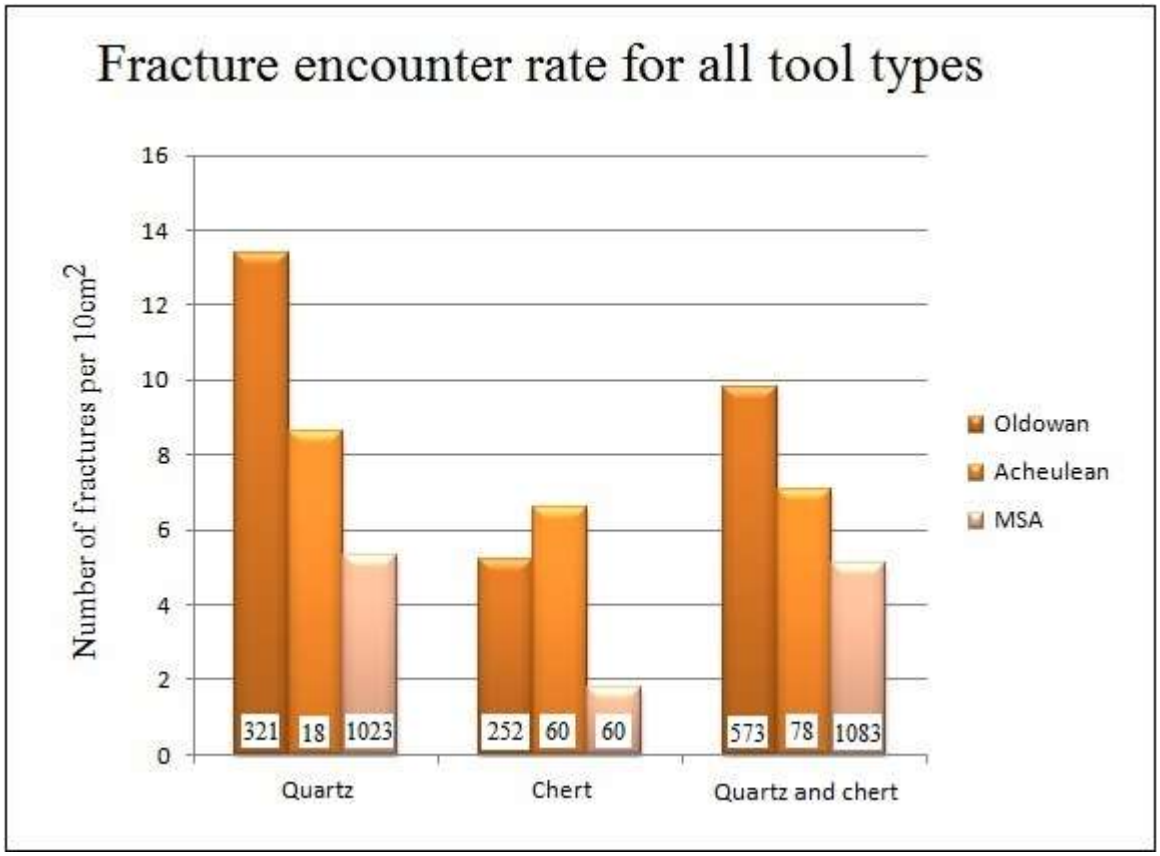

Fig 5.12: Fracture encounter rate for all tool types. Blocks with numbers indicate number of pieces analysed for each assemblage.

Yet again quartz is the only material exhibiting a decrease in FERs over time, but since t-tests cannot be performed due to the combination of various tool types, a different approach needs to be taken to indicate if there was any improvement over time. Additionally, the chi-square test could not be performed as this test needs at least two sample means to compare for each techno-complex. As a result, quartz was broken down into the various tool types, and means for the tool types that were shared between the techno-complexes were tested with the chi-square. Only two tool types were shared between all three techno-complexes: cores and pieces with edge modification. The chi-square indicated that there was a difference between the Oldowan and Acheulean at the 87% confidence interval, and between the Acheulean and the MSA beyond the 95% confidence interval. This indicates with 87% certainty that Acheulean hominids more frequently selected unfractured quartz pieces than Oldowan occupants. It is also apparent that MSA people practiced even stricter selection. The question then arises, why do the Acheulean chert pieces exhibit such a high FER if selection is shown for quartz pieces? A possible explanation is proposed and discussed in more detail in Chapter 6.

5.4 Weathering

This particular variable is important to assess since it encumbers the flaking predictability, durability and sharpness of a material. It is however very important to note that artefacts are not always deposited immediately after manufacture and use, and they can sometimes lie on the surface exposed to the elements for a long time. In addition to this, *in situ* artefacts are also exposed to fluids that penetrate into sediment and breccia from time to time, with the result that older assemblages might illustrate more weathered pieces than younger ones. However, the three rock types included in the analysis are silica based, which tends to weather very slowly, allowing for some flexibility. Results will be given and then discussed in more detail with regards to the above.

Since weathering was classed into ordinal categories and not quantitatively analysed, it was assessed for each lithic raw material as a whole instead of each tool type. Therefore, the three techno-complexes had to be compared to experimental assemblages which contained only the tool types that are synonymous with those techno-complexes. For example, flakes, chunks, cores and pieces with edge modification were included in all three techno-complexes, but for the experimental MSA, choppers were excluded and blade cores, prepared cores and blades

were included. Conversely, choppers were included for the Oldowan and Acheulean and MSA tool types were excluded. In addition, there was one core analysed from the Swartkrans Acheulean that had an edge modified, possibly for heavy cutting duties (large cutting tools). Thus experimentally created large cutting tools were also included to give weathering comparisons for large pieces.

5.4.1 Quartzite weathering

Most quartzite samples obtained from the study area were slightly weathered (beyond the cortex). Even so, fresh samples were available but, required some searching to obtain them. The preserved gravels have obviously been exposed to weathering in the last two million years, but since fresh gravels of all sizes could be obtained (on the surface and underground) it is likely that the weathering during this techno-complex was not extreme enough to compromise the gravels too extensively. Furthermore, pieces from the Oldowan would likely have experienced some weathering over that time period as well, making comparisons with the experimental assemblage possible. The problem arises when comparing the archaeological assemblages with each other, since pieces from the older assemblages might exhibit more weathering due to their ages.

Figure 5.13 and Table 5.5 show that the experimental lithics fall mostly within the slightly weathered category, whereas all three of the SWK assemblages predominantly included fresh quartzite pieces. Just over 63% of the quartzite lithics from the Oldowan are fresh, and if we presume that the gravels have undergone more or less the same amount of weathering, it would indicate that hominids selected for quartzite cobbles that were fairly fresh. This is confirmed with a chi-square test that was executed between the percentages of the experimental assemblage and the Swartkrans Oldowan (>95%). A significant difference beyond the 95% confidence interval was also obtained for the Acheulean and the MSA when compared to their experimental assemblages. This is a strong indicator that selection for fresher material was practiced in all techno-complexes.

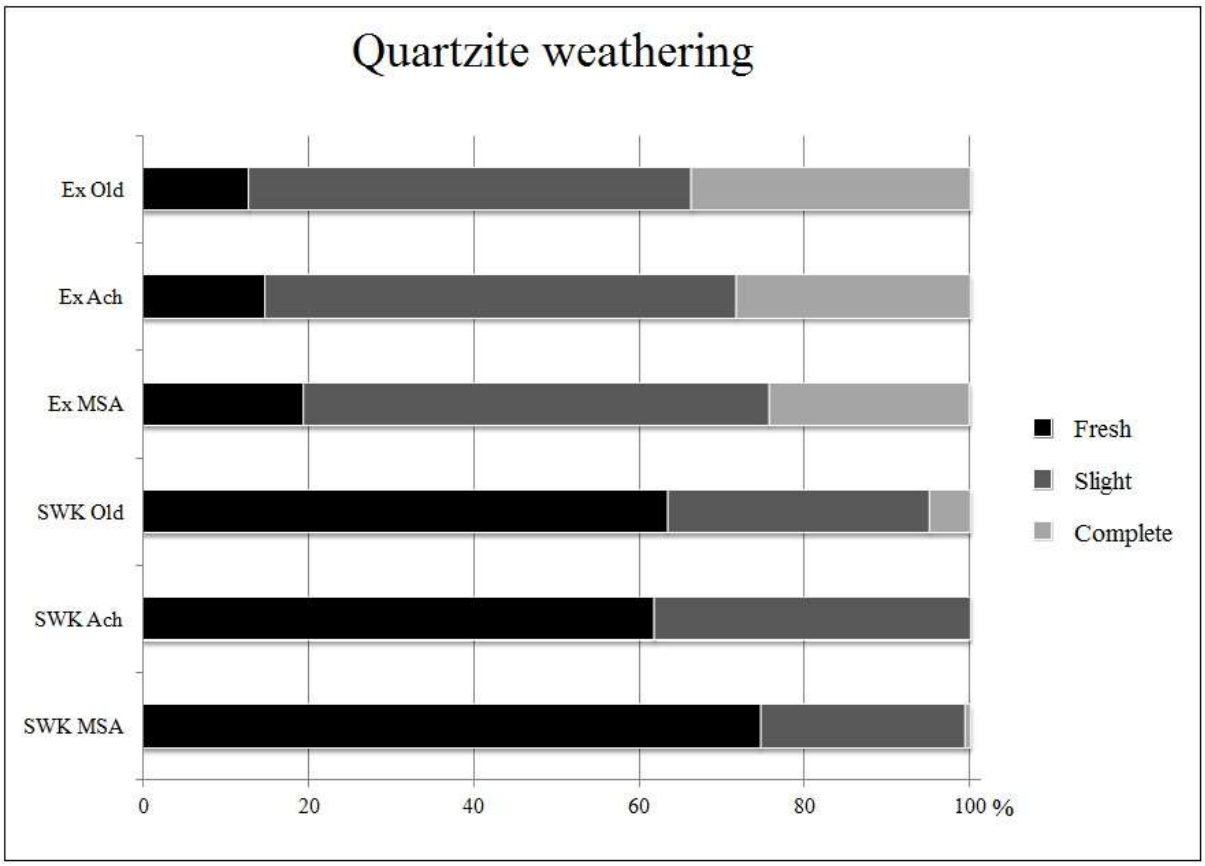

Fig. 5.13: Quartzite weathering. Ex Old: experimental Oldowan assemblage; Ex Ach: experimental Acheulean assemblage; Ex MSA: experimental MSA assemblage; SWK Old: Swartkrans Oldowan; SWK Ach: Swartkrans Acheulean and SWK MSA: Swartkrans MSA.

Table 5.5: Quartzite weathering.

	SWK Oldowan	**SWK Acheulean**	**SWK MSA**	**Exp. Oldowan**	**Exp. Acheulean**	**Exp. MSA**
Fresh	63.4 %	61.8 %	74.7 %	12.9 %	14.8 %	19.4 %
Slight	31.7 %	38.2 %	24.6 %	53.4 %	56.9 %	56.3 %
Complete	4.9 %	0.0 %	0.7 %	33.7 %	28.3 %	24.2 %

Most importantly though are the differences between the three techno-complexes. Fresh quartzite pieces are on average represented more often during the Oldowan than during the Acheulean. However, none of the pieces from the Acheulean is completely weathered, yet 5% of the Oldowan quartzite pieces are. A Pearson's chi-square test indicates that there is a significant difference between the Oldowan and the Acheulean (>95%), which is principally as a result of the last category (complete weathering). Thus, if we presume that some pieces

from the Oldowan were subjected to weathering before the deposition of the Acheulean, it is more reasonable to deduce that selection with regards to the state of weathering for the Acheulean and the Oldowan was fairly similar. Alternatively, there is a highly significant difference (much >95%) between the Acheulean and the MSA, as well as the MSA and the experimental tools (which would have undergone more weathering), indicating that the MSA people were most likely selective towards fresher material.

5.4.2 Quartz weathering

Quartz samples obtained from the study area were on average fresher than quartzite samples (Figure 5.14 and Table 5.6). Nonetheless, the percentages of fresh pieces present in all three archaeological assemblages are much greater than the experimental assemblages. The chi-square test confirms that all three techno-complexes are significantly different (>95%) from their experimental equivalents.

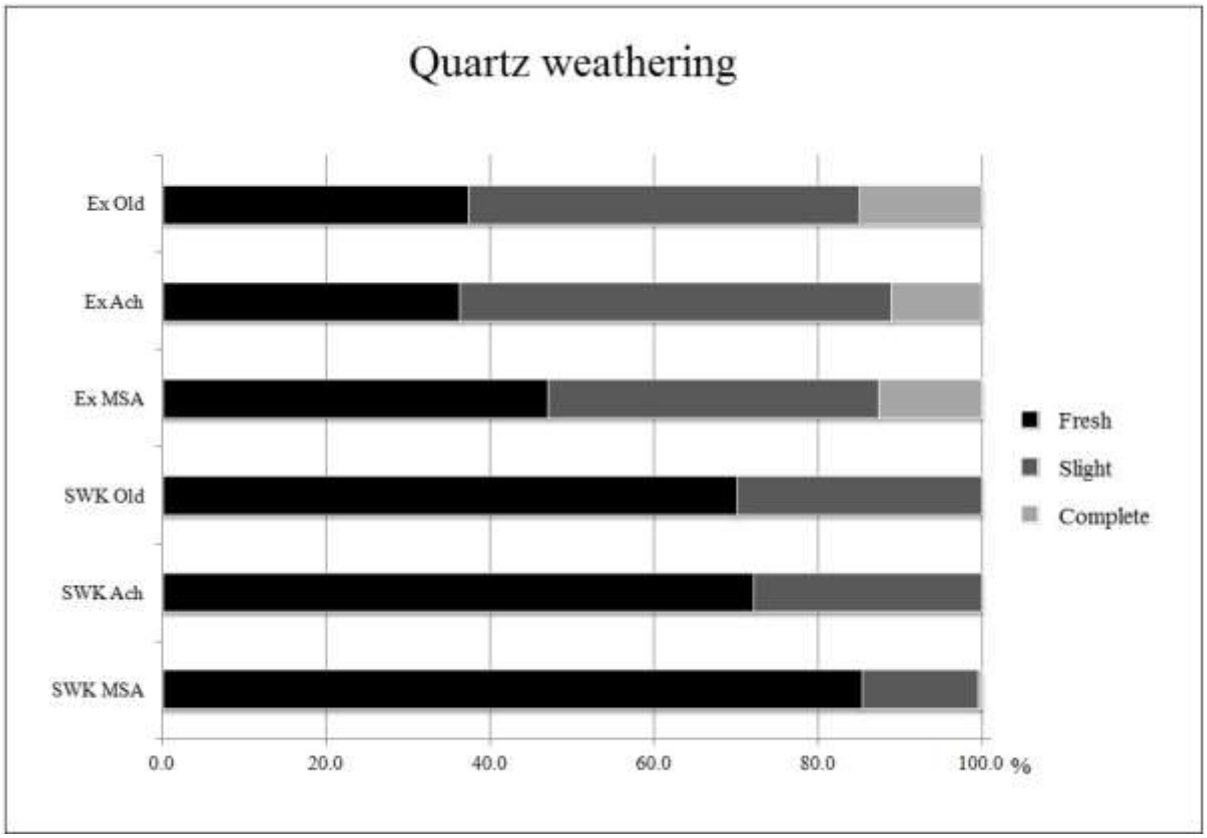

Fig. 5.14: Quartz weathering. Ex Old: experimental Oldowan assemblage; Ex Ach: experimental Acheulean assemblage; Ex MSA: experimental MSA assemblage; SWK Old: Swartkrans Oldowan; SWK Ach: Swartkrans Acheulean and SWK MSA: Swartkrans MSA.

Table 5.6: Quartz weathering.

	SWK Oldowan	SWK Acheulean	SWK MSA	Exp. Oldowan	Exp. Acheulean	Exp. MSA
Fresh	70.1 %	72.2 %	85.3 %	37.4 %	36.3 %	47.1 %
Slight	29.9 %	27.8 %	14.3 %	47.7 %	52.6 %	40.3 %
Complete	0.0 %	0.0 %	0.4 %	14.9 %	11.0 %	12.6 %

The chi-square test reveals that there is no significant difference between the Oldowan and the Acheulean. It does, however, indicate a significant difference between the MSA and the Acheulean, substantiating that the MSA people were decidedly selective towards fresh material.

5.4.3 Chert weathering

The majority of chert pieces sampled exhibited slight weathering, as is apparent from the experimental assemblages in Figure 5.15 and Table 5.7.

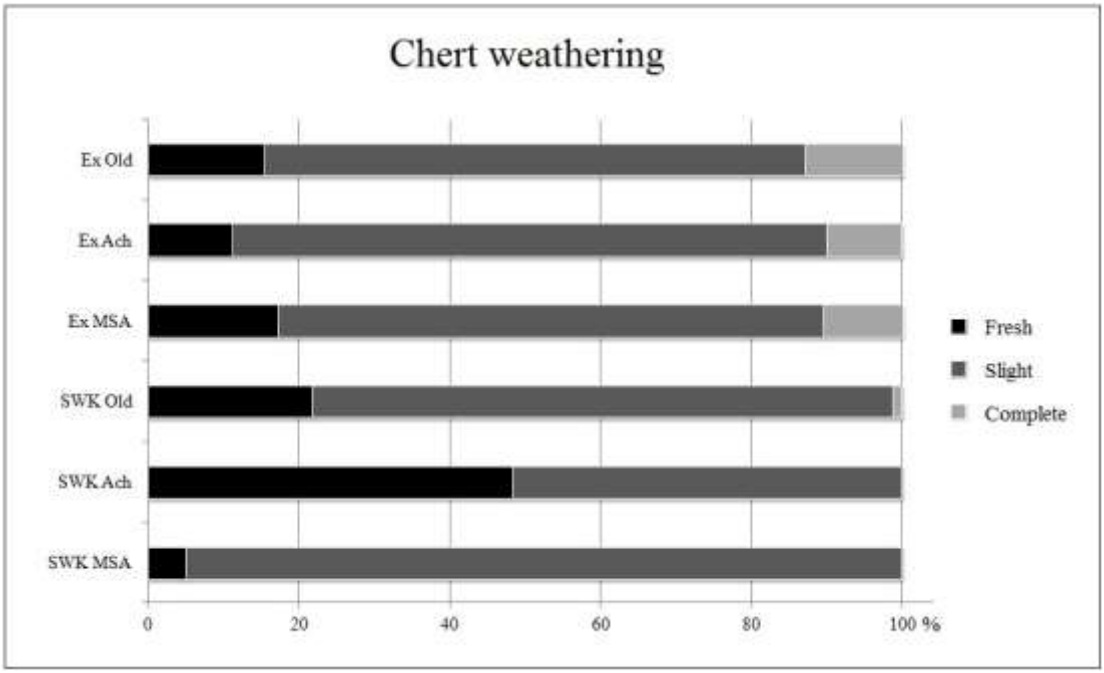

Fig. 5.15: Chert weathering. Ex Old: experimental Oldowan assemblage; Ex Ach: experimental Acheulean assemblage; Ex MSA: experimental MSA assemblage; SWK Old: Swartkrans Oldowan; SWK Ach: Swartkrans Acheulean and SWK MSA: Swartkrans MSA.

Table 5.7: Chert weathering.

	SWK Oldowan	SWK Acheulean	SWK MSA	Exp. Oldowan	Exp. Acheulean	Exp. MSA
Fresh	21.8 %	48.3 %	5.0 %	15.5 %	11.2 %	17.2 %
Slight	77.0 %	51.7 %	95.0 %	71.7 %	78.8 %	72.3 %
Complete	1.2 %	0.0 %	0.0 %	12.9 %	10.0 %	10.5 %

Quartzite and quartz pieces from the Swartkrans assemblages were mostly fresh, yet the majority of chert pieces from these assemblages exhibits slight weathering. Nonetheless, all three Swartkrans assemblages are significantly different from the experimental assemblages (>95%). It is however not the MSA that exhibits the majority of fresh pieces, but the Acheulean (48.3%), which is followed by the Oldowan (21.8%), and only then the MSA (5%). Chi-square tests indicate significant differences between the Oldowan and the Acheulean and the Acheulean and the MSA (>95%). However, the difference between the Acheulean and the MSA indicates more selection for fresh material during the Acheulean and not the MSA. This result does not necessarily signify a lack of selection during the MSA, but it could indicate that other influencing factors were present, which will be discussed further in Chapter 6.

5.5 Quartzite grain size

The only rock type that exhibited a range of different grain sizes was quartzite. The study area samples consisted mostly of medium to fine-grained quartzites, although both finer and coarser varieties are obtainable, but rare. Figure 5.16 and Table 5.8 demonstrate the abundances of the various grain sizes for the three techno-complexes, as well as the experimental assemblages. The experimental assemblages for the three techno-complexes were constructed the same as for the weathering analysis above, however, only quartzite tools were included.

Figure 5.16 and Table 5.8 illustrate that the majority of the experimental and archaeological pieces are medium to fine-grained, which reflects the abundances found in the study area. It is important to note that an abundance of fine to medium-grained material does not indicate a lack of selectivity as these grain sizes are still excellent for knapping.

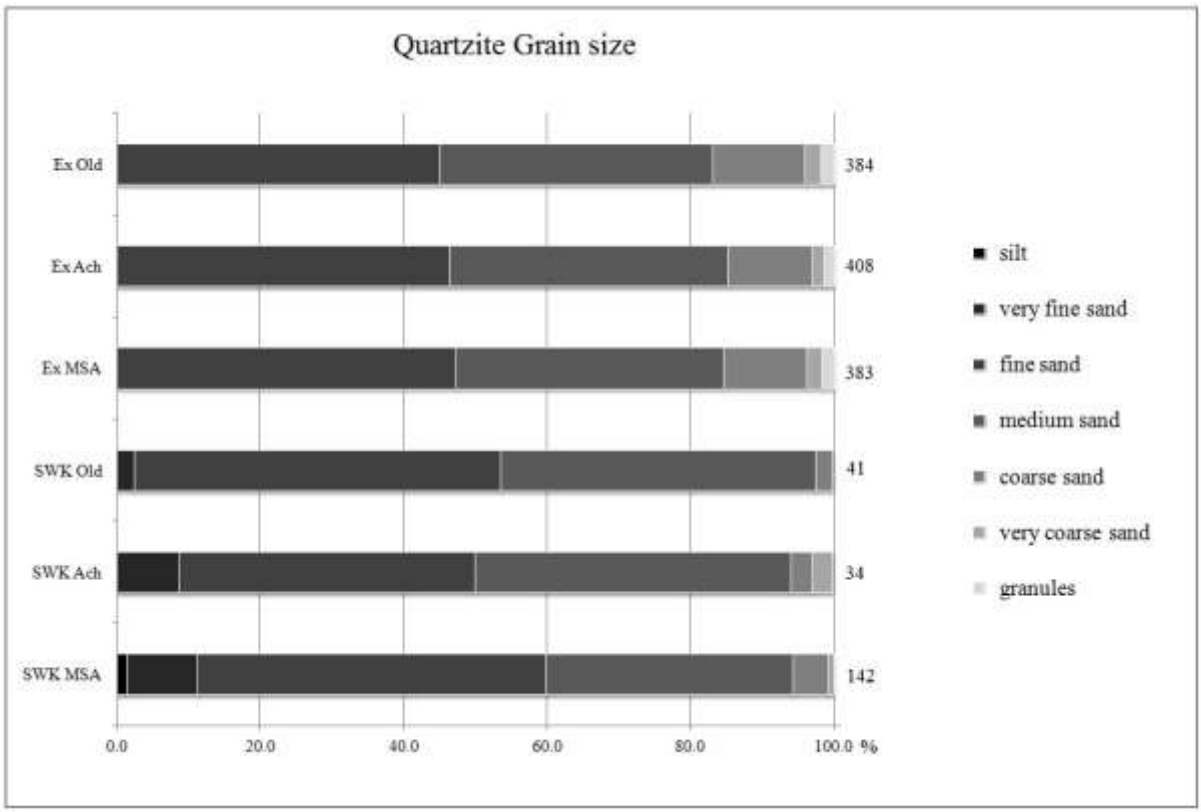

Fig. 5.16: Quartzite grain sizes. Ex Old: experimental Oldowan assemblage; Ex Ach: experimental Acheulean assemblage; Ex MSA: experimental MSA assemblage; SWK Old: Swartkrans Oldowan; SWK Ach: Swartkrans Acheulean and SWK MSA: Swartkrans MSA. Categories were classified according to the Wentworth scale.

Table 5.8: Percentage of quartzite grain sizes in each assemblage.

Grain size*	**SWK Oldowan**	**SWK Acheulean**	**SWK MSA**	**Exp. Old**	**Exp. Ach**	**Exp. MSA**
Silt	0.0%	0.0%	1.4%	0.0%	0.0%	0.0%
Very fine sand	2.4%	8.8%	9.9%	0.0%	0.0%	0.0%
Fine sand	51.2%	41.2%	48.6%	45.0%	46.4%	47.3%
Medium sand	43.9%	44.1%	34.5%	38.2%	38.9%	37.3%
Coarse sand	2.4%	2.9%	4.9%	12.8%	11.8%	11.7%
Very coarse sand	0.0%	2.9%	0.7%	2.3%	1.6%	2.1%
Granules	0.0%	0.0%	0.0%	1.7%	1.3%	1.6%
Total sample no.	**41**	**34**	**142**	**384**	**408**	**383**

*Classified via the Wentworth scale.

When chi-square tests are performed between the three experimental assemblages, no significant difference is detected between the means for each grain size. Conversely, this test indicated that all three Swartkrans assemblages are significantly different (>95%) from the experimental assemblages, thus indicating that some selection is present. The majority of the experimental and Oldowan pieces was fine grained; however, the finest grain size that was sampled for the experimental assemblage was fine sand, whereas the Oldowan included 2.4% very fine sand. In addition, the experimental assemblage only consisted of 45% fine grained sand, and the Oldowan of 51.2%, which comes to 53.6% if we add very fine grained sand pieces. The experimental assemblages also included very coarse material, which the Oldowan did not. This indicates that even as early as the Oldowan, hominids were selective for quality of lithic raw material. The Acheulean occupants, however, did not seem to practice much selection for grain size, as a substantial number of pieces are medium grained (more than the experimental pieces). This is further discussed in Chapter 6. The MSA is the only industry which includes some quartzite of silt sized grains (1.4% of all the quartzite pieces). Quartzite with silt sized grains and very fine grained sand, were not found in the study area upon sampling, which could signify that such material was transported from a distance, or that this variety is extremely rare. If we add the first two categories together, then 11.3% of the MSA quartzite pieces consist of material that does not feature in the experimental assemblage. This indicates a fairly high level of selection, since such materials are only found if one actively searched for them.

Was there an improved selection over time? A chi-square test indicated that there was a significant difference (>95%) between the Oldowan and the Acheulean. Closer examination of the equation indicated that the significance was largely determined by the very fine sand category, which makes up 8.8% of the quartzite pieces in the Acheulean, as opposed to 2.4% in the Oldowan. Since this value is higher in the Acheulean it indicates that there was some improvement from the Oldowan to the Acheulean. The chi-square test between the Acheulean and the MSA was also highly significant (>95%). Since the MSA had the finest grained quartzites, it is obvious that by this time period people were highly selective towards good quality material for tool making and use.

5.6 Quartzite homogeneity

Since quartzite comprises of sand grains, a variety of grain sizes could be found in one quartzite piece, especially since these various sand grain sizes define the bedding planes. It is thus also useful to evaluate the homogeneity of this material.

Quartzite pieces from each assemblage were classified according to four groups which are shown in Table 5.9. These categories classed the quartzite pieces based on the homogeneity of their grains and the presence or absence of banding/bedding planes. The categories in Table 5.9 start with pieces that exhibit a more desired homogeneity and progress downward in a descending order towards material that is inhomogeneous. From the experimental knapping it was apparent that quartzite pieces with banding present had a lower flaking predictability than pieces which had no banding, but had inhomogeneous grains. For that reason the last two categories included banding.

Table 5.9: Quartzite homogeneity given in percentage.

Quartzite homogeneity	**SWK Oldowan**	**SWK Acheulean**	**SWK MSA**	**Exp. Oldowan**	**Exp. Acheulean**	**Exp. MSA**
Yn	92.70%	85.30%	93.70%	69.80%	70.90%	71.50%
Nn	7.30%	8.80%	3.50%	14.20%	13.70%	13.30%
Yy	0%	0%	1.40%	10.50%	10.50%	9.90%
Ny	0%	5.90%	1.40%	5.40%	4.90%	5.20%
Sample no.	**41**	**34**	**142**	**384**	**408**	**383**

Yn: grains are homogeneous with no bands present; Nn: grains are not homogeneous but no banding is present; Yy: grains are homogeneous with banding present and Ny: grains are not homogeneous and banding is present.

The majority of quartzites from the study area are homogeneous and exhibit no banding, as is apparent from the experimental assemblages (approx. 71%). All three Swartkrans assemblages show a substantially larger percentage of homogeneous material: 92.7% for the Oldowan, 85.3 % for the Acheulean, and 93.7% for the MSA. Chi-square tests indicate that all three Swartkrans assemblages are significantly different (>95%) from the experimental assemblages. This indicates that selection towards homogeneous material was present in all

three techno-complexes, but since the majority of pieces fall within the first two categories, selection was not focussed on the homogeneity of the grain sizes, but for pieces with no banding present.

The chi-square test reveals a difference (>95%) between the Oldowan and the Acheulean, but this difference is attributed to some banded quartzites being used during the Acheulean. This indicates that the Oldowan hominids either selected for quartzite with no banding, or they were better at circumventing the bands. Since the Acheulean quartzite pieces were less homogeneous on average, the chi-square test thus also revealed a significant difference between the Acheulean and the MSA. However, the difference between the Oldowan and the MSA was not very significant, which suggests that selection against banded material was already present during the early ESA and was less strictly adhered to during the Acheulean, but persisted into the MSA.

5.7 Data distributions

Archaeological data are sometimes rather difficult to investigate quantitatively as samples are often small and are not always normally distributed, which limits the statistical tests that can be performed to indicate significant differences or patterns in the data. This study attempts to incorporate quantitative data and statistical analyses to facilitate the substantiation of significant patterns with regard to lithic raw material procurement over time at Swartkrans.

It was decided to perform Student's t-test on the quantitative data to indicate any significant patterns that might arise. This test works under the assumptions that data are normally distributed and are randomly selected for analysis (Mendenhall *et al*. 2006). The second assumption is met, since artefacts were selected randomly for each tool type, but it is also important to verify if the data followed a normal distribution (Figure 5.17). The quantitative data were all tested for normality, which indicated that they were all distributed normally, and therefore the last assumption was also met.

However, even though the data for the IER followed a normal distribution there were large amounts of data that accumulated on either side of the normal curve as is apparent from the experimental data in Figure 5.18. The archaeological assemblages followed a similar pattern but the amount of pieces that were 100% flawed tended to decrease over time and pieces with 0% IER increased over time as is apparent for the MSA (Figure 5.19).

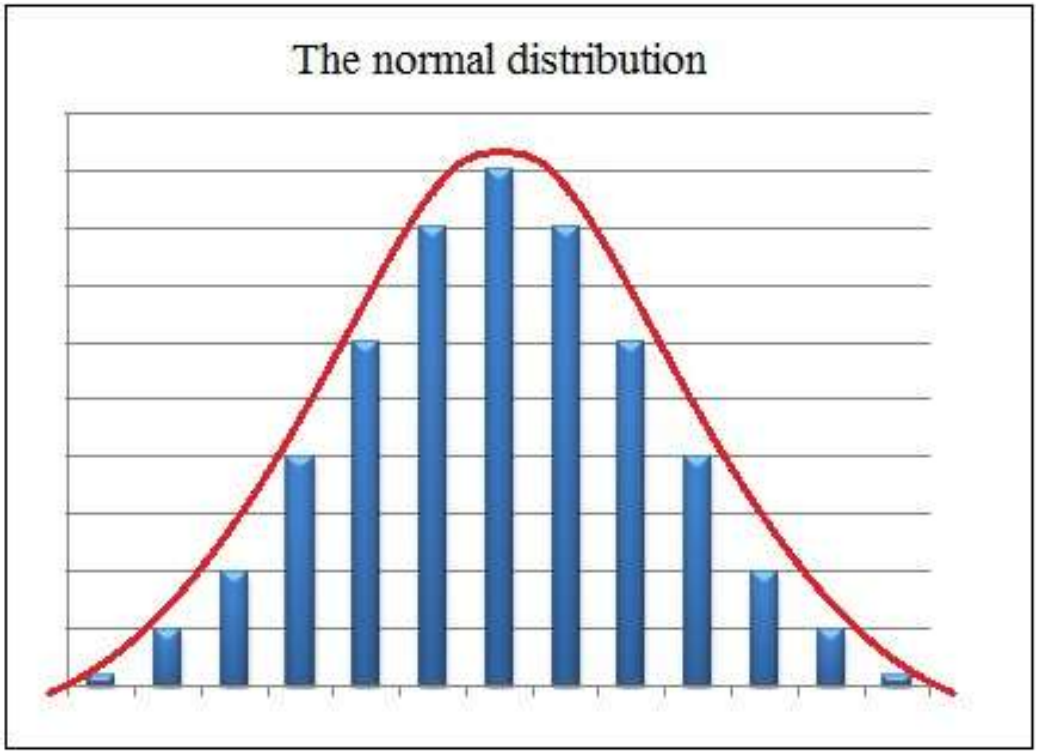

Fig. 5.17: A typical normal distribution.

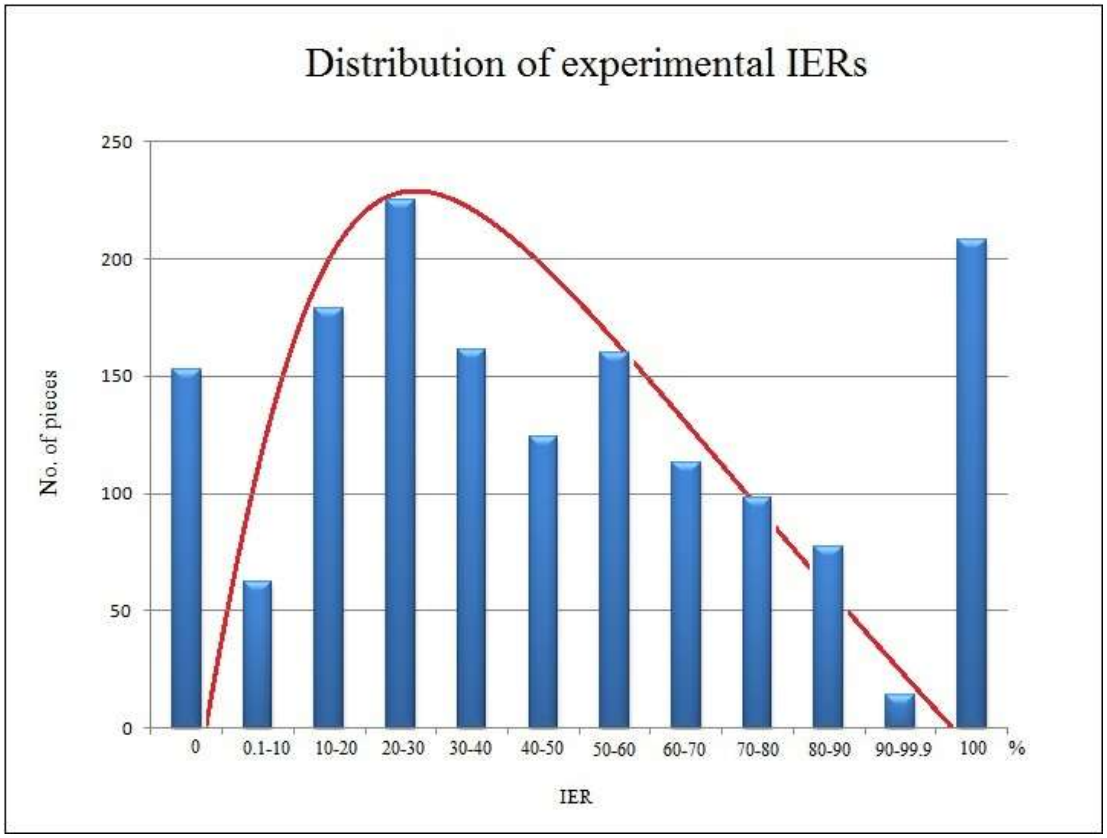

Fig. 5.18: Data distribution of experimental IERs: including all experimental pieces analysed from all three rock types.



Fig. 5.19: An example of how the archaeological data are distributed for the IER.

It was not entirely certain how much this would affect the sensitivity of the t-test. As a result the p value of ≤ 0.3 (70% chance that the tested data sets are significantly different) was selected as indicating a reliable enough significant difference between tested data. Furthermore, the chi-squares tests were conducted for additional statistical support. This was not really necessary for the FER as the data was distributed normally (Figure 5.20).

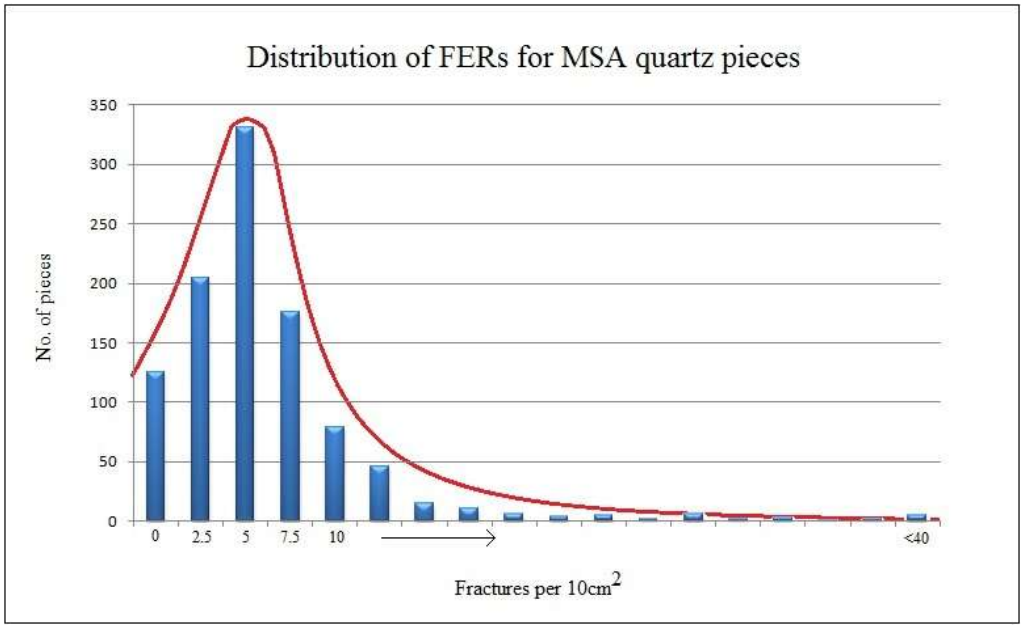

Fig. 5.20: An example of how the archaeological data are distributed for the FER.

5.8 Summary

Archaeological data are often based on small samples that do not always follow a normal distribution. It is thus very difficult to analyse such data quantitatively. Nonetheless, this project attempts to include some quantitative data to help understand lithic raw material selection patterns over time. As a result some valuable data were obtained and indicate the following:

- The IERs and FERs indicated that quality selection was present in all three techno-complexes.
- The IERs for quartzite shows substantially more quality selection during the Acheulean and the MSA.
- IERs for quartz and chert shows a slight increase in quality selection during the Acheulean and a substantial improvement during the MSA.
- Importantly, the IERs for pieces with edge modification / visible use-wear, for all three rock types, show improvement from Oldowan to the Acheulean and from the Acheulean to the MSA.
- The FERs for quartz indicate improvement from Oldowan to the Acheulean and from the Acheulean to the MSA.
- The FERs for chert shows improvement from the Oldowan to the MSA, but the chert FERs for the Acheulean reflect the selection for highly fractured chert. This is explained in the next Chapter.
- Fresher material is selected in all techno-complexes, most notably in the MSA.
- However, with the exception of chert from the MSA, which is more weathered than the experimental tools. This is explained in the next Chapter.
- Overall there is an increased selection for better quality material from the Oldowan to the Acheulean and from the Acheulean to the MSA.
- The MSA occupants were undoubtedly highly selective towards quality materials for knapping and use. On the other hand, smaller pieces exhibit less flaws due to their size, however, the lithic pieces analysed from the MSA were on average not much smaller in size than pieces analysed from both the Oldowan and the Acheulean.

CHAPTER 6 DISCUSSION AND CONCLUSION

To understand the complexity of lithic raw material selection, one first needs to isolate which factors are being selected for and how these factors affect the production of lithics. It is also important to note that certain rock types might be suited for certain functions, but not for others. Lithic raw material selection is in fact a very complex behaviour as multiple factors need to be considered which are often interrelated (Figure 6.1). Experimental knapping and examination of available literature have allowed me to isolate three features which are necessary for the production of functional stone tools (flaking predictability, durability and sharpness).

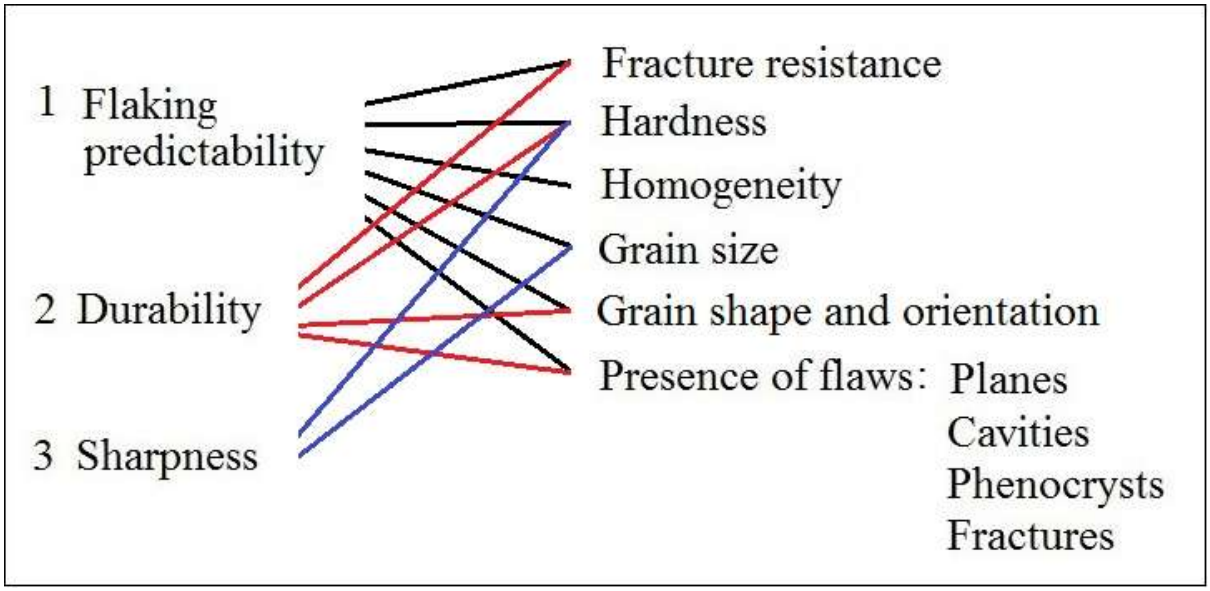

Fig. 6.1: Features to consider when selecting lithic raw material for knapping and their interconnectivity.

Various studies have shown that selectivity for specific rock types was already present in some of the earliest stone tool assemblages (Table 6.1). Such cognitive skills are one reason why the Stone Age industries become more archaeologically visible and more frequent from 2.6 Ma. Earlier stone use and manufacture might not have been based on selective factors, and thus it was not always effective and probably less frequently practiced, which could explain why they are not readily visible in the archaeological record.

Table 6.1: Findings on lithic raw material selection.

Paper	Findings	Time period	Location
Semaw *et al.* 2003	Selectivity for durable fine grained aphanitic (no phenocrysts) volcanic rocks and chert.	2.6 Ma	Gona, Ethiopia
Stout *et al*. 2005	Selection present for durable fine grained aphanitic volcanic rocks.	2.6 - 2.5 Ma	Gona, Ethiopia
Goldman-Neuman and Hovers 2012	Selectivity focused towards fine grained aphanitic volcanic rocks. At the younger site selection included quartz and chert.	2.36 Ma	Hadar, Ethiopia
Harmand 2009	Selection for medium to fine grained aphanitic homogenous material.	2.34 Ma	Turkana, Kenya
Braun *et al*. 2009	Selected material mainly for durability, but preference was for material that was both durable and exhibited fewer flaws.	2.3 - 1.95 Ma	Kanjera South, Kenya
Kuman 1996	Selection of specific rock type, in particular quartz.	1.9 Ma	Sterkfontein, South Africa
Field 1999	Selectivity was present for specific rock types. The Oldowan hominids selected quartz. Furthermore, there was still heavy selection for quartz in the Acheulean, but a marked increase towards quartzite.	1.9 - 1 Ma	Sterkfontein valley, South Africa
Wadley and Kempson 2011	Occupants selected material based on intended purpose and focussed on durable and fine grained material.	77 -38 ka	Sibudu, South Africa
Singer and Wymer 1982; Ambrose and Lorenz 1990; Villa *et al*. 2010	Selection of fine grained over coarse grained silcretes.	65 -60 ka	Klasies River Mouth, South Africa
Brantingham *et al.* 2000	Flaws were present in material but knappers adjusted knapping strategies.	Undated but late Middle Paleolithic (33ka)	Mongolia

6.1 Lithic raw material type

Table 6.1 demonstrates that early selection in East Africa was primarily for igneous rock types that were durable, sharp and somewhat predictable (determined via knapping a few pieces of similar igneous material obtained locally). Lithic raw materials used during the Oldowan in South Africa were somewhat different to the rock types used in East Africa. This does not necessarily indicate a disparity in selectivity, as the geologies of the areas differ. The Oldowan in the Sterkfontein valley shows selection for quartz, chert and quartzite, as opposed to fine grained igneous rocks. This is because these igneous materials are not very abundant in South Africa, especially on the Highveld.

Most importantly though it was necessary to determine if the three materials frequently used in the Sterkfontein valley are also durable, sharp and predictable. Therefore all twelve rock types found in the study area were knapped to determine which of these materials exhibited these characteristics and to what degree. The rock types were classed into very high, high, medium or low depending on their behaviour during knapping and use (Table 6.2). This was determined only for the best qualities that could be obtained for each material since weathering and flaws compromise these characteristics.

Table 6.2: Rock types and their ability to produce effective tools.

Lithic raw material type	Flaking predictability	Durability	Sharpness
Quartzite and Arkose	Very high	Very high	High
Vein quartz	Very high	High	Very high
Dolerite	Medium	Very high	Very high
Ferrous nodules	Medium	High	High
Chert	Very high	Medium	Medium
Dolomite	Very high	Medium	Medium
Banded iron formation	Low	Medium	Medium
Slate	Low	Low	Medium
Flowstone	Low	Low	Low
Chert breccia	Low	Low	Low
Shale	Low	Low	Low

The materials that ranked the highest were quartzite, quartz and dolerite, which are three of the four most predominant rock types present in the archaeological assemblages. Chert, on the other hand, only placed fifth. This is because a robust piece of chert (such as a scraper) tends to be durable and sharp, but a thin piece (such as a flake) tends to be rather brittle, and is thus only really suited for light duty work. Since quartz and quartzite are both durable and sharp, it could explain the decreased selection of chert over time.

From Table 6.2 it is apparent that quartzite and quartz are both exceptional materials for tool manufacture and use. However, the Swartkrans assemblages all display a favoured selection towards quartz. The dominance of quartz over quartzite is not fully understood, since quartzite is not only sharp enough to perform any cutting that would have been needed, but it is also slightly more effective than quartz for heavy duty activities, such as cutting into bone or wood. However, the prevalence of quartz for the Swartkrans Acheulean might be due to the small sample size, since the Sterkfontein Acheulean yields a much larger sample size and consists primarily of quartzite (Field 1999). The most likely explanation for the predominance of quartz during the Oldowan is that it is easy to identify and has a much higher abundance of fresh gravels present than any of the other rock types, which was apparent from the weathering analysis. Furthermore, weathering of quartz is immediately visible due to the staining between crystal interfaces. Conversely, the weathering state of a quartzite cobble is not always visible to the naked eye due to the weathering on the cortex. Therefore, test flaking is required to reveal the weathering state of quartzite gravels, which could take some time as gravels would have to be randomly tested. It is therefore possible that Oldowan hominids found it more efficient to search for a fresh quartz cobble and modify a few flakes for use, than to spend the time searching for a fresh quartzite.

There is a shift towards more use of quartzite during the Acheulean. This is most likely due to the nature of the Acheulean industry, as this industry is recognized for its larger heavy duty tool types. Experimental knapping indicated that the available quartz and chert sources were too small or too flawed to make very large heavy duty tools. It was therefore more efficient to spend the time looking for a large fresh piece of quartzite when wanting to produce such a heavy duty tool.

Quartz is the most abundant during the MSA as three quarters of the assemblage (pieces ≥2cm) consisted of this material. The majority of quartz pieces analysed exhibited some form of edge modification (72%), with the bulk being scrapers that appear to have been

extensively utilised. Since there is intense quality selection in the MSA it is not likely that the abundance of quartz could be explained by the reasons stated for the Oldowan, since the MSA people would likely take the time to search for fresh quartzite if this material would be better for tool manufacture and use. Consequently, I experimentally used some quartz, quartzite, chert and dolerite scrapers on hide and plant material to try and isolate possible reasons for the abundance of quartz during this techno-complex. The experiments revealed that quartz is ideal for scraping activities, whether it is on plant material or hide. However, quartzite and dolerite were equally efficient for such activities. Chert scrapers with a robust edge could perform these heavy duty tasks, but were not as proficient. The main difference between the other three materials was that quartz tended to leave a slightly smoother finish on hide. This is likely because quartzite and dolerite consists of individual grains/crystals, whereas quartz is a crystalline structure creating a smooth conchoidal surface when flaked. Moreover, a small piece of quartz is also easy to shape to desired dimensions and can be retouched with ease when it becomes dull. From this we can infer that the people occupying the site during the MSA most likely practiced hide working activities, but this cannot be said for certain without first analysing use wear for these artefacts.

Most notable in Table 6.2 is the excellent durability and sharpness of dolerite. These attributes are due to the material's exceptional hardness. However, because the fracture resistance of this material is very high, the flaking predictability is lower, as it requires a large amount of force to dislodge a large (>5cm) flake. Applying more force requires a larger and faster swing at the material, which could comprise accuracy and thus flaking predictability. Dolerite was occasionally utilised during the ESA, but not as predominantly as during the MSA (Figure 5.1). This could be because the MSA people were much more efficient knappers than the ESA hominids and could dislodge large dolerite pieces more effectively. The Acheulean occupants were capable of creating bifaces on large flake blanks, but they preferred quartzite over dolerite for such tool types. This makes sense, since quartzite is durable, sharp and much easier to flake.

Flakes produced from ferrous nodules were also rather durable and sharp. However the lack of this material is not surprising since the majority of nodules is too small to knap efficiently. Furthermore, the material had a fairly high fracture resistance, which made knapping them even harder.

It is clear that hominids (and MSA people) occupying the Swartkrans area practiced selection for specific rock types. The reasons for selection of specific rock types over others are not always very clear. However the rock types selected were generally very well suited for tool manufacture and use.

6.2 Quality selection

This study analysed not only the intensity of quality selection for the ESA and the MSA, but also if there was a marked improvement from the Oldowan to the Acheulean and from the Acheulean to the MSA. The Swartkrans site was therefore ideal for analysing the above since: 1) it holds assemblages from these three major techno-complexes, 2) it has the same rock types present in all three assemblages, and 3) it exhibits no mixing between the assemblages.

The impurity encounter rate indicated that there was an overall improvement at Swartkrans for quality selection from the Oldowan to the Acheulean and a marked improvement from the Acheulean to the MSA. In addition to the IER, the fracture encounter rate was also analysed to isolate if even finer quality selection was present. The data indicated that chert from the Acheulean exhibited an exceptionally high FER, signifying that the Acheulean occupants practiced very little selection for quality chert. This was also reflected in some of the IERs as exceptionally large and invasive fractures were also counted as planes. However, Clark (1991, 1993) stated that some pieces from Members 2 and 3 could have been broken or fractured from pressure of overburden due to the position of these Members, and since chert is the most brittle of the three materials it could have been affected most. In addition, the chert pieces from this techno-complex did exhibit less cavities and crystal inclusions than pieces analysed for the Oldowan, but due to the higher amount of large invasive fractures, the overall IER was the same as the Oldowan. Nonetheless, the FER for the Acheulean was substantially larger than the Oldowan. Consequently, it seems probable that some chert pieces were affected by pressure from the overburden and that quality selection for chert was practiced more frequently in the Acheulean than what the data reveals. Also, it seems unlikely that hominids would practice selectivity for quality quartzite and quartz, but not for chert.

It was also apparent that the Acheulean hominids were not as selective towards quartzite grain size and homogeneity as was practiced in the Oldowan. The reliance on more heavy duty tool types during the Acheulean might be the reason for the above. This is because quartzite cobbles would most probably have been selected for size, shape and a lack of visible joints, since these aspects would hinder tool creation most. Most quartzite gravels exhibited joints. Finding a large enough piece that had no joints, was fine grained and homogenous was much more difficult.

Most surprising was the weathering state of chert pieces from the MSA, which consisted of only 5% fresh pieces and 95% that exhibited slight weathering. The experimental chert assemblage consisted of 15% fresh, 74% slight, and 11% completely weathered pieces. The chi-square test indicated that the MSA chert was significantly different to the experimental chert, which meant that the MSA occupants did not select chert randomly. Closer examination of the calculation indicated that the difference was due to both the lack of completely weathered material and the small amount of fresh pieces in the MSA. There is a simple explanation for these results. In the field I noticed that chert from the outcrops was not as weathered as chert found in the gravels. This is likely because chert is easily hydrated, especially if it is submerged in water for long periods of time. The MSA was found in colluvium (Sutton *et al.* 2009) as opposed to breccias, which suggest that the MSA pieces were exposed to much more water, and elements contributing to the weathering process, than assemblages in the breccias.

Chert pieces from the Oldowan and the Acheulean that were classed as either slightly or completely weathered exhibited much more weathering (much milkier) on average than the chert from the MSA. It is apparent from Figure 6.2B that the MSA chert pieces exhibit only slight weathering on the cortex, since the darkish blue fresher material can be seen underneath. Since 95% of the MSA chert pieces were classed as slightly weathered but do not exhibit more weathering than what can be seen in Figure 6.2, it is very likely that most (if not all) of these pieces were fresh when knapped and would thus indicate that 100% of chert material selected during the MSA was fresh. It makes little sense that the MSA people would select fresh quartz and quartzite, but not chert.



Fig. 6.2: Some chert pieces from the Oldowan (A) and the MSA (B).

Furthermore, most of the MSA quartzite pieces exhibited slightly more surface weathering than Oldowan pieces, but not notable enough to be classed as slightly weathered pieces, whereas the MSA quartz pieces were mostly fresh. This is not surprising, since quartz is much more resistant to weathering, which was apparent from the experimental assemblage. Since the MSA, which is the youngest of the assemblages, contained more weathered pieces than the experimental assemblages, and since both the Oldowan and the Acheulean contained more fresh pieces than the experimental assemblages, it can be inferred that not much of the ESA assemblages have been subjected to intense surface and *in situ* weathering and that selectivity patterns with regards to weathering are relatively reliable.

6.3 Conclusion

The examination of the geology surrounding Swartkrans has revealed twelve different rock types, which would have been available for the creation of stone tools. Mainly four of these rock types were selected by hominids for the creation of lithics, and as knapping experiments indicated, these four rock types are the best suited for the creation of stone tools. The selection of these four rock types during the Oldowan and Acheulean indicate that these hominids understood the characteristics of various rock types and could identify certain features that impede or maximise the knapping process. In addition, the results indicate that early hominids not only selected certain rock types, but also selected better quality rocks of these different types. While the selection for quality in the Oldowan was not intensely practiced, it became more frequent as time progressed, as there is improvement from the Oldowan to the Acheulean. . Nonetheless, it is apparent that specific rock types were selected for the creation of particular tool types during the Acheulean (quartzite for larger flakes and possibly heavy duty tools). However, there is a very marked improvement from the Acheulean to the MSA. For many MSA sites, early humans often selected specific rock types for particular purposes. Additionally, the MSA people could circumvent and adjust flaking strategies if good quality materials were not available. This in itself is a rather complex behaviour, which might already have been present to some degree during the early Acheulean. Thus, the improvement in quality of material from the Oldowan to the Acheulean may to some extent be due to flaws being circumvented, which is reflected in the more flawed debris (flakes and chunks) but not in the formal tools. It is evident that the MSA tools were of quality of rock, which could indicate that either these occupants were skilled enough to circumvent flaws or meticulously selected the best quality rock from the surrounding landscape. It is however not clear whether these rocks come from the immediate landscape or were sourced further out. It is more likely that the rock was sourced close by as good quality material is present in the preserved gravels, but needs to be sought after.

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