A technological analysis of cryptocrystalline silicate bladelets from Holkrans Rock Shelter in the Vredefort Dome, North West Province, South Africa.

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ABSTRACT

Breaking from traditional typological classification, this project utilizes the principle of *chaîne opératoire* to conduct a technological analysis of a sample of cryptocrystalline silicate (CCS) cores, bipolar debitage and, blade and bladelets from Holkrans rock shelter in the Vredefort Dome, North West Province. Approaches to lithic material of the Later Stone Age in southern Africa have been predominantly typological, with a few recent studies focused on technological analysis. Holkrans rock shelter presents an opportunity to conduct a technological analysis in an area abundant with rock types that complicate standard typology. *Chaîne opératoire* is employed to understand how cores were reduced and the processes and techniques that were used to produce blades and bladelets within the chert-dominated CCS sample. Previous research at Holkrans noticed differences in the occurrence of various raw materials across the two occupational horizons (ceramic and pre-ceramic), and suggested possible differences in technology between the two phases (Bradfield & Sadr 2011; Banhegyi 2011). Analysis of chert and opaline raw material types in the present study revealed substantial differences in lithic technology moving from the pre-ceramic across to the ceramic phase. A major shift in the overall knapping technique occurred as the result of a change in the objectives of the reduction strategy.

Table of Contents

List of Tables

List of Figures

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CHAPTER 1: INTRODUCTION

Currently, there are too few researchers willing to engage with the lithic technology of the Later Stone Age in southern Africa. Looking at the history of study for this period, only technologically *informed* regional typologies are used to classify stone artefacts (e.g. Sampson 1974; Humphreys & Thackeray 1983; Deacon 1984). This means that questions about how stone artefacts were produced, and how they were used, become conflated with attributes related to morphology and function (*cf.* Odell 1981). The late Holocene site at Holkrans in the Vredefort Dome provides an opportunity to conduct a comparative technological analysis between two phases of occupation. Earlier research at Holkrans has established that there are differences in the frequencies of raw material types between the ceramic phase and the earlier pre-ceramic phase (Banhegyi 2011; Bradfield & Sadr 2011), and, because of this, the suggestion has been made that a number of knapping techniques might be present (Banhegyi 2011: 43). The diverse geology of the Vredefort Dome, having provided an abundance of raw materials in the past, creates havoc for lithic analysts today. Despite these challenges, *chaîne opératoire* may be used to assess the production of one aspect of the lithic technology at Holkrans, namely cryptocrystalline silicate (CCS) blades and bladelets.

1.1 AIM

The aim in this study is two-fold: (1) to understand the reduction processes and techniques behind the production of blades and bladelets from CCS blocks, and (2) to situate the blade and bladelet production sequence within a broader *chaîne opératoire* for Holkrans.

1.2 RESEARCH QUESTION

What techniques were employed in working cryptocrystalline silicate (CCS) raw material in the production of blades and bladelets from quads A and B in square H5 at the late Holocene site of Holkrans Rock Shelter?

1.3 RATIONALE

In southern Africa, technological analysis of lithics, and studies observing the *chaîne opératoire,* are relatively abundant in the study of the Earlier Stone Age (ESA) and Middle Stone Age (MSA) (e.g. Soriano *et al.* 2007; Sharon 2009; Wilkins & Chazan 2012; Porraz *et al.* 2013), but very few such studies exist in Later Stone Age (LSA) scholarship (Rivat 2006; Modikwa 2008). Stone tool typologies that predominantly focus on morphological and functional attributes (Sampson 1974; Humphreys & Thackeray 1983; Deacon 1984) currently define the lithic component of the LSA. Technological analysis seeks to overcome the homogenization of LSA lithic types to better the understanding of production and use.

1.4 HOLKRANS ROCK SHELTER

The material that forms the sample for this project was excavated from Holkrans rock shelter (hereafter referred to as Holkrans) in the Vredefort Dome Mountain Land. The site itself (BFK1) is in the North West Province, on the property of Thabela Thabeng, and is named after the original farm Buffelskloof 511 IQ (Fig. 1.1). The Vredefort Dome is what remains of a colossal meteorite impact crater that formed 2023 million years ago (Reimold & Gibson 2009). The Dome is populated by 'Bankenveld' vegetation (Bakker *et al*. 2004), and cross-cut by the Vaal River that flows generally west. Dated to within the last 2000 years, the archaeological deposits at Holkrans record evidence of interaction between hunter-gatherer and farming communities (Bradfield & Sadr 2011; Banhegyi 2011).

The square with which we are principally concerned is H5 (Fig. 1.2). Square H5 was excavated in sixteen alphanumeric subdivisions using letters A-D and numbers 1-4. Letters have four stacks (e.g. A1-A4) of up to 11 spits (each 3-5 cm). Only material from the 'A' and 'B' lines in H5 (plan area of 0.5x1 m) was analysed due to time constraints. The lithic component from H5. A and B contains 3216 pieces of stone comprising more than 11 raw material types (Table 4.3). From this, a sample (n=863) of CCS cores and debitage was selected for technological analysis following Soriano *et al*. (2007). Dates are provided in Table 1.1.

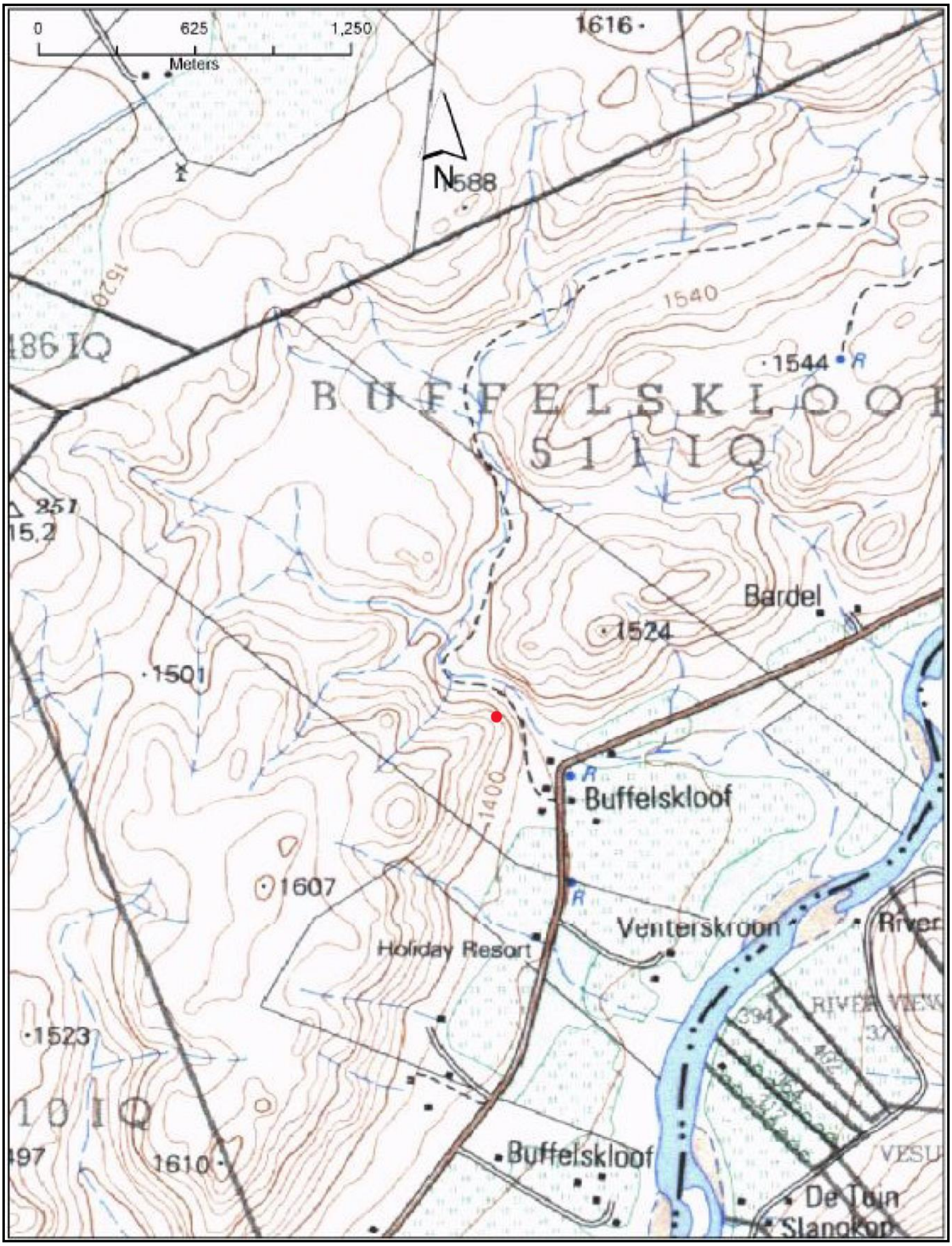


Figure 1.1: Map of Buffelskloof Farm. Holkrans rock shelter is marked by the red dot.

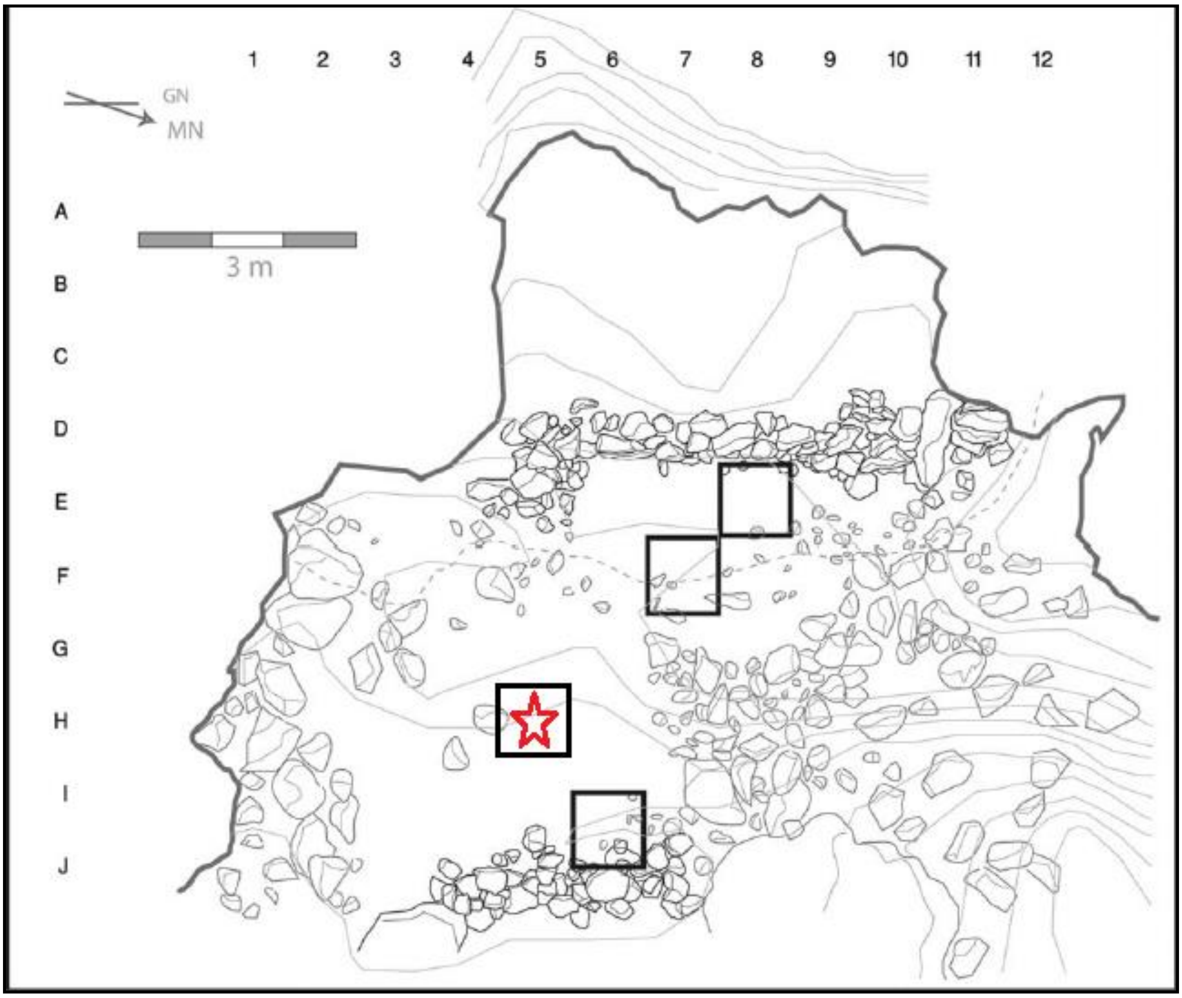


Figure 1.2: Plan view of the excavation site at Holkrans rock shelter. Material discussed in the present study comes from H5, indicated by the red star.

Excavations at Holkrans have taken place annually since 2008 (Sadr 2008b; 2009) under the supervision of Prof. Karim Sadr (permit number 80/08/04/004/51) on behalf of the University of the Witwatersrand. Sadr has held field schools at Holkrans to provide field training to Honours and 3rd-year Archaeology students.

Apart from field reports (Sadr 2008b; 2009), the initial publication of Holkrans focused on a suite of four bifacially tanged and barbed arrowheads from the very base of the ceramic phase of occupation in squares J6, F7, and E8 (Bradfield & Sadr 2011). One other bifacial arrowhead, neither tanged nor barbed, was also recovered (Bradfield & Sadr 2011).

Research at Holkrans has also investigated the frequencies and distribution of tool types produced on different raw materials (Banhegyi 2011), as well as use-wear (Law de Lauriston 2014) (to be discussed in Chapter 5).

Stephen Banhegyi's (2011) Honours project on material from Square E8, investigated temporal, possibly cultural differences between two phases of occupation. Using the dates in Table 1.1 to correlate his observations, Banhegyi (2011: 45) found that there were "punctuated, possibly seasonal, occupations between 2 000 and 1 000 years ago", with occupation becoming increasingly more sedentary from the second millennium AD (Banhegyi 2011: 45).

Banhegyi (2011) demonstrated that the distribution of raw materials as well as artefact types showed some discontinuity between the pre-ceramic and ceramic phases of occupation, suggesting significant interaction with farmers in the area (Banhegyi 2011: 45). Banhegyi suggests that further research could shed light on the kinds of social dynamics in the more recent levels of the deposits; a change in subsistence economy might help provide an explanation, but Banhegyi warns against moving from one extreme form of economy to the other in an attempt to understand the nature of the observed transition (Banhegyi 2011: 45).

Table 1.1: Radiocarbon dates from Holkrans

Lab	**Number**	**Context (BFK1)**	**BP**	**SD**
Beta	304272	H5.C4.2	60	40
Beta	287474	J6.B4.4	140	40
Beta	265301	F7.B2; B3.7	190	40
Beta	284940	E8.A2; A1; B1.5	270	40
Beta	304271	H5.C3.7	760	40
Beta	304270	H5.B3.5	900	40
Beta	304269	H5.B2.3	970	40
Beta	287473	J6.B3.10	1080	40
Beta	304273	H5.D4.9	1430	40
Beta	284941	E8. A4; A3; B2.9	1830	40
Beta	265300	F7.A2.11	2320	50

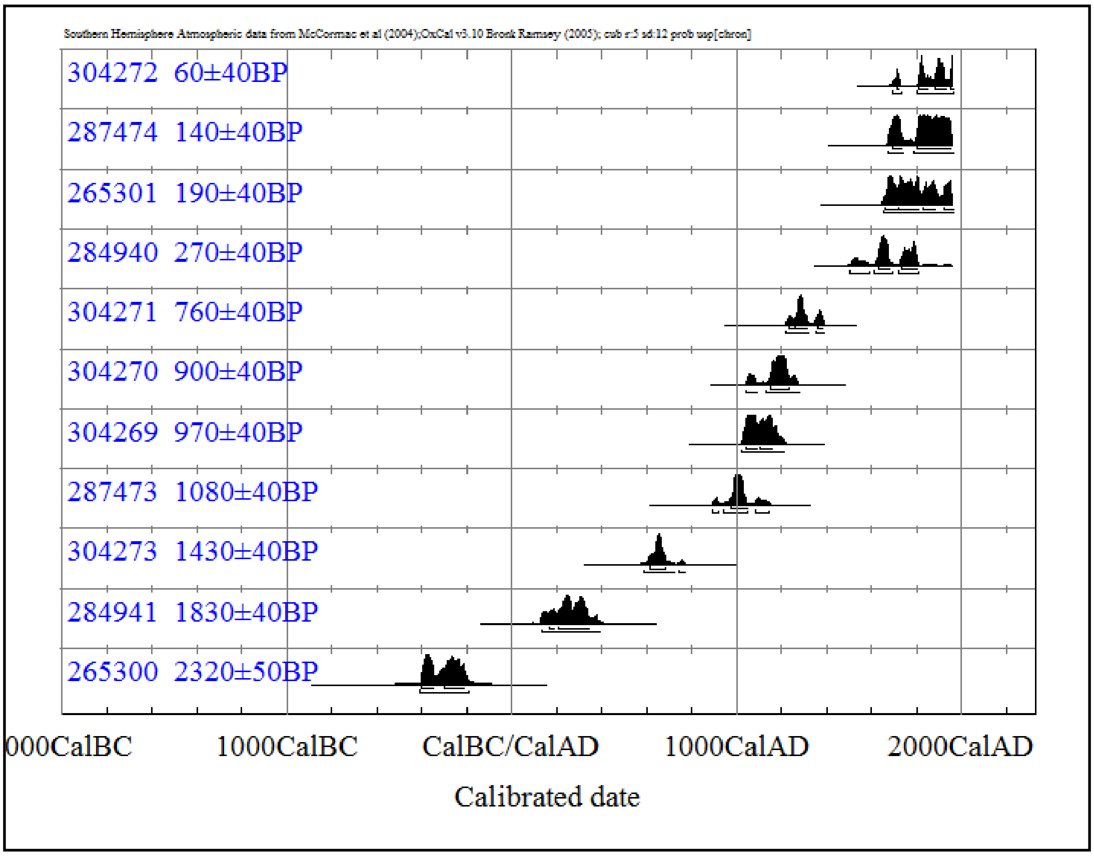


Figure 2: Diagram of radiocarbon dates calibrated using OxCal

CHAPTER 2: LITERATURE REVIEW

2.1 HOLKRANS AND THE SITES OF THE TERMINAL LATER STONE AGE

Known archaeological sites within the immediate vicinity of the Vredefort Dome represent cultural heritage ranging from the Middle Stone Age (MSA) right through to historic times (Pelser 2009). Most archaeological research in the area has focused on the significantly more abundant stone-walled sites that occur in and around the Dome (Mason 1968; Maggs 1976; Taylor 1979; Pelser 2003; Nkhasi-Lesaoana 2008; Byrne 2012).

Holkrans is, however, unusual for a number of reasons. No other rock shelters in the Vredefort Dome are known to show evidence of human occupation (Pelser 2009). Thus, deposits containing lithic artefacts are unique. Other finds of lithic artefacts in this region are usually single items or concentrated surface scatters (Pelser 2009).

One of the initial questions posed by Karim Sadr from the initial excavation of Holkrans asked if the apparent absence of ceramic wares (both thick and thin walled) from LSA and Early Iron Age (EIA) sites in the Free State and North West provinces (*cf.* Sadr 2008a: 184) was due to a lack of research focus, or if there was a real gap between ceramic-bearing LSA/EIA sites to the northern and southern parts of South Africa (K. Sadr, pers. comm. 2014). The absence of Early Iron Age (EIA) sites within or near to the Dome (Huffman 1996; Pelser 2009: 186; K. Sadr, pers. comm. 2014) and the relatively late arrival of ceramics at Holkrans within the last 500 years (Bradfield & Sadr 2011), suggest a reason other than a lack of research for the anomalous spatial distribution.

Holkrans is thus of interest as an archaeological site both because of its position and age relative to other sites. Jubilee Shelter (Wadley 1987), over 140km to the north, and Roosfontein Rock Shelter (Klatzow 2000), over 180 km to the south, are the nearest published sites with deposits that date to within the age range of Holkrans.

2.2 GEOLOGICAL CONSIDERATIONS

Since an investigation into technology necessarily considers raw materials (Inizan *et al.* 1999), it is important to consider the regional geology of the Vredefort Dome. This feature has an abundance of suitable raw materials for knapping, most of which are represented in the excavated material. Typologically, quartz, quartzite, shale, fine grained (chalcedony and chert) and 'other' (Banhegyi 2011: 27) were categories previously used to classify the raw materials from this region. Further typological analysis (since 2011) has recognised that other rock types are present in the Holkrans assemblage.

I discuss two kinds of geological deposits below. The first kind is regional ‘outcrop’ geology found on any geological map of the Vredefort Dome. The second is the alluvial deposits of the Vaal River.

Some of the rock types, in the first group, result from the Vredefort Impact Event that occurred *ca.* 2023 Ma ago (Reimold & Gibson 2009). The impact uplifted rocks belonging to the Dominion, Witwatersrand, Ventersdorp and Transvaal Supergroups (Reimold & Gibson 2009). Within this sequence of rocks, quartz, quartzite, metapelite, andesite, dolerite/gabbro, diamictite, shale, basalt, dolomite, chert and iron oxides all occur (Reimold & Gibson 2009).

Further rock types resulted specifically from the metamorphic conditions of the impact event. Two of these are pseudotachylitic breccia and the “Vredefort Granophyre” (Reimold & Gibson 2009: 132). These impact event-related rocks require geological ‘know-how’ to identify: although the Vredefort Granophyre has a homogenous composition and fairly regular appearance, the formation processes and composition (and therefore appearance) of pseudotachylite is highly variable (Reimold & Gibson 2009; Roger Gibson, pers. comm. 2013).

An unavoidable inconsistency in classification results if such unusually and variable rock types are identified using purely visual characteristics. In contrast, geochemical techniques (such as x-ray fluorescence spectrometry [XRF]) and neutron activation analysis [Herz & Garrison 1998]) are able to determine petrographic and compositional information. In turn, this information may then be used to link rocks from the excavation to the locality from which they were sourced (for example, Luedtke 1979).

The second kind of geological deposit in this discussion, the gravels of the Vaal River, are another possible source of suitable raw materials. Since the mid- 1900s, there has been significant interest in the archaeology and geology of the Vaal River Basin (Breuil *et al.* 1948; Van Riet Lowe 1952). In his study of the Lower Vaal Basin, Helgren (1979) identified primary and secondary sources of gravel in the Lower basin. Secondary sources are not significant to this project, and I move on to a discussion of the primary sources below.

Three primary sources of gravel were identified *in toto* by Helgren (1979). Two sources, somewhat restricted to the Lower Vaal Basin, derive from the Dwyka glacial sediments and other lithologies of the Karoo Basin. The third primary source, although “a less significant source of coarse clasts”, is most important to this review.

The gravels from the third source are not strictly limited to the lower part of the Vaal basin, and comprise

> the fine gravels dispersed in the bed-loads of nearly all rivers on the high plateaus of southern Africa. These pebble-grade particles of quartz, agates, chert, heavy mineral schists and gneisses and quartzite, produced by erosion of various Precambrian rocks in the Vaal basin, are virtually indestructible, and probably have migrated intermittently across the subcontinent since the early Mesozoic (Helgren 1979: 168).

Gravel deposits in the Vaal River consist of rounded pebbles found in the river terraces and in river bed itself (Van Riet Lowe 1952). On the subject of the kinds of rock types represented in the Vaal River gravels, Van Riet Lowe remarked that the during the river’s

> southward migration over and through the Karoo sediments all the softer elements in the conglomerates and shales were destroyed or washed away, and only such resistant rocks as quartzites, quartz, chert, agate, jasper, banded ironstone and chalcedony- rocks which had survived the

> rigours of glacial action during earlier geological times-survived for a second time (1952: 137).

Research in this project focuses on fine-grained, siliceous raw materials for two reasons. First, a consideration of the *chaîne opératoire* for all raw materials at Holkrans is beyond the scope of an Honours project. Secondly, the degree to which more macroscopically variable raw materials can be identified accurately without geochemical techniques is uncertain.

The regional ‘outcrop’ geology provides two types of fine-grained, siliceous raw materials suitable for knapping: quartz and chert (Reimold & Gibson 2009). In contrast, the alluvial deposits of the Vaal River contain several ‘pebble-grade’ varieties (Van Riet Lowe 1952: 137) of what are here called cryptocrystalline silicates (CCS).

2.3 CRYPTOCRYSTALLINE SILICA, CHERT, AND OPALINE

The terminology of cryptocrystalline silicates (CCS) requires some elaboration with respect to three common terms used for varieties of this raw material. The terms ‘cryptocrystalline silica’, ‘chert’ and ‘opaline’ are often used synonymously in archaeological literature. If not, other terms such as ‘agate’, ‘jasper’ and ‘chalcedony’ (effective synonyms) are used in their place. Obviously, it is confusing if the reason for the use of one term over another is not specified.

Crucially, it is important to note that the terms I am attempting to clarify refer to rocks, minerals and mineraloids with equivalent geological compositions; all are varieties of silica (SiO_2), more commonly known as quartz. A term should be specific within the context of a project. I therefore provide some definitions from a modern geology dictionary and explain how the terms will be used in this project.

The *McGraw-Hill Dictionary of Geology and Mineralogy* (MGHD) defines silica as

> naturally occurring silicon dioxide; occurs in five crystalline polymorphs (quartz, tridymite, cristobalite, coesite, and stishovite), in cryptocrystalline form (as chalcedony), in amorphous and hydrated forms (as opal), and combined in silicates

Cryptocrystalline silica

One of the raw material categories in the typology at Holkrans is cryptocrystalline silica (CCS). To be sure, every artefact analysed in this study from lines A and B in H5 was identified as CCS during typological classification based on macroscopic attributes relating to appearance, texture, colour, and lustre.

Cryptocrystalline (or microcrystalline) is one form of silica, as in chalcedony or agate (Dake *et al*. 1938; see also the definition for silica above). The *MGHD* defines cryptocrystalline as "a crystalline structure … of such a fine grain that individual components are not visible with a magnifying lens". Strictly speaking, CCS should thus be used in reference to *only* those forms of truly cryptocrystalline (*cf*. amorphous) silica.

In this research project, however, CCS has been used as a 'lumping' category, following on from previous research (Banhegyi 2011). The use of 'CCS' in this project refers, in the collective, to *chert and opaline.*

Chert

The term 'chert' has a less strict usage in geological literature than cryptocrystalline silica. Partly, this is due to conflation of 'chert' with other fine-grained siliceous rock types, such as flint (Dake *et al*. 1938: 128). Ironically, the geological context of 'chert' is a useful means of differentiating it from other rock types. According to Dake *et al*. (1938: 128) "Chert is one of the amorphous quartz minerals … usually … associated with limestones or dolomites". Southern Africa has an abundance of dolomites relative to limestones, and in the Vredefort Dome region, siliceous material is found within the dolomites of the Transvaal Supergroup (Reimold & Gibson 2009). Dolomitic cherts often bear internal textures and patterns due to their association with stromatolitic life-forms (for example, see Eriksson & Altermann 1998). Within chert from the Transvaal Supergroup, bands of lighter and darker areas, relating to domal stromatolitic formations, are macroscopically recognizable in the H5 assemblage.

'Chert' is used in this research project to refer *only* to that proportion of CCS which is macroscopically identifiable to originate from dolomites.

Opaline

The MGHD gives the following definition for ‘opaline’: “Any of several minerals related to or resembling opal”. Thus, ‘opaline’ effectively means ‘resembling opal’. In the paper by Soriano *et al.* (the method of which I follow in this project), it is stated that for opaline, “equivalent terms are chalcedony and opal” (2007:684). They add that “[o]paline is a fine-grained raw material, of variable colors (*sic)*, from opaque red and light brown to green; the geode-like nodules can be translucent or whitish” (2007:684).

Following the MGHD definition for silica, ‘chalcedony and opal’ are not equivalent *geological* terms at all: chalcedony is a form of cryptocrystalline silica and opal is amorphous hydrated silica (Dake *et al*. 1938). Indeed, chalcedony and opal are structurally different forms of silicon dioxide.

The reason ‘opaline’ is used in archaeological literature is, I suggest, because the term is useful to a technological analysis. Opaline, in this case, refers to a group of raw materials with several *physical* properties ‘resembling’ those of opal. As an example, Soriano (Soriano *et al.* 2007: 684) collected opaline material “from outcrops in the Golden Gate Highlands National Park (Lesotho)” and grouped the raw materials under “opaline”, establishing that they were “comparable to flint” (Soriano *et al.* 2007: 684). By doing this, he paid attention to the technological characteristics of raw materials and the implication of the raw material for different knapping techniques- a standard practice when investigating *chaînes opératoire*s (for example, see Inizan *et al*. 1999).

In this project, however, the term ‘opaline’ is used to *specify* material within the CCS category that is not chert.

In sum, a technological approach must necessarily be cognisant of the range, kinds, and possible sources for raw materials within the study areas. An understanding of raw materials from the Vredefort Dome, and artefact types produced from these unique rocks, will contribute to a developing body of LSA lithic technology research. In its entirety, such a task is beyond the scope of this project. However, I will attempt to gain an understanding of the relationship between sources of chert and opaline, and the technology of blade/bladelet production at Holkrans. Next, I discuss the most common approach to stone artefacts from the LSA in southern Africa.

2.4 TYPOLOGIES

The well-known standard typologies for early Holocene southern Africa, constructed by Deacon (1984), Humphreys & Thackeray (1983), and Sampson (1974), all classify LSA material culture according to raw material and artefact type categories. Each is regional, and understandably problematic when used outside of the appropriate area. The difficulty of constructing a typology for Holkrans has been recognised: the range of suitable raw materials available in the Dome is wide.

The practice of identifying artefact types has persisted in the study of the southern African 'Stone Age' since the later part of the 19th century (e.g. Péringuey 1911). One reason for such longevity is that a typology is a successful classificatory system that functions to simplify large volumes of data while attempting some degree of "prehistoric reality" (Humphreys & Thackeray 1983: 8).

Since the 1950s, debate has concerned the use and design of typologies (Krieger 1944; Spaulding 1953; Hayden 1984). Brian Hayden's (1984) discussion of the relevance of emic (mind-of-the-maker) compared to etic (subjective) classification usefully highlights the difficulties in treating a 'standard' typology as an approximation of any culturally-specific (emic) classificatory system. Typologies, it must be recognized, are 'stand-alone' constructions that must be corrected by as much independent evidence as possible (Hayden 1984; Bar-Yosef & Van Peer 2009).

Somewhat ironically, technological attributes are quite easily incorporated into a typological scheme. In general, studies of southern African lithic assemblages use a typology informed or determined by aspects of the technological process that reduced the core and produced the end products (the reduction sequence) classified within the typology.

The well-known and respected typologies of Janette Deacon (1984) and Humphreys & Thackeray (1983) are examples of what may termed "classification schemes based on lithic reduction sequences" (Barham 1987: 49). Indeed, Deacon (1984: 370) begins her typology by stating that "[t]his scheme is based on the reduction sequence from raw material to formal tool".

Technological aspects within such typologies are (correctly) only mentioned when relevant to the strict functioning of the typology. Humphreys & Thackeray (1983: 302), for example, observe that backed bladelets "were produced by means of a technological reduction process which resulted in both finished backed blades suitable for hafting and discard items" (Humphreys & Thackeray 1983: 302).

As can be seen, the incorporation of technological attributes into a typological scheme is not difficult. This is because some morphological types that are usually identified by "shape and location of retouch" (Odell 1981: 319), such as scrapers and burins, are technologically heterogeneous. Other morphological types, however, are technologically specific (Odell 1981).

Backed bladelets, as noted by Humphreys & Thackeray (1983: 302), can only be produced with blade technology. Blades (as a kind of flake) require specific techniques to be produced in contrast to most other kinds of debitage (Bar-Yosef & Kuhn 1999). Furthermore, blade production may relate to the size of the core as reduction progresses (Flenniken & White 1985), and thus a typology ignorant of technological attributes ignores the possibility of technological diversity for similar types.

Typological classification has, in the past, been regarded as paradigmatically different from *chaîne opératoire* (Sellet 1993). Pragmatically, the two are different: on one hand, typologies create a classification that simplifies the data, but always "[a]rtefact types remain the creation of archaeologists" (Humphreys & Thackeray 1983: 10; *cf*. Spaulding 1953). On the other, technological analysis aims to reconstruct a process closer to that originally followed from the procurement of raw material to the abandonment of the artefact (Soressi & Geneste 2011).

Recent literature has stressed the similarities that exist between aspects of typological and technological classification. Rather than coming from different paradigms, the two approaches do in fact share some common ground and are not mutually exclusive (Shott 2003; Bar-Yosef & Van Peer 2009). A form of typology called ‘technological classification’ forms one of the key aspects of *chaîne opératoire* methodology (Bar-Yosef & Van Peer 2009).

2.5 *CHAÎNE OPÉRATOIRE*

The method I employ follows Soriano *et al*. (2007), who drew on ideas stemming from *chaîne opératoire*, rather than ‘reduction sequences’. C*haîne opératoire* is therefore the focus in the discussion below.

Technological analysis can be traced back to the French tradition of *chaîne opératoire* (Sellet 1993) and the American concept of reduction sequences (Shott 2003). The concept of reduction sequences is generally accepted to have arisen contemporaneously with *chaîne opératoire* (but see Shott 2003; Bar-Yosef & Van Peer 2009: 105), and there are many areas of overlap between the two approaches (Shott 2003). Both the French and American approaches deal with an analysis of fracture mechanics, raw material sourcing, and reduction procedures (Andrefsky 1994, 2008; Inizan *et al.* 1999; Odell 2000). However, the two approaches remain distinct largely because of their intellectual origins.

It was André Leroi-Gourhan who coined the phrase *chaîne opératoire*. He grounded its definition in action and limited it to techniques:

> Techniques are at the same time gestures and tools, organized in sequences by a true syntax which gives the operational series both their stability and their flexibility. The operational syntax is generated by memory and is born from the dialogue between the brain and the material realm (Leroi-Gourhan 1993: 114, quoted in Audouze 1999: 168).

Leroi-Gourhan’s work on technique, together with Lemmonier’s insights from ethnology, was particularly influential to the French school of thought (Sellet 1993). Processual archaeology in America addressed equivalent issues with alternative terminology (Sellet 1993; Shott 2003).

Peter Bleed has recognized that

> In conception and application, however, *chaîne opératoire* remains distinctively French because, as Schlanger (1994) points out, two

> intersecting French intellectual traditions contributed to the development of the modern *chaîne opératoire* approach. The first of these was the replicative work of French archaeologists, such as Bordes and Tixier. The second was the interest of many French anthropologists - notably Mauss and Leroi-Gourhan - in cognitive aspects of behavior (*sic*) (2001: 105).

Thus, *chaîne opératoire* has a definite cognitive basis (Audouze 1999; Bleed 2001; Bar-Yosef & Van Peer 2009; Soressi & Geneste 2011).

In such an approach, "[t]echnology is considered a mediator between Nature and Culture, material and social" (Audouze 1999: 167). For *chaînes opératoires,* the production of a tool processes raw material from the natural world into a cultural product (Lemonnier 1992: 26). It is principally because stone tools are durable and physically preserve signs of technological gestures that they are suitable candidates for investigations of procedures behind the manufacture of specific products (Modikwa 2008: 8).

The *chaîne opératoire* approach boasts a well-conceptualized methodology that is effective because of an overarching conceptual scheme that can be understood by looking at the necessary relationship between the different stages in the sequence (Leroi-Gourhan's syntax). According to Soressi & Geneste, the principal conceptualization of the *chaîne opératoire* is that

> the constant elements (regularities) of the operational scheme allow determination of the conceptual scheme driving the operational scheme. The definition of the goals of the conceptual scheme allows definition of the initial project (2011: 337).

Ultimately, the final product of a particular sequence is related to, and determined step-wise from, the initial product. Contextually, the conceptual scheme is culturally situated; whatever the intended product, the overall technology of the group is constraining (Inizan *et al.* 1999; Soressi & Geneste 2011: 337).

The idea of an 'overarching conceptual scheme' has, not surprisingly, received some criticism. Peter Bleed (2001: 120) has argued that the study of process-orientated sequences, such as investigating the *chaîne opératoire* or reduction sequence, often places an emphasis *either* on predetermined patterning that follows a strict plan, *or* situational responses to developments that occur during the knapping activity. *Chaîne opératoire*, with its ‘overarching conceptual scheme’ places emphasis on the predetermined patterning towards an end product and does not allow much room for reactions to new situations during the knapping activity (Bleed 2001: 121).

In practice, *chaîne opératoire* methodology has been successful in addressing variability due to situational responses (Bleed 2001: 121, see also Lemonnier 1992; Bar-Yosef *et al*. 1992). This is because the *chaîne opératoire* can operate at different scales of analysis within specific contexts, observing small objects themselves and large-scale features, such as distances to raw material procurement sites (Soressi & Geneste 2011: 344). *Chaînes opératoires* are, nonetheless, detrimentally limited by problems of representation when ‘steps’ in the operational sequence are missing (e.g. from the technological classification) and are speculated about rather than critically acknowledged (Bar-Yosef & Van Peer 2009; Soressi & Geneste 2011: 339-341).

The methodology I have described above has four key pragmatic components that relate to levels of observation and inference (Inizan *et al*. 1999: 16). In no particular order, they are: experimental replication, refitting, reading the diacritical scheme, and technological classification (Bar-Yosef & Van Peer 2009). Experimental replication provides insight into the response of raw materials to various percussion and pressures, as well as the kind of technique required to produce specific blanks. Core refitting studies are recognized to be a fairly straight-forward but time consuming way of reconstructing the sequence of removals (for example, Bar-Yosef & Van Peer 2009). Reading the diacritical scheme (*lecture des schemás diacritiques* [Boëda 1986:16]) is a further key component, and entails analysing the relationship between different scar patters on an artefact to establish a relative sequence of removals and/or retouch phases. The remaining key component to be discussed, flagged during the discussion of typology, is technological classification.

Technological classification is essentially a typology but gives special consideration to technologically relevant attributes (Bar-Yosef & Van Peer 2009). Bar-Yosef & Van Peer (2009: 117) remark that technological classification “is instrumental to reveal patterning in the record and, hence, to provide us with an empirical basis for reflection on population-level processes”. Without the recognition of patterning no “regularities” can be identified, and what would otherwise be “determination of the conceptual scheme” is rendered as speculation (Soressi & Geneste 2011: 337).

Despite the pragmatic differences between typological and technological classification, the ‘regularities’ and ‘patterning’ allows for forms that demonstrate a reasonable frequency in a typology, such as blades, bladelets, and formal tool categories, to be considered conceptually as part of the technical knowledge of a group (Bar-Yosef & Van Peer 2009).

Southern African scholars have adopted technological analyses for studies in the ESA and the MSA, and then only very recently because of the lacuna that often exists between African and international scholars (e.g. Conard *et al.* 2004). Research into the LSA lacks the benefits of technological analyses. As noted by Judges Modikwa (2008: 15):

> Generally there have been few attempts at doing *chaînes opératoires* type studies in southern Africa (e.g. Conard *et al.* 2004; Rivat 2006; Soriano *et al.* 2007). Most of these works have pointed out the usefulness of the *chaîne* opératoire approach to lithic analysis more especially in unified taxonomy of lithic production sequences in Europe and southern Africa.

Modikwa (2008) analyzed LSA blades and bladelets from the sites of Toteng 1 and Mphekwane Rock shelter and followed the method of Soriano *et al.* (2007) that was originally designed to investigate the production of blades from Howiesons Poort (HP) and post-Howiesons Poort (post-HP) levels of Rose Cottage Cave. The use of the same method by these researchers is advantageous if comparisons are to be made between the two studies because, not only have they considered similar kinds of material (ignoring temporal differences), but that material has been considered in the same way- both studies have the same kind of data.

In the next section, I give the methodology used in this project with details of the characteristics used in the analysis of blades and bladelets by Soriano *et al*. (2007) and Modikwa (2008).

CHAPTER 3: METHODOLOGY

3.1 TYPOLOGY

The initial step of this research project was the typological classification of stone material from BFK1. H5. A and B. Lithic material was checked for non-lithic remains, and any organic or ceramic remains were removed, labelled and bagged separately. Remaining lithic material was then cleaned with water and a toothbrush and then left to dry. Once dry, lithic material was typologically classified following a modification of Deacon's (1984) typology for the southern Cape previously used by Banhegyi (2011). The typology for each square was recorded by spit into Microsoft Excel spread sheets. Pieces <1 cm^2 were classified as chips and are uncounted in this typology. A total of 3216 (Table 4.3) pieces of stone >1 cm^2 were analysed.

The typology used by Banhegyi (2011) required some revision of raw material categories because of the range of raw materials available in the Dome. The raw material types recorded are listed in Tables 4.1 and 4.3. The 'other' category contains unidentified rock types, as well as uncommon rock types, such as sandstone and pseudotachylitic breccia. Morphological types used are listed in Tables 4.1 and 4.2. 'Backed pieces' and 'MRPs' are further detailed in Chapter 4.

After classification was complete, data in each spread-sheet was combined into a 'master table'. Totals, as well as patterns relating to frequency and distribution of lithic and raw material types, can be analysed from the master table. Totals from the master table give most of the sample size for the CCS category (Table 4.2) which was also analysed technologically. However, the technological sample is larger (by precisely 18 pieces) (Table 4.3) because the procedure did not allow 'Wall-shavings' to be included in the 'master table', which is arranged by spits in stratigraphic order.

3.2 SEPARATION OF CCS FROM OTHER RAW MATERIALS

Every piece of CCS material (n=863) was labelled in a non-destructive way, using strips of Typek computer paper with printed numbers that were applied to the artefacts with wood glue. The labels preserved contexts during the investigation of refits between artefacts in adjacent spits and within squares. Refit relationships are a key part of the *chaîne opératoire* methodology (see Chapter 2) and could potentially contribute to the understanding of reduction strategies at Holkrans.

I chose to focus *only* on CCS material for four reasons. First, a *chaîne opératoire* for all the lithic material in H5. A and B is beyond the scope of an Honours project. Secondly, the structure and method of this project follows Soriano *et al.* (2007) who focus their study of blade technology exclusively on opalines, a kind of CCS. Thirdly, the formal tools at Holkrans are more often made on CCS than any other rock type (Table 4.1). Finally, the variety of raw materials in the Dome (and the small volume of individual pieces in the archaeological deposit) weakens the current typology that does not make use of geochemical techniques.

A minor part of this study details an attempt using a geochemical technique to determine where chert was sourced from. Geological field samples within a 10 km radius of Holkrans were analysed compositionally using a portable x-ray fluorescence (pXRF) spectroscope, and compared to an equally sized sample of chert from the archaeological sample. There is currently no entity from which one may obtain a research permit to remove rocks from the Vredefort Dome (*cf.* Bakker *et al.* 2004) I was advised to continue with my research in spite of this (Roger Gibson, pers. comm. 2014).

Geological field samples came from surface scatters and outcrops on public roads in and around the Vredefort Dome that overlay dolomite (Fig. 4.1). The sample was therefore naturally randomized. The sampling of archaeological material was randomized by the fact that the aperture of the Niton® Thermo Scientific pXRF machine could only take samples of a certain size.

The pXRF machine uses x-rays to excite electrons at the surface of a substance, only to a depth of 200 µm and is virtually non-destructive (Andrefsky 2005: 44). Two different ‘methods’ were run at 230 seconds per sample. The first method– called ‘soil’– tested for elements commonly found in soils (recorded in ppm). The second –called ‘mining’– tested for elements commonly found in rocks (recorded in %). The trace element data of the mining method can be found in Appendix 3, and graphical results in Fig. 4.2.

In addition to the pXRF analysis of chert, the macroscopic characteristics of a sample of pebbles from a gravel deposit in the Vaal River will be discussed.

The bulk of this project, however, concerns technological analysis. The first part of this analysis deals with technological classification.

3.3 TECHNOLOGICAL CLASSIFICATION

3.3.1 *BIPOLAR DEBITAGE*

Bipolar debitage (Fig. 4, Table 12) was identified during typological classification with a modification to Deacon's (1984) typology, since that typology does not consider bipolar reduction. Cores were originally classified as bipolar when crushing was identifiable on both ends of the core *and* had a minimum of three removals (*cf.* Deacon 1984). Flakes were called bipolar if the bulb was negative. This is now recognized to have been an inadequate way of typologically classifying the bipolar debitage.

Technological classification of bipolar debitage, however, loosely followed that of Barham (1987) for quartz and chalcedony, with some modification using the summary of characteristics provided by de la Peña & Toscano (2013: 42) for flint:

> The main characteristics of bipolar cores are:
>
> - The hammered edge and the opposite edge become smooth and rectilinear. If the hammered side is rotated, the core becomes quadrangular or rectangular.
> - Both the striking platform and the side placed on the anvil develop numerous scars. However, normally the majority of scars are on the striking platform
> - The scars are bifacial if the profile of the core is symmetrical, or they tend to occur on only one of the sides if the piece is asymmetrical. If the core profile has one straight and one convex side, the scars will tend to be on the convex side.
> - The core rapidly becomes smaller as a result of knapping. In fact, bipolar knapping can be applied to extremely small cores (as small as 2 or 3 cm).
> - Although the cores are not prepared in any way, a striking platform is automatically created as a result of the hammering process.
> - The scars resulting from hammering are usually step or hinge terminations.
> - The scars on bipolar cores normally have deep ripples.

> - The scars, especially on the striking platform, develop in the following way: at first, the scars are large and usually overlap. The fact that the initial scars are hinged means the subsequent ones are also hinged, but smaller. This second bout of hammering tends to produce a row of parallel scars. Eventually, the area immediately next to the edge fissures and becomes blunt.
>
> The main features of blanks resulting from bipolar knapping are described below:
>
> - A wide variety of bipolar blanks was obtained, including flakes, bladelets, and chunks.
> - They generally have broken or linear butts and the front part shows the fissures mentioned above.
> - They do not exhibit a distinguishable impact point.
> - The ripples on the bulbar faces are very marked and close to each other.
> - The profile of the bipolar blanks tends to be rectilinear, but this depends on the morphology of the core.
> - A specific feature of recurring knapping is a pronounced hinge bulb.

The above quotation excludes image references, and the important attention de la Peña & Toscano (2013) gave to hammers and anvils; none were found in H5. A and B.

Four categories have been identified for the purposes of this study: cores, flakes, bladelets, and other (falling outside of the other categories). The amount of bipolar debitage identified during technological classification is therefore greater because the scheme was more detailed and comprehensive.

3.3.2 *BLADES AND BLADELET*

Analysis focuses on the platform attributes of blades and bladelets (Fig 3.1 [Right]), following the method and using the specialized database for the blade platforms on opalines in Soriano *et al.* (2007: Fig. 5). The raw materials CCS, chert and opaline (see Chapter 2) are technologically similar enough that other studies of equivalent materials can be used comparably (e.g. Barham 1987; Inizan *et al.* 1999; Soriano *et al.* 2007; Modikwa 2008; de la Peña & Toscano 2013).

Blade and bladelet analysis includes all material identified as ‘blade’ or ‘bladelet’ during typological analysis. Following Deacon (1984: 375), a bladelet is treated as “A narrow parallel-sided flake with a length greater than twice the maximum width and a width less than 12 mm.” Blades were identified using the same definition but for widths greater than 12 mm. After identification, technological classification followed Soriano *et al.* (2007: 688) (see Fig. 3.2, Appendix 1, Table 5.1).

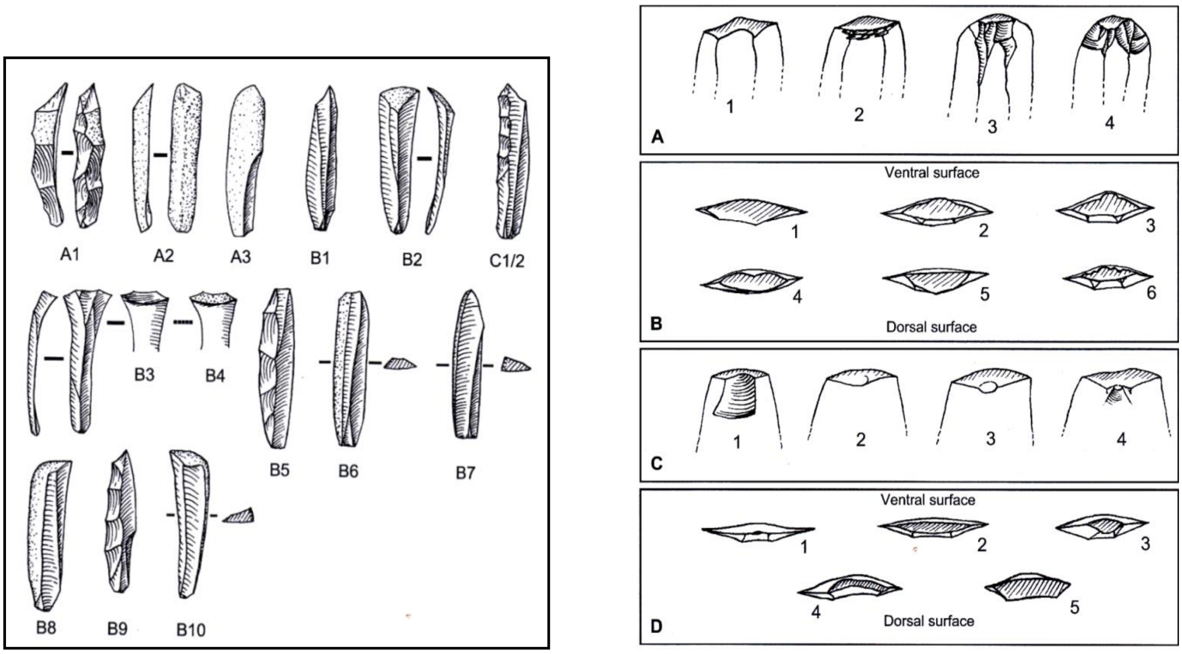


Figure 3.1: Left: Technological classification for blades after Soriano et al. (2007: Fig. 4). Right: Platform features from specialized database for after Soriano et al. (2007: Fig 5).

A sample of cores was identified during both typological and technological analysis. Definition of cores followed Deacon (1984). Cores were drawn following a modification of Inizan *et al.* (1999), and the diacritical scheme of the flake scars was noted during the drawing process (see Appendix 2; Table 3.1). Cores are classified according to Table 3.1 below:

Table 3.1: Core types in the Ceramic and Pre-ceramic levels

Core types	Ceramic		Pre-ceramic	
Free-hand cores:	n	%	n	%
Bladelet cores	1	5.6	2	28.6
Bladelet core fragments	2	11.1	0	0
Failed cores	2	11.1	3	42.8
‘Dual’ core	0	0	1	14.3
Bipolar cores:				
Bipolar cores (complete)	2	11.1	0	0
Bipolar cores (incomplete)	11	61.1	1	14.3
Totals	18		7	

Following a suggestion from Paloma de la Peña (pers. comm. 2014) that the width of blades and bladelets is the most likely dimension to preserve, the widths for all blades and bladelets were taken to check the typometrical distribution of sizes (Fig. 3.2). Blades and bladelets fall within a normally distributed data set. The terms ‘blade’ and ‘bladelet’ are thus used interchangeably in this study, unless otherwise specified. For the sake of discussion, I use blade(let)s to refer to the collective.

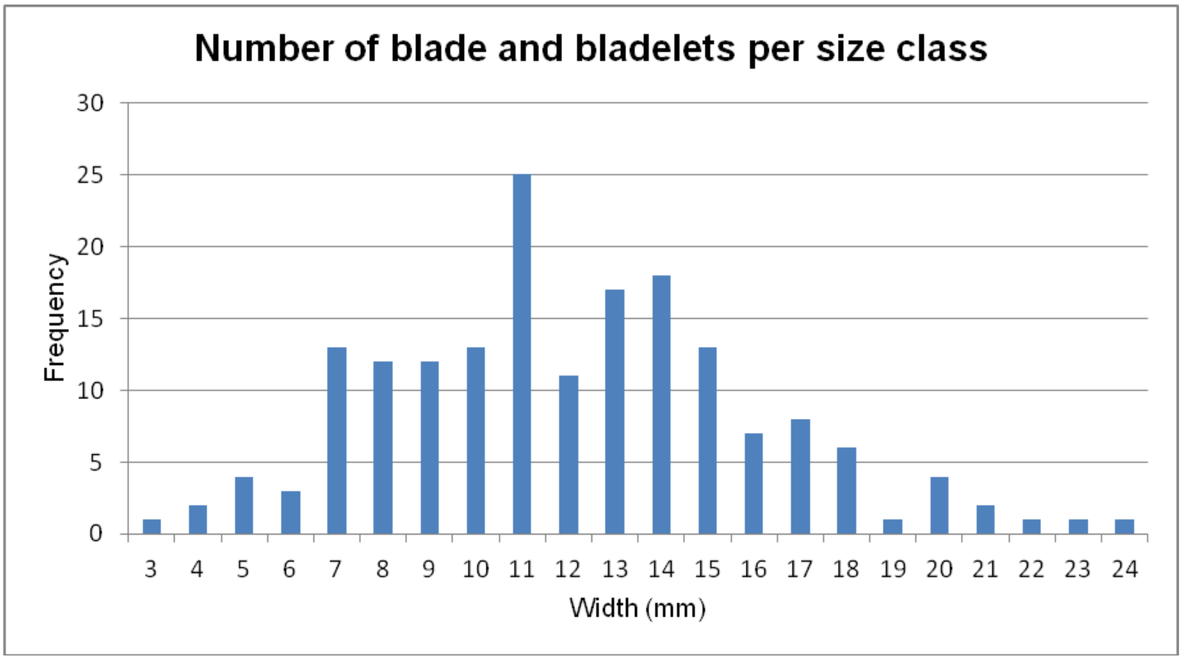


Figure 3.2: Typometric distribution of blade and bladelet sample by width

After the blade and bladelet technology at Holkrans has been analysed, stone artefacts further along the *chaîne opératoire*, namely retouched tools, will be comparatively assessed. The final part of the analysis looks at the possible changes through time in raw materials, technology and formal tools.

CHAPTER 4: ANALYSIS AND INTERPRETATION

Results are reported in two conceptual components. The first component is typological. The second component deals with technological analysis.

4.1 TYPOLOGICAL CLASSIFICATION

In Table 4.1 below, the results of the typological classification (following Deacon 1984, see Banhegyi 2011) for raw material and artefact types are summarized by collapsing artefacts contexts so that only totals are visible. Stone material from wall-shavings could not be included in Table 4.1 because of the stratigraphic nature of the recording system. It is, however, represented in Table 4.3.

I have already mentioned that cryptocrystalline silicate (CCS) material is the focus of this project for several reasons (Chapter 3). A detailed summary of the typological classification of CCS is given in Table 4.2.

Table 4.1: Summary of results from typological classification excluding wall-shavings

	Bipolar Cores	Bladelet Cores	Irregular Cores	Split pebble Cores	Scrapers	Miscellaneous retouched pieces	Backed pieces	Chunks	Flakes	Flake fragments	Blades	Bladelets	Bipolar debitage	Pebbles	Crystals (whole)	
Quartz	2	0	0	0	0	4	0	144	64	17	0	7	66	1	1	306
Quartzite	0	0	0	0	0	1	0	1410	107	41	3	22	2	0	0	1586
Hornfels	0	0	0	0	0	0	3	2	0	0	1	0	0	0	0	6
Andesite	0	0	0	0	0	0	0	8	30	10	1	1	0	0	0	50
CCS	6	4	4	2	3	39	9	147	347	201	14	46	24	1	0	847
Dolerite	0	0	0	0	0	0	0	15	31	3	0	0	0	0	0	49
Shale	0	0	0	0	0	0	0	86	32	16	0	2	0	0	0	136
Basalt	0	0	0	0	0	0	0	11	15	0	0	0	0	0	0	26
Other	0	0	1	0	0	3	0	46	39	9	0	1	0	0	0	99
Ochre	0	0	0	0	0	0	0	54	0	0	0	0	0	0	0	54
Specularite	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4
	8	4	5	2	3	47	12	1927	665	297	19	79	92	2	1	**3163**

Table 4.2: Typological classification of CCS excluding wall-shavings

Spit	% Artefact Type													
	Bipolar Cores	Bladelet Cores	Irregular Cores	Split pebble Cores	Scraper	Miscellaneous retouched pieces	Backed pieces	Chunk	Flake	Flake fragment	Blade	Bladelet	Bipolar debitage	Pebble
1	7.1	0	0	0	4.8	0	0	19	26.2	26.2	0	2.4	14.3	0
2	0	0	0	0	0	4.4	0	17.4	43.5	17.4	0	8.7	8.7	0
3	1.6	0	0	0	1.6	4.8	1.6	24.2	38.7	12.9	1.6	6.5	4.8	1.6
4	2.4	1.2	0	0	0	5.9	2.4	17.9	38.1	20.2	1.2	4.8	5.9	0
5	0	0.7	1.4	1.4	0	4.1	0	24.5	36.7	24.5	0	4.8	2.04	0
6	0	1.5	0	0	0	1.5	1.5	17.6	41.2	29.4	0	5.9	1.5	0
7	0	0	1.2	0	0	5.8	1.2	11.5	49.4	26.4	2.3	2.3	0	0
8	0	0	0	0	0	4.3	0	14	44.1	21.5	6.5	9.7	0	0
9	0	0	0.9	0	0	9.4	1.9	10.4	37.7	28.3	2.8	6.6	1.9	0
10	0	0	0	0	0	5.7	0	17.1	48.6	22.9	2.9	2.9	0	0
11	0	0	0	0	0	3.3	3.3	13.3	60	13.3	0	3.3	3.3	0

4.2 RAW MATERIALS IN THE PRE-CERAMIC AND CERAMIC LEVELS

A variety of raw materials are represented in the total sample from BFK1. H5. A and B. It is worth noting the general pattern that emerges from the frequency and distribution of these rock types. In Table 4.3, quartzite is the most abundant, comprising just under half of the total lithic sample by count (49.9%).

The relative abundance of quartzite may, however, be the result of ‘noise’ due to natural rather than cultural processes (Banhegyi 2011:32). Although some quartzite pieces show evidence of retouch, it is currently not clear which quartzite pieces are spalls or chunks from the shelter’s walls and ceiling. Nevertheless, some quartzite pieces are macroscopically different enough (in both colour and texture) from the shelter quartzite to suggest that they were transported to the shelter from elsewhere.

If we exclude quartzite because of possible ‘contamination’ from natural processes, CCS is the next most abundant raw material. Interestingly, the total amount of CCS (26.9%) is greater than the sum of all raw materials combined 23.2% (excluding quartzite).

Table 4.3: Raw material totals for H5. A and B including wall-shavings

Raw material type	Quartz	Quartzite	Hornfels	Andesite	CCS	Dolerite	Shale	Basalt	Other	Ochre	Specularite	Total
n	313	1606	6	50	865	49	137	26	103	57	4	3216
%	9.7	49.9	0.2	1.6	26.9	1.5	4.3	0.8	3.2	1.8	0.1	100

In Chapter 2, I mentioned that two phases of occupation at Holkrans have so far been identified. These two phases are distinguished by the presence or absence of pottery in the stratigraphy, hence the designated names ‘pre-ceramic’ and ‘ceramic’. The ceramic (C) phase in H5 is restricted to the upper 5 spits because no ceramics were found below spit 5 during excavation. The relative arrival of ceramics in H5 can be tied to radiocarbon dates of 970± 40 BP (Beta 304269) in spit 3 and 900 ± 40 BP (Beta 304270) in spit 5 (Table 1.1). Anything below the fifth spit should be older, belonging to the pre-ceramic (PC) phase.

Between these two phases there is a difference in the distribution of raw material types. Raw material patterning resembles that recorded by Banhegyi (2011) for E8. In Table 4.4, the last row of the table gives the average for each column. Coloured cells have above average counts of lithic artefacts. Blue indicates materials present in above average proportions throughout the sequence. Pink indicates above average counts in the lower levels of the stratigraphy (i.e. PC). Green indicates above average counts in the upper levels of the stratigraphy (i.e. C).

In general, quartz and quartzite are relatively abundant throughout the sequence. Hornfels, dolerite, basalt, ‘other’ and specularite, which are all dark grey to blackish, are predominant in the upper spits. In contrast, the averages of CCS, andesite, shale and ochre decrease in the upper spits and are most abundant in the PC levels.

Table 4.4: Above average lithic material concentrations by spit

HORIZ	Quartz	Quartzite	Hornfels	Andesite	CCS	Dolerite	Shale	Basalt	Other	Ochre	Specularite
1	0.05	0.54	0.01	0.02	0.16	0.04	0.04	0.04	0.09	0.00	0.00
2	0.05	0.61	0.01	0.01	0.13	0.07	0.02	0.02	0.07	0.01	0.01
3	0.10	0.48	0.00	0.01	0.19	0.05	0.03	0.03	0.10	0.02	0.00
4	0.15	0.57	0.00	0.00	0.15	0.01	0.07	0.00	0.02	0.02	0.00
5	0.10	0.48	0.00	0.02	0.33	0.00	0.02	0.00	0.02	0.02	0.00
6	0.08	0.44	0.00	0.02	0.40	0.00	0.04	0.00	0.01	0.01	0.00
7	0.03	0.51	0.00	0.01	0.38	0.01	0.03	0.00	0.00	0.02	0.00
8	0.07	0.47	0.00	0.03	0.36	0.00	0.02	0.00	0.01	0.03	0.00
9	0.12	0.43	0.00	0.03	0.32	0.00	0.08	0.00	0.01	0.01	0.00
10	0.09	0.50	0.00	0.04	0.31	0.00	0.04	0.00	0.00	0.03	0.00
11	0.16	0.53	0.00	0.01	0.24	0.00	0.03	0.00	0.02	0.02	0.00
AV	0.09	0.50	0.00	0.02	0.27	0.02	0.04	0.01	0.03	0.02	0.00

More resolution can be added to this observation. Keeping in mind the definitions in Chapter 2, I did a count of the 863 pieces in the sample of CCS (Table 4.3) to record the different CCS types. Approximately 39% was macroscopically identified as opaline, with 61% macroscopically identified as chert. The opaline material is concentrated (but not exclusive) to the upper 1-5 spits. The remaining chert material is concentrated (but not exclusive) to the lower 6-11 spits.

4.3 INVESTIGATION OF REFIT RELATIONSHIPS

It will be recalled that one practical component of the *chaîne opératoire* method is to refit detached flakes back onto the core. It is important to note that none of the refits found in this study are core-to-flake refits. All refits are broken or snapped pieces. Thus, the refit investigation does not inform the technological investigation. The lack of core-to-flake refits could be due to the small size of the sample.

In Table 4.5, I give the number of refits found in within the study sample. Each refit consists of two pieces that can be put back together along a single break. The stratigraphic position of each piece is provided indicated, along with the artefact's number. The refit relationships seem to be between ‘old’ rather than fresh breaks. This suggests that there has not been too much disruption of the stratigraphy.

Table 4.5: Refit pieces by square, spit and artefact number. Each refit is indicated by a boxed pair of numbers, unless indicated by underscored or ***bold*** *numbers*

A2		A3		A4		B2		B3		B4		B4/C4	
spit	#	spit	#	spit	#	spit	#	spit	#	spit	#	spits	#
3	116	3	338	1	427	7	547	7	661	3	776	5-9	954
3	121	4	359	1	430	7	549	7	662	3	780	5-9	955
9	289	4	361	1	429	8	557	8	694	4	787		
9	298	4	365	1	433	8	558	8	695	4	789		
						9	576	9	698	5	801		
5	*193*	6	*407*			9	584	9	703	5	806		
								9	725	7	842		
								9	731	7	843		
										9	901		
						8	**555**	8	**687**	9	919		

4.4 RESULTS OF TECHNOLOGICAL CLASSIFICATION

Less disappointing than the results of the refit investigation are the results of the technological classification. I have tabulated data from the technological classification following the method described in Chapter 3. In Table 4.6, different kinds of debitage have been identified and recorded relative to their position in either the ceramic or pre-ceramic phase. In Table 4.7, I present the results of the analysis of the available sample of blade and bladelet platforms. Some differences between several debitage classes (Table 4.6) and attributes (Table 4.7) between the two phases (PC and C) may be statistically significant. Due to time constraints, no statistical tests for significance were run. Nevertheless, the results recorded in Tables 4.6 and 4.7 will be discussed in subsequent sections.

Table 4.6: Frequency of debitage classes from Ceramic and Pre-ceramic levels

Debitage classes	Ceramic (n=359)	Pre-ceramic (n=506)
	%	%
Flakes and chunks	76.0	78.1
Bipolar flakes	5.8	0.8
Bipolar bladelets	1.7	0.0
Complete blades and proximal blade fragments	8.9	14.2
Mesial and distal blade fragments	7.5	8.1

Table 4.7: Frequencies of some of the attributes observed on the platforms of proximal blade and bladelets and proximal fragments from ceramic and pre-ceramic levels at Holkrans

Total number of observable platforms	Ceramic n=32 %	Pre-ceramic n=72 %
A: Platform preparation (Fig. 3A)		
Trimming of the edge on the exterior surface of the core	71.9	61.1
Abrasion on the edge	43.8	29.2
B: Platform thickness and width		
Width: 1-3 mm	37.5	29.2
3-5 mm	25.0	29.2
> 5 mm	25.0	26.4
Thickness: <2 mm	62.5	58.3
2-5 mm	21.9	23.6
> 5 mm	3.1	2.8
C: Impact point		
Lateralized	18.8	20.8
Central location	43.8	61.1
Non-expressed	25.0	4.2
Platforms with discernable impact point	65.6	81.9
D: Internal platform delineation (Fig. 3B)		
Straight or curved	31.3	34.7
Overhanging curved platform (B2)	9.4	18.1
Overhanging with bulb in clear relief (B3)	3.1	5.6
Double curve with two impact points	3.1	8.3
Indeterminate	46.9	23.6
Irregular	0.0	8.3
E: Platform morphology (Fig. 3D)		
Punctiform	15.6	2.8
Narrow linear	0.0	1.4
Oval or narrow triangular (constricted)	28.1	41.7
Curved	6.3	8.3
Quadrangular or wide trapezoidal (unconstricted)	6.3	5.6

Table 4.7 (continued)

Total number of observable platforms	Ceramic n=32 %	Pre-ceramic n=72 %
F: Bulb morphology		
Lipped, without a bulb	9.4	19.4
Prominent bulb with or without lipping (v. prom)	9.4	12.5
Weakly developed bulb with or without lipping (prom)	40.6	48.6
Negative bulb	9.4	0.0
G: Scars on the platform and on the bulb (Fig. 3C)		
Platform with impact point contoured by a fissure (C3)	0.0	0.0
Platform with partial fissuring around impact point (C2)	34.4	68.1
Platform with contoured Hertzian cone (C4)	3.1	5.6
Platform with shattered bulb (C1)	3.1	5.6

4.5 RECONSTRUCTION OF BLADE PRODUCTION *CHAÎNE OPÉRATOIRE*

Where were raw material blocks collected from?

I make two attempts to identify where the raw material blocks at Holkrans were collected from. The first is a geochemical comparison between archaeological chert (i.e. artefacts) from Holkrans, and geological samples of chert from outcrops and surface scatters along dirt roads in and around the Dome (Fig. 4.1). The second attempt happened by chance, when a gravel bar containing CCS material in the Vaal River was located in September of 2014 during the 3rd-year Archaeology field school.

The results of the first investigation are straightforward. A hierarchical cluster diagram of trace elements from the geochemical compositions shows that the archaeological samples are, in general, more similar to each other than they are to the collected geological material (Fig. 4.2). Hierarchical clustering is a statistical investigation of the amount of dissimilarity between different observations, which can be plotted as a dendrogram (Hastie *et al*. 2009).

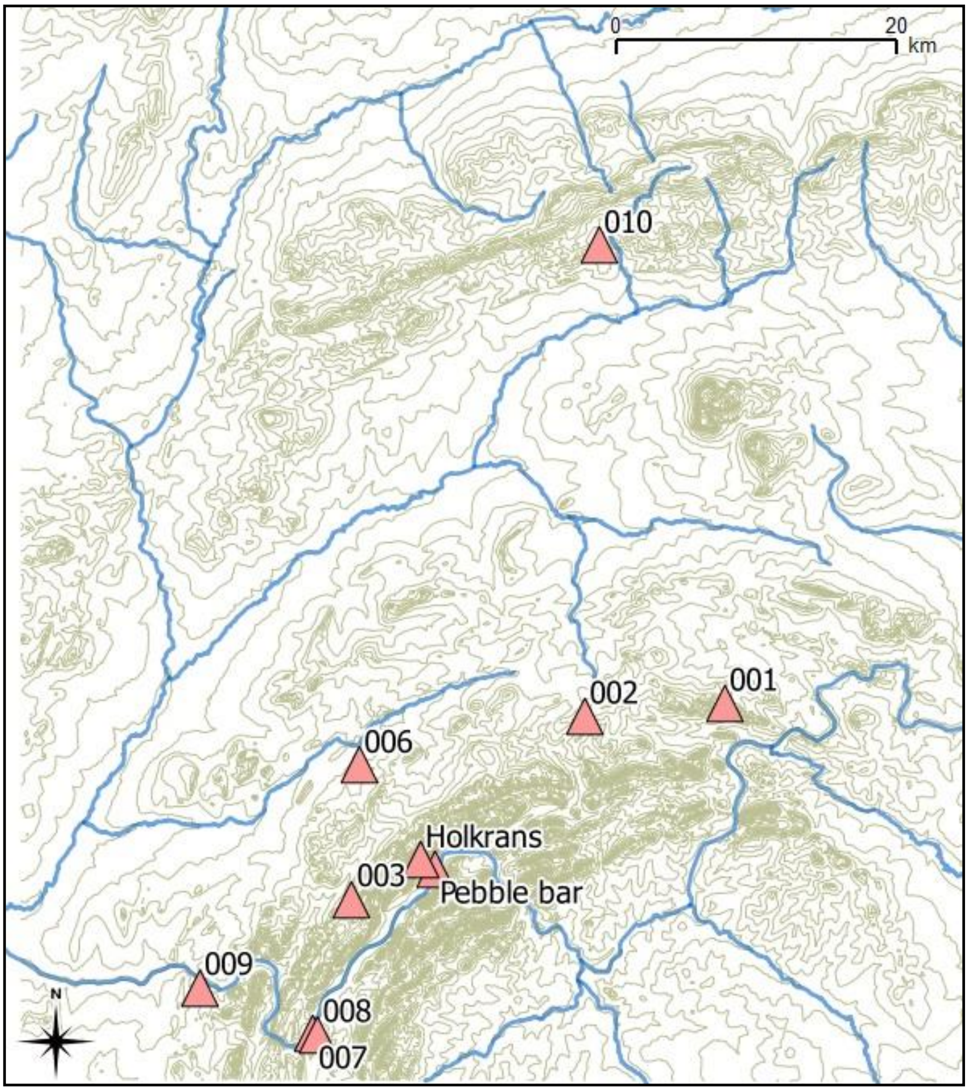


Figure 4.1: Map showing the localities of geological samples collected from around Holkrans

The diagram in Fig. 4.2 depicts a ‘divisive’ relationship- starting at the ‘top’ of the diagram, groups split off (as in a family tree) and become increasingly dissimilar with the number of times that an observation (in this case, an analysed sample) branches off. The small cluster on the right-hand side is therefore more similar to the very large cluster on the left-hand side than it is to Sample 44 (top left).

It must be said that XRF analysis is known to be an inferior method to analyse the compositions of CCS materials because of intra-source variability (e.g. Luedtke 1978: 414). Despite the shortcomings of this method, it appears from the use of trace element compositions (*cf.* Luedtke 1978, 1979) that almost none of the

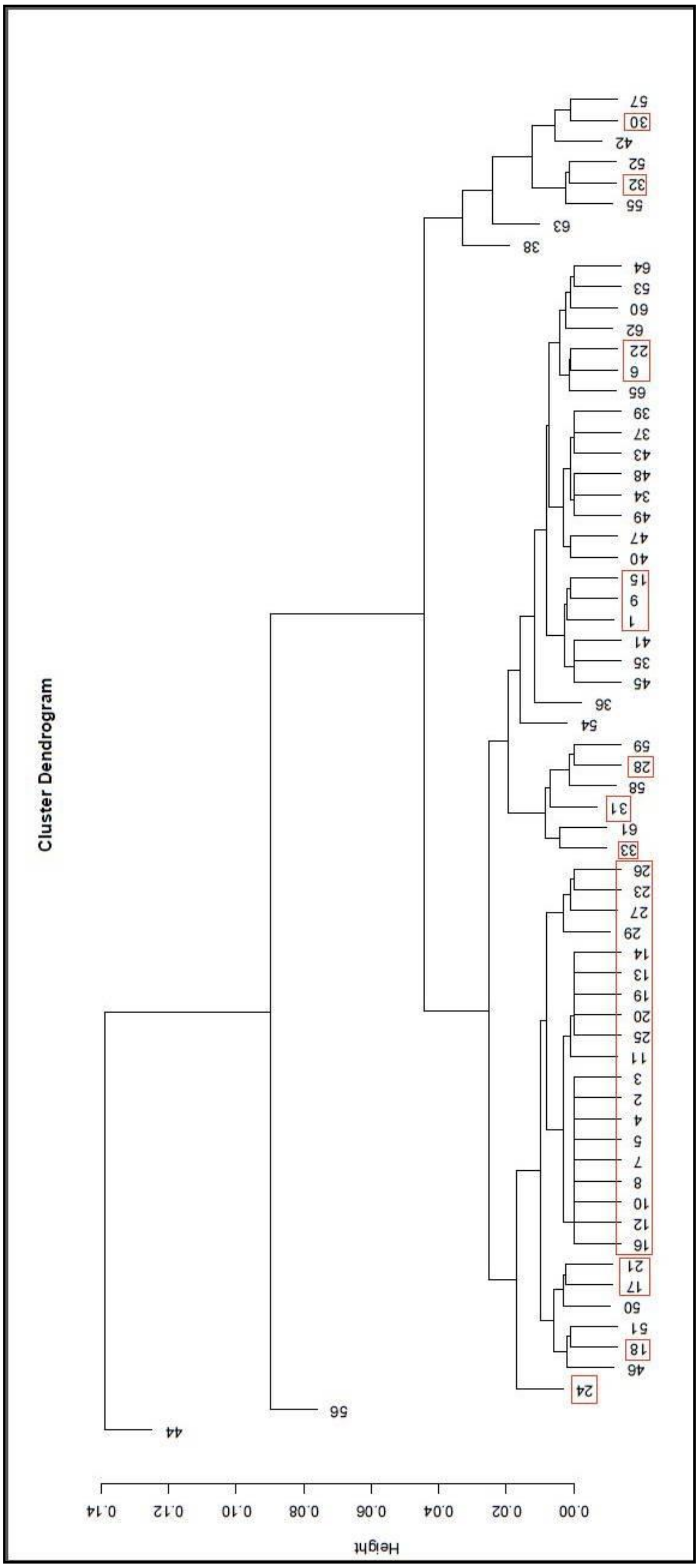


Figure 4.2: Cluster diagram of geological and archaeological samples. Archaeological samples are outlined in red.

geological samples found were from the source of the raw materials used by the Holkrans knappers. Although some of the archaeological samples seem to cluster at the same level as geological material (e.g. archaeological samples 28, 30 and 32) the geological material in each case *does not* resemble the archaeological material macroscopically. The geological material, in general, was not macroscopically homogenous in texture and colour to the same extent as the archaeological material, and often occurred as angular rather than rounded raw blocks (see below). We may thus have some confidence in the results indicated by the dendrogram despite the issues with chemical variability.

The clustering in the diagram suggests that the same source(s) were ‘tapped’ throughout the occupation at Holkrans, and that from this source was not located during the collection of the geological samples.

The second attempt, which looked at the similarities between the archaeological materials and a collection of pebbles from a gravel bank, is successful in that it located a source of rounded CCS material that macroscopically resembles opaline and chert material from Holkrans. Other than this macroscopic similarity, the gravel source is much nearer to the shelter than any of the geological sources. Because this sample comes from nearer to Holkrans, and because the gravel sample ‘looks’ more similar to the archaeological material than the geological samples, it is possible that the gravel bed, or at least similar gravel deposits, is the source of the raw materials.

All that can be stated with confidence in the present study is that the geological samples do *not* come from the same source of raw materials used by Holkrans knappers. The Vaal River gravels are the next most likely source and could be geochemically analysed with a more reliable method than XRF, such as neutron activation analysis.

What was the shape of the collected blocks of raw material?

There are several types of outer surfaces that are present on cores and debitage. Cortical surfaces in this assemblage of rocks represent the majority, and can be differentiated from patinated and natural planar surfaces. Raw material blocks in both the ceramic and pre-ceramic levels were pebbles (following the Wentworth scale for the classification of clast sizes), ranging between rounded and subangular degrees of roundness. A rounded rather than angular surface suggests that the pebbles at Holkrans were indeed from the Vaal River, having been subjected to the abrasive processes of transport in river systems for a significant amount of time. Only one manuport is present in the sample, but it is too small to have been selected to be reduced.

Almost all bipolar cores from H5. A and B are of opaline and come from the ceramic phase. The exception is Core 666, which was made on chert and comes from the pre-ceramic phase (see Appendix 2). Less reduced bipolar cores (that is, bipolar cores with a lot of cortex relative to fresh surfaces, see Appendix 2) suggest that pebbles subjected to the bipolar technique may have been smaller than pebbles selected for free-hand knapping. This may have been simply because the bipolar technique was better suited to the reduction of smaller pebbles rather than larger pebbles. In the collection of pebbles from the gravel bank (Fig. 4.1), opaline pebbles are relatively smaller and less rounded than chert pebbles.

How were raw material blocks prepared for core reduction?

For the two types of conceptual core categories in Table 3.1, only one of the categories, free-hand cores, shows evidence for the preparation of the core. The pattern amongst these cores is the removal of either a preferential cortical flake that creates a platform, or the attempted (failed) removal of a preferential flake if there is already an existing ‘natural’ platform that would allow for a series of bladelets to be removed. Failed cores are most common on large flake blanks or chunks, rather than on pebbles.

The percentage of bladelet platforms with cortex is relatively low (~ 11.5%, n=104). In addition to this, the lack of cortex on free-hand core striking platforms suggests that the most common way of setting up a striking platform was the removal of relatively large cortical flakes. Complete cores in this sample typically show a cortical back, similar to the Howiesons Poort cores from Rose Cottage Cave (Soriano *et al.* 2007).

The other category of cores, called bipolar, show no evidence of preparation of the core *per se.* However, it is possible that the raw block may have been heat treated prior to knapping. Many opaline pieces were noted to have feature pot-lidding and/or crazing (*cf.* Domanski & Webb 2007) during typological classification. The possible evidence for heat treatment has not been investigated in this research project due to time constraints.

How did knapping begin?

For bipolar cores, knapping began when the ‘core’ (originally a complete pebble) was placed between a ‘hammer and an anvil’. This set up what in effect is a bipolar application of force, and in most cases, force was applied along the long dimension of the core.

No crested blades or bladelets were identified in the sample of free-hand cores. In the absence of any crested blade(let)s, the first blade(let) removal appears to have been opportunistic, exploiting a natural ridge that performed the same function as a crest. Cortical blade(let)s (>50 % cortex) are present in levels from both phases of occupation (Table 5.1). Blades with a triangular cross-section (Fig. 3.1 [Left]: A2) are evidence for the initial opportunistic exploitation, along with the attempts evidenced by the failed cores (see Appendix 2).

How did knapping progress?

In the case of bipolar cores, knapping progresses as it began because of the limitation of the bipolar technique (described below). It is possible that the core was rotated such that its ‘poles’ reversed, but no such examples have been identified.

For the free-hand bladelet cores, knapping progresses perpendicular to the striking platform. Both types of configurations identified by Soriano *et al*. (2007: 687-688) for the HP at Rose Cottage Cave are identifiable at Holkrans:

Configuration 1: useful length of the flaking surface increases as knapping progresses. Examples from are seen in Core 223 (Fig. 4.3) and Core 952 (Fig. 4.4). Although few complete blades preserving distal cortex occur in the sample (2 from C, 2 from PC), the percentage of fragments with distal cortex is higher (C 0%, PC 10.3%).

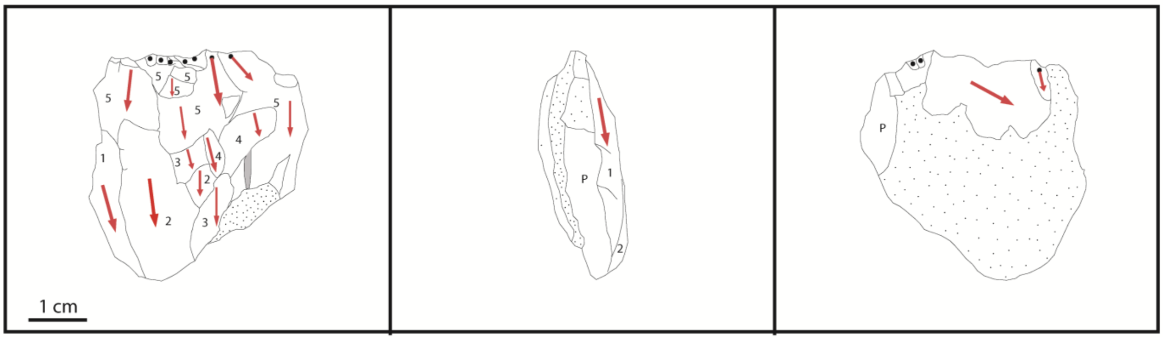


Figure 4.3: Core 223, single platform bladelet core

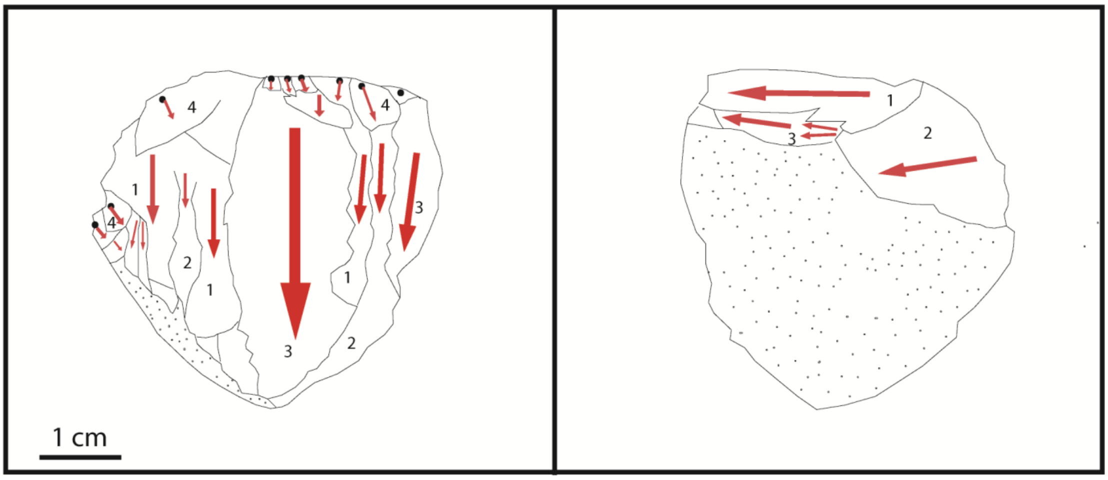


Figure 4.4: Core 952, bladelet core (from wall-shavings of spits 5-9)

Configuration 2: useful length of the flaking surface decreases as knapping progresses. The only example is Core 360 (Fig. 4.5).

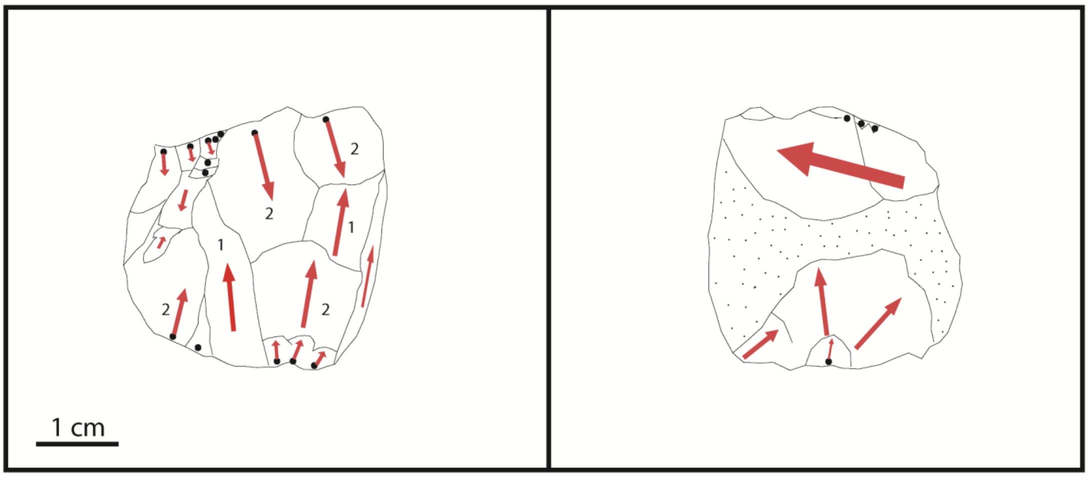


Figure 4.5: Core 360, opposed platform bladelet core

What were the core maintenance strategies?

If the platform on a free-hand core ran out, it was rejuvenated by doing one of three things. The first strategy was to create a new platform by removing a large flake whose butt was formed by the previous platform.

The second manner in which a core was maintained is evidenced by several blade(let) fragments. Although they are incomplete, 8 fragments preserve evidence in both phases of occupation of the rejuvenation of a bladelet core platform by the removal of a blade(let) parallel to the ridge of the platform edge. The platform edge is used as a ridge to guide the removal of a blade-like flake, whose long dimension was parallel to the length of the core. Other blade(let)s could then be removed.

The final strategy was that the remaining core could be reduced with the bipolar technique if suitable platforms for free-hand reduction ran out, or when the core became too small to work free-hand.

How were platforms prepared?

Platforms were only prepared in the free-hand technique. The platform edge was often abraded, and was often also trimmed with small removals either on the very edge of the platform edge, or parallel to ridges (Fig. 3.1 [Left]: A2 and A3). No evidence for faceting was found on either bladelets or cores.

When are cores abandoned?

Bipolar cores were abandoned when they became too small to hold or to be usefully reduced further.

All the free-hand bladelet and failed cores could have been reduced further. It appears that the reason these cores were abandoned before they were exhausted was either because of their size, or because of flaws in the raw material. However, the bipolar technique could have been used to reduce cores that had become too small to knap with the ‘free-hand’ method.

In at least one case, a core experienced both bipolar and free-hand knapping techniques. After being reduced with a free-hand technique, it was rotated and subjected to the bipolar technique (Fig. 4.6, extreme right frame).

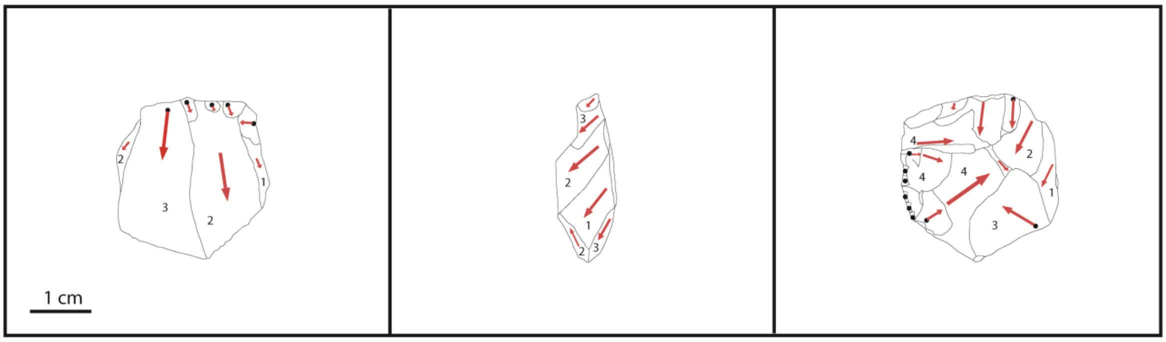


Figure 4.6: Core 244, 'Dual' core

It is not clear why the other cores where not reduced further, or reduced with the bipolar technique. The bipolar technique makes maximum use of raw material (Inizan *et al.* 1999), and in the case of Core 244 (Fig. 4.6) effectively extended the 'life' of the core. One possibility for the abandonment of cores is that the flaws so common in dolomitic chert prevented any further reduction. At Rose Cottage Cave, the range of "20-25 mm in length" was identified for abandoned cores of opaline by Soriano *et al.* (2007: 688). It is possible, although unlikely because of the scenario in Core 244, that the size of these cores is important to consider in their abandonment.

4.6 IDENTIFICATION OF KNAPPING TECHNIQUES AT HOLKRANS

Stone is knapped using three kinds of techniques: direct percussion, indirect percussion, and the application of pressure (Inizan *et al*. 1999). Direct percussion is the use of a soft or hard hammer (with or without an anvil) to deliver a blow. Indirect percussion involves the use of an arm (punch) to apply force to a highly concentrated area. The hammer blow is delivered to the punch rather than directly to the raw material. Pressure flaking involves the application of pressure with a tool to remove flakes.

Various schemes exist to detail technical information. Soriano *et al*. (2007: Fig. 10), most recently, drafted a dual axis diagram that considers hammer hardness and its relationship to the edge of the platform during contact. It is based on three parameters proposed by Tixier for identifying the mode of blank production (1967: 807, cited in Soriano *et al.* 2007: 689). At Rose Cottage Cave (RCC), it was noticed that the percussion technique plotted in the lower left quadrant, being marginal and employing a stone hammer core. With this in mind, I consider the techniques present at Holkrans.

4.6.1 TECHNIQUE 1: BIPOLAR

The bipolar technique introduces variability into the assemblage at Holkrans, not merely because it is present in the pre-ceramic phase (Core 666, see Appendix 2) and predominates the ceramic phase.

Table 4.8: Summary of bipolar debitage identified during technological classification

Debitage	n	Ceramic	Pre-ceramic	%
Cores	14	13	1	26.4
Bladelets	6	6	0	11.3
Flakes	25	21	4	47.2
Other	8	7	1	15
Total	53	47	6	100

As mentioned above, the bipolar technique is a fairly standard technique. One particular example of this kind of technique was described by Goodwin (1945: 73). A more recent description of this technique is that

> Bipolar knapping is a method in which the core is placed on an anvil and held with the bare hand. The rock is hit from above with a hammer held in the other hand, causing blanks to fly off from the top and also from the edge that is in direct contact with the anvil (Crabtree 1972) (de la Peña & Toscano for flint (2013: 33).

Crabtree (1972), and Barham (1987) in more detail, each describe ways of producing bladelets with the bipolar technique. All of the bipolar bladelets from Holkrans preserve at least some cortex on the dorsal face, and do not seem to match the technique described by Barham (1987). The sample size is, however, too small to make a reliable comparison.

Six bladelets (Table 4.8), all coming from the ceramic phase, match some of the characteristics for bipolar products described by de la Peña & Toscano (2013: 42) (see Chapter 3). Five of these do not have a distinguishable impact point (*cf*. de la Peña & Toscano 2013: 42), whilst the sixth it is missing a terminal end. Four of the six are rectilinear, whilst two are slightly curved. They all have broken (n=4) or linear butts (n=2).

In addition to the very small bladelet sample, a total of 14 cores appear to have been reduced with a bipolar technique (see Appendix 2). These cores match the description of features for bipolar cores summarised by de la Peña & Toscano (2013: 42). 13 of the 14 cores are restricted to the upper 4 spits of the ceramic phase. One core is from spit 7 of the pre-ceramic phase. Only 2 of the cores are entirely complete. Both have flake scars that suggest bladelet products and preserve evidence of the very final stage of the reduced bipolar core. Furthermore, the rectilinear nature of the “hammered edge and opposite edge” (de la Peña & Toscano 2013: 42) for the two complete bipolar cores may indicate that the hammerstone and the anvil used both had flat rather than round surfaces (P. de la Peña, pers. comm. 2014). The remaining 11 cores are missing the distal end which is most likely to have broken off during the knapping activity rather than post-depositionally.

Bipolar debitage from H5. A and B is very similar to the debitage represented in Barham (1987), and contains most of the features summarised by de la Peña & Toscano (2013: 41-45). There is no suggestion that any of the bipolar cores were hammered into soft organic material, such as bone or wood, that would result in ‘wedges’ (*cf*. de la Peña & Toscano 2013). It is explicitly assumed that all 14 bipolar cores at Holkrans were produced using stone hammers and stone anvils.

4.6.2 TECHNIQUE 2: FREE-HAND PERCUSSION

I consider the free-hand percussion blade(let) production by looking at three aspects, following Soriano *et al*. (2007). First, the method used to apply force. Next, I consider the motion of the knapping activity. And finally, I consider the kind of knapping tool used. Proportions reported under the subheadings below come from Table 4.7 unless otherwise indicated.

Method used to apply force

The use of indirect percussion or pressure in blade/bladelet production is unlikely at Holkrans. Inizan *et al*. (1999:76) note that blade/bladelets produced using indirect percussion have fairly consistent morphology and a flaking angle of near 90°. The characteristics of blade debitage produced by pressure are similar in that such debitage often has “parallel edges and arises”, “constant thickness”, “no obvious ripples on the lower face”, and “a butt always narrower than the maximum width of the blades” (*ibid*: 79). In contrast, blade debitage from Holkrans does not have the consistent morphology that would be the result of indirect percussion or pressure techniques (Fig. 4.7).

An indirect percussion technique at Holkrans is even more unlikely when one considers contact point diameter, that is, “the point (in fact small surface) where the blow is applied to fracture a piece of raw material” (Inizan *et al*. 1999: 143). The contact point diameter on the platform of debitage produced by indirect percussion is larger relative to debitage produced by direct percussion (e.g. Soriano *et al.* 2007: 690). It may be inferred from the majority of platform thicknesses < 2 mm wide (C 62.5%, PC 58. 3%), that contact point diameter is too small (< 3 mm, following Soriano *et al.* 2007: 690) for indirect percussion to have been used, although the diameter in each case was not directly measured.

For the reasons outlined above, I argue that blade and bladelet products from H5. A and B were not produced by indirect percussion or by the application of pressure. Rather, a direct percussion technique is identified for blade/bladelet production at Holkrans.

The motion of knapping

There is much evidence to show that the knapping activity focused not on the surface of platforms, but on the edge. Abrasion on the (dorsal) edge of blade(let) platforms is particularly noticeable (C 43.8%, PC 29.2%). Trimming of the overhang is more abundant (C 71.9%, PC 61.1%). Blade(let) platforms are so thin that we may be confident that “the hammer did not strike the platform surface but its edge” (Soriano *et al.* 2007: 690). More than half the platforms in each phase are < 2 mm thick (C 62.5%, PC 58.3%).

Figure 4.7: The irregular morphology of blade and bladelet debitage from Holkrans suggests that indirect percussion was not used at Holkrans. Complete: a-e. Proximal fragments: f-i. Distal fragment: j. Mesial fragments: k and l.

Only one bladelet from the pre-ceramic phase had a lip without a bulb, indicative of “a “dragging” and striking motion” (Soriano *et al.* 2007: 690). Although anomalous in the present study, it may have implications for a technological study with a larger sample size.

<u>The knapping tool</u>

At first, it appears that there may have been two kinds of hammers used at Holkrans. Both soft organic percussion (lip only: C 9.4%, PC 19.4 %) and hard mineral percussion are suggested in both phases (marked point of contact, strong bulb: C 9.4%, PC 12.5%). However, a simple identification of two kinds of hammer is, in this case, misleading because platforms with less-developed bulbs are predominant in both phases (C 40.6%, PC 48.6%).

Here I wish to provide detail of several features that indicate that a *soft stone hammer* was the percussor used at Holkrans. These features, all relating to visible impact points (*cf.* de la Peña & Toscano 2013: 42), result from “sharp contact with the hammer”- a trait of soft stone hammer percussion (Pelegrin 2000; Soriano *et al.* 2007: 691).

1) Partial fissuring and contoured cones predominate over circular fissuring and shattered bulbs

    Partial fissuring of the bulb is predominant at Holkrans (C 34.4%, PC 68.1%), whilst some impact points are marked by a contoured cone (C 3.1%, PC 5.6%). No circular fissuring is present that would suggest a hard stone hammer (*cf*. Soriano *et al.* 2007: 691).

2) Abrupt delineation of some platforms on ventral surface

    The sharp contact characteristic of a soft stone hammer (Soriano *et al.* 2007: 691) resulted in an overhang of the contact point that abruptly delineates the platform on the ventral surface. This is visible on several blades and bladelets in both phases (Fig. 2.1 [Right]: B3), (C 3.1%, PC 5.6%).

3) Accidents

    Several blade(let)s have shattered bulbs (C 3.1%, PC 5.6%). These accidental features “unequivocally prove the occurrence of soft stone percussion” (Soriano *et al.* 2007: 69).

Having discussed the techniques for blade production at Holkrans, we can be fairly confident that the kind of production at Holkrans falls within a similar part of the diagram to that identified for the Howiesons Poort of Rose Cottage Cave (RCC) by Soriano *et al.* (2007: Fig. 10). Across both phases of occupation at Holkrans, free-hand blade(let) production was carried out with a soft stone hammer (such as sandstone). Direct blows from the hammerstone were concentrated on the very edge of the core's platform. The implications of technological similarities between the Howiesons Poort at RCC and lithic technology at Holkrans will be discussed in Chapter 5.

4.7 HOLKRANS FORMAL TOOLS

In general, flake blanks appear to have been modified into formal tools through pressure-flaking (any other technique is assumed to be too destructive for these small tools). Three categories of formal tools have been identified. The sample of formal tools (n=43) is summarized by percentage and phase in Table 4.9. I discuss each category from Table 4.9 in turn, comparing the two phases. Some of the tools are depicted in Fig. 4.8.

Table 4.9: Summary of the formal tools from both phases of occupation

Formal Tools	ceramic n=21 %	pre-ceramic n=20 %
Scrapers (% total)	23.8	0.0
end	14.3	0.0
side	0.0	0.0
indeterminate	9.5	0.0
Backed artefacts (% total)	19.1	45.0
segments	4.8	5.0
broken segments (halves)	9.5	5.0
backed bladelet fragments	0.0	10.0
partially backed pieces	0.0	5.0
triangular fragments	0.0	10.0
indeterminate (truncated?)	4.8	5.0
truncated blades	0.0	5.0
Miscellaneous retouched pieces (% total)	57.1	55.0

Figure 4.8: Selected formal tools. Scrapers: a-e. Segment fragments: f-h. Triangular fragments: i-j. Truncated blade: k. Indeterminate (truncated?): l and n. Partially backed piece: m. Backed bladelets: o and p. Segments: q and r.

4.7.1 SCRAPERS

A total of 5 scrapers (C 23.8%, PC 0.0%) were identified following Deacon (1984) (Fig 4.8: a-e). End scrapers are predominant in this small sample (*cf*. Humphreys

& Thackeray 1983). There is no consistency in the morphology of the 5 scrapers, yet all five seem to have been made on flakes that have a convex curvature that has been retouched or utilized to produce the characteristic morphology. This demonstrates the technological heterogeneity for morphological types argued by Odell (1981).

4.7.2 BACKED ARTEFACTS

SEGMENTS

Both complete and broken segments were identified (Fig. 4.8). Broken segments were differentiated from other backed artefacts by the curvature of their backed edge that very closely resembled the two complete segments (*cf.* Deacon 1984).

One complete segment was found in the ceramic phase (4.8%), and a less complete one was found in the pre-ceramic phase (5.0%). The ceramic-phase segment is smaller than the other, and was made on a cortical chert blade flake blank. The larger segment is missing an extremity, and was produced from an opaline blade flake blank that lacked any cortex.

The very large segment in the pre-ceramic phase comes from spit 11. It is unusually large for the period (spit 11 has been dated to at 2320 ± 50 BP in F7 [Beta 265300]). At present, no other dates could be obtained to clarify the age and context of the pre-ceramic segment. Because it is so unusual, it is possible that we may have another lithic industry present in the lower levels of the stratigraphy at Holkrans, such as the Howiesons Poort (Garth Sampson, pers. comm. 2014). This statement is, at present, an unsubstantiated claim and requires further excavation to assess its validity.

In addition to the two complete segments, two broken segments (‘half segments’) were identified in the ceramic phase (9.5%), and one in the pre-ceramic phase (5.0%). Two are on chert and one on opaline. The broken segment pieces are similar in size and are more similar to the ceramic-phase segment than the pre-ceramic segment.

There appears to be a consistency in design for the segments and the broken pieces; all the segments from the ceramic and pre-ceramic have been made on a blade flake blank with backing retouch that follows an arc, creating the segment shape. No retouch has been applied to the opposite edge.

BACKED BLADELETS

Only two bladelet fragments have backing (Fig. 4.8). One is a mesial fragment and the other is proximal. Both are from the pre-ceramic phase and were made on chert. It is interesting to note that the backing on the proximal fragment is present near the proximal part of the flake and has rounded this edge. This may mean that the backed bladelet is part of the production sequence of segments, rather than backed bladelets. No complete backed bladelets were found.

PARTIALLY BACKED PIECES

In the pre-ceramic phase, one piece of a refit set is partially backed in such a manner that it may represent an early stage in the production of a segment (Fig. 4.7). For some reason, the retouch activity was abandoned.

TRIANGULAR FRAGMENTS

Two triangular pieces are backed, both from the pre-ceramic phase. In each case, a straight flake edge makes an angle with the opposite edge that has been backed to give a straight edge. These fragments may or may not relate to segment production; one is smaller than the other segment fragments, and one is larger. It is difficult to tell whether they are part of the production sequence for segments or whether they belong to another class of backed geometric artefact because they are fragmentary and the backing is straight, rather than curved. The blanks for these are likely to be blade and bladelet flake blanks since the dorsal scars on several of the pieces are straights and parallel.

TRUNCATED PIECES

One truncated blade was found in the levels of the pre-ceramic phase (Fig. 4.7). Two other pieces are incomplete, and it cannot be said with certainty if these pieces (which appear to be bladelet fragments) are truly truncated.

4.7.3 MISCELLANEOUS RETOUCHED PIECES

The remaining retouched artefacts have miscellaneous retouch. In each case, the artefact does not resemble a specific morphological type (*cf.* Odell 1981). Various kinds of retouch are present within this category, including flat retouch and edge damage due to use. Use-wear analysis, already done for some artefacts from E8 by Law de Lauriston (2014), would be able to identify the use of these pieces and add nuance to an otherwise lumped category. Because tool use falls outside the scope of this project, I do not discuss the MRPs any further in this section.

No bifacially tanged and barbed arrowheads were recovered in H5.

CHAPTER 5: DISCUSSION AND CONCLUSION

The results from this study allow for an interesting discussion of changes in lithic technology through time at Holkrans. In his Honours project, Banhegyi (2011: 43) wrote that

> one might expect that the different sizes, shapes and fracturing properties of raw materials in the preceramic *(sic)* and ceramic levels would have necessitated the use of different flaking techniques (2011: 43).

His supposition is correct, even for raw materials within the same raw material category (CCS). During the ceramic phase, lithic technology concentrated on the bipolar reduction of opaline and was therefore significantly different from the predominantly free-hand production of bladelets during the pre-ceramic.

5.1 CHANGES IN THE KNAPPING TECHNIQUE

In Chapter 4, we saw that there were two techniques used in the production of blade and bladelets. Overall, the bipolar technique was used to a lesser extent in the production of blade(let)s than the predominant direct percussive technique. Discussion of the bipolar technique referred to six (6) bipolar bladelets, which make up only 1.7% of the entire sample for the ceramic phase (Table 4.6).

From the values in Tables 4.6 and 4.7, we can see that the bipolar technique became the predominant knapping technique in the ceramic phase. In Table 4.7, there is a decrease in platforms with a discernable impact point as we move from the pre-ceramic into the ceramic (C 65.6%, PC 81.9%). Similarly, there is a dramatic rise in platforms without impact points in the ceramic phase (Table 4.7: C 25%, PC 4.2%). A lack of a discernable impact point, it will be recalled, is one of the characteristics of debitage produced using the bipolar technique (de le Peña & Toscano 2013: 42). Blades and bladelets in the ceramic phase also see an almost 6-fold increase in the number of punctiform platforms (Table 4.7: C 15.6%, PC 2.8%) and a sudden appearance of blades with negative bulbs (Table 4.7: C 9.4%, PC 0.0%). The decrease in the number of discernable impact points, and the increase in punctiform platforms and negative bulbs can be understood to result from increased bipolar reduction in the ceramic phase.

Increased bipolar production in the ceramic phase makes it difficult to tell if any significant changes occurred in the free-hand knapping technique. Overall, the relatively large proportion of complete free-hand blade(let)s in the pre-ceramic phase decreases drastically in the ceramic phase (Table 4.6: C 8.9%, PC 14.2%). Several of the attributes related to the direct percussive technique (Chapter 4) show increased values in the ceramic phase (for example, platform preparation and platform thicknesses <2 mm, see Table 4.7). In contrast, the values of several attributes associated with soft stone hammer percussion (Chapter 4) decrease in the ceramic phase relative to the pre-ceramic (overhang with bulb in clear relief, partial fissuring around the impact point, platform with contoured Hertzian cone, platform with shattered bulb).

The increase in some attribute values with simultaneous decrease in other attributes presents a somewhat ambiguous scenario that may result from unequal sample sizes. On the other hand, the ‘ambiguity’ may reflect consequences of the shift in reduction strategy (i.e. increased bipolar reduction). Indeed, all the attributes that increased are associated with a direct percussive technique of which bipolar reduction may be considered a special example. It therefore appears that the change in the proportion of free-hand blades across the two phases is not due to changes in bladelet production *technique* but rather a change in overall *reduction strategy*.

5.2 CHANGES IN REDUCTION STRATEGIES

Two aspects are important for a consideration of the changes in reduction strategy at Holkrans. First, changes in free-hand blade(let) production, and second, changes in bipolar debitage.

5.2.1 *CHANGES IN FREE-HAND PRODUCTION*

Table 5.1: Frequency distribution of complete blade types (excluding bipolar bladelets) for both phases of occupation

Type of blades	Ceramic n=10 %	Pre-ceramic n=31 %
Initial stage (>50% cortex)	20.0	16.1
Main production phase, central debitage surface	60.0	38.7
Main production phase, from the side of the debitage surface	20.0	35.5
Core maintenance blades	0.0	0.0
Other blades	0.0	6.5
Indeterminate blades	0.0	3.2
Frequencies of specific blade types		
Crested blades of first generation	0.0	0.0
Totally cortical blades or with >50% cortex	20.0	12.5
Blades with total or partial cortex	40.0	46.9
Plunging blades	0.0	0.0
Blades with bidirectional flake scars	0.0	3.1
Blades with a cortical or natural back	10.0	15.6
Blades with a cortical lateral edge	10.0	3.1

In Table 5.1, we are again confronted by a problem of sampling. A comparison of the changes between the phases is made difficult because the sample size of the pre-ceramic sample is almost triple that of the ceramic phase sample (C n=10, PC n=31).

Nevertheless, from Table 5.2 we may infer that free-hand blade(let) production during both phases concentrated on the central debitage surface (C 60%, PC 38.7%). During the ceramic phase, however, a decreased amount of fully or largely cortical blades (ceramic 40.0%, pre-ceramic 46.9%) suggests that more time was taken to remove cortex and prepare the core before blade(let) production.

Supplementing the small sample sizes above with a consideration of cortex on blade fragments (Table 5.2) allows us to see that, during the ceramic phase, cores were indeed prepared more since the percentage of blade(let) fragments without cortex is higher in the ceramic phase (Table 5.2: C 74%, PC 67.8%)

Table 5.2: Frequency distribution of cortex type for blade fragments (excluding bipolar) from both phases of occupation

Type of cortex on fragment	Ceramic n=49 %	Pre-ceramic n=91 %
Edge and lateral	2.0	0.0
Fully cortical	4.0	2.2
Lateral	8.0	7.8
Plunging distal end	2.0	1.1
Distal	0.0	3.3
Edge	8.0	7.8
Back	0.0	4.4
Other	0.0	6.7
No cortex	74.0	67.8

5.2.2 *CHANGES IN BIPOLAR DEBITAGE*

A more significant change in reduction strategy at Holkrans is seen in the abundance of other bipolar debitage that appears in the ceramic phase (Fig. 5.1). Just less than 85% of all bipolar debitage occurs in the ceramic phase with 13 of the 14 bipolar cores restricted to the upper 5 spits. As seen in Table 3.1, 72% of all the cores in the ceramic phase are bipolar.

The abundance of bipolar cores relative to other bipolar debitage suggests that some of it is missing (recall that pieces <1 cm^2 were not studied), perhaps due to the shattering nature of the bipolar technique, or the choice of some bipolar debitage to make formal tools (e.g. scrapers). Indeed, the abundance of bipolar flakes (47.2%) is not even double the amount of cores (26.4%), and the percentage of cores is greater than both bipolar bladelets (11.3%) and other debitage (15%).

Although the bipolar technique is indisputably present in the pre-ceramic phase (Table 5.2, Core 666 Appendix 2), the relative increase in bipolar debitage seen in the ceramic phase (Table 5.2) when compared to the relative decrease in blades and bladelets (Table 5.1) suggests *a shift in the objectives* of the knapping activity. Blade and bladelet blanks are not as important in the ceramic phase as they were in the pre-ceramic phase.

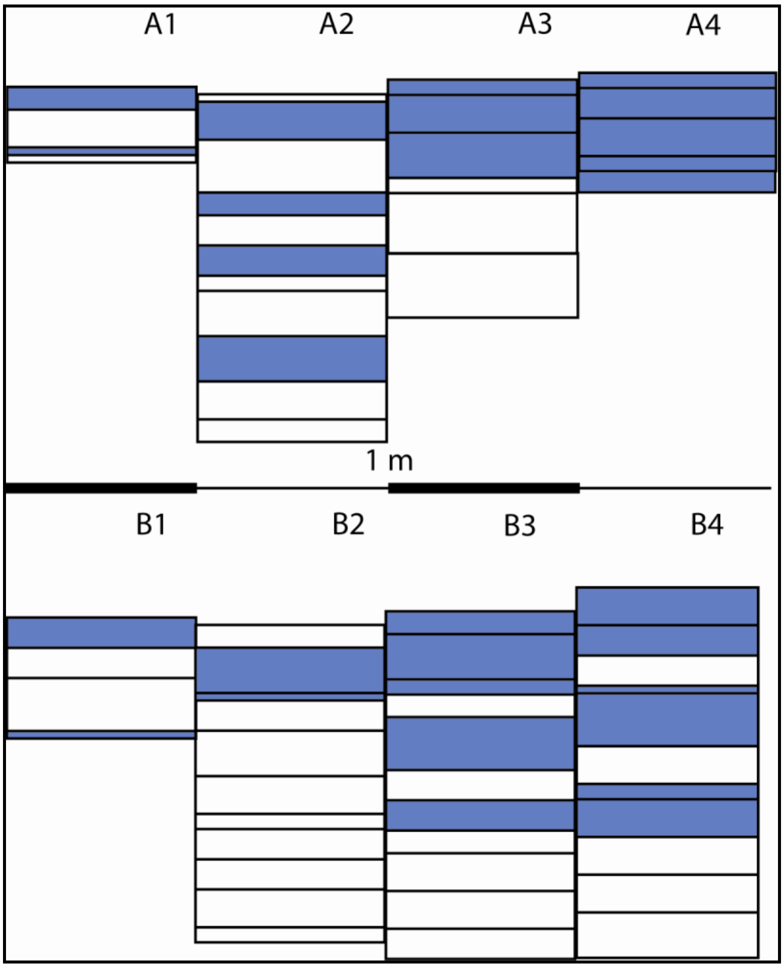


Figure 5.1: West wall profiles for A and B in H5. Locations of all bipolar debitage within the stratigraphy are indicated in blue. Horizontal scale is 1 m.

5.3 CHANGES IN FORMAL TOOLS

The formal tool component of the lithic assemblage at Holkrans seems to have experienced some significant changes between the ceramic and pre-ceramic phases of occupation. In the ceramic phase, scrapers appear without having been (morphologically) identified in the pre-ceramic (Table 4.9). Backed artefacts become less numerous in the ceramic phase, and there is a slight increase in MRPs.

Since the designation ‘MRP’ is a lumping category and thus technologically heterogeneous (*cf.* Odell 1981), it is necessary to look at use-wear in order to glean more information from this category. The use of the implements before discard in square E8 was investigated by MacLaren Law-de-Lauriston using lowpower microscopy (2014). Law de Lauriston (2014) found that there was continuity in the function of stone tools from pre-ceramic to ceramic phases of occupation. He observed a statistically insignificant change in formal tool types, but noticed that raw materials changed significantly across the pre-ceramic to the ceramic transition (Law de Lauriston 2014).

The same change in raw materials was noted in E8 by Banhegyi (2011) and has been demonstrated for H5 (Table 4.4). Since the discontinuity in raw materials across the pre-ceramic to the ceramic holds in E8 and H5, Law de Lauriston's (2014) research can be used to make the suggestion that the change in formal tool types in H5 is not likely to be statistically significant.

5.4 COMPARISONS

Broad comparisons between the isolated site of Holkrans (Chapter 1) and other sites can be made by considering characteristics of the lithic assemblage. In Table 5.3, I provide a summary of twenty-nine (29) sites within an arbitrary 400 km radius of Holkrans. Table 5.3 refers only to securely dated sites with terminal LSA deposits (Lombard *et al.* 2012). Lombard *et al.* (2012) follow Peter Mitchell's (2002:10) 'framework' approach that acknowledges the biomes in which sites occur. I follow the same approach in Table 5.3.

The lithic assemblage at Holkrans appears to be dominated by CCS material (*cf.* Banhegyi 2011:32) so far as retouched artefacts are concerned (*cf*. discussion of chert at Wonderwerk Cave in Humphreys & Thackeray 1983: 53). Lithic assemblages dominated by CCS material have been recorded at two sites; at Clarke's Shelter (Mazel 1984a), and at Dikbosch 1 (Humphreys & Thackeray 1983).

The four tanged and barbed arrowheads identified by Bradfield & Sadr (2011) (Chapter 1) are thought to have been made with a pressure-flaking technique (e.g. Klatzow 2000). The use of the pressure-flaking technique has been documented at Likoaeng in Lesotho (Mitchell 2009; Plug *et al*. 2010; Mitchell *et al*. 2011), as well as at Roosfontein, specifically in the production of a tanged and barbed arrowhead (Klatzow 2000).

Table 5.3: Summary of sites within a 400 km radius of Holkrans by biome

SAVANNA BIOME :

- North West Province: Holkrans rock shelter (Bradfield & Sadr 2011)
- Gauteng: Fort Troje (Wadley 1987)
- Northern Cape: Jubilee Shelter (Wadley 1987); Dikbosch and Wonderwerk Cave (Humphreys & Thackeray 1983)
- Limpopo: Goergap 113 KR, New Belgium, and Schurfpoort 112 KR (Van der Ryst 1998)
- KwaZulu-Natal: Mzinyashana Shelter (Mazel 1997)

GRASSLAND BIOME:

- Free State: Mauermanshoek (Wadley 2001); Rooikrans (Thorp 1996); Roosfontein (Klatzow 2000); Rose Cottage Cave (Wadley & Vogel 1991; Wadley 1992; Thorp 1996); Tandjiesberg (Thorp 1996, 1997; Wadley & McLaren 1998); Orange Springs (Thorp 1996); De Hoop (Klatzow 2010); Twyfelpoort (Backwell *et al*. 1996)
- In Gauteng Province are the sites of Hope Hill (Wadley 1989; Wadley & Turner 1987) and Cave James (Wadley 1987, 1996).
- KwaZulu-Natal: Nkupe Shelter (Mazel 1988); Clarke's Shelter (Mazel 1984a); Collingham Shelter (Mazel 1992); Driel Shelter (Maggs & Ward 1980); Good Hope Shelter (Cable *et al*. 1980); Mgede Shelter (Mazel 1986b)
- Lesotho: Likoaeng (Mitchell *et al*. 2008, 2011) and Sehonghong (Mitchell 1996, 2010; Vinnicombe 2009)

THICKET BIOME:

- KwaZulu-Natal: Mbabane Shelter (Mazel 1986a); Gehle Shelter (Mazel 1984b); iNkolimahashi Shelter (Mazel 1999)

A more specific comparison is currently only possible with Soriano *et al*. (2007) and Modikwa (2008) because they both have the same kind of data.

A close reading of this project reveals that many similarities exist between the observations made in this study and those made by Soriano *et al.* (2007). This should not be come as a surprise, given that a) both studies consider blade production on technologically similar raw materials, and that b) the two sites are both in the interior of southern Africa, and are c) separated by less than 300 km of geography, which may have implications for the relationship of similarity between the technologies at each site.

Despite these similarities there are some significant differences. These differences principally result from the fact that bipolar debitage of the post-HP sequence at

RCC makes up a relatively smaller proportion in comparison to bladelet debitage than it does at Holkrans.

Table 5.4 is a composition of the data from Holkrans and two levels from RCC taken from Soriano *et al*. (2007: Table 7), one from the HP and one from the post-HP. This comparison highlights several things. First, it demonstrates that the lithic technology, overall, at Holkrans is not *dominated* by blade production but rather by flakes, unlike lithic technology at RCC. Second, the proportion of bipolar debitage (flakes and bladelets) in the post HP (18.1%) at RCC is much greater than in the ceramic phase (7.5%) at Holkrans. However, an important point of difference is that in the post HP of RCC, blade debitage (complete and fragments) completely overshadows bipolar debitage (flakes and blades). The amount of difference between the proportions of the two kinds of debitage is less vast at Holkrans: bipolar debitage (flakes and blades, 8.9%) is almost half of the proportion of blade debitage (complete and fragments, 18.1%). The importance of the bipolar technique as a reduction strategy in the ceramic phase at Holkrans is again underscored.

Table 5.4: Comparison of debitage frequencies from Holkrans and Rose Cottage Cave (using data from Soriano et al. *2007).*

Debitage classes	Pre-ceramic (n=506)	Ceramic (n=359)	HP (EMD) (n=536)	Post HP (KAR) (n=72)
	%	%	%	%
Flakes and chunks	78.1	76.0	8.2	23.6
Bipolar flakes	0.8	5.8	0.6	5.6
Bipolar bladelets	0.0	1.7	0	12.5
Complete blades and proximal blade fragments	14.2	8.9	80.2	54.2
Mesial and distal blade fragments	8.1	7.5	11.0	4.2

The marked increase of debitage produced by the bipolar technique in the ceramic seems somewhat unusual. Nevertheless, Modikwa (2008) observed that, at the sites of Toteng 1(Botswana) and Mphekwane Shelter (Limpopo), bipolar reduction occurred alongside blade production in all three phases of occupation (Modikwa 2008) (Table 5.5).

Table 5.5: Comparison frequencies of core types between Holkrans, Toteng 1 and Mphekwane

	Holkrans (n=25)		Toteng 1 (n=18)			Mphekwane (n=53)		
Core types	Ceramic	Pre-ceramic	Pottery	Middle	Pre-pottery	Pottery	Middle	Pre-pottery
Free-hand cores:	%	%	%	%	%	%	%	%
Bladelet cores	5.6	28.6	12.5	12.5	17.8	28.9	11.1	13.4
Bladelet core fragments	11.1	0	-	-	-	-	-	-
Failed cores	11.1	42.8	-	-	-	-	-	-
'Dual' core	0	14.3	-	-	-	-	-	-
Bipolar cores:								
complete	11.1	0	25	12.5	28.6	44.4	50.0	46.7
incomplete	61.1	14.3	-	-	-	-	-	-

Furthermore, as seen in Table 5.5, the number of bipolar blades recorded by Modikwa (2008) for all three phases at both Toteng 1(n=40) and Mphekwane (n=19) is greater than the total number of bipolar bladelets at Holkrans (n=6). This suggests that the bipolar technique, in contrast to CCS lithic technology at Holkrans, was used significantly in the production of bladelets at the other two sites.

A point of difference between the collective work of Soriano *et al.* (2007) and Modikwa (2008) in juxtaposition to this research is that I have given very little consideration to flake debitage and other raw materials. I stress that these have been excluded not because of negligence but because of time constraints imposed by the Honours project. The partial but focused *chaîne opératoire* described in this project for CCS bipolar and bladelet debitage is therefore limited, and could easily be expanded with a consideration of other debitage and raw materials. A more comprehensive comparison with the research of Modikwa (2008) could certainly be made in future research if other debitage and raw material types are considered, although some of Modikwa's (2008) analytical categories are too different from the present study to make any comparison (e.g. blade platform widths).

5.6 CONCLUSION

An investigation of the *chaîne opératoire* of blade technology for CCS at Holkrans has revealed some interesting results. Blade technology, with the intention to produce blade and bladelet blanks, was predominant in the pre-ceramic phase. The technique during this period entailed the use of direct percussion with a soft stone hammer (possibly a rock type such as sandstone), delivering blows to the very margin of cores. The raw materials used for cores, namely chert and opaline, are most likely to have come from the gravels of the Vaal River. The arrival of ceramics at Holkrans, which in H5 seems to have been just under a thousand years ago (970 ± 40 BP and 900 ± 40 BP), seems to have be accompanied by a change in the use of several raw materials: I have shown that the usage of opaline raw material increased in addition to the above-average percentages of 'grey-and-black' raw materials previously observed by Banhegyi (2011) in E8. The increased use of opaline materials over chert was tied to a significant change in the objectives of the knapping sequence. In the ceramic phase, blades and bladelets were no longer, for some reason, important to the inhabitants of Holkrans rock shelter.

APPENDICES

APPENDIX 1: BLADE ANALYSIS TABLES

Blade classification observing position on the flaking surface (cf. Fig. 2). Types do not necessarily reflect successive stages in the debitage sequence. (after Soriano *et al.* 2007: Table 5).

A: Initial stage

- A1 Crested blades
- A2 Entirely cortical blades
- A3 Blades with more than 50% of cortex (or natural surface)

B: Main production phase

Blades from the central part of the debitage surface

- B1 Blades produced during the optimal phase of the debitage, without cortex, with unidirectional or bidirectional scars
- B2 Blades with distal cortical edge
- B3 Plunging blades preserving a portion of the opposite striking platform, and unidirectional or bidirectional scars
- B4 Plunging blades preserving a portion of the opposite cortical end, and unidirectional or bidirectional scars

Blades from the sides of the debitage surface

- B5 Blades directly underlying a crested blade with symmetrical or asymmetrical section and unidirectional or bidirectional scars
- B6 Blades with a lateral cortical edge (less than 50% of cortex) and unidirectional or bidirectional scars
- B7 Blades with a cortical or natural steep back and unidirectional or bidirectional scars
- B8 Blades with a lateral and distal cortical edge (less than 50% of cortex)
- B9 Blades with centripetal dorsal scars on one side only
- B10 Blades with a cortical or natural steep back and distal cortical edge
- B11 Plunging blades of type B4 + B6 (blades with a lateral cortical edge and plunging on a cortical end)
- B12 Plunging blades of type B4 + B7 (blades with a cortical steep back and plunging on a cortical end)
- B13 Plunging blade of type B3 + B6 (blades with a lateral cortical edge and plunging on a portion of the opposite striking platform)
- B14 Plunging blade of type B3 + B7 (blades with a cortical steep back and plunging on a portion of the opposite striking platform)

C: Core maintenance blades

- C1 Crested blade of second generation (crest along the midline of the blade)
- C2 Crested blade of second generation (crest in lateral position)

D: Other

- D1 Generic crested blades (that cannot be classed as first or second generation)
- D2 Blades that fall outside any of the listed category

E: Indeterminate blades

- E1 Unclassifiable pieces as a result of damage, breakage or irregular raw material

List of criteria used to diagnose the percussion technique (cf. Fig. 3) (modified after Soriano et al. 2007: Table 6)

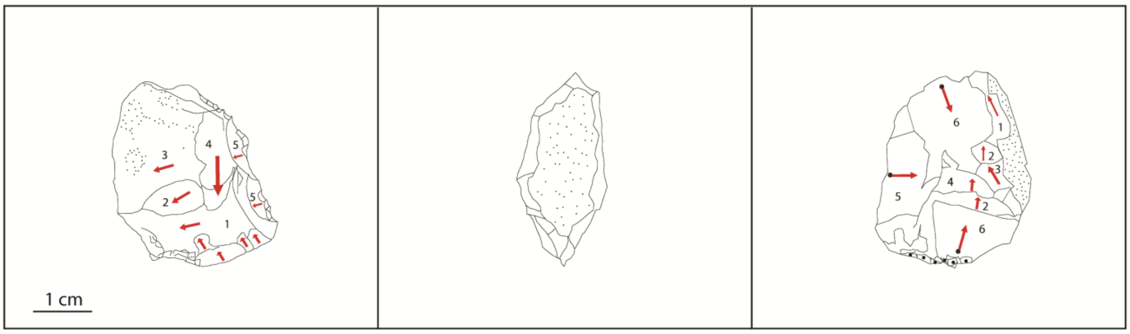
Morphometric attributes
- Width (1-3 mm, 3-5 mm and > 5 mm) and thickness (< 1 mm, 1-2 mm, 2-5 mm and > 5 mm) by class
- Exterior platform angle

Attributes associated with platform preparation
- Presence of cortex on the platform
- Platform preparation: none (plain); faceted (bulb negatives are present); residual faceting (ridges, but no bulb negatives); absent (broken platform, reduced to an edge); other; indeterminate
- Nature of preparation toward the flaking surface (Fig. 3, A): none (A1); trimming of the platform edge by very short hinged removals; (A2); reduction of the overhang by small removals following scar ridges (A3); lateral notching (making the point of impact more prominent by lateral removals (A4); other; indeterminate
- Intensity of platform abrasion: none; slight (hardly visible to the naked eye); high; very high (the abrasion covers nearly the entire platform); indeterminate

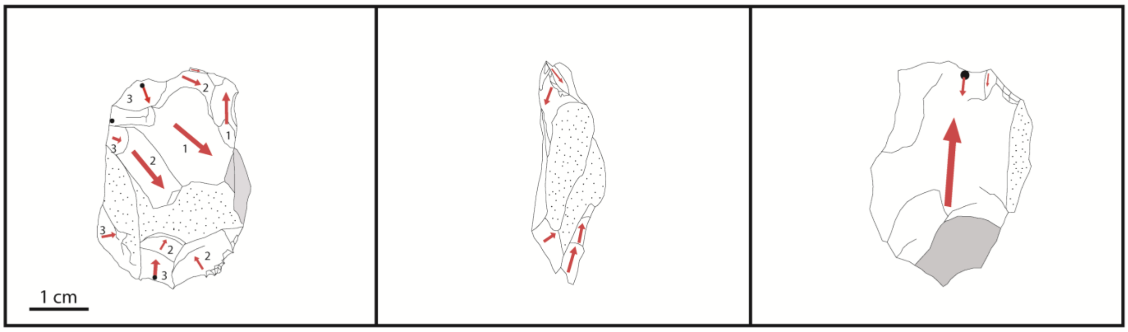
Attributes associated with the application of force, percussion movement and the kind of hammer
- Expression and location of the fracture initiation point: non-expressed; expressed and centred on the platform; expressed and lateralized on the platform; indeterminate
- Delineation of the platform on the ventral face (Fig. 3, B): regular curve (B1); curved and overhanging from the point of impact but without a break in the delineation (B2); curved and overhanging from the point of impact with a break in the delineation (B3); double-curved with two points of contact (B4); rectilinear (B5); irregular (B6); indeterminate; other
- Presence of fissuring on the platform and intensity (Fig. 3, C): none; total or nearly total circular fissuring at the point of impact (C3); accurate partial fissuring (C2); contoured Hertzian cone (C4); other; indeterminate
- Specific marks: closely spaced, fine ripples on the ventral face; siret (longitudinal split) break; split or shattered bulb (Fig. 3, C1); other; indeterminate
- Bulb attributes: absent, small or large lip; absent, diffuse or pronounced bulb; other; indeterminate
- Platform morphology (Fig. 3D): punctiform (D1); narrow linear (D2); oval/triangular (D3); lunate (D4); quadrangular or wide trapezoidal (D5); other; indeterminate

APPENDIX 2: DIACRITICAL SCHEMATA OF CORE SAMPLE

CERAMIC PHASE CORES

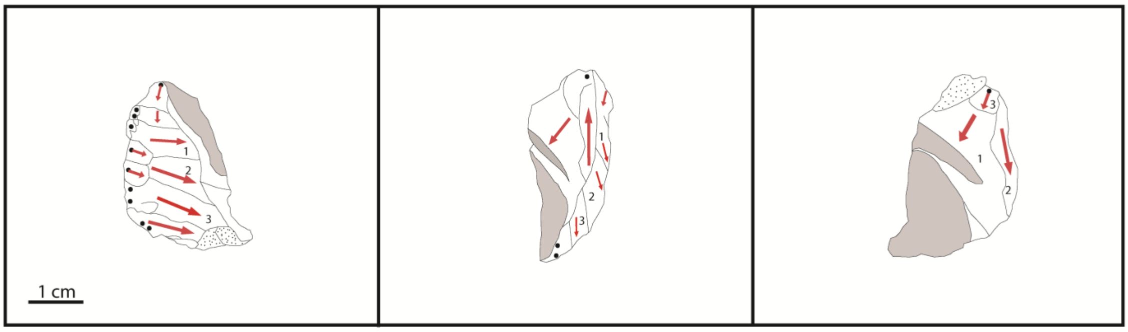


Core 128

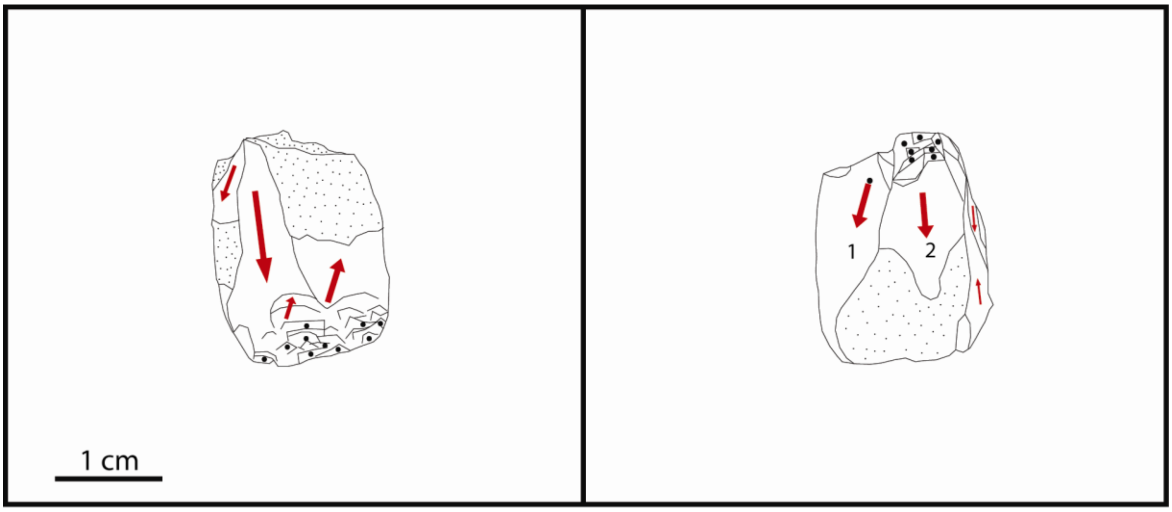


Core 177

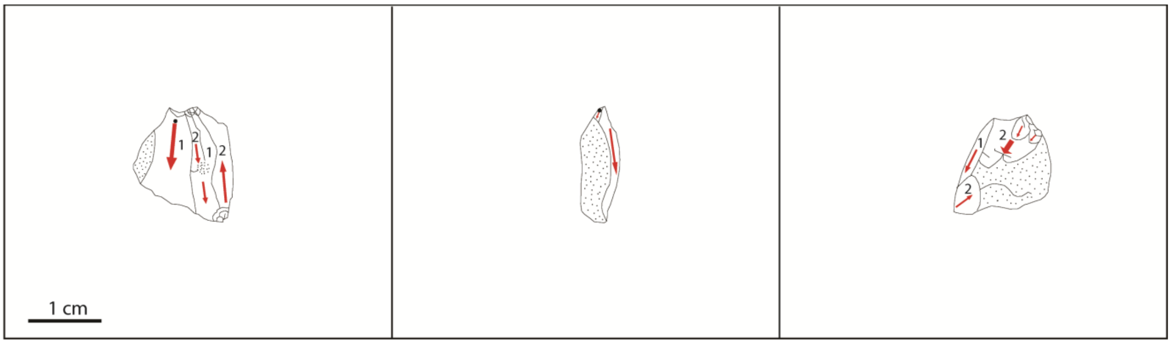
Core 191, bladelet core fragment



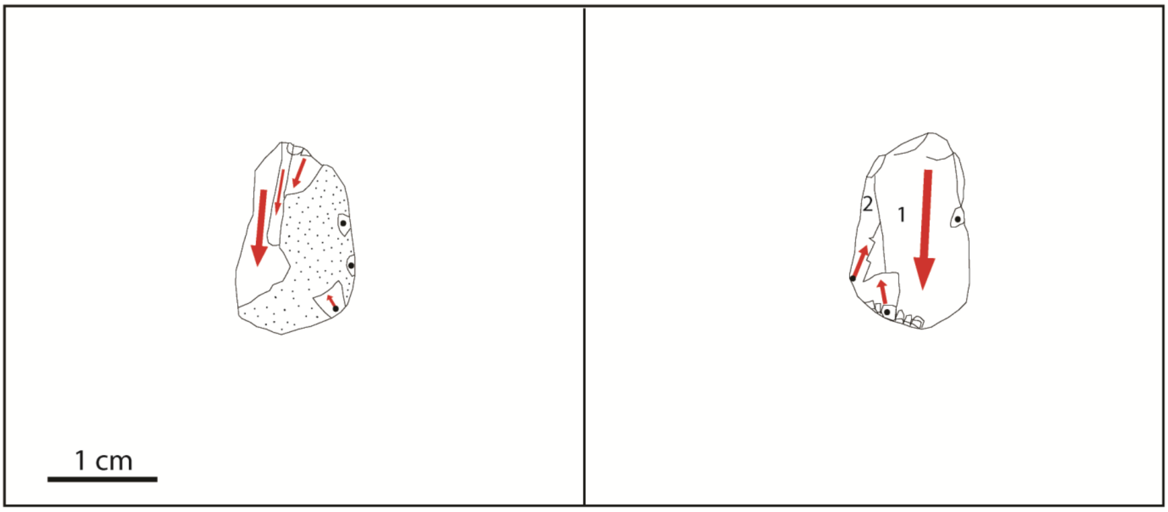
Core 619, bladelet core fragment



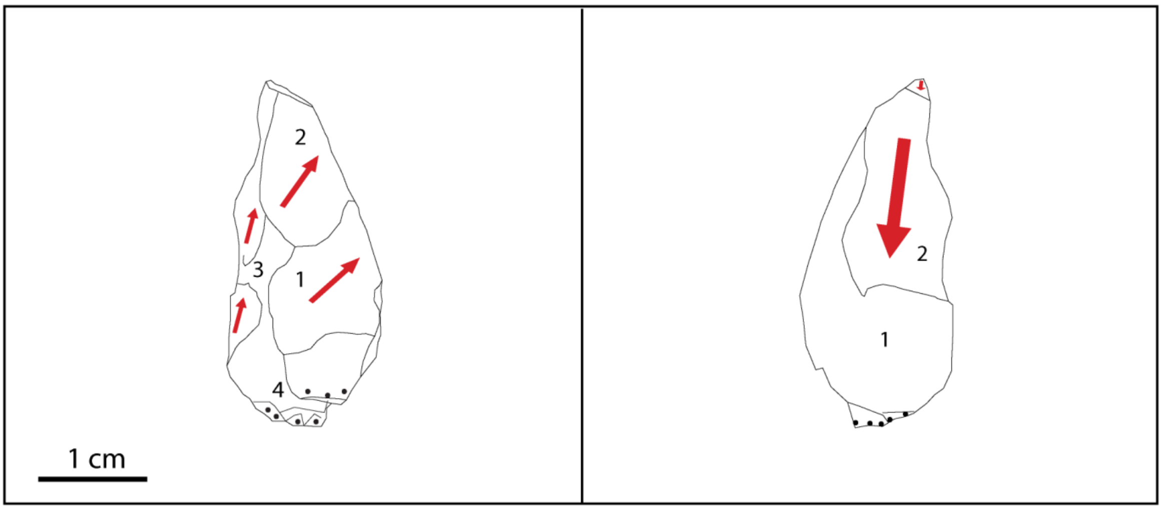
Core 102, bipolar



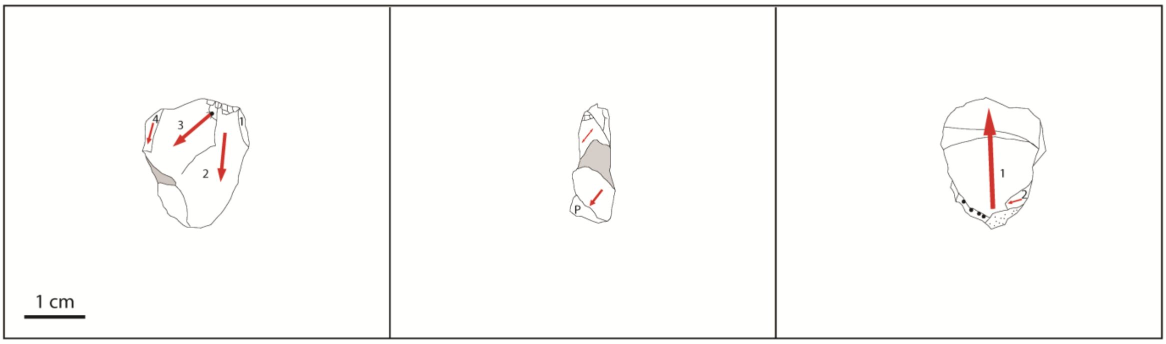
Core 104, bipolar incomplete



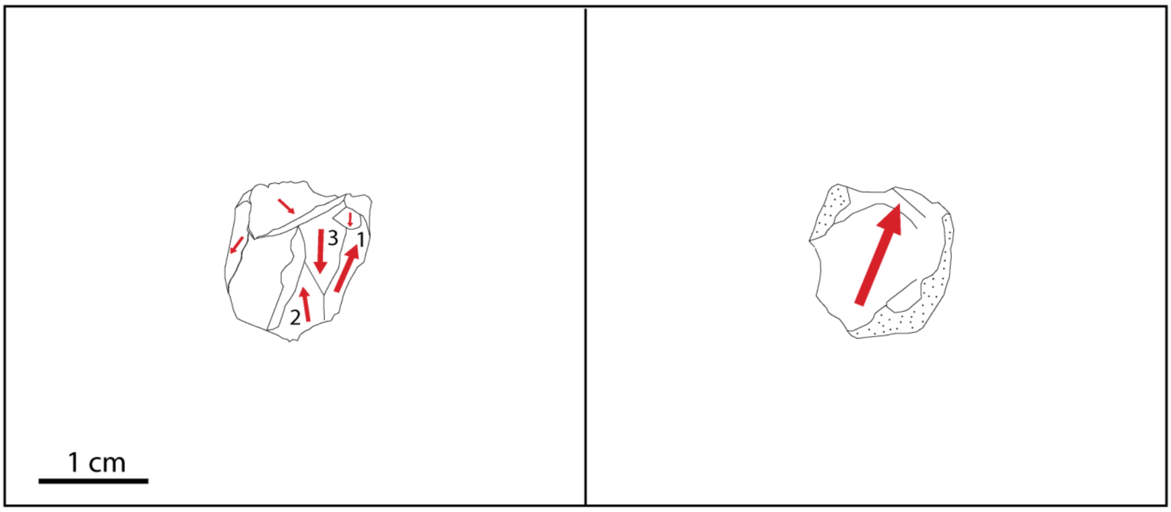
Core 107, bipolar incomplete



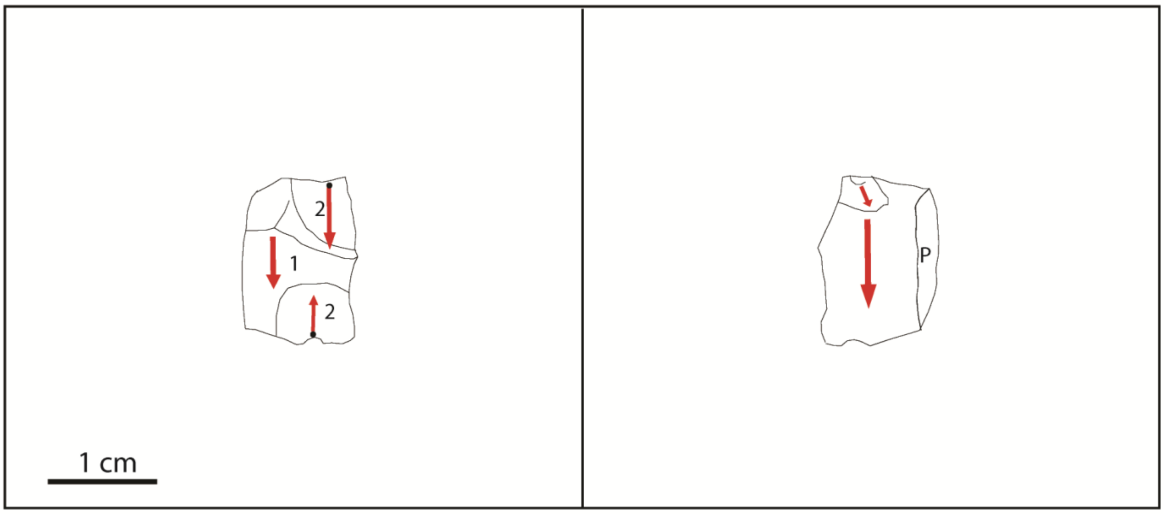
Core 134, bipolar incomplete



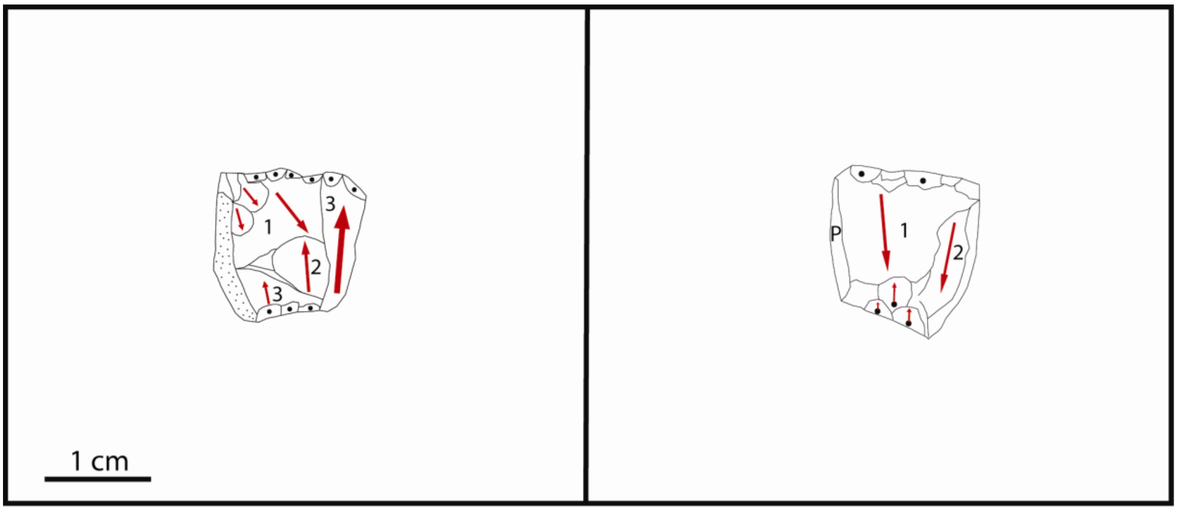
Core 424, bipolar incomplete



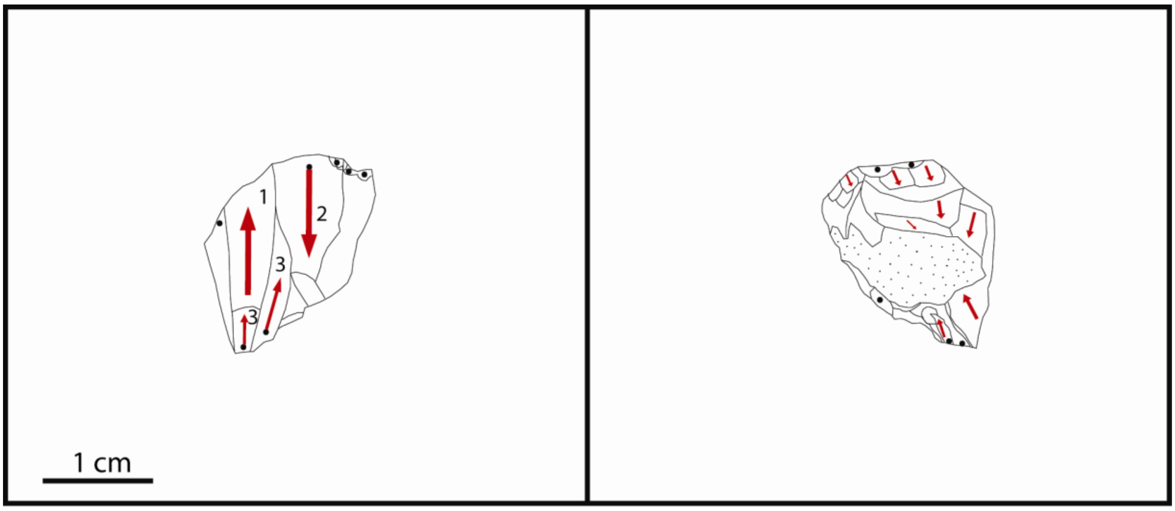
Core 478, bipolar incomplete



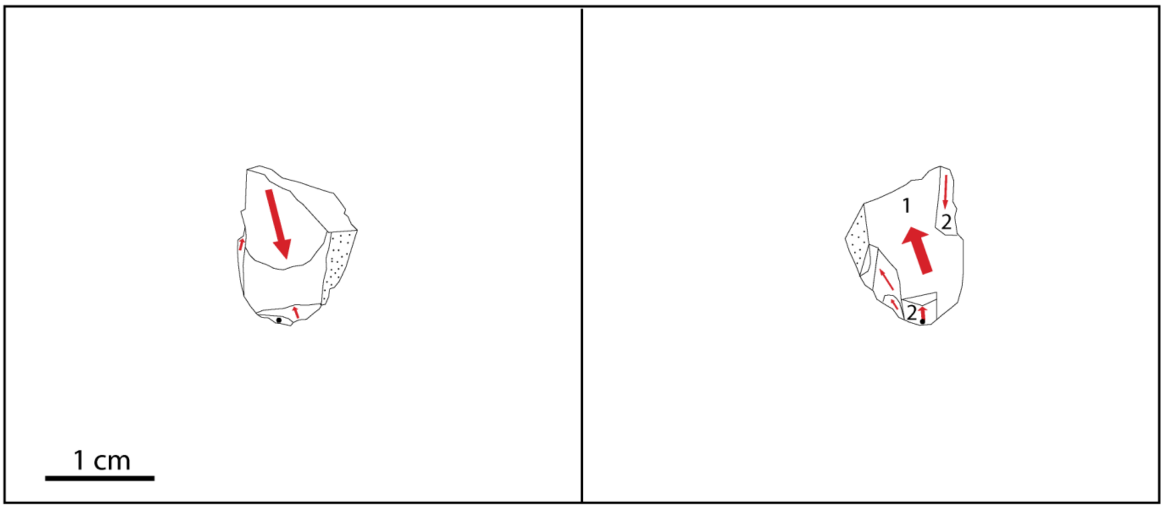
Core 484, bipolar incomplete



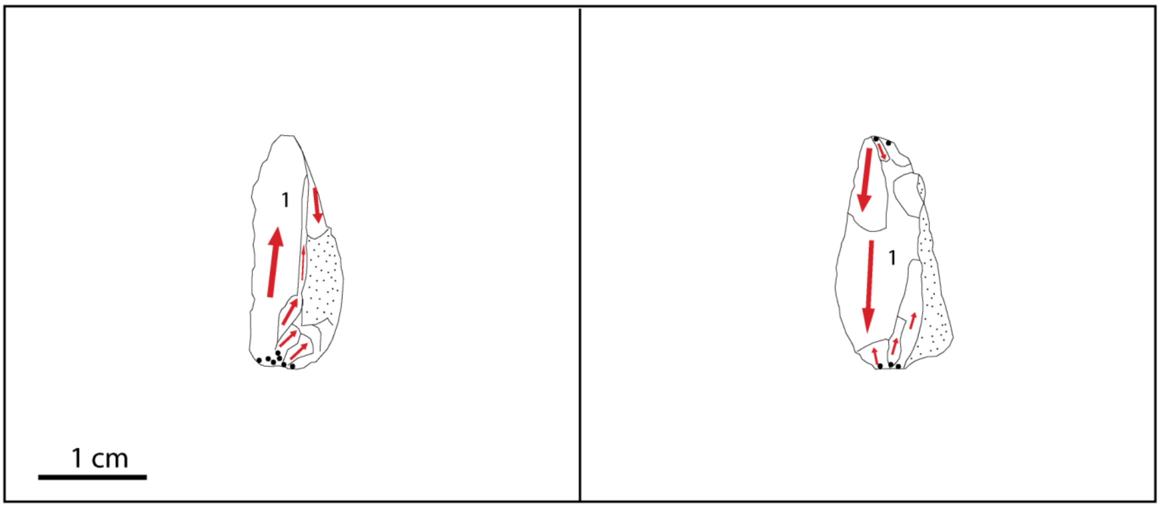
Core 596, bipolar



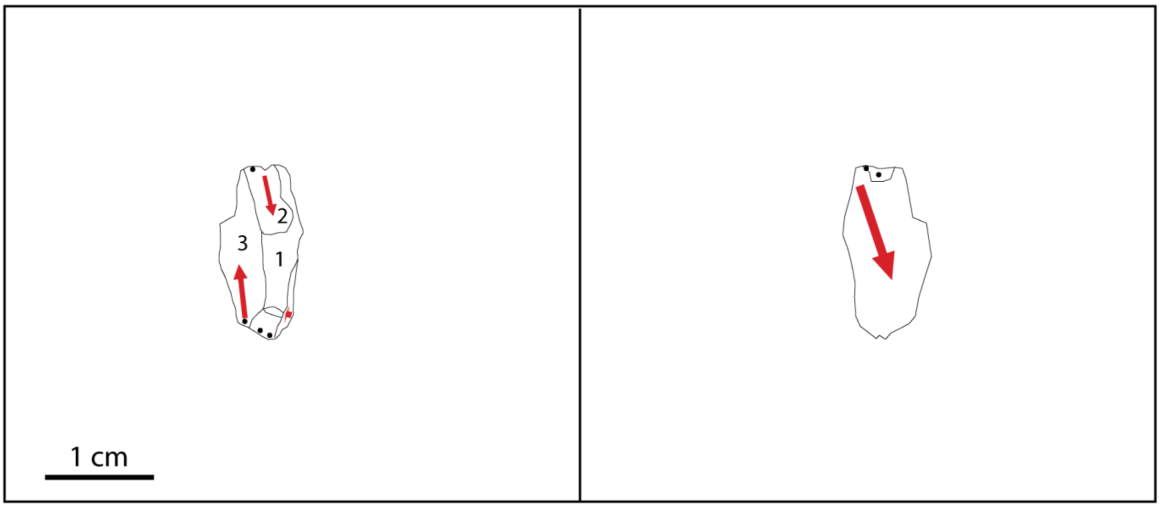
Core 765, bipolar incomplete



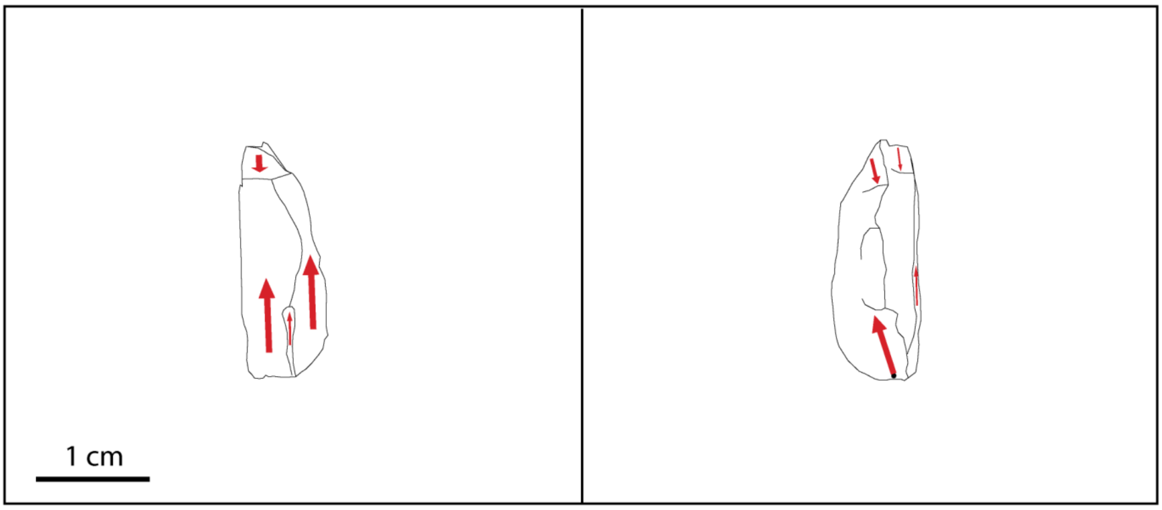
Core 766, bipolar incomplete



Core 769, bipolar incomplete



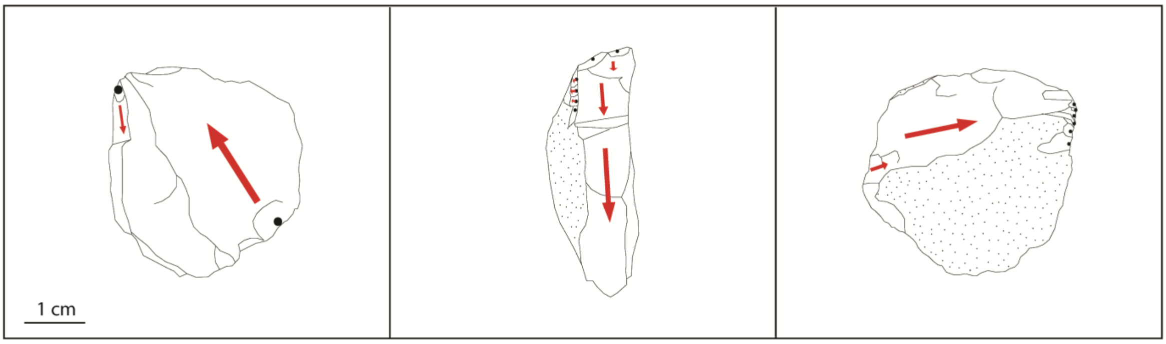
Core 785, bipolar incomplete



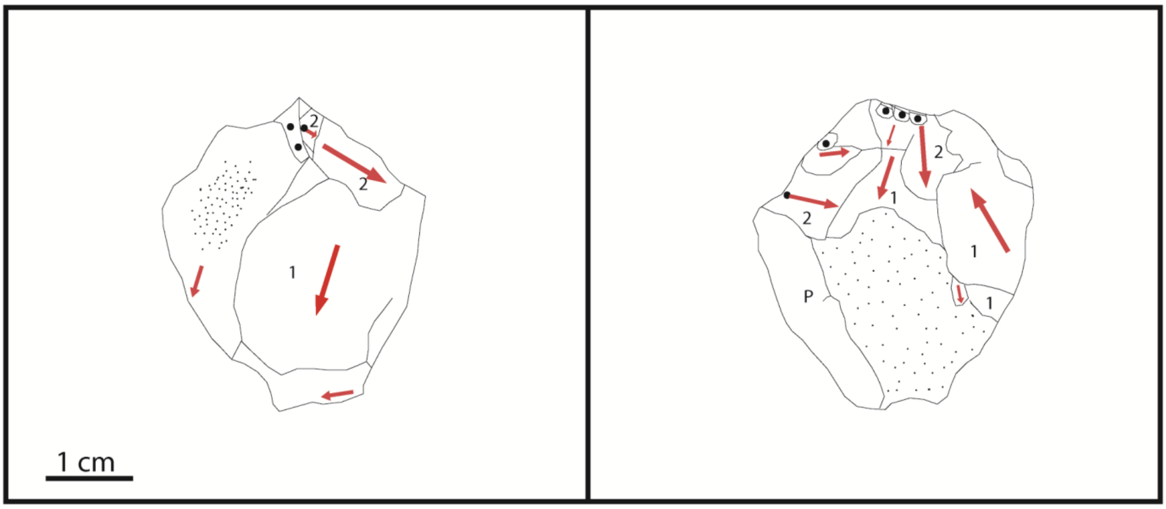
Core 799, bipolar incomplete

PRE-CERAMIC PHASE CORES

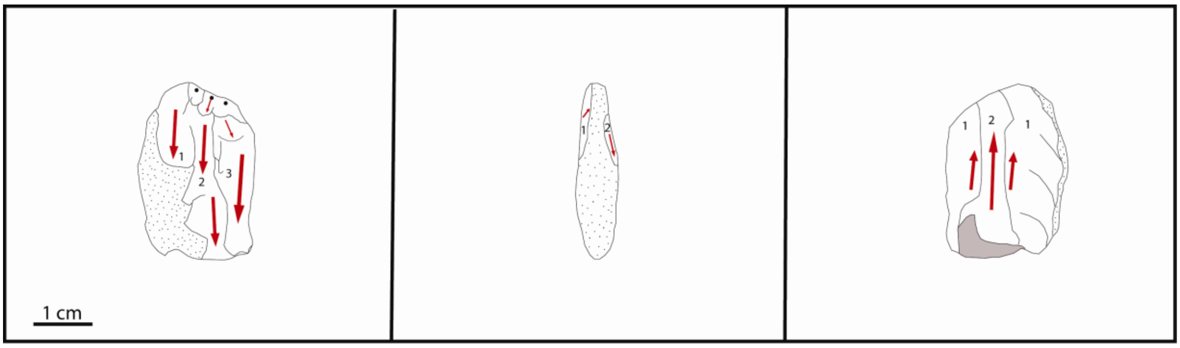
Core 243



Core 390



Core 906



Core 666, bipolar incomplete

APPENDIX 3: pXRF TRACE ELEMENT DATA

The following are the numerical results obtained from pXRF analysis of the trace elements in both the geological (GEO) and archaeological (ARCH) chert samples. The results are graphically represented as a dendrogram in Fig. 4.2

Number	Type	Label	Units	Ba	Sr	Pb	Mn	V	Ti
1	ARCH	244	%	0.012	< LOD	< LOD	< LOD	< LOD	0.002
2	ARCH	875	%	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
3	ARCH	543	%	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
4	ARCH	161	%	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
5	ARCH	113	%	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
6	ARCH	501	%	0.017	< LOD	< LOD	< LOD	< LOD	0.003
7	ARCH	647	%	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
8	ARCH	384	%	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
9	ARCH	803	%	0.011	< LOD	< LOD	< LOD	< LOD	0.002
10	ARCH	955	%	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
11	ARCH	945	%	< LOD	< LOD	< LOD	< LOD	< LOD	0.002
12	ARCH	289	%	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
13	ARCH	713	%	< LOD	< LOD	< LOD	< LOD	< LOD	0.003
14	ARCH	849	%	< LOD	< LOD	< LOD	< LOD	< LOD	0.003
15	ARCH	473	%	0.01	< LOD	< LOD	< LOD	< LOD	0.002
16	ARCH	298	%	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
17	ARCH	845	%	0.008	< LOD	< LOD	< LOD	< LOD	0.003
18	ARCH	642	%	0.004	< LOD	< LOD	< LOD	< LOD	< LOD
19	ARCH	117	%	< LOD	< LOD	< LOD	< LOD	< LOD	0.003
20	ARCH	695	%	< LOD	< LOD	< LOD	< LOD	< LOD	0.003
21	ARCH	683	%	0.007	< LOD	< LOD	< LOD	< LOD	0.005
22	ARCH	550	%	0.017	< LOD	< LOD	< LOD	< LOD	0.004

23	ARCH	889	%	< LOD	< LOD	< LOD	< LOD	< LOD	0.005
24	ARCH	280	%	< LOD	< LOD	< LOD	< LOD	< LOD	0.016
25	ARCH	944	%	< LOD	< LOD	< LOD	< LOD	< LOD	0.003
26	ARCH	536	%	< LOD	< LOD	< LOD	< LOD	< LOD	0.005
27	ARCH	848	%	< LOD	< LOD	< LOD	< LOD	< LOD	0.006
28	ARCH	853	%	0.016	< LOD	< LOD	< LOD	< LOD	0.01
29	ARCH	694	%	< LOD	< LOD	< LOD	< LOD	< LOD	0.008
30	ARCH	503	%	0.017	< LOD	< LOD	< LOD	< LOD	0.023
31	ARCH	767	%	0.009	< LOD	< LOD	< LOD	< LOD	0.011
32	ARCH	953	%	0.018	< LOD	< LOD	< LOD	< LOD	0.017
33	ARCH	541	%	0.011	< LOD	< LOD	< LOD	< LOD	0.016
34	GEO	1	%	0.016	< LOD	< LOD	< LOD	< LOD	< LOD
35	GEO	10010	%	0.012	< LOD	< LOD	< LOD	< LOD	< LOD
36	GEO	1009a	%	0.017	< LOD	< LOD	0.009	< LOD	< LOD
37	GEO	4006a	%	0.015	< LOD	< LOD	< LOD	< LOD	< LOD
38	GEO	3006	%	0.017	< LOD	< LOD	< LOD	< LOD	0.041
39	GEO	5009	%	0.015	< LOD	< LOD	< LOD	< LOD	< LOD
40	GEO	3009	%	0.018	< LOD	< LOD	< LOD	< LOD	< LOD
41	GEO	2006	%	0.012	< LOD	< LOD	< LOD	< LOD	< LOD
42	GEO	1003	%	0.018	0.002	< LOD	< LOD	< LOD	0.028
43	GEO	2010	%	0.015	< LOD	< LOD	< LOD	< LOD	< LOD
44	GEO	4009	%	0.019	< LOD	< LOD	0.119	< LOD	< LOD
45	GEO	1009b	%	0.012	< LOD	< LOD	< LOD	< LOD	< LOD
46	GEO	1010	%	0.006	< LOD	< LOD	< LOD	< LOD	< LOD
47	GEO	2002	%	0.017	< LOD	< LOD	< LOD	< LOD	< LOD
48	GEO	3010	%	0.016	< LOD	< LOD	< LOD	< LOD	< LOD
49	GEO	5010	%	0.016	< LOD	< LOD	< LOD	< LOD	< LOD
50	GEO	4006b	%	0.005	< LOD	< LOD	< LOD	< LOD	0.003
51	GEO	1008	%	0.005	< LOD	< LOD	< LOD	< LOD	< LOD

52	GEO	3002	%	0.019	< LOD	< LOD	< LOD	< LOD	0.016
53	GEO	6010	%	0.016	< LOD	< LOD	< LOD	< LOD	0.005
54	GEO	2003	%	0.016	< LOD	< LOD	< LOD	0.012	0.005
55	GEO	1008b	%	0.02	< LOD	< LOD	< LOD	< LOD	0.018
56	GEO	9010	%	0.088	0.015	0.004	< LOD	0.005	0.008
57	GEO	1002	%	0.018	< LOD	< LOD	< LOD	< LOD	0.023
58	GEO	5002	%	0.015	< LOD	< LOD	< LOD	< LOD	0.011
59	GEO	4002	%	0.016	< LOD	< LOD	< LOD	< LOD	0.01
60	GEO	4010	%	0.015	< LOD	< LOD	< LOD	< LOD	0.005
61	GEO	2002	%	0.015	< LOD	< LOD	< LOD	< LOD	0.017
62	GEO	7010	%	0.014	< LOD	< LOD	< LOD	< LOD	0.006
63	GEO	1006	%	0.016	< LOD	< LOD	0.02	< LOD	0.015
64	GEO	8010	%	0.016	< LOD	< LOD	< LOD	< LOD	0.005
65	GEO	11010	%	0.016	< LOD	< LOD	< LOD	< LOD	0.003

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