

OCHRE USE AT SIBUDU CAVE  
AND ITS LINK TO  
COMPLEX COGNITION  
IN THE  
MIDDLE STONE AGE

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Doctor of Philosophy

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## DECLARATION

I declare that this thesis is my own work and has not been submitted before for any degree or examination at any other University. By thesis, it is understood to mean my contribution for submission for the degree of Doctor of Philosophy at the University of the Witwatersrand by published and submitted articles.

A handwritten signature in black ink, appearing to read 'Hodgskiss', is written on a light blue rectangular background. The signature is cursive and fluid.

Tamaryn Penny Hodgskiss

Date 25 September 2013

## ABSTRACT

Ochre is found at many Middle Stone Age (MSA) sites and its use is often attributed by archaeologists to enhanced mental abilities and symbolism. However, the links between the visible uses of ochre, cognition and symbolism have not been clearly demonstrated. Here it is argued that by understanding ochre processing technology and some of the stages involved in using ochre, one can determine the skill, knowledge and cognitive abilities required to execute those activities. In order to understand the use-traces found on ochre, and to enable the identification of them, as well as the types of ochre used, experiments were first performed with geological ochre specimens. Ochre pieces collected from the Sibudu surrounds were used experimentally for a variety of grinding, scoring and rubbing activities. All use-traces created on the ochre piece during an activity were macro- and microscopically examined, recorded and compared.

Experimental ochre pieces ground against a coarse or fine-grained slab develop parallel striations. Grinding results in significant changes to the surface shape of the ochre, and often results in faceted edges. Scoring can be performed with the intention to create powder, or to create a design. The incisions created from scoring often do not reach all the edges of the used surface and they regularly have frayed terminations. A frayed incision termination shows that the incision was created by multiple scoring strokes. When ochre is scored to manufacture powder the incisions that are generated are parallel groups of grooves with erratically oriented grooves as well. Grooves created through both grinding and scoring have microstriations within them and they show a range of profile shapes. The most common use-wear from rubbing ochre on soft materials is smoothing, edge rounding and polish. Microstriations and metallic lustre occasionally form during rubbing. The collection of utilised experimental ochre formed a comparative collection for the examination of the Sibudu ochre.

The main body of this research comprises a study of the Middle Stone Age ochre assemblage from Sibudu, KwaZulu-Natal, South Africa. Sibudu has a large Middle Stone Age ochre assemblage of over 9000 pieces of ochre from layers dating between ~77 ka and ~37.6 ka. All pieces were examined to determine the types of ochre used and to inspect all use-traces present on the pieces. The assemblage comprises 5449 ochre pieces

>8 mm, including 682 pieces with markings from use. The pre-Still Bay (~77 ka) and Howiesons Poort (~65–62 ka) layers have the highest percentage of utilised pieces. Bright-red ochre was preferentially selected for use throughout most of sequence. There is evidence of the preferential selection of specific types of ochre for use in the Sibudu assemblage. Shale and pieces with medium hardness values are common throughout the sequence. Grain sizes change through time – pieces with clayey grain sizes are favoured during the Still Bay and Howiesons Poort, whereas silty grain sizes are preferred in the younger Middle Stone Age occupations. High frequencies of bright-red amongst the utilised pieces, coupled with high frequencies of yellow or orange pieces with no evidence of use, suggest that colour choices were deliberate and not a product of post-depositional heating. Chemical analysis of a sample of utilised pieces indicates that they all contain iron, silicon, aluminium and calcium; many pieces contain hematite and some contain maghemite.

Use-traces were divided into activity categories, based on experimental results. Combined grinding and rubbing is the most frequent activity for which ochre pieces were used. Grinding and rubbing use-wear also occurs independently on many pieces. Scored pieces are rare, but are more frequent in the pre-Still Bay (~77 ka) industry than elsewhere in the sequence. Some of the incisions appear to be deliberate engravings, and parallel lines and fan-like marks are the most often repeated patterns. Use-traces acquired during powder-producing activities predominate, implying a desire to create ochre powder. Powder-producing activities were mainly performed with bright-red pieces, while minimal scoring is mainly present on brown-red pieces. Pieces with mica inclusions are not common, but were frequently used for powder-producing activities.

Once the activities performed with ochre were established, thought-and-action sequences, or cognigrams, were constructed. This helped establish the steps involved in each activity and the temporal and physical distance between the commencement of a task to its completion. Inferential sequences were constructed to establish the procedures and knowledge needed to complete an activity, thereby establishing the cognitive prerequisites. Cognitive interpretations are made using the concept of enhanced executive functions of the brain. The construction of the inferential thought-

and-action sequences showed that the various ways that ochre was used have different cognitive requirements.

Powder-production alone is not an indicator of complex cognitive processes, although some planning, foresight and knowledge of materials is required. Some of the powder was used in the creation of hafting adhesives, which is a cognitively demanding process requiring attention-switching ability, response inhibition and abstract thought. Grinding ochre and then rubbing the piece on a soft material for the direct transfer of powder does require some complex mental abilities, such as multi-tasking and switching attention. Scoring a piece of ochre with a sharp tool does not necessitate enhanced executive functions, but some engravings demonstrate foresight, intentionality and an awareness of space and symmetry that may demonstrate abstract thought.

This research provides a complete description of the Middle Stone Age ochre assemblage at Sibudu, and establishes the way that ochre was used at the site. This contributes to the debate on the advent of enhanced behaviours in the past by providing insight into the cognitive abilities required by the ochre users. It offers a method of analysing ochre use in the past by drawing on cognitive theory and the visible applications of ochre. Both simple and complex cognitive abilities were required for ochre activities at Sibudu. The requirement for cognitively complex abilities in some of the ochre-related activities at Sibudu suggests that the people living there during the MSA had advanced mental capabilities like modern humans living today. This research shows how ochre use can be employed as a proxy for cognitive capabilities, and can therefore shed light on the evolution of the modern mind.

To my wonderful parents, Dave and Dot Hodgskiss.  
You have shown me how to tackle life and work with enthusiasm,  
determination, love, respect and laughter.  
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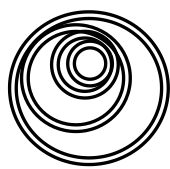
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# CHAPTER 1

## Introduction



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## 1.1 Rationale and Research Hypothesis

Archaeological evidence of ‘advanced’ behaviours is well documented from about 40,000 years ago (40 ka) in the European Upper Palaeolithic and the Later Stone Age in sub-Saharan Africa (e.g. Marshack 1972; Klein 1983, 1996; White 1989; Belfer-Cohen & Hovers 1992; Wadley 1993, 2001; Barton *et al.* 1994; d’Errico *et al.* 1998, 2003; d’Errico & Nowell 2000; Bar-Yosef 2002; Shea 2006; Zilhão 2007; Dubreil & Grosman 2009; Pike *et al.* 2012; Villa *et al.* 2012). However, there is increasing evidence that the behavioural and cognitive advancements occurred at ~80 ka or earlier. These findings are mostly associated with anatomically modern humans (McBrearty & Brooks 2000; Marean & Assefa 2005), but in Europe, both Neanderthals and modern humans are responsible for the Middle-Upper Palaeolithic accumulations (e.g. d’Errico *et al.* 2003; Mellars 2004; Wynn & Coolidge 2004; Soressi & d’Errico 2007; Roebroeks *et al.* 2011). Some of the advanced behaviours seen in the Middle Stone Age and Middle Palaeolithic include the hafting of tools, compound adhesive and possible paint manufacture, the use of intricate tool technologies, deliberate heat treatment of geological materials, the use of non-local raw materials, perforated shells (possibly beads), engraved ostrich eggshell and ‘designs’ engraved on ochre (Singer & Wymer 1982; Bar-Yosef Mayer *et al.* 2009; McBrearty & Brooks 2000; d’Errico *et al.* 2001, 2005, 2008, 2012a; Villa & d’Errico 2001; Dickson & Gang 2002; Henshilwood *et al.* 2002, 2004, 2009, 2011; d’Errico 2003; Hovers *et al.* 2003; Lombard 2005; Ambrose 2006; Vanhaeren *et al.* 2006; Henshilwood 2007; Soressi & d’Errico 2007; Backwell *et al.* 2008; Mackay & Welz 2008; Brown *et al.* 2009; Goldberg *et al.* 2009; Texier *et al.* 2010; Wadley 2010a, b; Jerardino & Marean 2011; Wadley *et al.* 2011).

At Middle Stone Age and Middle Palaeolithic sites, dated between ~300–40 ka, unutilised and utilised pieces of ochre are regular finds. In the more recent past, ochre was often used for symbolic and ritual purposes (e.g. Marshall 1976; Peile 1979; Rudner 1983; Shaw & van Warmelo 1988; Knight *et al.* 1995), but it also has many functional roles, such as for protection from the sun and insects, an aggregate in hafting adhesives or to aid hide tanning (e.g. Audouin & Plisson 1982; Shaw & van Warmelo 1988; Dubreuil & Grosman 2009; Wadley *et al.* 2009; Rifkin 2011). The varied uses of ochre have resulted in conflicting interpretations of ochre use in the ancient past. The

presence of ochre pieces bearing engraved ‘designs’ (Henshilwood *et al.* 2002, 2009; Mackay & Welz 2008; d’Errico *et al.* 2012a) and the preferential use of bright-red and visually distinctive ochre at many sites has prompted symbolic interpretations of ochre use in the Middle Stone Age (Boshier & Beaumont 1972; Knight *et al.* 1995; Henshilwood *et al.* 2001a, 2009; Watts 2002, 2009, 2010; Hovers *et al.* 2003; Marean *et al.* 2007). The ability for abstract thought, shown through the symbolic use of colour or design, is generally accepted as an indicator of advanced behaviour (McBrearty & Brooks 2000; Henshilwood & Marean 2003; Amati & Shallice 2007; d’Errico & Stringer 2011). However not all applications of the ochre pieces and powder are known, and so these symbolic interpretations may be incorrect or may represent an incomplete component of ochre use. Further, the link between the established uses of ochre in the Middle Stone Age and cognition has not been clearly described. It is these opposing elements that make ochre a perfect candidate with which to explore ancient cognition with the use of cognitive theory.

While interpretations of ochre use in the Middle Stone Age have become a contentious issue, detailed descriptions and analyses of ochre assemblages are relatively rare (e.g. Watts 1998, 2002, 2010; Barham 2002; Hovers *et al.* 2003; d’Errico 2008; Dayet *et al.* 2013). Site reports often mention ochre frequencies and ochre colour, or numbers of pieces with evidence of utilisation, but they sometimes fail to comment on other characteristics that may have been responsible for the collection and use of the ochre pieces. Various ochre properties could have determined collection and use even though colour may have been the most obvious attraction. Additionally, ochre that is unmodified is often not examined because analyses are aimed at utilised pieces. Establishing the nature of the unutilised sample can be beneficial in concluding what types of pieces were preferentially selected for use.

This study produces a detailed description of ochre found at Sibudu, KwaZulu-Natal, South Africa. The research concentrates on the types of ochre used, the various processing techniques employed, and the markings that these actions leave on the ochre pieces. The examination of the Sibudu ochre assemblage will contribute to the extensive research that has been done on other Middle Stone Age cultural material from the site. The construction of inferential activity sequences will help to interpret the cognitive

abilities that the ochre users required. Cognitive interpretations are made using the concept of enhanced executive functioning (Baddeley & Hitch 1974; Wynn 2002; Wynn & Coolidge 2007; Coolidge & Wynn 2009). This kind of comparative study, and the creation of technological-cognitive inferential sequences, is necessary when attempting to establish the relationship between the activities, behaviours and mental capabilities of the Middle Stone Age ochre users.

## **1.2 Aims**

- To investigate the many varieties of rocks that constitute the category ‘ochre’ at Sibudu, and to establish how ochre can be used and the markings that form on the ochre surface from use.
- To determine what types of ochre comprise the Middle Stone Age ochre assemblage at Sibudu.
- To establish how (and possibly why) ochre was used in the Middle Stone Age at Sibudu.
- To obtain data on the cognitive abilities needed for ochre use in the Middle Stone Age.

## **1.3 Theory and Method**

The first stage of this research is focused on replicative work. The experiments are aimed at providing both qualitative and quantitative data about the use of ochre. Experimental procedure involves grinding, rubbing and scoring activities, and combinations thereof, using assorted mediums and techniques. Each activity is performed numerous times with the same set of variables so that statistically significant results are obtained. Therefore, by using this kind of ‘Middle Range Theory’ for archaeological ochre, past behaviours can be inferred (Binford 1977). The experimental procedures are informed by previous use-trace experiments on bone, stone and ochre (e.g. Olsen & Shipman 1988; Shipman & Rose 1988; d’Errico 1992; Blumenschine *et al.* 1996; Backwell & d’Errico 2001; Wadley 2005a; Soressi & d’Errico 2007; Domínguez-Rodrigo *et al.* 2009; Rifkin 2012). The types of experiments performed are determined by ethnographic and historical records of ochre use (e.g. Bleek & Lloyd 1911; Goodwin

1938; Marshall 1976; Peile 1979; Rudner 1983; Shaw & van Warmelo 1988) as well as ethnographically and/or archaeologically established ways that ochre pieces, and other earth pigments, were used (e.g. Singer & Wymer 1982; Henshilwood *et al.* 2002, 2009; Watts 2002, 2010, 2012; Lombard 2006a; Mackay & Welz 2008; Soressi *et al.* 2008; Soriano *et al.* 2009; d'Errico *et al.* 2012a).

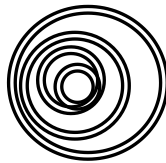
All ochre pieces excavated (by Prof. Lyn Wadley and her team) prior to April 2011 are examined. Analyses of the Sibudu ochre involve qualitative and quantitative exploration of the assemblage. Each piece is measured and given an individual code (e.g. Sb204). Physical attributes of all the pieces are recorded – including rock type, hardness, grain size, colour and mica inclusions. Pieces are divided into utilised, possibly utilised and unutilised categories after examination of the surface features. To obtain qualitative mineralogical and chemical data on the ochre, a sample of utilised pieces is analysed using Scanning Electron Microscope–Energy Dispersive X-ray Spectroscopy (SEM–EDS), Fourier Transform Infrared Spectroscopy (FTIR) and Raman Spectroscopy. The utilised pieces are further microscopically examined and all use-traces are recorded in an Excel database. Once all use-traces have been identified recorded, the activity responsible for the use-traces can be identified. Data is then statistically analysed to obtain frequencies, correlations and associations within and between the various ochre properties, use-traces and activity categories. Percentage frequencies, Chi-squared (using Yates Correction) and Fisher's exact tests are used where applicable and necessary.

The cognitive model of enhanced executive functioning, embedded in the broader theoretical concept of enhanced working memory, is drawn upon for cognitive interpretations (Baddeley & Hitch 1974; Wynn 2002; Wynn & Coolidge 2003, 2007; Kane *et al.* 2004; Coolidge & Wynn 2005, 2009). This model has been chosen based on the critical investigation of the hypotheses and models that can facilitate interpretations of cognitive abilities in the past. Various methods are not effective for the interpretation of activities and cognition in the past because they rely on direct evidence or knowledge of the social system in which they were created (e.g. symbolism). By producing thought-and-action and cognitive inferential sequences for each activity for which ochre was used, one deconstructs an activity into a series of steps – the artefact, the technical system, the procedures and knowledge required and finally the cognitive prerequisites.

Each step is supported by empirical data and/or supported inferential arguments. These sequences establish the complexity of the task as well as the distance between the awareness of a problem and its resolution. By establishing the technology and processes involved in using ochre, one can determine the skill, knowledge and cognitive abilities required to execute those activities. This will enable the exploration of the similarities and differences between the cognition of people living in the Middle Stone Age and complex cognition of the kind used by modern people.

# CHAPTER 2

## Thesis Structure



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## 2.1 Thesis Structure

This thesis contains a series of papers that I researched and compiled during the period of my Ph.D. registration (2009/01/28 – 2013/02/26). The structure of the thesis is in accordance with the guidelines provided by the Faculty of Science at the University of the Witwatersrand for the submission of a Ph.D. thesis by publication. Currently, the four papers submitted for this thesis are in various stages of publication, that being published ( $n = 3$ ) and provisionally accepted ( $n = 1$ ).

A review of academic sources that focus on the uses and nature of ochre in the Middle Stone Age and in the more recent past is provided in the Literature Review (Chapter 3). The Literature Review includes a discussion of the models for interpreting ochre use, a background to use-trace studies and an introduction to Sibudu. The separate papers make up Chapters 4, 5, 6 and 7 in the thesis. The first paper presents the background, methods and results of the experimental ochre work that was performed at the beginning of the research (Chapter 4). The results of the analysis of the Sibudu ochre are divided into two papers. One discusses the properties and ochre types in the utilised and unutilised assemblages and includes background and research methodologies (Chapter 5). The other paper on the Sibudu ochre assemblage discusses the use-traces found on the utilised ochre pieces and considers both the activities that ochre was used for and the possible meanings of ochre usage (Chapter 6). The final paper deals with the cognitive abilities required to use ochre in the way that is evident at Sibudu. This is done through the use of thought-and-action sequences as well as inferential sequences rooted in cognitive theory (Chapter 7). The papers presented here are in their original format as prescribed by the journals to which they were submitted. The final chapter (Chapter 8) discusses the temporal and spatial patterns of ochre use at Sibudu and the cognitive conclusions that can be drawn from an analysis of ochre activities in the Middle Stone Age. Avenues for future work that may stem from this study are also suggested. A complete reference list of all works cited is included at the end of the thesis. A brief overview of the chapters is provided in Section 2.2 below.

## 2.2 Thesis Chapters

### *Chapter 3: Literature Review*

This chapter reviews previous research on ochre use, use-trace assessment and related topics. The focus is on Middle Stone Age assemblages and ochre use, but relevant data from Middle Palaeolithic assemblages are also discussed. Confirmed archaeological and ethnographic applications of ochre are considered. A review of cognitive and experimental methodologies for interpreting ochre use (and its significance) in the Middle Stone Age and Middle Palaeolithic is provided. Lastly, Sibudu, the site on which this research is focussed, is then discussed. This is done to place the ochre assemblage in the context of the Middle Stone Age sequence at the site. The literature review incorporates background information provided in the papers.

### *Chapter 4: Experimental Paper*

Hodgskiss, T. 2010. Identifying grinding, scoring and rubbing use-wear on experimental ochre pieces. *Journal of Archaeological Science* 37(12): 3344–3358.

The first stage of this research focuses on replicative work. The experiments have a dual purpose. First, they were performed so that I could familiarise myself with the variety of rock types that fall under the umbrella term ‘ochre’, and specifically the types of ochre in the Sibudu surrounds. Secondly, the experiments demonstrated the markings that form on the surface of a piece as a result of different activities.

Geological samples of ochre were collected from the Ndwedwe shale quarry that is about one kilometre from Sibudu. The activities chosen are documented ways in which ochre was used in the more recent past. The ochre pieces were used for a variety of grinding, scoring and rubbing activities, and some were exposed to the post-depositional processes of trampling and water-soaking. Various modifications of each activity were also attempted, such as using the ochre in wet or dry conditions, so that various methods of use could also be established. The experiments assisted in determining which techniques are more effective – the (best) techniques for producing ochre powder, the most effective way to colour a material or the best way to incise a piece. Each technique was performed a number of times with different pieces to obtain

statistically significant results. All the markings resulting from each activity, or combination of activities, were identified, examined microscopically and recorded in a database.

There is rare evidence of the applications of ochre and ochre powder in the Middle Stone Age and these experiments help to establish plausible ways that ochre may have been applied. Knowing what markings each activity (or combinations of activities) forms, allows for interpretations of the use-traces on the archaeological pieces, and their subsequent placement into activity categories. The experiments emphasise the necessary steps that are involved in each activity, and which other tasks need to be implemented beforehand or consecutively in order to complete the activity. The experimental pieces function as a comparative sample for the interpretation of the Sibudu archaeological ochre. These experiments are vital in the interpretation of ochre use at Sibudu and the cognitive inferences that can be made from that.

#### *Chapter 5: Ochre Properties Paper*

Hodgskiss, T. 2011. An investigation into the properties of the ochre from Sibudu, KwaZulu-Natal, South Africa. *Southern African Humanities* 24: 99–120.

In this paper I describe the attributes of the entire ochre assemblage from the Middle Stone Age layers at Sibudu. All the ochre pieces excavated (by Prof. Lyn Wadley and her team) prior to April 2011 are examined. Sibudu presents us with a large collection of utilised and unutilised pieces. The quantity of ochre at Sibudu suggests it was a desired commodity that was regularly brought to the site. The assemblage comprises 5449 pieces (>8 mm), including 682 pieces with markings from use. All pieces were examined, measured and numbered individually. Examination initially focussed on geological properties: rock type, hardness, grain size, colour, mica content and mineralogy. This was done to determine whether there was a preference to collect and use ochre pieces with certain attributes.

The research conducted for this paper helps to establish whether different geological sources and ochre types could be responsible for intra-site differences in ochre use. Various attributes are likely to have determined why the material was

collected and used. Colour appears to be the most obvious attraction, but may not have been the sole, or even the most important, criterion for ochre selection and use.

#### *Chapter 6: Ochre Use-trace Paper*

Hodgskiss, T. 2013. Ochre use in the Middle Stone Age at Sibudu: grinding, rubbing, scoring and engraving. *Journal of African Archaeology* 11 (1): 75–95.

This paper discusses the anthropogenically-created use-traces on the ochre pieces from the Middle Stone Age layers at Sibudu. This is done to explore the issue of how (and possibly why) ochre was used.

There are 682 pieces with definite signs of use. Each utilised piece was microscopically examined and described with the use of the comparative ochre sample created during experimental work. Use-traces were recorded on a database and all pieces were macro- and microscopically photographed to create a visual record of the use-traces. Using the comparative experimental material, I could then infer which activity (or combination of activities) caused the markings on each piece. Not all the use-traces could be securely categorised into activities – this paper focuses on the use-traces and activity groups that could be definitively identified. The activity categories were then correlated with the physical and geological properties of the ochre to determine whether certain types of ochre or ochre powder were preferentially selected for certain activities. In establishing how ochre was utilised, coupled with detailed physical and chemical analyses, possible applications and reasons for use were also obtained, and are presented in this paper.

#### *Chapter 7: Cognition Implications*

Hodgskiss, T. Accepted, subject to corrections. Cognitive requirements for ochre use in the Middle Stone Age at Sibudu, South Africa. Submitted to the Cambridge Archaeological Journal.

Ochre collection and use is often associated with enhanced mental abilities and symbolism, but the link between the visible uses of ochre found at archaeological sites and cognition has not been established. The concluding paper in this research suggests a

way of linking ochre use with cognitive interpretations, through constructing inferential activity sequences within a cognitive model. Use-trace analysis, combined with experimental understanding, provides a solid foundation on which cognitive conclusions can be built. In this analysis, the established ochre activities at Sibudu were divided into a series of steps based on use-traces and other related evidence of use. Identification of the types of ochre that were utilised is also important for these interpretations because this information can support hypotheses about ochre use. Through the in depth analysis of the ochre assemblage – focusing on the thought-and-action sequence, technology and processes involved in using ochre – the skill, knowledge and cognitive abilities required to execute the various activities can be inferred.

The neuropsychological model of enhanced executive functioning of the brain (used by Botha 2008; Wynn 2009) is used to draw cognitive conclusions. This cognitive model is used with full awareness of the symbolic interpretations often attached to ochre use, and possible reasons for these interpretations are incorporated into the argument. Steps in the processing or use of ochre that can only be performed by drawing on cognitive abilities associated with modern mental architecture (such as composition, abstract thought or cognitive fluidity) are taken as evidence to demonstrate that the Middle Stone Age ochre-user possessed complex cognitive processes. I also consider whether the ochre found at Sibudu can be interpreted as a means to relay a message to a social group in the Middle Stone Age, or whether, for example, engraved ochre functioned in an individualistic, but still symbolic arena.

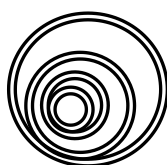
#### *Chapter 8: Discussion and Conclusion*

The concluding chapter provides a summary of the nature of the ochre assemblage and discusses the ochre finds within the site context – in terms of temporal and spatial changes. I look at how ochre use at Sibudu fits into the rest of the cultural processes and artefacts found at the site – faunal, environmental and lithic – by looking at changes that occurred through the sequence. This is done to establish whether ochre use may have been influenced by external factors, such as technological advancements. The discussion also contains a summary of the cognitive conclusions made about ochre usage in the Middle Stone Age at Sibudu, and these are placed into a chronological context within the site.

The analytical procedures used in this study are evaluated as well as how this research has contributed methodologically and theoretically to Middle Stone Age ochre use and Middle Stone Age and/or Middle Palaeolithic cognitive research. The value of using this type of model to understand Middle Stone Age cognition is also discussed. Future research possibilities that stem from this study are identified; while I focus on the Sibudu assemblage, the findings in this research can be applied to other assemblages. I conclude by summarising the main outcomes of the project.

# CHAPTER 3

## Literature Review



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### 3.1 What is ochre?

‘Ochre’ is a general term for a range of iron-rich rocks with red, yellow, orange or purple streaks and is commonly made up of iron oxides and iron oxyhydroxides ( $\text{Fe}_2\text{O}_3$  and  $\text{FeOOH}$ ) (Schwertmann & Cornell 1991; Jercher *et al.* 1998; Cornell & Schwertmann 2003; Popelka-Filcoff *et al.* 2007; Fiore *et al.* 2008). In this thesis the terms ‘pigment’ and ‘colouring material’ are avoided in the descriptions of the rocks because they pre-empt how and why the material was used in the past. Ochre includes a variety of sedimentary (and sometimes igneous and metamorphic) rocks and weathered products that include hematite, goethite, specularite, shale, snuffbox shale, mudstone, siltstone and sandstone (Watts 1998, 2002; Erlandson *et al.* 1999; Hughes & Solomon 2000; Henshilwood *et al.* 2001a, 2009; Barham 2002; Hovers *et al.* 2003; Popelka-Filcoff *et al.* 2007). Ochre is found in various sedimentological, mineralogical and metamorphic stages that occur during and after rock formation, and is also affected by environmental conditions (Cornell & Schwertmann 2003; Hradil *et al.* 2003; Fiore *et al.* 2008; Iriarte *et al.* 2009; Bonneau *et al.* 2012). Inclusions such as mica, quartz crystals, organic materials and various impurities occur frequently in ochre (Ruan *et al.* 2002; Hradil *et al.* 2003).

The colour of ochre is influenced by numerous factors such as mineralogy, crystal structure, particle and grain size, and organic and inorganic inclusions (Bikiaris *et al.* 1999; Hradil *et al.* 2003; Elias *et al.* 2006; Mastrotheodoros *et al.* 2010). The presence of iron oxides and iron oxyhydroxides is vital to the colouring of ochre, and very small amounts of hematite can influence colour (Schwertmann & Cornell 1991; Cornell & Schwertmann 2003; Hovers *et al.* 2003). Colour can be further altered by heat. If temperatures  $\sim 250^\circ\text{C}$  are reached, iron oxyhydroxide-rich pieces become dehydrated, resulting in hematite formation and a colour change from yellow to red (Schwertmann & Cornell 1991; Edwards *et al.* 2000; Ruan *et al.* 2001, 2002; Godfrey-Smith & Ilani 2004; Wadley 2009; Gialanella *et al.* 2011). If organic matter is present, maghemite forms and dark reds or browns are produced (Schwertmann & Cornell 1991; Minzoni-Déroche *et al.* 1995; Pomiès *et al.* 1998, 1999). It is problematic to determine whether heating was intentional, accidental, or whether it occurred post-depositionally (e.g. Godfrey-Smith & Ilani 2004; Wadley 2009, 2010c; d’Errico *et al.* 2012a).

### 3.2 Middle Stone Age and Middle Palaeolithic ochre assemblages

Ochre has become a common and expected find at Middle Stone Age and Middle Palaeolithic sites, as well as at younger sites. A range of ochre types constitute the assemblages and the ochre pieces are used in a variety of ways. Below I describe some of the studied Middle Stone Age and Middle Palaeolithic ochre assemblages. Some of these sites are further discussed throughout the thesis and published articles.

- *Blombos Cave*. The ochre assemblage from the Middle Stone Age layers at Blombos Cave, South Africa, comprises over 7500 pieces from levels dating ~100–70 ka (Henshilwood *et al.* 2001a, 2002, 2009, 2011; Watts 2009). About 15% (n=1534) of the assemblage is utilised. There are a variety of colours of ochre, but the assemblage is dominated by bright- or saturated red pieces (Henshilwood *et al.* 2009; Watts 2009). Yellow pieces contribute a small percentage of the assemblage and few of them are utilised (Watts 2009). Fine-grained shales and siltstones are most common, especially in the earlier levels, whereas coarse rock types are rare throughout (Watts 2009). Over 60% of the utilised assemblage is composed of bright- (or saturated) red pieces that have been ground (Henshilwood *et al.* 2009; Watts 2009).

The primary objective of ochre use at Blombos was most probably to create powder and many pieces have use-wear from grinding (Henshilwood *et al.* 2009). There is evidence in the 100 ka layers that an ochre-rich mixture was produced, possibly used as paint (Henshilwood *et al.* 2011). ‘Scraping’ (or scoring) occurs on 34.5% of the utilised pieces and grinding and scoring occur together on 9.4% of the pieces (Henshilwood *et al.* 2009). Some pieces appear to be deliberately engraved and the incisions are parallel, fan-shaped, or form cross-hatched patterns (Henshilwood *et al.* 2002, fig. 2, 2009, figs. 4, 6, 7, 143, 16, 20). Scored pieces have a higher percentage of soft pieces (<Mohs 3) than ground pieces, and scoring is more likely to be on pastel-coloured pieces than saturated pieces (Henshilwood *et al.* 2009). Rubbing, in the form of smoothing, is not common in the assemblage. A possible source of the ochre is found about 35 km from the site (Henshilwood *et al.* 2009).

- *Pinnacle Point Cave 13B*. Over 500 pieces of ochre from Pinnacle Point Cave 13B (PP13B), South Africa, were examined from Middle Stone Age layers dated to ~115–92 ka. The utilised pieces comprise 12.7% of the assemblage and are mostly red (Marean *et al.* 2007; Watts 2010). Siltstone, iron oxide and shale dominate the assemblage. Ground pieces constitute 93.7% of the utilised assemblage and in six cases grinding occurs with other forms of utilisation – mostly scoring (Watts 2010). There are few soft pieces (<Mohs 3) which is a likely reason why there is poor scoring representation at the site (Watts 2010). The intensively ground pieces at Pinnacle Point display a limited colour range, mostly red shades, but the lightly ground pieces have a wide colour profile range like the unutilised assemblage (Watts 2010). Based on use-trace analysis and utilisation rates, saturated red, dark red pieces and iron oxides were preferentially used at PP13B (Watts 2010). Likely sources of the ochre are found five to ten kilometers from the site (Watts 2010).
- *Klasies River*. The Middle Stone Age ochre collection at Klasies River, South Africa, is comprised mostly of shale and claystone. The collection consists of 314 pieces dated to 110–60 ka. Most pieces are red, although there is some soft, yellow sandstone (Singer & Wymer 1982; Watts 1998). Some pieces are ground and faceted and few pieces have scored incisions (McBrearty & Brooks 2000; d’Errico *et al.* 2012a).
- *Diepkloof Rock Shelter*. Shale, ferricrete and intermediate varieties thereof make up the ochre assemblage at Diepkloof, South Africa (Dayet *et al.* 2013), in layers dated to ~110–52 ka (Jacobs *et al.* 2008a; Tribolo *et al.* 2013). The total excavated assemblage contains 558 pieces of ochre; most pieces are fine-grained and 16% of the pieces in the assemblage show signs of use (Dayet *et al.* 2013). All the utilised pieces have been ground, some showing additional signs of knapping and only two have signs of possible scraping or scoring (Dayet *et al.* 2013).
- *Border Cave*. Over 100 pieces of ochre were found at Border Cave, South Africa, with associated ochre powder patches (Beaumont *et al.* 1978; Watts 2002). Intensively ground and faceted hematite pieces are found throughout the sequence, in layers dated to 100 ka (Beaumont *et al.* 1978; Beaumont 1980).
- *Klein Kliphuis*. The ochre collection at Klein Kliphuis, South Africa, consists of 919 pieces of ochre weighing 1.47 kg (Mackay 2006; Mackay & Welz 2008). A piece of red ground and scored ochre was found in Howiesons Poort/early post-

Howiesons Poort layers, dated to between ~66–58 ka (Mackay & Welz 2008). The piece is ground on one side and the other side is engraved with a cross-hatched pattern.

- *Wonderwerk Cave*. Red ochre and specularite pieces were found at Wonderwerk Cave, South Africa. A scored red stone plaque of low grade hematite was found in levels dated to ~70 ka at Wonderwerk (Bednarik & Beaumont 2010). There are numerous engraved incisions on most of the facets of the piece. (Bednarik & Beaumont 2010). Another piece was found in layers possibly older than ~270 ka. This piece has some narrow parallel incisions on its surface (Bednarik & Beaumont 2010). Some of the sources are 50 km from the site, but others are local (Beaumont & Vogel 2006).
- *Twin Rivers*. Over 300 pieces of ochre were found at Twin Rivers, Zambia, dated to ~350–195 ka (Barham 1998, 2002). Most of the pieces are specularite with dark purple-red streaks, but a variety of geological forms and colours are represented. Less than 4% of the assemblage is utilised and most of the pieces are specularite and one piece is an earthy hematite (Barham 2002; Watts 2009). The preference to use hard pieces when soft pieces were available indicates that they may have been chosen for their high iron content (Barham 2002). These pigments were probably collected about two kilometers from the site (Barham 2002).
- *Lion Cavern*. Tons of specular, red hematite was reportedly mined ~40 ka at Lion Cavern, Swaziland (Dart & Beaumont 1969; Boshier & Beaumont 1972; Beaumont 1973; Robbins *et al.* 1998). The contextual evidence for Lion Cavern has not been published; therefore the date for the mining of the ochre has not yet been substantiated.
- *Porc Épic*. About 300 fragments of ochre were found in layers dated to ~77 ka at Porc Épic, Ethiopia (Clarke & Williamson 1984; Clark 1988). Varieties of hard and soft rock types were found, including hematite and specular hematite, in various shades of red and yellow (Clarke & Williamson 1984). Many of the pieces have been ground and faceted, and some of the pieces were possibly heat-treated (Clarke & Williamson 1984).
- *GnJh-15*. In levels up to ~285 ka at GnJh-15, in the Kapthurin formation in Kenya, more than 70 ochre pieces, mostly hematite, were found. Most are red, many are soft and friable and they seldom bear traces of use (McBrearty 1999,

2001; Tryon & McBrearty 2002; Roebroeks *et al.* 2011). Ochre powder patches are also apparent in the sediment (e.g. van Noten *et al.* 1987 in McBrearty & Brooks 2000).

- *Qafzeh Cave*. At Qafzeh Cave, Israel, 71 pieces of ochre were found in the ~90 ka layers. Red, soft, silty and clayey ochre pieces are most common in the assemblage and most are siltstones and fine-grained sandstones (Hovers *et al.* 2003). Some of the pieces have been scored (or scraped), there is evidence of grinding on some pieces, and some pieces have been rubbed (Hovers *et al.* 2003). There is an extremely small quantity of yellow pieces at the site, even though yellow ochre is available locally. Hovers and colleagues (2003) conclude that a red hue is the crucial selection criterion of ochre at Qafzeh. Godfrey-Smith & Ilani (2004) demonstrated that some of the ochre pieces were heated (to high, but controlled temperatures) and that some of the red ochre from the site is probably the result of deliberate heat treatment. Ochre pieces and also residues on perforated sea shells were found associated with human burials in the ~92 ka layers (Bar-Yosef Mayer *et al.* 2009). The ochre was transported 8–60 km from its source to the cave (Hovers *et al.* 2003; Bar-Yosef Mayer *et al.* 2009).
- *Es-Skhul*. Four pieces of red and yellow ochre were found in Mousterian layers at Es-Skhul, Israel (d’Errico *et al.* 2010). The pieces have varying mineral and geological signatures, and three pieces were exposed to heat from a hearth (d’Errico *et al.* 2010).
- *El-Wad*. Excavations in el-Wad cave, Israel, revealed some ochre fragments in Middle and Upper Palaeolithic layers (Weinstein-Evron & Ilani 1994). Various geological types were identified from the sample of 82 pieces that were analysed – hematite, goethite, calcite, dolomite and jasperoid. Most pieces at the site are red, orange and brown, and there are few yellow pieces. Some pebbles and pestles were found with ochre staining; the latter is evidence of ochre grinding and processing at the site (Weinstein-Evron & Ilani 1994). Sources of the ochre pieces are within 1–10 km of the site (Weinstein-Evron & Ilani 1994).
- *Maastricht-Belvédère*. Fifteen small areas of concentrated red material were found in layers dating to ~250 ka at Maastricht-Belvédère, The Netherlands (Roebroeks *et al.* 2011). The fine-grained concentrations vary in colour from yellows to reds and the material was found to be hematite with a quartz component (Roebroeks *et al.*

2011). The material is non-local and was transported, by the Neanderthal inhabitants of the site, over possibly dozens of kilometres.

- *Terra Amata*. At Terra Amata, in France, 75 pieces of red, brown, and yellow limonite as well as patches of ochre powder have been found in layers dated to ~300 ka (Wreschner 1980; Marshack 1981). These layers are associated with *Homo erectus*. Some of the ochre was worn smooth (de Lumley suggests they were possibly rubbed during body painting) and colour variations suggest that some of the pieces were heated (de Lumley 1969 as cited in Dickson 1990).

Most European Middle Palaeolithic sites containing earth pigments contain manganese, many of which are dated between 60–40 ka (Soressi & d’Errico 2007; Soressi *et al.* 2008; Roebroeks *et al.* 2011). Of note is Pech de l’Azé I in France. Here, 450 pieces of manganese dioxide (black, brown, grey and blue) were found with a few pieces of red and yellow ochre (Soressi & d’Errico 2007; Soressi *et al.* 2008). The ochre pieces bear no signs of utilisation, but 250 of the manganese dioxide pieces are utilised (Soressi *et al.* 2008). Many have been ground and are faceted, especially on the narrow edges or pointed edges of pieces. Some of these pieces are polished and were probably rubbed on soft materials such as hide or human skin (Soressi *et al.* 2008).

### **3.3 Ochre applications in the Middle Stone Age and Middle Palaeolithic**

Although ochre pieces are regular findings at Middle Stone Age sites, direct evidence for ochre (powder) use is sparse. The evidence for ochre use and ochre powder application in the Middle Stone Age and Middle Palaeolithic includes:

- Ochre pieces that display diverse use-traces and engravings (e.g. Singer & Wymer 1982; McBrearty & Brooks 2000; Henshilwood *et al.* 2001a, 2002, 2009; Henshilwood 2004, 2007; Mackay & Welz 2008; Bednarik & Beaumont 2010; d’Errico *et al.* 2012a).
- Intensively ground, ‘crayon’-shaped pieces (Mason 1962; Beaumont *et al.* 1978; Singer & Wymer 1982; Watts 1998; Henshilwood *et al.* 2001a, 2002, 2009; Henshilwood 2004; Fiore *et al.* 2008). There is little uniformity on what constitutes a so-called crayon, making inter-site comparison difficult. They are loosely defined

as intensively ground, multi-faceted pieces that are crayon-shaped. More recently, they have been described as ground ochre pieces with three or more facets that converge to a point (Henshilwood *et al.* 2001a). At Pech-de-l'Azé I in France it appears that these pieces were sometimes used to draw linear marks on another raw material (Soressi & d'Errico 2007; Soressi *et al.* 2008). No direct evidence of drawn coloured lines or marks has been found in or before the Middle Stone Age, therefore it has been proposed, and experimentally supported, that perishable objects such as leather, wood or human skin were likely objects of decoration (d'Errico 2003; Marshack 2003; Soressi & d'Errico 2007). However, experimental work by Wadley (2005a) has shown that crayon-shaped pieces may be the waste products from prolonged grinding. If the pieces are used like a crayon then their tips show signs of use, such as micro-facets, residues, polish or smoothing (Wadley 2005a; Soressi & d'Errico 2007). Intensively ground and faceted pieces must be thoroughly examined using the above-mentioned criteria before conclusions can be made about their use.

- Ochre powder or stains have been found on functional artefacts such as stone and bone tools and grindstones (e.g. Louw 1969; Carter *et al.* 1988; Avery *et al.* 1997; Ambrose 1998; McBrearty & Brooks 2000; Thackeray 2000; Henshilwood *et al.* 2001b; McBrearty 2001; Tomlinson 2001; Williamson 2004, 2005; Lombard 2006a, 2007; d'Errico & Henshilwood 2007; Mercader *et al.* 2009). Ochre is found on the proximal and medial portions of stone tools where the ochre was used as an aggregate in adhesives with which tools were hafted (Wendt 1976; Audouin & Plisson 1982; Singer & Wymer 1982; Allain & Rigaud 1986; Ambrose 1998; Wurz 1999; McBrearty & Brooks 2000; Gibson *et al.* 2004; Lombard 2004a, 2005, 2006a, 2007, 2011; Wadley *et al.* 2004, 2009; Wadley 2006a, b, 2010a, 2013; Villa *et al.* 2009; Rots *et al.* 2011). Hafting with (red) ochre-loaded adhesives has also been experimentally proven to be effective (Wadley 2005b; Wadley *et al.* 2009). Additionally, ochre is occasionally found on the working edges of tools (Williamson 2004), which may be the result of processing the ochre itself or working hides with ochre.
- Ochre powder or stains have been discovered on perforated shells (e.g. Henshilwood *et al.* 2004; d'Errico *et al.* 2005, 2008, 2009a; Vanhaeren 2006; Bouzouggar *et al.* 2007). Some of the ochre may have been accidentally deposited

on the shells – perhaps post-depositionally or while the shells were being perforated (d’Errico *et al.* 2005). Alternatively the shells may have been purposefully coloured red or, if the shells were worn as decorative beads, the ochre may have been transferred from skin, hides or thread that were covered in ochre (Henshilwood *et al.* 2004; d’Errico *et al.* 2005, 2009a).

- Ochre has been used in the manufacture of bifacial points (Soriano *et al.* 2009). At Sibudu, ochre was used both as an abrader and soft stone hammer for the manufacture of bifacial points during the Still Bay (Soriano *et al.* 2009).
- Ochre patches and activity areas involving ochre use have been discovered (Beaumont *et al.* 1978; Marshack 1981; Henshilwood *et al.* 2011). These are sometimes associated with ochre-stained items or cemented ash surfaces (Wadley 2010d, 2012a).

### **3.4 Recent applications of ochre**

There are many documented uses of ochre (powder) in the more recent past. Some of the uses have been explored experimentally, often to aid archaeological interpretations. Below is a list of some ethnographically documented uses of ochre.

- Body paint. Ochre powder is mixed with various other substances, such as animal fat or oil, to protect the skin from sun and insects (Marshall 1976; Shaw & van Warmelo 1988; Volman 1988; Watts 1998). Ochre paint is also often used for ritual purposes (Bleek & Lloyd 1911; Goodwin 1938; Boshier & Beaumont 1972; Marshall 1976; Rudner 1983; Shaw & van Warmelo 1988; Knight *et al.* 1995; Wadley 1997; Wallis & O’Conner 1998). The recent find of 100,000 year old ‘ochre-processing workshop’ at Blombos is evidence of the production of some kind of paint or compound mixture (Henshilwood *et al.* 2011). Its application is not yet known.
- Red and yellow ochre powder for cosmetic use (Rudner 1983; Shaw & van Warmelo 1988; Knight *et al.* 1995).
- Medicine – for external and/or internal use (Peile 1979; Audouin & Plisson 1982; Velo 1984).
- Paint for the production of rock art (e.g. Wendt 1976; Rudner 1983; Shaw & van Warmelo 1988; Hughes & Solomon 2000; Hradil *et al.* 2003; Prinsloo *et al.* 2008; Bonneau *et al.* 2012). The earliest evidence in Africa of ochre used for art is in the

form of painted slabs at Apollo 11, Namibia, which are dated to 27 ka (Wendt 1976). At Altamira, El Castillo and Tito Bustillo, Spain, cave paintings made with red pigment are dated back to ~40.8–35.6 ka (Pike *et al.* 2012).

- An aggregate in hafting adhesives. The use of ochre powder in hafting adhesives has been recorded in the Middle Stone Age, Later Stone Age and Middle and Upper Palaeolithic contexts as well as in the more recent past (Allain & Rigaud 1986; Brandt 1996; Brandt & Weedman 1997; Ambrose 1998; Rots 2002; Weedman 2002a, b; Gibson *et al.* 2004; Williamson 2004, 2005; Wadley *et al.* 2004; Lombard 2005, 2006a, 2007, 2008, 2011; Wadley 2006a; Rots *et al.* 2011).
- Hide preparation. Ochre is used to cure, tan and colour hides (Bleek & Lloyd 1911; Mandl 1961; Audouin & Plisson 1982; Rudner 1983; Velo 1984; Hooper *et al.* 1989; Brandt & Weedman 2002a, b). This has been established experimentally; ochre, and specifically red ochre, is an effective substance with which to tan hides because some varieties of ochre inhibit collagenase formation due to their antibacterial and antifungal properties (Audouin & Plisson 1982; Rifkin 2011). It is primarily the iron content in the ochre powder, but also the presence and quantity of chlorides, sulfates and nitrates that prevent the breakdown of collagen (Rifkin 2011). There is rare evidence of hide tanning or of the use of ochre for hide tanning in archaeological assemblages (Dubreuil & Grosman 2009; Griffins 2009).

### **3.5 Models for interpreting ochre use in the ancient past**

Much Middle Stone Age research is focussed on finding ways to reconstruct behaviours to determine whether the people living in the Middle Stone Age had modern cognition or cognitive functioning similar to ours today (Lindly & Clark 1990; Noble & Davidson 1991; McBrearty & Brooks 2000; Wadley 2001, 2013; Henshilwood *et al.* 2002; Henshilwood & Marean 2006; Amati & Shallice 2007; d’Errico & Stringer 2011; Shea 2011). In the past, research has focused on a list of artefactually-based traits that display progressive or advanced behaviours. These include: the exploitation of extreme environmental conditions, the use of large geographic ranges, seasonal resource exploitation, the use of remote capture methods, long-distance exchange of raw materials, increased artefact diversity, standardized tool types and manufacture

techniques, technological sophistication, art and ritual (e.g. Mellars 1989; Klein 2000; McBrearty and Brooks 2000; Ambrose 2001; d’Errico *et al.* 2003; Henshilwood & Marean 2003; Brumm & Moore 2005; Parkington *et al.* 2005; Wadley 2010b, 2013). There are many inadequacies of the, sometimes theoretically unsupported, trait list approach (see Wadley 2001, 2006a; Henshilwood & Marean 2003; Shea 2011). Importantly, this approach does not take account of environmental and temperature changes, demographic stress and social processes that may have prompted behavioural innovations or adaptations (for discussions see McBrearty & Brooks 2000; Shennan 2001; Wadley 2001; Henshilwood & Marean 2003; Bird & O’Connell 2006; McCall 2007; Zilhão 2007; Jacobs *et al.* 2008a).

The rare evidence for the application of ochre in the Middle Stone Age makes behavioural interpretations complicated, and has prompted a variety of interpretations for the potential use of ochre. Interpretations often focus on ‘symbolically mediated behaviour’ due the prevalence of (bright-) red specimens (Watts 2002, 2009, 2010; Hovers *et al.* 2003; Marean *et al.* 2007; Mackay & Welz 2008; Henshilwood *et al.* 2009), the presence of abstract, engraved designs on some ochre pieces (Henshilwood *et al.* 2004, 2009; Mackay & Welz 2008; d’Errico *et al.* 2012a) and the well documented ethnographic uses of ochre (see Section 3.4). Abstract representations and some forms of symbolising denote the ability for external information storage, which was a crucial step in becoming behaviourally modern (Donald 1991; Wadley 2001, 2013; Henshilwood & Marean 2006; Botha 2008). However, the use of symbols does not necessarily constitute evidence for enhanced cognitive functioning (Coolidge & Wynn 2009; Wynn & Coolidge 2011).

Berlin & Kay (1969) propose a cross-cultural order of appearance of the terminology for different colours, with white, black and red being among the first colours to be defined. This could suggest a universality of colour identification and categorisation in humans (Wreschner 1980; Hovers *et al.* 2003), with red being highly significant. Wadley (2005a, b; 2006a; 2009) and d’Errico and colleagues (2009b) have cautioned against making assumptions about the exclusively symbolic nature of archaeological ochre. They encourage exploration of the practical uses of ochre prior to assigning symbolic and ritual meanings to an assemblage. It is possible that obtaining

red pigment was not the primary reason for ochre use. Ochre of certain colours may have been preferred because colour functioned as an indicator of (and can have direct correlation to) grain size or hardness (Cornell & Schwertmann 2003; Mastrotheodoros *et al.* 2010). All aspects of ochre use should, therefore, be thoroughly examined to establish possible selection criteria before any conclusions are reached. It is problematic to differentiate potentially symbolic artefacts from those produced by functional activities (d'Errico *et al.* 2003; Wadley 2006a; Botha 2008; Shea 2011) and some artefacts can have both functional and symbolic applications (d'Errico & Stringer 2011).

Research often focuses on ways to demonstrate enhanced abilities (physical and cognitive) that confirm whether humans living in the past did in fact have the same cognitive functioning as we do today. To do this, one needs to look at the behavioural and ecological practices as well as the neural systems present (Barnard 2008; Haidle 2010). To access past cognitive abilities the use of models from neuro- and developmental psychology and (cognitive) neuroscience is imperative (Coolidge & Wynn 2009). Cognitive insight can be acquired by identifying the behavioural stages involved throughout the activity process and by establishing the temporal and physical distance between the commencement of a task to its completion (Botha 2008; Wynn 2009; Haidle 2010; Lombard & Haidle 2012).

Interpretation of ochre is focused on how the use-traces and the activities involving the Sibudu ochre can be seen as proxies for cognitive capabilities. This involves breaking down each activity down into a series of thought-and-action sequences (Lombard & Haidle 2012) and identifying all the elements involved in each activity. These sequences demonstrate the steps involved in each activity, the distance between the awareness of a problem and its resolution, and the complexity of each task. By modularizing action sequences into cognigrams, novel cognitive developments and increased complexity of behavioural and cognitive abilities can be demonstrated (Lombard & Haidle 2012).

The cognitive model of enhanced executive functioning (Baddeley & Hitch 1974; Wynn 2002; Wynn & Coolidge 2007; Kane *et al.* 2004; Coolidge & Wynn 2009) was drawn upon to establish the cognitive prerequisites for each activity. By using this model

one can bypass the fact that there are many unknown entities involved in the use of ochre in the Middle Stone Age, but still reconstruct the cognitive abilities for the activities that are visible archaeologically. This is essential for interpreting Middle Stone Age ochre use.

Executive functions are heritable traits (Coolidge *et al.* 2000; Ando *et al.* 2001; Rijdsdijk *et al.* 2002), and recognising their use in the archaeological record is a way to examine evolutionary cognitive changes. These functions include (from Coolidge *et al.* 2000; Wynn & Coolidge 2003, 2011; Coolidge & Wynn 2009):

- innovative thought
- fluid intelligence
- the use of unique problem-solving methods
- the capacity for abstract thought (the ability to hold several ideas in active attention, compare them and then extract ‘generalities’ from them)
- analogical thinking (transferring a set of ideas into an unrelated situation)
- flexibility in problem-solving and strategizing
- the ability to perform complex goal-oriented behaviours
- switching-attention during activities
- response inhibition
- the ability to plan and organise activities over space and time

Past activities that have been shown to require enhanced executive functions are: long-range planning, which is required for agriculture, long-range transportation of raw materials for specific uses, the use of traps and snares, and the creation of composite hafting adhesives (Coolidge & Wynn 2009; Wadley *et al.* 2009; Haidle 2010; Wadley 2010a, b).

To establish the cognitive abilities required to utilise ochre, it is vital to understand how use-traces are created, and the different ways that ochre can be (and was) used.

### 3.6 Background to use-trace studies

Lithic use-wear methodology and bone use-trace studies provide an analogy for studies of ochre, even though ochre is used differently from bone and other knapping lithics. To identify the markings left on utilised ochre pieces it is essential to know what tools or motions were used to produce the markings, for example, was the ochre held and abraded against a coarse stone, or was a stone tool used to score the piece of ochre? Experimental work is invaluable in understanding the nature of ochre and establishing which types of ochre are more successful in certain activities. They also provide invaluable information about the markings that activities create on materials. Even early use-trace studies of lithics encouraged systematic tool use experimentation and microscopic analysis (Semenov 1964). Previous experimental and use-trace studies (on bone, lithics and ochre) helped to set up a protocol to follow during investigation and categorisation of use-wear markings and types. The main criteria for use-trace examination are listed below:

- *Placement.* It is important to note the orientation and placement of grooves (d’Errico 1992; Blumenschine *et al.* 1996; d’Errico & Henshilwood 2007; Henshilwood *et al.* 2009) and when possible, the direction of movement in the creation of markings (d’Errico 1992; d’Errico *et al.* 2001, 2012a; Mackay & Welz 2008; Domínguez-Rodrigo *et al.* 2009; Henshilwood *et al.* 2009). The location of markings and facets can also be a useful indicator of how the piece was manipulated and used (Backwell & d’Errico 2001; Soressi & d’Errico 2007; Backwell *et al.* 2008; d’Errico *et al.* 2008; Henshilwood *et al.* 2009). Prehensile wear traces denote how pieces were held and can be useful in reconstructing activities when viewed in relation to the use-traces (Rifkin 2012).
- *Sequence.* Determining the sequence in which markings were made can show the accumulative formation of the use-traces (d’Errico 1992; d’Errico *et al.* 2001, 2012a; Soressi & d’Errico 2007; Mackay & Welz 2008; Henshilwood *et al.* 2009; Texier *et al.* 2010). This is applied mainly to pieces with scored incisions, although layering of grinding striations is sometimes visible and may denote multiple episodes of use (Henshilwood & Sealy 1997; Henshilwood *et al.* 2001b). A change in tool type,

especially of scored incisions, may indicate separate episodes of use (d'Errico *et al.* 2012a).

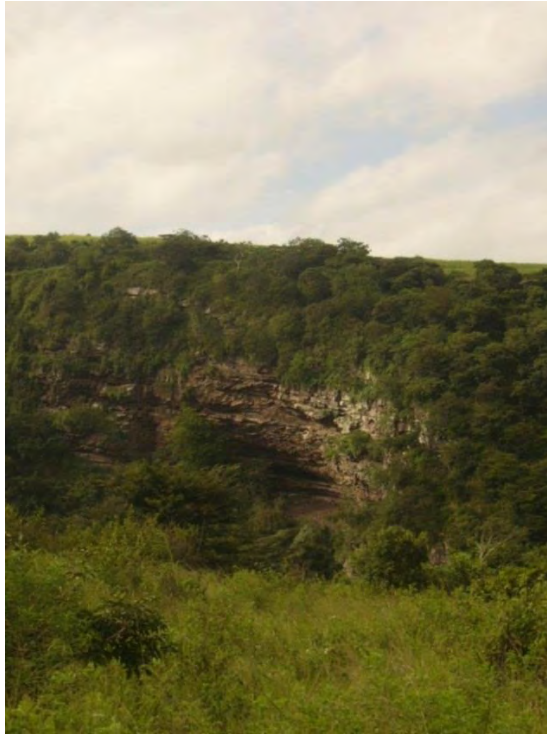
- *The ends of grooves.* The nature of groove ends can help to ascertain whether grooves were made with single or multiple strokes (d'Errico *et al.* 2001) or if they were created during trampling (Domínguez-Rodrigo *et al.* 2009). Additionally, the start and the end of the grooves may taper and may be difficult to differentiate, so the direction of the creation of markings might not be obvious (Shipman & Rose 1983).
- *Profile shape.* The shape and depth of grooves must also be considered (d'Errico *et al.* 2001). The shape and internal appearance of grooves can also help to establish whether markings were made with the same or different tools on a single piece, or with retouched or unretouched tools (d'Errico *et al.* 2001; d'Errico & Henshilwood 2007; Mackay & Welz 2008; Domínguez-Rodrigo *et al.* 2009; Texier *et al.* 2010). A change of the shape and depth of grooves could be indicative of inconsistent application of pressure during scoring (Mackay & Welz 2008) and not necessarily a change of tool.
- *Intensity of modification.* The intensity of modification (percentage of surface used), number of facets and the amount of variation in groove directions on one piece may give clues as to whether a piece was re-used (Watts 2002, 2009, 2010). This can be difficult to establish with ochre because one session of grinding can result in facet formation and variable direction of movement (Hodgskiss 2010; Rifkin 2012).
- *Piece shape.* Importantly, the final shape of a utilised piece is not necessarily intentional. It depends primarily on the shape of the piece before use as the shape also dictates how it is held and where it is ground (Wadley 2005a; Rifkin 2012). Hard sections in a piece also tend to be avoided so that softer areas are focused on because they are easier to grind (Rifkin 2012).
- *Post-depositional processes.* Post-depositional processes can also play a significant role in the appearance of ochre pieces. Trampling can result in the removal of fine, microscopic features from incisions, such as internal microstriations, and also produce randomly oriented and shallow scratches (Shipman & Rose 1983, 1988; Olsen and Shipman 1988; Domínguez-Rodrigo *et al.* 2009). Unintentional scratches and scuffmarks can indicate that certain markings, such as internal microstriations, could have been removed post-depositionally and are not necessarily absent due to an activity for which the ochre was intentionally used (Hodgskiss 2010).

### 3.7 Sibudu

The site from which I obtain the material and data for this study is Sibudu, KwaZulu-Natal, South Africa. It is situated approximately 15 km inland from the Indian Ocean, northwest of Durban in a cliff in the Mariannhill Formation, part of the Natal Group (Maud 1965; Turner 2000) (Figs 3.7.1 & 3.7.2). The rock shelter is directly above the uThongathi River and is ~90 m above sea-level. The shelter is about 55 m in length and 18 m wide and excavations cover 21 square meters. Sibudu has a long Middle Stone Age (MSA) cultural sequence (Fig. 3.7.3). A pre-Still Bay (pre-SB) industry is at the base of the sequence, above that a Still Bay (SB) Industry, then Howiesons Poort (HP), and post-Howiesons Poort (post-HP), late MSA and final MSA assemblages are in sequence above (Wadley 2006a; Wadley & Jacobs 2006) (Table 3.7). Optically stimulated luminescence ages for the Middle Stone Age at Sibudu range between  $77.2 \pm 2.1$  ka and  $38.0 \pm 2.6$  ka (Wadley & Jacobs 2006; Wadley 2007; Jacobs *et al.* 2008a, b). There is no Later Stone Age material at the site and the Middle Stone Age occupations are directly overlain by Iron Age ones. There are numerous hearths, burning events and ash patches preserved throughout the sequence (Wadley 2009, 2010d, 2012a, b; Bentsen 2012) and a large proportion of the faunal remains and plant material is burnt (Sievers & Wadley 2008; Clark & Ligouis 2010; Wadley *et al.* 2011).



**Fig. 3.7.1.** Location of Sibudu, KwaZulu-Natal, South Africa (modified from Wadley & Jacobs 2006).



**Fig. 3.7.2.** Sibudu. Situated in a sandstone rock shelter on a cliff above the uThongathi River.



**Fig. 3.7.3.** The long and intricate Middle Stone Age stratigraphic sequence at Sibudu. Photograph courtesy of L. Wadley.

The oldest layers excavated at the site, ~77 ka, contain ‘pre-Still Bay’ stone tools. Hornfels and dolerite are the most common rock type used in these layers, and quartz and quartzite are also present. Flakes and blades are common and there are some rare unifacial points and denticulates, and the lowest layers also contain large blades and bifacial points (Wadley 2012b). Deliberately constructed (unburnt) fossilized bedding, made with sedges and aromatic, insect-repellent leaves, is found in the pre-Still Bay layers (Wadley *et al.* 2011; Wadley 2012b). The bedding probably functioned as work and/or sleeping areas as it is associated with various tools and cultural items (Wadley *et al.* 2011). Marine shell has been found in the pre-Still Bay layers (Plug 2006).

The Still Bay Industry, above the pre-Still Bay layers, is dated to ~71 ka. Bifacial points characterize the industry (Wadley 2007), some of which have hafting traces on the proximal portions and residues (including animal tissue, bone and fat) on the distal portions of some of the points (Lombard 2006a; Wadley 2007). This indicates that these points were used as spearheads (Lombard 2006a). Unifacial points, bifacial cutting tools, scaled pieces (*pièces esquillées*), segments and scrapers are rare in the Still Bay layers (Wadley 2007, 2012b). Dolerite is the most common raw material used, followed by hornfels, quartz and quartzite (Wadley 2007). Ochre was used for soft hammer shaping of bifaces in these layers (Soriano *et al.* 2009).

Smaller animals such as monkeys, birds, reptiles, rodents and fish, and especially blue duiker and bushpig, are common in the Still Bay faunal assemblage (Clark & Plug 2008). Large bovids such as buffalo, eland and wildebeest, are present in low frequencies (Clark & Plug 2008). Marine shell fragments and some perforated *Afrolittorina africana* shells (beads) have also been found in these layers (Plug 2006; d’Errico *et al.* 2008; Wadley 2012b). A few of these have red ochre staining and are clustered with unperforated shells near to combustion features (d’Errico *et al.* 2008; Wadley 2012b). Sedge and leaf bedding is also found in the Still Bay layers, but the bedding is mostly burnt, probably for site maintenance (Wadley *et al.* 2011).

**Table 3.7.** The Sibudu stratigraphic layers, abbreviations and the dates for each industrial complex (Wadley & Jacobs 2006; Wadley 2007; Jacobs *et al.* 2008b; Wadley *et al.* 2011).

| Industry       | Layer                           | Abbreviation | Date (OSL)       |
|----------------|---------------------------------|--------------|------------------|
| Final MSA      | Coffee                          | Co           | ~39.1 ± 2.5 ka – |
|                | Buff                            | Bu           | 38.0 ± 2.6 ka    |
|                | Light Brown Mottled Deposit     | LBMOD        |                  |
|                | Milk Chocolate                  | MC           |                  |
|                | Espresso                        | Es           |                  |
|                | Mousse                          | Mou          |                  |
|                | D Mousse                        | Dmou         |                  |
|                | L Mousse                        | Lmou         |                  |
| Late MSA       | Polar Bear                      | PB           | ~49.9 ± 2.3 ka – |
|                | Oreo (1-2)                      | Ore (1-2)    | 46.6 ± 2.3 ka    |
|                | Red Decomposed                  | RD           |                  |
|                | Red Speckled                    | RSp          |                  |
|                | Cadbury                         | Cad          |                  |
|                | Pumpkin                         | Pu           |                  |
|                | Mottled Deposit                 | MOD          |                  |
|                | Orange Mottled Deposit (1-3)    | OMOD (1-3)   |                  |
|                | Grey Mottled Deposit            | GMOD         |                  |
|                | Brown Mottled Deposit           | BMOD         |                  |
|                | Reddish Black                   | RedBl        |                  |
|                | Red Speckled (1-2)              | RSp (1-2)    |                  |
|                | Yellow Speckled                 | YSp          |                  |
| Post-Howiesons | Brown Speckled (1-2)            | BSp (1-2)    | ~59.0 ± 2.2 ka – |
| Poort          | Spotty Camel (1-2)              | SPCA (1-2)   | 57.6 ± 2.1 ka    |
|                | Black Level                     | BL           |                  |
|                | Black Lens                      | BL           |                  |
|                | Orange                          | Or           |                  |
|                | Midnight                        | Mi           |                  |
|                | Speckled Sunrise (1-3)          | SS (1-3)     |                  |
|                | Speckled                        | Sp           |                  |
|                | Chestnut                        | Che          |                  |
|                | Ebony                           | Eb           |                  |
|                | Mahogany                        | Ma           |                  |
|                | Mexican Yellow                  | MY           |                  |
|                | Flame                           | Fl           |                  |
|                | Burnt Ochre                     | BO           |                  |
|                | Pox (1-2)                       | P (1-2)      |                  |
|                | O Pox                           | OP           |                  |
|                | B Pox                           | BP           |                  |
|                | Y Pox                           | YP           |                  |
|                | Brown Lens                      | BrL          |                  |
|                | Ivory                           | Iv           |                  |
|                | Black Magic                     | BM           |                  |
|                | Chocolate 1                     | Ch           |                  |
|                | Sulphur (1-2)                   | Su (1-2)     |                  |
|                | White Speckled                  | WS           |                  |
|                | Pink                            | P            |                  |
|                | Grey                            | G            |                  |
|                | Chocolate 2                     | Ch2          |                  |
|                | Yellow                          | Y            |                  |
|                | Brown/Grey Mix (1-2)            | B/Gmix (1-2) |                  |
|                | PhD Hearth                      | PhDH         |                  |
|                | Black Lens (2-3)                | BL (2-3)     |                  |
|                | Brown Organic                   | Bor          |                  |
|                | Yellow Mix                      | Ymix         |                  |
|                | Yellow Ash 1                    | YA           |                  |
|                | Brown Under Yellow Ash 1        | BuYA         |                  |
|                | Brown 2 Under Yellow Ash 1      | B2uYA        |                  |
|                | Yellow Ash 2                    | YA2          |                  |
|                | Brown under Yellow Ash 2        | BuYA2        |                  |
|                | Mottled Grey under Yellow Ash 2 | MGuYA2       |                  |
|                | Yellow Ash 2(i)                 | YA2(i)       |                  |
|                | Brown under Yellow Ash 2(i)     | BuYA2(i)     |                  |
| Howiesons      | Dark Reddish-grey (1-2)         | DRG (1-2)    | ~64.7 ± 1.9 ka – |
| Poort          | Reddish Brown                   | RedBr        | 61.7 ± 1.5 ka    |
|                | Grey Rocky (1-2)                | GR (1-2)     |                  |
|                | Grey Sand (1-3)                 | GS (1-3)     |                  |
|                | Pinkish-grey Sand(1-3)          | PGS (1-3)    |                  |
| Still Bay      | Reddish-grey Sand (1-2)         | RGS (1-2)    | 70.5 ± 2.0 ka    |
| Pre-Still Bay  | Light Brownish-Grey (1-3)       | LBG (1-4)    | ~77.2 ± 2.1 ka – |
|                | Brown Sand (1-15)               | BS (1-15)    | 72.5 ± 2.0 ka    |

The Howiesons Poort Industry at Sibudu has ages between ~65–62 ka. The Howiesons Poort industry is characterised by blade technology and geometric backed tools, including segments (Wadley & Mohapi 2006; Lombard 2006a, 2007, 2008, 2009). Dolerite, hornfels and quartz were used regularly throughout the sequence for tool production. Micro-residue and wear patterns show that the backed tools were hafted, sometimes with ochre-loaded adhesives (Lombard 2006b, 2007, 2008; Fig. 3.7.4). They were probably hafted for projectile hunting weaponry (sometimes arrowheads) and sometimes for butchery (Lombard & Pargeter 2008; Wadley & Mohapi 2008). Bone points also seem to make up the Howiesons Poort hunting arsenal, and were probably used as arrow heads, indicating that bow and arrow technology was possibly in use (Backwell *et al.* 2008). There is a rich bone tool assemblage in the Howiesons Poort Industry, including bone retouchers, awls and scraper-like tools (d’Errico *et al.* 2008, 2012b).

The Howiesons Poort fauna represents similar animals to those found in the Still Bay. The assemblage consists mostly of small bovids, such as blue duiker and bushpig, with a high percentage of juveniles and old individuals as well as some medium and large bovids such as zebra, eland and buffalo (Clark & Plug 2008; Wadley 2010b). The faunal assemblage provides indirect evidence for the use of remote capture methods – snares, traps and/or nets (Wadley 2010b). Unworked marine shell is also found in higher frequencies than in the Still Bay and pre-Still Bay layers (Plug 2006).

A mosaic of different environments existed around Sibudu throughout the Middle Stone Age (Allott 2006; Glenny 2006; Herries 2006; Reynolds 2006; Sievers 2006; Clark & Plug 2008; Bruch *et al.* 2012). Charcoal, seed and faunal data indicate some shifts in environment around Sibudu – at pre-62 ka the surrounds inclined towards closed or semi-closed ever-green forest, but after ~58 ka there is a shift to more arid, open and savannah-like environments (Allott 2006; Sievers 2006; Clark 2011; Bruch *et al.* 2012). A wide variety of animals species were available and obtained, especially in the Howiesons Poort (Clark & Plug 2008; Clark 2011; Wadley 2010b). It is possible that the concentration of forest species during the Howiesons Poort may be a result of intensified exploitation of the species in the immediate vicinity of Sibudu (Clark & Plug 2008). The invention of more reliable and specialised tools (such as snares, traps and

nets) allowed for the capture of smaller, younger and harder to catch, but more predictable, animals (Wadley 2010b; Clark 2011). These specialised tools sometimes included the use of ochre in hafting adhesives, therefore making an effective adhesive that would have held tools securely onto hafts (Wadley *et al.* 2009).



**Fig. 3.7.4.** Segment from Sibudu with ochre residues on the proximal portion of the tool. Photograph courtesy of L. Wadley.

The post-Howiesons Poort Industry at Sibudu is dated to ~58 ka. Although the post-Howiesons Poort spans a short time the sediments are about 80–100 cm deep. Numerous hearths, often larger than those found in the Howiesons Poort, are present and are often built on top of each other (Wadley 2012a). Large ochre patches are found on some hardened crusts of hearths, which were probably used as work surfaces (Wadley 2010d). There is high artefact density as well, indicating intensified tool use (Cochrane 2006; Wadley *et al.* 2011). The lithic assemblage in the lowest post-Howiesons Poort layers contains mostly quartz and quartzite tools, few of which are retouched. The upper post-Howiesons Poort layers contain predominantly hornfels and

dolerite; there are many retouched scrapers and unifacial points (Cochrane 2006). The faunal remains consist mostly of small browsing bovids and large bovids, such as wildebeest, hartebeest and zebra (Clark & Plug 2008). A 22 mm rib fragment was found with ten human-made notches on the long axis of the bone (Cain 2004). The notches were made with a retouched stone tool (Cain 2004).

The inhabitants of Sibudu were skilled hunters during the Still Bay, Howiesons Poort and post-Howiesons Poort, but there are marked transformations in hunting strategies over time (Clark & Plug 2008; Wadley 2006a, b; 2010b; Clark 2011). There is intensified sedge bedding use during the post-Howiesons Poort (Wadley *et al.* 2011). This, coupled with intensive hearth and tool use, implies that the post-Howiesons Poort at ~58 ka was a period where people stayed for longer or when group size at the site increased (Wadley *et al.* 2011).

The late MSA layers are dated to ~47 ka. Flakes and blades are the predominant lithic form found in these layers and there is a relatively high frequency of retouched pieces (Villa *et al.* 2005). Unifacial points, some triangular Levallois flakes are common, and bifacial points, scrapers, *pièces esquillées* and burins are rare (Villa *et al.* 2005). Tools were hafted and used for hunting weapons, possibly spears (Villa *et al.* 2005; Wadley 2006a). The faunal assemblage is similar to the post-Howiesons Poort assemblage, with a focus on a range of large bovids. Prey included buffalo and bushpig as well as occasionally giraffe and hippopotamus (Cain 2004; Plug 2004).

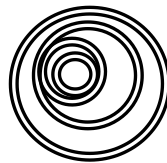
The youngest Middle Stone Age layers at Sibudu are called the final MSA layers, which are dated to ~38 ka. These layers contain bifacial and unifacial points, side scrapers, *pièces esquillées*, segments and hollow-based points (Wadley 2005c). Some of the tools were hafted and used for hunting weapons, possibly as throwing spears (Villa & Lenoir 2006; Lombard 2007). A ground and subsequently polished bone pin was found in the uppermost layer of the Middle Stone Age sequence (Cain 2004).

The papers that constitute the following four chapters discuss numerous aspects of ochre use in the Middle Stone Age. The Sibudu ochre assemblage, from the pre-Still Bay layers to the final MSA layers, is examined in detail (with the use of an experimental,

comparative sample). This is done to obtain data on the types of ochre collected and used at the site, and the ways in which it was utilised. This information contributes towards, and is considered in the context of, the large body of research that has been done on other cultural items from the Sibudu sequence. This research will further contribute towards ascertaining whether the people living during the Middle Stone Age at Sibudu had complex and enhanced cognition, like that of modern humans.

## CHAPTER 4

### Ochre Experiments



Hodgskiss, T. 2010

Identifying grinding, scoring and rubbing use-wear on  
experimental ochre pieces.

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# Identifying grinding, scoring and rubbing use-wear on experimental ochre pieces

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## ABSTRACT

Ochre pieces were used experimentally for a variety of grinding, scoring and rubbing activities to record and compare the use-wear markings that each activity creates on the ochre piece. Ochre that is ground on coarse or fine-grained slabs develops parallel striations that cover the surface of the piece. The striations have unfayed ends. Grinding is the only activity that results in significant changes to the surface shape of the ochre, producing a plane. When ochre is scored either to create a deliberate design or to produce powder, the grooves that form often do not reach all the edges of the used surface and they regularly have frayed terminations. This demonstrates that the incisions were created by multiple scoring strokes. When ochre is scored to manufacture ochre powder the incisions that are generated are parallel groups of grooves with erratically oriented grooves as well. Bone and wooden tools are soft and they therefore do not generally create obvious incisions on ochre pieces. Grooves created through grinding on a slab or scoring with a stone tool have microstriations within them and they show a range of profile shapes. The most common use-wear from rubbing ochre on animal hide, human skin, human hair and wood is smoothing, edge rounding and polish, although incisions and microstriations also occur occasionally. Residues are often left on an ochre piece after rubbing or scoring with organic materials. The comparative collection of macro- and microscopic use-wear marks from experimentally ground, scored and rubbed ochre is useful as an aid to classifying archaeological collections of ochre.

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## 1. Introduction

Most archaeological studies of ochre focus on *whether* ochre was utilised at a site and the implications of its use, but not *how* it was used. This is a shortcoming because understanding how ochre was processed is critical for interpretations of behaviour in the past. Experiments with ochre and subsequent microscopy on use-wear markings make it possible to recognise some methods of ochre processing. There are many activities, chains of activities and natural processes that have the potential to affect the appearance of ochre pieces and the markings on their surfaces.

The aims of my experiments with ochre are to: 1) record the use-wear markings that result from various activities and combinations of activities; 2) examine the types, variability, and arrangement of use-wear markings; 3) explore the effects of natural processes such as water damage and post-depositional trampling on use-wear markings and surfaces. In sum, the experiments focus on replicating archaeologically visible use-wear on ochre pieces in order to distinguish ways that ochre may have been processed in the past. By applying this kind of 'Middle Range

Theory' (Binford, 1977) to archaeological ochre, one can move past the artefact to interpret the behaviour or series of behaviours that created it. These experiments create a comparative sample that will ultimately be used to assist with the analysis of ochre found in Sibudu Cave (KwaZulu-Natal, South Africa) Middle Stone Age (MSA) layers, which have estimated ages between 77,200 and 37,600 years ago (Jacobs et al., 2008). Analysis of the Sibudu ochre is underway and some of the use-wear markings are identified here using the classification system created during the experiments described in this paper.

## 2. Background

'Ochre' is a general term that is used, archaeologically, to describe a variety of iron-rich or ferruginous minerals that produce a reddish or yellowish streak (Jercher et al., 1998; Volman, in press; Watts, 2009; Wreschner, 1983). Therefore, the term 'ochre' encompasses a variety of sedimentary rocks that produce a red, orange, yellow or even a purple streak, including hematite, limonite, goethite, specularite, shale, snuffbox shale, mudstone and sandstone (Barham, 2002; Henshilwood et al., 2001a, 2009; Hovers et al., 2003; Hughes and Solomon, 2000; Watts, 1998, 2002, 2009; Wadley, 2005a). The terms 'pigment' and 'colouring material' are

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avoided here because they imply why and how the material was used.

The earliest evidence of ochre use in Africa is around 300 ka at Twin Rivers in Zambia, where over 300 pieces of ochre of a variety of geological forms and colours were found. About 3% of the sample shows evidence of working by grinding or rubbing and some pieces have faceted surfaces (Barham, 1998, 2002). At Gnjh-15 in Kenya, over 70 pieces of ochre were found suggesting that ochre was systematically collected at 285 ka (McBrearty, 2001). At Lion Cavern, in western Swaziland, tons of specularite-rich hematite are reported to have been mined around 40 ka (Beaumont, 1973; Boshier and Beaumont, 1972; Dart and Beaumont, 1969).

Many MSA sites from South Africa have yielded large quantities of ochre. Over 9000 pieces of ochreous material (not all of which have colouring potential, based on streak tests) were found at Blombos Cave on the south coast of South Africa from levels with a mean age of 77 ka (Henshilwood et al., 2001a, 2002, 2009; Watts, 2009). Most of these pieces are <1 cm in size and there is a range of geological forms and colours (Henshilwood et al., 2002). Twenty percent of the pieces from Blombos show signs of use-wear, and a few pieces have clear geometric incisions on the ochre (Henshilwood et al., 2009). In the Western Cape, Pinnacle Point Cave 13B yielded over 1000 potential pieces of ochre (380 of which have been classified as 'pigment'), 57 of which are from layers dated to 164 ka ago (Watts, pers. comm.). Just over 12% of these pieces show definite signs of working, and most of them have reddish streaks (Marean et al., 2007; Watts, pers. comm.). Crayon-shaped hematite pieces were found, along with a large variety of ochre at Border Cave in northern KwaZulu-Natal, as well as some hematite 'crayons' and lithics that had been stained with ochre (Beaumont et al., 1978). At Klasies, in the Eastern Cape, more than 200 pieces of ochre were found, mainly shales and mudstones, a large portion of which are red although there is some soft, yellow sandstone. Many of the pieces show signs of smoothing and scratching (Singer and Wymer, 1982; Watts, 1998). Approximately 600 pieces of worked and over 8000 pieces of unworked ochre have been recovered at Sibudu Cave (Hodgskiss, in prep.) along with tools bearing traces of ochre (Lombard, 2004a, 2004b, 2005, 2006; Wadley, 2005a; Williamson, 2004).

Ochre use became a common phenomenon during the MSA and the mere presence of ochre (whether worked or unworked) at archaeological sites is often interpreted as conveying symbolic meaning for the people that collected and used it (Deacon, 1997; d'Errico, 2003; Hovers et al., 2003; Knight et al., 1995; Marean et al., 2007; McBrearty and Brooks, 2000; Watts, 2002, 2009). Ritual, symbolic (sometimes in the form of artwork) and cosmetic uses of pigments (and ochre) are widely documented ethnographically (for example, Marshall, 1976; Peile, 1979; Rudner, 1982). The assumed ritual role for ochre seems reinforced by the predominance of red ochre use at many MSA sites. Colour is the main distinguishing feature of ochre, but this does not mean it was collected and used solely for that reason. Qualities vary greatly in different geological forms of ochre and this could influence how and why some pieces were used. Qualities such as texture or grain size, iron content and plasticity (Hodgskiss, 2006; Sagona, 2003; Wadley et al., 2009; Watts, 2002) may have been more desired than colour, depending on the end product for which the ochre was intended. High iron content, for example, preserves organic materials such as leather (Cameron, 1991; Jones, 2009) and ochre has been used as an aid in tanning and working hides (Audouin and Plisson, 1982; Brandt and Weedman, 2002a, 2002b; Keeley, 1978 cited in Volman, in press; Mandl, 1961; Velo, 1984). Other recorded ethnographic uses of ochre include: body paint for protection from the sun, cold and insects (Bonwick, 1898, cited in Volman, in press; Ling Roth, 1890, cited in Volman, in press; Marshall, 1976; Pitsi,

cited in Wadley, 2001: 7; Watts, 1998); an internal and external medicine (Audouin and Plisson, 1982; Peile, 1979; Velo, 1984); an aggregate in adhesives with which to haft tools (Allain and Rigaud, 1986; Gibson et al., 2004; Hodgskiss, 2006; Lombard, 2002, 2004a, b, 2005, 2006, 2007; Rots, 2002; Wadley, 2005b, 2006; Wadley et al., 2004, 2009; Williamson, 2000); a deodorant on human skin and a waterproofing and protecting agent for wood (Chase, 2008).

The presence of crayon-shaped ochre pieces at some sites has prompted the suggestion that ochre was sometimes used, like a crayon, directly on surfaces to create a coloured pattern. Since no direct evidence of this practice has been found for the MSA, it has been proposed that soft, organic and perishable objects such as leather, wood or human skin were the objects of decoration (d'Errico, 2008; d'Errico et al., 2003; Marshack, 2003). d'Errico and Soressi experimented with manganese dioxide and were able to show that marked pieces found in archaeological sites were first ground and then used to mark soft materials such as human skin or animal hide (d'Errico et al., 2003; Soressi and d'Errico, 2007; d'Errico, 2008). Manganese nodules from Pech-de-l'Azé I, for example, are often ground on the narrow edges, which would allow for the easy drawing of linear lines or designs (Soressi et al., 2008). However, experimental work by Wadley (2005b, 2006) found that 'crayons' of ochre were produced as a by-product of grinding the nodules to produce powder. This demonstrates that the shape of the piece and used surface(s) alone are not necessarily enough to imply use.

Lithic use-wear methodology and bone use-wear studies provide an analogy for studies of ochre, even though ochre is generally used differently from other types of stone and also bone. Even early use-wear studies of lithics encouraged systematic tool-use experimentation and microscopic analysis (Semenov, 1964). To identify the markings left on worked ochre pieces it is essential to know what tools or motions were used to produce the markings, for example, was the ochre held and abraded against an animal hide or a coarse stone or was a stone tool used to score the piece of ochre?

Previous studies of ochre and use-wear markings have focused on: 1) the profile shape, orientation, alignment and type of striations (Henshilwood et al., 2001b; Blumenshine et al., 1996); 2) intensity of the modification on pieces (Watts, 2002, 2009); 3) direction of movement during the creation of marks (d'Errico et al., 2001; Domínguez-Rodrigo et al., 2009; Vaughan, 1985); 4) the sequence of markings (d'Errico et al., 2001; Henshilwood et al., 2001a, b; Soressi and d'Errico, 2007); 5) the location of facets and markings to find out how the piece was held (Backwell and d'Errico, 2001; Backwell et al., 2008; Soressi and d'Errico, 2007) and 6) the chemical make-up of the ochre (Hughes and Solomon, 2000; Hovers et al., 2003; Wadley et al., 2009). Here I shall examine a selection of use-wear markings and other attributes of used ochre produced during experiments.

### 3. Methods

#### 3.1. Collection and preparation of ochre and other raw materials

##### 3.1.1. Ochre

The ochre used for experiments was collected about 1 km from Sibudu from a shale and mudstone quarry. Each piece is labelled and a record is kept of its geological form, colour and size. Grain size and hardness were recorded as well but they are not mentioned again here; they proved not to be influential attributes in these experiments. Shales and mudstones are the most common geological types found at many archaeological sites, including Sibudu. 'Snuffbox shale' has its origin in the Pietermaritzburg Shale

Formation near Sibudu. These irregular ‘boxes’ containing iron oxides and iron oxyhydroxides formed when iron within the shale dissolved and migrated into the joint and bedding planes of the rock (Hughes and Solomon, 2000). Ochre pieces (as opposed to ochre powder), were used for all experiments, therefore each activity involved direct contact between the ochre piece and the object used for processing it. All powders created during activities were kept for future experiments.

### 3.1.2. Grindstones

Flat slabs of non-archaeological sandstone and dolerite were collected from Sibudu to be used as grindstones for producing ochre powder. Sandstone was used because it is coarse and is readily available at Sibudu and, additionally, the lower grindstones with ochre traces found in the MSA levels of Sibudu are sandstone slabs (for images of sandstone grindstones see Wadley et al., 2009, supplementary online material). Dolerite was chosen as an additional material because it is abundant near Sibudu and it is smoother with a much finer grain size than the sandstone.

### 3.1.3. Stone flakes

Stone flakes from knapping experiments were used for scoring designs and also for scoring ochre pieces to extract ochre powder. Hornfels was selected because it is a rock commonly found at Sibudu. There is no retouch on any of the flakes, and sharp-edged flakes of similar sizes were chosen.

### 3.1.4. Wood

The wood used for rubbing and scoring activities is *Sideroxylon inerme* (White Milkwood), a fine-grained hardwood found today as well as during the MSA at Sibudu. Dry branches between 2 and 3 cm in diameter were used for rubbing experiments. Dry, stripped branches of 0.5 cm diameter were sharpened to a point on a sandstone slab and used for the scoring activities. The point was continually re-sharpened during use.

### 3.1.5. Bone

Dry pieces of sheep (*Ovis aries*) bone were used for some scoring activities. These pieces of approximately 0.5 cm width were sharpened to points on a sandstone slab. As with wooden implements, these pieces also had to be re-sharpened during use.

### 3.1.6. Animal hide

Kudu (*Tragelaphus strepsiceros*) hide was used. The hide was dry and partly preserved with salt, but was still slightly soft in places. It was cut into 7 cm × 3 cm strips, which were rubbed (on the inner and outer sides of the hide) with ground and unground (wet and dry) ochre pieces.

### 3.1.7. Human skin

Ochre was rubbed on the author's forearm, which was cleaned and dried before each experiment. Ground and unground ochre pieces were used dry and wet for these activities.

### 3.1.8. Human hair

Ochre was rubbed onto the author's coarse hair. Ground and unground ochre pieces were used dry and wet for this activity.

## 3.2. Activities

Three hundred and fifty-four experiments were performed, involving 178 pieces of ochre. Sometimes one activity required multiple steps, such as grinding a piece before it was used to rub on hide. The sample size was ten, except when activities produced no use-wear markings, indistinct traces, or when ochre could not

perform the activity properly. In such cases, the sample size is smaller. Each piece was examined and photographed macro- and microscopically before and after each step to record use-wear. Pieces were photographed with a Panasonic Lumix camera and analysed and photographed using an Olympus SZ61 Zoom Stereo microscope fitted with an Olympus DP12 digital camera, using various lighting angles.

### 3.2.1. Grinding

One hundred and twenty ochre pieces were ground on sandstone or dolerite slabs for 1 min. Grinding experiments to produce ochre powder did not focus on uni- or multi-directional grinding, but rather on applying the same amount of pressure at roughly the same speed. Wet grinding involved dipping the ochre in water and then grinding it on a dry slab. While there is no evidence that ochre was used wet in the past, grinding wet ochre has potential for producing coloured paste. The sample size of ground ochre is large because many of the pieces were later used for rubbing or scoring activities.

### 3.2.2. Scoring

Sixty-three ochre pieces were scored with stone flakes, bone, or wood. Scoring was performed for two reasons, first, to create designs on ochre pieces, and secondly, to create ochre powder. Powder production during both kinds of scoring was recorded. The beginnings and ends of the incisions were not intentionally placed during either activity because the potential importance of this attribute was only realised after experiments were completed. Scoring to create a design (engraving) was continued until the required design was achieved; scoring to produce powder was performed for a minute. All scoring was executed on unground and ground ochre, because some archaeologically recovered ochre pieces appear to have been ground prior to scoring (for example, Henshilwood et al., 2009). The artisan dictates the placement, alignment and nature of the markings during scoring to create a design; this is a subjective act. Consequently, fifteen additional ochre pieces were scored by five volunteers, with each person scoring three unground pieces to establish whether variability occurs between them.

### 3.2.3. Rubbing

One hundred and eleven ochre pieces were rubbed on animal hide, human skin and hair, and wooden branches. These experiments were performed with ground, unground, dry and wet ochre. For wet rubbing, ochre was dipped in water when necessary during the activity.

### 3.2.4. Trampling

Trampling experiments on 45 pieces replicated natural processes that the ochre pieces might undergo at Sibudu. The pieces were placed in an area 50 cm × 50 cm under the archaeologists' sorting table in Sibudu where a raised platform has been created from the coarse fraction remaining after sieving the sandy-silty Sibudu sediment (Goldberg et al., 2009). Here the ochre pieces were intermittently trampled for ten days.

### 3.2.5. Soaking

Twenty-eight pieces that had been used for previous activities were placed together for 48 h in a tub filled with tap water. Every 12 h the pieces were manually moved around in the water for a minute. The pieces were removed from the water and were allowed to dry naturally.

## 3.3. Documentation and definitions

1. Grooves, incisions, striations and scratches. A *groove* is a broad category used here to include any narrow, linear furrow; this

incorporates incisions, striations and scratches. No method of creation is implied by the term. Attributes of grooves are described below. *Incisions* are individual grooves or a series of grooves. They can be oriented erratically in relation to each other or they can create a regular design. Incisions are sometimes repeatedly cut within the same groove. *Striations* are multiple, parallel grooves that are repeatedly, but not exclusively, formed by grinding against a hard material. *Scratches* are generally accidental marks that are shallow and erratically placed and oriented. The terms groove, incision and striation do not imply specific depths. The edge or highest part of a groove is called the peak, the lowest point or the base is called the valley, and the area in between grooves is called the plateau (after d'Errico and Backwell, 2009) (Fig. 1).

#### Attributes of grooves:

- a) Orientation and grouping. Individual or clustered grooves can have various orientations on an ochre surface: 1. parallel alignment (Fig. 2A and B); 2. erratically oriented grooves (Fig. 2C); 3. parallel alignment together with erratically oriented grooves; 4. groups of parallel grooves intersecting at angles to each other (Fig. 2D); 5. groups of parallel grooves intersecting at angles to each other, together with erratically oriented grooves; or 6. other (Fig. 2E and F). In these experiments, engraved designs are included in this last category, which includes cross-hatching, a checkerboard pattern and parallel lines. The group called 'other' is distinguished from the former groups because of the deliberate positioning of the grooves.
  - b) Placement. Groove placement is recorded by its proximity to the edges of the ochre: 1. all grooves reach the edges of the piece (both the beginning and end of the groove, e.g. Fig. 2A); 2. some grooves reach the edges (Fig. 2E and F); or 3. no grooves reach the edges (Fig. 2G).
  - c) Profile shape. Profiles are mostly V-, U- or \\_/(trough)-shaped (Fig. 1A and B), but sometimes the grooves are superficial and merely leave coloured markings on the ochre surface. These can be easily confused with scratches and scuffmarks.
  - d) Termination. The ends of grooves reveal whether multiple or single strokes were made. When multiple strokes are scored in the same groove, the ends often become frayed due to the direction of movement changing slightly (Fig. 2G). When grooves reach the edge of the surface and no fraying is visible, these are classified as unfrayed (e.g. Fig. 2A and H).
2. Microstriations. These are microscopically visible parallel striations. Internal microstriations occur within grooves (Fig. 2I and J).

External microstriations occur across the surfaces of rubbed pieces (Fig. 3A). Superficial grooves can sometimes appear to be made up of a collection of internal microstriations (Fig. 3B).

3. Chipping. Small flakes are unintentionally chipped from the ochre piece during use. Chipping forms on the edges of the piece (Fig. 3C) or along the peaks of grooves (Fig. 2F).
4. Polish. Shiny areas that appear on the ochre surface after use (Fig. 3D and E).
5. Metallic lustre. Shiny, silver, metallic-looking areas (Fig. 3A) usually in the valley of grooves or on the plateaus between grooves.
6. Smoothing. When a surface becomes homogeneous or previous natural features or use-wear become partially or fully reduced (Figs. 3F and 4A). Smoothing does not imply a shiny or flat surface. External microstriations may form (Fig. 4A).
7. Edge rounding (Fig. 2G). The artificial rounding of the edges of the ochre piece.
8. Faceted surface. Adjacent worked surfaces may form at angles to each other during an activity.
9. Residues. These include any non-ochre substances found on the ochre piece resulting from its use (Fig. 4B and C). Clay deposits are included in this category.
10. Scuffmarks are powder smudges that are the result of impact between ochre and hard objects (Fig. 5A). Scuffmarks often result from post-depositional processes.
11. Surface topography. The shape of the used surface is classified as flat, concave, convex, or unchanged.

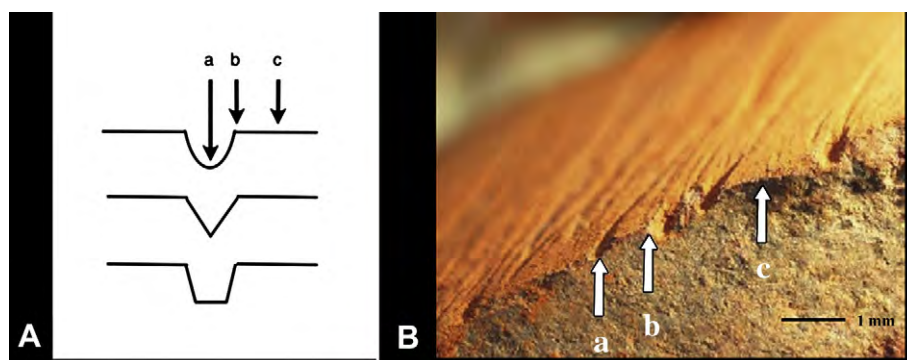
The terminology used in this paper is based on descriptions used in previous use-wear studies (mentioned above). There are no universal classifications for all the use-wear markings I found on the ochre pieces and I therefore have used common terms that best describe these markings.

## 4. Results

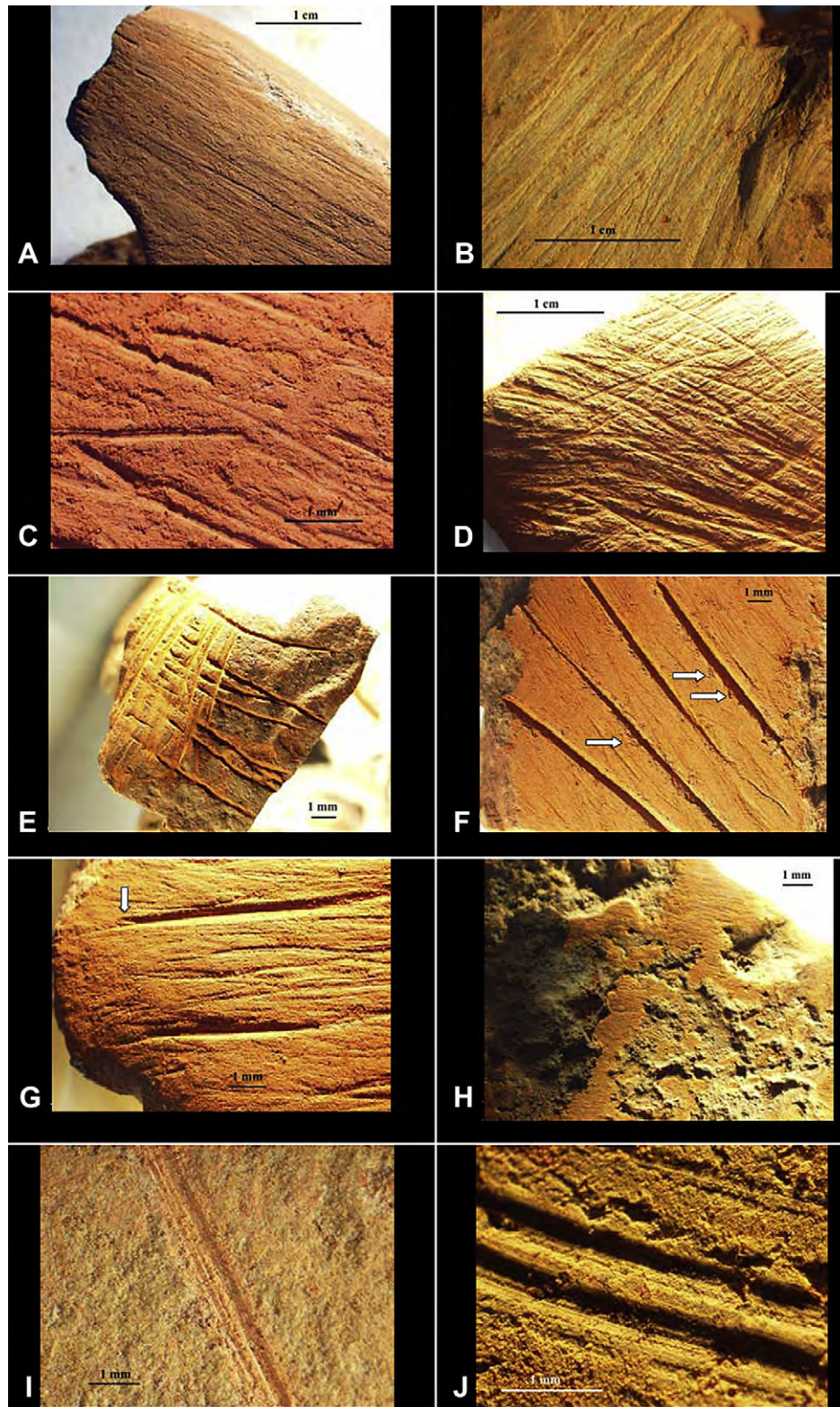
### 4.1. Actions involving grinding, scoring and/or rubbing

#### 4.1.1. Grinding (Table 1)

Most grinding use-wear is in the form of uni-directional parallel striations or groups of parallel striations at angles to each other. A few pieces have some erratically placed short grooves on top of the striations, and these could be mistaken for deliberate incisions (as seen in Fig. 2C). These are caused by protrusions (often quartz grains) on the slabs used for grinding. Nearly all ground pieces have striations that start and finish at their edges, and all ground pieces have straight, unfrayed terminations (for example, Fig. 2A). Several combinations of striation profile shapes occur, but most pieces



**Fig. 1.** Groove profile shapes. (A) From top to bottom: U-, V- and \\_/(trough)-shaped striations. a. valley of a groove, b. peak of a groove, c. the plateau in between grooves. (B) U-shaped grooves created by scoring with a stone flake on a piece (E84) that had been previously ground, dry, on a sandstone slab.



**Fig. 2.** Grinding and scoring use-wear. (A) Parallel grinding striations reaching the edges of a piece (E114) that was ground, dry, on a sandstone slab. (B) Ochre piece (E115) scored with a stone flake to produce powder. The numerous grooves are parallel and, as with grinding striations, they reach the edges of the piece. (C) Erratic grooves created from grinding a piece of ochre (E61), dry, on a sandstone slab. Parallel striations did form but are only faintly visible on this section of the piece. (D) Ochre piece (E28) that has been ground, dry, on a sandstone slab. Note the clusters of parallel striations that intersect at perpendicular and oblique angles. Not all striations reach the edges of the piece. (E) Incisions made by scoring with a stone flake on an unground ochre piece (E73). The incisions were scored with the intent of creating a design and were mostly made with single strokes; therefore most incision ends are not frayed. Most of the deep incisions, particularly the underlying ones, reach the edge of the piece. After the change of direction for the secondary set of motions, the incisions no longer reach the edge of the piece. (F) Ochre piece (E85) that was first ground, dry, on a sandstone slab and then scored with a stone flake, with the intent of creating a design. These scoring incisions were made with small back and forth movements. Arrows point to the chipping along the deep incisions, few of which terminate before the edge of the piece. (G) V-shaped scoring incisions made on an ochre piece (E84) that had been previously ground on a sandstone slab. The scoring incisions are on top of grinding

display a combination of shapes. Grinding on dolerite, although not significantly different, shows fewer combinations of striation profiles, with most pieces having only U-shaped striations. Overall, U-shaped striations are the most common profile associated with grinding. Internal microstriations within the grooves occur on nearly all the ground pieces (Fig. 2J), except for those that are ground wet on sandstone slabs.

Polish is not apparent on any of the dry ground pieces, though there are a few instances of metallic lustre. Metallic lustre does not occur on any of the wet ground pieces. Smoothing is evident on a majority of the pieces that were ground wet on sandstone, but it is rare on the dry ground pieces. Flat surfaces and rounded edges tend to form from grinding – especially the wet ground pieces. Nonetheless, there are many pieces with unchanged surface shapes, meaning that the original shape of the piece is kept after grinding, even when the surface is reduced. Some uneven surfaces only get ground down on their highest points, resulting in these becoming flat while depressions remain unmodified (Fig. 2H). Wet grinding on sandstone results in a thick clay-like residue collecting on the surfaces and edges of the pieces. Only a thin layer of powder builds up on various surfaces of dry ground ochre.

#### 4.1.2. Scoring (Table 2)

##### a) Use-wear created when scoring ground and unground ochre

Using a previously ground or unground ochre piece for scoring activities does not influence the type of incisions that are created. Most incisions do not reach the edges of the pieces. Most pieces have a combination of incision profile shapes even though only one scoring tool was used per piece. The majority of incisions scored with bone and wood are superficial. In contrast, all pieces scored with a stone flake have clear incisions with a variety of profile shapes (Fig. 2E, F and G). All incisions, even the superficial ones, contain internal microstriations (Figs. 2I and 3B). Most incisions made by organic tools obtain an opaque layer of residue and it is within this layer that the internal microstriations occur (Fig. 3B). Consequently, these microstriations are not necessarily embedded in the ochre surface. Most of the pieces scored with bone and wooden tools also have powdered organic residues on their surfaces (Figs. 3B and 4B). The only difference between the use-wear created by scoring with the intention of creating powder and scoring to create a design is the orientation of the incisions. Scoring to create powder usually results in incisions that are parallel or in groups of parallel lines (Fig. 2B), sometimes at angles to each other. Scored designs have individual lines that have a controlled orientation because they form a clear pattern. Surprisingly, the depth of incisions is not a distinguishing feature of either activity; therefore incision depth has not been dealt with in this paper.

Results from the scoring of 15 pieces by five volunteer artisans were compared against the results I obtained from scoring with stone flakes (on unground pieces). All grooves from scoring exercises contain internal microstriations. Nearly all pieces lack metallic lustre, smoothing, surface shape change, or rounded or faceted edges. Most artisans created collections of parallel lines when creating a design or when scoring to produce powder. The majority of pieces (60%) had a few incisions reaching the edges of the piece, while 20% of pieces lacked incisions reaching the edges. Compared with my results from scoring unground ochre with a stone tool, this

represents an increase in ochre pieces with some incisions reaching the edges and a decrease in incisions that reach none of the edges. Incision terminations with some fraying comprise 53.3% of pieces, 33.3% have no fraying and 13.3% are entirely frayed. This differs from my experimental results in which 30% of pieces have some frayed terminations, 20% have no fraying and 50% have all incisions frayed. The volunteers' incision profile shapes were similar to mine, but instead of most pieces having U- and V-shaped incisions, they also included \\_/profile shapes. This is because some people held their tools at an angle, using any edge, whereas I always used the sharpest edge of the tool. This 'human variable test' shows that, notwithstanding frequencies different from mine, all grooves created by scoring ochre with a stone flake possess internal microstriations, they regularly have some frayed ends, have a variety of profile shapes and they often do not reach the edges of the ochre piece. Additionally, scoring seldom results in surface shape change, metallic lustre, smoothing, polish or edge modification.

##### b) Modification of grinding striations after previously ground ochre pieces are scored

Grinding striations are still visible on most of the pre-ground pieces (Fig. 2F and G) and few pieces have grinding striations that have become smoothed. Edge rounding, surface shape or faceted edges created during grinding are not modified by any of the scoring activities.

#### 4.1.3. Rubbing (Tables 3 and 4)

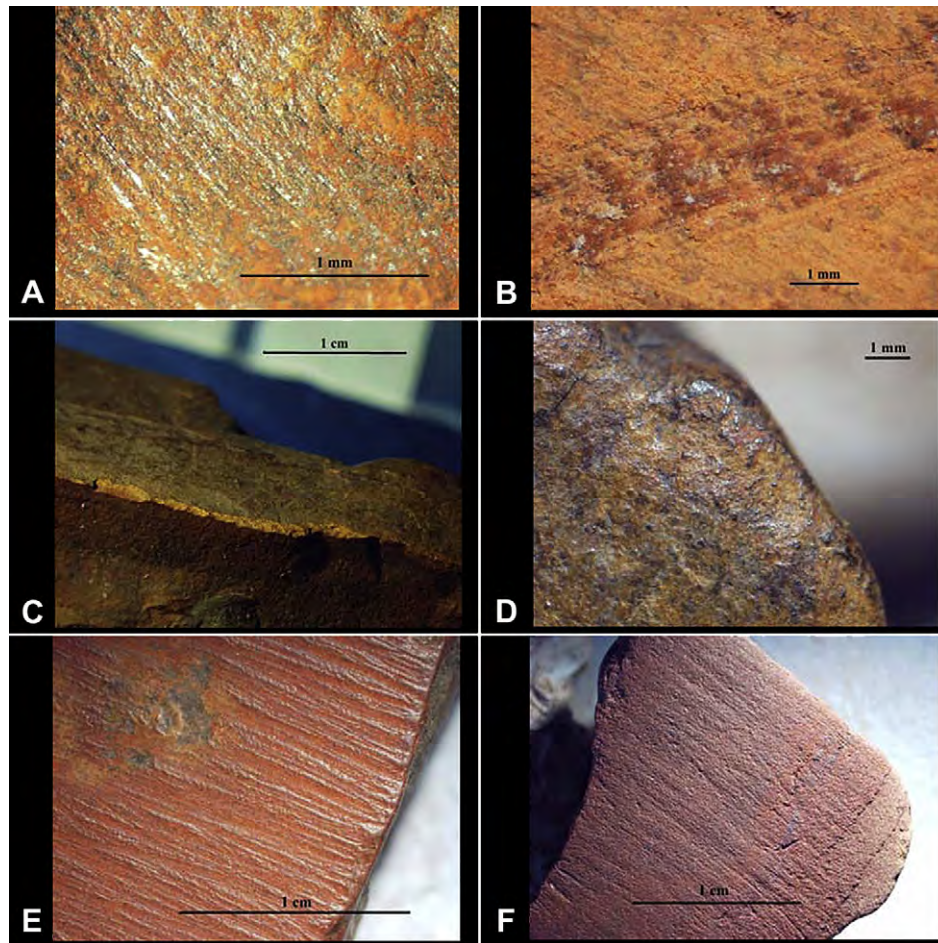
##### a) Use-wear from rubbing ground and unground ochre on various materials (Table 3)

Rubbing produces few grooves or diagnostic markings. Most pieces that develop grooves are previously unground pieces, but this may be because new grooves go unnoticed on previously ground surfaces. Where rubbing creates grooves, these are parallel or groups of parallel striations at angles to each other, with infrequent erratic grooves. The grooves rarely have internal microstriations, but external microstriations occur on one-third of the pieces (Fig. 3A). Some grooves are unfrayed and reach from edge to edge, but this is uncommon. Profile shapes vary considerably amongst the few grooves that do exist. Edge chipping and metallic lustre are rare use-wear markings created during rubbing activities, and they occur more often from rubbing hide (Fig. 3C) than other materials, though occasionally occurring when rubbing wood, and only occurring on one piece that was rubbed on human skin (Fig. 3A). Polish and residues are common (Figs. 3D and 4C). Nearly all of the pieces are smoothed during rubbing and have rounded edges, but the smoothing generally occurs only on the raised areas of the pieces (Fig. 4A). Rubbing seldom modifies the surface shape of pieces, but a few pieces become either flat or slightly convex.

##### b) Modification of grinding striations after ochre pieces used for rubbing activities (Table 4).

Rubbing changes grinding striations by smoothing, especially when rubbed wet. U-shaped striations are found on most pieces after rubbing as existing V- and \\_/shaped striations become smoothed to create U-shaped striations. Rubbing does not modify

striations, in the same direction. Scoring was performed with the intention of creating clear grooves. The arrow points to the frayed end of the scored incision. The grinding striations had previously rounded the edge of the piece slightly and scoring incisions do not reach to the edge of the piece. (H) Grinding striations that formed only on the higher areas of a piece (E119.2) that was ground, dry, on a sandstone slab. (I) Groove made by a single stroke with a stone flake on an ochre piece (E71). Clear internal microstriations occur within the groove. (J) Internal microstriations within a groove that was formed when an ochre piece (E59.1) was ground, dry, on a sandstone slab.



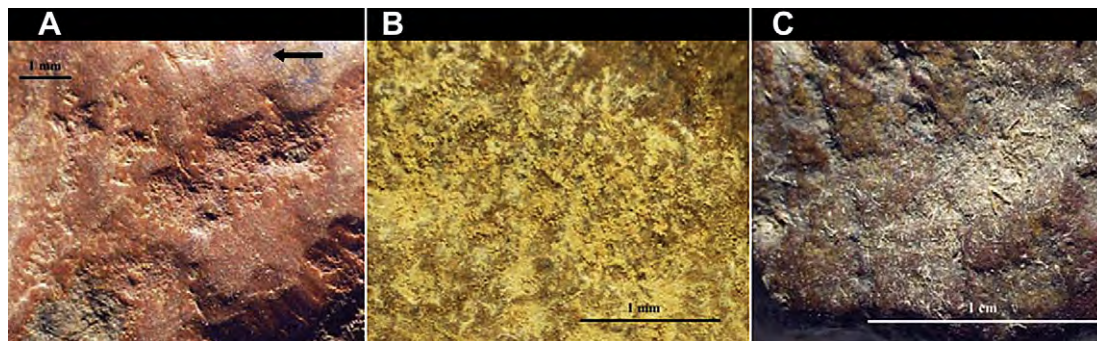
**Fig. 3.** Range of use-wear markings created on ochre pieces during various activities and chains of activities. (A) Metallic lustre and microstriations that formed on a previously ground ochre piece (E110) after it was rubbed, wet, on human skin. (B) Ground ochre piece (E80.2) scored with wood to create an oblique, shallow groove with internal microstriations. Note the waxy, opaque residue and the fragments of white ground wood within the scored incision. (C) Edge of an ochre piece (E43.4) that chipped while rubbing dry animal hide. (D) Slight polish and smoothing on an ochre piece (E99) after rubbing, dry, on animal hide. The polish is limited to the higher areas on the piece. (E) Polish that formed on a previously ground ochre piece (E144) that was rubbed, dry, on human skin. (F) Smoothing of grinding striations on a previously ground ochre piece (E130) that was rubbed, wet, on animal hide. The original grinding striations have become ill defined.

the orientation, grouping, placement and terminations of the grinding striations. Rubbing results in many grinding striations losing their microstriations, particularly when the pieces are wet (Fig. 3F). A few pieces acquire metallic lustre from rubbing (Fig. 3A), but importantly the pieces that had metallic lustre before rubbing do not lose their lustre when rubbed.

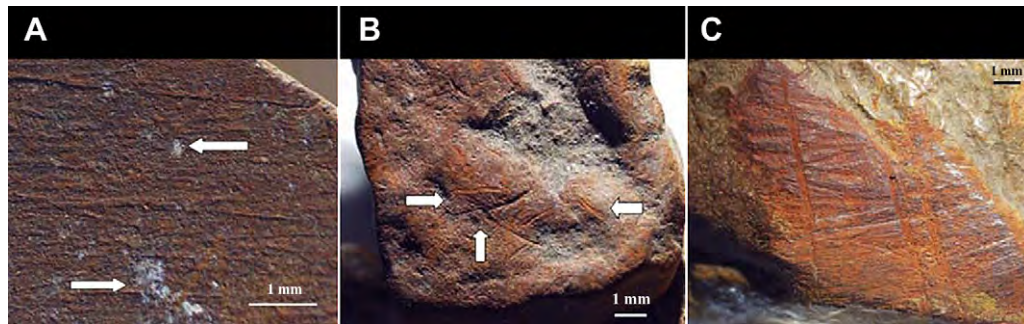
#### 4.2. Post-depositional effects of trampling and water on use-wear

##### 4.2.1. Trampling (Table 5)

When the trampled ochre pieces were collected, only 32 were recovered even after searching and raking an area larger than that used for the experiment. Some pieces were found as far as a meter



**Fig. 4.** Use-wear markings and residues on ochre pieces that were used for various scoring and rubbing activities. (A) Smoothing on a piece of ochre (E105) that was rubbed, dry, on human skin. Note that the smoothing is only on the higher areas of the piece. The arrow points to a section where faint external microstriations have formed. The little white dots are skin residues. (B) White powder residues on an ochre piece (E34.2) after scoring with bone. (C) Stringy plant fibres found on an unground ochre piece (E179) that was rubbed, wet, on wood.



**Fig. 5.** Trampling and soaking. (A) scuffmarks on a trampled piece (E84) that had been previously ground, dry, on a sandstone slab. (B) Trampling scratches on an unground piece (E105) that had been rubbed on human skin, dry. (C) Smoothing and polish on the surface of a piece (E12) that was first ground, dry, on a sandstone slab, then scored with a stone flake, and finally soaked in water.

away from where they had been placed, others had moved vertically by a few centimetres. This indicates the potential for drastic movement of pieces due to trampling. Trampling does not change the orientation and grouping of grooves from previous activities, but sometimes superficial grooves disappear or deep grooves are partially removed from pieces. This partial removal results in fewer grooves reaching all the edges of the pieces. The partial removal of grooves also results in profile shape change, with a large decrease in

V-shaped profiles. The ends of the grooves remain mostly unchanged. Over half the pieces lost their external and internal microstriations. The opaque residues are removed on a few pieces, but clay, fibre and powder residues are removed from most pieces. Pre-existing facets are sometimes removed, as well as polish and metallic lustre. Minor edge rounding and smoothing increase as a result of trampling, and many pieces acquire trampling scratches and scuffmarks (Fig. 5A and B).

**Table 1**

Use-wear created on ochre pieces during grinding activities. For definitions of orientation and grouping of grooves see Section 3.3. Percentages indicate how many pieces of the sample have each use-wear type. Dashes (–) represent 0%.

| Attributes |                          |                             | Sandstone |        | Dolerite | Total   |
|------------|--------------------------|-----------------------------|-----------|--------|----------|---------|
|            |                          |                             | Dry       | Wet    | Dry      |         |
|            |                          |                             | n = 95    | n = 10 | n = 15   | n = 120 |
| Grooves    | Orientation and grouping | % with grooves              | 100%      | 100%   | 100%     | 100%    |
|            |                          | Parallel                    | 53.7%     | 100%   | 46.7%    | 66.7%   |
|            |                          | Erratic                     | –         | –      | –        | 0%      |
|            |                          | Parallel and erratic        | 18.9%     | –      | 53.3%    | 24.1%   |
|            |                          | Parallel groups             | 22.1%     | –      | –        | 7.4%    |
|            |                          | Parallel groups and erratic | 5.3%      | –      | –        | 1.8%    |
|            |                          | Other                       | –         | –      | –        | –       |
|            | Placement across surface | To all edges                | 92.6%     | 100%   | 93.3%    | 95.3%   |
|            |                          | To some edges               | 5.3%      | –      | 6.7%     | 4%      |
|            |                          | To no edges                 | 2.1%      | –      | –        | 0.7%    |
|            | Profile shape            | U + V + \_ /                | 55.8%     | 66.7%  | 10%      | 44.2%   |
|            |                          | U + V                       | 31.6%     | –      | 20%      | 17.2%   |
|            |                          | U + \_ /                    | 10.5%     | 33.3%  | 30%      | 24.6%   |
|            |                          | V + \_ /                    | –         | –      | –        | 0%      |
|            |                          | V                           | 1.1%      | –      | –        | 0.4%    |
|            |                          | U                           | 1.1%      | –      | 40%      | 13.7%   |
|            |                          | \_ /                        | –         | –      | –        | 0%      |
|            | Terminations             | Superficial                 | –         | –      | –        | 0%      |
|            |                          | No frayed                   | 100%      | 100%   | 100%     | 100%    |
|            |                          | Some frayed                 | –         | –      | –        | 0%      |
|            | Microstriations          | All frayed                  | –         | –      | –        | 0%      |
|            |                          | Internal                    | 95.8%     | 20%    | 100%     | 71.9%   |
| Other      | Chipping                 |                             | –         | –      | –        | 0%      |
|            | Polish                   |                             | –         | 10%    | –        | 3.3%    |
|            | Metallic lustre          |                             | 13.7%     | –      | 13.3%    | 9%      |
|            | Smoothing                |                             | 12.6%     | 80%    | 13.3%    | 35.3%   |
|            | Microstriations          | External                    | –         | –      | –        | 0%      |
|            | Edges                    | Rounded                     | 53.7%     | 80%    | 60%      | 64.6%   |
|            |                          | Faceted                     | 6.8%      | 30%    | 20%      | 18.9%   |
|            |                          | Flat                        | 48.4%     | 20%    | 53.3%    | 40.6%   |
|            | Surface of piece         | Concave                     | 7.4%      | 10%    | –        | 5.8%    |
|            |                          | Convex                      | 1.1%      | –      | 6.7%     | 2.6%    |
|            |                          | Unchanged                   | 36.8%     | 40%    | 20%      | 32.3%   |
|            | Residues                 | Clay                        | –         | 100%   | –        | 33.3%   |
|            |                          | Opaque layer                | –         | –      | –        | 0%      |
|            |                          | Powder                      | –         | –      | –        | 0%      |
|            |                          | Fibres                      | –         | –      | –        | 0%      |

**Table 2**

Use-wear created on ochre pieces during scoring activities. Percentages indicate how many pieces of the sample have each use-wear type. In 'Orientation and grouping' the numbers in brackets after the percentages are firstly, the amount of pieces scored to create powder and secondly, the amount of pieces scored to create a design. For definitions of orientation and grouping of grooves see Section 3.3 and Table 1. Note that powder residues are not ochre powder, but powder from the scoring tool (such as, ground bone powder). Dashes (–) represent 0%. Not applicable (n/a) indicates that the use-wear category does not apply for that activity. When markings are indistinguishable the use-wear type for that activity is marked 'IND', therefore the percentages will not add up to 100%.

| Attributes |                                  |                             | Stone flake            |                         | Bone                   |                         | Wood                   |                         | Total<br><i>n</i> = 63<br>(6.7% IND) |
|------------|----------------------------------|-----------------------------|------------------------|-------------------------|------------------------|-------------------------|------------------------|-------------------------|--------------------------------------|
|            |                                  |                             | Ungr.<br><i>n</i> = 10 | Ground<br><i>n</i> = 12 | Ungr.<br><i>n</i> = 10 | Ground<br><i>n</i> = 10 | Ungr.<br><i>n</i> = 11 | Ground<br><i>n</i> = 10 |                                      |
| Grooves    | Orientation and grouping         | % with grooves              | 100%                   | 100%                    | 100%                   | 100%                    | 100%                   | 100%                    | 100%                                 |
|            |                                  | Parallel                    | 10% (1,0)              | 33.3% (4,0)             | –IND                   | –                       | –                      | –                       | 7.2% (5,0)                           |
|            |                                  | Erratic                     | 10% (1,0)              | –                       | –IND                   | –                       | 10% (1,0)              | –                       | 3.3% (2,0)                           |
|            |                                  | Parallel and erratic        | –                      | –                       | –IND                   | –                       | –                      | –                       | 0%                                   |
|            |                                  | Parallel groups             | 10% (1,0)              | 16.7% (2,0)             | –IND                   | 10% (1,0)               | –                      | –                       | 6.1% (4,0)                           |
|            |                                  | Parallel groups and erratic | 20% (2,0)              | –                       | –IND                   | –                       | –                      | –                       | 3.3% (2,0)                           |
|            |                                  | Other                       | 50% (0,5)              | 50% (0,6)               | 60% (0,6) IND          | 90% (0,9)               | 90% (0,9)              | 100% (0,10)             | 73.3% (0,45)                         |
|            |                                  | Placement across surface    |                        |                         |                        |                         |                        |                         |                                      |
|            |                                  | To all edges                | 10%                    | 16.7%                   | –                      | 10%                     | 18.1%                  | 10%                     | 10.8%                                |
|            |                                  | To some edges               | 40%                    | 33.3%                   | 30%                    | –                       | 9.1%                   | 30%                     | 23.7%                                |
|            |                                  | To no edges                 | 50%                    | 50%                     | 70%                    | 90%                     | 72.7%                  | 60%                     | 65.5%                                |
|            | Profile shape                    | U + V + \                   | 40%                    | 8.3%                    | –IND                   | –                       | –                      | –                       | 8.1%                                 |
|            |                                  | U + V                       | 40%                    | 58.3%                   | –IND                   | –                       | –                      | –                       | 16.4%                                |
|            |                                  | U + \                       | 10%                    | –                       | 20% IND                | 30%                     | 36.4%                  | 10%                     | 17.7%                                |
|            |                                  | V + \                       | –                      | 8.3%                    | –IND                   | –                       | –                      | –                       | 1.4%                                 |
|            |                                  | V                           | 10%                    | 16.7%                   | –IND                   | –                       | –                      | –                       | 4.5%                                 |
|            |                                  | U                           | –                      | 8.3%                    | –IND                   | –                       | 9.1%                   | 20%                     | 6.2%                                 |
|            |                                  | \                           | –                      | –                       | 10% IND                | –                       | –                      | –                       | 1.7%                                 |
|            |                                  | Superficial                 | –                      | –                       | 70% IND                | 70%                     | 54.5%                  | 70%                     | 44.1%                                |
|            | Terminations                     | No frayed                   | 20%                    | 16.7%                   | –IND                   | –IND                    | 18.1% IND              | 20%                     | 12.5%                                |
|            |                                  | Some frayed                 | 30%                    | 25%                     | 30% IND                | 20% IND                 | 18.1% IND              | 50%                     | 28.9%                                |
|            |                                  | All frayed                  | 50%                    | 58.3%                   | 10% IND                | 60% IND                 | 45.5% IND              | 30%                     | 42.3%                                |
|            | Microstriations                  | Internal                    | 100%                   | 100%                    | 100%                   | 100%                    | 100%                   | 100%                    | 100%                                 |
| Other      | Chipping                         | Along grooves               | –                      | 33.3%                   | –                      | –                       | –                      | –                       | 5.6%                                 |
|            |                                  | Polish                      | –                      | –                       | –                      | –                       | –                      | –                       | 0%                                   |
|            |                                  | Metallic lustre             | –                      | 25%                     | –                      | –                       | –                      | –                       | 4.2%                                 |
|            | Smoothing                        | Microstriations             | –                      | –                       | –                      | –                       | –                      | –                       | 0%                                   |
|            |                                  | External                    | –                      | –                       | –                      | –                       | –                      | –                       | 0%                                   |
|            |                                  | Rounded                     | –                      | –                       | –                      | –                       | –                      | –                       | 0%                                   |
|            | Edges                            | Faceted                     | –                      | –                       | –                      | –                       | –                      | –                       | 0%                                   |
|            |                                  | Flat                        | –                      | –                       | –                      | –                       | –                      | –                       | 0%                                   |
|            |                                  | Concave                     | –                      | –                       | –                      | –                       | –                      | –                       | 0%                                   |
|            | Surface of piece                 | Convex                      | –                      | –                       | –                      | –                       | –                      | –                       | 0%                                   |
|            |                                  | Unchanged                   | 100%                   | 100%                    | 100%                   | 100%                    | 100%                   | 100%                    | 100%                                 |
|            | Residues                         | Clay                        | –                      | –                       | –                      | –                       | –                      | –                       | 0%                                   |
|            |                                  | Opaque layer                | –                      | –                       | 90%                    | 100%                    | 81.70%                 | 100%                    | 62%                                  |
|            |                                  | Powder                      | –                      | –                       | 90%                    | 90%                     | 54.5%                  | 90%                     | 54.1%                                |
|            |                                  | Fibres                      | –                      | –                       | –                      | –                       | 9%                     | –                       | 1.5%                                 |
|            | Smoothing of grinding striations |                             | n/a                    | –                       | n/a                    | 10%                     | n/a                    | 10%                     | 6.7%                                 |

#### 4.2.2. Soaking (Table 5)

The orientation and grouping of grooves changes slightly after soaking, but this is mainly due to the removal of the superficial incisions, whereas the alignment of grinding striations is unchanged. Consequently, only grinding striations or pieces that look unused remain. There is very little change in groove profile shapes with a slight decrease in the number of V-shaped profiles. Many of the grooves with no frayed terminations become indistinct after soaking. Smoothing and edge rounding increase and any facets that formed in previous activities are still clear after soaking. Many microstriations and much of the residues are removed by soaking, but polish and metallic lustre increase slightly (Fig. 5C). Some pieces acquire scratches, scuffmarks and new residues during soaking.

### 5. Recognising use-wear markings on ochre from Sibudu

Analysis of Sibudu MSA ochre is underway and the comparative sample has proved essential for the identification of the use-wear found on the archaeologically recovered pieces. Grinding use-wear is by the far the most common type and it is the most

easily recognizable use-wear on the 1200 pieces already analysed (grinding use-wear is represented by Fig. 6A and B). As is the case with the experimentally ground ochre pieces, the MSA pieces from Sibudu contain clear, parallel striations that reach the edges of the pieces. Grinding striations have predominantly U-shaped profiles. They do not always contain internal microstriations, and when internal microstriations are absent, this implies that the pieces were used wet because the experiments showed that internal microstriations only form when dry ochre is ground. Rubbing use-wear in the form of polish, smoothing and edge rounding is hard to identify because the markings can be confused with natural formations and markings; however there are some convincing examples of ochre pieces that have been rubbed to form smoothing, polish and external microstriations (Fig. 6C and D). The external microstriations are restricted to the elevated portions of the ochre surface and smoothing is absent from the hollows on the ochre surface. No scored designs have yet been found on the archaeologically recovered ochre from Sibudu. A full description of the ochre analysis will be published in a separate paper when all 9000 pieces have been thoroughly examined.

**Table 3**  
Use-wear created on ochre pieces during rubbing activities. Percentages indicate how many pieces of the sample have each use-wear type. The percentages in shaded sections apply to the pieces that have grooves. Dashes (–) represent 0%. When markings are indistinguishable the use-wear type for that activity is marked IND because pieces are missing and so the percentages will not add up to 100%.

| Attributes |                          |                             | Animal hide |        |        |        | Human skin |        |        |       | Human hair |       |        |       | Wood     |        |        | Total |
|------------|--------------------------|-----------------------------|-------------|--------|--------|--------|------------|--------|--------|-------|------------|-------|--------|-------|----------|--------|--------|-------|
|            |                          |                             | Ungr.       |        | Ground |        | Ungr.      |        | Ground |       | Ungr.      |       | Ground |       | Ungr.    | Ground |        |       |
|            |                          |                             | Dry         | Wet    | Dry    | Wet    | Dry        | Wet    | Dry    | Wet   | Dry        | Wet   | Dry    | Wet   | Wet      | Dry    | Wet    |       |
|            |                          |                             | n = 6       | n = 10 | n = 7  | n = 10 | n = 10     | n = 10 | n = 10 | n = 9 | n = 2      | n = 2 | n = 2  | n = 3 | n = 10   | n = 10 | n = 10 |       |
| Grooves    | Orientation and grouping | % with grooves              | 16.7%       | 20%    | 0%     | 0%     | 0%         | 20%    | 0%     | 0%    | 0%         | 50%   | 0%     | 33.3% | 30%      | 0%     | 0%     | 11.3% |
|            |                          | Parallel                    | —           | 50%    | —      | —      | —          | 50%    | —      | —     | —          | 100%  | —      | —     | 100%     | —      | —      | 20%   |
|            |                          | Erratic                     | —           | —      | —      | —      | —          | 50%    | —      | —     | —          | —     | —      | —     | —        | —      | —      | 3.3%  |
|            |                          | Parallel and erratic        | —           | —      | —      | —      | —          | —      | —      | —     | —          | —     | —      | —     | —        | —      | —      | 0%    |
|            |                          | Parallel groups             | —           | 50%    | —      | —      | —          | —      | —      | —     | —          | —     | —      | —     | —        | —      | —      | 3.3%  |
|            |                          | Parallel groups and erratic | 100%        | —      | —      | —      | —          | —      | —      | —     | —          | —     | —      | 100%  | —        | —      | —      | 13.3% |
|            |                          | Other                       | —           | —      | —      | —      | —          | —      | —      | —     | —          | —     | —      | —     | —        | —      | —      | 0.0%  |
|            | Placement across surface | To all edges                | 100%        | 50%    | —      | —      | —          | —      | —      | —     | —          | —     | —      | 100%  | —        | —      | —      | 16.7% |
|            |                          | To some edges               | —           | —      | —      | —      | —          | 100%   | —      | —     | —          | 100%  | —      | —     | 33.3%    | —      | —      | 15.6% |
|            |                          | To no edges                 | —           | 50%    | —      | —      | —          | —      | —      | —     | —          | —     | —      | —     | 66.7%    | —      | —      | 7.8%  |
|            | Profile shape            | U + V + \                   | —           | —      | —      | —      | —          | —      | —      | —     | —          | —     | —      | 33.3% | —        | —      | —      | 2.2%  |
|            |                          | U + V                       | —           | —      | —      | —      | —          | 50%    | —      | —     | —          | —     | —      | —     | —        | —      | —      | 3.3%  |
|            |                          | U + \                       | —           | —      | —      | —      | —          | —      | —      | —     | —          | —     | —      | 33.3% | —        | —      | —      | 2.2%  |
|            |                          | V + \                       | —           | —      | —      | —      | —          | —      | —      | —     | —          | —     | —      | —     | —        | —      | —      | 0%    |
|            |                          | V                           | 100%        | —      | —      | —      | —          | 50%    | —      | —     | —          | 100%  | —      | 33.3% | —        | —      | —      | 18.9% |
|            |                          | U                           | —           | 100%   | —      | —      | —          | —      | —      | —     | —          | —     | —      | —     | 100%     | —      | —      | 13.3% |
|            |                          | \                           | —           | —      | —      | —      | —          | —      | —      | —     | —          | —     | —      | —     | —        | —      | —      | 0%    |
|            | Ends                     | Superficial                 | —           | —      | —      | —      | —          | —      | —      | —     | —          | —     | —      | —     | —        | —      | —      | 0%    |
|            |                          | No frayed                   | 100%        | 50%IND | —      | —      | —          | 100%   | —      | —     | —          | 100%  | —      | 100%  | 66.7%IND | —      | —      | 34.4% |
|            |                          | Some frayed                 | —           | —IND   | —      | —      | —          | —      | —      | —     | —          | —     | —      | —     | —IND     | —      | —      | 0%    |
|            |                          | All frayed                  | —           | —IND   | —      | —      | —          | —      | —      | —     | —          | —     | —      | —     | —IND     | —      | —      | 0%    |
|            | Microstriations          | Internal                    | —           | —      | —      | —      | —          | 50%    | —      | —     | —          | 100%  | —      | —     | —        | —      | —      | 10%   |
| Other      | Chipping                 | Along edges                 | 50%         | —      | —      | —      | —          | —      | —      | —     | —          | —     | —      | —     | —        | —      | —      | 3.3%  |
|            | Polish                   |                             | 100%        | 40%    | 100%   | 20%    | 80%        | 20%    | 30%    | 22.2% | —          | 50%   | —      | —     | 10%      | —      | —      | 31.5% |
|            | Metallic lustre          |                             | 16.7%       | 10%    | 28.6%  | 10%    | —          | —      | —      | 11.1% | —          | —     | —      | —     | 60%      | —      | 9.1%   |       |
|            | Smoothing                |                             | 100%        | 60%    | 100%   | 100%   | 80%        | 80%    | 100%   | 100%  | 100%       | 50%   | 100%   | 66.7% | 80%      | 100%   | 100%   | 87.8% |
|            | Microstriations          | External                    | 33.3%       | 20%    | 28.6%  | 40%    | 20%        | 10%    | —      | 11.1% | —          | 50%   | 100%   | 66.7% | 30%      | 50%    | 10%    | 31.3% |
|            | Edges                    | Rounded                     | 50%         | 90%    | 57.1%  | 60%    | 80%        | 60%    | 60%    | 44.4% | 100%       | 100%  | —      | 100%  | 40%      | 60%    | 40%    | 62.8% |
|            |                          | Faceted                     | —           | 10%    | 14.3%  | 10%    | —          | —      | 20%    | —     | —          | —     | —      | —     | —        | —      | 10%    | 4.3%  |
|            |                          | Flat                        | 16.7%       | —      | 28.6%  | 10%    | —          | —      | —      | —     | —          | —     | —      | —     | —        | 10%    | —      | 4.4%  |
|            | Surface of piece         | Concave                     | —           | —      | —      | —      | —          | —      | —      | —     | —          | —     | —      | —     | —        | —      | —      | 0%    |
|            |                          | Convex                      | —           | —      | —      | 10%    | —          | —      | 20%    | 11.1% | —          | —     | —      | —     | —        | —      | 20%    | 4.1%  |
|            |                          | Unchanged                   | 83.3%       | 100%   | 71.4%  | 80%    | 100%       | 100%   | 80%    | 88.9% | 100%       | 100%  | 100%   | 100%  | 100%     | 90%    | 80%    | 91.6% |
|            | Residues                 | Clay                        | —           | —      | —      | —      | —          | —      | —      | —     | —          | —     | —      | —     | —        | —      | —      | 0%    |
|            |                          | Opaque layer                | 16.7%       | —      | —      | —      | 60%        | —      | 50%    | —     | —          | 50%   | —      | 33.3% | 10%      | 70%    | 10%    | 20%   |
|            |                          | Powder                      | —           | —      | —      | —      | 60%        | —      | 30%    | —     | —          | 50%   | —      | —     | —        | 50%    | 10%    | 13.3% |
|            |                          | Fibres/Hair                 | —           | 30%    | —      | 10%    | —          | 30%    | —      | —     | —          | —     | 50%    | 33.3% | 100%     | 40%    | 80%    | 24.9% |



**Table 5**

The effects of trampling and soaking on use-wear created during previous activities. Negative totals show that a use-wear marking was removed from the ochre piece, and positive totals show that the use-wear was gained on the ochre piece. Percentages indicate how many pieces of the sample have each use-wear type. 'Grooves' are calculated by looking at how many pieces of the sample have each use-wear type. 'Other' use-wear is calculated within each use-wear type (note the sample size changes) because some categories have very few pieces. Percentage values worked out within the whole sample would underestimate how trampling and soaking modify use-wear. 'Individual profile shapes' represent the appearance of a certain shaped groove on each piece, not the exclusive appearance of that profile shape on a piece. Dashes (–) represent 0%. Not applicable (n/a) indicates that the use-wear category does not apply for that activity.

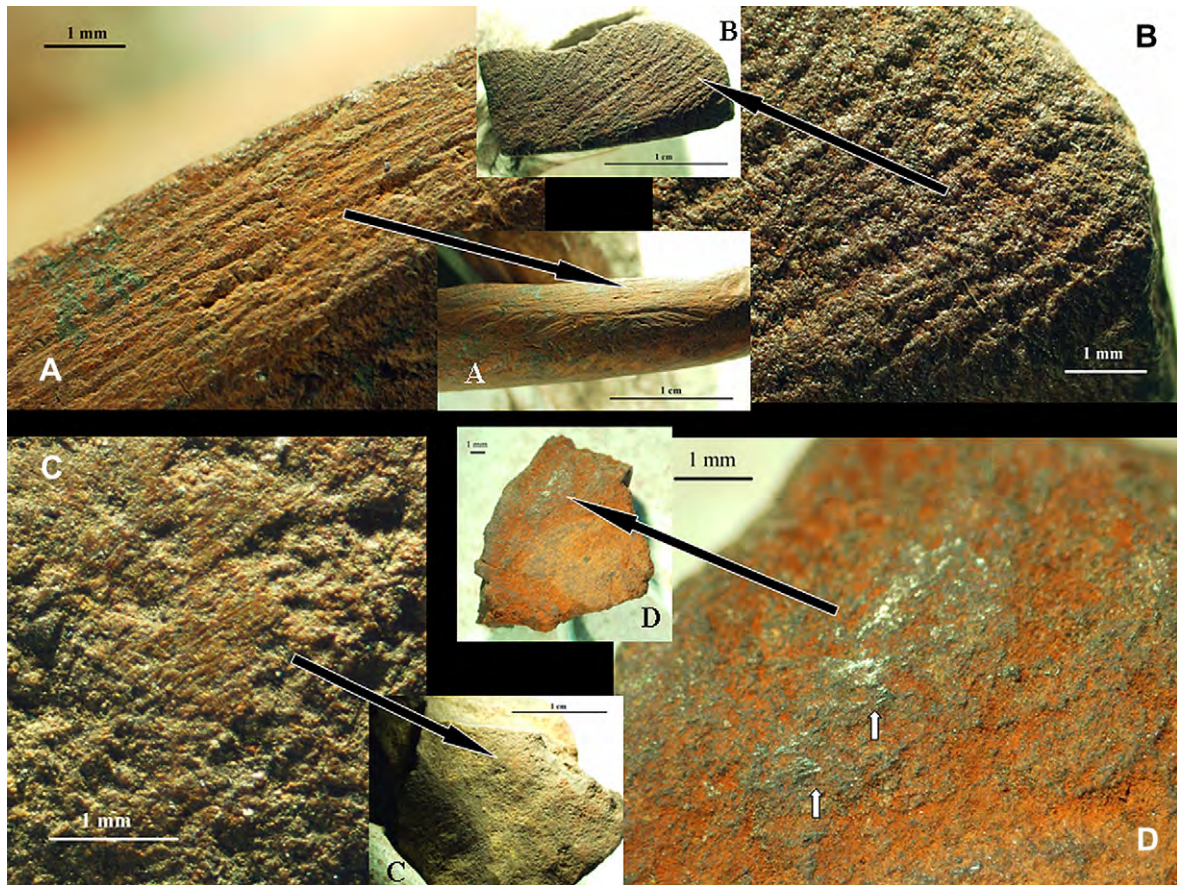
| Attributes                   |         |                                                          |                                    | Trampling |        |        | Soaking |       |        |
|------------------------------|---------|----------------------------------------------------------|------------------------------------|-----------|--------|--------|---------|-------|--------|
|                              |         |                                                          |                                    | Before    | After  | Total  | Before  | After | Total  |
| Changes to previous use-wear | Grooves | Orientation and grouping<br>T n = 30<br>S n = 22 (3 IND) | Parallel                           | 53.3%     | 53.3%  | 0%     | 40.9%   | 45.5% | +4.6%  |
|                              |         |                                                          | Erratic                            | 3.3%      | 3.3%   | 0%     | 9.1%    | 9.1%  | 0.0%   |
|                              |         |                                                          | Parallel and erratic               | 3.3%      | 3.3%   | 0%     | 9.1%    | 13.6% | +4.5%  |
|                              |         |                                                          | Parallel groups                    | 3.3%      | 3.3%   | 0%     | 4.5%    | 4.5%  | 0%     |
|                              |         |                                                          | Parallel groups and erratic        | 3.3%      | 3.3%   | 0%     | –       | –     | 0%     |
|                              |         |                                                          | Other                              | 33.3%     | 33.3%  | 0%     | 36.4%   | 18.2% | –18.2% |
|                              |         | Placement<br>T n = 30 (1 IND)<br>S n = 22                | To all edges                       | 70%       | 33.3%  | –36.7% | 45.5%   | 50%   | +4.5%  |
|                              |         |                                                          | To some edges                      | 6.7%      | 40%    | +33.3% | 18.2%   | 18.2% | 0%     |
|                              |         |                                                          | To no edges                        | 23.3%     | 23.3%  | 0%     | 36.4%   | 31.8% | –4.6%  |
|                              |         | Individual profile shapes<br>T n = 30, S n = 22          | V                                  | 53.3%     | 26.7%  | –26.6% | 63.6%   | 54.5% | –9.1%  |
|                              |         |                                                          | U                                  | 76.7%     | 73.3%  | –3.4%  | 81.8%   | 86.4% | +4.6%  |
|                              |         |                                                          | └/                                 | 36.7%     | 26.7%  | –10%   | 45.5%   | 40.9% | –4.6%  |
|                              |         |                                                          | Superficial                        | 20%       | 6.7%   | –13.3% | 27.3%   | 4.5%  | –22.8% |
|                              |         | Terminations<br>T n = 30, S n = 22                       | No frayed                          | 88%       | 92%    | +4%    | 72.7%   | 40.9% | –31.8% |
|                              |         |                                                          | Some frayed                        | –         | –      | –      | –       | –     | –      |
|                              |         |                                                          | All frayed                         | 12%       | 8%     | –4%    | 18.2%   | 18.2% | 0%     |
|                              |         |                                                          | Indistinct                         | –         | –      | –      | 9.1%    | 40.9% | +31.8% |
|                              | Other   | Microstriations<br>T n = 19, S n = 18                    | Internal and external              | 100%      | 42.1%  | –57.9% | 100%    | 55.6% | –44.4% |
|                              |         | Edge rounding T n = 12,<br>S n = 7                       |                                    | 100%      | 141.7% | +41.7% | 100%    | 157%  | +57%   |
|                              |         | Faceted surface T n = 2,<br>S n = 2                      |                                    | 100%      | 50%    | –50%   | 100%    | 100%  | 0%     |
|                              |         | Metallic lustre T n = 3,<br>S n = 7                      |                                    | 100%      | 0%     | –100%  | 85.7%   | 100%  | +14.3% |
|                              |         | Residues                                                 | Clay T n = 4, S n = 1              | 100%      | 0%     | –100%  | 100%    | 0%    | –100%  |
|                              |         |                                                          | Opaque layer<br>T n = 7, S n = 7   | 100%      | 71.4%  | –28.6% | 100%    | 0%    | –100%  |
|                              |         |                                                          | Powder, fibres<br>T n = 8, S n = 9 | 100%      | 12.5%  | –87.5% | 100%    | 66.6% | –33.4% |
|                              |         | Polish T n = 6, S n = 5                                  |                                    | 100%      | 33.7%  | –66.7% | 100%    | 120%  | +20%   |
|                              |         | Smoothing T n = 18,<br>S n = 11                          |                                    | 100%      | 150%   | +50%   | 100%    | 181%  | +81%   |
|                              | New     | Residues                                                 | Clay                               | n/a       | –      | 0%     | n/a     | 7.1%  | +7.1%  |
|                              |         | T n = 32, S n = 28                                       | Powder, Fibres                     | n/a       | –      | 0%     | n/a     | 3.6%  | +3.6%  |
|                              |         | Scratches T n = 32, S n = 28                             |                                    | n/a       | 68.8%  | +68.8% | n/a     | 17.9% | +17.9% |
|                              |         | Scuffmarks T n = 32, S n = 28                            |                                    | n/a       | 81.3%  | +81.3% | n/a     | 25%   | +25%   |

other evidence, such as residues or external microstriations. Some ochre rubbing is not effective because the ochre is too hard and does not leave coloured powder on the material being rubbed. This is particularly the case when a piece has not been previously ground. Rubbing with ochre that was previously ground is briefly successful until the loose powder from the ochre surface is transferred to the rubbed material. Thereafter the ochre piece begins to damage the hide and hair or hurt human skin. Using wet ochre is less damaging and it enables transfer of some colour. External microstriations on ochre occur exclusively with rubbing; they never occur on the ochre surface from scoring or grinding.

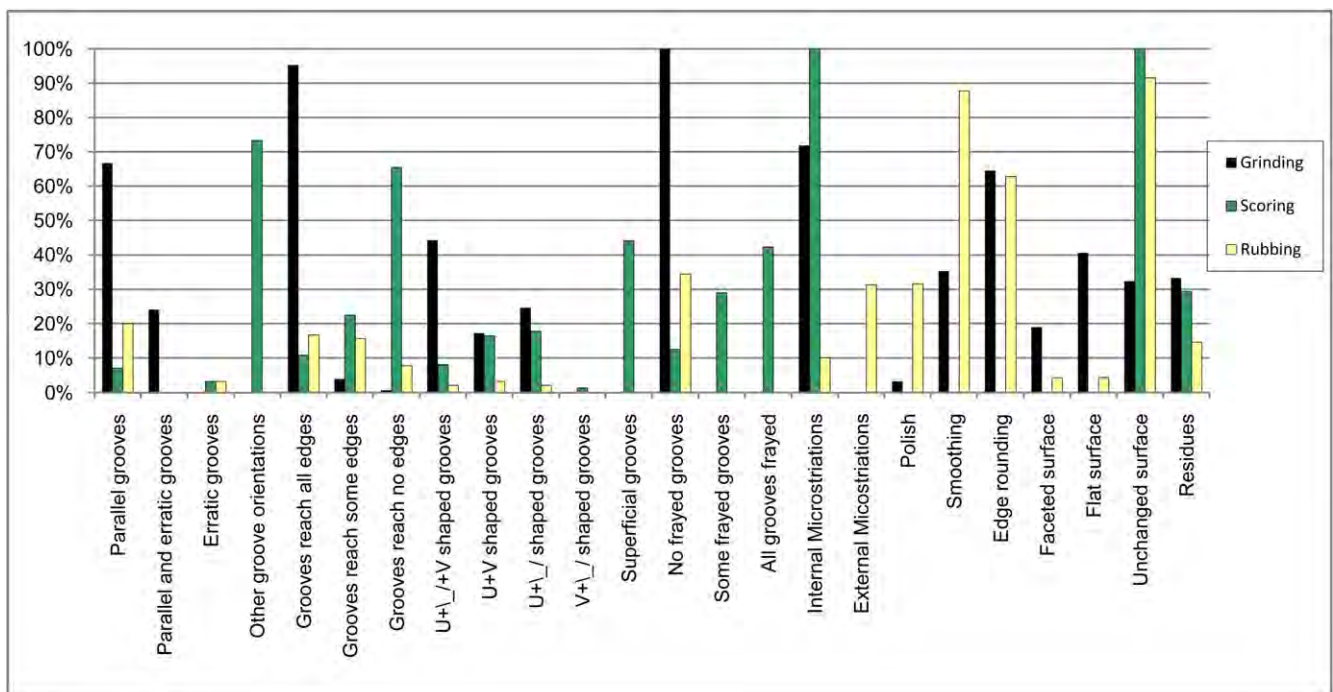
Ochre surfaces suitable for scoring can be different from those suitable for grinding. Surface area, topography and the ease with which an ochre piece can be held steady during scoring, influence its choice for this activity. Most natural ochre surfaces are not completely flat, and flat surfaces are best for scoring deep, straight incisions (assuming that engraving is the primary purpose). It is useful to grind a piece first to create a flat working surface before scoring it. It is also helpful to have a flat surface on the opposite side of the surface being scored so that the ochre can stand steady while the scoring is performed. Only grinding ochre resulted in noteworthy surface shape change – grinding creates flat surfaces. Prolonged grinding is likely to reduce ochre pieces sufficiently to create

a plane that is determined by geological type, the original shape of the piece, soft areas on the piece and ease of handling. Ochre planes changed during my experiments, but change may be difficult to recognise archaeologically because the original shape of such pieces is unknown.

Grooves are the most noticeable use-wear markings that form on ochre pieces during use, but other use-wear markings might sometimes be helpful indicators of activities. Chipping occurs on few pieces and, when it does, it is either on incision peaks created by a stone flake used on previously ground ochre pieces, or on the edges of an ochre piece rubbed on dry hide. Polish mainly forms on ochre pieces rubbed on hide or human skin, but in rare instances it forms on pieces rubbed on wood and human hair or even on ochre pieces ground wet on stone. Polish is not always distinct, and it can be mistaken for an opaque layer or metallic lustre, but it is distinguished by a sheen. This sheen is not silver like metallic lustre and it does not form an opaque layer on top of the piece. Careful microscopic examination is necessary to recognise this use-wear marking. Metallic lustre is not a diagnostic use-wear marking because it does not occur regularly and it results from a variety of activities. Metallic lustre may be due to the chemical or physical make-up of the piece. Mineralogical studies are necessary to investigate this issue. Smoothing is most often acquired during



**Fig. 6.** Use-wear on archaeological ochre samples from Sibudu Cave. (A) Ochre (Sb1110) with clear striations on the narrow edge of the piece. The striations reach the edges of the piece, have unfrayed terminations and are mostly parallel or in parallel groups. Some internal microstriations are still apparent. This piece was ground, dry, on a hard stone. (B) Ochre (Sb1139) with parallel striations that were formed from grinding on a hard stone. As with Sb1110, the striations reach the edges of the piece and are unfrayed. The striations and the edges of the piece have been rounded and smoothed and no microstriations are visible – indicating that the piece was probably wet when used. (C) Ochre (Sb746) with smoothing, polish and external microstriations. The smoothing covers most of the shown surface. The combination of the polish on the top edge of the piece and the small patch of microstriations indicate that it has been used. This piece is likely to have been rubbed against a soft material because no grooves have formed, only microstriations. (D) Ochre (Sb1291) with metallic lustre, smoothing and external microstriations. The white arrows point to the sections where the microstriations are visible. The use-wear is limited to the higher areas of the used surface. This piece was probably rubbed against a soft material, such as animal hide.



**Fig. 7.** Frequencies of the diagnostic use-wear markings that grinding, scoring and rubbing activities produced on ochre pieces. The superficial grooves are from scoring with wooden or bone tools. Residues exclude ochre powder found on the pieces.

rubbing actions, and not from grinding and scoring actions. Smoothing is more likely to be seen on pieces with grooves from previous activities that were then used for rubbing activities. Smoothing does not result in significant surface contour change although it does cause groove profile shape change. No non-ochre residues form during grinding activities or scoring with a stone flake. Many of the ochre pieces used in scoring and rubbing activities involving organic materials obtained residues.

The analysis of 1200 Sibudu ochre pieces suggest that the methodology developed here is of considerable assistance for the classification of archaeologically recovered ochre. Amongst the Sibudu ochre, the evidence for grinding is unequivocal on the majority of worked pieces. Rubbing is present, but less common. Scoring for ochre powder seems rare amongst the present sample and, thus far, scoring to create a design is absent.

## 7. Conclusion

Distinctive use-wear markings are created on ochre through grinding, scoring and rubbing (Fig. 7). However, some attributes overlap, and careful macro- and microscopic examination of all surfaces for all types of use-wear is imperative. Combinations of use-wear markings are especially diagnostic.

- *Grinding* creates the most easily recognizable use-wear markings in the form of multiple, parallel striations with a variety of profile shapes. The striations reach the edges of the pieces and have unfrayed terminations. Grinding striations always have internal microstriations within them, unless the ochre was ground wet. Grinding is also the only activity performed here that creates significant changes to the shape of the ochre piece. Grinding often causes edge rounding, but importantly it creates a flat, striated plane.
- *Scoring* produces incisions with a variety of profile shapes, which contain internal microstriations. Incisions often do not reach all the edges of the used surface. Many incisions have frayed terminations showing that the incision was created by multiple scoring strokes. Unlike scoring with a stone flake, scoring with bone and wooden tools leaves opaque or powdery residues in the superficial incisions. Scoring to produce powder most often results in parallel incisions, but may also result in groups of incisions that are mostly parallel to each other or parallel groups at angles to each other. Scoring to create a design results in individually placed incisions of variable orientation. No other attribute distinguishes these incisions from those made to produce ochre powder.
- *Rubbing*. The most common use-wear from rubbing ochre on animal hide, human skin, human hair or wood is smoothing, edge rounding and polish. Characteristically, these use-wear markings tend to occur only on the elevated surfaces of the ochre pieces. Grooves and external microstriations also occur occasionally. Organic residues are often left on the ochre piece after rubbing.
- *Post-depositional actions of trampling and soaking on used ochre pieces*. Trampling and soaking remove some of the original use-wear markings left on ochre, especially residues and internal and external microstriations. Both processes result in some modification of groove profile shapes. New use-wear markings, in the form of smoothing, edge rounding, scuffmarks and scratches, also sometimes develop.

The experimental sample described here provides a comparative collection for analysing ochre recovered from archaeological sites. Analysts need to be aware that not all use-wear types can be recognised with the same level of confidence. Grinding can be

identified most securely, but rubbing on soft materials is a difficult use-wear marking to identify. Even so, single-phase activities of grinding, scoring or rubbing can be identified relatively successfully and unproblematically. When activities become multi-phase, interpretations can be less reliably made, even when the various processing steps and sequence of use-wear seem possible to trace. Post-depositional trampling or prolonged wetting of ochre can also mask original use-wear markings. Analysts who study ochre from archaeological sites need to be aware that it is not easy to distinguish rubbing of ochre on hide and human skin. Furthermore, scoring incisions to extract ochre powder cannot be differentiated from incisions that create a deliberate design. It is only the design itself that exemplifies such pieces. Nonetheless, the protocol developed in this study provides an effective empirical means of classifying use-wear on ochre. In the case of Sibudu, it is fortunate that the majority of use-wear markings on ochre pieces can be ascribed to grinding, which is the attribute that can be most securely identified.

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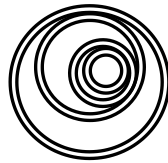
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## CHAPTER 5

### Ochre Properties



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An investigation into the properties of the ochre from Sibudu,  
KwaZulu-Natal, South Africa.

**Southern African Humanities** 24: 99–120.

## **An investigation into the properties of the ochre from Sibudu, KwaZulu-Natal, South Africa**

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### **ABSTRACT**

The properties of ochre from the Middle Stone Age (MSA) layers of Sibudu, KwaZulu-Natal, South Africa, are described here. The assemblage comprises 5449 pieces (>8 mm), including 682 pieces with markings from use. Shale is the most common geological form. Ochre of medium hardness is common and the grain sizes are generally silty or clayey. Some change in ochre types occurs through time. The pre-Still Bay and Howiesons Poort layers have the highest percentage of utilised pieces. Clayey grain sizes are favoured during the Still Bay and Howiesons Poort, whereas silty grain sizes are preferred in the younger MSA occupations. Bright-red ochre was preferentially selected for use throughout the sequence, with the exception of the final MSA where a wider range of colours was utilised. High frequencies of red amongst the utilised pieces, coupled with high frequencies of yellow or orange pieces with no evidence of use, suggest that colour choices were deliberate and not a product of post-depositional heating. Chemical analysis on a sample of utilised pieces indicates that they all contain iron, silicon, aluminium and calcium. Many pieces contain hematite and some maghemite. There is evidence of preferential selection of specific types of ochre for use in the Sibudu assemblage.

**KEY WORDS:** ochre, hardness, grain size, colour, geological form, mica, utilisation, selection preferences.

Ochre is a common occurrence at Middle Stone Age (MSA) archaeological sites (300–22 ka). While interpretation of ochre use in the MSA has become a contentious issue, detailed descriptions and analyses of ochre assemblages are rare (e.g. Watts 1998, 2002, 2010; Barham 2002; Hovers et al. 2003). Site reports often mention ochre frequencies and ochre colour, or numbers of pieces with evidence of utilisation, but they sometimes fail to comment on other characteristics that might have been responsible for the collection and use of the ochre pieces. Various ochre properties may have determined collection and use, even though colour might seem the most obvious attraction. Further, unmodified ochre is often not examined because analyses are focused on utilised pieces.

Here I describe the properties of the entire MSA ochre assemblage from Sibudu, KwaZulu-Natal, South Africa. Sibudu presents us with a large collection of utilised and unutilised pieces (that is pieces with and without traces of use). I concentrate on geological properties, grain size, hardness, colour, mica content and mineralogy to determine preferences for the collection and use of ochre pieces with certain properties. This will also establish whether there were intra-site differences in ochre choice and usage.

### **OCHRE: ITS COMPOSITION AND OCCURRENCE IN ARCHAEOLOGICAL SITES**

‘Ochre’ is a term that encompasses a range of iron-rich rocks with a red, yellow, orange or purple streak. Typically ochre is made up of iron oxides and iron oxyhydroxides ( $\text{Fe}_2\text{O}_3$  and  $\text{FeOOH}$ ) (Schwertmann & Cornell 1991; Jercher et al. 1998; Cornell &

Schwertmann 2003; Popelka-Filcoff et al. 2007; Fiore et al. 2008). Ochre includes a variety of sedimentary (and sometimes igneous and metamorphic) rocks as well as weathered products, soils and unlithified sediments including hematite, goethite, specularite, shale, snuffbox shale, mudstone, siltstone and sandstone (Watts 1998, 2002; Erlandson et al. 1999; Hughes & Solomon 2000; Henshilwood et al. 2001, 2009; Barham 2002; Hovers et al. 2003; Popelka-Filcoff et al. 2007). Ochreous materials can be found in various sedimentological, mineralogical and metamorphic stages that occur during and after rock formation, and these can be subsequently affected by environmental conditions (Cornell & Schwertmann 2003; Hradil et al. 2003; Fiore et al. 2008; Iriarte et al. 2009; Bonneau et al. 2012). Additionally, inclusions such as mica, quartz crystals, organic materials and various impurities occur frequently in these materials (Ruan et al. 2002; Hradil et al. 2003).

The presence of iron oxides and iron hydroxides is a vital factor in the colouring of ochre, and very small amounts can influence the colour of a piece (Schwertmann & Cornell 1991; Cornell & Schwertmann 2003; Hovers et al. 2003). Mineralogy, crystal structure, particle and grain size, and organic and inorganic inclusions also influence the appearance and colour of the piece (Bikiaris et al. 1999; Hradil et al. 2003; Elias et al. 2006; Mastrotheodoros et al. 2010). Ochre colour can be further altered by heating. If temperatures as relatively low as 250°C are reached, iron oxyhydroxide-rich pieces become dehydrated, resulting in hematite formation and a colour change from yellow to red, or, if organic matter is present, maghemite forms and dark reds or browns are produced (Schwertmann & Cornell 1991; Minzoni-Déroche et al. 1995; Pomiès et al. 1998, 1999; Edwards et al. 2000; Ruan et al. 2001, 2002; Godfrey-Smith & Ilani 2004; Wadley 2009; Gialanella et al. 2011). It may be difficult to determine whether heating is post-depositional or intentional (e.g. Godfrey-Smith & Ilani 2004; Wadley 2009, 2010a; d'Errico et al. 2012). Fires can be unintentionally built directly on ochre pieces, resulting in post-use colour changes, or pieces may have been deliberately placed in fires, or buried under fires, to obtain a colour change.

Ethnographic data and the dominance of red ochre in many archaeological assemblages (e.g. Barham 1998, 2002; Watts 1998, 2002, 2010; Henshilwood et al. 2001, 2002, 2009; Hovers et al. 2003) have led to the assumption that red pieces were more highly valued (Marshack 2003), with interpretations focusing on 'symbolically mediated behaviour'. Wadley (2005a, b; 2006a; 2009) and d'Errico et al. (2009) have nevertheless cautioned against making assumptions about the exclusively symbolic nature of archaeological ochre and they encourage exploration of the practical uses of ochre prior to assigning symbolic and ritual meanings to an assemblage. It is possible that colour was not the primary reason for ochre use, but that certain colours functioned as indicators of grain size or hardness, since both properties can have a direct effect on colour (Cornell & Schwertmann 2003; Mastrotheodoros et al. 2010).

If ochre powder was used as paint, or for ritual and cosmetic purposes, then colour may have determined its choice, but other important criteria would have included pulverulence, fine texture, staining power and lack of gritty impurities (Brabers 1976). Such qualities would presumably predominate in the utilised assemblage if the ochre was used to produce paint. If used for hafting, hide tanning or medicinal activities, then other properties might have dictated the pieces chosen. In hafting adhesives the criteria for ochre use as an aggregate would be a mixture of grain sizes; it is imperative

to have a large grain-size component, and also an iron content (Wadley et al. 2009), of which colour can be an indicator. Ochre, and specifically red ochre, is an effective substance with which to tan hides because some varieties of ochre inhibit collagenase formation due to their antibacterial and antifungal properties (Audouin & Plisson 1982; Rifkin 2011). It is primarily the iron content in the ochre powder that prevents the breakdown of collagen (Rifkin 2011). For hafting and hide tanning, colour may not have been the primary reason for choice, but it may have served as an indicator of another desired quality, such as mineral content or hardness.

#### SIBUDU AND ITS OCHRE ASSEMBLAGE

Sibudu is located in KwaZulu-Natal, roughly 15 km inland from the Indian Ocean (Fig. 1), NW of Durban in a cliff in the Mariannhill Formation, part of the Natal Group (Maud 1965; Turner 2000). The rock shelter is directly above the uThongathi River and is about 90 m above sea level. The shelter is about 55 m in length and 18 m wide. Excavations cover 21 square metres (Fig. 2) and the lowest, pre-Still Bay (pre-SB), layers have been reached in five of the 21 excavated squares. The Sibudu cultural sequence comprises a pre-SB industry at its base, with Still Bay (SB), Howiesons Poort (HP), post-Howiesons Poort (post-HP), late MSA and final MSA industries in sequence above (Wadley 2006b; Wadley & Jacobs 2006). There is no Later Stone Age material at the site and the MSA occupations are directly overlaid by Iron Age ones. Optically stimulated luminescence ages for the MSA at Sibudu range between  $77.2 \pm 2.6$  ka and  $37.6 \pm 2.6$  ka (Wadley & Jacobs 2006; Wadley 2007; Jacobs et al. 2008a, b). Numerous hearths and burning events are preserved at Sibudu (Wadley 2009, 2010b) and a large



Fig. 1. Location of Sibudu, KwaZulu-Natal, South Africa (modified from Wadley & Jacobs 2006).

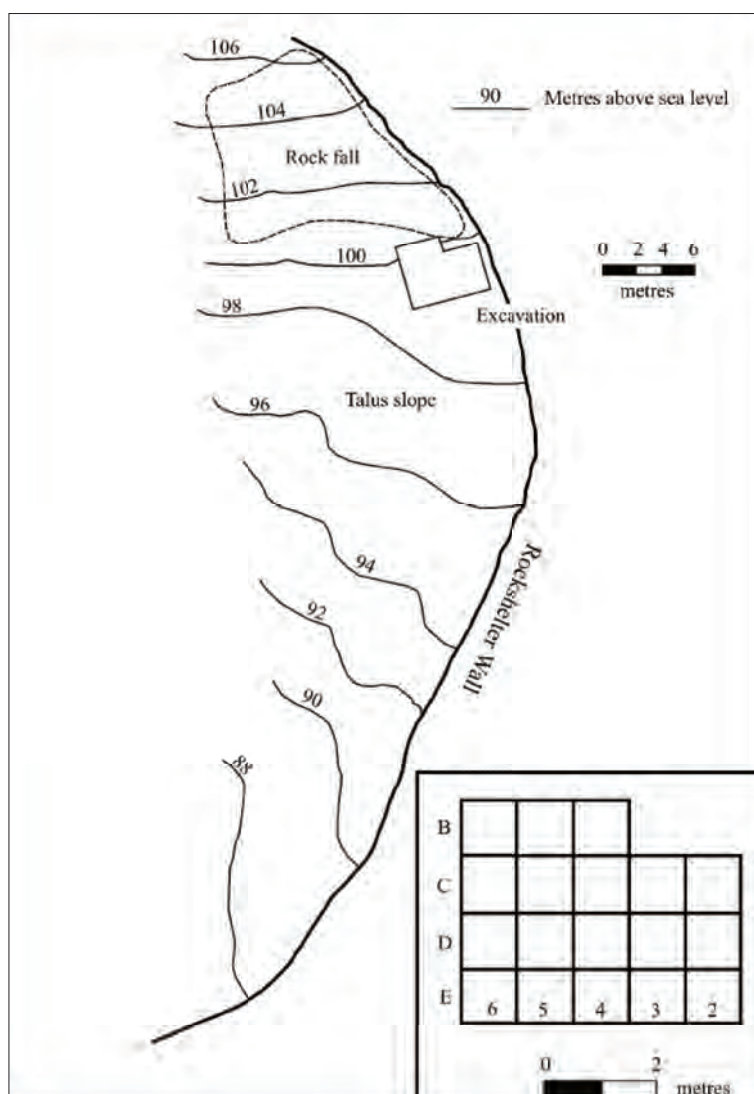


Fig. 2. Plan of Sibudu with location of excavated squares (modified from Wadley & Jacobs 2006).

proportion of the faunal remains and plant material is burnt (Sievers & Wadley 2008; Clark & Ligouis 2010; Wadley et al. 2011).

Ochre pieces are found throughout the MSA occupations at Sibudu. However, ochre use at Sibudu is not only evident in the form of utilised ochre pieces, such as ground and scored pieces. Patches of various colours of ochre powder are found on occupation floors, sometimes on what appear to be 'cemented' hearths used as work surfaces (Wadley 2010b). In addition, ochre residues are found on assorted stone tools, sometimes on the distal working edges, but more often on the proximal and medial edges of pieces that have been hafted with an ochre-loaded adhesive (Lombard 2004,

2005, 2006, 2007; Williamson 2004; Wadley et al. 2004, 2009; Wadley 2005b). The ochre powder found on stone tools at Sibudu is predominantly red (Lombard 2005, 2006, 2007, 2008). Red ochre powder is also found on one perforated shell (d'Errico et al. 2008).

One likely source of Sibudu's ochre is the Ndwedwe shale quarry, which is about one kilometre from the site and is part of the Mariannhill Formation, Eccra Group (Turner 2000; Clarke et al. 2007). No ochre source occurs at the site so all ochre was brought onto the site, though there are a number of earthy sandstone pieces that have been included in the ochre assemblage that could be from the shelter itself.

## METHODS

The Sibudu ochre assemblage is curated at the Institute for Human Evolution (IHE), University of the Witwatersrand, Johannesburg, South Africa. The assemblage is stored in dry conditions, away from sunlight, and at room temperature. All pieces were examined in the IHE archaeology laboratory under the same light conditions, which were a combination of natural light and artificial white light. After examination with a 10x hand lens and an Olympus SZ61 Zoom Stereo microscope, with a WHS-10x FN22 eyepiece (0.67 to 45x magnification), all pieces were individually numbered and bagged. Basic refitting was attempted within each quadrant (by stratigraphic layer); refitted pieces are classified as a single piece. Pieces  $\leq 8$  mm were counted and weighed, but were not allocated individual numbers or examined further unless they had markings from use ( $n=9$ ). Reliable identification of geological properties is problematic with very small pieces. All pieces  $>8$  mm were measured, weighed and then classified by geological form, grain size, hardness, colour, mica content and by any utilisation markings present on the piece. Pieces with any use-traces were further macro- and microscopically examined and photographed using a Panasonic Lumix Camera and an Olympus D212 microscope camera system. Use-traces (utilised pieces) include any anthropogenic modification of a piece, which includes grinding, rubbing, scoring, engraving and scraping. Once quantities and percentages of the nominal data were established, Chi-squared and Cramer's V tests were performed to determine the significance of the relationships between different properties.

The following properties were investigated (examples in Fig. 3):

1. *Geological form.* Pieces were assigned to geological categories. The pieces are often heterogeneous and broad classification categories were used because identification to a more specific level can be unreliable (see also Watts 1998, 2010). Siltstone, mudstone and sandstone are sedimentary rocks that are distinguished from each other by grain size (sandstone has coarse grain sizes). Shale is recognised by the presence of fissile laminations (Tucker 2001) (Fig. 3a). Snuffbox shale is non-fissile and is created during the formation of the rock when pyrite ( $\text{FeS}_2$ ) fills the original bedding planes within the shale, forming irregular 'boxes' of hard ironstone (Hughes & Solomon 2000). The remaining softer iron oxide- and oxyhydroxide-rich shale becomes soft and powdery during weathering (Hughes & Solomon 2000) (Fig. 3b). Sandstone pieces classified as ochre are not the same colour as the purple-red sandstone that is native to the shelter wall; the manuports are mostly bright-red or yellow and often have a silty grain component (Fig. 3c).

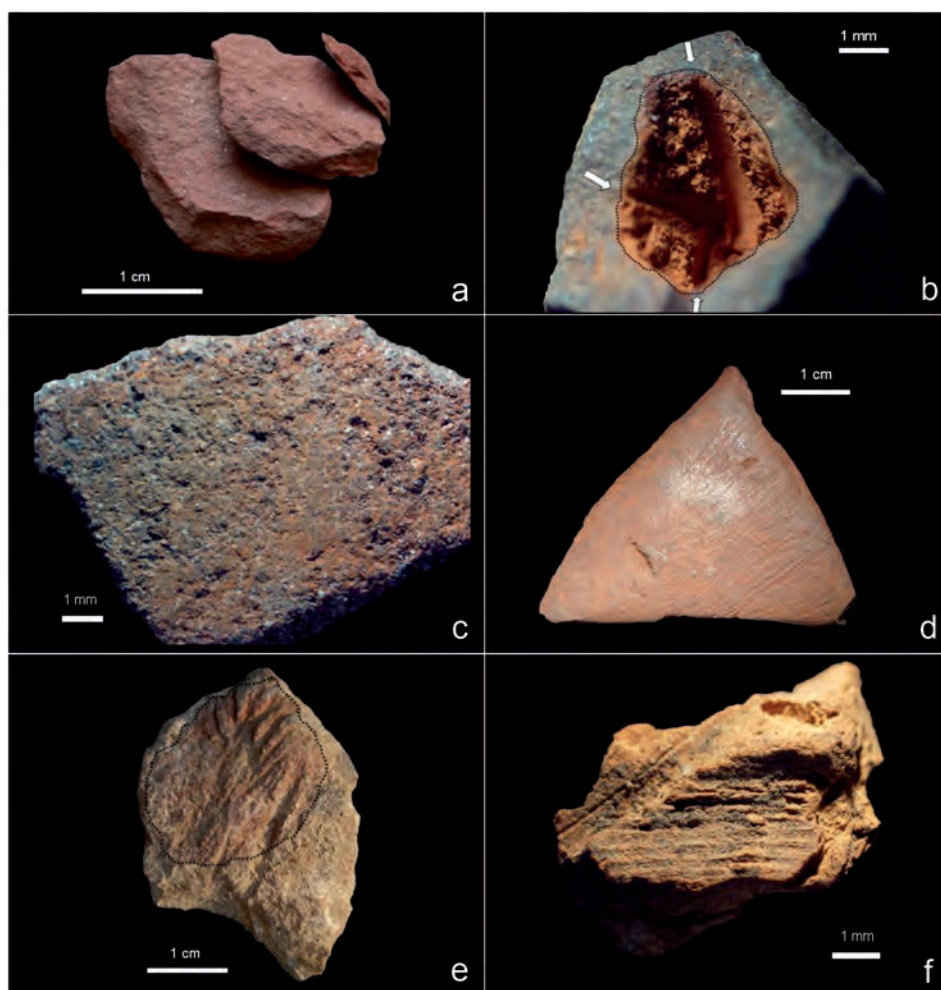


Fig. 3. Various types of ochre pieces from the Sibudu assemblage. (a) An unutilised, naturally broken piece of mica-rich shale (Sb1868 from late MSA layer YSp, square C4), which has broken along lines of fissility. (b) Utilised snuffbox shale piece (Sb1985 from post-HP layer BSp, square C2), which has had the pocket of soft, red, fine-grained powder (indicated by the dotted line) removed from the hard, grey matrix. Incisions from the removal are still visible and are indicated by arrows. The soft pocket is about 8 mm deep. (c) Rubbed and smoothed piece of sandstone (Sb1916 from post-HP layer RSp, square D2); the sandy matrix is still visible underneath although the smoothed area is more silty. (d) An intensively ground piece of iron oxide (Sb1567 from late MSA layer OMOD3, square C2). Note the metallic lustre characteristic of iron oxide-rich pieces. (e) Scored, weathered dolerite (Sb5242 from pre-SB layer BS5, square B4). The softer, red area (indicated by the dotted line) has been scored. (f) An unutilised piece of hardened yellow clay (Sb5177 from SB layer RGS, square C4) that has plant impressions oriented in two directions.

‘Iron oxide’ is a general grouping for dense materials such as chemically altered shale and hematite (Fig. 3d), and often has a dark streak (Watts 2010). The dolerite pieces usually have inclusions of softer red or yellow pigment that appear to be a

part of the outer surface of the rock or a result of weathering (Fig. 3e). Hardened (or burnt) clay pieces are included in the collection reported here, because they may be an important aspect of pigment use at the site. These clays could have been brought to the site accidentally, for example on sedge or grass roots (Fig. 3f) (Wadley et al. 2011), and they were subsequently hardened by heat from fires. It is possible that some lumps of clay were collected intentionally for use as low-grade ochre, as some of these pieces do show signs of use. The pieces that did not fit any of the categories, could not be definitively identified or were a combination of forms, were placed into a separate category, 'other'.

2. *Grain size.* Pieces were assigned to approximate grain size or textural groupings: clayey (diameter  $<4\ \mu\text{m}$ ), silty (diameter  $4\text{--}50\ \mu\text{m}$ ) and sandy (diameter  $\sim 50\ \mu\text{m}\text{--}2\ \text{mm}$ ) (Tucker 1982). This was done by microscopic examination where necessary (Fig. 3c for an example of a silty/sandy piece and Fig. 3f for a clayey piece). Often pieces have a combination of grain sizes, making a sliding scale necessary: clayey, clayey/silty, silty, silty/sandy and sandy.
3. *Hardness.* Hardness values were assigned to each piece using Moh's hardness scale and these values were later grouped to aid analysis: soft is Moh 2 and below, medium is Moh 3 and 4, and hard is Moh 5 and above. Hardness tests were done on the unutilised sides of pieces where possible (so as not to damage or modify any use-traces), but due to the lack of uniformity within individual pieces, pieces may have several different hardness values (Fig. 3b, 3 e). When there were visible variances in hardness (often snuffbox shale), the hardness test was performed on the edge of the utilised surface (after examination and photography), or on two areas of the piece. Readings were taken for both areas, but the hardness values of the softer areas were used in the analysis, given that the softer areas of these pieces were preferentially used in the assemblage.
4. *Colour.* The surface colour of ochre pieces may be different from the colour of the powder it produces. As an indication of the colour of the powder most likely to be created, streak tests were performed. This was done by rubbing the ochre piece against a white, unglazed porcelain tile. Colour classification can be problematic because pieces can contain layers or areas with different colours (see Watts 2010). The most prevalent colour was given as the primary colour. Pieces with two streak colours were placed in a separate category called 'two colours'. The streaks were then given Munsell Colour Chart (Munsell Colour Company 2000) codes. The Munsell Chart was used due to its worldwide accessibility and use (e.g. Hughes & Solomon 2000; Barham 2002; Hovers et al. 2003; Fritsch et al. 2005; Popelka-Filcoff et al. 2008; Mastrotheodoros et al. 2010). Munsell Colours were grouped into colour groups based on Coventry & Robinson (1981), who used a polythetic divisive classificatory program, POLYDIV. Streak colours were then divided further into light and dark colours where necessary and common colour names were used, that is, orange instead of reddish-yellow. The ochre pieces with no streaks or faint streaks were included in the ochre assemblage because hardness, grain size or inclusions may prevent a streak from forming.

The numerous hearths and burning events at Sibudu sometimes make it difficult to determine the exact relationship between hearths and ochre. Colour changes can occur in ochre that is as much as 10 cm below hearths (Wadley 2009, 2010b;

Bentsen 2012). Pieces directly associated with hearths were examined to determine whether there is a significant relationship between colour and hearths at Sibudu, indicating post-depositional heating.

5. *Occurrence of mica.* Some pieces have mica inclusions and the surfaces display small, glistening particles (Fig. 3a). When present, mica is usually consistently visible across the piece. Mica content is not sufficient to categorise pieces as another geological form, such as specularite or muscovite.
6. *Chemical composition.* To obtain qualitative mineralogical and chemical data on the ochre, a selection of pieces was analysed using Scanning Electron Microscope–Energy Dispersive X-ray Spectroscopy (SEM–EDS), Fourier Transform Infrared Spectroscopy (FTIR) and Raman Spectroscopy. These are non-destructive techniques aimed at determining what elements and minerals are present in the pieces. Twenty-six utilised pieces were selected for analysis from the six industrial divisions at Sibudu. SEM–EDS was performed using an FEI ESEM Quanta 400F. The FTIR spectrometry was performed with a Bruker ALPHA FTIR with external reflection. The spectra were acquired with 15–24 scans in a 400–4000  $\text{cm}^{-1}$  range. After spectra were acquired, they were processed using first and second derivatives with vector normalisation. Using multivariate and principal component analyses on the FTIR spectra, the 26 spectra could be divided into four statistically derived groups. Raman spectra were acquired using a Jobin-Yvon T64000 Raman spectrometer. This was operated in single spectrograph mode using the 647.1 nm line of a Kr-ion laser as the excitation source. No coating or preparation was needed for any of the samples and none of the tests modified or damaged the pieces.

## RESULTS

The Sibudu ochre assemblage comprises 9286 pieces. The crumbs (pieces  $\leq 8$  mm;  $n=3837$ ) were excluded, making the analysed assemblage 5449 pieces, with a total weight of 15.4 kg. There are 682 pieces with use-traces (12.5 % of the assemblage). The pieces with markings that could not be distinguished as use-wear or natural markings have been separated and labelled ‘possibly utilised’ ( $n=88$ ). Based on sediment volumes from the late MSA to the SB layers in the B5 and B6 squares, the post-HP and the HP assemblages have the highest frequencies of ochre. The pre-SB and HP layers have the highest percentages of utilised pieces (20.8 % and 16.9 %, respectively), followed by the SB (15.3 %) and then the post-HP (14.3 %). The late and final MSA have the smallest percentages of utilised pieces (10.6 % and 5.4 %, respectively).

### *Size*

There are many small pieces in the unutilised assemblage; 58.6 % of the unutilised pieces have maximum lengths  $\leq 1.5$  cm, but only 28 % of the utilised pieces are  $\leq 1.5$  cm. Pieces with maximum lengths ranging between 1.6 cm and 3 cm account for 54.8 % of the utilised assemblage and are especially common in the pre-SB, but account for only 36.7 % of the unutilised assemblage. Pieces with a maximum length  $> 3$  cm account for 17.2 % of the utilised assemblage, but only 4.7 % of the unutilised assemblage.

*Geological form* (Table 1)

The utilised and unutilised assemblages show similar trends in geological form. Forms in order of decreasing frequency are: shale, siltstone, snuffbox shale, sandstone, iron oxide, hardened clay, mudstone, weathered dolerite, and 'other'. Shale is present in higher frequencies in the utilised than in the unutilised assemblage and it predominates in all industries. There is more clay and sandstone in the unutilised than in the utilised assemblage. The pre-SB has a small range of geological forms that was utilised—only shale, snuffbox shale and dolerite—but this limited range may be due to the small sample size.

*Grain size* (Table 1)

Silty pieces are frequent throughout the assemblage, but more so in the utilised assemblage. Stratigraphically, the grain size frequencies of the utilised and unutilised assemblages mirror each other (Fig. 4). Silty pieces dominate both the utilised and unutilised assemblages in the upper layers, whereas clayey pieces are more prevalent in the lower layers, especially in the SB and HP. Sandy and silty/sandy pieces are uncommon throughout, with a slight increase in frequency in the final MSA, but are especially underrepresented in the utilised assemblage.

*Hardness* (Table 1)

Hardness values of the utilised and unutilised assemblages are similar, with high frequencies of pieces with medium hardness values. Both have as the highest frequency pieces with a hardness of Moh 3 (57 % of the utilised assemblage and 47.8 % of the unutilised assemblage). There is an increase in soft pieces ( $\leq$  Moh 2) in the HP unutilised assemblage and in the SB utilised. Pieces with hardness values above Moh 4 are rare throughout the sequence.

*Colour* (Table 1)

Colour frequencies of the utilised and unutilised assemblages are similar, but the utilised assemblage has a substantial predominance of bright-red pieces. Brown-red and then orange utilised pieces are also quite common. Bright-red utilised pieces have reduced frequency in the final MSA (Fig. 5) and the percentage of brown-red pieces increases in the pre-SB. The unutilised assemblage also has a high frequency of pieces with bright-red streaks, followed closely by orange and brown-red pieces. There is an increase in the frequency of yellow-brown and brown unutilised pieces in the SB. There are few yellow pieces in the Sibudu assemblage and they are almost entirely unutilised. Pieces with two colours and pieces with no streak are mostly snuffbox shale. There is a correlation between colour and grain size at Sibudu ( $\chi^2=71.99$ ;  $df=16$ ;  $p<0.0001$ ), where yellow pieces are usually clayey and pieces with red hues are more often silty.

*Mica inclusions* (Table 1)

More pieces in the utilised assemblage are mica-rich compared to the unutilised assemblage. The micaceous pieces in the utilised and unutilised assemblages are mostly shale (85.3 % and 69.7 %, respectively). The geological forms with the highest frequency of pieces with mica inclusions are shale, iron oxide and 'other'. More mica-rich pieces occur in the utilised late MSA and post-HP layers than in other industries. There are few pieces with mica inclusions in the SB and pre-SB.

TABLE 1

Analysis of the properties of ochre pieces from Sibudu. The percentages indicate the frequency of pieces with each property in the utilised and unutilised assemblages, in each industry. To highlight elevated values, an arbitrary cut-off ( $\geq 40\%$ ) was chosen. A dash represents 0 %.

| OCHRE PROPERTIES | Final MSA (n=727)  |          | Late MSA (n=1296) |          | Post-HP (n=2859) |          | HP (n=304) |          | SB (n=59)  |          | Pre-SB (n=116) |          | Total (n=5361) |          |
|------------------|--------------------|----------|-------------------|----------|------------------|----------|------------|----------|------------|----------|----------------|----------|----------------|----------|
|                  | Unutilised         | Utilised | Unutilised        | Utilised | Unutilised       | Utilised | Unutilised | Utilised | Unutilised | Utilised | Unutilised     | Utilised | Unutilised     | Utilised |
| Geological form  | n=687              | n=40     | n=1155            | n=141    | n=2445           | n=414    | n=251      | n=53     | n=50       | n=9      | n=91           | n=25     | n=4679         | n=682    |
|                  | Shale              | 45%      | 50%               | 42.8%    | 56%              | 46.5%    | 70.1%      | 37.1%    | 69.8%      | 32%      | 33.3%          | 56%      | 44.9%          | 65.7%    |
|                  | Snuffbox shale     | 17.5%    | 12.5%             | 17.1%    | 15.6%            | 11.5%    | 8.7%       | 14.3%    | 11%        | 8%       | 33.3%          | 8.8%     | 20%            | 13.8%    |
|                  | Mudstone           | 2%       | -                 | 3%       | 2.1%             | 2.6%     | 2.4%       | 4%       | 1.9%       | 4%       | 11.1%          | 2.2%     | -              | 2.7%     |
|                  | Siltstone          | 16.2%    | 12.5%             | 17.8%    | 12.1%            | 15%      | 12.6%      | 12.7%    | 11.3%      | 4%       | 11.1%          | 9.9%     | -              | 15.5%    |
|                  | Sandstone          | 7%       | 12.5%             | 6.8%     | 3.6%             | 11%      | 2.2%       | 15.5%    | -          | 26%      | -              | 8.8%     | -              | 9.8%     |
|                  | Iron oxide         | 3.5%     | 7.5%              | 6.5%     | 6.4%             | 7%       | 3.6%       | 6.4%     | 5.7%       | 4%       | 11.1%          | 2.2%     | -              | 6.2%     |
|                  | Weathered dolomite | 3.1%     | 2.5%              | 0.7%     | -                | 0.6%     | 0.5%       | 1.2%     | -          | 4%       | -              | -        | 1%             | 0.6%     |
|                  | Hardened clay      | -        | -                 | 1.1%     | 0.7%             | 5.4%     | -          | 8.8%     | -          | 18%      | -              | 12.1%    | -              | 4%       |
|                  | Other              | 5.8%     | 2.5%              | 4.2%     | 3.6%             | 0.5%     | -          | -        | -          | -        | -              | -        | -              | 0.9%     |
| Grain size       | Clayey             | 15%      | 22.5%             | 22.9%    | 29.8%            | 26.6%    | 30.4%      | 42.6%    | 52.8%      | 44%      | 55.5%          | 39.6%    | 36%            | 25.2%    |
|                  | Clayey/Silty       | 3.6%     | 7.5%              | 8.8%     | 6%               | 19.1%    | 17.1%      | 18.3%    | 15.1%      | 22%      | 11.1%          | 14.3%    | 32%            | 14.2%    |
|                  | Silty              | 60.7%    | 45%               | 53.2%    | 61.7%            | 36.5%    | 46.4%      | 19.5%    | 30.2%      | 8%       | 11.1%          | 29.7%    | 28%            | 42.9%    |
|                  | Silty/Sandy        | 3.6%     | 7.5%              | 3%       | -                | 8.8%     | 4.1%       | 15.1%    | 1.9%       | 20%      | 22.2%          | 11%      | -              | 7.1%     |
|                  | Sandy              | 17%      | 17.5%             | 12%      | 2.9%             | 9%       | 1.9%       | 4.4%     | -          | 6%       | -              | 5.5%     | 4%             | 10.6%    |
| Hardness         | Soft               | 12.4%    | 25%               | 24.2%    | 25.5%            | 28.4%    | 15.9%      | 40.6%    | 28.3%      | 36%      | 44.4%          | 35.2%    | 16%            | 25.9%    |
|                  | Medium             | 86.9%    | 72.5%             | 72.8%    | 73.1%            | 71.3%    | 83.6%      | 59.4%    | 71.7%      | 62%      | 55.5%          | 64.9%    | 84%            | 73.1%    |
|                  | Hard               | 0.7%     | 2.5%              | 3%       | 1.4%             | 0.3%     | 0.5%       | -        | -          | 2%       | -              | -        | -              | 1%       |
|                  | Dark red           | 3.1%     | 5%                | 5.9%     | 6.4%             | 5%       | 2.7%       | 2.8%     | 9.4%       | 2%       | -              | 3.3%     | 4%             | 4.7%     |
|                  | Bright red         | 23.4%    | 30%               | 38.1%    | 49.7%            | 39.3%    | 50%        | 29.1%    | 49.1%      | 30%      | 44.4%          | 23.1%    | 44%            | 35.7%    |
| Colour           | Weak red           | 7.4%     | 5%                | 0.7%     | -                | 0.8%     | -          | 0.8%     | -          | 4%       | -              | 2.2%     | -              | 1.8%     |
|                  | Purple-red         | 18.5%    | 12.5%             | 6.5%     | 9.2%             | 4.7%     | 5.3%       | 4%       | 9.4%       | 2%       | 11.1%          | 4.4%     | 12%            | 7.1%     |
|                  | Brown-red          | 11.2%    | 7.5%              | 16.9%    | 13.5%            | 19.5%    | 20.5%      | 16.3%    | 17%        | 16%      | 22.2%          | 22%      | 28%            | 17.5%    |
|                  | Orange             | 21.4%    | 15%               | 22.6%    | 14.9%            | 25.3%    | 18.8%      | 25.5%    | 9.4%       | 16%      | 11.1%          | 29.7%    | 8%             | 24.1%    |
|                  | Yellow-brown       | 0.9%     | -                 | 1.1%     | -                | 1.8%     | 0.2%       | 8%       | -          | 10%      | 11.1%          | 4.4%     | -              | 2%       |
|                  | Yellow             | -        | -                 | 0.3%     | -                | 0.3%     | -          | 2.8%     | -          | 10%      | -              | 2.2%     | 4%             | 0.5%     |
|                  | Brown              | 2.6%     | 5%                | 0.3%     | 0.7%             | 0.7%     | -          | 2.4%     | 1.9%       | 4%       | -              | 5.5%     | -              | 1.1%     |
|                  | Grey               | 0.7%     | -                 | -        | -                | 0.1%     | -          | 1.2%     | -          | 2%       | -              | 2.2%     | -              | 0.3%     |
|                  | Dark colours       | 1%       | 2.5%              | 0.2%     | -                | 0.3%     | -          | 2.8%     | 3.8%       | 2%       | -              | -        | -              | 0.5%     |
|                  | Two colours        | 9.3%     | 17.5%             | 6.6%     | 5.7%             | 1.8%     | 2.2%       | 3.6%     | -          | -        | -              | 1.1%     | -              | 4.2%     |
| Mica             | No streak          | 0.4%     | -                 | 1%       | -                | 0.5%     | 0.2%       | 0.8%     | -          | 2%       | -              | -        | -              | 0.6%     |
|                  | Present            | 12.4%    | 17.5%             | 20.6%    | 41.8%            | 19.7%    | 34.3%      | 10%      | 13.2%      | 6%       | 7.7%           | 8%       | 18%            | 31.8%    |

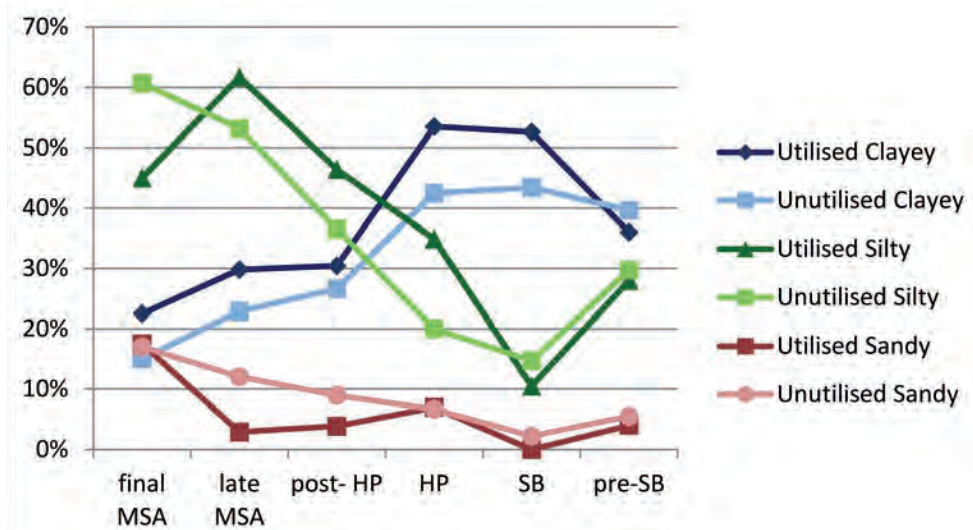


Fig. 4. Temporal variations of the percentages of pieces with clayey, silty or sandy grain sizes, in the utilised and unutilised ochre assemblages at Sibudu.

#### *Chemical analyses (EDS, FTIR and Raman)*

The pieces for SEM/EDS analysis were chosen initially by use-traces in order to obtain SEM imagery of the markings. Bright-red, brown-red and purple-red pieces are the most represented, and yellow pieces are missing from this analysis. Qualitative EDS identified iron (Fe), silicon (Si), oxygen (O), calcium (Ca) and aluminium (Al) in all 26 pieces (Table 2). Magnesium (Mg) is present in 67 % of the pieces and manganese (Mn) in just under half (44 %) the pieces tested (Table 2). Based on other studies, the range of elements is normal (see Fysh & Clark 1982; Erlandson et al. 1999; Hughes & Solomon 2000; Gil et al. 2007; Fiore et al. 2008; Iriarte et al. 2009; Wadley 2010b; Bonneau et al. 2012).

The same 26 pieces were tested using external FTIR (Table 2). Spectra were very noisy and not very clear, but some distinctions were visible between the groups. All the groups have evidence of some O-H-O bending, showing between  $\sim 3000\text{ cm}^{-1}$  and  $3600\text{ cm}^{-1}$ , which indicates water content. Group 1 has the most prominent O-H-O bending between  $3150\text{ cm}^{-1}$  and  $3640\text{ cm}^{-1}$ , and a peak at  $1650\text{ cm}^{-1}$ . There are uncertain hematite or lepidocrocite bands in Group 1 between  $710\text{ cm}^{-1}$  and  $790\text{ cm}^{-1}$ , and also at  $535\text{ cm}^{-1}$ . Group 2 has a peak at  $1220\text{ cm}^{-1}$  indicating Si-O-Si bending, uncertain hematite or lepidocrocite bands between  $250\text{ cm}^{-1}$  and  $790\text{ cm}^{-1}$ , and hematite bands at  $420\text{ cm}^{-1}$  and  $540\text{ cm}^{-1}$ . Group 3 has an unidentified peak at  $2360\text{ cm}^{-1}$ . Groups 3 and 4 have hematite/lepidocrocite peaks at  $720\text{ cm}^{-1}$  as well as hematite peaks at  $540\text{ cm}^{-1}$  and  $430\text{ cm}^{-1}$ . There are no associations between the grouped FTIR spectra and any of the physical attributes, including colour.

Reliable Raman spectra could only be obtained for 15 of the 26 pieces (Table 2); however, many of these pieces still have high levels of reflectance, resulting in some uncertain interpretations (e.g. 'possible hematite'). Raman spectra did not reveal goethite

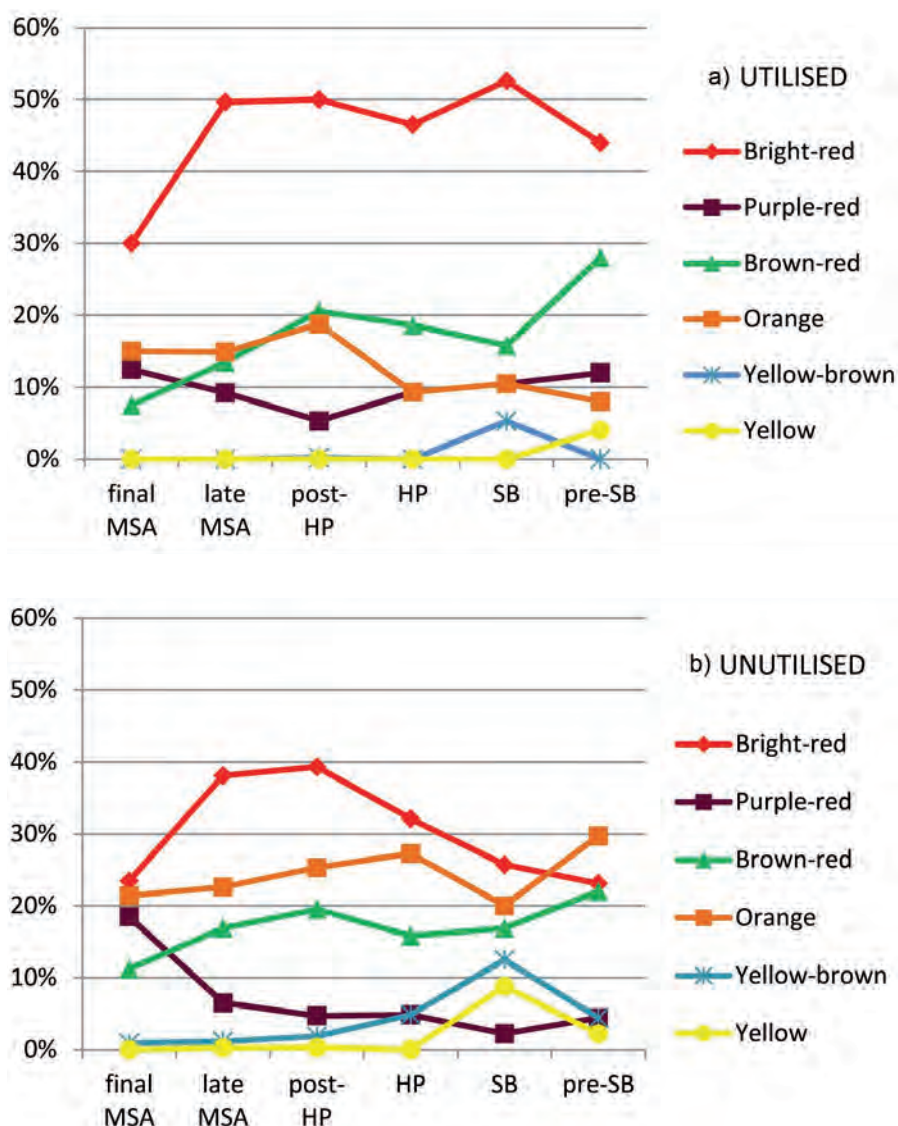


Fig. 5. Temporal changes in frequencies of pieces with bright-red, purple-red, brown-red, orange, yellow-brown and yellow streaks, from the utilised ochre (a) and unutilised ochre (b) assemblages at Sibudu.

( $\alpha$ -FeOOH) in any of the pieces. Spectra showed that all 15 pieces contain hematite ( $\alpha$ -Fe<sub>2</sub>O<sub>3</sub>) with characteristic peaks in the spectral range 200–650 cm<sup>-1</sup>. Four pieces also contain maghemite (Fe<sub>3</sub>O<sub>4</sub>). All of the pieces in Groups 3 and 4 of the FTIR spectra have strong hematite signatures in the Raman spectra. All the tested pieces from the HP layers contain hematite, but sample size is small and the observation may not be archaeologically significant. There is a wide range of minerals present in most of the pieces, but hematite is most prominent.



## DISCUSSION

Bright-red pieces are overwhelmingly abundant throughout the sequence and significantly so in the utilised assemblage; other colours are poorly represented in the utilised category. The unutilised assemblage at Sibudu has a wide variety of colours represented, with many pieces with bright-red, orange and brown-red streaks. Most of the yellow, yellow-brown, and brown pieces have a clayey grain size and these are more prevalent in the unutilised than in the utilised assemblage. The pieces with no streak are mostly sandstone and iron oxide—the large silicon (quartz) inclusions in the sandstone and the hardness of the iron oxide are likely reasons for the lack of streak. The high frequencies of bright-red pieces in the utilised assemblage show a preference for this colour, even though pieces with many other colour streaks were brought to the site. Ochre of shale origin is most common. Overall, silty, bright-red pieces of medium hardness predominate and are the most likely pieces to have been utilised. There is a slight preference towards using mica-rich pieces.

*Temporal changes in selection preferences*

There are some clear similarities and differences over time in ochre property choices. Shale and bright-red pieces are predominant throughout the sequence. The oldest layers (~77 ka), the pre-SB layers, contain few pieces of ochre, but have the highest frequency of utilised (versus unutilised) pieces. The pre-SB utilised assemblage has only three geological forms represented, but there is a wide variety of grain sizes and colours. Orange pieces are most common in the pre-SB unutilised assemblage—this is the only time that bright-red pieces do not dominate. In the SB layers (~71 ka), clayey pieces with a medium hardness are most common in the unutilised assemblage, while in the utilised assemblage there is an increase in soft pieces. There is a high frequency of utilised bright-red pieces. The HP layers (~65–62 ka) have the second highest percentage of utilised pieces. The HP stone tool industry was geared towards production of backed pieces functioning as part of hafted tools (e.g. Lombard 2008; Wadley et al. 2009), so the use of ochre for hafting purposes could be expected to increase. However, the types of ochre chosen are not markedly different from those in the other industries. Clayey pieces predominate and there is an increase in soft unutilised pieces, but pieces with a medium hardness are still most frequent in the utilised assemblage. There is a decrease of bright-red unutilised pieces in the HP.

The post-HP layers (~58 ka) constitute the largest stratigraphic unit and so it is no surprise that they have the largest quantity of ochre, but the proportion of utilised pieces is lower than in the HP. Most pieces are silty and there is an increase in orange utilised pieces as well as mica-rich pieces. Large ochre powder patches were found in the post-HP (Wadley 2010b) and so ochre powder production is a recognised activity. The late MSA and final MSA (~48 and 38 ka, respectively) have the smallest percentages of utilised pieces. The late MSA utilised assemblage has many silty pieces of medium hardness and there is a marked increase in mica-rich utilised pieces. The final MSA layers have a smaller percentage of bright-red pieces than the other industries, especially in the utilised assemblage. Silty pieces and pieces of medium hardness are still common, but there is an increase in sandy pieces in both assemblages.

*What properties of ochre determined its use?*

Visual and mechanical (and perhaps, indirectly, chemical) properties of ochre would have determined its selection and use in the MSA. Bright-red pieces dominate throughout the sequence and are especially frequent in the utilised assemblage. It appears that the bright-red ochres were preferentially used. However, grain size variability through time is conspicuous in the ochre assemblage. Silty pieces are most common in the post-58 ka assemblages (post-HP, late MSA and final MSA) but clayey ochre pieces are better represented in the earlier assemblages. A fine, clayey grain size provides the most desirable texture for paints, including body paints suitable for cosmetic, ritual or practical reasons (e.g. sun or insect protection). The grain size selections suggest that much of the ochre in the older occupation horizons (especially the SB and HP) could have been used for such purposes, or at least, that fine-grained powder was desired. Pieces may initially have been collected by colour, which is the most prominent feature, but on closer investigation it may have been found that the particle size was too large (sand-sized), hence the large quantity of unutilised bright-red and orange sandy pieces. The upper layers have a larger percentage of silty than clayey pieces, as well as an increase in sandy pieces, suggesting that ochre and ochre powder were used for different purposes through time. Tools were hafted in the SB, HP, post-HP and final MSA at Sibudu using ochre-loaded adhesives (Lombard 2004, 2005, 2006, 2007, 2011; Wadley et al. 2004), and this, coupled with evidence that coarse-grained ochre-loaded adhesives are effective aggregates (Wadley et al. 2009), might offer an explanation for the increase in frequency of silty and sandy pieces. Mixed grain sizes are necessary for aggregates in hafting adhesives, just as they are for concrete manufacture (Elvery 1958; Addis 1986; Lea 1970).

The ochre pieces tested contain a variety of chemical elements. All contain Fe, Si, Al, O and Ca. The origin of the Ca is uncertain. Future investigation into this and into the quantities of minerals present in the ochre would be beneficial. Most pieces contain hematite and some contain maghemite. An assortment of ochre types is represented at Sibudu, evidenced by the wide variety of properties of ochre in the unutilised assemblages. Later discrimination, possibly by less immediately visible properties such as hardness and grain size, reduced the numbers of ochre pieces that were used. The final choice for use reveals selection preferences. Mid-range FTIR spectra function as a rough screening tool for this ochre sample, but have not produced a complete mineralogical profile. Due to the elemental composition of ochre, a lower spectrum, rather than a middle range ( $400\text{--}4000\text{ cm}^{-1}$ ) FTIR, would be more beneficial (below  $400\text{ cm}^{-1}$ ) because some usual components, such as hematite, have additional peaks and bands below  $400\text{ cm}^{-1}$  (Ishii et al. 1972; Fysh & Fredericks 1983; Vempati et al. 1990; Wang et al. 1998; Mazzocchin et al. 2003; Blanchard et al. 2008). For this study, these components would have been detected in SEM/EDS.

Medium hardness values were preferred, but there are a variety of hardness values in the assemblage. Specific hardness values may have been desired for various (functional or symbolic) activities, but softer pieces are a likely choice if powder production is the ultimate goal. Hardness may be a useful, but not always accurate, indicator that ochre pieces contain large quantities of minerals such as hematite and magnetite (Barham 2000; Hovers et al. 2003; Wadley et al. 2009; Watts 2010). Although the MSA ochre-user would not have understood the chemical properties of the material, the hard pieces

may have been used for specific activities in which iron is valuable—hide tanning, for example (Rifkin 2011). Chemical variations might help to explain why pieces of medium hardness were preferred for use over soft pieces, even when these were available and would have demanded less effort and time for preparation.

Ease of use may have been aided by choosing pieces of a certain size. Pieces over 1.6 cm in maximum length are most common in the utilised assemblage. Pieces were probably used until a certain point and then discarded, perhaps because they became difficult to hold and control during the desired activity. Pieces <1.5 cm are more common in the unutilised assemblage. These pieces are difficult to hold and use. Small utilised pieces may be processing debris; alternatively, they might be waste from breaking a piece to get to a desired colour or softer product (e.g. Hovers et al. 2003). Much of the local KwaZulu-Natal ochre (Hodgskiss 2010) is two-tone or has layers of colours, and it is probable that unwanted colours, yellow for example, were removed from the red to get to desired colours such as bright-red. The high number of yellow unutilised pieces <1.5 cm supports this supposition.

#### *Colour and proximity to hearths*

Heating or burning of ochre pieces can result in an overrepresentation of ochre with a red hue. It is difficult to know which pieces, if any, were accidentally or deliberately affected by heat, due to the prevalence of combustion events at Sibudu. Temperatures as relatively low as ~250°C can change ochre colour and such temperatures can be reached unintentionally in sediments 10 cm below hearths, even with small fires (Sievers & Wadley 2008; Wadley 2009; Wadley 2010a; Bentsen 2012). If heating of pieces was unintentional or post-depositional, the unutilised and utilised pieces associated with hearths are likely to have similar colour frequencies. There is a significant correlation between colour and hearths ( $\chi^2=41.756$ ;  $df=8$ ;  $p<0.0001$ ) and the pieces directly associated with hearths have a slightly higher frequency of bright-red and brown-red streaks than pieces not associated with hearths (Fig. 6). However, there is still a considerably higher proportion of bright-red pieces in the utilised assemblage, whether associated with hearths or not.

The varied colour proportions between the two assemblages implies that post-depositional heating is not responsible for the prevalence of utilised red pieces at Sibudu. Additionally, the utilised pieces associated with hearths have more pieces with two colours than the unutilised pieces associated with hearths, showing that not all pieces associated with hearths have necessarily been heated enough to cause colour transformations. It is evident that bright-red pieces were preferentially used, but it is not yet determined whether red pieces were collected, nor whether ochre was heated in order to obtain the desired bright-red colour. The prevalence of utilised bright-red ochre at Sibudu and the larger quantities of orange and yellow unutilised pieces may imply that some ochre was intentionally heated. Further, the presence of maghemite and hematite together in some pieces indicates that the ochre was most likely heated, because maghemite forms when oxyhydroxides, such as goethite, are heated together with organic matter (Pomiès et al. 1999). Microscopy, together with further chemical analysis, would be necessary to confirm the possibility of heating. However, these results would still not necessarily be able to distinguish between accidental and intentional heating.

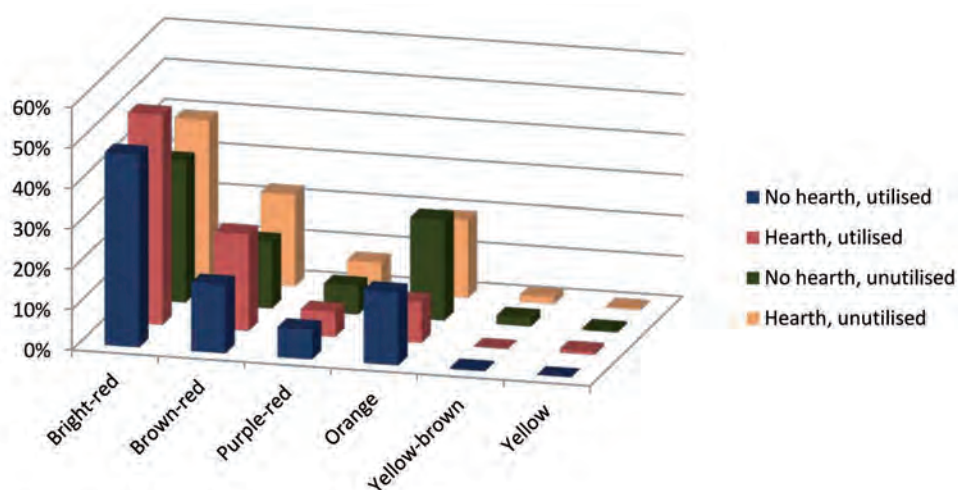


Fig. 6. Differences in colour frequencies between (utilised and unutilised) pieces associated with hearths and those that are not.

#### *Sibudu and other South African MSA ochre assemblages*

In many ways, the Sibudu ochre assemblage is comparable to the other MSA ochre assemblages. The percentage of pieces utilised is similar to that found at Blombos Cave and Pinnacle Point 13B (PP13B). The Blombos ochre assemblage comprises over 7500 pieces of ochreous material with a range of geological forms and colours; from levels dating ~77 ka (Henshilwood et al. 2001, 2002, 2009, 2011; Watts 2009). About 15 % of the assemblage bears signs of use. Over 500 pieces of ochre from PP13B were examined from MSA layers up to ~164 ka. The utilised pieces constitute 12.7 % of the assemblage (Watts 2010).

There is similarity in the geological forms used, and variations are likely to be influenced by regional variation in forms. The Blombos and PP13B assemblages contain predominantly fine-grained shale and siltstone, and coarse geological forms are rare throughout (Watts 2009). In contrast with Blombos and Sibudu, at PP13B shale and siltstone are the least likely rock types to be utilised (Watts 2010). Like Sibudu, PP13B has fine-grained pieces in older layers and silty and sandy pieces in the younger layers (e.g. fine sandstone and iron oxide). Shale and mudstone are most common in the Klasies River MSA ochre collection, which consists of 314 pieces dated to between 60–110 ka. Even at Qafzeh Cave, Israel, 71 pieces of ochre from ~90 ka were analysed, and most pieces are siltstones and fine-grained sandstones (Hovers et al. 2003).

The prevalence of red pieces and increased numbers of utilised red pieces is obvious at other MSA sites as well. The Blombos assemblage is dominated by bright-red or saturated red pieces, about 40 % of which are utilised (Henshilwood et al. 2009). Yellow pieces contribute a small percentage of the assemblage and only 10 % of them are utilised (Watts 2009). Like at Sibudu, utilised pieces at Blombos are represented by a variety of colours (including yellow and weak red), but soft, pastel-red pieces are preferentially used, and especially saturated reds (Henshilwood et al. 2001, 2002, 2009;

Watts 2009). The intensively ground pieces at PP13B display a limited colour range, mostly red shades, but the lightly ground pieces resemble the wide colour profile range of the unutilised assemblage (Marean et al. 2007; Watts 2010). Based on use-trace analysis and utilisation rates, saturated red pieces, dark-red pieces and iron oxides were preferentially used at PP13B. The Klasies ochre pieces are mostly red, although there is some soft, yellow sandstone (Singer & Wymer 1982; Watts 1998). Further afield at Qafzeh Cave, red ochre pieces also dominate the assemblage (Hovers et al. 2003). There is an extremely small number of yellow pieces at the site, even though yellow ochre is available locally. The red ochre at the site was intentionally collected and is unlikely to be heated yellow ochre because of the extremely rare occurrences of yellow ochre pieces at the site when it was available on the landscape (Hovers et al. 2003). However, further studies have shown that some of the Qafzeh ochre pieces were heated (to high, but controlled temperatures) and that some of the red ochre from the site is probably the result of the deliberate heat treatment, done in order to obtain specific shades (Godfrey-Smith & Ilani 2004).

#### CONCLUSION

The Sibudu MSA ochre assemblage consists of 4679 unutilised, 88 possibly utilised and 682 utilised pieces. The types of ochre used were based on what was available and so differences in geological forms represented in archaeological sites may be due to availability in the landscape. It will be useful to confirm the sources of ochre at Sibudu in the future because this will give an indication of the distances people travelled to obtain the types of ochre that they valued.

There is a wide variety of ochre types in the Sibudu assemblage and some ochre properties varied through time. Colour was selected over all other properties, and bright-red pieces were the most coveted. High frequencies of bright-red amongst the utilised pieces, and elevated frequencies of yellow or orange amongst pieces with no use-wear markings, suggest possible heat treatment of ochre, as is the case at Qafzeh. Future research on the chemical properties and chemical structure of the various types and colours of ochre at Sibudu would be highly beneficial and could help ascertain further selection preferences as well as establish whether intentional heating of ochre occurred at Sibudu.

Shale is preferentially used, with varying silty and/or clayey textures and medium hardness values. The texture of the ochre is the feature that changes the most through time because high frequencies of clayey pieces are found in the older industries, but silty pieces are more frequent in the younger ones. This may represent a change in the manner in which ochre and ochre powder were processed and used. The utilised assemblage has higher percentages of mica-rich pieces than the unutilised assemblage, and the late MSA and post-HP industries have higher frequencies of micaceous pieces than the other industries.

The properties of the utilised and unutilised ochre pieces demonstrate that specific types of ochre were desired in the MSA at Sibudu. Plausible applications have been suggested for the ochre and ochre powder, based on physical, mechanical and mineralogical findings. The next stage of research is to link these properties to use-traces on the ochre. This will enable more answers to questions about the ways in which ochre was processed and used at Sibudu.

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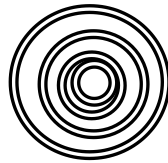
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## CHAPTER 6

### Use-traces



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Ochre use in the Middle Stone Age at Sibudu: grinding, rubbing, scoring and engraving.

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# OCHRE USE IN THE MIDDLE STONE AGE AT SIBUDU, SOUTH AFRICA: GRINDING, RUBBING, SCORING AND ENGRAVING

Tammy Hodgskiss

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## Abstract

Many Middle Stone Age (MSA) sites have evidence of the regular collection and use of ochre. Sibudu (KwaZulu-Natal, South Africa) has a large MSA ochre assemblage of over 9000 pieces from layers dating between ~77 ka and ~38 ka. There are 682 pieces with signs of use. All use-traces were examined and activity categories were defined based on published ochre experiments. The most frequent markings on ochre pieces are grinding striations that are smoothed by subsequent rubbing. Grinding and rubbing also occur independently on many pieces. Scored pieces are rare, but are more common in the pre-Still Bay (~77 ka) industry than elsewhere in the sequence. Some scored pieces may represent deliberate engravings. Markings acquired during powder-production are most numerous in the assemblage. Powder was mostly produced from bright-red pieces, but scoring was mainly performed on brown-red pieces. Pieces with mica inclusions are not common, but were favoured for powder production. Ochre powder was used as an aggregate in hafting adhesives, but other possible applications are as paint or as a substance to aid hide tanning.

## Résumé

Divers témoignages attestant d'une collecte et d'un usage réguliers de l'ocre ont été retrouvés dans de nombreux sites Middle Stone Age (MSA). Sibudu a livré un assemblage important de colorants, composé d'environ 9000 pièces d'ocre, provenant des niveaux datés entre ~77 et ~38 ka. Parmi ces pièces, 682 portent des traces d'utilisation. Toutes les traces ont été examinées et plusieurs catégories, correspondant à différentes activités, ont été définies, sur la base de résultats issus d'études expérimentales. Les traces les plus fréquemment observées sur les pièces en ocre sont les stries de d'abrasion, qui ont été émoussées par des frottements postérieurs. Abrasions et émoussés interviennent aussi de façon indépendante. Les éléments striés sont rares mais néanmoins plus fréquents dans le niveau pré-Still Bay (~77 ka) que dans les autres niveaux. Quelques pièces striées ont peut-être été gravées de manière intentionnelle. Les traces les plus nombreuses correspondent à celles créées lors de la production de poudre. Les blocs d'ocre rouge vif ont été majoritairement utilisés pour la production de poudre, tandis que pour les incisions, ce sont les blocs marron-rouge, qui ont été choisis. La poudre d'ocre a été utilisée comme agrégat dans les adhésifs nécessaires à l'emmanchement mais d'autres utilisations sont également possibles, par exemple comme colorant pour la peinture ou comme ingrédient pour améliorer le tannage des peaux.

**Keywords:** Middle Stone Age, ochre, use-wear, grinding, rubbing, scoring, engraving, powder

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## Introduction

The term *ochre* is a general term that encompasses a wide variety of ferruginous rocks that produce red, orange, yellow or purple streaks (JERCHER *et al.* 1998; ERLANDSON 1999; HUGHES & SOLOMON 2000; BARHAM 2002: 183–185; WATTS 2002, 2009; HOVERS *et al.* 2003). Unutilised and utilised pieces of ochre are regular finds at Middle Stone Age (MSA) and Upper Palaeolithic sites, but evidence showing how ochre pieces or ochre powder were used is rare (for example, LOMBARD 2006; WADLEY *et al.* 2009; HENSHILWOOD *et al.* 2011). This is probably because some of the media on which ochre was used have not preserved, such as animal hide or human skin. Consequently, investigating the use-traces left on ochre pieces can be essential in reconstructing how the ochre was used.

The high frequencies of ochre in the MSA layers at Sibudu, in KwaZulu-Natal, South Africa, suggest that ochre was a desired commodity and that it was regularly brought to the site for use. The types of ochre and selection preferences apparent in the assemblage have been discussed elsewhere (HODGSKISS 2012). Here, I examine all the markings that are the result of anthropogenic use of the ochre pieces from these MSA layers at Sibudu. Using comparative experimental material (HODGSKISS 2010), I infer the activities that caused the markings. The use-traces are then further correlated with the geological and physical properties of the pieces to determine whether different qualities of ochre may have been preferentially selected for specific activities and applications.

## Background

Many MSA occupations from South African sites have yielded large quantities of ochre, which exhibit a variety of markings from use (SINGER & WYMER 1982: 117; WATTS 1998, 2002, 2010; HENSHILWOOD *et al.* 2001: 413–433, 2009; BARHAM 2002; MAREAN *et al.* 2007; MACKAY & WELZ 2008). Use-wear from grinding is the most common use-trace type in many of these assemblages, and faceted ochre pieces discarded following this process are often evidenced (WADLEY 2005a; HODGSKISS 2010: 3354; RIFKIN 2012: 188). Pieces that have been scored or scraped with a sharp tool are less common archaeologically (MACKAY & WELZ 2008; HENSHILWOOD *et al.* 2009; D'ERRICO *et al.* 2012). Where it does occur, scoring can be intensive and it would have produced significant amounts of powder; other pieces display light scoring that would only have resulted in the production of small quantities of powder. The scored incisions sometimes appear to be deliberately placed and occasionally form a pattern on the surface

of the piece. The purpose of the light scoring or the engraved markings is unclear.

The presence of ochre pieces bearing engraved 'designs' (HENSHILWOOD *et al.* 2002, 2009; MACKAY & WELZ 2008; D'ERRICO *et al.* 2012) and the preferential use of bright-red and visually distinctive ochre at many sites has prompted symbolic interpretations of ochre use (BOSHIER & BEAUMONT 1972: 9–10; KNIGHT *et al.* 1995: 85–97; HENSHILWOOD *et al.* 2001: 431–433, 2009; WATTS 2002, 2009, 2010: 407–409; HOVERS *et al.* 2003: 510; MAREAN *et al.* 2007). The ability for abstract thought, as conveyed for example through the symbolic use of colour or design, is generally accepted as an indicator of complex behaviour (MCBREARTY & BROOKS 2000: 492; HENSHILWOOD & MAREAN 2003: 628–635; AMATI & SHALLICE 2007: 360; D'ERRICO & STRINGER 2011: 1065–1066). However, these finds alone may not be enough to draw behavioural or cognitive conclusions about those using ochre in the past.

Determining why ochre was collected and how ochre was utilised and applied may give more insight into the behaviours surrounding ochre use in the MSA. This paper presents the use-wear found on ochre pieces at Sibudu, links the use-wear markings to the activities which caused them and determines the varieties of ochre chosen for each activity. Experimental work is invaluable for gaining an understanding of how markings form on materials. Previous use-wear and experimental studies on bone, lithics and ochre helped establish the protocol for the investigation and categorisation of use-trace markings on ochre (*e.g.*, SHIPMAN & ROSE 1983, 1988; OLSEN & SHIPMAN 1988; D'ERRICO 1992; BLUMENSCHINE *et al.* 1996; BACKWELL & D'ERRICO 2001; D'ERRICO *et al.* 2001, 2012; VILLA & D'ERRICO 2001; CAIN 2004; WADLEY 2005a; D'ERRICO & HENSHILWOOD 2007; SORESSI & D'ERRICO 2007; BACKWELL *et al.* 2008; MACKAY & WELZ 2008; SORESSI *et al.* 2008; DOMÍNGUEZ-RODRIGO *et al.* 2009; HENSHILWOOD *et al.* 2009; HODGSKISS 2010; WATTS 2010; RIFKIN 2012).

## Sibudu and its ochre assemblage

Sibudu is a rock shelter in the Mariannhill Formation, part of the Natal Group sandstone formation (MAUD 1965). It is located north-west of Durban, 15 km inland from the coast, and overlooks the uThongathi River (**Fig. 1**). Twenty-one square meters have been excavated. There is a long MSA cultural sequence at the site with a pre-Still Bay (pre-SB) Industry at its base, above which lies a Still Bay (SB) Industry, a Howiesons Poort (HP), a post-Howiesons Poort (post-HP), and late MSA assemblages and, marking the upper end of the MSA layers, a final MSA assemblage (WADLEY



**Fig. 1.** Location of Sibudu, KwaZulu-Natal, South Africa (modified from WADLEY & JACOBS 2006).

2006: 315–316). Single grain optically stimulated luminescence ages for the MSA at Sibudu range between ~77 ka and 38 ka (WADLEY & JACOBS 2006; JACOBS *et al.* 2008a, b). There are no Later Stone Age occupations at the site.

The Sibudu ochre assemblage comprises 9286 pieces. Pieces  $\leq 8$  mm were excluded, making the analysed assemblage 5449 pieces with a total weight of 15.4 kg. There are 682 pieces with markings from use, or 12.5 % of the assemblage. The utilised assemblage has a total weight of 3.9 kg. The post-Howiesons Poort and the Howiesons Poort assemblages have the highest frequencies of ochre throughout the sequence (HODGSKISS 2012: 106). The Howiesons Poort and pre-Still Bay assemblages have the highest percentages of utilised pieces.

There are a reduced range of ochre varieties in the utilised assemblage compared to the unutilised assemblage, suggesting that specific types of ochre were selected for use, after being brought back to the site (**Tab. 1**; HODGSKISS 2012). Streak tests were performed to obtain accurate colour readings (HODGSKISS 2012). Colours were classified using Munsell Chart codes. Bright-red pieces predominate throughout the sequence and are especially frequent in the utilised assemblage. The unutilised assemblage, although also composed predominantly of bright-red pieces, has higher frequencies of yellow pieces than the utilised assemblage. Shale was the main ochreous geological form that was collected and utilised. Hardness readings were obtained using Mohs' hardness tests. Pieces with a medium hardness (Mohs 3 and 4) dominate the assemblage. Grain size frequencies are similar in the utilised and unutilised assemblages, but frequencies change through time. There are more silty and sandy pieces in the younger industries than in the

older industries, where there are predominantly clayey pieces. Mica-rich pieces are not common in the assemblage but there are more of these pieces in the utilised assemblage than in the unutilised assemblage.

## Methods

The MSA Sibudu ochre assemblage is curated at the Institute of Human Evolution (IHE), University of the Witwatersrand, in Johannesburg, South Africa. All pieces were examined under a combination of natural light and artificial white light. Pieces were firstly classified by geological form, grain size, hardness, colour, and the presence of mica inclusions (**Tab. 1**; also see HODGSKISS 2012). Pieces were then further examined for any use-traces on their surfaces. Pieces were classified into 'utilised', 'possibly-utilised' and 'unutilised' categories. The utilised pieces display markings that are definitely anthropogenically created. All utilised markings and use-traces were then recorded on a database, using the same criteria set up during experiments (HODGSKISS 2010: 3354–3357). All utilised pieces were examined under an Olympus SZ61 Zoom Stereo microscope, with a WHS-10 x FN22 eyepiece (0.67 to 45x magnification) and photographed using an Olympus D212 microscope camera system. Macroscopic images were photographed with a Panasonic Lumix Camera.

The experimental ochre pieces were used as a comparative sample and source of terminology for the identification of use-traces on the archaeological assemblage (**Tab. 2**; HODGSKISS 2010: 3346–3347). Grooves are described by their orientation, placement, profile shape, termination types and the presence or absence of internal microstriations. The occurrence of

| OCHRE PROPERTIES       |                       | Final MSA (n=727) |          | Late MSA (n=1296) |          | Post-HP (n=2859) |          | HP (n=304) |          | SB (n=59)  |            | Pre-SB (n=116) |          | Total (n=5361) |          |
|------------------------|-----------------------|-------------------|----------|-------------------|----------|------------------|----------|------------|----------|------------|------------|----------------|----------|----------------|----------|
|                        |                       | Unutilised        | Utilised | Unutilised        | Utilised | Unutilised       | Utilised | Unutilised | Utilised | Unutilised | Utilised   | Unutilised     | Utilised | Unutilised     | Utilised |
| <b>Geological form</b> | Shale                 | n=687             | n=40     | n=1155            | n=141    | n=2445           | n=414    | n=251      | n=53     | n=50       | n=9        | n=91           | n=25     | n=4679         | n=682    |
|                        | Snuffbox shale        | 45 %              | 50 %     | 42.77 %           | 56.03 %  | 46.5 %           | 70.05 %  | 37.1 %     | 69.8 %   | 32 %       | 3 (33.3 %) | 56 %           | 76 %     | 44.88 %        | 65.69 %  |
|                        | Mudstone              | 17.5 %            | 12.5 %   | 17.06 %           | 15.6 %   | 11.53 %          | 8.69 %   | 14.3 %     | 11.3 %   | 8 %        | 3 (33.3 %) | 8.8 %          | 20 %     | 13.83 %        | 11.29 %  |
|                        | Siltstone             | 2 %               | -        | 3.03 %            | 2.13 %   | 2.57 %           | 2.42 %   | 4 %        | 1.9 %    | 4 %        | 1 (11.1 %) | 2.2 %          | -        | 2.69 %         | 2.2 %    |
|                        | Sandstone             | 16.2 %            | 12.5 %   | 17.84 %           | 12.06 %  | 14.96 %          | 12.56 %  | 12.7 %     | 11.3 %   | 4 %        | 1 (11.1 %) | 9.9 %          | -        | 15.52 %        | 11.88 %  |
|                        | Iron oxide            | 7 %               | 12.5 %   | 6.84 %            | 3.55 %   | 11 %             | 2.17 %   | 15.5 %     | -        | 26 %       | -          | 8.8 %          | -        | 9.75 %         | 2.79 %   |
|                        | Weathered dolerite    | 3.5 %             | 7.5 %    | 6.49 %            | 6.38 %   | 7.03 %           | 3.62 %   | 6.4 %      | 5.7 %    | 4 %        | 1 (11.1 %) | 2.2 %          | -        | 6.22 %         | 4.55 %   |
|                        | Hardened clay         | 3.1 %             | 2.5 %    | 0.69 %            | -        | 0.6 %            | 0.48 %   | 1.2 %      | -        | 4 %        | -          | -              | 4 %      | 0.96 %         | 0.59 %   |
|                        | Other                 | -                 | -        | 1.13 %            | 0.71 %   | 5.36 %           | -        | 8.8 %      | -        | 18 %       | -          | 12.1 %         | -        | 4.04 %         | 0.15 %   |
|                        | Clay                  | 5.8 %             | 2.5 %    | 4.16 %            | 3.55 %   | 0.45 %           | -        | -          | -        | -          | -          | -              | -        | 2.12 %         | 0.88 %   |
| <b>Grain size</b>      | Clayey/Silty          | 15 %              | 22.5 %   | 22.86 %           | 29.79 %  | 26.63 %          | 30.43 %  | 42.6 %     | 52.8 %   | 44 %       | 5 (55.5 %) | 39.6 %         | 36 %     | 25.24 %        | 32.11 %  |
|                        | Silty                 | 3.6 %             | 7.5 %    | 8.9 %             | 5.7 %    | 19.1 %           | 17.1 %   | 18.3 %     | 15.1 %   | 22 %       | 1 (11.1 %) | 14.3 %         | 36 %     | 14.21 %        | 14.66 %  |
|                        | Silty/Sandy           | 60.7 %            | 45 %     | 53.3 %            | 61.7 %   | 36.52 %          | 46.38 %  | 19.5 %     | 30.2 %   | 8 %        | 1 (11.1 %) | 29.7 %         | 28 %     | 42.9 %         | 47.07 %  |
| <b>Hardness</b>        | Sandy                 | 3.6 %             | 7.5 %    | 3.03 %            | -        | 8.79 %           | 4.1 %    | 15.1 %     | 1.9 %    | 20 %       | 2 (22.2 %) | 11 %           | -        | 7.12 %         | 3.37 %   |
|                        | Soft ( $\leq$ Mohs 2) | 17 %              | 17.5 %   | 12.03 %           | 2.8 %    | 8.96 %           | 1.9 %    | 4.4 %      | -        | 6 %        | -          | 5.5 %          | -        | 10.56 %        | 2.79 %   |
|                        | Medium (Mohs 3+4)     | 12.37 %           | 25 %     | 24.24 %           | 25.54 %  | 28.4 %           | 15.9 %   | 40.6 %     | 28.3 %   | 36 %       | 4 (44.4 %) | 35.2 %         | 16 %     | 25.9 %         | 19.79 %  |
| <b>Colour</b>          | Hard ( $\geq$ Mohs 5) | 86.9 %            | 72.5 %   | 72.82 %           | 73.05 %  | 71.31 %          | 83.57 %  | 59.4 %     | 71.7 %   | 62 %       | 5 (55.5 %) | 64.9 %         | 84 %     | 73.09 %        | 79.47 %  |
|                        | Dark red              | 0.74 %            | 2.5 %    | 2.95 %            | 1.4 %    | 0.29 %           | 0.48 %   | -          | -        | 2 %        | -          | -              | -        | 1 %            | 0.73 %   |
|                        | Bright-red            | 3.06 %            | 5 %      | 5.89 %            | 6.38 %   | 4.95 %           | 2.66 %   | 2.8 %      | 9.4 %    | 2 %        | -          | 3.3 %          | 4 %      | 4.72 %         | 4.12 %   |
|                        | Weak red              | 23.44 %           | 30 %     | 38.1 %            | 49.65 %  | 39.3 %           | 50 %     | 29.1 %     | 49.1 %   | 30 %       | 4 (44.4 %) | 23.1 %         | 44 %     | 35.7 %         | 48.39 %  |
|                        | Purple-red            | 7.42 %            | 5 %      | 0.69 %            | -        | 0.8 %            | -        | 0.8 %      | -        | 4 %        | -          | 2.2 %          | -        | 1.82 %         | 0.29 %   |
|                        | Brown-red             | 18.49 %           | 12.5 %   | 6.49 %            | 9.22 %   | 4.7 %            | 5.31 %   | 4 %        | 9.4 %    | 2 %        | 1 (11.1 %) | 4.4 %          | 12 %     | 7.1 %          | 7.18 %   |
|                        | Orange                | 11.21 %           | 7.5 %    | 16.88 %           | 13.48 %  | 19.5 %           | 20.53 %  | 16.3 %     | 17 %     | 16 %       | 2 (22.2 %) | 22 %           | 28 %     | 17.46 %        | 18.33 %  |
|                        | Yellow-brown          | 21.4 %            | 15 %     | 22.6 %            | 14.89 %  | 25.3 %           | 18.8 %   | 25.5 %     | 9.4 %    | 16 %       | 1 (11.1 %) | 29.7 %         | 8 %      | 24.06 %        | 16.57 %  |
|                        | Yellow                | 0.87 %            | -        | 1.13 %            | -        | 1.84 %           | 0.2 %    | 8 %        | -        | 10 %       | 1 (11.1 %) | 4.4 %          | -        | 1.99 %         | 0.29 %   |
|                        | Brown                 | -                 | -        | 0.26 %            | -        | 0.3 %            | -        | 2.8 %      | -        | 10 %       | -          | 2.2 %          | 4 %      | 0.51 %         | 0.15 %   |
|                        | Grey                  | 2.6 %             | 5 %      | 0.26 %            | 0.71 %   | 0.7 %            | -        | 2.4 %      | 1.9 %    | 4 %        | -          | 5.5 %          | -        | 1.07 %         | 0.59 %   |
|                        | Dark Colours          | 0.73 %            | -        | -                 | -        | 0.1 %            | -        | 1.2 %      | -        | 2 %        | -          | 2.2 %          | -        | 0.28 %         | 0 %      |
| <b>Mica</b>            | Two Colours           | 1.02 %            | 2.5 %    | 0.17 %            | -        | 0.3 %            | -        | 2.8 %      | 3.8 %    | 2 %        | -          | -              | -        | 0.53 %         | 0.44 %   |
|                        | No Streak             | 9.3 %             | 17.5 %   | 6.58 %            | 5.67 %   | 1.8 %            | 2.2 %    | 3.6 %      | -        | -          | -          | 1.1 %          | -        | 4.17 %         | 3.52 %   |
|                        | Present               | 0.44 %            | -        | 1 %               | -        | 0.5 %            | 0.2 %    | 0.8 %      | -        | 2 %        | -          | -              | -        | 0.6 %          | 0.15 %   |
|                        |                       | 12.4 %            | 17.5 %   | 20.6 %            | 41.84 %  | 19.71 %          | 34.3 %   | 10 %       | 13.2 %   | 6 %        | -          | 7.7 %          | 8 %      | 17.97 %        | 31.82 %  |

**Tab. 1.** The properties of the ochre pieces from Sibudu. Percentages indicate the frequency of pieces with each property in the utilised and unutilised assemblages, in each industry. The utilised Still Bay sample is small, rendering percentages questionable — numbers of pieces are given and percentage frequencies are shown in brackets. Arbitrary cut-offs were chosen to indicate elevated values: dark shading represents values  $\geq 30$  % and light shading represents values  $\geq 20$  %. A dash represents 0 %. HP = Howiesons Poort, SB = Still Bay.

| Term            | Definition                                                                                                                                                                                                             |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Groove          | A narrow, linear furrow. No depth, orientation or method of creation is implied by the term                                                                                                                            |
| Striations      | Multiple, parallel grooves. These are most often created during grinding                                                                                                                                               |
| Incision        | Narrow, linear furrow seemingly created by scoring or engraving                                                                                                                                                        |
| Scratch         | Accidental mark that is shallow and erratically placed and oriented                                                                                                                                                    |
| Microstriations | Microscopically visible parallel striations. Internal microstriations occur within grooves, external microstriations occur on the surface of a piece and are independent of grooves                                    |
| Polish          | Shiny areas that appear on the ochre surface from use                                                                                                                                                                  |
| Metallic lustre | Silver, metallic-looking areas that appear on an ochre surface from use. These are often, but not exclusively, found at the base of grooves                                                                            |
| Smoothing       | When a surface is unnaturally regular and homogeneous, or previous natural features or use-traces are partially or fully reduced. Smoothing does not imply a shiny or polished surface and/or external microstriations |
| Faceted surface | Adjacent worked surfaces that form at angles to each other during an activity                                                                                                                                          |
| Residues        | Any non-ochre substances found on the ochre piece resulting from its use                                                                                                                                               |
| Surface shape   | The topography of the used surface                                                                                                                                                                                     |

**Tab. 2.** Definition of terms used to describe use-wear markings, based on HODGSKISS (2010).

polish, metallic lustre, smoothing, chipping and external microstriations is noted, as is the surface shape and edge shape of each piece. Basic refitting was also performed. It is impossible to know how large the piece was prior to use, so intensity of use is quantified by the number of sides evidencing utilisation. The number of surfaces with use-traces was recorded: one, two, and three or more utilised sides. Post-depositional markings and residues are also recorded.

Once the use-wear on each piece was identified, pieces were then placed into activity groups: ‘grinding’, ‘scoring’ and ‘rubbing’, and various combinations of these activities. Not all interpretations of activities can be made with the same level of confidence. The definite use-type and activity categories are the focus of this paper. Activities and their indicative use-wear markings — established during actualistic studies (HODGSKISS 2010; RIFKIN 2012) — and the criteria used in this study, are described below.

### *Grinding*

Grinding use-wear appears in the form of multiple, parallel striations with a variety of profile shapes. The striations usually reach the edges of the piece and have unfrayed ends. Grinding striations have internal microstriations within them unless they have been rubbed against a soft material after grinding, if the ochre was ground with water or a wet substance, or if the piece was trampled or exposed to water during post-depositional processes. Experimental ochre grinding demonstrated that internal microstriations form when grinding on fine or coarse-grained grindstones such as dolerite and sandstone, but the profile shape of the grinding striations themselves may vary.

Grinding causes significant changes to the shape of the piece and often results in facet formation and edge rounding. Grinding sometimes results in the formation of polish and metallic lustre within and around striations. The irregular appearance of polish and metallic lustre may be associated with the mineralogy of the piece, perhaps indicative of elevated iron oxide (hematite) or aluminium levels. Further mineralogical research would be needed to establish this. A change in the angle of striations does not necessarily indicate multiple episodes of use, but rather changes in grinding direction or how the piece was held. Grinding ochre is an efficient method of powder-production (ŠAJNEROVÁ-DUŠKOVÁ *et al.* 2009).

### *Rubbing*

The most common use-wear markings from rubbing ochre on soft materials are smoothing, edge rounding, external microstriations and polish. Rubbing rarely causes proper striations to form and seldom results in surface shape change or facet formation. On previously ground pieces, rubbing causes smoothing and sometimes partial or complete removal of striations and internal microstriations, as well as the widening and shallowing of grooves.

Smoothing is problematic to identify because it can be caused either by rubbing or by post-depositional processes (SORESSI *et al.* 2008). As a result, when smoothing occurs on pieces without additional markings such as polish, metallic lustre and external microstriations — which would indicate it was anthropogenically created — it is categorised as post-depositional. Polish, metallic lustre and external microstriations are likely to be removed after deposition rather than being caused

by post-depositional processes (HODGSKISS 2010) and so are good indicators of the method of creation. Post-depositional processes such as trampling and water leaching were experimentally shown to cause edge rounding, scuffmarks and shallow, erratic scratches. Evidence of these markings on the pieces also helps to establish whether the rubbing is post-depositional. Intentional rubbing is also distinguished by the degree of smoothing, and the placement of smoothing primarily on the grinding striations and on the edge of the surfaces adjacent to the ground surface(s).

### Scoring

Scored incisions usually contain internal microstriations and often do not reach all the edges of the used surface. Frayed terminations indicate that the incision was created by multiple strokes. Incisions made with stone flakes are clearer and deeper than those made with bone or wood tools, but profile shapes are variable with any tool type. The depth and orientation of the scored incisions varies, but if scoring was performed with the intention of producing powder, then deep, frequent, randomly oriented and intersecting incisions more often result (see also D'ERRICO *et al.* 2012: 949). The light scoring of pieces, causing few or shallow incisions, results in minimal powder production.

Once pieces were classified into activity groups, the frequencies and properties of the pieces in each activity class were established statistically.

## Results

### Use-traces (Tab. 3)

There are 682 utilised pieces. Grooves are found on 401 of the utilised pieces, of which only 40.5 % contain internal microstriations. Parallel striations are the most frequent groove orientation, and most grooves reach both edges of the piece and are not frayed. The grooves have a wide variety of profile shapes. Smoothing is common and is found on all of the pieces with no grooves (n=281). Smoothing also occurs on 295 (n=73.6 %) of the pieces with grooves (*i.e.*, the grooves are smoothed). External microstriations occur on less than half the pieces (44.9 %, n=306), of which nearly all (97.1 %, n=297) occur with smoothing, and 29.4 % (n=90) occur with polish. All three of these use-traces occur together on 17 pieces (2.5 % of the utilised assemblage).

Metallic lustre occurs on a fifth (21.8 %, n=149) of the pieces and chipping is rare. Over half the pieces (56.7 %, n=387) are lightly modified with utilisation only on one surface. Only 17 pieces have any non-

ochreous residues on them. There is evidence of some post-depositional markings on 12.6 % (n=86) of the pieces. Some of the damage could have been obtained during excavation or sieving, but it probably indicates that some disturbance and/or trampling occurred at the site. Post-depositional markings are represented in all industries.

### Activities

Ochre was used most frequently for grinding and rubbing activities at Sibudu. These two activities occur independently as well as together on many pieces. Scoring is rare.

### Grinding (Fig. 2)

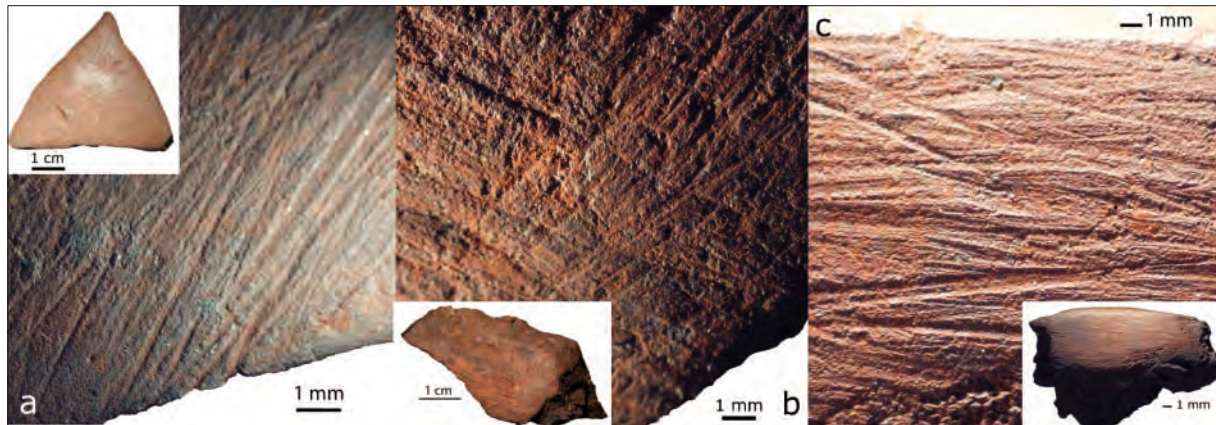
There are 158 pieces with grinding use-wear markings alone. All of these pieces have parallel striations, which occur occasionally in groups at oblique angles to each other (Fig. 2b) and/or with erratic striations (Fig. 2c). The striations on most pieces have a variety of profile shapes (V-, U- and/or wide-U-shaped (\\_/\_)). Nearly all (98.1 %, n=155) of the striations have unfrayed ends, and most striations reach both edges of the piece (83.5 %, n=132). Internal microstriations occur within the striations of 57.6 % (n=91) of the ground pieces (Fig. 2c) and 42.4 % (n=67) of ground pieces have smoothing. The smoothing is minimal and cannot be attributed to rubbing. Additionally, it rarely occurs with external microstriations (11.9 %, n=8) and is not necessarily and/or exclusively situated on the grinding striations.

Most ground pieces have modified surface shapes: 70.9 % (n=112) have flat surfaces and 25.9 % (n=41) have convex surfaces. Edge modification, which results in rounded and faceted edges, occurs on 41.8 % (n=66) and 25.9 % (n=41) of the ground pieces respectively. About half of the pieces (52.5 %, n=83) that only have grinding use-wear are lightly modified (only used on one side). Only 19.6 % (n=31) of the ground pieces are intensively modified (with three or more sides utilised). Pieces used for grinding activities occur throughout the sequence (Tab. 4; Fig. 3).

There are 32 intensively ground and faceted pieces that have three or more facets converging to a point (so-called *crayons*). None of these pointed pieces has micro-facets around the tip (Figs. 4 and 5). A further 70 pieces have three or more ground facets that do not converge to a point. The use-wear indicates that these intensively ground pieces were rotated during grinding, which resulted in facet formation (WADLEY 2005a). Many of these pieces are smoothed and have external microstriations, suggesting that they may have been rubbed on a soft surface after grinding.

| USE-TRACES                                                                  |                                        |                             | Final MSA | Late MSA | Post-HP | HP     | SB         | Pre-SB | Total  |
|-----------------------------------------------------------------------------|----------------------------------------|-----------------------------|-----------|----------|---------|--------|------------|--------|--------|
|                                                                             |                                        |                             | n=40      | n=141    | n=414   | n=53   | n=9        | n=25   | n=682  |
| G<br>R<br>O<br>O<br>V<br>E<br>S                                             |                                        | Pieces with grooves         | 21        | 99       | 230     | 31     | 4          | 16     | 401    |
|                                                                             |                                        | % with grooves              | 52.5 %    | 70.2 %   | 55.6 %  | 58.5 % | 44.4 %     | 64 %   | 58.8 % |
|                                                                             | Orientation<br>and<br>grouping         | Parallel                    | 66.7 %    | 72.7 %   | 76.5 %  | 54.8 % | 2 (50 %)   | 56.3 % | 72.3 % |
|                                                                             |                                        | Erratic                     | -         | 2 %      | 1.7 %   | 3.2 %  | -          | 18.8 % | 2.5 %  |
|                                                                             |                                        | Parallel and erratic        | 19 %      | 9.1 %    | 12.2 %  | 22.6 % | 1 (25 %)   | 12.5 % | 12.7 % |
|                                                                             |                                        | Parallel groups             | 14.3 %    | 7.1 %    | 6.1 %   | 12.9 % | -          | -      | 7 %    |
|                                                                             |                                        | Parallel groups and erratic | -         | 6.1 %    | 3 %     | 3.2 %  | -          | -      | 3.5 %  |
|                                                                             |                                        | Possible design             | -         | 3 %      | 0.4 %   | 3.2 %  | 1 (25 %)   | 12.5 % | 2 %    |
|                                                                             | Placement<br>across surface            | To all edges                | 66.7 %    | 72.7 %   | 77.8 %  | 67.7 % | 3 (75 %)   | 43.8 % | 73.8 % |
|                                                                             |                                        | To some edges               | 23.8 %    | 23.2 %   | 20.4 %  | 29 %   | 1 (25 %)   | 50 %   | 23.2 % |
|                                                                             |                                        | To no edges                 | 9.5 %     | 2 %      | -       | -      | -          | 6.3 %  | 1.2 %  |
|                                                                             |                                        | Indistinguishable           | -         | 2 %      | 1.7 %   | 3.2 %  | -          | -      | 1.7 %  |
|                                                                             | Profile shape                          | U+V+ \ /                    | 19 %      | 26.3 %   | 17.4 %  | 29 %   | 1 (25 %)   | 12.5 % | 20.4 % |
|                                                                             |                                        | U+V                         | 14.3 %    | 13.1 %   | 10 %    | 6.5 %  | 2 (50 %)   | 25 %   | 11.5 % |
|                                                                             |                                        | U+ \ /                      | 42.9 %    | 33.3 %   | 42.6 %  | 22.6 % | -          | 37.5 % | 38.2 % |
|                                                                             |                                        | V+ \ /                      | -         | 4 %      | 2.2 %   | 6.5 %  | -          | -      | 2.7 %  |
|                                                                             |                                        | V                           | 9.5 %     | -        | 0.9 %   | 3.2 %  | -          | -      | 1.2 %  |
|                                                                             |                                        | U                           | 14.3 %    | 11.1 %   | 5.2 %   | 3.2 %  | -          | 6.3 %  | 7 %    |
|                                                                             |                                        | \ /                         | -         | 12.1 %   | 21.7 %  | 29 %   | 1 (25 %)   | 18.8 % | 19 %   |
|                                                                             | Terminations                           | No frayed                   | 90.5 %    | 93.9 %   | 94.8 %  | 90.3 % | 4 (100 %)  | 87.5 % | 93.8 % |
|                                                                             |                                        | Some frayed                 | 4.8 %     | 3 %      | 3 %     | 9.7 %  | -          | 12.5 % | 4 %    |
|                                                                             |                                        | All frayed                  | -         | 1 %      | -       | -      | -          | -      | 0.2 %  |
|                                                                             |                                        | Indistinguishable           | 4.8 %     | 2 %      | 2.2 %   | -      | -          | -      | 2 %    |
|                                                                             | Microstriations                        | Internal                    | 47.6 %    | 44.4 %   | 37.8 %  | 32.3 % | 1 (25 %)   | 50 %   | 40.6 % |
|                                                                             | Smoothing                              | Of grooves                  | 71.4 %    | 77.8 %   | 75.2 %  | 71 %   | 3 (75 %)   | 50 %   | 73.6 % |
| O<br>T<br>H<br>E<br>R<br><br>U<br>S<br>E<br>-<br>T<br>R<br>A<br>C<br>E<br>S | Chipping                               |                             | -         | 1.4 %    | 0.7 %   | -      | -          | -      | 0.4 %  |
|                                                                             | Polish                                 |                             | 50 %      | 36.2 %   | 24.6 %  | 20.8 % | 2 (22.2 %) | 8 %    | 27.6 % |
|                                                                             | Metallic lustre                        |                             | 25 %      | 35.5 %   | 17.1 %  | 28.3 % | 2 (22.2 %) | 4 %    | 21.8 % |
|                                                                             | Smoothing                              | Of unused surface           | 47.5 %    | 29.8 %   | 44.4 %  | 41.5 % | 5 (55.6 %) | 36 %   | 41.2 % |
|                                                                             | Microstriations                        | External                    | 45 %      | 36.9 %   | 48.6 %  | 43.4 % | 4 (44.4 %) | 28 %   | 44.9 % |
|                                                                             | Edges                                  | Rounded                     | 63 %      | 46.1 %   | 53.1 %  | 49.1 % | 5 (55.6 %) | 48 %   | 51.8 % |
|                                                                             |                                        | Faceted                     | 7.5 %     | 26.2 %   | 18.8 %  | 35.8 % | 2 (22.2 %) | 20 %   | 21.1 % |
|                                                                             |                                        | Unchanged                   | 30 %      | 27.7 %   | 28 %    | 15.1 % | 2 (22.2 %) | 32 %   | 27.1 % |
|                                                                             | Surface of<br>piece                    | Flat                        | 47.50 %   | 53.9 %   | 58.9 %  | 71.7 % | 5 (55.6 %) | 56 %   | 58.1 % |
|                                                                             |                                        | Concave                     | 7.50 %    | 1.4 %    | 1.9 %   | 1.9 %  | 1 (11.1 %) | 8 %    | 2.5 %  |
|                                                                             |                                        | Convex                      | 12.5 %    | 23.4 %   | 30.2 %  | 17 %   | 1 (11.1 %) | 16 %   | 26 %   |
|                                                                             |                                        | Unchanged                   | 18 %      | 12.1 %   | 3.4 %   | 3.8 %  | 1 (11.1 %) | 16 %   | 6.6 %  |
|                                                                             |                                        | Undulating                  | 15 %      | 9.2 %    | 5.6 %   | 5.7 %  | 1 (11.1 %) | 4 %    | 6.9 %  |
|                                                                             | Residues                               | Clay                        | -         | -        | 1 %     | -      | -          | -      | 0.6 %  |
|                                                                             |                                        | Opaque layer                | 2.5 %     | 3.5 %    | 1 %     | -      | -          | -      | 1.5 %  |
|                                                                             |                                        | Fibres                      | 2.5 %     | 1.4 %    | -       | -      | -          | -      | 0.4 %  |
|                                                                             | Sides with use                         | 1 side                      | 65 %      | 57.4 %   | 57.5 %  | 43.4 % | 5 (55.6 %) | 56 %   | 56.7 % |
|                                                                             |                                        | 2 sides                     | 15 %      | 24.1 %   | 24.4 %  | 34 %   | 2 (22.2 %) | 24 %   | 24.5 % |
|                                                                             |                                        | 3 or more sides             | 20 %      | 18.4 %   | 18.1 %  | 22.6 % | 2 (22.2 %) | 20 %   | 18.8 % |
|                                                                             | Faceted, crayon-shaped                 |                             | 2.5 %     | 4.3 %    | 5.3 %   | 3.8 %  | -          | 4 %    | 4.7 %  |
| POST-<br>DEPOSITIONAL<br>MARKINGS                                           | Pieces with post-depositional markings |                             | 37.5 %    | 17 %     | 8.5 %   | 11.3 % | 2 (22.2 %) | 16 %   | 12.6 % |
|                                                                             | Scratches                              |                             | 30 %      | 12.1 %   | 4.8 %   | 9.4 %  | 1 (11.1 %) | -      | 8.1 %  |
|                                                                             | Scuffmarks                             |                             | 15 %      | 6.4 %    | 3.6 %   | 5.7 %  | 2 (22.2 %) | 8 %    | 5.4 %  |
|                                                                             | Definite post-depositional smoothing   |                             | 12.5 %    |          |         | 3.8 %  |            |        | 2.9 %  |
|                                                                             | Gypsum or crystals                     |                             | -         | 8.5 %    | 10.9 %  | -      | -          | 4 %    | 8.5 %  |
|                                                                             | Ash                                    |                             | -         | -        | 1 %     | -      | -          | -      | 0.6 %  |
|                                                                             | Gypsum and ash                         |                             | -         | 0.7 %    | 1.2 %   | 1.9 %  | -          | -      | 1 %    |

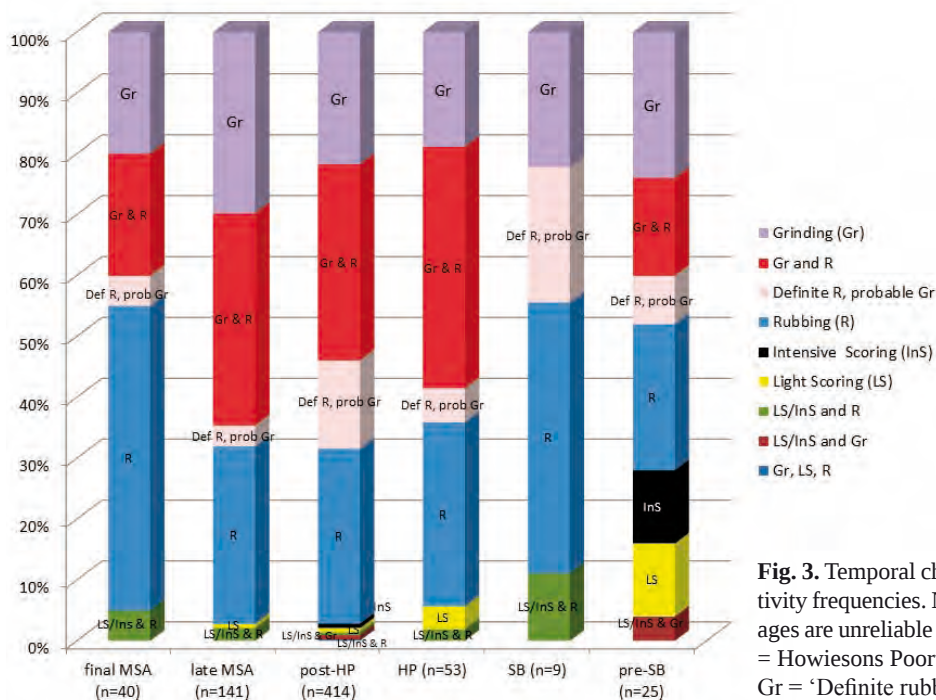
**Tab. 3.** Temporal analysis of the use-traces on ochre pieces from Sibudu. Values indicate the percentage of pieces per industry with each use type. Due to the small size of the Still Bay utilised assemblage, numbers are given (and percentage frequencies are shown in brackets). Note: no method of production or activity is implied by any category, except for pieces with possible designs, which imply that the scored incisions appear to be deliberately placed. The percentages in shaded sections apply only to the pieces that have grooves. Some pieces have more than one post-depositional marking on them; therefore combined post-depositional markings will be greater than the percentage of pieces with post-depositional markings. A dash represents 0 %. HP = Howiesons Poort; SB = Still Bay.



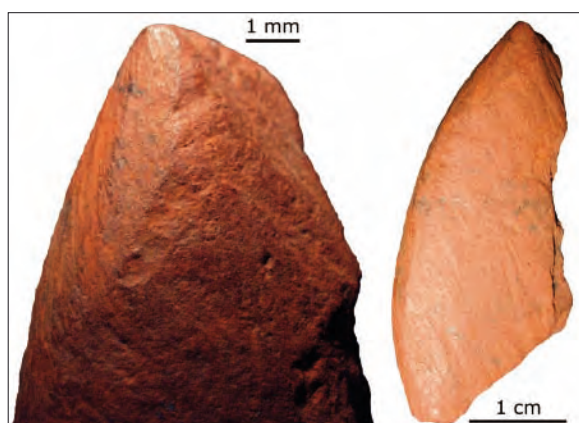
**Fig. 2.** Selected ochre pieces from Sibudu with grinding use-wear. (a) Intensively ground ochre piece (Sb1567 from late MSA layer OMOD3, square C2) exhibiting parallel striations. The surface is flat, striations reach both edges of the piece and have variable depths and profile shapes. (b) Ground ochre piece (Sb5278 from final Howiesons Poort layer RBr, square C4) where the direction of grinding was changed resulting in striations that form a design that looks like cross-hatching. (c) Piece (Sb1566 from late MSA layer OMOD3, square C2) that has been ground to form a flat surface with a small, adjacent surface. This piece displays parallel and erratic grooves with internal microstriations.

|                         | Grinding (Gr) | Gr and R | Def R, prob Gr | Rubbing (R) | Intensive Scoring (InS) | Light Scoring (LS) | LS/InS and R | LS/InS and Gr | Gr, LS, R |
|-------------------------|---------------|----------|----------------|-------------|-------------------------|--------------------|--------------|---------------|-----------|
| <b>Final MSA (n=40)</b> | 20 %          | 20 %     | 5 %            | 50 %        | -                       | -                  | 5 %          | -             | -         |
| <b>Late MSA (n=141)</b> | 29.8 %        | 34.8 %   | 3.5 %          | 29.1 %      | -                       | 0.7 %              | 2.1 %        | -             | -         |
| <b>Post-HP (n=414)</b>  | 21.7 %        | 32.1 %   | 14.5 %         | 28.7 %      | 0.7 %                   | 0.7 %              | 0.5 %        | 0.7 %         | 0.2 %     |
| <b>HP (n=53)</b>        | 18.9 %        | 39.6 %   | 5.7 %          | 30.2 %      | -                       | 3.8 %              | 1.9 %        | -             | -         |
| <b>SB (n=9)</b>         | 2 (22.2 %)    | -        | 2 (22.2 %)     | 4 (44.4 %)  | -                       | -                  | 1 (11.1 %)   | -             | -         |
| <b>Pre-SB (n=25)</b>    | 24 %          | 16 %     | 8 %            | 24 %        | 12 %                    | 12 %               | -            | 4 %           | -         |

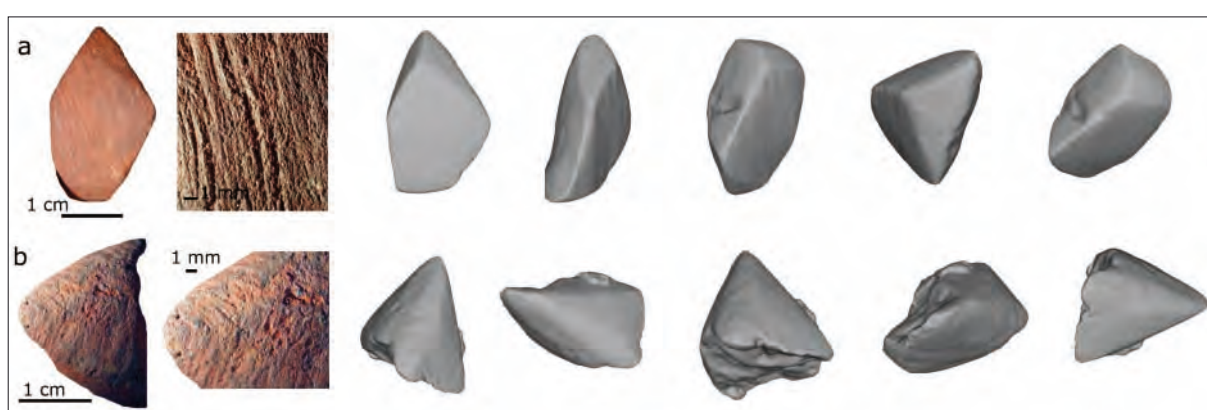
**Tab. 4.** Temporal changes in the frequency of Sibudu ochre pieces used for each activity. This is represented visually in **Figure 3**. Due to the small size of the Still Bay utilised assemblage, numbers are given (and percentage frequencies shown in brackets). Arbitrary cut-offs were chosen to indicate elevated values: dark shading represents values  $\geq 20\%$  and light shading represents values  $\geq 5\%$ . A dash represents 0 %. HP = Howiesons Poort; SB = Still Bay; Def R, prob Gr = 'Definitely rubbed, probably ground'.



**Fig. 3.** Temporal changes in the Sibudu ochre activity frequencies. Note that the Still Bay percentages are unreliable due to a small sample size. HP = Howiesons Poort; SB = Still Bay; Def R, prob Gr = 'Definite rubbed, probably ground'.



**Fig. 4.** Intensively ground, faceted ochre piece from Sibudu (Sb1110 from final MSA layer Coffee, square C2). Three adjacent ground edges converge to a point.



**Fig. 5.** 3D images of two intensively ground and faceted ochre pieces from Sibudu. Note that the 3D images show the shape of the piece, but do not show the striations that are on the facets. Use-wear reveals that the adjacent facets were formed during grinding. (a) Sb2871 from post-Howiesons Poort layer Mi, square B5, (b) Sb2879 from post-Howiesons Poort layer SS, square C6.

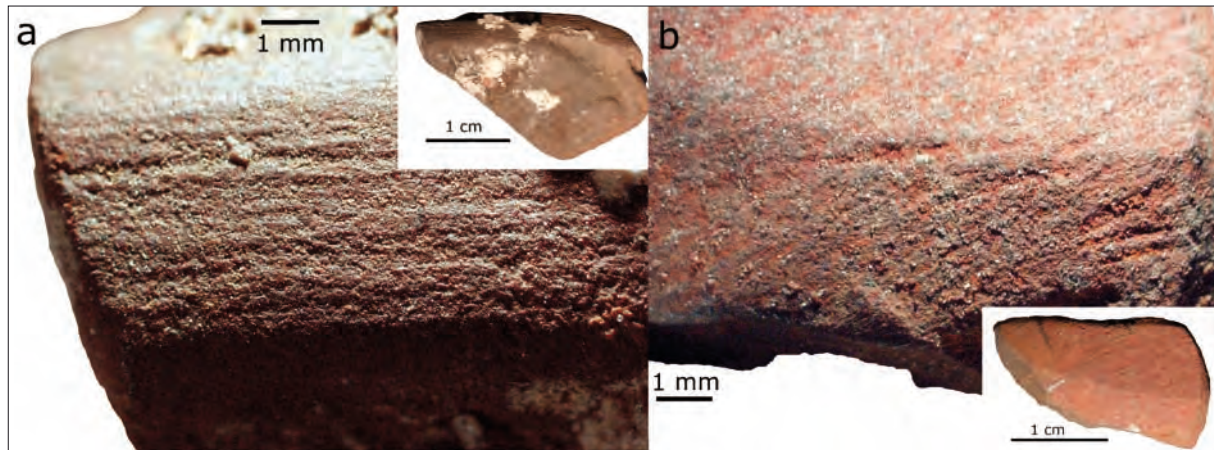
#### Grinding and rubbing (*Fig. 6*)

This combination is the most frequent use-wear type, with 215 pieces bearing signs that pieces were ground and then rubbed on a soft surface. These pieces have grinding use-wear that has been heavily smoothed or partially removed. As with the ground pieces, many ground and rubbed pieces have flat surfaces (66.5 %,  $n=143$ ) and some have convex surfaces (28.4 %,  $n=61$ ). The striations left on the pieces are mostly parallel (73 %,  $n=157$ ) and unfrayed (83.7 %,  $n=180$ ) (*Fig. 6a, b*). The majority of pieces (72.1 %,  $n=155$ ) have striations that reach both edges of the piece. Only 21.9 % ( $n=47$ ) of the ground and rubbed pieces have striations that contain internal microstriations. Profile shapes vary, but striations with wide-U-shaped profiles ( $\backslash$  /) occur more frequently than on the exclusively ground pieces. Pieces with both grinding and rubbing have a higher percentage of pieces with use-traces on three or more sides of a piece (27.4 %,  $n=59$ , versus 19.6 %), however pieces with utilisation on one side alone still predominate (46 %,  $n=99$ ). Pieces

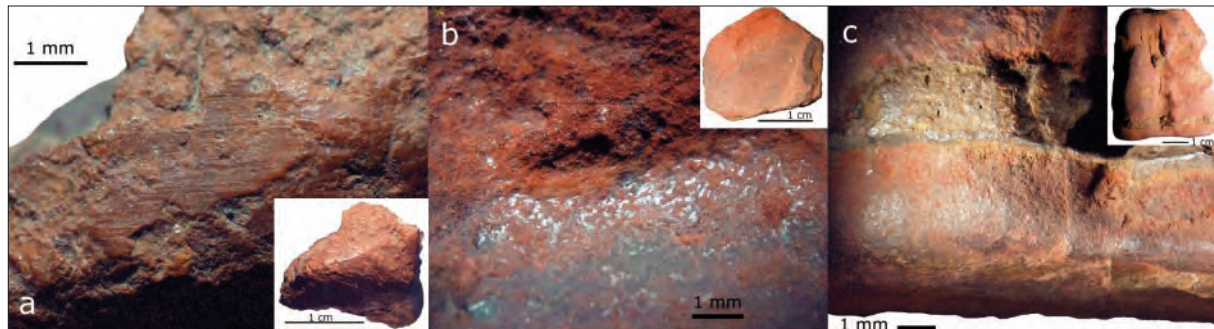
with grinding and rubbing are frequent in the late MSA, Howiesons Poort and post-Howiesons Poort industries and are not found in the Still Bay (*Tab. 4; Fig. 3*).

#### Rubbing (*Fig. 7*)

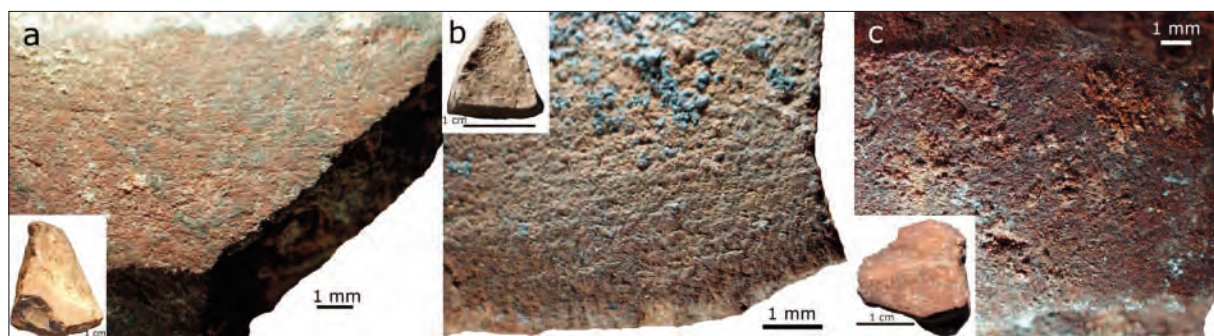
Exclusive rubbing use-wear occurs on 206 pieces. Few of these pieces have grooves (10.7 %,  $n=22$ ). Smoothing is the main indicator of rubbing and it occurs on all of the pieces, usually with external microstriations (81.6 %,  $n=168$ ) (*Fig. 7a*). Polish and metallic lustre each occur on about 30.1 % of the pieces ( $n=62$ , *Fig. 7b*), but rarely occur together on a piece. Many (69.9 %,  $n=144$ ) of the exclusively rubbed pieces have rounded edges (*Fig. 7b, c*) and only 4.4 % ( $n=9$ ) have facets. Many of the utilised areas are flat (41.3 %,  $n=85$ ) and unmodified surface shapes are also common (30.1 %,  $n=62$ ). Over 70 % ( $n=145$ ) of rubbed pieces are utilised on one side only. Pieces with rubbing are common throughout the sequence and are especially frequent in the final MSA assemblage (*Tab. 4; Fig. 3*).



**Fig. 6.** A selection of ochre pieces from Sibudu showing grinding use-wear that has been rubbed. (a) Shale (Sb3727 from post-Howiesons Poort layer G, square C5) with ground facets exhibiting parallel grinding striations. The striations have been intensively smoothed and microstriations are not present. (b) Faceted shale (Sb1272 from late MSA layer MOD, square A6) where the grinding striations have been smoothed.



**Fig. 7.** A selection of ochre pieces from Sibudu showing rubbing use-wear. (a) External microstriations on a small section of siltstone (Sb1926 from post-Howiesons Poort layer BSp, square D2). (b) Smoothing and polish on a piece of snuffbox shale (Sb2126 from post-Howiesons Poort layer BSp2, square E2). (c) Edge rounding, smoothing and polish on altered, hard shale (Sb1121 from late MSA layer Pu, square D2).



**Fig. 8.** A selection of ochre pieces from Sibudu that have been extensively rubbed, probably resulting in the removal of grinding striations ('Definitely rubbed, probably ground'). (a) Shale (Sb4814 from post-Howiesons Poort layer BuYA2(i), square C4) that has been smoothed to form a flat surface. Only external microstriations are visible on the utilised surface. (b) A faceted piece of mudstone (Sb4967 from Howiesons Poort layer GS, square B4) that has been rubbed and smoothed so that no grinding striations are present. (c) Smoothed and faceted piece of shale (Sb4062 from post-Howiesons Poort layer B/Gmix, square B4).

There are 74 additional pieces that are definitely rubbed and were probably ground prior to rubbing, but the grinding use-traces cannot be positively identified (**Fig. 8**). As a result, it is unclear whether rubbing was the primary or secondary activity. Most of the pieces have modified surface shapes (63.5 %,  $n=47$ , are flat and 29.7 %,  $n=22$ , are faceted) even though they all have  $\geq$  Mohs 3 hardness values. All pieces except one have no striations or grooves, all the pieces are smoothed, and most (83.8%,  $n=62$ ) have external microstriations (**Fig. 8a**). These pieces are placed in a separate 'definitely rubbed, probably ground' activity category.

#### Scoring (**Figs. 9–12**)

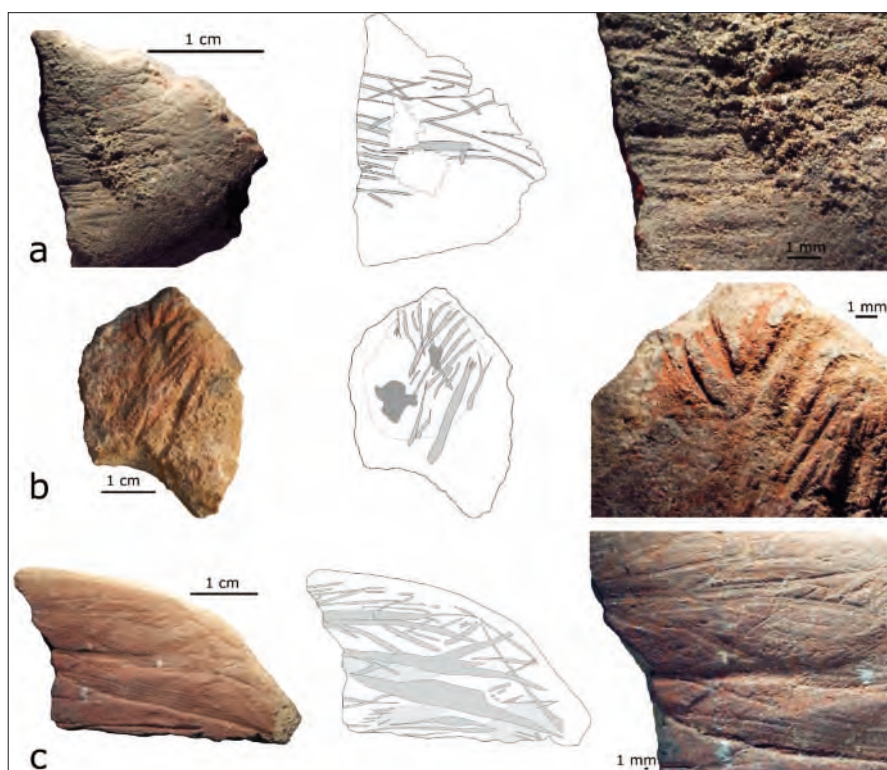
All the pieces featuring scoring ( $n=29$ ), with or without other use-traces, are further divided into 'intensively scored' (**Fig. 9**) and 'lightly scored' (**Figs. 10 and 11**). Divisions are based on the number of incisions, the direction and degree of the intersection of incisions, and the depth of incisions (D'ERRICO *et al.* 2001: 315–317, 2012: 949; HENSHILWOOD *et al.* 2009: 38–40). These categories are not always clear-cut and there are some ambiguous pieces (**Fig. 12**).

There are 15 pieces with scoring use-traces alone. They display a variety of incision profile shapes. All the scored pieces are worked on one or two sides only. All of the intensively scored pieces ( $n=6$ ) have incisions that reach some edges of the piece (**Fig. 9a, b**) and one of the pieces has incisions with frayed ends (**Fig. 9b**). Three (50 %) of the intensively scored pieces have internal

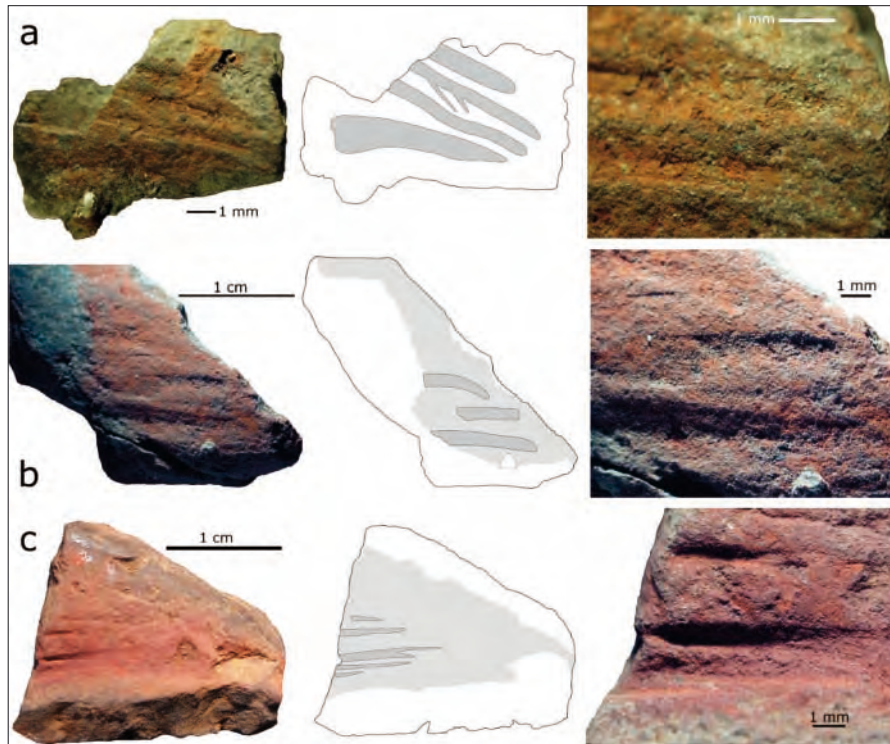
microstriations within the incisions. Six (66.6 %) of the lightly scored pieces have incisions reaching some edges of the piece and three (33.3%) of the pieces have incisions with some frayed ends. Six (66.6 %) of the lightly scored pieces have internal microstriations within the incisions (**Fig. 10a**). The pre-Still Bay assemblage has higher percentages of lightly and intensively scored pieces than any other industry (**Tab. 4; Fig. 3**).

There are 14 more pieces featuring scoring together with markings from other activities. Nine pieces have both scoring and rubbing use-traces (**Figs. 10b, 12c**), only one of which has rubbing on a different surface from the scoring (**Fig. 9c**). Most incisions on these scored and rubbed pieces are erratically oriented and six (66.7 %) of the pieces have incisions that reach only some edges of the piece. Only one piece has frayed incisions (**Fig. 9c**). There are internal microstriations in the grooves on 44.4 % ( $n=4$ ) of the pieces. All the pieces have smoothing, two (22.2 %) have external microstriations and none have polish or metallic lustre. Just over half the pieces are utilised on one side only.

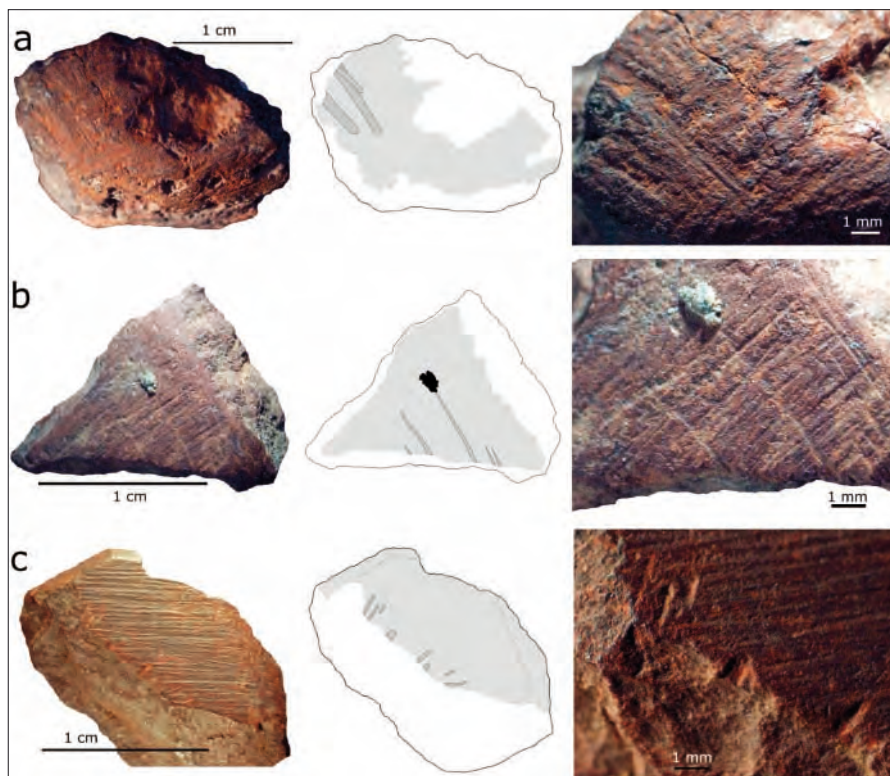
There are five pieces with grinding and scoring use-traces occurring together (**Fig. 11**), one of which is also rubbed (**Fig. 11a**). Scoring is minimal on these pieces and most incisions are parallel (perpendicular to the grinding striations), are unfrayed, and have internal microstriations. Four of the pieces (80 %) have incisions that reach some edges only.



**Fig. 9.** A selection of ochre pieces from Sibudu with intensive scoring. (a) Broken shale piece (Sb5394 from pre-Still Bay layer BS10, square C4) with intensive parallel and erratic scoring, resulting in a concave surface. Clumps of gypsum and hardened sand are visible on the striations. (b) Weathered dolerite (Sb5242 from pre-Still Bay layer BS5, square B4) which has been scored on the soft, red area. Some incisions were made with multiple strokes. Sequencing of incisions is erratic. (c) Shale (Sb5092 from Howiesons Poort layer PGS, square C5) that has intensive erratically-placed incisions of various widths and depths. Some incisions reach the edge of the piece and some are frayed. Many incisions were made with multiple strokes. Different tools appear to have been used to score this piece. One edge of the piece is rounded from rubbing.

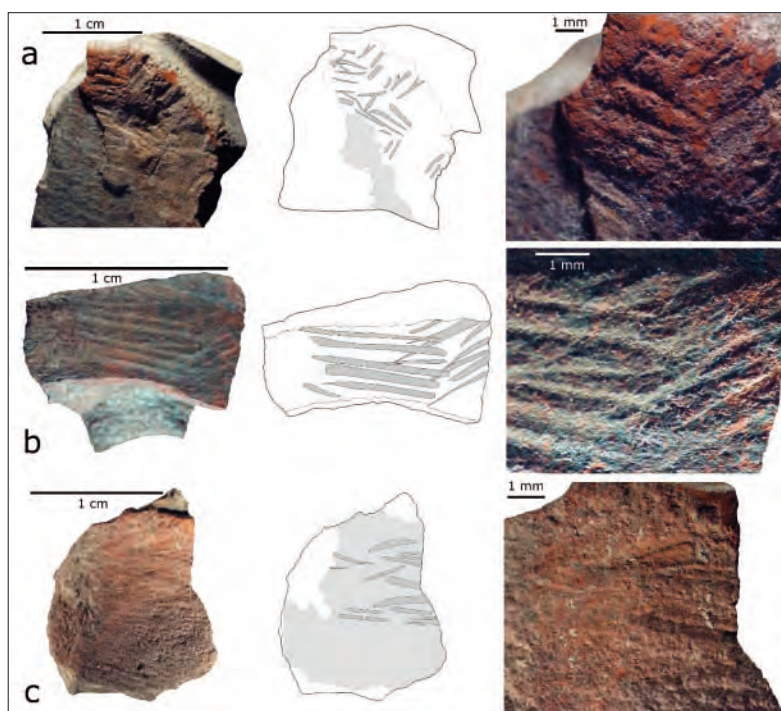


**Fig. 10.** A selection of lightly scored ochre pieces from Sibudu, some with rubbing. (a) Broken shale fragment (Sb2741 from post-Howiesons Poort layer BL2, square A4) with four parallel incisions that contain internal microstriations. Most incisions were made with single strokes. (b) Snuffbox shale (Sb4800 from post-Howiesons Poort layer BuYA2(i), square C4) that has a few scored incisions on the soft, red area of the piece, which was then rubbed. (c) Snuffbox shale (Sb2705 from post-Howiesons Poort layer BL2, square B4) that has been scored on the soft, red area. Only a few striations are visible, but a large amount of the soft, red area has been removed. Method of removal is unknown. Some incisions were made with multiple strokes.



**Fig. 11.** A selection of ochre pieces from Sibudu showing scored incisions on a ground surface. (a) Siltstone nodule (Sb2306 from post-Howiesons Poort layer BSp2, square D2) with grinding striations overlain by perpendicular scored incisions. The grinding striations have been smoothed from rubbing and do not contain internal microstriations, but the scored incisions contain internal microstriations. (b) Triangular shale piece (Sb3112 from post-Howiesons Poort layer SS2, square C4) that has been ground and then scored. The single-stroke incisions are perpendicular to the grinding striations. The grinding is on one surface (shaded area), but on one edge of the surface the grinding changes direction. (c) Shale (Sb2187 from post-Howiesons Poort layer BSp2, square E2) that has been ground and has small

scored incisions on the side of ground surface. The incisions are randomly spaced and some irregularity in incision width suggests they may have been made with different tools. Each incision was made in a single stroke.



**Fig. 12.** A selection of scored ochre pieces from Sibudu, some with rubbing. (a) Snuffbox shale (Sb3300 from pre-Still Bay layer BS8, square C5) which is scored on the soft, red area. (b) Shale (Sb5058 from Howiesons Poort layer PGS, square B5) that has two groups of parallel incisions that cross over each other at one end. No internal microstriations are present and incisions were made in single strokes. The incisions in the centre of the piece were made after the ones on the (right) side. (c) Snuffbox shale (Sb5173 from Still Bay layer RGS, square C4) that has been scored and rubbed. A concave surface has been created from scoring. The scoring may have been more extensive on the piece, but the incisions were removed during rubbing.

#### *Activities and ochre properties* (**Tab. 5**; HODGSKISS 2012: 107)

##### Rock type

Shale dominates the utilised and unutilised assemblages and all activity categories within it. Shale is especially popular for grinding activities. Snuffbox shale has increased frequency in both rubbing and scoring activities.

##### Grain size

Silty pieces dominate most activity categories, but clayey pieces are favoured for scoring activities. Following the trends of the unutilised assemblage, clayey pieces are more common in the older layers (Howiesons Poort, Still Bay and pre-Still Bay) and silty pieces in the younger layers (**Tab. 1**). A sandy grain size is uncommon in the assemblage and no sandy pieces were scored.

##### Hardness

Pieces with medium hardness (Mohs 3 and 4) dominate the assemblage and are common in all activity categories. A larger percentage of the rubbed pieces are soft compared with the ground pieces, but there is only a weak association between hardness and activity ( $\chi^2=3.53$ ;  $df=1$ ;  $\alpha=0.1$ ).

##### Colour

Bright-red is the predominant streak colour in the unutilised and utilised assemblages. Pieces with a bright-red streak are the most represented across all activities. There is an increase of pieces with brown-red and orange streaks among the scored pieces.

##### Mica inclusions

Mica-rich pieces, which have a glistening quality, are infrequent in the assemblage, but are more frequent in the utilised assemblage than in the unutilised. Pieces with mica inclusions are more prevalent in the layers younger than ~58 ka (**Tab. 1**).

#### Discussion

Classification of the use-traces on the Sibudu ochre is aimed at answering questions about the use of ochre pieces and powder. I have identified the use-traces on the pieces, the activities denoted by the markings, and the ochre properties chosen for each activity. What remains to be explored is the application of the by-products of and materials used during the activities — powder, the materials on which the ochre was rubbed and the scored pieces. The types of ochre chosen for the activities help to infer how these materials were applied or used and what the reason for the activities may have been.

##### *Powder production and the choice of ochre types*

Ochre use can be divided into activities that produce powder and those that would have only produced small quantities of powder, perhaps unintentionally. Throughout the sequence, the use-traces on the ochre at Sibudu suggest that most pieces were used for powder-production (76.1 %) rather than for other activities (23.9 %) (**Fig. 13**). Activities resulting in powder-production

| OCHRE PROPERTIES |                    | Grinding (Gr) | Gr and R | Def R and prob Gr | Rubbing (R) | Intensive Scoring (InS) | Light Scoring (LS) | LS/InS and R | LS/InS and Gr | Gr. LS. R | Total   |
|------------------|--------------------|---------------|----------|-------------------|-------------|-------------------------|--------------------|--------------|---------------|-----------|---------|
|                  |                    | 158           | 215      | 74                | 206         | 6                       | 9                  | 9            | 4             | 1         | 682     |
| Geological form  | Shale              | 78.5 %        | 78.1 %   | 56.8 %            | 47.1 %      | 66.7 %                  | 55.6 %             | 44.4 %       | 100 %         | -         | 65.7 %  |
|                  | Snuffbox shale     | 7.0 %         | 6.1 %    | 4.1 %             | 20.9 %      | 33.3 %                  | 22.2 %             | 33.3 %       | -             | -         | 11.3 %  |
|                  | Mudstone           | 1.3 %         | 1.9 %    | 1.4 %             | 3.9 %       | -                       | -                  | -            | -             | -         | 2.2 %   |
|                  | Siltstone          | 5.7 %         | 8.4 %    | 20.3 %            | 18.5 %      | -                       | -                  | -            | -             | 100 %     | 11.9 %  |
|                  | Sandstone          | 1.3 %         | 1.9 %    | 8.1 %             | 3.4 %       | -                       | -                  | -            | -             | -         | 2.8 %   |
|                  | Iron oxide         | 5.7 %         | 3.7 %    | 6.8 %             | 3.9 %       | -                       | 11.1 %             | -            | -             | -         | 4.5 %   |
|                  | Weathered dolerite | -             | -        | 2.7 %             | 0.5 %       | -                       | 11.1 %             | -            | -             | -         | 0.6 %   |
|                  | Hardened clay      | -             | -        | -                 | 0.5 %       | -                       | -                  | -            | -             | -         | 0.1 %   |
|                  | Other              | 0.6 %         | -        | -                 | 1.5 %       | -                       | -                  | 22.2 %       | -             | -         | 0.9 %   |
|                  | <b>Total</b>       | 100 %         | 100 %    | 100 %             | 100 %       | 100 %                   | 100 %              | 100 %        | 100 %         | 100 %     | 100 %   |
| Grain size       | Clayey             | 37.3 %        | 30.2 %   | 21.6 %            | 33 %        | 66.7 %                  | 33.3 %             | 33.3 %       | 25 %          | -         | 32 %    |
|                  | Clayey/Silty       | 10.1 %        | 18.1 %   | 10.8 %            | 14.1 %      | -                       | 44.4 %             | 33.3 %       | 25 %          | -         | 14.7 %  |
|                  | Silty              | 49.4 %        | 48.8 %   | 54.1 %            | 42.7 %      | 33.3 %                  | 22.2 %             | 33.3 %       | 50 %          | 100 %     | 47.2 %  |
|                  | Silty/Sandy        | 1.9 %         | 0.9 %    | 9.5 %             | 5.3 %       | -                       | -                  | -            | -             | -         | 3.4 %   |
|                  | Sandy              | 1.3 %         | 1.9 %    | 4.1 %             | 4.9 %       | -                       | -                  | -            | -             | -         | 2.8 %   |
|                  | <b>Total</b>       | 100 %         | 100 %    | 100 %             | 100 %       | 100 %                   | 100 %              | 100 %        | 100 %         | 100 %     | 100 %   |
| Hardness         | Soft               | 19.6 %        | 18.6 %   | 1.4 %             | 27.7 %      | 33.3 %                  | 33.3 %             | -            | 25 %          | -         | 19.8 %  |
|                  | Medium             | 80.4 %        | 80.9 %   | 98.7 %            | 70.4 %      | 66.7 %                  | 66.7 %             | 100 %        | 75 %          | 100 %     | 79.5 %  |
|                  | Hard               | -             | 0.5 %    | -                 | 1.9 %       | -                       | -                  | -            | -             | -         | 0.7 %   |
|                  | <b>Total</b>       | 100 %         | 100 %    | 100 %             | 100 %       | 100 %                   | 100 %              | 100 %        | 100 %         | 100 %     | 100 %   |
| Colour           | Dark Red           | 5.1 %         | 4.7 %    | -                 | 4.9 %       | -                       | -                  | -            | -             | -         | 4.1 %   |
|                  | Bright-Red         | 51.3 %        | 48.4 %   | 52.7 %            | 44.7 %      | 50 %                    | 33.3 %             | 55.6 %       | 50 %          | -         | 48.2 %  |
|                  | Weak-Red           | -             | 0.5 %    | -                 | 0.5 %       | -                       | -                  | -            | -             | -         | 0.3 %   |
|                  | Purple-Red         | 8.9 %         | 8.4 %    | 4.1 %             | 6.3 %       | 16.7 %                  | -                  | -            | -             | -         | 7.2 %   |
|                  | Brown-Red          | 14.6 %        | 16.7 %   | 23.0 %            | 20.4 %      | 16.7 %                  | 44.4 %             | 11.1 %       | 25 %          | -         | 18.3 %  |
|                  | Orange             | 15.8 %        | 15.8 %   | 16.2 %            | 17.5 %      | 16.7 %                  | 22.2 %             | 22.2 %       | 25 %          | 100 %     | 16.7 %  |
|                  | Yellow-Brown       | -             | -        | 1.4 %             | 0.5 %       | -                       | -                  | -            | -             | -         | 0.3 %   |
|                  | Yellow             | -             | -        | -                 | 0.5 %       | -                       | -                  | -            | -             | -         | 0.1 %   |
|                  | Brown              | 0.6 %         | 0.9 %    | -                 | 0.5 %       | -                       | -                  | -            | -             | -         | 0.6 %   |
|                  | Grey               | -             | -        | -                 | -           | -                       | -                  | -            | -             | -         | 0 %     |
|                  | Dark Colours       | -             | 0.9 %    | -                 | 0.5 %       | -                       | -                  | -            | -             | -         | 0.4 %   |
|                  | Two Colours        | 3.2 %         | 3.7 %    | 2.7 %             | 3.9 %       | -                       | -                  | 11.1 %       | -             | -         | 3.5 %   |
|                  | No Streak          | 0.6 %         | -        | -                 | -           | -                       | -                  | -            | -             | -         | 0.1 %   |
|                  | <b>Total</b>       | 100 %         | 100 %    | 100 %             | 100 %       | 100 %                   | 100 %              | 100 %        | 100 %         | 100 %     | 100 %   |
| Mica             | Present            | 39.2 %        | 42.8 %   | 23 %              | 18 %        | 16.7 %                  | 33.3 %             | 33.3 %       | 50 %          | -         | 31.80 % |
|                  | Absent             | 60.8 %        | 57.2 %   | 77 %              | 82 %        | 83.3 %                  | 66.7 %             | 66.7 %       | 50 %          | 100 %     | 68.20 % |
|                  | <b>Total</b>       | 100 %         | 100 %    | 100 %             | 100 %       | 100 %                   | 100 %              | 100 %        | 100 %         | 100 %     | 100 %   |

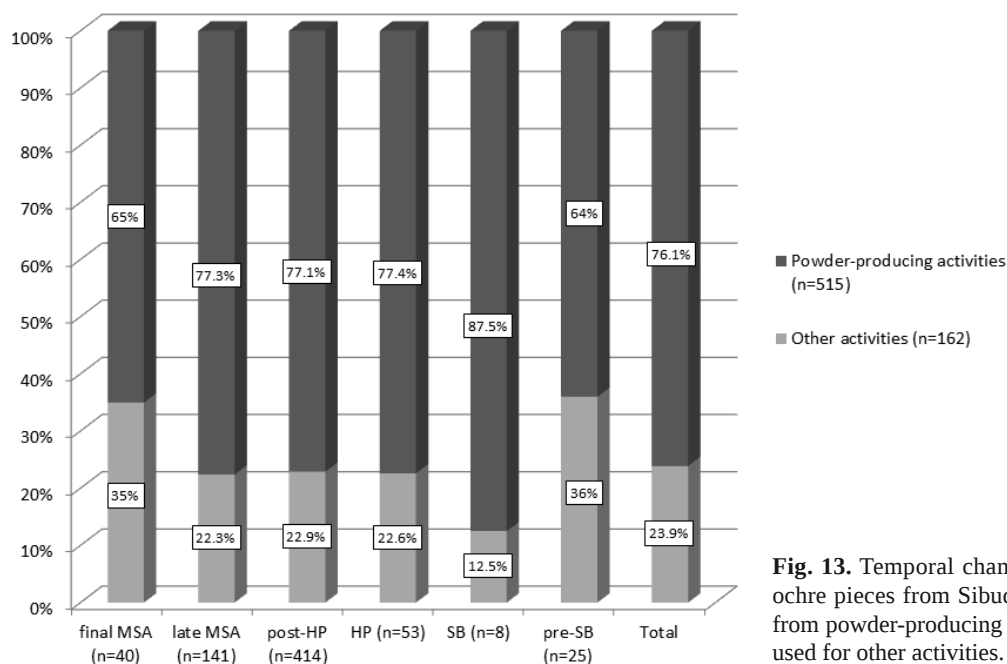
**Tab. 5.** Frequencies of the properties of the utilised Sibudu ochre pieces represented in each activity category. Each piece is only represented in one activity category. To highlight elevated values, an arbitrary cut-off ( $\geq 40\%$ ) was chosen. A dash represents 0 %. Def R, prob Gr = 'Definitely rubbed, probably ground'. Some of the intensively and lightly scored pieces also display grinding and rubbing use-wear.

include grinding, grinding and rubbing, rubbing with soft pieces, and intensive scoring. Activities that produce small quantities of powder include rubbing with un-ground hard pieces ( $\geq$  Mohs 3) and light scoring. The rubbed pieces are divided by hardness, because it was experimentally determined that rubbing hard, unused ochre pieces against soft material resulted in little or no transfer of powder (HODGSKISS 2010: 3355). The reason for the rubbing of hard pieces is unknown.

The intensively scored pieces have many incisions, mostly erratically placed, and making the incisions would have resulted in the production of some powder.

The incisions on the pieces with light scoring appear to be deliberately placed and they sometimes form what, to our eyes, appears as a pattern. Five pieces that have both powder-producing use-traces and use-traces from other activities have not been included in the percentages mentioned above.

Various geological types were chosen for the different production outcomes. Shale is most common in the pieces used to produce powder (72.6 %) whereas the pieces not used for powder production constitute a wide range of raw materials. Mica-rich, glistening pieces were frequently used for activities that produce



**Fig. 13.** Temporal changes in frequencies of ochre pieces from Sibudu that have use-wear from powder-producing activities versus those used for other activities.

powder (36.1 % versus 17.9 % in the other activities), which is a noticeable, but weak correlation (Fishers exact  $p=0.261$ ). Colour distribution is similar in the two categories, but bright-red pieces are more often used for powder-production than for other activities (51.1 % vs. 40.1 %). The choice of bright-red pieces for powder creation suggests that powder colour was important, but there is only a weak correlation between colour and powder-production in the Sibudu assemblage ( $\chi^2=2.573$ ;  $df=2$ ;  $\alpha=0.25$ ).

Choice of ochre properties may not be straightforward, and alternative reasons for the choice of types of ochre need to be explored. Ochre residues found on the medial and proximal portions of hafted stone tools at Sibudu have indicated that ochre powder was used in compound hafted adhesives (GIBSON *et al.* 2004: 4–6; WADLEY *et al.* 2004; WILLIAMSON 2004: 175, 2005; LOMBARD 2006, 2007, 2011: 1925). Experimental work on compound hafting adhesives highlights the importance of using an aggregate with high iron and silicon contents and a combination of grain sizes (WADLEY *et al.* 2009: 9591–9593). Although the MSA ochre-user would not have understood the chemical properties of the material, the choice of hard pieces (when soft pieces are easily accessible) and strong-red pieces may have been due to use of the material in specific activities in which iron is valuable. Colour may have been an indicator of other attributes, such as iron content. Hide tanning experiments demonstrate that red ochre is a more effective inhibitor of putrefaction and desiccation than yellow ochre, and it produces a more pliable hide (RIFKIN 2011: 145). This is a likely option at Sibudu

because of the large quantity of pieces with combined grinding and rubbing use-wear, which could have been caused from rubbing on hide.

Grain size changes through time may indicate changes in the application of ochre powder. A small grain size is effective for paint, whereas a varied grain size is effective for hafting adhesives (WADLEY *et al.* 2009). However grain size variation may also indicate changes in the ochre available at the time, especially since the unutilised and utilised assemblages both show similar frequency changes.

#### *Intensively ground pieces*

The use of some pieces like a crayon or pencil (*e.g.*, SORESSI & D'ERRICO 2007: 303–306; SORESSI *et al.* 2008: 127), resulting in the utilisation of three or more adjacent surfaces has not been established in the Sibudu assemblage. None of the intensively ground pieces display micro-wear facets around the tips, indicating that the pieces were not used to draw linear marks on a surface (WADLEY 2005a: 8; SORESSI *et al.* 2008: 127). The ground facets are most likely the result of intensive grinding activities and powder production. Colour frequencies of the intensively ground pieces are similar to those of the whole utilised assemblage, with bright-red pieces dominating (44.1 %). The intensively ground pieces have a high occurrence of mica-rich pieces (65.6 %). There is a significant relationship between the number of sides utilised and pieces with mica inclusions ( $\chi^2=8.938$ ;  $df=2$ ;  $\alpha=0.01$ ) — that is, the

more intensively utilised a piece is, the more likely it is to have mica inclusions. Therefore, throughout the sequence, pieces that produced a bright-red, glistening powder were more likely to be intensively utilised. This indicates that these visual qualities were desired for powder.

### *Rubbing and smoothing*

Due to the problems with distinguishing rubbing and smoothing, it is necessary to discuss circumstances that may result in smoothing. Some of the smoothing may be the result of handling or incidental prolonged contact with a soft material — for example if the pieces were transported in a leather bag. The pieces would then be likely to acquire some scratching and scuff marks from contact with other pieces/items. These markings only occur on 20 of the 215 pieces that were classified as ground and then rubbed (9.3 %). Further, the smoothing would be found on various surfaces of the pieces or relatively consistently around the piece, but in the Sibudu assemblage smoothing is usually focussed on the grinding striations or on only one or two sides of a previously unused piece. If the smoothing occurred from transporting then it is still noteworthy; it indicates that specific ochre pieces were probably considered valuable and were kept for future use. Smoothing may also be from prehensile wear traces or handling (RIFKIN 2012), showing how the pieces were held. These traces are unlikely to occur in association with other markings, such as external microstriations that show the direction of the rubbing.

Grinding ochre on a wet surface, or with a moist substance, results in smoothing of the grinding striations and the removal of internal microstriations (HODGSKISS 2010: 3351, tab. 1). All of the experimental pieces also had clay residues on them after wet-grinding. These residues could easily be removed during normal post-depositional processes and so may be removed over time. However, the absence of external microstriations is an important aspect because external microstriations would indicate that the pieces were rubbed.

### *Combined grinding and rubbing*

Combined grinding and rubbing would have resulted in powder production as well as powder transferal onto a soft material (SORESSI & D'ERRICO 2007: 303–304; SORESSI *et al.* 2008: 127; HODGSKISS 2010: 3355). The soft materials on which the ochre was rubbed are not preserved at Sibudu. Unfortunately we cannot know why the ochre powder was transferred onto the material — for aesthetic, ritual or practical purposes — but the use of

ochre in this way shows that this action was occurring. This use-wear demonstrates an innovative way in which ochre was applied to another material, apart from using powder created by grinding or intensive scoring.

### *Scored and engraved ochre*

Intensive scoring results in some powder-production and this technique may sometimes have been an alternative method to grinding. The purpose behind light scoring, on the other hand, is unknown. At Sibudu, the pieces that are lightly scored (without any other use-wear) have increased percentages of brown-red pieces compared to the other activities. The scoring may have been performed as a colour-test to see what colour the ochre powder would be because the outer colour of the piece is often different from the powder produced. When the scoring showed that the colour of the ochre was not the desired colour, the piece may have been discarded with only a few incisions on the surface. Alternatively, the use of these geological forms for light scoring may denote that unique pieces were chosen for scoring, or that the colour was not a vital attribute for the scored pieces.

Some of the pieces are small (~10 mm) and holding the piece during scoring would have been difficult (*e.g.*, **Fig. 12b**). A few of the pieces may have broken during or post-scoring so that the remnant piece represents only a small portion of the original scored surface (**Figs. 9a, 10a**). Scoring small pieces would demand good hand control as well as care and concentration. This shows that actions were probably planned and deliberate — from the type of piece chosen (softness, size and grain size), to the tool used and the surface chosen to utilise. Some of the incisions on the lightly scored pieces have evidence that they were also carefully and deliberately placed (or engraved). The incisions have uniform profile shapes, suggesting that the incisions on each piece were made by the same tool. The surfaces may have been chosen for their topography or prepared to create the desired shape, since many of the incisions are made on flat surfaces, making engraving easier. Other indicators that some of the engravings are deliberate and required controlled motions are the regularity and symmetry of the incisions (*e.g.*, **Figs. 9b, 10a, 12a, b**) and the sequence in which the incisions were scored (*e.g.*, **Fig. 12b**).

Some of the incisions are erratically placed and do not form a noticeable design. However some are more ordered giving an appearance of repeated motifs (**Tab. 6**). Parallel incisions are found on many pieces (*e.g.*, **Figs. 10a, c, 11b, 12b**). On each piece, the incisions appear to have been made with the same tool and most incisions are made with individual strokes. Pieces

| Industry             | Square | Layer    | Engraving type     | Figure |
|----------------------|--------|----------|--------------------|--------|
| Final MSA            | C2     | Coffee   | Erratic            | -      |
|                      | D2     | LB MOD   | Parallel           | -      |
| Late MSA             | B6     | MOD      | Fan                | -      |
|                      | D4     | MOD      | Fan                | -      |
|                      | E3     | RSp      | Erratic            | -      |
|                      | E4     | MOD      | Parallel           | -      |
| Post-Howiesons Poort | C2     | BSp      | Erratic            | -      |
|                      | E2     | BSp2     | Parallel           | 11c    |
|                      | D2     | BSp2     | Parallel (& grid)  | 11a    |
|                      | A4     | BL2      | Parallel           | 10a    |
|                      | B4     | BL2      | Parallel           | 10c    |
|                      | B6     | BIL      | Parallel           | -      |
|                      | B6     | BIL      | Parallel           | -      |
|                      | C6     | SS       | Parallel & erratic | -      |
|                      | C5     | SS2      | Parallel & erratic | -      |
|                      | C4     | SS2      | Parallel (& grid)  | 11b    |
|                      | B4     | Ivory    | Erratic            | -      |
|                      | C4     | BuYA2(i) | Parallel           | 10b    |
| Howiesons Poort      | C6     | GS       | Fan                | -      |
|                      | B5     | PGS      | Fan & parallel     | 12b    |
|                      | C5     | PGS      | Forked & parallel  | 9c     |
| Still Bay            | C4     | RGS      | Erratic (broken)   | 12c    |
| Pre-Still Bay        | C5     | BS13     | Erratic (& grid)   | -      |
|                      | C4     | BS       | Erratic            | -      |
|                      | B4     | LBG3     | Erratic            | -      |
|                      | C5     | BS8      | Fan                | 12a    |
|                      | B4     | BS5      | Fan                | 9b     |
|                      | C4     | BS10     | Forked & parallel  | 9a     |
|                      | C4     | BS10     | Parallel           | -      |

**Tab. 6.** The arrangement of the incisions on all of the Sibudu ochre pieces with scoring (light and intensive) and/or engraving.

with parallel scored incisions are found in all industries although they occur regularly in the post-Howiesons Poort. The repeated act could indicate a cultural motif, but the lack of standardization between the pieces only allows for tentative conclusions. Two pieces have parallel and forked incisions (**Fig. 9a, c**). Both pieces are intensively scored and the forked markings may not have been deliberately engraved.

Fan-shaped arrangements of incisions are found on six pieces (**Figs. 9b, 12a, b**). They are not uniform in their design, but the incisions on each piece appear to be made with the same pointed tool and the incisions show a degree of symmetry. Some of the incisions are formed by multiple strokes, resulting in a deep or widened (and clear) groove. The fan-shaped incisions are found on pieces from the Howiesons Poort, the late MSA and the pre-Still Bay assemblages.

The placement and orientation of the incisions on some of the Sibudu ochre pieces suggests there is likely to have been some significance attached to the act of incising them (*e.g.*, **Figs. 9b, 10a, 11b, 12b**). Perhaps they held meaning for the individual who created them. Whether these 'engravings' held a message understood by others is uncertain.

#### Alternative uses

There is minimal use-wear evidence suggesting ochre in the Sibudu assemblage was used for the soft hammer shaping of bifaces (SORIANO *et al.* 2009). Few of the pieces are large enough to use for knapping, but the pieces may have broken during use (especially the fissile shale pieces) making use-markings mostly invisible. Less than one percent of the pieces in the entire ochre assemblage have evidence of chipping or impact points that may indicate that this activity occurred (**Tab. 3**). However, ochre flakes are present in both the utilised and unutilised assemblages (11.1 % and 14.1 % of pieces respectively). This may signify that the ochre itself was knapped, perhaps to get smaller pieces or to establish the physical properties of the ochre piece.

The crushing of ochre is another alternative method of use. This is a plausible technique of powder-production, but it is a method that results in little remaining evidence of the action. The small fragments or crumbs excluded from the analysis due to size ( $n=3837$ ) may be remnants of this action; however there is no use-wear to confirm this possibility.

#### Sibudu ochre use in a MSA context

Ochre use at Sibudu has many similarities with other MSA ochre assemblages, especially those from Blombos and Pinnacle Point 13B (PP13B). Grinding use-wear is common and the objective of obtaining powder from the ochre is apparent (HENSHILWOOD *et al.* 2001: 432, 2009: 30; WATTS 2010: 403). The preference to use bright-red pieces for powder-production is clear at Blombos and PP13B (HENSHILWOOD *et al.* 2001: 433; WATTS 2009: 86, 2010: 399–402) as it is at Sibudu. There is a high frequency of pieces with rubbing use-wear at Sibudu, but at other South African sites with ochre, rubbing is rare, undocumented or may not have been placed into the 'possibly utilised' samples. Sibudu has a higher percentage of lightly used pieces than Blombos and PP13B, perhaps owing to the presence of pieces that are rubbed on one side.

Scoring (or scraping) and combined grinding and scoring on ochre pieces are rare use-traces at PP13B,

but account for ~40 % of the utilised sample at Blombos (HENSILWOOD *et al.* 2009: 30). The Blombos scored ochre pieces, like those at Sibudu, also have both intensively and lightly scored pieces. The Blombos scored ochre pieces are found in the layers containing Still Bay and earlier occupations (HENSILWOOD *et al.* 2002, 2009: 28). Contrarily, the engraved Klein Kliphuis piece comes from Howiesons Poort/post-Howiesons Poort occupations (MACKAY & WELZ 2008). The scored pieces from Sibudu are most frequent in the pre-Still Bay and are also common in the Still Bay and Howiesons Poort layers.

There are generally few scored ochre fragments at MSA sites, so to conclude design preferences is problematic. There are some similarities in form and technique between the sites, but the significance of this is largely speculative. Similarly to the KRM 13 ochre fragment from Klasies River (D'ERRICO *et al.* 2012) and some of the Blombos ochre fragments (HENSILWOOD *et al.* 2009), several of the scored incisions on the Sibudu ochre are shallow, do not appear to be spatially organised, and are not symmetrical. The parallel incisions on the Sibudu ochre are not as defined and deep as those on KRM 13 (D'ERRICO *et al.* 2012: 946–948) or ochre piece M1-6 from Blombos (HENSILWOOD *et al.* 2002, 2009: 36, fig. 9). They are more comparable to M1-2 from Blombos (HENSILWOOD *et al.* 2009: 32, fig. 4), which also has broad and shallow incisions. At Sibudu there may be a preference for creating fan-shaped designs, but there are no scored cross-hatched designs like those found at Blombos and Klein Kliphuis (HENSILWOOD *et al.* 2002; MACKAY & WELZ 2008), nor are there ladder-like designs like the ones engraved on ostrich eggshell from ~60 ka layers at Diepkloof (TEXIER *et al.* 2010). These Diepkloof designs occur in high frequencies and they appear to imply cultural significance. Some of the scored incisions at Sibudu seem to have been deliberately engraved, but it is uncertain whether they were made with symbolic intent.

### Summary and conclusion

Ochre use was regular throughout the MSA sequence at Sibudu, resulting in a large and varied ochre assemblage. Ochre pieces used for powder-production are predominant throughout the sequence and bright-red and mica-rich pieces were regularly used, which implies a desire for a bright-red, brilliant powder. The importance of red in universal colour identification and categorisation in humans (BERLIN & KAY 1969; WRECHNER 1980; KNIGHT *et al.* 1995) suggests that the predominance of the brightest red ochre in MSA utilised assemblages could have held symbolic importance. In the MSA the saliency of red and the resemblance of ochre powder to blood, for example, may have been

significant and ochre may have been collected and used for symbolic reasons. At present there is no direct evidence to justify this conclusion at Sibudu.

The ochre powder may have had various applications. We know from residue analyses that some of this powder was used for the manufacture of compound hafting adhesives at Sibudu (WADLEY *et al.* 2004, 2009; WILLIAMSON 2004: 175; WADLEY 2005b; LOMBARD 2006, 2007, 2011: 1025). The powder may have been added for its chemical and physical properties or for its visual saliency. However, it has been proven that the addition of ochre powder in hafting adhesives is functionally effective (WADLEY *et al.* 2009). Evidence for hafting tools with an ochre-loaded compound adhesive is found in the Still Bay, Howiesons Poort, post-Howiesons Poort and final MSA layers at Sibudu (WADLEY *et al.* 2004; LOMBARD 2006, 2007, 2011).

Another use of ochre powder is the direct transfer of ochre powder onto a soft material by rubbing. Using this method, ochre was transferred directly from the ochre piece to the soft material. Pieces with use-wear denoting grinding and subsequent rubbing possibly demonstrate a novel way of applying ochre powder to soft materials. These pieces represent the most common use-traces found on the Sibudu ochre and, as with compound adhesive manufacture, they indicate behavioural innovation in the way ochre was used. They are especially frequent in the Howiesons Poort, post-Howiesons Poort and late MSA layers.

Scoring or engraving is uncommon in the assemblage. The use of unique geological forms for engraving at Sibudu and other MSA sites (HENSILWOOD *et al.* 2009; WATTS 2010; D'ERRICO *et al.* 2012) may indicate that the pieces had an unconventional purpose. A few scored pieces from Sibudu display symmetrical incisions and deliberate placing of incisions, forming groups of parallel incisions or incisions arranged in a fan shape. The repeated act could indicate the portrayal of a cultural motif, but the lack of standardization between the pieces only allows for tentative conclusions about their symbolic meaning. The deliberately and carefully engraved incisions on the ochre pieces suggest that there was some significance attached to the act of engraving them.

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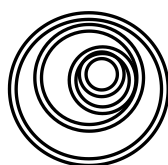
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## CHAPTER 7

### Cognitive Implications



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Cognitive requirements for ochre use in the Middle Stone Age  
at Sibudu, South Africa.

**Cambridge Archaeological Journal.**

# **Cognitive Requirements for Ochre Use in the Middle Stone**

## **Age at Sibudu, South Africa**

Tammy Hodgskiss

*Ochre is found at many Middle Stone Age sites and its use is often associated with enhanced mental abilities and symbolism, but the link between the visible uses of ochre and cognition have not been clearly defined. By establishing the technology and processes involved in using ochre, one can determine the skill, knowledge and cognitive abilities required to execute those activities. This is done here by constructing thought-and-action sequences and inferential cognitive sequences for the various ochre activities performed at Sibudu, KwaZulu-Natal, South Africa. This analysis found that powder-production alone is not an indicator of complex cognitive processes, although some planning, foresight and knowledge of materials is required. Some of the powder was used in the creation of hafting adhesives – a cognitively demanding process requiring attention-switching ability, response inhibition, analogical reasoning and abstract thought. The direct transfer of ochre powder from an ochre piece to a soft material through grinding and rubbing processes requires some complex thought and action procedures – analogical reasoning and the ability to multi-task and switch attention between activities. Scoring a piece of ochre with a sharp tool does not necessitate enhanced executive functioning, and the activity sequence is simple. However, some engravings demonstrate intentionality and an awareness of space and symmetry that may demonstrate abstract thought.*

Middle Stone Age (MSA) research is often focussed on finding ways to reconstruct behaviours to determine whether the people living then had modern cognition or cognitive functions similar to ours today (Amati & Shallice 2007; d’Errico & Stringer 2011; Henshilwood & Marean 2006; Henshilwood *et al.* 2002; McBrearty & Brooks 2000; Noble & Davidson 1991; Shea 2011; Wadley 2001, 2013). Interpretations have relied on a list of artefact-based traits that display progressive or advanced behaviours (Ambrose 2001; Brumm & Moore 2005; d’Errico *et al.* 2003; Henshilwood & Marean 2003; Klein 2000; McBrearty & Brooks 2000; Mellars 1989; Wadley 2010a). The many inadequacies of the trait list approach have been discussed in detail (e.g. Henshilwood & Marean 2003; Shea 2011; Wadley 2001, 2006a). Some of these criticisms are that the list is taphonomically biased and that it is not theoretically justified. Further, the trait list does not consider that behavioural innovation may have been prompted by (or have been an adaptation to) environmental and temperature changes, demographic stress and social processes (e.g. Bird & O’Connell 2006; Jacobs *et al.* 2008; McBrearty & Brooks 2000; McCall 2007; Shennan 2001; Zilhão 2007). The inadequacies of the trait list approach have prompted research into the cognitive requirements for behaviours and how to identify the cognitive enhancements that resulted in behavioural changes.

Abstract and symbolic representations denote the ability for external information storage, which was a crucial step in becoming behaviourally modern (Botha 2008; Donald 1991; Henshilwood & Marean 2006; Wadley 2001). The abstract designs engraved on some ochre pieces and the prevalence of (utilized and unutilized) bright-red ochre in many assemblages (d’Errico *et al.* 2012; Henshilwood *et al.* 2002, 2009; Hodgskiss 2013; Hovers *et al.* 2003; Mackay & Welz 2008; Watts 2002, 2009, 2010)

are often interpreted as early representations of art and symbolism, and as indicators of cognitive advancements and complex behaviour. Utilized and unutilized ochre pieces and evidence of ochre use is common at MSA sites (see Ambrose 1998; Barham 2002; d'Errico *et al.* 2012; Gibson *et al.* 2004; Henshilwood *et al.* 2002, 2009, 2011; Lombard 2006, 2007, 2011; Marean *et al.* 2007; McBrearty & Brooks 2000; Rots *et al.* 2011; Singer & Wymer 1982; Vanhaeren *et al.* 2006; Wadley 2010b; Watts 2010), but the application of these earth pigments is not always evident. The issue of interpreting the use of ochre is further complicated because it is problematic to differentiate potentially symbolic artefacts from those produced by functional activities (Botha 2008; d'Errico *et al.* 2003; Henshilwood & d'Errico 2011; Shea 2011; Wadley 2006a) and some artefacts can have both functional and symbolic applications (d'Errico & Stringer 2011).

Besides utilized (especially ground) ochre, there is further evidence that ochre powder was regularly produced from the ochre pieces. Ochre powder patches and activity areas involving ochre use have been discovered at MSA sites (Henshilwood *et al.* 2011; Wadley 2010b). Ochre powder is visible on stone tools where it was used as an aggregate in adhesives with which tools were hafted (Allain & Rigaud 1986; Ambrose 1998; Gibson *et al.* 2004; Lombard 2006, 2007, 2011; Rots *et al.* 2011; Wadley *et al.* 2004; Williamson 2004) and ochre powder is occasionally found on the working edges of stone tools (Wadley 2010b; Williamson 2005). Ochre powder has been discovered embedded in a variety of artefacts: perforated shell (beads) (Bouzouggar *et al.* 2007; d'Errico *et al.* 2005, 2009; Henshilwood *et al.* 2004; Vanhaeren *et al.* 2006), bone awls and points (d'Errico & Henshilwood 2007; Henshilwood *et al.* 2001) and on grindstones (Ambrose 1998; Avery *et al.* 1997;

d'Errico & Henshilwood 2007; McBrearty 2001; McBrearty & Brooks 2000; Thackeray 2000; Wadley 2006a).

The unseen elements of ochre use (why and how it was used) coupled with the imbuing of symbolic meaning to the earth pigment have resulted in many inconsistencies in interpreting ochre use in the MSA. Examination of the Sibudu MSA ochre, with the help of an experimentally produced comparative sample, has established the varieties of ochre collected and chosen for use, how ochre was processed and which types of ochre were used for specific activities (Hodgskiss 2010, 2012, 2013). By drawing on these finds and the experimental procedures, it is possible to reconstruct the technology and actions involved in activities with ochre. Based on cognitive theory and method, these reconstructions have allowed for inferences to be made about the skill, knowledge and cognitive abilities required to execute those activities.

## **Theory and Method**

In my interpretations, I attempt to move away from the 'symbolic-functional' debate, in which many interpretations of ochre use in the MSA are embedded.

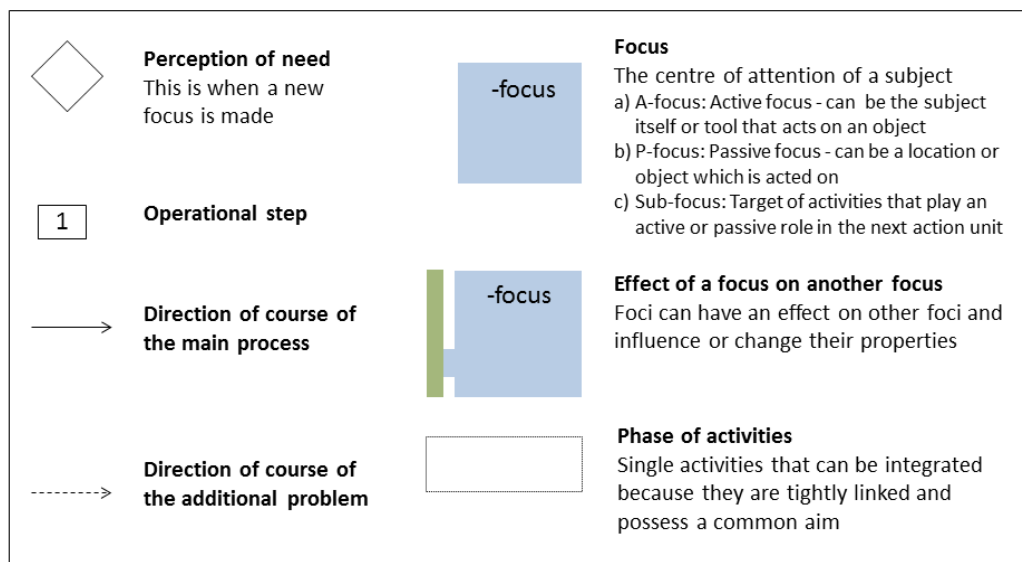
Interpretation is focused on how the use-traces and the activities involving the Sibudu ochre can be seen as proxies for cognitive capabilities. This is achieved by identifying the behavioural stages involved throughout the process and by establishing the temporal and physical distance between the commencement of a task to its completion (Botha 2008; Haidle 2010; Lombard & Haidle 2012; Wynn 2009).

Each activity can be individually examined and broken down into a series of thought-and-action sequences, as illustrated by Marlize Lombard and Miriam Haidle in

their analysis of the processes involved in making a bow and arrow set (Lombard & Haidle 2012). This involves identifying all the elements involved in each activity (Haidle 2010; Lombard & Haidle 2012):

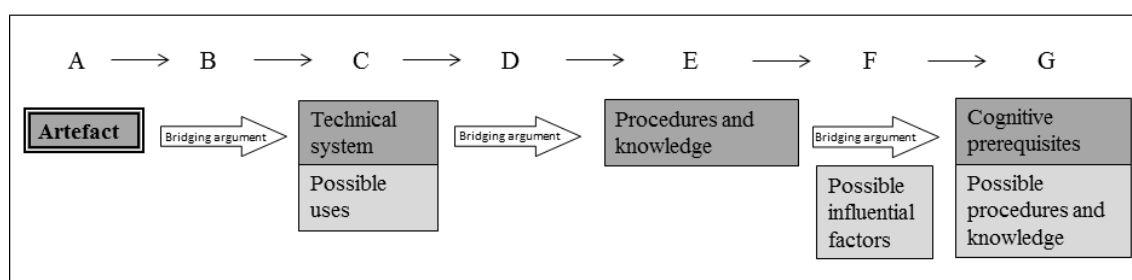
- the underlying perceptions of need (that encouraged the activity)
- the objects and agents involved in each activity
- the individual steps that need to be completed
- the foci of each activity
- the effects of each foci (and object) on each other
- the subsequent use of different tools
- the simultaneous handling of objects
- how all the individual actions in the process are linked.

These elements are presented graphically and consider both spatial and temporal arenas (Fig. 1). Showing the thought-and-action sequence graphically demonstrates the number of steps involved, the distance between the awareness of a problem and its resolution, and the complexity of each task. By modularizing action sequences into cognigrams, technical symbiosis (showing a novel cognitive development, e.g. composition) can be demonstrated (Lombard & Haidle 2012). This can indicate increased complexity of behavioural abilities as well as cognitive abilities, such as cognitive fluidity, flexibility and abstraction.



**Figure 1.** Description of the graphical elements used in the cognigrams (modified from Lombard & Haidle 2012).

Development of these cognitive interpretations is based on both Rudolf Botha and Thomas Wynn's use of inferential steps to determine the minimum cognitive functions needed to complete a task (Botha 2008; Wynn 2009). Here, the ochre activities are divided into a series of 'windows' (after Botha 2008) (Fig. 2). These sequences look at the thought procedures and abilities that were required during each activity sequence. Each step is linked by a hypothesis or bridging argument, which is supported by experimental and/or empirical data (see Botha 2008; Wadley 2010c).



**Figure 2.** Structure of the archaeological inferential sequence about cognition (adapted from Wynn 2009). Uncertain applications and interpretations are stated in the lightly shaded blocks.

Cognitive interpretations are made using the concept of enhanced executive functioning, which is embedded in the broader theoretical concept of enhanced working memory (Baddeley & Hitch 1974; Coolidge & Wynn 2005, 2009; Kane *et al.* 2004; Rossano 2010; Wynn 2002; Wynn & Coolidge 2003, 2007). Working memory is a limited-capacity temporary storage system based in the pre-frontal cortex that allows the mind to hold information temporarily and manipulate the information during tasks (Baddeley 2000; Wynn & Coolidge 2007). It underlies many important actions, such as attention, intelligence, language acquisition, reading, response inhibition, thought strategies and theory of mind (Coolidge & Wynn 2009). Through enhanced connectivity between the different parts of the brain, modern humans are able to do and think several things at the same time, incorporating both long- and short-term memories (Baddeley 2000, 2001; Kane *et al.* 2004; Mithen 1996).

Executive functions are heritable traits (Ando *et al.* 2001; Coolidge *et al.* 2000; Rijdsdijk *et al.* 2002), and recognizing them offers a way to examine evolutionary cognitive changes and advances shown in the archaeological record. These functions (seen here as indicators of cognitive complexity) include innovative thought, fluid intelligence, the use of unique problem-solving methods, the capacity for abstract thought (the ability to hold several ideas in active attention, compare them and then extract ‘generalities’ from them), analogical thinking (transferring a set of ideas into an unrelated situation), flexibility in problem-solving and strategizing, the ability to perform complex goal-oriented behaviours, switching-attention during activities, response inhibition, and the ability to plan and organize activities over space and time (Coolidge & Wynn 2009: 203–204; Coolidge *et al.* 2000; Wynn & Coolidge 2003, 2011). These enhanced executive functions are necessary for long-range planning,

which is required for agriculture, the use of traps and snares, long-range transportation of raw materials for specific uses, and the creation of complex hafting adhesives (Coolidge & Wynn 2009; Haidle 2010; Wadley 2010a,c, 2013; Wadley *et al.* 2009).

An advantage of using these interpretive methods is that even when we do not know why ochre (or ochre powder) was used in the past, this does not necessarily impede interpreting what cognitive abilities were required for the technical tasks. Constructing cognigrams and developing the inferential sequences based thereon allows us to interpret the problem-solution distance for ochre. This can still be done with ochre even though we do not always know the reason (or perceived reason) for the use of the ochre, especially if there are potentially symbolic meanings attached to an activity. We can then interpret the immediate needs, such as the desire to obtain powder, even though we may not know what the motivating need was. By coding the activity sequence, inferences can be made about the cognitive prerequisites needed to perform the activities, technologies and behaviours involved in ochre use.

### **Experimental ochre use**

Using ochre experimentally was an essential first step in understanding the way ochre can be used and the use-traces that form as a result (Hodgskiss 2010; Rifkin 2012). Experiments established the characteristic markings that various (combinations of) activities, involving grinding, rubbing and/or scoring, caused and helped to identify the individual procedures involved in each activity (for full descriptions of experimental finds see Hodgskiss 2010: 3347–57). Experiments demonstrated that not all use-traces can be definitively linked to specific activities, especially when multi-phase procedures

are adopted. The archaeological pieces considered in this paper are only those that have been securely identified to be caused by specific grinding, rubbing and/or scoring processes and combinations thereof.

Post-depositional trampling or prolonged wetting of ochre can mask original use-traces and these processes were considered during analysis of the archaeological ochre (Hodgskiss 2013). The experiments demonstrated that it is difficult to distinguish rubbing of ochre on hide from rubbing ochre on human skin, and so all rubbing use-traces are identified as being rubbed on a soft material and no further division is attempted. The experimental work also showed that scored incisions made with the apparent intent to produce ochre powder cannot be differentiated from incisions that form a deliberate design; it is only the design itself and the positioning of the incisions across the surface of the piece that exemplify such pieces.

Importantly, experimental ochre use demonstrated the processes involved in each task and the steps that need to be concurrently or successively planned or performed during a task. A personal understanding of the thought and action sequences aided interpretations of the distance between problem and solution in each activity. It was also vital in defining the cognitive abilities that were then required to produce the use-traces found on the archaeological ochre.

### **Sibudu and its ochre assemblage**

Sibudu is located in KwaZulu-Natal, South Africa, roughly 15 km inland from the Indian Ocean, NW of Durban. Optically stimulated luminescence ages for the MSA at Sibudu range between  $77.2 \pm 2.6$  ka and  $37.6 \pm 2.6$  ka (Jacobs *et al.* 2008; Wadley &

Jacobs 2006). The Sibudu MSA cultural sequence comprises a pre-Still Bay industry at its base, with Still Bay, Howiesons Poort, post-Howiesons Poort, late MSA, and final MSA assemblages in sequence above (Wadley 2006a; Wadley & Jacobs 2006). There are no human remains at Sibudu that can be securely attributed to the MSA occupations (Plug 2004; Wadley 2006b), however, considering the human remains from other MSA sites in South Africa and farther afield in Africa, it is most likely that the people responsible for the Sibudu assemblage were anatomically modern (Marean & Assefa 2005; McBrearty & Brooks 2000; Wadley 2006b).

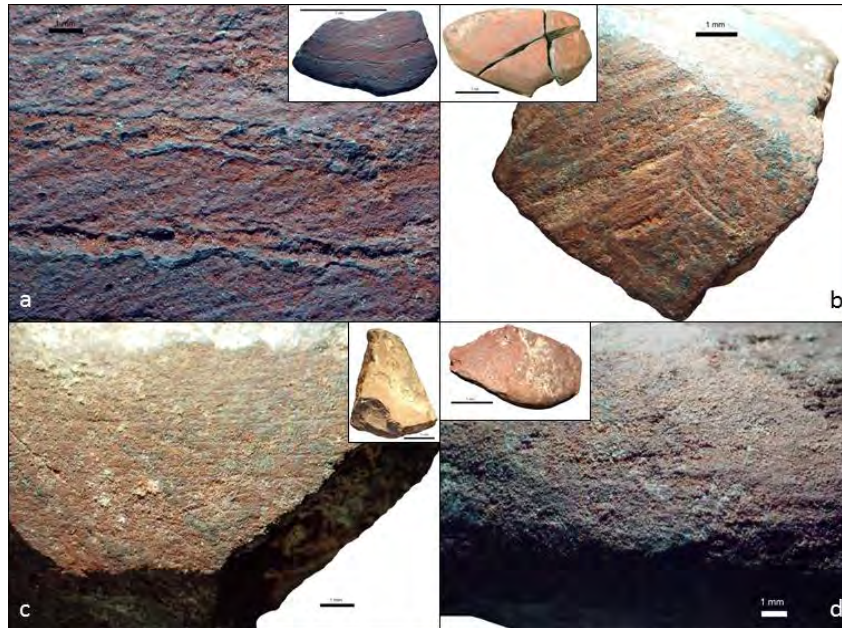
The Sibudu MSA ochre assemblage consists of 9286 pieces, with a total weight of 15.4 kg. All pieces >8 mm were analysed, making the analysed assemblage 5449 pieces (Hodgskiss 2012). There are 682 pieces with signs of utilization, that is, 12.5 per cent of the assemblage. Pieces were microscopically examined to identify all use-traces. Based on the types of use-traces, pieces were then placed into activity categories that were established from the experimental ochre studies (Hodgskiss 2010).

Ochre at Sibudu was used for a variety of activities (Hodgskiss 2013). Throughout the sequence, the use-traces on the ochre at Sibudu suggest that most pieces were used for powder-production (76.1 per cent) rather than for other activities where negligible quantities of powder were produced, perhaps unintentionally. The most common use-traces found at Sibudu are ground pieces that were subsequently rubbed on a soft material (n=215) (Fig. 3a, b). These pieces are frequent throughout the sequence. A further 74 pieces have definitely been rubbed and were probably ground prior to rubbing, but the grinding cannot be positively identified (Fig. 3c, d).

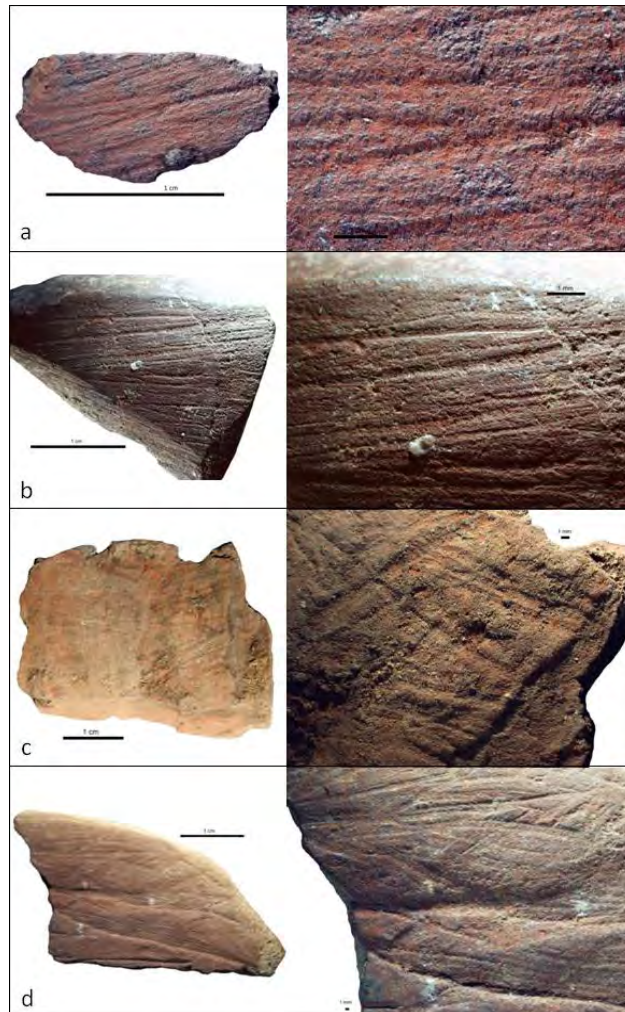
There are 158 pieces with grinding use-wear markings alone (Fig. 4a, b). Grinding has been experimentally determined to be an effective way of producing powder

(Hodgskiss 2010; Rifkin 2012; Wadley 2005a). Fifteen pieces display only scoring use-traces and 14 more pieces have scored incisions and markings from other activities. Some scoring is intensive and would have resulted in powder production (Fig. 4c, d). Other scored incisions are more carefully engraved, sometimes forming parallel lines (Fig. 5) or fan-shaped designs (Fig. 6).

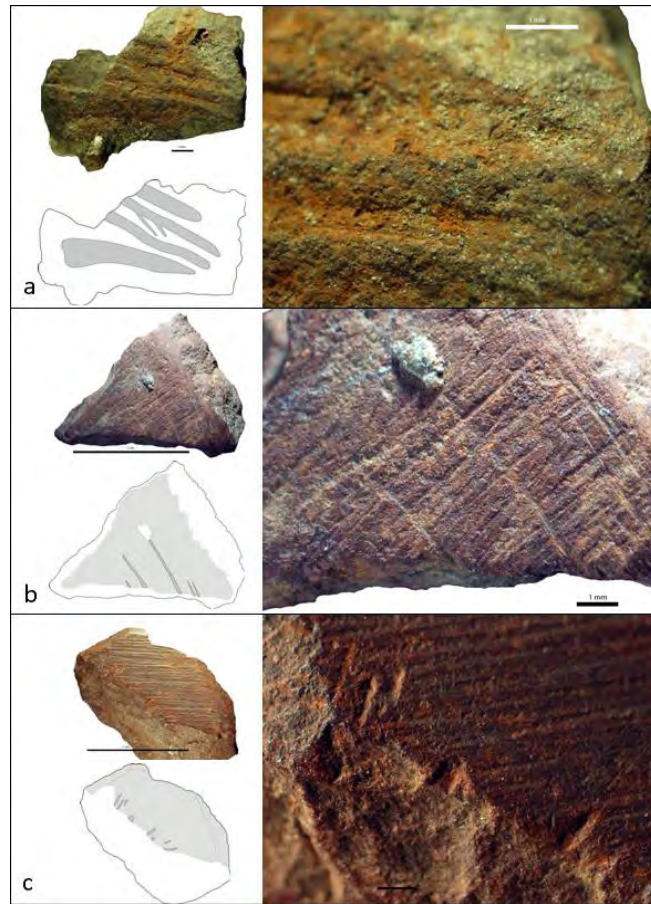
There is considerable geological variety in the ochre assemblage (Hodgskiss 2012, table 1). A smaller range of ochre properties is evident in the utilized assemblage than in the unutilized assemblage, which suggests that specific types of ochre were chosen for use. Shale and pieces with a medium hardness were favoured for use (Hodgskiss 2012). Grain size frequencies change through time in the utilized and unutilized assemblages (Hodgskiss 2012, fig. 4); silty pieces predominate in the upper layers, whereas clayey pieces are more prevalent in the lower layers. Bright-red pieces predominate throughout the sequence, but brown-red pieces are also common (Hodgskiss 2012, fig. 5). Bright-red pieces dominate all the activity categories except the pieces with light scoring, where brown-red pieces are more common. There are few yellow pieces in the Sibudu assemblage and they are almost entirely unutilized. Mica-rich, bright-red pieces were favoured for activities that result in the production of powder.



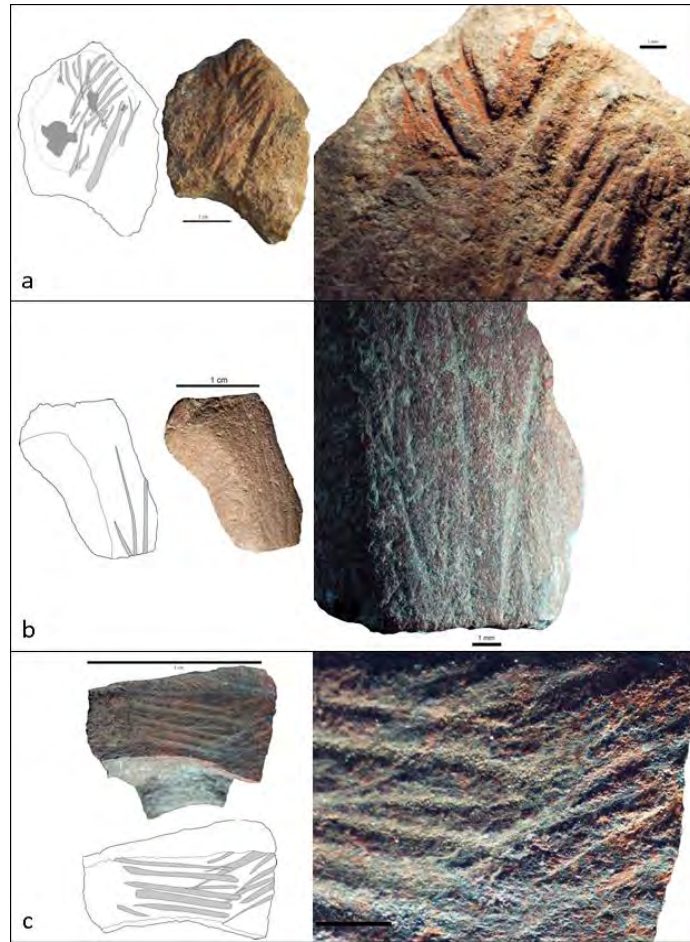
**Figure 3.** Ochre pieces from Sibudu with use-traces indicating they were used for combined grinding and rubbing activities or ‘probable grinding, definite rubbing’ activities. (a) Shale (Sb5044) with a flat, ground surface. The striations have been smoothed from subsequent rubbing activities. (b) Shale refit (Sb2310) that was ground intensively causing facets to form. The piece was then rubbed against a soft material resulting in polish and the smoothing of striations. (c) Shale (Sb4814) that was probably ground before rubbing causing facets to form, but only external microstriations (and no striations) are visible on the utilized surface. (d) Shale (Sb3741) that is faceted and smoothed, implying it was ground and then rubbed, but grinding striations have been removed.



**Figure 4.** Powder production: ochre pieces from Sibudu that have use-traces from grinding or from intensive scoring. (a) Shale (Sb4802) that has been ground to form a flat, striated surface. (b) Shale (Sb4074) that has been ground to form facets. (c) Shale (Sb5372) with intensive, erratically-placed incisions of various widths and depths. (d) Shale (Sb5092) that has intensive erratically-placed incisions of various widths and depths. Different tools were used to score this piece and many incisions were made with multiple strokes. One edge of the piece is rounded from rubbing.



**Figure 5.** Ochre pieces from Sibudu that are engraved with parallel lines, sometimes on top of grinding striations. (a) Broken shale fragment (Sb2741) with four parallel incisions, most of which were made with single strokes. (b) Triangular shale piece (Sb3112) that was ground and then scored. The single-stroke incisions are perpendicular to the grinding striations. (c) Shale (Sb2187) with small scored incisions on one side of the ground surface. The single-stroke incisions are randomly spaced and some irregularity in incision width suggests they may have been made with different tools.



**Figure 6.** Ochre pieces displaying fan-shaped engravings. (a) Weathered dolerite (Sb5242) that has been scored on a soft, red section of the piece. Some incisions were made with multiple strokes and the sequencing of incisions is somewhat erratic. (b) Shale (Sb5000) with three, single-stroke incisions that form a simple fan-shape. The piece has superficial scratches on it and the piece was originally larger, but was broken (on the right side of the piece) after scoring. (c) Shale (Sb5058) that has two groups of parallel incisions that cross over each other at one end. The incisions on the right (edge) of the piece were made before the group of incisions in the centre of the piece.

## **Cognitive implications of ochre use**

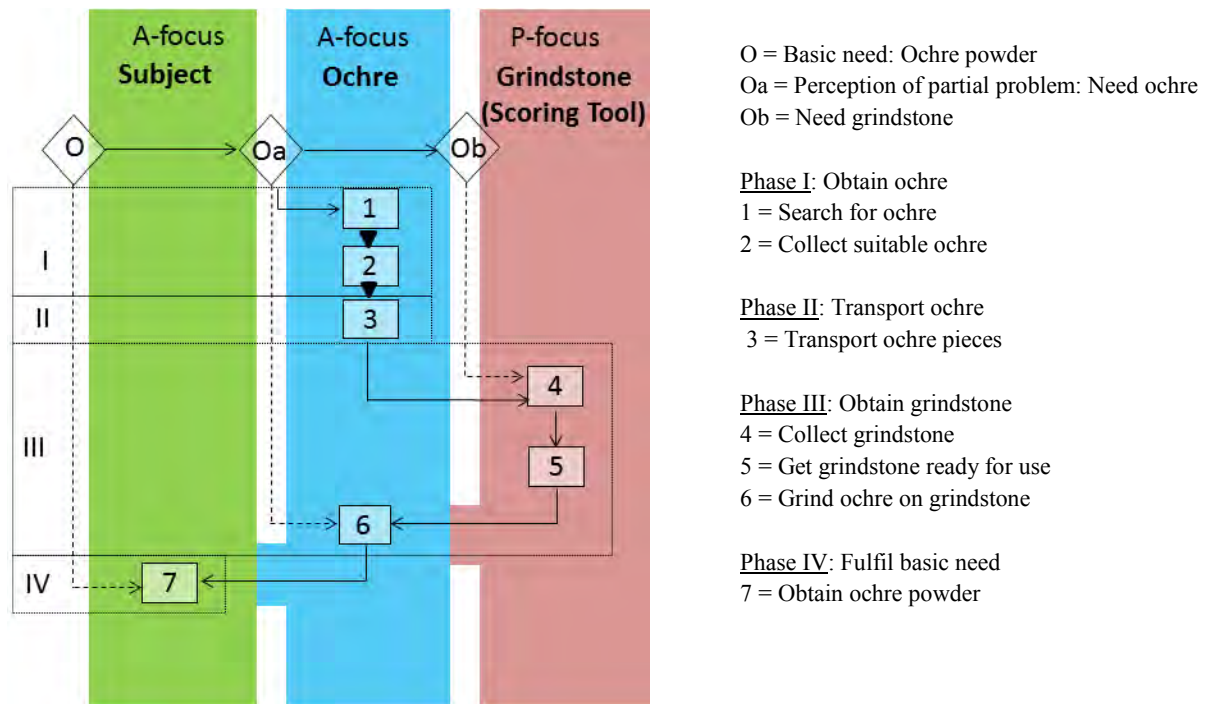
*1) The cognitive implications of powder production by grinding or scoring (Fig. 7 & Fig. 8).*

Most ochre pieces at Sibudu were used to produce powder (76.1 per cent), mostly by grinding, but also by intensively scoring the ochre pieces (Fig. 4c, d). Apart from the use-traces, we know ochre powder was being produced at Sibudu because it has been found on various objects – ochre powder residues on stone tools (Lombard 2006, 2007, 2011; Wadley 2005b, 2010c; Wadley *et al.* 2004, 2009; Williamson 2004, 2005) and grindstones (Wadley 2006a, 2010d), and ochre powder patches that are sometimes on cemented work surfaces (Wadley 2010b, 2012).

Besides the use of ochre powder in MSA adhesives (discussed in section 2), interpretations of how and why ochre powder was used are largely speculative. While this is frustrating, it is possible to bypass the fact that we do not know some of the applications of the powder and construct a thought-and-action sequence for powder production at Sibudu (Fig. 7). From this, reinforced with archaeological evidence and insight gained from experimental ochre use, we can infer what cognitive abilities were necessary to produce ochre powder (Fig. 7 & Fig. 8).

The motivating and basic need is therefore powder production (Fig. 7 ‘O’ & Fig. 8C) and the active foci in the process of producing powder are the ochre and the subject – the ochre powder (Fig. 7). The grindstone and/or the stone flake are passive-foci during the activity (although a scoring tool may be an active focus). The grinding procedure is the more common way of producing powder at Sibudu than by intensive scoring (n=503 versus n=12). Powder production takes place over four phases and

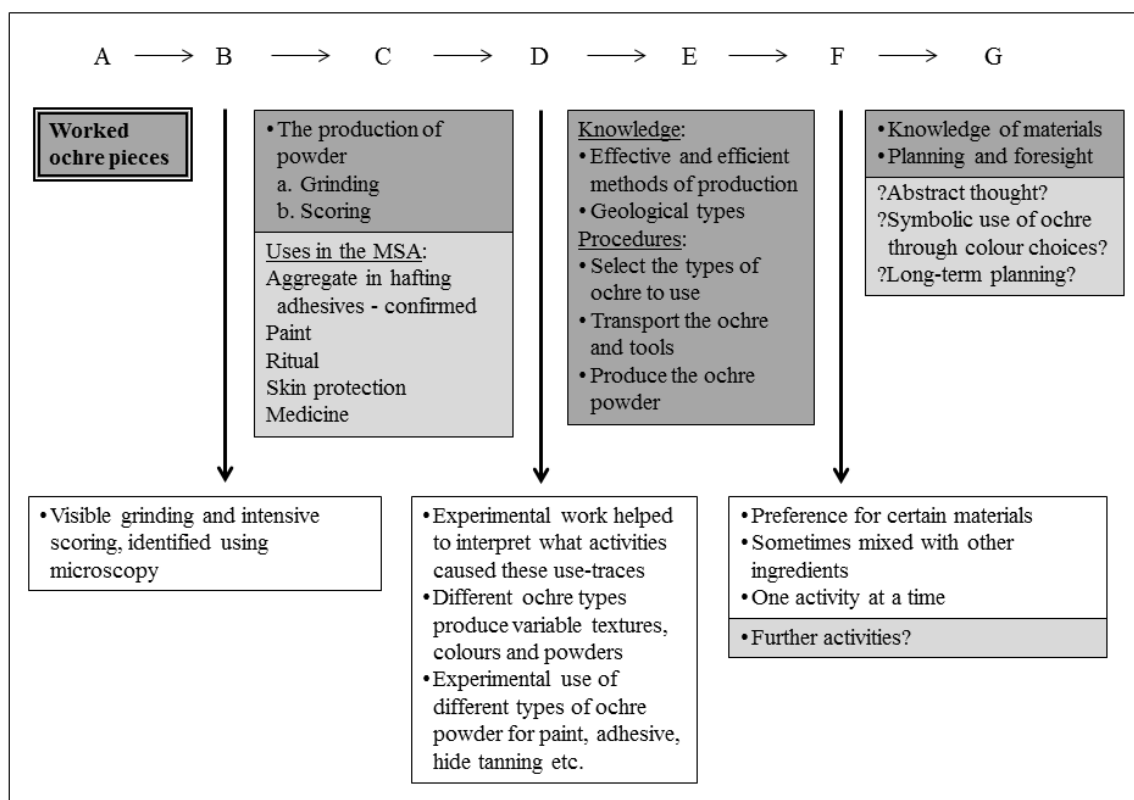
requires seven operational steps. The first phases are finding, collecting and transporting the desired ochre pieces (Fig. 7 phase I). The Ndwedwe shale quarry is about one kilometre from Sibudu and may have offered a convenient source of ochre for the inhabitants at the shelter.



**Figure 7.** The thought-and-action sequence for powder production

The types of ochre chosen for powder production may denote certain applications (which presumably would have motivated the desire to produce ochre powder). The colour distribution of these pieces at Sibudu is similar to the whole utilized assemblage, but there is an increase in the percentage of bright-red and mica-rich pieces. Red pieces may have been chosen for symbolic or emblematic reasons, for example red may have been used ceremonially to symbolize blood. Alternatively, colour may have been an indicator of chemical content (Cornell & Schwertmann 2003; Hovers *et al.* 2003). For instance, it is possible that red pieces and powder were chosen because they are efficient

substances for hide tanning (see Rifkin 2011). The choice of visually salient bright-red and micaeous pieces for powder-production may denote a more visually-dependent and aesthetic use. The grain size changes through time at Sibudu, from clayey in the older layers to silty in the younger, may signify different applications of the ochre powder. These aspects all expand the problem-solution distance of this activity as well as provide insight into the thought processes used during the activity (Fig. 8D, E).



**Figure 8.** The cognitive inferential sequence for ochre pieces used for powder-production.

After the ochre has been collected, a suitable grindstone has to be collected or the correct scoring tool (stone flake) has to be found or made (Fig. 7 step 4). Grindstones suitable for ochre grinding are readily available in the Sibudu sandstone shelter. The final steps in the activity involve picking up the ochre and grinding it against the grindstone until powder is produced, or picking up the scoring tool and scraping it

against the ochre piece until ochre powder is produced (Fig. 7 phase III). These actions result in the fulfilment of the basic need for ochre powder (Fig. 7 step 7). The procedure shows simple thought-and-action processes and does not demonstrate a great distance between problem and solution.

Looking deeper at the cognitive steps required, the link between the ochre piece and obtaining ochre powder is relatively straightforward. The use-wear and activity sequence shows that the users knew efficient ways to create powder, and all the tools needed to do so (Fig. 8E, F). The collection and choice of certain types of pieces (bright-red, mica-rich) demonstrates knowledge of the material and a desire to utilize particular types of ochre for powder creation (Fig. 8E). The activity demonstrates the ability to plan for future activities – although we do not know how long-term this planning was (Fig. 7 & Fig. 8G).

Ochre powder production does not require cognitively advanced skills. There is no evidence to suggest that these activities were executed concurrently with another activity (technological symbiosis), therefore there is no evidence of the need to multi-task or switch attention during these activities (Fig. 7 & Fig. 8F, G). The powder may have been mixed with other substances for various applications, but the only evidence of this is the adhesive residues at some MSA sites. Future analysis of the residues found on (ochre-stained) grindstones may add to this interpretation.

## *2) The cognitive implications of the use of ochre powder in compound adhesives (Fig. 9).*

One confirmed application of ochre powder in the MSA at Sibudu is as an aggregate in hafting adhesives (Lombard 2006, 2007, 2011; Wadley 2005b, 2010c; Wadley *et al.* 2004, 2009, 2013; Williamson 2004, 2005). We do not know for certain why ochre powder was

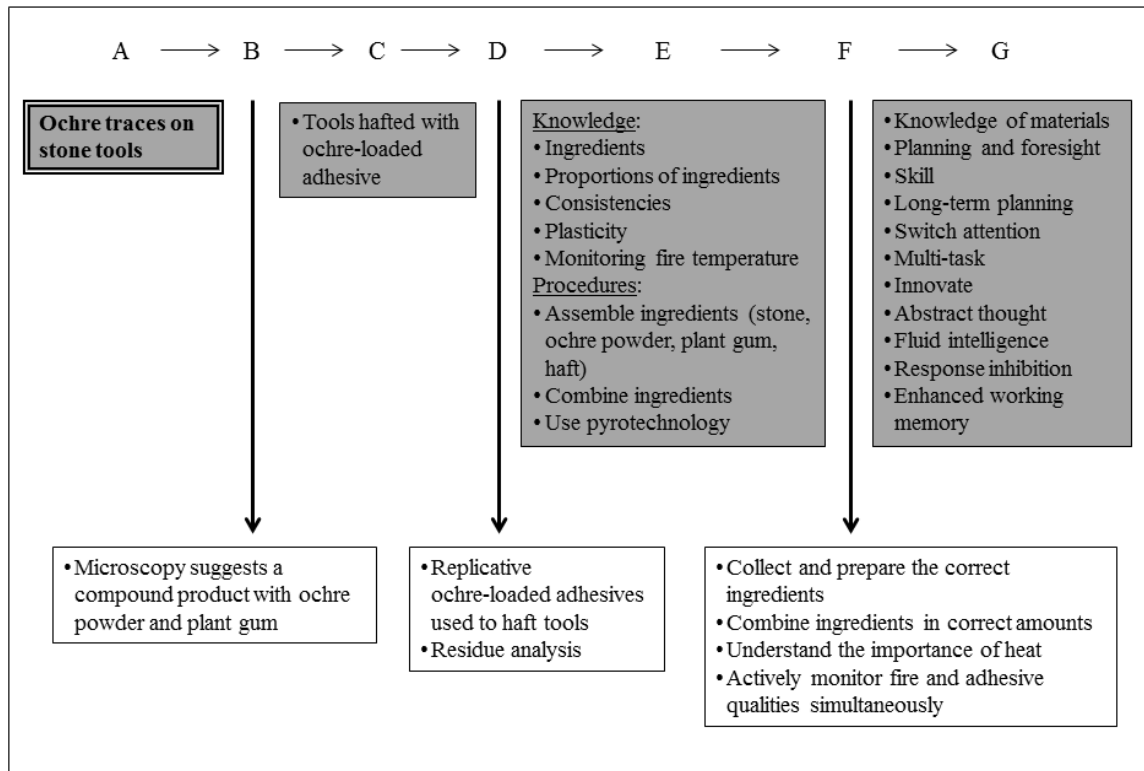
added into the hafting adhesives at Sibudu (or at other MSA sites); we do not know whether it stemmed from an advanced understanding of its workability in the adhesive, or if its addition was symbolic. However, it has been experimentally determined that the addition of (red) ochre powder in hafting adhesives is functionally effective (Wadley 2005, 2006a, 2010c; Wadley *et al.* 2009).

The thought-and-action sequences and cognitive requirements for this activity have been previously demonstrated by Lombard & Haidle (2012: 248, fig. 6c) and Wadley (Wadley *et al.* 2009, 2013; Wynn 2009). The procedures and knowledge needed to perform this activity were ascertained by both residue analysis and replication studies. Ochre residues and plant gum, fat and/or plant tissue residues, as well as microwear and macro-fractures, on the stone tools imply that the tools were hafted, sometimes with an ochre-loaded, compound adhesive (Fig. 9B, C, & D; Lombard 2006, 2007, 2011; Wadley 2005b; Wadley *et al.* 2004; Williamson 2004). This evidence allows us to confirm the technical system for which (at least some of) the ochre powder at Sibudu was used (Fig. 9C).

Creating compound adhesive requires two passive foci – the plant gum and the ochre, which have to be manipulated with the active foci – the grindstone, the stirring tool and the fire (Wadley *et al.* 2009; Lombard & Haidle 2012: 248, fig. 6c). The whole process involves 15 operational steps taking place over six phases (as in Lombard & Haidle 2012). The process of hafting with ochre-loaded adhesives was established through experiments (Fig. 9D; Allain & Rigaud 1986; Wadley 2005b, 2006a, 2010c; Wadley *et al.* 2009).

The creation of these adhesives is not straightforward because qualities of the ingredients vary constantly (Fig. 9E). The moisture content in plant gum fluctuates, for

example, and this dictates how much aggregate is necessary for the adhesive. A mixture of particle sizes in the aggregate is important for successful adhesive manufacture. Further, it is necessary to add aggregates containing iron or silicon, which causes a chemical reaction to occur in the mixture and in turn raises the pH and guarantees successful cementation (Wadley *et al.* 2009).



**Figure 9.** The cognitive inferential sequence for hafting with an ochre-loaded compound adhesive.

Once the mixture is made, attention is switched between checking adhesive properties, which change continually during heating, and simultaneously monitoring the fire and controlling its heat (Wadley *et al.* 2009). Immediate, unexpected changes to tasks may be necessary. The artisans would need to understand the vital role of heat in the process of compound adhesive manufacture because heating ensures successful dehydration and hardening of the adhesive. Once the tool has been inserted onto the haft

with the moist adhesive, the adhesive still needs to be monitored. The heat from the fire must not dry out the adhesive quickly or burn it, and the adhesive must not seep or slip, causing the tool to move.

The most important development in this thought-and-action process is when the separate components with different qualities (plant gum and ochre, as well as the addition of heat) all come together to form one unit, in order to best solve a problem or need. This development is identified as the complex cognitive component of *composition* (Lombard & Haidle 2012: 248, fig. 6c). The steps required for making compound adhesives (with ochre) found at Sibudu require the use of various enhanced executive functions (Fig. 9F, G; Wadley 2013). These include: long-term planning (collect and prepare materials and ingredients, and make the stone tools and hafts beforehand), multi-tasking and switching attention (monitor and change the adhesive properties and heat), abstract thought (produce a new compound by combining and heating various ingredients), fluid intelligence and response inhibition (monitor and change the ingredients and their ratios, the amount of heat and the position of tool if necessary) and the ability to hold one aspect of the procedure in conscious attention – such as monitoring adhesive properties while doing something else, such as stoking the fire.

A similar inferential argument can be made for the creation of the ‘ochre-rich compounds’ in ~100 ka layers at Blombos (Henshilwood *et al.* 2011: 219). These mixtures are composed of ochre (in one case, ferruginous siltstone), crushed bone, charcoal and quartz and quartzite particles. They were blended together and stored in two *Haliotis midae* shells, and were found together with grinding implements, knapping tools and mammal bone, most of which have ochre residues on them. There is no

evidence (yet) of what the mixture was used for, or applied to, but possible uses include decoration or skin protection (Henshilwood *et al.* 2011).

There are numerous processes involved in creating the mixture, such as obtaining ochre powder, crushing bone and collecting the silicon-rich substance. The process of combining all these elements is evidence of deliberate planning and shows that the user possessed an understanding of why the various ingredients were needed (Henshilwood *et al.* 2011). They also indicate the ability for innovative thinking and long-term planning in the collection, preparation and storing of the materials (Henshilwood *et al.* 2011). The procedure demonstrates composition and requires the use of abstract thought because the ingredients, once combined, form a unique compound that no longer bears resemblance to the original ingredients. Although the method of manufacture and use has not yet been established or confirmed (e.g. was heat imperative to create the mixture? Did certain tasks need to be performed simultaneously?), some enhanced cognitive abilities are required to produce any compound substance. Future research into the chemical properties of the mixture may help develop this sequence.

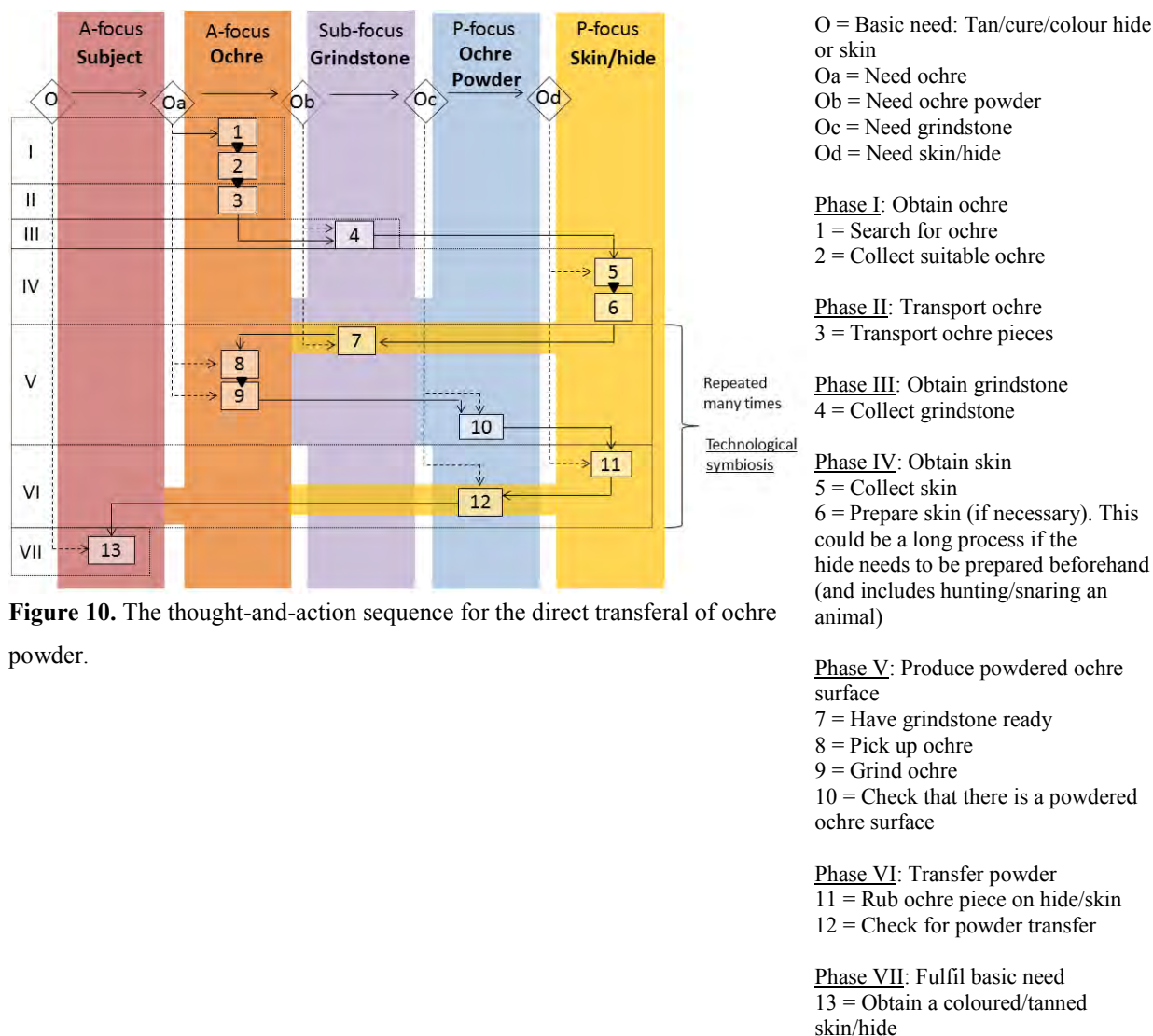
*3) The cognitive implications of applying ochre powder to materials through direct rubbing* (Fig. 10 & Fig. 11).

Combined grinding and rubbing is the most common use-wear found on the Sibudu ochre (n=215, almost a third of the utilized assemblage). In order to transfer any powder directly from a piece of ochre to a soft material, the ochre piece (especially if Mohs 3 or harder) needs to be ground from time to time during the rubbing activity (Fig. 11D; Hodgskiss 2010; Soressi & d'Errico 2007; Soressi *et al.* 2008). Further, to cause smoothing of grinding striations (to the degree found at Sibudu) together with other use-

wear markings, such as external microstriations, metallic lustre and polish, the ground surface must have been rubbed on a soft material such as human skin or animal hide (Fig. 11A, B, C & D; Hodgskiss 2010; Rifkin 2012). The soft materials against which ochre pieces were rubbed are not preserved at Sibudu (or at any MSA sites), but the use-traces on ochre confirm that this activity did occur. Whether the ochre was applied onto the material for aesthetic, symbolic or functional purposes is inconsequential for understanding the thought-and-action sequence.

The thought-and-action sequence for the direct transferal of ochre powder (Fig. 10) shows that this procedure is more complex than that of powder production. There are two active foci in the sequence – the subject and the ochre. There is one sub-focus, which is the grindstone, and two passive foci – the ochre powder and the skin/hide. The procedure takes place over six phases and requires 14 operational steps. First, the user needs to find, collect and transport the ochre as well as the grindstone (Fig. 10 steps 1–4).

The types of ochre used are the same as those used for the activities that produced powder (bright-red, mica-rich pieces), which indicates that they were treating the same materials in various ways depending on the task at hand, or in response to different needs. This may imply that the visual qualities were important and were used for ritual or aesthetic reasons. However, it is plausible that they were used for hide tanning because it has been experimentally determined that red ochre is a more effective inhibitor of the putrefaction and desiccation of hides than yellow ochre, and that it produces a more pliable hide (Rifkin 2011).



**Figure 10.** The thought-and-action sequence for the direct transfer of ochre powder.

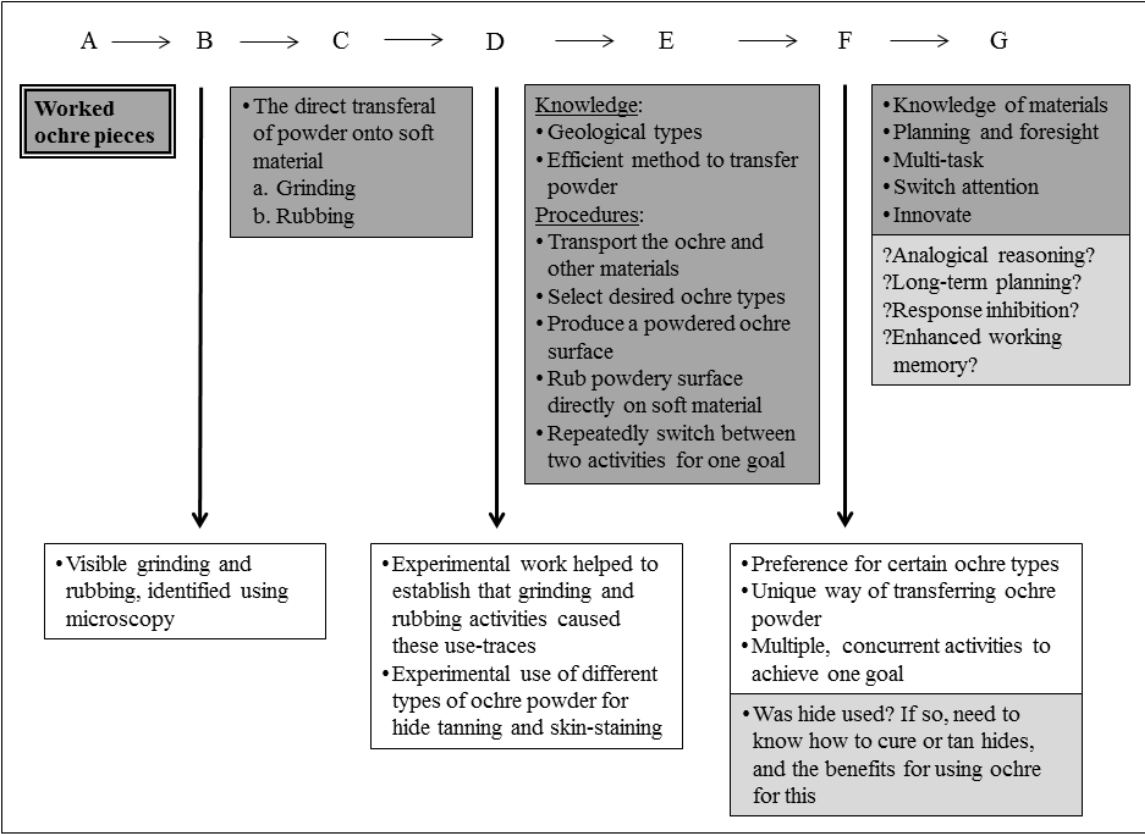
After the tools are acquired, the soft material needs to be prepared for the rubbing activity. This process may have been lengthy in itself if an animal needed to be hunted and skinned, and the hide then obtained. The most parsimonious option in the activity sequence is that human skin was the soft material acted on. It would not have required much (if any) preparation and hence, for the purpose of this analysis, the activity sequence for obtaining and preparing the material takes place over only two operational steps (Fig. 10 phase IV). When the soft material is ready, the ochre pieces and grindstone will need to be available so that the direct transfer of powder can occur. The

ochre is then intermittently ground against the grindstone between rubbing the powdered ochre surface against the soft material (Fig. 10 steps 7–12) in order to abrade its surface and facilitate further powder removal in another rubbing sequence.

There is a substantial distance between problem and solution in this sequence, especially because phases V and VI need to be repeated many times in order to fulfil the basic need (Fig. 10 steps 7–12). The direct transferal of ochre powder to the soft material bypasses the need to store the powder, and could also be done at any time when the hide or skin was ready for use. This activity demonstrates that the user knew what types of ochre to transport and use, as well as the most efficient way to produce and transfer the powder (Fig. 11E). It also shows an innovative way in which ochre was applied to a material, apart from using powder created by grinding or intensive scoring (Fig. 11F, G). This direct rubbing method would have been more time-consuming and probably less efficient than grinding ochre and placing the powder on the hide. A possible reason this method was used was to help soften the hide by rubbing the ochre (and may have been done as part of the scraping and cleaning of the hide).

Direct powder transferal requires multiple inter-dependent and concurrent activities, with a variety of materials, be performed to complete one goal. This reveals technological symbiosis and the capacity for flexible thinking (Fig. 10) because these methods are associated with other procedures, but have here been adapted to achieve a unique goal (Fig. 11E, F & G). Alternating between grinding and rubbing ochre on different mediums (grindstone and soft material) to perform a common goal requires the ability to multi-task and switch attention between the different activities. The process may also require the capacity for analogical reasoning (by performing two separate activities to complete one goal). Response inhibition may be required as well because

the length of time between the grinding stints changes depending on how quickly the powder is rubbed off the surface of the ochre. This timing, however, could be learnt through experience and procedural memory and so may not denote enhanced working memory capabilities.



**Figure 11.** The cognitive inferential sequence for the direct transferal of ochre powder through direct rubbing and intermittent renewal of the ochre surface by grinding.

This procedure can be likened to the abrading of the platform during blade manufacture (e.g. Delagnes *et al.* 2006, Soriano *et al.* 2007). This technique was used in the Howiesons Poort at Sibudu (Delagnes *et al.* 2006). Fewer raw materials are needed to create a blade than to apply ochre to a soft surface, but both processes require that the surface first be prepared (by grinding) for the secondary activity to be successful. The grinding also needs to be performed from time to time during the knapping or rubbing

process. The main difference between this knapping technique and applying ochre by direct rubbing is that there is no switching between the passive and sub-foci during knapping. Therefore the grinding during knapping does not exhibit a technological symbiosis or the same degree of task and attention switching than grinding and direct rubbing does. Using abrasion in the knapping procedure during blade creation requires an advanced level of skill and expertise, but this can be learnt through practice and procedural memory.

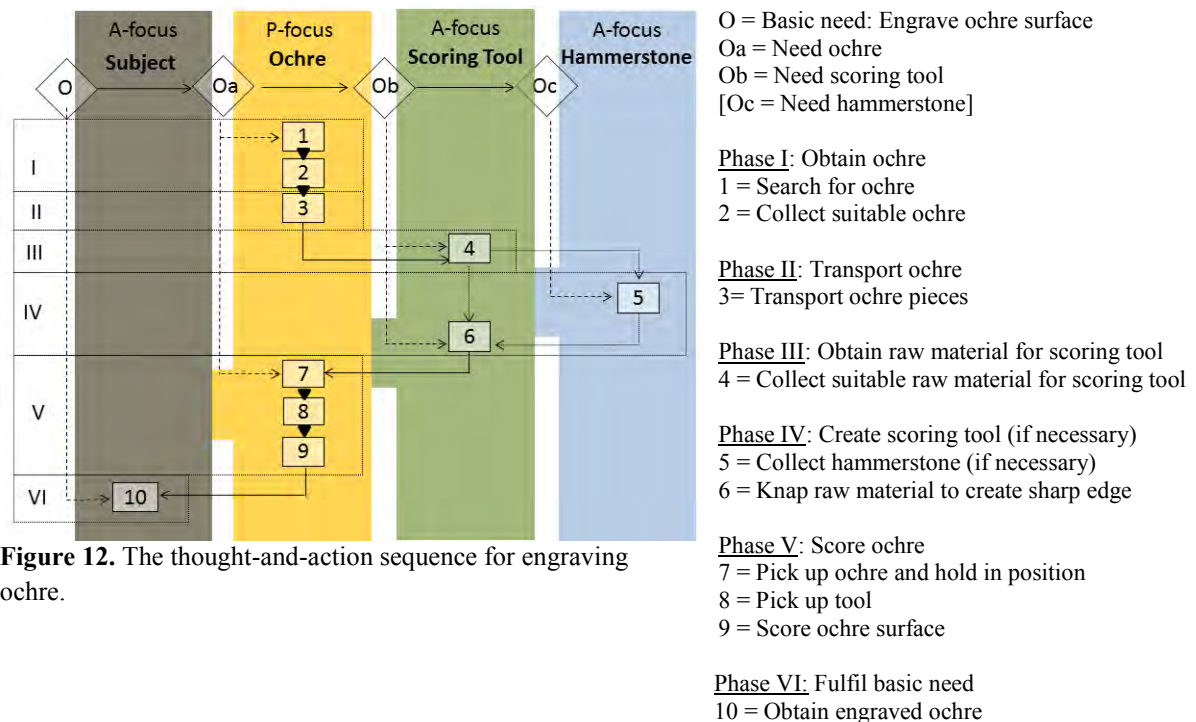
#### *4) The cognitive implications of engraving ochre (Fig. 12 & Fig. 13).*

There are few deliberately engraved ochre pieces from Sibudu. They occur with and without other use-wear from grinding and rubbing activities (Fig. 5 & Fig. 6). Pieces that appear deliberately engraved are different from those displaying intensive scoring for powder production (discussed in section 1). The incisions or engravings were created by controlled strokes, some of which were re-incized with multiple strokes, signifying that the engraver wished to create deep or clear incisions (Fig. 12 'O' & Fig. 13B, C & D).

There are three active foci in the engraving thought-and-action sequence – the subject, the scoring tool and the hammerstone (Fig. 12). There is one passive focus – the ochre piece. The first steps in the procedure are to find, collect and transport the ochre piece (Fig. 12 steps 1–3). Unique pieces appear to have been chosen for engraving (Hodgskiss 2013) since more brown-red pieces were used for engraving than for powder production and transferal. This may imply that the colour was not as vital an attribute for these ochre pieces as it was for powder production. The choice of unique ochre

pieces for engraving is documented at other MSA sites (d'Errico *et al.* 2012; Henshilwood *et al.* 2009; Watts 2010).

The thought-and-action sequence to create engraved ochre takes place over six phases and requires 10 operational steps (Fig. 12). Microscopic analyses of the incisions did not show that a retouched edge was used, but sharp edges of stone flakes were needed, so it is likely that the flakes were chosen or made with some consideration (Fig. 12 steps 4–6; Hodgskiss 2013). The process may have been simpler than shown in Figure 12 because phase IV may not have been necessary.



**Figure 12.** The thought-and-action sequence for engraving ochre.

The incisions on most of the pieces have uniform profile shapes, indicating that one tool was used per piece and incisions were made with controlled motions (Fig. 13D, E). This is substantiated by the presence in the Sibudu MSA sequence of some stone tools with ochre residues on the working edges (Williamson 2005). Only one ochre

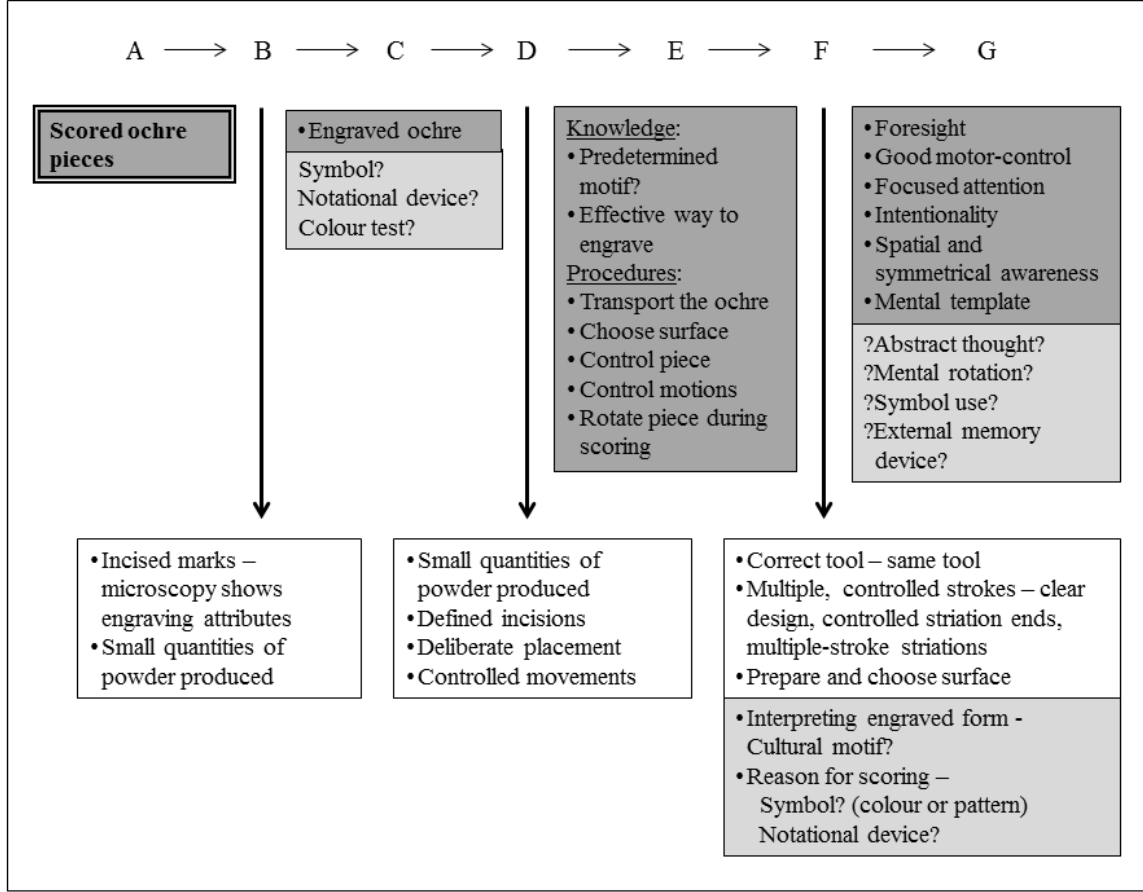
piece (with intensive scoring) has evidence that a tool of a different material may have been used (Fig. 4d). The incisions on this piece vary in width, with some single-stroke incisions almost 5 mm wide.

Many of the incisions are made on flat surfaces, making engraving easier and implying that the surfaces may have been chosen for their topography (Fig. 13D). The grinding evident on some pieces may have been performed to prepare a flat surface on which to engrave (e.g. Fig. 5b). The act of scoring requires that the ochre be held securely or be stabilized on a surface while the flake tool is held with the other hand (Fig. 12 phase V). The controlled motions and deliberate placing can be further seen in the regularity and symmetry of the incisions (Fig. 5a, b & Fig. 6a), the sequence in which the incisions were engraved (Fig. 6c), the consistent pressure applied shown by the steady depth of the incisions on each piece, and the controlled placing of the start or end of the incisions (Fig. 5b, Fig. 6c & Fig. 13E, F; see also Henshilwood & d'Errico 2011).

To create the Sibudu engravings therefore required good hand control and focussed attention (Fig. 13F, G). A mental conception of form and space (visuo-spatial guidance) are required for a few of the pieces that have clear designs and/or sequenced incisions (Fig. 5 & Fig. 6), suggesting foresight and intentionality of actions (Fig. 13F, G). The thought-and-action sequence may seem overly simplistic because we cannot know the reasons for making the incisions and whether the engravings formed part of a larger social system or were imbued with symbolism.

The repeated appearance of parallel incisions may indicate a motif or cultural theme, but there is great variety between the pieces incized in this way. Some of the parallel lines on the Sibudu ochre may have functioned as notational or tallying devices

(e.g. Fig. 5b, c), which acquired markings over time (d’Errico *et al.* 2012; Hodgskiss 2013; Wynn & Coolidge 2011). More evidence is necessary to conclude that these pieces were indeed notational devices.



**Figure 13.** The cognitive inferential sequence for the engraving of ochre.

Fan-shaped designs are found on six Sibudu pieces. They are not uniform in their design, but the incisions on each piece are made with the same pointed tool and the incisions show a degree of symmetry. There is a link between fan-shapes and natural motor patterns (in humans and chimpanzees, see Wynn 2002), but the careful placing of incisions on some of the Sibudu ochre pieces, and the presence of symmetrical, multiple-stroke incisions insinuate that the incisions were intentionally engraved.

Depending on the reason for the engraving, the act may require abstract thought (Wynn & Coolidge 2007, 2011).

Engraved ochre pieces are rare in MSA sites. The pieces at Blombos and Klein Kliphuis that display crosshatched designs are clear examples of intentional engraving (Henshilwood *et al.* 2002, fig. 2; Mackay & Welz 2008, fig. 5) and likely symbol use. The examples at these sites as well as at Diepkloof Rock Shelter, where ladder-like motifs are found on ostrich eggshell fragments (Texier *et al.* 2010), show the deliberate placing and positioning of incisions (spatial awareness and intentionality) and good motor control (see also Henshilwood & d'Errico 2011). A mental template was needed for some examples because there is intentional sequencing of the incisions, and this possibly also required mental rotation. The thought-and-action sequence does not show that complex cognitive processes were required for the act of engraving. The types of pieces chosen, the markings on the pieces and their placement on the surface may be more telling than the act of engraving.

## **Discussion and Conclusion**

Ochre collection and use was standard practice in the MSA at Sibudu. Ochre was used for a range of activities in a variety of ways. It is clear that time was invested in ochre exploitation – from its collection, preparation and use to the organization of the materials that were used with it (grindstone, scoring tool, soft material, plant gum). The use of MSA ochre processing to interpret cognitive abilities is not straightforward when we do not know the intended application of the ochre pieces (and ochre powder). Notwithstanding this disadvantage, creating thought-and-action sequences and

inferential activity sequences can provide insight into behavioural and cognitive abilities of people in the past.

Evidence of ochre powder production is common throughout the Sibudu sequence. Producing powder from ochre is a simple process that requires planning, foresight and knowledge of the materials, but the activity has a short problem-solution distance and does not require that the artisans possessed cognitively advanced brain functions (Table 1). Having knowledge about the application of the ochre powder in the MSA can change this interpretation by both establishing the basic need in the creation of ochre powder and demonstrating the complete problem-solution distance in the procedure.

Some of the ochre powder at Sibudu was transformed into compound adhesive. Evidence of hafting with compound adhesives is found as early as ~71 ka at Sibudu, in the Still Bay. The adhesive making process involves an intricate series of diverse actions that require the complex cognitive component of *composition* (Lombard & Haidle 2012: 248, fig. 6c). The steps necessary for making compound adhesives exhibit various enhanced executive functions, such as long-term planning, multi-tasking, switching attention, response inhibition and abstract reasoning (Table 1).

Powder transferral by direct rubbing on soft materials is frequent at Sibudu especially in the post-65 ka layers, but is also evident in the ~77 ka, pre-Still Bay layers. This innovative procedure is quite complex and requires advanced cognitive abilities to multi-task and switch attention because the rubbing needs to be alternated with grinding of the ochre surface on a grindstone to refresh its ability to transfer powder (Table 1). Technological symbiosis is demonstrated because these independent methods have been adapted to achieve a common goal. If hides were in fact the soft material used, then the

problem-solution distance increases. In the post-65 ka layers, there is also a sophistication of hunting and capture methods. The faunal remains show an increase of small animals, such as the blue duiker, monkey and small carnivores (Wadley 2010a). Hide tanning methods may have had to change because of the increased availability of small hides and it may have been necessary to invent new and efficient ways to preserve hides.

**Table 1.** Temporal changes in the mental abilities required during each activity. The percentages indicate the portion of pieces used for each activity in the industry. Percentages >30 are darkly shaded, percentages between 20 and 29 have medium shading and percentages between 10 and 19 have light shading. The Still Bay sample is small and so percentages may be unreliable. The amount of ochre pieces that were ground and used for hafting adhesives is unknown.

|                             |                   |             | Simple cognitive abilities |                        |       |                    |            | Complex cognitive abilities |                  |                    |                     |                      |                  |
|-----------------------------|-------------------|-------------|----------------------------|------------------------|-------|--------------------|------------|-----------------------------|------------------|--------------------|---------------------|----------------------|------------------|
|                             |                   |             | Knowledge of Materials     | Planning and Foresight | Skill | Good Motor Control | Innovation | Multi-task                  | Switch Attention | Fluid Intelligence | Response Inhibition | Analogical Reasoning | Abstract Thought |
| <b>Final MSA</b>            | Powder            | 20%         | y                          | y                      | y     | -                  | -          | -                           | -                | -                  | -                   | -                    | -                |
|                             | Direct Transferal | 20%         | y                          | y                      | y     | -                  | y          | y                           | y                | -                  | -                   | y                    | -                |
|                             | Hafting           | <20%        | y                          | y                      | y     | y                  | y          | y                           | y                | y                  | y                   | y                    | y                |
|                             | Engraving         | 2.5%        | -                          | y                      | -     | y                  | -          | -                           | -                | -                  | -                   | -                    | -                |
| <b>Late MSA</b>             | Powder            | 29.8%       | y                          | y                      | y     | -                  | -          | -                           | -                | -                  | -                   | -                    | -                |
|                             | Direct Transferal | 34.8%       | y                          | y                      | y     | -                  | y          | y                           | y                | -                  | -                   | y                    | -                |
|                             | Hafting           | 0           | -                          | -                      | -     | -                  | -          | -                           | -                | -                  | -                   | -                    | -                |
|                             | Engraving         | 2.8%        | -                          | y                      | -     | y                  | -          | -                           | -                | -                  | -                   | -                    | -                |
| <b>Post-Howiesons Poort</b> | Powder            | 21.7%       | y                          | y                      | y     | -                  | -          | -                           | -                | -                  | -                   | -                    | -                |
|                             | Direct Transferal | 32.1%       | y                          | y                      | y     | -                  | y          | y                           | y                | -                  | -                   | y                    | -                |
|                             | Hafting           | <20%        | y                          | y                      | y     | y                  | y          | y                           | y                | y                  | y                   | y                    | y                |
|                             | Engraving         | 1.7%        | -                          | y                      | -     | y                  | -          | -                           | -                | -                  | -                   | -                    | -                |
| <b>Howiesons Poort</b>      | Powder            | 18.9%       | y                          | y                      | y     | -                  | -          | -                           | -                | -                  | -                   | -                    | -                |
|                             | Direct Transferal | 39.6%       | y                          | y                      | y     | -                  | y          | y                           | y                | -                  | -                   | y                    | -                |
|                             | Hafting           | <20%        | y                          | y                      | y     | y                  | y          | y                           | y                | y                  | y                   | y                    | y                |
|                             | Engraving         | 3.8%        | -                          | y                      | -     | y                  | -          | -                           | -                | -                  | -                   | -                    | -                |
| <b>Still Bay</b>            | Powder            | 22.2% (n=2) | y                          | y                      | y     | -                  | -          | -                           | -                | -                  | -                   | -                    | -                |
|                             | Direct Transferal | 22.2% (n=2) | y                          | y                      | y     | -                  | y          | y                           | y                | -                  | -                   | y                    | -                |
|                             | Hafting           | <20%        | y                          | y                      | y     | y                  | y          | y                           | y                | y                  | y                   | y                    | y                |
|                             | Engraving         | 0           | -                          | -                      | -     | -                  | -          | -                           | -                | -                  | -                   | -                    | -                |
| <b>Pre-Still Bay</b>        | Powder            | 24%         | y                          | y                      | y     | -                  | -          | -                           | -                | -                  | -                   | -                    | -                |
|                             | Direct Transferal | 16%         | y                          | y                      | y     | -                  | y          | y                           | y                | -                  | -                   | y                    | -                |
|                             | Hafting           | 0           | -                          | -                      | -     | -                  | -          | -                           | -                | -                  | -                   | -                    | -                |
|                             | Engraving         | 12%         | -                          | y                      | -     | y                  | -          | -                           | -                | -                  | -                   | -                    | -                |

Most clear engraved designs at Sibudu are in layers dated to ~77–58 ka (Table 1).

Engravings are difficult to assess (Henshilwood & d’Errico 2011). The thought-and-

action procedure is simple and there are few steps required in the procedure. However, engraved incisions may imply greater cognitive demands than is initially apparent because of the intentionality of incision placement and an awareness of space and symmetry, implying the use of a mental template before the designs were produced. The creation of these engravings (Fig. 5a, b & Fig. 6a, c) requires visuo-spatial awareness, good motor control, foresight and intentionality (Table 1), but without knowing what the engravings signified to their makers, it is difficult to develop the interpretation further.

Some motifs, such as the fan, are repeated, but there is a lack of clarity of form and standardization between the incisions. This makes it difficult to conclude whether the engravings at Sibudu formed part of an organized system of symbols or held cultural meaning. Some motifs do reappear through time at the site, but they are not found at other sites. Engraving of ochre is therefore not especially certain evidence for complex cognition.

Some of the engraved incisions at Sibudu, Blombos (Henshilwood *et al.* 2009; Henshilwood & d’Errico 2011), Klein Kliphuis (Mackay & Welz 2008) and Klasies (d’Errico *et al.* 2012) show that the engraver had good motor control (this is seen in tool production as well), an awareness of space and symmetry, and possibly had a preconceived idea of the form to be engraved. The creation of some of the more complex designs (e.g. Henshilwood *et al.* 2002; Mackay & Welz 2008), where careful sequencing of incisions is obvious, may have required mental rotation. Further, the use of unique geological forms and/or colours for the engraved pieces is documented in the ochre assemblages at Sibudu, Blombos and Klasies (d’Errico *et al.* 2012; Henshilwood

*et al.* 2009; Hodgskiss 2013; Watts 2010), and may represent a special, perhaps unconventional, use for these engraved pieces.

The colour choices in the Sibudu ochre assemblage may also imply other cognitive capabilities. Bright-red ochre was preferred for use over other colours, especially for powder production. The high frequencies of utilized bright-red ochre and the larger quantities of orange and yellow unutilized ochre, as well as the occasional presence of maghemite, may mean that some pieces were intentionally heated to obtain desired colours (Wadley 2010d). Although there are numerous hearths and combustion features preserved at Sibudu (Goldberg *et al.* 2009; Wadley 2009, 2010b,d, 2012; Wadley *et al.* 2011) and much of the faunal remains and plant material are burnt (Clark & Ligouis 2010; Sievers & Wadley 2008; Wadley *et al.* 2011), the different colour proportions between the utilized and unutilized assemblages imply that post-depositional heating is not responsible for the prevalence of utilized bright-red pieces at Sibudu (Hodgskiss 2012). Research on the possible intentional heating of ochre at Sibudu opens another avenue from which ochre use and its cognitive implications can be explored (Wadley 2013).

It is difficult to determine the reason for the choice of colour because we cannot be certain of the applications of the ochre (powder). Red is visually salient to humans possibly because of the neurophysiology of our colour vision (Hovers *et al.* 2003; Wreschner 1980) and this colour is often linked to ritual or symbolic behaviours (Knight *et al.* 1995). The use of bright-red pieces with mica inclusions suggests that the saliency of the ochre was a likely reason for choice, although the use of red ochre for practical purposes has also been demonstrated (Rifkin 2011; Wadley *et al.* 2009). If ochre was used only for its colour and brightness, then the repeated use of the same

selection parameters throughout an archaeological sequence suggests that ochre use may have been a symbolic tradition that was handed down from generation to generation (Hovers *et al.* 2003).

The meanings and some of the specific uses of ochre in the MSA may be beyond our reach. We cannot know for certain whether the use of bright-red pieces stood for something to the MSA users, whether red ochre was aesthetically important, or whether the colour and mineralogy of the ochre was relevant for its chemical advantages. We also cannot know whether some of engraved designs held (symbolic) meaning for the people who used them or if they functioned on a social level and had meaning to the community in which they were created. The time invested in ochre, from collection and preparation to use, suggests that activities involving ochre were regular and valued.

By investigating the preparation and use of ochre in the MSA, we can gain behavioural and cognitive insight into the people responsible for their collections. The technical evidence provides an indication of the thoughts and actions of the artisans during specific endeavours. Both simple and complex cognitive abilities were required for ochre activities at Sibudu. Performing a simple activity does not mean that the artisan did not have the ability for more complex tasks; it merely shows that the activity itself did not require cognitively advanced abilities. The activities with ochre that require cognitively complex functioning are more prevalent in the Howiesons Poort and younger layers than in the Still Bay and pre-Still Bay layers. The requirement for cognitively complex abilities in some of the ochre-related activities at Sibudu suggests that the people living there during the MSA had advanced mental capabilities like humans living today.

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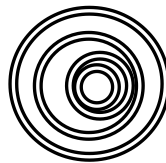
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### **Author biography**

Tammy Hodgskiss has recently completed her PhD in the School of Geography, Archaeology and Environmental Studies and the Evolutionary Sciences Institute, at the University of the Witwatersrand. Her research involved the use of ochre in the Middle Stone Age and how experimental and (micro-) use-wear studies can be used to reconstruct past activities, behaviour and cognition.

# CHAPTER 8

## Discussion and Conclusion



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## 8.1 Temporal and spatial patterns of ochre use at Sibudu

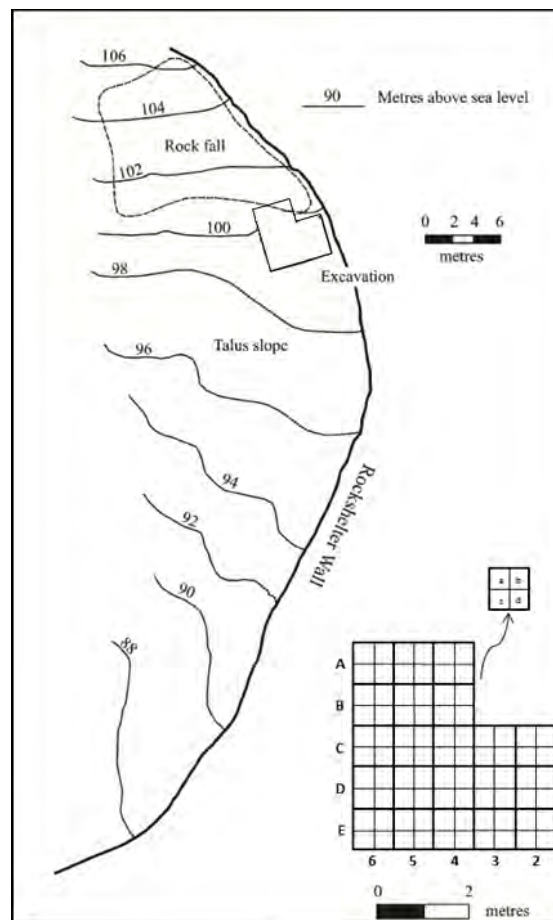
There are significant changes in the lithic and faunal assemblages through the long sequence at Sibudu. The ochre assemblage also reflects some temporal changes and there is evidence of ochre activity areas. Based on sediment volumes in the B5 and B6 squares, the post-Howiesons Poort and the Howiesons Poort assemblages have the highest frequencies of ochre. The pre-Still Bay and Howiesons Poort layers (note that the pre-Still Bay assemblage is small) have higher percentages of utilised ochre pieces than the other industries (20.8% and 16.9% respectively). Compared with the site's mean percentage frequency of utilised pieces (12.5%), there are unusually high percentages of utilised pieces in squares D6 and A6 (~40%) (Fig. 8.1.1). Squares B5, B6 and E6 also have slightly higher percentages of utilised pieces (~25% of ochre pieces from each square are utilised). The elevated frequencies suggest that these areas, situated close to the back of the cave or alongside the rock fall to the north of the excavated area, may represent ochre activity areas. Further details of activity areas through the sequence are provided below. Other ochre activity areas are the ochre patches of various colours sometimes on cemented ash work surfaces (Wadley 2010d). All the industries at Sibudu contain a high percentage of pieces utilised in ways that result in the production of powder.

I begin discussion of the temporal and spatial changes at Sibudu with the oldest excavated layers (~77 ka), the pre-Still Bay layers. They contain relatively few pieces of ochre, but have a high frequency of utilised versus unutilised and possibly utilised pieces (20.8%). There are only three geological forms represented in the pre-Still Bay utilised assemblage – shale, snuffbox shale and weathered dolerite – with shale predominating. Orange pieces are most common in the pre-Still Bay unutilised assemblage—this is the only time in the sequence (in both the utilised and unutilised assemblages) that bright-red pieces do not dominate (see Table 8.1.1).

The pre-Still Bay layers have higher percentages of pieces with scoring than the other layers, with intensively scored pieces (e.g. Fig. 8.1.2f & h) and engraved pieces (e.g. Fig. 8.1.2e & g; Table 8.1.1). The engraved incisions appear to be carefully and intentionally created, forming fan shapes or parallel lines. Pieces used for powder-

production, with grinding and/or rubbing use-traces (Fig. 8.1.2a-d), occur more frequently than scored pieces in the pre-Still Bay ochre assemblage.

The B4 square contains high frequencies of ochre and utilised ochre in many of the pre-Still Bay layers. Square B4 in layer Brown Sand 6 (BS6) has an age of  $\sim 77$  ka and is covered with a layer of unburnt, fossilized plant material comprising layers of aromatic and insecticidal bedding that also contains unutilised ochre, bone fragments, lithics, and a piece of worked bone (d'Errico *et al.* 2012b; Wadley 2012b). In contrast, between  $\sim 73$  ka and 58 ka at Sibudu most of the bedding has been burnt (Wadley *et al.* 2011; Wadley 2012b). The pre-Still Bay bedding found in layer BS6 is unburnt, suggesting changes in site use between these layers and more recent occupations (Wadley *et al.* 2011; Wadley 2012b). The pre-Still Bay lithic assemblage is composed mostly of flakes and blades, and some unifacial and bifacial points (Wadley 2012b).



**Fig. 8.1.1.** Plan of Sibudu with location of excavated squares (modified from Wadley & Jacobs 2006). Each square is divided into four quadrants labelled a to d.

**Table 8.1.1.** The highest and most significant frequencies of ochre properties and use-traces in the pre-Still Bay, Still Bay and Howiesons Poort layers at Sibudu. Percentages indicate the frequency of pieces with each variable in the utilised (U), possibly utilised (PossU) and unutilised (Unu) ochre assemblages per industry. Not all variables are shown in this table therefore percentages do not equal 100% for each category. See Chapters 5 and 6 for unabridged data. Light shading marks the utilised assemblage. Dark shading marks elevated frequencies (>50%).

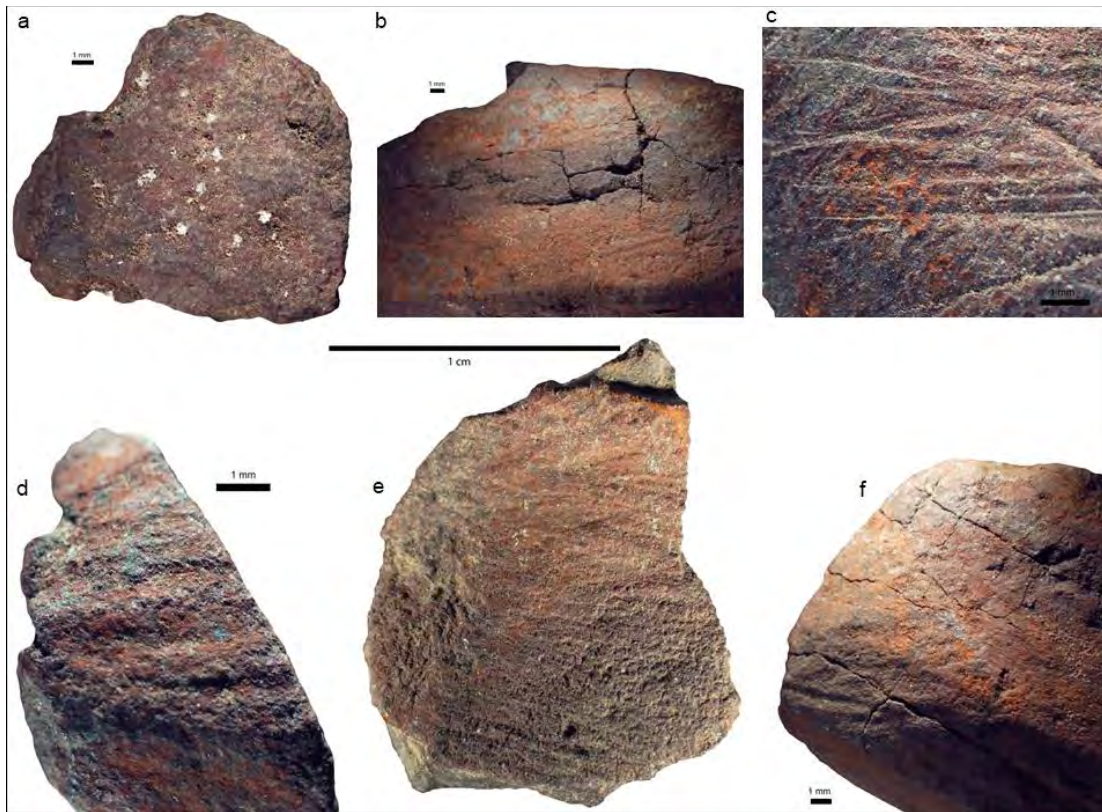
|                                 | Pre-Still Bay (n=120) ~77 ka |     |       |      |     |     | Still Bay (n=59) ~71 ka |     |       |       |       |      | Howiesons Poort (n=313) 65-62 ka |     |       |       |       |      |
|---------------------------------|------------------------------|-----|-------|------|-----|-----|-------------------------|-----|-------|-------|-------|------|----------------------------------|-----|-------|-------|-------|------|
|                                 | UnU                          |     | PossU |      | U   |     | UnU                     |     | PossU |       | U     |      | UnU                              |     | PossU |       | U     |      |
|                                 | n=91                         | n=4 | n=25  | n=50 | n=0 | n=9 | n=50                    | n=0 | n=9   | n=251 | n=9   | n=53 | n=251                            | n=9 | n=53  | n=251 | n=9   | n=53 |
| Ochre properties and use-traces | %                            | n   | %     | n    | %   | n   | %                       | n   | %     | n     | %     | n    | %                                | n   | %     | n     | %     | n    |
| Ochre                           | 56%                          | 51  | 25%   | 1    | 76% | 19  | 32%                     | 16  | -     | 0     | 33.3% | 3    | 37.1%                            | 93  | 44.4% | 4     | 69.8% | 37   |
| Properties                      | 8.8%                         | 8   | 25%   | 1    | 20% | 5   | 8%                      | 8   | -     | 0     | 33.3% | 3    | 14.3%                            | 36  | 11.1% | 1     | 11.3% | 6    |
|                                 | 9.9%                         | 9   | -     | 0    | -   | 0   | 4%                      | 2   | -     | 0     | 11.1% | 1    | 12.7%                            | 32  | 11.1% | 1     | 11.3% | 6    |
|                                 | 39.6%                        | 36  | 25%   | 1    | 36% | 9   | 44%                     | 22  | -     | 0     | 55.5% | 5    | 42.6%                            | 107 | 33.3% | 3     | 52.8% | 28   |
|                                 | 29.7%                        | 27  | -     | 0    | 28% | 7   | 8%                      | 4   | -     | 0     | 11.1% | 1    | 19.5%                            | 49  | 22.2% | 2     | 30.2% | 16   |
|                                 | 35.2%                        | 32  | 75%   | 3    | 16% | 4   | 36%                     | 18  | -     | 0     | 44.4% | 4    | 40.6%                            | 102 | 44.4% | 4     | 28.3% | 15   |
|                                 | 64.9%                        | 59  | 25%   | 1    | 84% | 21  | 62%                     | 31  | -     | 0     | 55.5% | 5    | 59.4%                            | 149 | -     | 0     | 71.7% | 38   |
|                                 | 23.1%                        | 21  | -     | 0    | 44% | 11  | 30%                     | 15  | -     | 0     | 44.4% | 4    | 29.1%                            | 73  | 22.2% | 2     | 49.1% | 26   |
|                                 | 22%                          | 20  | 75%   | 3    | 28% | 7   | 16%                     | 8   | -     | 0     | 22.2% | 2    | 16.3%                            | 41  | 22.2% | 2     | 17%   | 9    |
|                                 | 29.7%                        | 27  | -     | 0    | 8%  | 2   | 16%                     | 8   | -     | 0     | 11.1% | 1    | 25.5%                            | 64  | 22.2% | 2     | 9.4%  | 5    |
|                                 | 6.6%                         | 6   | -     | 0    | 4%  | 1   | 20%                     | 10  | -     | 0     | 11.1% | 1    | 10.8%                            | 27  | 11.1% | 1     | -     | 0    |
|                                 | 7.7%                         | 7   | -     | 0    | 8%  | 2   | 6%                      | 3   | -     | 0     | -     | 0    | 10%                              | 25  | 11.1% | 1     | 13.2% | 7    |
| Use-traces                      | n/a                          | n/a | n/a   | n/a  | 24% | 6   | n/a                     | n/a | n/a   | n/a   | 22.2% | 2    | n/a                              | n/a | n/a   | n/a   | 18.9% | 10   |
|                                 | n/a                          | n/a | n/a   | n/a  | 16% | 6   | n/a                     | n/a | n/a   | n/a   | 44.4% | 4    | n/a                              | n/a | n/a   | n/a   | 30.2% | 16   |
|                                 | n/a                          | n/a | n/a   | n/a  | 16% | 4   | n/a                     | n/a | n/a   | n/a   | -     | 0    | n/a                              | n/a | n/a   | n/a   | 39.6% | 21   |
|                                 | n/a                          | n/a | n/a   | n/a  | 28% | 7   | n/a                     | n/a | n/a   | n/a   | 11.1% | 1    | n/a                              | n/a | n/a   | n/a   | 5.7%  | 3    |



**Fig. 8.1.2.** A selection of utilised ochre pieces from the pre-Still Bay layers at Sibudu. (a) Shale piece (Sb5208 from layer LBG3, square B4) that has been rubbed, resulting in the smoothing and external microstriations. (b) Shale (Sb5420 from layer BS13, square C5) that has been ground and then rubbed. (c) Brown-red shale piece (Sb5432 from layer BS15, square B4) that has been ground. (d) Piece of shale (Sb5375 from layer LBG3, square B5) that has been ground. (e) Weathered dolerite (Sb5242 from layer BS5, square B4) which has been scored on the soft, red area. The incisions form a fan shape. (f) Shale (Sb5372 from layer LBG3, square B4) with intensive, erratically-placed scored incisions of various widths and depths. (g) Snuffbox shale (Sb3300 from layer BS8, square C5) which is scored on the soft, red area. The incisions form a fan shape. (h) Broken shale piece (Sb5394 from layer BS10, square C4) with intensive parallel and erratic scoring, resulting in a concave surface.

The Still Bay layers (~71 ka) contain small amounts of ochre and only nine utilised pieces. Percentage frequencies within the utilised assemblage are therefore not very reliable. Bright-red pieces predominate and there is an increase of yellow and yellow-brown pieces in the unutilised assemblage (Table 8.1.1). The most frequent use-trace type in the total Sibudu assemblage, combined grinding and rubbing, does not occur in the Still Bay, but exclusively rubbed or ground pieces are common (Fig. 8.1.3; Table 8.1.1). Therefore powder-production was occurring at this time. One of the uses of this powder was in hafting adhesives because some of the bifacial points found in the Still Bay have evidence that they were hafted, sometimes with ochre-loaded adhesive (Lombard 2006a; Wadley 2007). There is also evidence that ochre in the Still Bay

assemblage was used for the soft hammer shaping of bifaces (Soriano *et al.* 2009), but there is no clear evidence of ochre pieces that might have been used as hammers in the ochre assemblage. The unutilised ochre pieces in these layers, like the points and lithics, are scattered around the excavated area.



**Fig. 8.1.3.** A selection of utilised ochre pieces from the Still Bay layers at Sibudu. (a) Snuffbox shale piece (Sb5157 from layer RGS, square C5) that has been rubbed. Smoothing and polish are visible on the surface. (b) Shale (Sb5164 from layer RGS, square B4) that has been rubbed. Smoothing and microstriations are visible. The layers of different colours in the rock are also apparent. (c) Piece of iron oxide (Sb5163 from layer RGS, square B4) that has been ground and has parallel and erratic grooves on its surface. (d) Shale (Sb5168 from layer RGS, square B4) that has been ground along one edge of the piece. This piece was possibly rubbed, as striations are smoothed, but no microstriations are present. (e) Snuffbox shale (Sb5173 from layer RGS, square C4) that has been scored and rubbed. A concave surface has been created from scoring. (f) Shale (Sb5164 from layer RGS, square B4) that has been rubbed. Smoothing, microstriations and rounded edges are noticeable.

Marine shell, although rare, occurs in higher frequencies in the Still Bay layers than elsewhere in the sequence (Plug 2006; d'Errico *et al.* 2008). Perforated *Afrolittorina africana* (abalone) shells were discovered in the Still Bay layers, some of which contain ochre residues (Plug 2006; d'Errico *et al.* 2008). In Still Bay layer Reddish Grey Sand (RGS), square B4, *A. africana* shells are associated with combustion features (Wadley

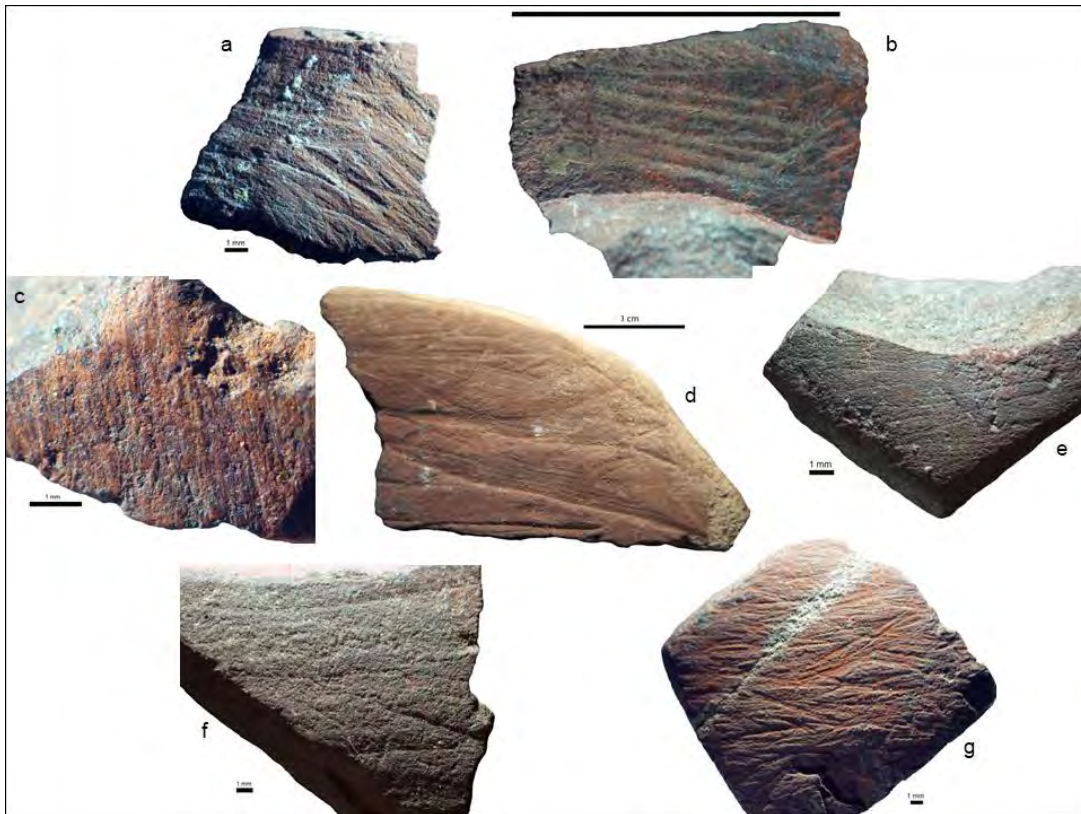
2012b) and are in close proximity to utilised and unutilised ochre nodules (of various colours). The ochre pieces are found in relatively high frequencies in these areas (B4a and B4b; see Wadley 2012b, fig. 8), but the Still Bay ochre sample is small. The ochre assemblage offers additional evidence of a work area where both perforated shells and ochre were used.

There is evidence that tools were hafted with an ochre-loaded compound adhesive in the Still Bay, Howiesons Poort, post-Howiesons Poort and final MSA layers at Sibudu (Wadley *et al.* 2004, 2009; Lombard 2006a, 2007, 2008, 2011; Wadley & Mohapi 2006). These layers span a long period (~35 000 years). Hafting powder found on the lithics is usually fine-grained and bright-red. Bright-red pieces used for powder-production are common in these assemblages and various grain-sizes are represented. The shift from a predominance of clayey pieces to mostly silty pieces (from the older assemblages to those younger than the Howiesons Poort) may represent changes in the ochre powder or ochre nodule applications at the site.

The Howiesons Poort layers (~65–62 ka), like the Still Bay layers, contain a high percentage of utilised pieces (e.g. Fig. 8.1.4). Clayey pieces predominate and there is an increase in soft unutilised pieces, but pieces of medium hardness are still most numerous in the utilised assemblage (Table 8.1.1). There is a decrease of bright-red unutilised pieces in the Howiesons Poort, although they still predominate. The direct transfer of powder by combined grinding and rubbing activities is popular at this time (e.g. Fig. 8.1.4e & f), as is rubbing (Table 8.1.1). There are only a few scored pieces in the Howiesons Poort assemblage; two appear to have deliberate incision placing with the incisions forming fan shapes (e.g. Fig. 8.1.4b), and one has intensive scoring that forms parallel and forked-shaped marks (Fig. 8.1.4d). Ground pieces (Fig. 8.1.4a, c & g) are slightly less common in the Howiesons Poort than they are in the rest of the sequence (Table 8.1.1).

Utilised and unutilised ochre is found scattered around the excavated part of the site in the Howiesons Poort layers. There are high frequencies of unutilised ochre pieces in the ~64 ka layer Grey Sand (GS) in squares C4, C5 and C6 around the hearth, ash dump and bone patches (Wadley 2012b, fig. 11b). However, only a few utilised pieces

are found here (10.5% of the pieces are utilised,  $n=4$ ). In the layer Grey Rocky 2 (GR2), not much younger than GS, a high percentage of the ochre pieces associated with the hearth, ash dump and bone accumulations in squares C4 and B4 (Wadley 2012b, fig. 11b) are utilised (50% of ochre pieces here are utilised,  $n=6$ ); the unutilised ochre is concentrated away from these activity areas (the unutilised pieces are concentrated in squares C5 and B5).



**Fig. 8.1.4.** A selection of utilised ochre pieces from the Howiesons Poort layers at Sibudu. (a) Shale (Sb4935 from layer GR2, square C5) that has been ground. Facets have formed and the grinding striations overlap at angles. (b) Shale (Sb5058 from layer PGS, square B5) that has two groups of parallel incisions which cross over each other at one end forming a fan-shape. (c) Shale (Sb4956 from layer GR2, square B5) that has been ground. (d) Shale (Sb5092 from layer PGS, square C5) that has intensive erratically-placed incisions of various widths and depths. One edge of the piece is rounded from rubbing. (e) Shale fragment (Sb5041 from layer GS2, square B4) that has been ground and then rubbed, causing smoothing of the striations. (f) Shale (Sb4857 from layer DGR2, square B5) that has been ground and then rubbed, causing smoothing of the striations. (g) Shale (Sb5084 from layer PGS, square C5) that has been ground. The white line is an inclusion in the rock itself.

The range of ochre types, the increased percentage of utilised pieces and the increased numbers of pieces used for the direct transferal of powder shows that the Howiesons Poort ochre assemblage also reflects the resource intensification that we see in the rest of the cultural accumulations. Resource intensification is evidenced by: backed tools, blade technology, hafted tools, notched and worked bone tools, including a possible bone arrowhead, small, forest-dwelling bovids, high faunal taxonomic diversity, and burnt bedding (e.g. Cain 2004; Plug 2006; Lombard 2007, 2008; Backwell *et al.* 2008; d'Errico *et al.* 2008, 2012b; Clark & Plug 2008; Wadley & Mohapi 2008; Wadley 2010b; Wadley *et al.* 2011). The invention of traps and snares allowed people in the Still Bay and Howiesons Poort to capture animals that were previously rarely obtained, such as the blue duiker, monkey and small carnivores (Wadley 2010b). The development of sophisticated capture methods is also shown through ochre usage with the manufacture of ochre-loaded compound hafting adhesives (Wadley *et al.* 2009).

Fluctuating environmental conditions may have resulted in changes in the size of animal populations that were available on the landscape (Bird & O'Connell 2006; Clarke 2011; Bruch *et al.* 2011), and a mosaic of different environments was found around the site (Allott 2006; Glenn 2006; Reynolds 2006; Sievers 2006; Clark & Plug 2008). The addition of small animals to the diet may have influenced hide tanning practices if the small hides were indeed processed. Hide tanning/curing methods may have changed because of the increased availability and use of small hides. More efficient ways to preserve hides may have been required for small versus large hides. The use of (red) ochre powder would have been effective for any kind of hide processing because of its antibacterial and antifungal properties (Audouin & Plisson 1982; Rifkin 2011). This may also explain the increased number of (red) pieces used for the direct transferal of ochre powder from ochre pieces to a soft material.

The post-Howiesons Poort layers (~58 ka) constitute the largest stratigraphic unit at Sibudu. They also hold the greatest quantity of ochre, but the proportion of utilised pieces is lower than in the Howiesons Poort. There is an increase in orange utilised pieces as well as mica-rich pieces (Table 8.1.2). The post-Howiesons Poort layers have many (large) ochre patches (Fig. 8.1.5) and so ochre powder production there is a well-recognised activity (Wadley 2010d). Utilised and unutilised ochre pieces are

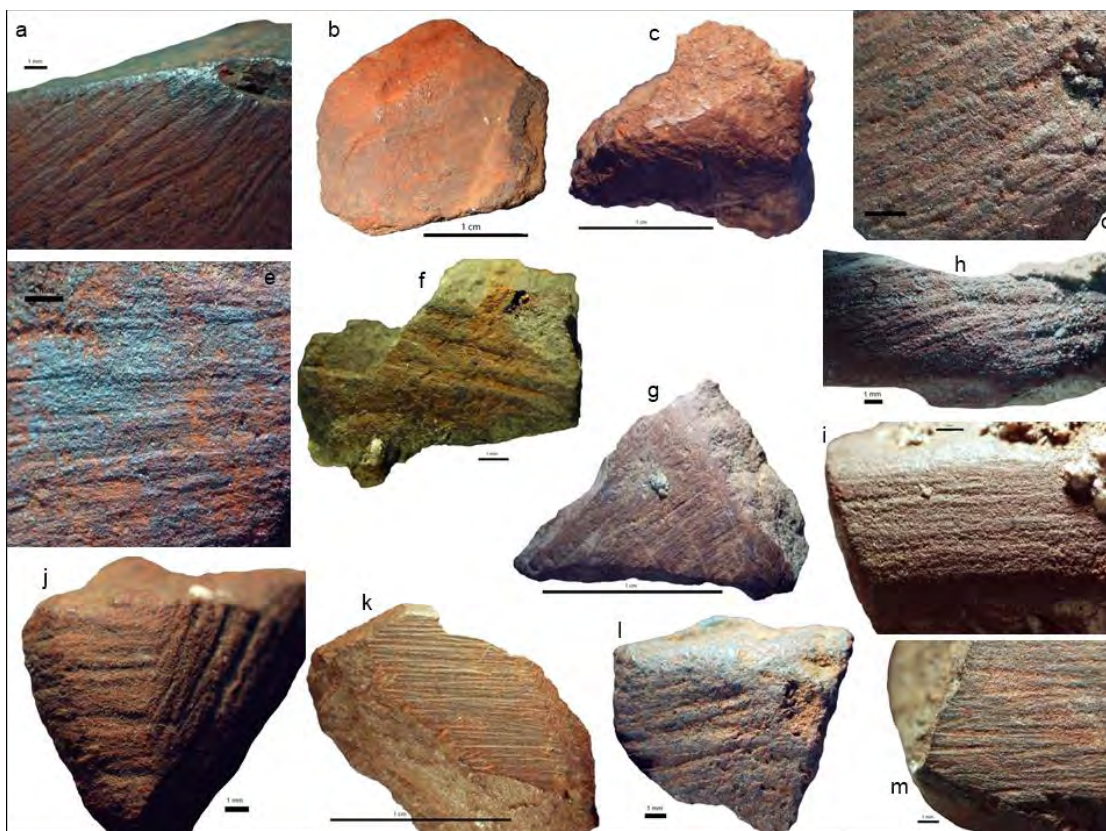
concentrated around the ochre patches found on cemented ash patches found in the post-Howiesons Poort layers (Wadley 2010d) Brown under Yellow Ash (i) (BuYA2(i)) in square B4 (Wadley 2010d, fig. 2) and Yellow (Y1) in squares B6 and C6. The Y1 patch is red and the ochre pieces associated with it are mostly bright-red and have been used for grinding and/or rubbing activities. The other patch however is yellow, but the ochre pieces associated with it are mostly bright red and are predominantly used for rubbing. It appears that the pieces now associated with the patch in BuYA2(i) are not responsible for the creation of the patch itself. There is a red powder patch near to this patch and the pieces may be responsible for that patch. Further mineralogical analyses would be useful in proving these inferences.



**Fig. 8.1.5.** An ochre powder patch in post-Howiesons Poort layer Brown Pox at Sibudu.  
Photograph courtesy of L. Wadley.

**Table 8.1.2.** High and significant frequencies Table 8.1.2. The highest and most significant frequencies of ochre properties and use-traces in the post-Howiesons Poort, late and final MSA layers at Sibudu. Percentages indicate the frequency of pieces with each variable in the utilised (U), possibly utilised (PossU) and unutilised (UnU) ochre assemblages per industry. Not all variables are shown in this table therefore percentages do not equal 100% for each category. See Chapters 5 and 6 for unabridged data. Light shading marks the utilised assemblage. Dark shading marks elevated frequencies (>40%).

|                                            | Post-Howiesons Poort (n=2890) ~58 ka |      |       |     |       |     | Late MSA (n=1327) ~48 ka |     |       |     |       |     | Final MSA (n=740) ~38 ka |     |       |     |       |    |
|--------------------------------------------|--------------------------------------|------|-------|-----|-------|-----|--------------------------|-----|-------|-----|-------|-----|--------------------------|-----|-------|-----|-------|----|
|                                            | UnU                                  |      | PossU |     | U     |     | UnU                      |     | PossU |     | U     |     | UnU                      |     | PossU |     | U     |    |
|                                            | n=2445                               |      | n=31  |     | n=414 |     | n=1155                   |     | n=31  |     | n=141 |     | n=687                    |     | n=13  |     | n=40  |    |
| Ochre properties and use-traces            | %                                    | n    | %     | n   | %     | n   | %                        | n   | %     | n   | %     | n   | %                        | n   | %     | n   | %     | n  |
| Shale                                      | 46.5%                                | 1137 | 35.5% | 11  | 70%   | 290 | 42.8%                    | 494 | 41.9% | 13  | 56%   | 79  | 45%                      | 309 | 38.5% | 5   | 50%   | 20 |
| Snuffbox shale                             | 11.5%                                | 282  | 12.9% | 4   | 8.7%  | 36  | 17.1%                    | 197 | 16.1% | 5   | 15.6% | 22  | 17.5%                    | 120 | 30.8% | 4   | 12.5% | 5  |
| Siltstone                                  | 15%                                  | 366  | 22.6% | 7   | 12.6% | 52  | 17.8%                    | 206 | 29%   | 9   | 12.1% | 17  | 16.2%                    | 111 | 15.4% | 2   | 12.5% | 5  |
| Clayey Grain Size                          | 26.6%                                | 651  | 22.6% | 7   | 30.4% | 126 | 22.7%                    | 262 | 22.6% | 7   | 29.8% | 42  | 15%                      | 103 | 38.5% | 5   | 22.5% | 9  |
| Silty Grains Size                          | 36.5%                                | 893  | 38.7% | 12  | 46.4% | 192 | 53.3%                    | 616 | 35.5% | 11  | 61.7% | 87  | 60.7%                    | 417 | 30.8% | 4   | 45%   | 18 |
| Soft (≤Mohs 2)                             | 28.4%                                | 695  | 29%   | 9   | 15.9% | 66  | 24.2%                    | 280 | 32.3% | 10  | 25.5% | 36  | 12.4%                    | 85  | 69.2% | 9   | 25%   | 10 |
| Medium (Mohs 3 and 4)                      | 71.3%                                | 1743 | 71%   | 22  | 83.6% | 346 | 72.8%                    | 841 | 61.3% | 19  | 73%   | 103 | 86.9%                    | 597 | 46.2% | 6   | 72.5% | 29 |
| Bright-Red Streak                          | 39.3%                                | 960  | 25.8% | 8   | 50%   | 207 | 38.1%                    | 440 | 29%   | 9   | 49.6% | 70  | 23.4%                    | 161 | 53.8% | 7   | 30%   | 12 |
| Brown-Red Streak                           | 19.5%                                | 476  | 19.4% | 6   | 20.5% | 85  | 16.9%                    | 195 | 9.7%  | 3   | 13.5% | 19  | 11.2%                    | 77  | 7.7%  | 1   | 7.5%  | 3  |
| Orange Streak                              | 25.3%                                | 619  | 32.2% | 10  | 18.8% | 78  | 22.6%                    | 261 | 35.5% | 11  | 14.9% | 21  | 21.4%                    | 147 | 7.7%  | 1   | 15%   | 6  |
| Yellow/Yellow-Brown Streak                 | 2.1%                                 | 52   | -     | 0   | 0.2%  | 1   | 1.4%                     | 16  | -     | 0   | -     | 0   | 0.9%                     | 6   | 23.1% | 3   | -     | 0  |
| Mica Inclusions                            | 19.7%                                | 482  | 29%   | 9   | 34.3% | 142 | 20.6%                    | 239 | 22.6% | 7   | 41.8% | 59  | 12.4%                    | 85  | 15.4% | 2   | 17.5% | 7  |
| Grinding                                   | n/a                                  | n/a  | n/a   | n/a | 21.7% | 90  | n/a                      | n/a | n/a   | n/a | 29.8% | 42  | n/a                      | n/a | n/a   | n/a | 20%   | 8  |
| Rubbing                                    | n/a                                  | n/a  | n/a   | n/a | 28.7% | 119 | n/a                      | n/a | n/a   | n/a | 29.1% | 41  | n/a                      | n/a | n/a   | n/a | 50%   | 20 |
| Grinding and Rubbing                       | n/a                                  | n/a  | n/a   | n/a | 32.1% | 133 | n/a                      | n/a | n/a   | n/a | 34.8% | 49  | n/a                      | n/a | n/a   | n/a | 20%   | 8  |
| Scoring (with or without other use-traces) | n/a                                  | n/a  | n/a   | n/a | 2.9%  | 12  | n/a                      | n/a | n/a   | n/a | 2.8%  | 4   | n/a                      | n/a | n/a   | n/a | 5%    | 2  |



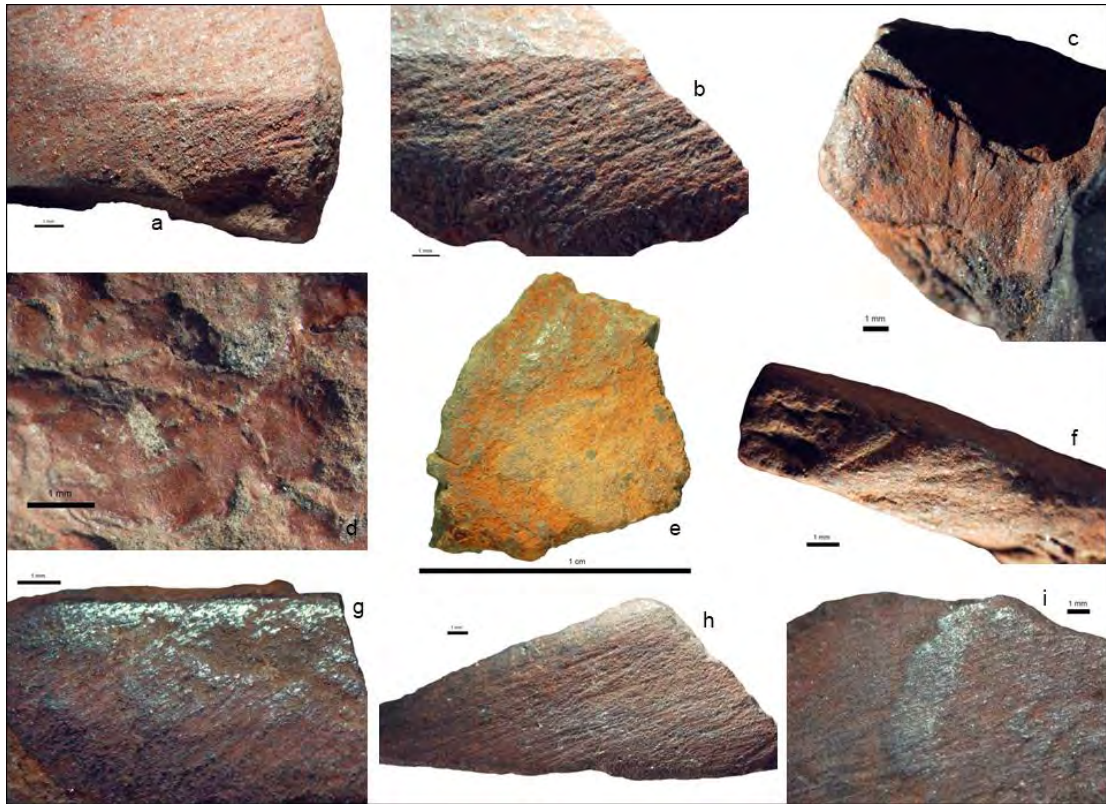
**Fig. 8.1.6.** A selection of utilised ochre pieces from the post-Howiesons Poort layers at Sibudu. (a) Shale (Sb2704 from layer BL2, square B4) that has been ground causing striations and metallic lustre. (b) Smoothing and polish on a snuffbox shale that has been rubbed (Sb2126 from layer BSp2, square E2). (c) External microstriations on rubbed siltstone (Sb1926 from layer BSp, square D2). (d) Shale piece (Sb3225 from layer Ebony, square B5) that has been ground and then rubbed. (e) Shale (Sb2750 from layer BL2, square A4) that has been ground and then rubbed. (f) Broken shale fragment (Sb2741 from layer BL2, square A4) with four parallel incisions. (g) Triangular shale piece (Sb3112 from layer SS2, square C4) that has been ground and then engraved. (h) Shale fragment (Sb3790 from layer Choc2, square C4) that has been ground. (i) Shale (Sb3727 from layer G, square C5) with ground facets exhibiting grinding striations that have been smoothed from rubbing. (j) Small piece of shale (Sb5369 from layer BSp2, square A6) that has been intensively ground. (k) Shale (Sb2187 from layer BSp2, square E2) that has been ground and has scored incisions on a ground surface. (l) Piece of shale (Sb2798 from BL1, square B6) with parallel scored incisions. (m) Piece of ground siltstone (Sb2706 from layer BL2, B4).

The direct transferal of powder occurred regularly during the post-Howiesons Poort layers because pieces with combined grinding and rubbing use-wear are common (see Fig. 8.1.6). Pieces only used for grinding activities and other powder-producing activities are also common. The post-Howiesons Poort layers contain 12 pieces of scored ochre. Carefully placed parallel incisions are common (Fig. 8.1.6f & l) and some scored incisions are placed on top of grinding striations (Fig. 8.1.6g & k). Only a few

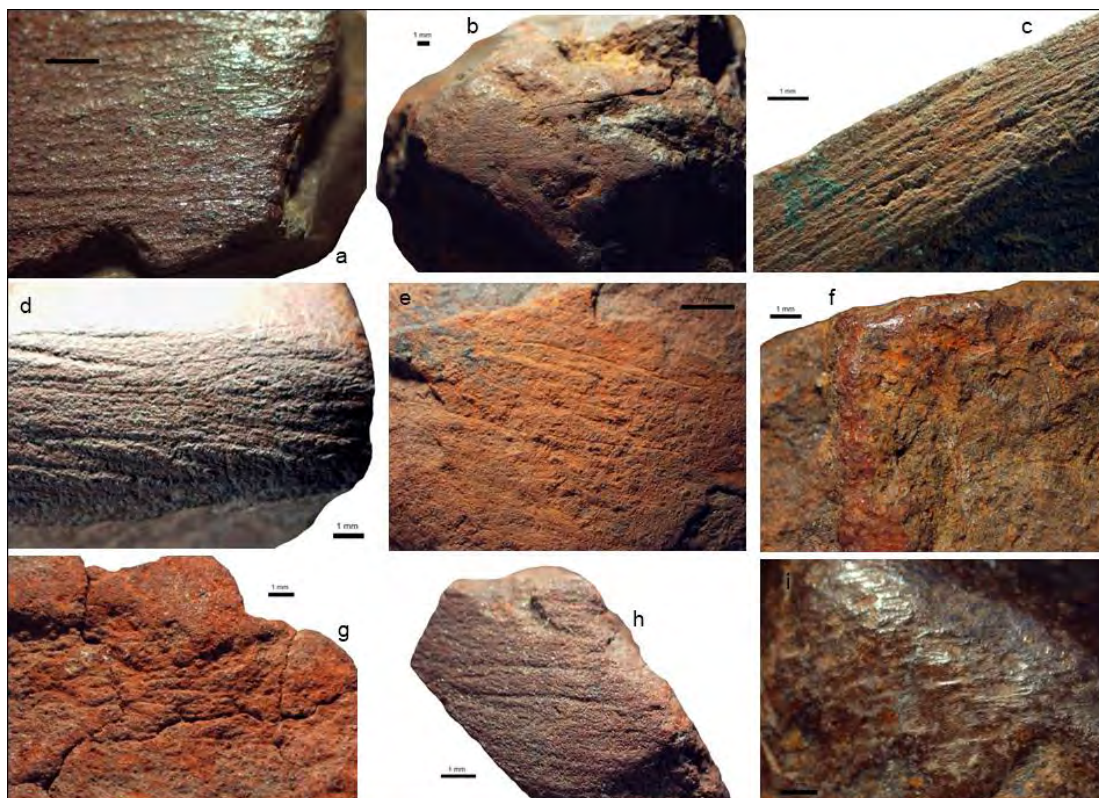
pieces have intensive and/or erratic scoring. The increase in the collection and use of ochre during this time corresponds with other resource intensification – there is intensified bedding use and burning of bedding, high artefact density, numerous hearths, notched and worked bone, a wide range of animal species and increased frequency of large bovids (Cain 2004; Cochrane 2006; Clark & Plug 2008; Wadley *et al.* 2011; d’Errico *et al.* 2012b). The ochre assemblage offers further evidence that the post-Howiesons Poort occupations may represent periods when large groups stayed at the site longer than before.

The uppermost layers of the Middle Stone Age assemblage, the late MSA and final MSA assemblages, have the smallest percentages of utilised pieces in the sequence (10.6% and 5.4% respectively). The late MSA assemblage (~48 ka) has high frequencies of utilised mica-rich pieces (Table 8.1.2) and bright-red pieces are common. The majority of the utilised pieces in the late MSA layers have been used for the direct transfer of powder (Fig. 8.1.7a & b), but grinding and rubbing use-traces also occur independently on many pieces (Fig. 8.1.7d, e, g, h & i). Ochre powder production is noted also in the use of hafting adhesives (Villa *et al.* 2005). There are few scored pieces, and most of the scoring is minimal and sometimes forms fan shapes (Fig. 8.1.7c & f). The pieces in the late MSA levels have higher frequencies of ochre in the squares lining the back of the cave and near the edge of the rock fall (A4, A5, C2, D2 and E2; see Fig 8.1.1).

The final MSA layers (~38 ka) have a smaller percentage of bright-red pieces than the older layers, and the frequency of utilised bright-red pieces is also smaller (Table 8.1.2). There is an increase of sandy pieces in both the utilised and unutilised assemblages. The majority of pieces in the final MSA are rubbed, but grinding and combined grinding with rubbing is also common (Fig. 8.1.8). Scored pieces are rare (e.g. Fig. 8.1.8e & g). At least some of the ochre powder produced during the final MSA was used for hafting adhesives (Villa & Lenoir 2006; Lombard 2007). As in the late MSA, ochre pieces are mostly found in the squares lining the back of the cave (C2, C3, D2, D3, E2 and E3; see Fig 8.1.1), possibly representing activity areas.



**Fig. 8.1.7.** A selection of utilised ochre pieces from the late MSA layers at Sibudu. (a) Faceted shale (Sb1272 from layer MOD, square A6) where the grinding striations have been smoothed during rubbing activities. (b) Snuffbox shale (Sb1161 from layer MOD, square C6) that has been ground and then rubbed. (c) Snuffbox shale (Sb1135 from layer MOD, square B6) that has been scored and then rubbed on the soft, red area of the piece. (d) Shale piece (Sb1227 from layer MOD, square E4) that has been rubbed, resulting in smoothing and polish formation. (e) Sandstone nodule (Sb1291 from layer MOD, procedures A6) that has been rubbed causing smoothing and metallic lustre to form. (f) Shale piece (Sb1189 from layer MOD, square D4) that has been scored along the narrow edge of the piece and then rubbed. (g) Shale (Sb1283 from layer MOD, square A6) that has been ground causing striations and metallic lustre to form. (h) Triangular shale piece (Sb1210 from layer MOD, square D6) that has been ground, forming striations and polish. (i) Grinding striations on an unknown raw material (Sb1282 from layer MOD, square A6).



**Fig. 8.1.8.** A selection of utilised ochre pieces from the late MSA layers at Sibudu. (a) Shale piece (Sb1117 from layer Lmou, square D2) that has been ground and then rubbed, resulting in smoothing and metallic lustre formation. (b) Siltstone nodule (Sb100 from layer Co, square C2) that has been rubbed, causing smoothing and polish formation. (c) Grinding striations on the narrow edge of a shale piece (Sb1110 from layer Co, square C2). (d) Shale piece (Sb1657 from layer LB MOD, square C2) with grinding striations. (e) Scored parallel incisions on the soft powdery area of a shale fragment (Sb1658 from layer LB MOD, square D2). (f) Polish that has formed on the corner a sandstone conglomerate from rubbing (Sb49 from layer Co, square C2). (g) Fragment of unknown raw material (Sb1108 from layer Co, square C2) that has been scored and then rubbed on the soft section of the piece. (h) Shale (Sb328 from layer LB MOD, square D2) that has been ground and then rubbed. (i) Hard piece of iron oxide (Sb1111 from layer Co, square C2) that has been rubbed, resulting in the formation of external microstriations, polish and smoothing.

## 8.2 Cognitive Implications of ochre use in the Middle Stone Age at Sibudu

The final aim of this research was to establish whether, through examining ochre usage patterns, insight can be obtained into the cognitive abilities needed for those activities. After examination and consideration of the ochre assemblage, the principal ways in which ochre was used at Sibudu were placed into thought-and-action sequences and inferential activity sequences. The cognitive abilities required for each activity were then ascertained by applying the cognitive model of enhanced executive functioning. Summaries of the cognitive abilities and procedures required for ochre processing at Sibudu are provided below.

### 8.2.1 Powder production: grinding and intensive scoring

Evidence of ochre powder production is common throughout the Sibudu sequence and is predominantly represented by bright-red and mica-rich pieces. The act of producing powder from ochre requires planning, foresight and knowledge of the materials, but the act itself does not require enhanced executive brain functioning. The ability to plan for the collection and preparation of ochre and other materials needed to produce the powder also does not necessarily portray an advanced level of cognition. Evidence for powder-production is common throughout the Sibudu MSA sequence. Many of the uses of the powder may be invisible to us now, but one of the established applications of the ochre powder is in hafting adhesives.

The process of using ochre powder as an ingredient in compound adhesives involves several actions that require long-term planning, multi-tasking, switching attention, response inhibition and abstract reasoning. The activity requires that independent elements are brought together to form a unique unit. This development requires the complex cognitive component of composition. We can infer complex cognition from this use of the powder (Wadley *et al.* 2009; Wadley 2010a, 2013). Evidence of hafting with complex adhesives, sometimes using ochre, is found as early as ~71 ka at Sibudu. Apart from ochre use in hafting adhesives and the staining of some shell and bone artefacts, other evidence for the uses for ochre powder is lacking. The ‘obvious’ use of ochre powder mixtures as paint, as suggested for an ochre-rich paste

found in two large abalone shells at Blombos (Henshilwood *et al.* 2011), is yet to be firmly established in Middle Stone Age contexts. Without other evidence for the application of the ochre powder, or the putative paint, no further cognitive conclusions can be made about these products.

### **8.2.2 Direct transference of ochre powder: combined grinding and rubbing**

Use-traces denoting grinding and rubbing activities are the most prevalent markings found on the Middle Stone Age ochre from Sibudu. The action of combined grinding and rubbing would have resulted in powder production as well as powder transference onto a soft material (Soressi & d'Errico 2007; Soressi *et al.* 2008; Hodgskiss 2010). With the evidence we have, we cannot know why the ochre powder was transferred onto the material, whether it was for aesthetic, ritual or practical purposes such as hide preparation. This use-wear, however, demonstrates an innovative way in which ochre was applied to soft material. The use-traces provide indirect evidence for an activity that is no longer preserved at Sibudu – or anywhere in the Middle Stone Age. The process of transferring powder directly from a ground ochre piece to a soft surface shows an innovative way in which to apply ochre powder to a soft material. The activity is likely to require the ability to multi-task, switch attention and a capacity for analogical reasoning because the rubbing needs to be alternated with grinding of the ochre surface on a grindstone to refresh its ability to transfer powder. This activity is frequent at Sibudu especially in the post-65 ka layers, but pieces used in this way are also found in the pre-Still Bay, ~77 ka, layers.

### **8.2.3 Engraving**

Most of the clear engraved designs at Sibudu are in layers dated to ~77–58 ka. There appears to be an awareness of space and symmetry in the placing of incisions on a few of the pieces (Figs 8.1.2e, 8.1.4b, 8.1.6f, g & k). Some of the engravings were created with controlled strokes, but the thought-and-action sequence is simple. The pieces with incisions that appear to be intentionally created would have required visuo-spatial control on the part of the maker, focussed attention, foresight (using a mental template) and intentionality. However, without knowing what the engravings signified to their makers, it is difficult to develop the interpretation further. There is a lack of clarity of form or standardisation between the pieces. It is therefore difficult to conclude whether

the engravings at Sibudu formed part of an organised system of motifs; the parallel lines and fan-shaped designs do reappear at the site, through time, and may have formed part of a formal design strategy. However, even if the engravings did hold cultural meaning, this does not automatically imply enhanced executive brain functioning (Coolidge & Wynn 2009; Wynn & Coolidge 2011).

### **8.3 Analytical contributions**

The four aims identified at the commencement of this research (listed in Chapter 1) have been fulfilled. Below I evaluate the methods used in this research, and the contributions made to ochre studies, as well as to an understanding of the cognitive capabilities of people living in the Middle Stone Age.

#### **8.3.1 Experimental**

Experiments helped with the identification of the geological materials and features present in the ochre, because the pieces could be broken and examined in detail. This was not possible with the archaeological pieces. Importantly, the experiments demonstrated the distinctive (yet variable) use-traces that different activities create, so that they could be identified archaeologically. The experimental pieces then functioned as a comparative sample during my interpretations of the archaeological ochre. Performing each activity a number of times and trying to limit the variables introduced in each test allowed for statistical evaluation of the experimental outcomes.

The experiments highlighted the procedures involved in each activity, as well as the planning that needs to be done beforehand or during an activity in order to successfully complete the activity. Additionally, they showed which activities are more efficient and effective than others. All these elements were vital to the creation of the activity sequences which later provided the cognitive data necessary for this study.

#### **8.3.2 Quantitative, qualitative and microscopic examination of ochre**

The classification, recording and evaluation of the Sibudu ochre assemblage was a lengthy process, but it was vital for the retrieval of all the necessary data. Recording of all the ochre properties and use-traces on an excel database subsequently enabled an extensive

quantitative and qualitative analysis of the assemblage and ensured that all aspects of a piece were considered – rock type, physical qualities and use-traces. The microscopic examination of all pieces was essential, because use-traces are often only visible under magnification, or under certain lighting. Understanding natural features and variability in ochre (from experimental work) guaranteed that meaningful descriptions of the use-traces and natural, or post-depositional, markings were obtained.

Obtaining quantifiable values for hardness, colour and grain size enabled a more thorough exploration of the ochre (and ochre use) at Sibudu. Quantifying use-trace types and variability was vital for identifying the activities that were performed and valued at Sibudu.

### **8.3.3 Cognitive and interpretive models**

Ochre use offers an avenue through which one can explore the behavioural and cognitive capacity of people using ochre in the Middle Stone Age. It can be problematic to make cognitive interpretations because we do not always know how (and why) ochre and ochre powder was applied. By creating arguments that are grounded in cognitive theory one can get around the problem; one can discover the basic cognitive requirements that are necessary to complete an activity. Thus, the methods adopted here offer an alternative way to analyse ochre use. Careful construction of thought-and-action sequences establishes the problem-solution distance for each activity and demonstrates the complexity or simplicity of different procedures. Each inferential sequence focuses on only one task, based on the archaeological evidence provided, and each step in the process shows what cognitive abilities were needed to complete the task itself. Investigation into the preparation and use of ochre in the Middle Stone Age at Sibudu has provided insight into the cognitive abilities of the people responsible for creating the assemblage. The approach used here did not require direct evidence for the applications of the ochre powder (or piece) and it bypassed the need to make extravagant inferential leaps of faith about what ochre meant to people living in the Middle Stone Age.

## **8.4 Future Work**

### **8.4.1 Examination of scoring and grinding tools**

Useful information might eventually be retrieved from the analysis of the use-wear that formed on the tools used during ochre processing, such as on grindstones and on the edges of scoring tools. Experimental work would be highly beneficial for establishing types of use-traces so that they can be identified in archaeological assemblages. By looking at these tools, ochre-related activities might be better understood. Further, the types of tools used for ochre activities may be established (for example, whether coarse- or fine-grained grindstones were used, or whether retouched scoring tools were used) because this evidence is not usually distinguishable from the use-traces. This will also help to strengthen cognitive inferential sequences for the various activities.

### **8.4.2 Grindstone residues**

Examination of the residues found on grindstones might help to determine whether the ochre was ground together with other substances, such as animal fat or plant material. This will provide further evidence of the ochre processing techniques employed, which will in turn aid interpretations of use-traces. For example, if ochre is ground with a wet substance, the striations often become smoothed and shallow. Residue studies could be done in conjunction with research into the use-wear found on grindstones. Future research on the grindstone residues at Sibudu will be undertaken by Geeske Langejans.

### **8.4.3 Sourcing the ochre**

The types of ochre that comprise assemblages are often a reflection of the rock types available around the site. It is likely that the Ndwedwe shale quarry, about one kilometre from Sibudu, was the ochre source, but this has not been confirmed. It will be useful to confirm the source(s) of the ochre found at Sibudu because this will give an indication of the distances people travelled to obtain the types of ochre that was valued. If ochre sources are a distance from the site, then further cognitive inferences may be possible.

### **8.4.4 Intentional heating of ochre**

The high frequencies of bright-red utilised pieces, and elevated frequencies of yellow or orange amongst pieces with no traces of use, suggests that some of the ochre at Sibudu

may have been heat-treated prior to use. Research on the chemical properties and chemical structure of the various types and colours of ochre would be highly beneficial for establishing whether intentional heating of ochre occurred at Sibudu. Most pieces tested in the current study contain hematite and some contain maghemite. The presence of these two minerals together in some pieces indicates that the ochre was most likely heated, because maghemite forms when oxyhydroxides, such as goethite, are heated together with organic matter (Pomiès *et al.* 1999). Further chemical analysis of a large sample of ochre pieces from Sibudu (utilised and unutilised), would be necessary to confirm the possibility of heating. One problematic aspect is that chemical analysis alone would not necessarily be able to differentiate accidental heating from intentional heating. This could be somewhat rectified through performing a spatial analysis of ochre pieces around hearths and other combustion features. Establishing whether intentional heating of ochre was occurring at Sibudu provides another avenue from which ochre use and its cognitive implications can be explored (see also Hovers *et al.* 2003; Godfrey-Smith & Ilani 2004; Brown *et al.* 2009).

#### **8.4.5 Chemistry of the (utilised) ochre assemblage**

A chemical analysis of the utilised ochre assemblage could help to establish selection preferences. Although the Middle Stone Age ochre user would not have known the chemistry of a piece, the colour may have indicated elevated levels of iron oxide or aluminium, for example. Chemical variations may help to explain why pieces of medium hardness were preferred for use over soft pieces. Mid-range FTIR spectra used in this study (400–4000  $\text{cm}^{-1}$ ) did not produce a complete mineralogical profile for the ochre, and had to be supplemented by Raman and SEM-EDS data. X-ray fluorescent (XRF) analysers, such as the Niton XL3t XRF Analyser GOLDD+ (Thermo Scientific), offer another non-destructive way to analyse ochre. XRF analysers are easy to use, portable, take about one minute per sample and produce a reliable and complete mineralogical profile. An XRF analysis would therefore enable the testing of a large sample in a relatively short time and would provide complete (trace and major) elemental signatures of the ochre pieces. This analysis could be done as part of the sourcing of ochre and could also contribute towards finding out whether ochre was heated. Mineralogical analyses of ochre patches (over and above those by Wadley 2010d) and the associated

utilised ochre pieces will also help to provide insight into the activities taking place around the patches, as well as help characterise activity areas at Sibudu.

#### **8.4.6 Mineralogical testing of experimental pieces to look at variations in metallic lustre and polish formation.**

Experimental ochre use showed that metallic lustre and polish formed on some pieces of ochre during grinding, rubbing and/or scoring activities. The formation of these attributes has been attributed to the friction between the ochre and the grindstone or tool, but such use-traces do not occur consistently during activities. It is possible that the formation of these use-traces is caused by different mineralogical properties in the ochre – such as increased levels of iron oxide or aluminium. Research into the mineralogical properties (and quantities) of experimental ochre pieces, may help to determine whether this is the cause of these use-traces or whether they can be definitively linked to the use of a piece.

### **8.5 Conclusion**

The analysed Middle Stone Age ochre assemblage from Sibudu consists of 4679 unutilised, 88 possibly-utilised and 682 utilised pieces. Ochre use was habitual throughout the sequence at Sibudu, resulting in a large and varied ochre assemblage. There is a smaller range of geological types in the utilised assemblage than in the unutilised, suggesting that specific types of ochre were chosen for use, after being brought back to the site. Shale and pieces with a medium hardness are favoured for utilisation; although a range of rock types is represented in the assemblage. Grain size frequencies change through time in the utilised and unutilised assemblages, with large quantities of silty pieces in the upper layers, and high frequencies of clayey pieces in the lower layers. Mica-rich pieces were preferentially used for (intensified) activities resulting in powder production. Bright-red pieces predominate throughout the sequence and were preferentially chosen for use. Colour is the most prominent (and consistent) feature in the assemblage. Colours other than red (and specifically bright-red) are poorly represented in the utilised category.

The ochre was processed and used in a variety of ways. Most pieces in the Sibudu assemblages (and many other Middle Stone Age assemblages) were used to produce (or transfer) ochre powder. Activities that resulted in powder production were usually implemented with bright-red and mica-rich pieces. This indicates a desire to obtain a bright-red, brilliant powder. The most common ochre processing activity at Sibudu is grinding followed by rubbing on a soft material. This direct transferal of ochre from a ground ochre piece to a soft surface requires the cognitive processes of multi-tasking, switching attention and analogical reasoning. There are also many pieces in the assemblage that have use-traces from grinding only. Rubbing use-wear is also common; the use of these pieces is likely for the direct transferal of ochre powder onto a soft material. However, many of these pieces have hardness values above Mohs 2 and experimental work showed that pieces need to be very soft (<Mohs 2) to transfer powder directly. As yet there is no secure explanation for the exclusively rubbed pieces, but they may imply a specific methodology for treating small hides.

Powder is produced during many of the ochre processing activities performed at Sibudu, and these activities were regularly executed with bright-red pieces. The ochre powder may have been used for a variety of purposes, and variations in grain sizes through time may signify ochre powder application changes. It has been confirmed through residue analyses and experiments, that at least some of the powder produced at Sibudu was used for the manufacture of compound hafting adhesives (Wadley *et al.* 2004, 2009; Williamson 2004; Wadley 2005b; Lombard 2006a, 2007, 2011), which occurs in the Still Bay, Howiesons Poort, post-Howiesons Poort and final MSA layers. We cannot know whether the powder was added for its chemical and physical properties or for its visual saliency, but the addition of red ochre powder in hafting adhesives has been proven to be functionally effective (Wadley *et al.* 2009).

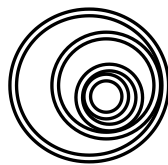
There are few ochre pieces with scoring use-traces. Some scoring is intensive and would have resulted in powder production. Other scored incisions are more carefully engraved, sometimes forming parallel lines or fan-shaped patterns. Some of these engraved pieces are soft and many are brown-red. The use of different geological materials for the rare engraved pieces at Sibudu and other Middle Stone Age sites (Henshilwood *et al.* 2009; Watts 2010; d'Errico *et al.* 2012a), may indicate that they had an unconventional

purpose. We also cannot know whether the engraved designs held (symbolic) meaning for the people who used them or if they held meaning in the community in which they were created. The use of space and symmetry in the placement of the incisions on a few of the pieces shows that their creation required visuo-spatial control, foresight (using a mental template) and intentionality. Therefore, even though the meanings of the engravings may be unobtainable, it can still be inferred that some enhanced cognitive abilities were required for the creation of the relatively formal incisions.

It is clear that time was invested in ochre exploitation at Sibudu – from its collection, preparation and the organisation of the materials that were used with it (grindstone, scoring tool, soft material, plant resin, storage container), to the final application of the ochre or powder. The time and effort invested in ochre use shows that ochre was a valued (and perhaps even essential) artefact at the time. The various ways in which ochre was used each have different physical and mental requirements. Some of the activities involving ochre use require enhanced cognitive functions, such as the direct transferal of powder, the manufacture of compound adhesives and possibly engraving. Other ochre-processing activities are simple and do not require enhanced cognitive abilities, but this does not mean that the user did not have the ability to perform more cognitively complex tasks. Some of the specific uses of ochre and their meanings to people in the Middle Stone Age are beyond our grasp at present, but by investigating the preparation of ochre, some insight into the ochre user's mental capabilities has been gained.

The information obtained from the Sibudu ochre assemblage, coupled with evidence of composite hafting procedures, insecticidal treatment of bedding construction and remote capture techniques implies that the people living during the Middle Stone Age at Sibudu, as early as 77 000 years ago, had complex cognitive functioning like that of humans today.

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