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The pigments from Pinnacle Point Cave 13B, Western Cape, South Africa☆

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ABSTRACT

Earth pigments from the three excavations at Pinnacle Point Cave 13B (Western Cape Province, South Africa), spanning the terminal middle Pleistocene and earlier late Pleistocene, are described and analyzed. Qualitative geological categorization primarily rested on textural, fabric, and iron enrichment attributes. Comprehensive recovery allowed identification of non-anthropic pigmentaceous materials, questionable pigments, and 380 pigments (1.08 kg). Less chemically altered pigments were typically fine-grained sedimentary (FGS) rocks, tending to be soft, highly micaceous, prone to laminar fragmentation, and with reddish-brown streaks of intermediate nuance. More iron-enriched forms tended to be harder, denser, poorly micaceous, and with redder streaks of more saturated nuance. Some still qualified as FGS forms, but a large number were categorized as sandstone or iron oxide. Despite some temporal change in raw material profiles, circumstantial evidence suggests primarily local procurement from one outcrop throughout the sequence. Definitely utilized pieces (12.7%) were overwhelmingly ground. Unusual forms of modification include several notched pieces and a deliberately scraped 'chevron.' Controlling for fragmentation, streak properties of utilized versus unutilized pieces were used to investigate selective criteria. There was robust evidence for preferential grinding of the reddest materials, strongly suggestive evidence for saturation and darkness being subordinate selective criteria, and some indication of more intensive grinding of materials with the reddest, most saturated, and darkest streaks, and for some deliberate heating of pigments. These findings challenge the initial stages of color lexicalization predicted by the various versions of the basic color term (BCT) hypothesis, they provide grounds for rejecting hafting as a general explanatory hypothesis, and they cannot be accounted for by incidental heating. The results are more consistent with agreed upon canons of ornamentation than with individual display. It is concluded that the material was processed to produce saturated red pigment powders. On theoretical grounds, these are presumed to have served primarily as body paints in ritual performance.

Introduction

With consensus regarding our African origin close to 200 ka, the use of what are generally presumed to be earth pigments (overwhelmingly red ochre/hematite) in the African Middle Stone Age (MSA) has figured prominently in debates about the evolution of symbolic culture (Deacon, 1995; Knight et al., 1995; Power and Aiello, 1997; Power, 1999, 2004, 2009; Watts, 1999, 2002, 2009; McBrearty and Brooks, 2000; Wadley, 2001, 2005a; Barham, 2002, 2004; Henshilwood and Marean, 2003; van Peer et al., 2004; d'Errico, 2008; see also Hovers et al., 2003). Ochre is the only artifactual material frequently encountered alongside MSA stone tools. Despite the unprecedented interest, detailed or even moderately detailed accounts of pigment assemblages—whether in Africa or elsewhere—are rare (e.g., Couraud and Laming-Emperaire, 1979; Couraud, 1991; Smith et al., 1998; Barham et al., 2000; Henshilwood et al., 2001; Barham, 2002; Hovers et al., 2003). A corollary and partial explanation of this situation has been an underdeveloped research agenda.

With a wide range of views regarding the antiquity of symbolic culture (cf. Henshilwood and Marean, 2003) and with few potential early pigments adequately reported, there are divergent claims regarding basic issues such as the antiquity of pigment use and the range of colors (compare Hovers et al., 2003; Watts, 2009). Problems in evaluating the archaeological record are compounded by unresolved epistemological and methodological issues as to what qualifies as pigment, appropriate quantitative measures, and whether there are systematic taphonomic and excavator biases in 'pigment' assemblages (Marshack, 2003; Kuhn and Stiner, 2007; Wadley, 2009). At an interpretative level, was ochre used as a tanning agent or as a functional ingredient in hafting cement and could such uses account for much MSA 'pigment' (Wadley et al., 2004; Wadley, 2005a)? Do pigment hypotheses have temporal and color selection implications (Knight et al., 1995; Hovers et al.,

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2003)? Are these different from predictions derivable from functional hypotheses? Can rates of utilization between colors be used to identify past selective criteria?

An underlying issue is that archaeologists have often been reluctant or unable to undertake descriptive analysis, viewing this as either beyond their expertise or likely to offer little return for the effort involved. The following analysis of material from Pinnacle Point Cave 13B (PP13B) provides both an empirical contribution and an illustration of how simple descriptive methods can help to characterize raw material variability, identify past selective criteria, and possibly provide clues as to the manner of use. New questions are raised, some of which will be better addressed by archeometric techniques or more refined descriptive methods.

Context

While there can be no formal definitional criteria, the utility of potential earth pigments primarily rests on pulverulence (softness and absence of gritty impurities), staining power, and the particular color (Brabers, 1976; Chaloupka, 1993: 83; Jercher et al., 1998: 385). Red and yellow earth pigments—generally referred to as ochre (cf. Supplementary Online Material [SOM], published with the online version of this article at doi:10.1016/j.jhevol.2010.07.006)—typically take their colors from hematite (an iron oxide producing a red streak) and/or goethite (an iron oxide-hydroxide producing a yellowish-brown streak). Ochre typically results from chemical weathering of a parent rock, involving—inter alia—oxidation and concentration of iron (with or without hydration). The most common accessory minerals are clays (including clay-micas) and quartz. Mineral ratios can vary enormously within a weathering profile, so ochre can be relatively pure or highly heterogeneous (Jercher et al., 1998: 385). The heating of pigments, whether deliberate or incidental (through proximity to hearths), may change their color. Goethite transforms to hematite at fairly low temperatures (Wadley, 2009), while ethnographic evidence suggests that heating of already red forms (ochre or hematite) may further redden and darken the streak (e.g., Jones and Meehan, 1978: their Fig. 3 and p. 32; Le Roux and White, 2004: 98; SOM; but see Wadley, 2009). The specific environment of heating (oxidizing versus reducing conditions and the presence/absence of organic material) may also affect color change, inhibiting or facilitating the phase transition to browner maghemite (Capel et al., 2006; Herries and Fisher, 2010). Small fragments of ochre (<21 mm thick) are more likely to undergo uniform color change than larger pieces (Wreschner, 1983: 33).

A preference for relatively pure hematite over earthy red ochre is ethnographically documented (e.g., How, 1962: 34; Chaloupka, 1993: 83; see SOM), hematite typically producing a darker, more saturated, redder powder—that when burnished may provide a metallic sheen. Heating of both earthy red ochre and of relatively pure hematite to similarly enhance pigment properties is as widely reported ethnographically as the heating of yellow ochre (SOM). In cultures with just two or three 'basic color terms' (cf. Berlin and Kay, 1969), saturated red is invariably identified as exemplary of one of the terms (Heider, 1972: 451; Jones and Meehan, 1978: 27; Levinson, 2000: 10; see SOM); the same cannot necessarily be said of black or white. Dark saturated red tends to be singled out as particularly salient (Heider, 1972: 451; Jones and Meehan, 1978: their Fig. 3).

Global evidence for early (pre-40 ka) pigment use has briefly been reviewed elsewhere (Watts, 2009; see also SOM [including the missing bibliographic details for works cited in Watts, 2009: his Table 4.2]). Initial use probably dates to the middle of the middle Pleistocene at ∼400–500 ka. African later middle Pleistocene occurrences greatly outnumber Eurasian counterparts. Some sites in the African tropics document regular use from ∼300 ka (McBrearty, 2001; Barham, 2002). In South Africa, despite a cluster of Fauresmith occurrences (probably spanning from 276 ± 29 ka to >350 ka; cf. Beaumont and Vogel, 2006: their Table 2), regular and ubiquitous use in rock shelters can only be inferred from between 150 and 170 ka (Watts, 2009). In Eurasia, by contrast, following three or four occurrences >200 ka there is a find gap of approximately 100,000 years (Wreschner, 1982) and nearly all Neanderthal Mousterian occurrences postdate c. 60 ka (Soressi and d'Errico, 2007: 303). The late Mousterian record remains patchy, but includes compelling indirect evidence for body ornamentation (Zilhão et al., 2010). Pigment use may have been more influenced by locally contingent ecological factors (e.g., demography and seasonality) than genetic/cognitive constraints (cf. Power, 2009; Zilhão et al., 2010). Nevertheless, habitual and ubiquitous use of red ochre (where regionally available) approximates a species-specific behavioral trait for *Homo sapiens*. That within the African tropics such behavior may precede our speciation accords with the view that behavioral change tends to be the 'pacemaker' of evolutionary change (Mayr, 1982: 612).

Of approximately 18 African sites with middle Pleistocene pigment assemblages, only Twin Rivers (Zambia) has been adequately published (Barham, 2002). There, the principal finding was that specularite (laminar crystalline hematite), providing a dark, 'purple shade of red' that sparkled (Barham, 2002: 185), was preferentially procured and utilized over lateritic hematite—despite being harder to grind and probably coming from further away (for discussion of additional possible pigments, see SOM). Preferential use of saturated reds was reported at PP13B (South Africa; Marean et al., 2007). Yellow predominates in the 'Lower Sangoan' horizon at Sai Island (Sudan; van Peer et al., 2004), the only middle Pleistocene assemblage not exclusively or overwhelmingly comprising red pigments. The only late Pleistocene MSA assemblages to have been reported in some detail are from Mumba Cave (Zambia; Barham et al., 2000) and Blombos Cave (Henshilwood et al., 2001; Watts, 2009), a coastal site 85 km west of Pinnacle Point. Blombos also showed preferential use of the reddest, most saturated pigments. Rare evidence for use of black, white, or yellow pigments in Southern Africa is largely restricted to post 80 ka contexts (Watts, 2002: 10; Klein et al., 2004: 5710), although some very light, poorly chromatic, utilized pieces are reported from c. 100 ka at Blombos (Henshilwood et al., 2009: their Figs. 16 and 18).

This report expands on the brief, published account of the middle Pleistocene PP13B assemblage (Marean et al., 2007), integrating it with an analysis of the late Pleistocene assemblages. Most late Pleistocene excavation aggregates have provided sequential age estimates between 128 and 91 ka, although there is an MSA aggregate dating to c. 37 ka and several disturbed aggregates. The stratigraphy and dating are described elsewhere (Jacobs, 2010; Marean et al., 2010).

Interpretative frameworks

Summaries of most of the principal interpretative frameworks have been presented elsewhere (Watts, 2009; see also SOM). The original version of the 'basic color term' (BCT) hypothesis (Berlin and Kay, 1969)—invoked by some archaeologists (e.g., Hovers et al., 2003: 493)—predicted that the earliest color terms would be 'black' and 'white' followed by 'red.' Kay and McDaniel's (1978) revision predicted an initial pair of 'light/warm' and 'dark/cool' composite terms (jointly partitioning the perceptual color space), followed by a division of the former into 'white' versus a 'warm' composite focused on red or yellow. The latest revision (Kay and Maffi, 2000) predicts two possible starting points: either a 'black,' 'white,' and 'red' lexicon, with the rest of the color space unnamed, or the composite term version of 1978. In the only detailed research on a culture with just two BCTs most informants selected dark saturated red as exemplary of the 'light/warm' term (Heider, 1972: 451). Vision science still cannot explain the greater salience of red over other unique hues (Kay and Maffi, 2000: 748). Retreating from the strong innatism of Kay and McDaniel's (1978) paper, neurophysiology is now considered an important constraint rather than direct determinant of color lexicons (Kay and Maffi, 2000: 746; Levinson, 2000: 45; Ross, 2004; Franklin et al., 2008). In its current form, the BCT hypothesis has no temporal implications, is indifferent to the social context in which color lexicons arose, and makes no claim to be evolutionary in any Darwinian sense.

The 'pigment-to-bead' model of the development of body ornamentation (Kuhn and Stiner, 2007: their Table 4.1, not considered in Watts, 2009) highlights primarily quantitative contrasts in performance characteristics of these two technologies. Discussing standardization, Kuhn and Stiner (2007: 49) suggest that the only redundant aspect of early pigment use is in color selection ("mainly black manganese and red ochre") and that this impression might be skewed by the absence of evidence for use of "terra rossa clays, charcoal and white ash." Arguments based on the absence of evidence can rarely be refuted, but where soft, pigmentaceous materials are adequately preserved, it should be possible to evaluate their artifactual status. Comparison of the streaks of utilized versus unutilized pigments might provide evidence just as consistent with "agreed-upon cannons of ornamentation" (Kuhn and Stiner, 2007: 51) as the redundancy of form among early beads. If so, this would challenge the suggestion that 'pigment only' body ornamentation "was basically a form of individual display, a way to stand out and express individual uniqueness rather than a medium for communicating about more constant, institutionalized relationships" (Kuhn and Stiner, 2007: 51).

Durkheim (1961 [1912]), in the context of theorizing collective ritual's role in establishing religion (see SOM), predicted that the earliest form of 'art' would have been red ochre painting of geometric designs on the bodies of ritual performers (1961: 149 footnote150, see also pp. 148, 264–5, 417). While ethnographically informed, he advanced theoretical reasons why the medium should be red ochre, the canvas the human body, and the content abstract rather than figurative (Watts, 2009). The prediction seems prescient in the light of the geometric engravings on Blombos ochre (Henshilwood et al., 2009). It also highlights the possibility that individual episodes of ochre use might only involve processing small amounts of powder. In the Durkheimian perspective, color terms are, at origin, ritually defined categories (e.g., Turner, 1966; Sahlins, 1976; Knight, 1999: 233).

A Darwinian reformulation of Durkheim's insight on the role of collective ritual is the 'female cosmetic coalitions' model of the evolution of symbolic culture (Knight et al., 1995; Power and Aiello, 1997; Knight, 1998, 1999, 2009; Power, 1999, 2009; SOM), premised in behavioral ecology. This claims (inter alia) to account for the main features of the archaeological record of early pigment use (Watts, 2009). It predicts that the earliest evidence of symbolic behavior will be found in a cosmetics industry focused on 'blood-red' pigment, initial use in the middle of the middle Pleistocene, a shift from irregular to regular and ubiquitous use (at least among our ancestors) by the time modern encephalization quotients were achieved (c. 200 ka), and that where 'blood-red' earth pigments are locally unavailable, considerable costs should be incurred to procure them.

The two leading non-pigment hypotheses of early ochre use concern tanning and hafting. The tanning hypothesis (Wadley et al., 2004; Wadley, 2005a) is not considered here; it appears to be based on a misunderstanding of basic chemistry and lacks ethnographic support (Watts, 2009; SOM). The hafting hypothesis is empirically grounded: the inclusion of ochre in hafting cement is supported in some post 80 ka MSA contexts (Lombard, 2007 with references) and its utility in replicated adhesives—reducing brittleness and acting as a desiccant—has been experimentally demonstrated (Allain and Rigaud, 1986; Wadley, 2005a; Wadley et al., 2009). Replicative studies have been used to support arguments for complex cognition in the MSA (Wadley et al., 2009). However, like tanning, the hypothesis has also been deployed as a possible alternative general explanation for ochre use; specifically, that it might account for large, early MSA ochre assemblages such as Twin Rivers (Wadley, 2005a: 599; Lombard, 2007: 414). This rested on the suggestion that such assemblages may contain large amounts of non-pigmentaceous material, a suggestion based not on Barham's (2002) observations but on the material used in Wadley's initial hafting experiments (ironstone nodules), where only the cortex was pigmentaceous (Wadley 2005b; SOM). A general application of the hafting hypothesis would not predict significant use of homogenously fine-grained ochre, as experimental findings indicate that a coarse component is essential (Wadley et al., 2009). More importantly, it would not predict preferential use of the reddest, most saturated materials, as various yellow and red ochres have proved effective (Allain and Rigaud, 1986; Wadley et al., 2009).

The proposition that much red ochre may be incidentally heated yellow ochre (Wadley, 2009; SOM), while not an interpretative hypothesis about use, has been raised as grounds for challenging the inference of selection for red (and any attendant semiotic hypotheses). It is, however, a null hypothesis with respect to the streaks of utilized versus unutilized pieces. It would also predict that yellow ochre should provide a lower proportion of small debris than red ochre—smaller fragments being more likely to undergo uniform color change.

Questions addressed

Questions concerning the artifactual status of possible pigments, forms of utilization consistent with pigment use, and whether pigment reporting adequately represents the amounts of pigmentaceous material, can all be treated as broadly concerned with how the field of study is defined and what constitutes appropriate reporting procedures. Some of these questions are more pertinent to evaluating very early claims for potential pigment use. In later contexts, as here, their main relevance is in helping to distinguish between probable pigments and materials of more questionable status.

- Autochthony: Could the material be a natural part of the deposit, whether as: (1) a fire-reddened (rubified) deposit (cf. Butzer, 1980; Wreschner, 1983, 1985); (2) other pigmentaceous materials formed through secondary mineralization, such as calcium carbonate or manganese concretions, or ferruginous crusts (e.g., Schweitzer, 1970: 138; Deacon et al., 1984: 350; Barham et al., 2000: 84; this paper); or (3) deriving from shelter/cave host rock (Beaumont and Vogel, 2006: 222; this paper)? A secondary question is whether autochthonous pigmentaceous material is incidental or artifactual (see below).
- Non-pigmentaceous material: Is there significant non-pigmentaceous material, adhering to or forming the core of pigment pieces (Wadley, 2005a: 599)?
- Utilization: What evidence is there for utilization? Is such evidence consistent with pigment production? While grinding and scraping are consistent, flaking per se is not (e.g., Butzer, 1980; Volman, 1981: 325; Barham et al., 2000: 84, 92 and

their Table 8.14). Contextual evidence, such as hardness, flaking properties, streak quality, and the presence/absence of other forms of utilization, become critical.

Assuming that such first-order questions have been addressed, a reasonable working hypothesis is that the materials constitute a pigment assemblage, and the following questions arise:

- What physical attributes most usefully characterize assemblage variability?
- What attributes are most clearly associated with streak variability?
- Which materials are most prone to fragmentation, and why?
- With potential white and yellow pigments liable to be softer and more friable than red ochre (e.g., Armstrong, 1931: 251), and yellow ochre possibly reddened through proximity to hearths (Wadley, 2009), do taphonomic or excavation biases result in the under representation of non-red pigments (Marshack, 2003: 515;Wadley, 2005b: 2, 2009)?
- Controlling for fragmentation, how does the incidence of modification vary by geological form and streak?
- Can intensities of utilization be assessed? How do these relate to streak?
- Based on the above, what can be inferred about past selective criteria?
- With temporal sequences, what—if anything—changes?
- Can provisional inferences be made about procurement practices?
- At PP13B, do particular expressions of pigment permit correlations between excavation areas?

Methods

Qualitative physical description is the baseline for overall assemblage analysis and for informing the targeted use of petrographic, geochemical, and mineralogical characterization. Archeometric techniques do not form a part of the present study (see SOM for discussion), being the subject of a future paper; nevertheless, preliminary mineralogical assays indicate that the predominant chromophore is hematite, while hematite/maghemite admixtures characterize the few magnetic pieces, predominantly from the front of the cave (Herries and Fisher, 2010; Herries, pers. comm.). In describing the material I adopt—with some adaptations—basic characterization techniques geologists routinely use in the field, drawing upon American Geological Institute Data Sheets (Driscoll et al., 1989). Table 1 summarizes the main descriptive fields and their component values. A detailed account of descriptive methods is provided in the SOM, but comment is required for some key fields.

Table 1
Fields and values used to describe the population of potential pigments (exclusive of provenance and excavation details)

Field	Values
Weight	To the nearest 0.1 g. Values < 0.1 g assigned arbitrary value of 0.05 g.
Dimensions	Length, width, depth, measured by digital calipers to nearest 0.1 mm.
Geological form	Mudstone, shale, siltstone, coarse siltstone, fine sandstone, medium sandstone, iron oxide, quartzite, calcium carbonate, other (see SOM).
Hardness	Adapted from Mohs' scale, values 1 to greater than or equal to 5.
Fabric	Cleavage, massive, voids, clasts, voids & clasts, nodular.
Texture	Clay; clay & silt; silt; silt & sand; fine sand; clay, silt & sand; crystalline & clay; & silt; crystalline, sand & silt; cryst', med' sand, silt;med' sand & silt;
Shape	Chips & crumbs, chip, chunk, tabular, irregular nodular, prismoidal
Weathering	Fresh, moderately worn, extensively worn, moderate patina, extensive patina
Luster	Earthy, lustrous, earthy glister, submetallic, metallic
Mica abundance/size	Abundant, moderate, trace, absent; V fine, fine, moderate, coarse (2 fields)
Surface color	Subjective adjectival description
Iron content	Background, moderately hematized, hematized, ferruginized.
Magnetic	Yes/No
Streak	NCS notation
Streak comment	Made as necessary regarding crushing, pulverulence, staining, internal variability.
General comments	
Conjoins	Definite conjoins = A, probable conjoins = B, identical form = C, followed by numerical identifier of set and lower case alphabetical identifier of case
Pigment confidence	Qualitative assessment: definite, probable, possible, doubtful, non-pigment
Modification	Qualitative assessment: definite, probable, possible, unutilized
Modification form	Ground, scraped, notched, flaked, pressure release, and combinations thereof.
Facets & profile	Number of facets; profile = flat, concave, convex, & combinations thereof (2 fields)
Facet disposition	1 main, 1 main & edge, 1 main & edges, edge only, adjoining edges, 1 minor surface (not edge), 2 opposed, 2 adjacent, 2 opposed & edges, 3 convergent, 4 surface, all over
Completeness	Chip, fragment, c. 50%, c. 75%, >90%, whole
Percentage utilized	c. 2%, 5%, 10%, 15%, 20%, 25%, 33%, 50%, 66%, 75%, >90%
Typology	Ground frag'; lightly ground; moderately ground; mod' ground tablet; frag' mod' ground tablet; intensively ground; ground & scraped frag'; scraped frag'; mod' ground & superimposition; intensively ground, lightly scraped & engraved; intensively grnd, mod' scrpd & notched; isolated striae; notched; flaked; pressure release
Utilization comments	

A problem facing non-archeometric geological categorization of potential pigments is that most are—to varying degrees—products of chemical weathering processes. Where such processes are well-developed, they obscure relationships to the parent material. Most material could be categorized along a textural spectrum from mudrocks to sandstones, with fabric attributes distinguishing mudstone from shale. Mudstone, shale, siltstone, and coarse siltstone are collectively referred to here as 'fine-grained sedimentary' (FGS) forms. With sandstones, particularly 'medium sandstone,' the categorization need not imply that quartz grains were sedimentary—in a considerable but undetermined proportion of cases—they are likely to have formed through secondary alteration. 'Iron oxide' was used in preference to 'hematite' so as to include maghemite (reddish-brown streak). It refers to materials that typically felt relatively dense, showing little trace of sedimentary origin, with dense aggregates of dark material (frequently dark-gray with a platy structure [at 20× magnification], sometimes finer-textured, massive dark-brown or black material; cf. Cornell and Schwertmann, 2003: 6, 134) and producing a red streak. The quality of red played no part in categorization. Pieces could have a visible quartz component, prohibiting a sharp distinction from hematized sandstone; similarly, there will be some overlap with hematized, massive, FGS forms. Density and hue should rule out inclusion of manganese, but for the very darkest pieces some uncertainty must remain. Examples of the principal categories are illustrated in SOM Figure 1.

Hematized pieces were similarly defined to iron oxide, but inclusive of clearly sedimentary morphologies. In the dichotomized hardness variable, the distinction between hard and soft pigments rested on whether they scratched copper.

Streak

On the rare occasions archaeologists have reported streaks, Munsell charts have generally been used (e.g., Wreschner, 1983; Barham, 2002; Hovers et al., 2003). Munsell has several drawbacks (Sivik, 1997): it is based on psychophysical definitions rather than phenomenology—how color appears to observers; it idiosyncratically includes purple among the 'principal' hues; the form of notation is difficult to comprehend; and the chroma scale is open-ended. I consider the Natural Color System (NCS) to be preferable and recommend its use in future studies. Based on the dominant paradigm in color vision research (Herring's opponent-color theory refined by Jameson and Hurvich [cf. Sivik, 1997 with references]), NCS also has the advantage of a percentage-based metric. The attributes describing a color (gray scale, chroma, and hue) take the form of three pairs of digits (e.g., 4040 Y70R). The first pair is the percentage blackness (whiteness can be calculated as the sum of blackness and chroma subtracted from 100), the second pair is the chroma percentage (the intensity of color sensation, see SOM), while the letter-digit combination denotes the percentage ratio of non-opposed unique hues (using red as the notational base in the yellow:red ratio). Blackness and chroma constitute the 'nuance' of a color; in the NCS Index, for each 10% increase in blackness maximal chroma is reduced by 10%. Consequently, chroma—unlike blackness and hue—cannot be treated as an independent variable. Streak was recorded by abrading a tiny portion of each piece on unglazed porcelain (Fig. 1) and matching this against chips in the NCS Index (2nd edition).

In grouping NCS values, nuances were divided into pastel, intermediate, and saturated categories; for some analyses, these were further divided into light and dark subgroups (SOM). Hue was divided into yellowish-brown (<50% red), reddish-brown (50–74% red), and very red (≥75% red) groupings. Cutting across distinctions of nuance and hue, the darkest values (≥56% blackness) were separately grouped. Subjective adjectival descriptors were also used. Pulverulence and staining were assessed during streaking (SOM).

Utilization

Ordinal confidence assessments were made concerning the presence/absence of utilization. Grinding was distinguished from scraping along lines outlined elsewhere (Henshilwood et al., 2001, 2009). Other identified forms of utilization are flaking, notching,

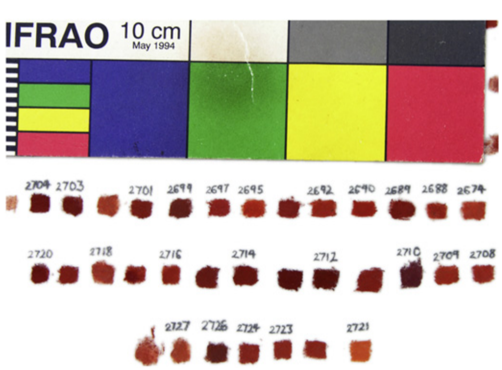

Fig. 1. Streak plate. To get an impression of NCS codings: ID 2710, coarse siltstone from Upper Roof Spall (Plot 63683), 6020 Y60R ('very dark'; see SOM Fig. 8c); ID 2711 (unmarked, between 2710 and 2712) coarse siltstone from Upper Roof Spall (Plot 64505), 4247 Y60R (dark saturated reddish-brown); ID 2712, one of two iron oxide conjoins from Lower Roof Spall (Plot 77724), 5043 Y75R, 'dark saturated very red' (see SOM Fig. 8a); ID 2721, siltstone from Truncation Fill, 2353 Y40R (light intermediate yellowish-brown).

and pressure release. The number of use-wear facets, their profile, and their disposition (both in relation to the shape of the specimen and—in the case of multiple facets—to each other) were recorded. A rough estimate of the proportion of total surface area bearing utilization traces was made. Where shape and/or the distribution of wear (natural or artifactual) permitted, estimates of completeness were also made. Both fields used a limited array of preset ordinal 'percentages.'

The descriptive typology conveys the most salient features of use-wear. Most pieces could only be categorized as 'ground fragments,' but with more informative pieces (generally where an estimate of completeness was possible) 'light,' 'moderate,' or 'intensive' prefixes were assigned. 'Intensively ground' were utilized over the majority of surface area, 'moderately ground' had between 25% and 50% of surface area utilized, 'lightly ground' were utilized over ≤15% of surface area.

Pigment confidence assessments

'Non-pigment' produced no streak. 'Doubtful' pigments produced a streak, but were judged autochthonous components of the deposit. 'Possible' pigments produced a streak and were probably introduced into the cave, but there remained grounds for doubt regarding their pigment status, typically concerning pulverulence or staining properties. Remaining pieces were treated as pigments (although, as argued below, a small proportion could probably be treated as pigment processing waste).

Assemblage treatment

Preliminary sorting of plotted and screened material was done by sorters, separating any material looking as if it might have served as pigment. Secondary sorting and data entry was based on this material, together with my sort through 'fire-modified rock' (FMR) and six cases passed on from faunal analysis.

During initial data entry, so as not to prejudge pigment status and to get baseline observations on non-pigments and questionable pigments, everything set aside during primary sorting was entered. Later, material I was confident was not pigment (primarily host rock and secondary mineralization concretions) was not entered. Consequently, the amount of material judged to be 'non-pigment' or 'doubtful' pigment (see below), while representative of the range of expressions, is of arbitrary size. Cases were individual or collective. Collective entries were either: multiple sub-10 mm fragments from the same Excavation Lot (see Marean et al., 2010), the same screening fraction (generally 3 mm), and having the same geological form; or, pieces that appeared to have fragmented during or after excavation. No refitting program was undertaken, but pieces identified during data entry as conjoining, probably conjoining, or appearing identical, were recorded (see SOM).

Apart from some of the 'non-pigment' and 'doubtful' pigment, full details were recorded for all pieces with a maximum dimension ≥10 mm (including conjoins). With smaller pieces, full details were entered where possible (primarily constrained by ease of manipulation, particularly for streaking). Low power microscopy was generally at 20× magnification.

Possible local sources of pigment

The host rock of the cave and the cave deposits were examined with the excavation director (C. Marean) and one of the project micromorphologists (P. Karkanas) to evaluate possible autochthonous pigmentaceous materials. The local landscape (within c. 10 km of Pinnacle Point) was explored for pigmentaceous materials. In the immediate vicinity of the cave there are iron enriched weathering features in the host rock, calcrete horizons in the dunes mantling the hard rock geology, and calcium carbonate concretions in the cave deposits (see SOM). Nothing suggests that any of these served as pigments (see below). About 5 km north of Pinnacle Point is the southern limit of a c. 1 km wide remnant of Bokkeveld shale and siltstone, extending east/west from the coast in Mossel Bay to c. 4 km west of Pinnacle Point. This is the only likely source of pigment in the local environment. The outcrop is a syncline within the underlying Table Mountain Group (TMG) sandstone, actively being eroded by a stream, forming a steep valley. Over 5.5 km, the valley ascends from sea level to ~140 m a.s.l. A brief search of the valley found small amounts of widely distributed, variably iron enriched shale/siltstone. Four field samples were examined. A piece categorized as 'iron oxide,' with silt and clay texture and some crystalline expression, provided a streak of 5437 Y70R. A hematized shale provided a streak of 4046 Y70R, a 'moderately hematized' example was less chromatic (4238 Y70R), while a poorly iron enriched sample had a streak of 3045 Y40R. No ochreous sandstone and no distinctly yellow ochre were found.

Potential pigment sources in the regional environment (>10 km), whether Bokkeveld or other substrates, still need investigation. Approximately 60 km west of Pinnacle Point, around the town of Albertinia, deeply weathered Bokkeveld has been the principle source of commercially quarried red and yellow ochre in South Africa (Visser, 1937; Brabers, 1976). There are several outcrops between Mossel Bay and Albertinia. Bokkeveld weathering profiles in the southern Cape vary enormously, often a function of their height above sea level. As a result of Tertiary marine transgressions, coastal profiles tend to be poorly developed, whereas outcrops ≥200 m a.s.l. (as around Albertinia and some of the intervening outcrops) generally have developed profiles and more extensive ochre. Although Blombos and PP13B have similar local geologies, Bokkeveld in proximity to Blombos lies close to the present sea level (cf. Rogers, 1988) and has been planed more often and recently than the upper reaches of the Mossel Bay outcrop. The latter might, therefore, be expected to provide more saturated and redder material.

The parent population and the pigment sample

The analyzed material comes from the Eastern, Western, and Northeastern (Lightly Cemented Middle Stone Age; LC-MSA) excavation areas, along with two (large) pieces recovered from a crevice above the LC-MSA deposits, apparently cached, possibly between ~115 and 92 ka. A small amount of the 3 mm fraction, from some aggregates in the Eastern and Western excavations, remained unsorted during data entry. While this will have some affect on counts of more fragmentary materials, it will not significantly affect mass-based profiles. At Blombos (Henshilwood et al., 2001; Watts, 2009), large assemblages required that analysis be restricted to pieces ≥10 mm. Here, smaller assemblages—together with the piece plotting of sometimes very small pieces—made it both practical and necessary to describe smaller pieces. Reference to individual pieces will be by plot or catalog number, or by the identification number automatically generated as pieces were described.

The 643 case level entries weighed almost 2 kg (1977.58 g, $n = 640$, see SOM regarding the missing weights). The number of pieces, irrespective of size, was 1,032. Analysis was restricted to fully described individual cases ≥0.1 g or ≥10 mm in maximum dimension, and collective entries ≥0.2 g. The weight/size criteria reduced the sample to 501 cases, while the requirement for full descriptive details reduced it to 467 (432 individual cases, 35 collective entries, 1961.9 g in total). Of these, 40% from the 10 mm screen ($n = 156$) and 22% of the plotted material ($n = 117$) were misidentified during initial sorting as 'fire-modified rock' (see SOM). Pigment is clearly not a self-evident category. In any examination of existing collections, inspection of all geological categories is strongly recommended.

Twenty-two cases—predominantly quartzite roof spall—were categorized as 'non-pigment,' and 47 as 'doubtful' pigment – predominantly roof spall with a ferruginous matrix or calcium carbonate concretions (see SOM). Hardness and poor pulverulence made the ferruginous quartzite an unattractive potential pigment. Calcium carbonate was excluded because of its identity with secondary concretions in the deposit and the absence of use-wear. It was typically soft (hardness 2), but with fairly well-preserved surfaces. The adequate preservation of such material permits evaluation of whether MSA people used soft white or yellow earth pigments.

Eighteen pieces were categorized as 'possible' pigments (SOM and SOM Table 1). Widely distributed across excavation aggregates, these predominantly comprise unique geological forms, along with a few weakly pigmentaceous expressions of the major pigment categories. Owing to several weight outliers (including one of the two pieces from the crevice) the group accounts for 37% of total mass. The grounds for uncertainty were almost as diverse as the pieces themselves, but nine cases were poorly pulverulent. Although four cases were utilized, use-wear for three was inconsistent with powder production (two flaked and one pressure release), and the fourth—while abraded—was poorly pulverulent. Yellow was the predominant hue in eleven cases and eight cases were poorly chromatic. Adopting a moderately conservative approach to circumscribing the pigment population, these pieces are excluded from the overall analysis, but are taken into account when evaluating inferences about streak based selective criteria.

Table 2 summarizes the derivation of the 380 pigment cases (553 pieces, 1082.7 g), together with age estimates of the aggregates and summary measures of mass. Despite incomplete data, the 3 mm fraction is fairly consistently represented across the three excavations (40%–45.8%; SOM Table 2) suggesting no substantial loss of information.

Two FGS pieces had ochre grading into leached (light-gray) expressions (Cat. 111499, see Fig. 7a; and ID 2747). Otherwise, as far as could be determined, pieces were fairly homogenously pigmentaceous so assemblage mass adequately represents the amount of pigment.

Overall characterization

Siltstone is numerically predominant, followed by coarse siltstone, iron oxide, fine sandstone, and shale; other categories are fairly insignificant (Table 3). By mass, fine sandstone predominates, followed by iron oxide, coarse siltstone, siltstone, and shale. The predominance of fine sandstone is attributable to two weight outliers (Cat. 29689, Upper Roof Spall, 104.8 g; and the second of the two pieces recovered from the crevice above the LC-MSA, Plot 54713, 78.9 g). Among the fine sandstone, similarities to coarse siltstone were frequently noted, and among the iron oxide, similarities to fine sandstone, coarse siltstone, or (most often) siltstone were frequently noted (SOM).

Pieces ≥5 g are predominantly coarse siltstone, fine sandstone, and iron oxide. Shale and siltstone have the lowest mean weights. Their fragmentary character is more pronounced if collective entries are factored in (SOM Table 3), with successive, pronounced increases in small debris (<0.5 g) percentages along the textural gradient from coarse siltstone to shale.

Hardness partially explains these different weight profiles (Table 3; see also SOM Table 4). While values ≥4 predominate

Table 2
Frequency and mass distributions of the pigment sample by stratigraphic aggregate, with approximate ages of the aggregates (adjusted minimum and maximum estimates, RD = Recent disturbance, RS = Recent sediments), and mean weights by aggregate

Excavation area	Straigraphic aggregate	~ age (ka)	*n*	% *n*	Mass (g)	% mass	Mean (g)	s.d.
West	Surface sediments	RS	24	6.3	26.20	2.4	1.1	3.0
	Northeast Fill	RD	4	1.1	2.30	0.2	0.6	0.2
	LB Sand 1	91–94	22	5.8	123.20	11.4	5.6	12.5
	DB Sand 2	91–102	19	5.0	25.80	2.4	1.4	2.4
	LB Sand 2	91–102	5	1.3	0.80	0.1	0.2	0.1
	DB Sand 3	91–102	47	12.4	251.15	23.2	5.3	11.8
	LBG Sand 1	94–134[a]	17	4.5	36.90	3.4	2.2	3.5
	DB Sand 4b	152–166	2	0.5	0.70	0.1	0.4	0.2
	LBG Sand 4	152–349	1	0.3	0.20	0.0		
	LB Silt	152–349	2	0.5	3.60	0.3	1.8	2.0
	LB Silt-G	152–349	1	0.3	0.10	0.0		
	Laminated Facies	349–414	1	0.3	0.70	0.1		
	Section cleanings		21	5.5	31.35	2.9	1.5	1.9
	Western total		166	43.7	503.00	46.5	3.0	8.2
East	Surface sediments	RS	25	6.6	36.40	3.4	1.5	1.8
	Re-Deposited Disturbance	RD	31	8.2	78.20	7.2	2.5	3.8
	Truncation Fill	35–39	16	4.2	29.70	2.7	1.9	5.0
	Shelly brown sand	91–98	22	5.8	32.30	3.0	1.5	1.5
	Roof Spall-Upper	91–98	39	10.3	176.75	16.3	4.5	17.5
	Roof Spall-Lower	106–114	14	3.7	39.20	3.6	2.8	6.1
	Section cleanings		16	4.2	17.90	1.7	1.1	2.8
	Eastern total		163	42.9	410.45	37.9	2.5	9.1
Northeast	Surface cleanings		1	0.3	0.10	0.0		
	LC-MSA Upper	115–133	1	0.3	0.40	0.0		
	LC-MSA Lower	153–174	48	12.6	89.85	8.3	1.9	4.8
	Northeast total		50	13.2	90.35	8.3	1.8	4.4
	Crevice above LC-MSA		1	0.3	78.90	7.3		
Overall total			380		1082.70		2.8	9.1

[a] LBG Sand 1 includes two occupations with approximate ages centred on 98 ka and 122 ka, with a hiatus between.

among sandstone and iron oxide, approximately 60% of the principal FGS forms were hardness 3 (just three cases were softer). Similar hardness differences were noted at Blombos (Henshilwood et al., 2001: 431). Quartz content may be a factor, but much of the hardness variation is attributable to variable iron enrichment (SOM Table 5). Among harder expressions of shale and siltstone ($n = 66$), 60.6% were 'hematized' or 'moderately hematized,' compared to 15% of softer expressions ($n = 100$).

More resolved patterning among the principal FGS forms emerges from fabric and histocity-related attributes (Fig. 2). Histocity concerns the layered microcrystalline structure of most clays and clay-micas (phyllosilicates; e.g., illite, chlorite, muscovite, etc). There are successive declines in cleavage, from 100% of shale (part of the category definition) to one-third of coarse siltstone (see SOM Fig. 2 for fabric profiles by raw material). Most shale was also tabular, lustrous, and with abundant, very fine mica. Siltstone percentages for these attributes are also high. Very little coarse siltstone was lustrous or had very fine mica, but one-third had abundant mica and cleaved fabrics, and a quarter was tabular. The successive increases in small debris from coarse siltstone to shale (SOM Table 3) are presumably a correlate of greater histocity and propensity to fragment along planes of secondary cleavage. Poor consolidation of the cementing matrix, rather than histocity, probably accounts for fine sandstone small debris. Cleaved fabrics were least likely to be judged particularly iron enriched, while nodular and vesicular fabrics were overwhelmingly so (SOM Fig. 3).

With phyllosilicates responsible for important characteristics of much of the fine-grained sedimentary material, secondary alteration distinguishes a minority of shale and siltstone, larger proportions of coarse siltstone and fine sandstone, and largely defines iron oxide (Fig. 3). The presence of voids and/or macrocrystalline development is intrinsically indicative of some secondary alteration. Although more subjectively determined, the same goes for iron enrichment assessments. The absence of mica or its presence only as a trace has no necessary relationship to secondary alteration. But, if mica were abundant in unaltered parent material (and illite, a typical clay-mica [Konta, 1995], is the predominant clay mineral in fresh or moderately weathered Bokkeveld [Danchin, 1970]), its hydrolysis may correlate with iron enrichment. Fine sandstone only partially fits the overall trend; it is distinct from coarse siltstone with respect to mica content (Figs. 2 and 3) and hardness (Table 3), but shows little difference for voids, crystallinity, and iron enrichment (Fig. 3).

Table 3
Raw material frequency, mass, mean weight, percentages of small and large pieces, and of dichotomized hardness (3 missing values for all weight-based attributes)

	n	% *n*	wgt (g)	% wgt	Mean wgt.	Mean s.d.	% <0.5 g	% ≥5 g	Hardness ≤3	Hardness ≥4
Mudstone	7	1.8	47.5	4.4	6.8	17.0	57.1	14.3	71.4	28.6
Shale	42	11.1	65.2	6.0	1.6	2.9	43.9	4.9	59.5	40.5
Siltstone	124	32.6	151.1	14.0	1.2	4.7	59.8	2.5	60.5	39.5
Coarse siltstone	65	17.1	204.7	18.9	3.1	7.5	56.9	15.4	56.9	43.1
Fine sandstone	55	14.5	303.2	28.0	5.5	17.4	43.6	18.2	29.1	70.9
Medium sandstone	12	3.2	23.8	2.2	2.0	3.3	41.7	8.3	0.0	100.0
Iron oxide	59	15.5	260.3	24.0	4.4	9.4	37.3	22.0	18.6	81.4
Other	16	4.2	27.0	2.5	1.7	2.0	43.8	12.5	18.8	81.3
Total	380	100.0	1082.7	100.0	2.8	9.1	50.4	11.1	45.3	54.7

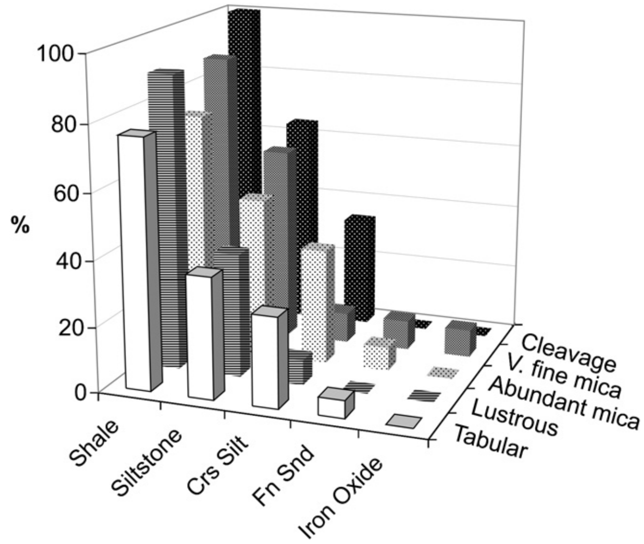

Fig. 2. Percentage bar chart of selected attributes indicative of high phyllosilicate content for the principal raw materials. Crs Silt = Coarse Siltston; Fn Snd = Fine Sandstone.

There were no pronounced differences between materials in weathering state attributes (SOM and SOM Table 6), plausibly consistent with derivation from the same outcrop. More significant, however, is the rarity of extensive natural wear (n = 5), that moderate wear was restricted to c. 10% of the sample, and that there was no evidence for shoreline procurement of the kind reported at Blombos (Henshilwood et al., 2001). This suggests that the material was not procured from marine exposed outcrops (where high-energy mechanical weathering should produce large proportions of worn pieces). This needs to be corroborated for LC-MSA Lower, representing the MIS 6 regression (see below). Magnetic pieces were also fairly infrequent (7.2% of the total, SOM Table 2) and were surprisingly heterogeneous (SOM Table 6). There was suggestive evidence that pieces became magnetic after procurement: some elements of probably conjoining sets were magnetic while others were not, and magnetic percentages were lowest in the rear of the cave, where magnetic susceptibility of sediments (a proxy of heating) was also lowest (Herries and Fisher, 2010; SOM).

Turning to streak attributes, redness and blackness are positively correlated ($r = 0.278$, $n = 380$, $p < 0.000$) but the relationship is weak, accounting for just 8% of the variation ($r^2 = 0.078$). There is also a relationship between nuance and redness, with saturated reds (mean 3951 Y70R, s.d. 8:8:7, $n = 125$) significantly redder than intermediate counterparts (mean 3844 Y62R, s.d. 7:8:8, $n = 193$; Welch's t [292.04] = 9.119, p = 0.000).

As all 'very dark' values ($n = 34$, 8.9%) had ≥60% redness, red is the dominant hue for 92.9% of the sample (Table 4). Redness is probably the most perceptually salient streak attribute for approximately 88% of the sample (blackness having greater salience among low chroma 'very dark' values [see SOM]). Six 'very dark' streaks had ≥70% blackness, five being subjectively described as 'dark-brown' and one as 'black.' Among the yellowish hues ($n = 27$, 7.1%), none had saturated nuances and three quarters lay within 10% of the boundary with reddish-brown, more consistent with an extended range to the latter category than with a distinct category focus. Pastel nuances ($n = 8$, 2.1%) were rare and predominantly yellowish. Saturated nuances account for 32.9% (36.6% including saturated 'very dark' nuances). 'Very red' hues account for 12.4% (16.3% including 'very dark' nuances). Saturated, very red, and very dark streaks are considerably better represented than at Blombos (Watts, 2009: his Fig. 4.5), where the respective percentages were 15.5%, 7.7%, and 1.5% ($n = 1534$). Comparison of frequency and mass percentages indicates that most yellowish and light intermediate reddish-brown pieces are small debris, as is much of the dark intermediate reddish-brown material (see SOM for subjective yellowness of the light intermediate reddish-brown sample). Three quarters (74.1%, $n = 27$) of yellowish hues weighed <0.5 g, compared to half of reddish hues (48.7%, $n = 349$). If heating of yellow ochre had been significant, one might expect these proportions to be reversed. Saturated reds, accounting for 54.1% of total mass, appear to have been the main target of procurement.

Raw material average streaks (Table 5a) show that iron oxide is by far the reddest and marginally the darkest category, and the only form where nuance is unequivocally saturated. Mudstone is the lightest and yellowest category (but with exceptionally high hue variance) and there are successive increases in blackness across the textural spectrum. Most forms (except fine sandstone and iron oxide) are comparably chromatic for their respective blackness levels (see SOM). Shale, siltstone, coarse siltstone, and medium sandstone have closely comparable hues. Shale and siltstone average streaks are almost indistinguishable, suggestive of essentially identical material. Coarse siltstone is significantly darker than siltstone (Welch's t [102.6] = 3.5, p = 0.001), fine sandstone is significantly less red than coarse siltstone (Student's t [118] = 2.101, p = 0.038) and less chromatic. Raw material profiles of grouped NCS values (SOM Fig. 4) show small, successive increases in the combined representation of very dark, saturated, and/or very red

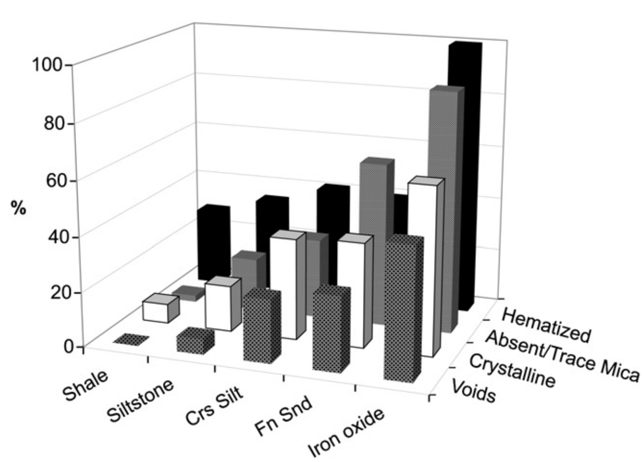

Fig. 3. Percentage bar chart of selected attributes indicative of secondary alteration for the principal raw materials ('Hematized' = hematized and moderately hematized). Crs Silt = Coarse Siltston; Fn Snd = Fine Sandstone.

Table 4
Grouped NCS values by frequency and mass

NCS Groupings[a]	n	% n	Weight (g)	% mass
Pstl Yellow-Brown	7	1.8	7.80	0.7
Pstl Red-Brown	1	0.3	0.40	0.0
Int light Yellow-Brown	10	2.6	5.85	0.5
Int dark Yellow-Brown	10	2.6	10.70	1.0
Int light Red-Brown	23	6.1	10.90	1.0
Int dark Red-Brown	156	41.1	321.15	29.7
Int. dark very Red	14	3.7	37.25	3.4
Sat. light Red-Brown	23	6.1	35.20	3.3
Sat. dark Red-Brown	69	18.2	335.10	31.0
Sat. light very Red	12	3.2	70.40	6.5
Sat. dark very Red	21	5.5	144.80	13.4
Very dark	34	8.9	103.15	9.5
Total	380	100.0	1082.70	100.0

[a] Pstl = Pastel; Int = Intermediate; Sat = Saturated.

Table 5a
Average streaks of geological categories (excluding 'other')

	n	Mean NCS	s.d. of mean
Mudstone	7	3249 Y48R	0.9:07:22
Shale	42	3448 Y63R	0.6:10:12
Siltstone	124	3648 Y62R	0.7:09:11
Coarse siltstone	65	4143 Y63R	0.9:12:10
Fine sandstone	55	4339 Y59R	0.8:11:08
Medium sandstone	12	5033 Y62R	14:12:10
Iron oxide	59	5139 Y74R	11:13:05

values across the FGS spectrum, a trend correlating with the successive increases in iron enriched percentages. Fine sandstone's low average redness is partly attributable to the absence of very red values. This may reflect inadequate criteria for distinguishing hematized fine sandstone from iron oxide with quartz clasts (both categories had similar fabric profiles, SOM Fig. 2).

The difference between frequency and mass contributions of NCS groupings to the overall sample (Table 4) is not reducible to, for example, large pieces of iron oxide. Within raw materials, average streaks of small debris ($<$0.5 g) are fairly consistently lighter, yellower, and less chromatic than their larger ($\geq$1 g) counterparts (Table 5b; but see SOM regarding coarse siltstone). Shale debris is significantly lighter, while siltstone and fine sandstone debris are significantly yellower. Among larger pieces, shale, siltstone, and coarse siltstone have indistinguishable average nuances (although coarse siltstone has much greater variance) and show only slight hue differences (the slightly lower average redness for shale $\geq$1 g is attributable to two pieces from the Re-Deposited Disturbance arguably qualifying as pigment processing waste; cf. SOM 'aggregate samples'). This suggests a common provenance and that they were probably regarded by MSA people as a homogenous category. The improvement in fine sandstone chroma and redness is particularly pronounced; the category is now only distinguished from FGS forms by being marginally significantly darker (relative to coarse siltstone, Student's $t[40] = 2.021$, $p = 0.05$; see below for why fine sandstone debris exerts such a bias). The within form streak differences between smaller and larger pieces strengthen the inference of preferential procurement of redder, more chromatic materials, and suggest that much of the debris entered the deposit in this state (rather than arising from post-deposition fragmentation).

While iron oxide presents a distinctive profile and fine sandstone is significantly darker than FGS forms, geological categories per se are fairly uninformative about streak variation. More informative are the attributes indicative of secondary alteration (Table 6). Within raw material categories, iron enriched samples ('hematized' or 'moderately hematized') are significantly redder and much more chromatic than 'background' counterparts (even with yellowish hues excluded). Iron enriched siltstone and fine sandstone samples are also significantly darker (dramatically so for fine sandstone). Samples with little or no mica are all significantly darker, most are more chromatic, but only siltstone is significantly redder. It seems that high mica content significantly lightens the nuance (cf. Elias et al., 2006). Harder expressions of shale and siltstone are significantly darker and redder, and much more chromatic than soft counterparts. Harder coarse siltstone is also appreciably more chromatic than softer expressions. Unexpectedly, softer iron oxide is significantly darker than the harder sample, hinting at possible mineralogical variability requiring investigation. For whole sample *t*-tests of these dichotomized attributes and for streak comparisons of the component values of the iron enrichment variable, see SOM Table 7a and b. For some raw materials, a vesicular fabric or the presence of a crystalline component is also associated with significant streak differences (SOM Table 7c). That these effects are not as systematic across materials is sometimes attributable to small samples and—for crystallinity—to methodological shortcomings (SOM).

Stratigraphic aggregate samples

A detailed account of the variability within and between aggregate samples is presented in the SOM (see also SOM Tables 2 and 8 and SOM Figs. 5–7). Despite samples being invariably fairly small ($<$50), many aggregates having mass profiles dominated by single pieces (typically iron oxide), and some having frequency profiles biased by the fragmentation of once larger pieces, temporal trends in raw material representation can be identified.

Figure 4 illustrates the mass-based raw material profiles for primary context aggregates (where $n \geq 14$), in approximate chronological order (for frequency-based profiles, see SOM Fig. 5). The following summary pertains to both mass and frequency profiles. In the terminal middle Pleistocene of MIS 6 (LC-MSA Lower), FGS forms predominate. In the earlier part of the Last Interglacial (MIS 5e to 5d, a portion of LBG Sand 1 and Lower Roof Spall [LRS]), fine sandstone and iron oxide predominate. Substage MIS 5c witnesses successive declines in these materials in both Eastern (Upper Roof Spall [URS] and Shelly Brown Sand [SBS]) and Western (Dark-Brown Sand [DBS] 3, DBS 2, Light Brown Sand [LBS] 1) aggregates, with corresponding increases in FGS material (the percent frequency of FGS forms declines slightly in LBS 1 relative to DBS 2, but mass percentages suggest no significance should be attached to

Table 5b
Comparison of average streaks between small debris ($<$0.5 g) and pieces $\geq$ 1 g for principal raw materials and the overall sample (including mudstone, medium sandstone, and other). Chroma difference is the percentage by which larger pieces are more chromatic, controlling for blackness

		n	Mean NCS	s.d. of mean	Chroma diff'	Significant Student' s *t*-tests (5% level) for blackness or hue
Shale	$<$0.5 g	18	3248 Y61R	06:09:13		
	$\geq$1 g	18	3747 Y63R	07:10:11	4	Blackness: $t(34) = -2.217$, $p = 0.033$
Siltstone	$<$0.5 g	73	3548 Y61R	07:09:11		
	$\geq$1 g	32	3748 Y66R	06:08:11	2	Hue: $t(103) = -2.139$, $p = 0.035$
Grouped shale and siltstone	$<$0.5 g	91	3448 Y61R	07:09:12		Blackness $t(139) = 2.18$, $p = 0.031$
	$\geq$1 g	50	3748 Y65R	06:09:11	3	Hue $t(139) = 2.044$, $p = 0.043$
Coarse siltstone	$<$0.5 g	37	4043 Y62R	09:11:11		
	$\geq$1 g	18	3847 Y65R	10:12:10	2	
Fine sandstone	$<$0.5 g	24	4236 Y56R	09:11:07		
	$\geq$1 g	24	4442 Y63R	08:11:07	8	Hue: $t(46) = -3.261$, $p = 0.002$
Iron oxide	$<$0.5 g	22	4842 Y72R	13:16:05		
	$\geq$1 g	31	5337 Y74R	10:12:05		
All forms	$<$0.5 g	190	3944 Y61R	10:11:12		Blackness: $t(324) = -3.588$, $p = 0.000$
	$\geq$1 g	136	4343 Y66R	11:11:10	3	Hue: $t(324) = -3.972$, $p = 0.000$

Table 6
Within form streak comparisons for dichotomized iron enrichment, mica content, and hardness

Form	Paired comparison[a]	n	Mean NCS	s.d. of mean	Blackness t-test	Chroma diff'	Hue t-tests
Iron content							
Shale	Background	27	3449 Y62R	06:08:08			
	Iron-rich	12	3751 Y71R	06:08:07		5	$t(37) = 3.584$, $p = 0.001$
Siltstone	Background	67	3548 Y61R	06:08:07			
	Iron-rich	43	3950 Y70R	07:08:06	$t(108) = 3.559$, $p = 0.001$	5	$t(108) = 6.549$, $p = 0.000$
Coarse siltstone	Background	37	4042 Y61R	08:10:07			
	Iron-rich	26	4245 Y68R	11:13:08		5	$t(61) = 3.582$, $p = 0.001$
Fine sandstone	Background	30	3940 Y58R	08:11:07			
	Iron-rich	22	4839 Y64R	07:10:05	$t(50) = 4.246$, $p = 0.000$	8	$t(50) = 3.505$, $p = 0.001$
Mica content							
Siltstone	Abndt/Mod	100	3548 Y61R	07:09:11			
	Absent/Trace	24	4047 Y67R	06:08:08	$t(122) = 2.870$, $p = 0.005$	4	$t(122) = 2.296$, $p = 0.023$
Coarse siltstone	Abndt/Mod	46	3845 Y63R	07:10:10			
	Absent/Trace	19	4639 Y62R	12:14:10	$t(24.3) = 2.639$, $p = 0.014$	2	
Fine sandstone	Abndt/Mod	22	3942 Y58R	07:10:09			
	Absent/Trace	33	4538 Y60R	08:11:07	$t(53) = 2.492$, $p = 0.016$	2	
Medium sandstone	Abndt/Mod	4	3545 Y61R	14:11:06			
	Absent/Trace	8	5727 Y63R	08:07:12	$t(10) = 3.527$, $p = 0.005$	5	
Iron oxide	Abndt/Mod	7	4248 Y71R	05:06:02			
	Absent/Trace	52	5238 Y74R	12:14:05	$t(57) = 2.138$, $p = 0.037$		
Hardness							
Shale	Soft	25	3248 Y60R	06:11:13			
	Hard	17	3750 Y67R	05:07:08	$t(40) = 2.649$, $p = 0.012$	7	$t(40) = 2.010$, $p = 0.051$
Siltstone	Soft	75	3446 Y59R	07:09:11			
	Hard	49	3850 Y67R	07:08:09	$t(122) = 3.077$, $p = 0.003$	8	$t(122) = 4.619$, $p = 0.000$
Coarse siltstone	Soft	37	4141 Y63R	10:12:10			
	Hard	28	4046 Y63R	09:11:09		4	
Fine sandstone	Soft	16	4140 Y57R	08:09:09			
	Hard	39	4339 Y61R	09:11:07		1	
Iron oxide	Soft	11	6127 Y73R	11:13:05			
	Hard	48	4942 Y74R	10:12:05	$t(57) = 3.645$, $p = 0.001$	3	

[a] "Iron-rich" = hematized & moderately hematized; background excludes hues <50% red. Coarse Siltstone 'absent/trace' Abundant/Moderate mica is Welch's t-test.

this). That similar trends are seen in Eastern and Western excavations greatly increases confidence as to their reality.

The most pronounced change between successive aggregates is between LC-MSA Lower and the early Last Interglacial samples. This need not imply changes in procurement. The long occupation hiatus during the glacial maxima of MIS 6 (Marean et al., 2010) would coincide with significant down cutting of the valley in the local Bokkeveld outcrop. Speculatively, a returning population would probably find (limited) new exposures of relatively hematized material and would preferentially exploit these over less altered expressions.

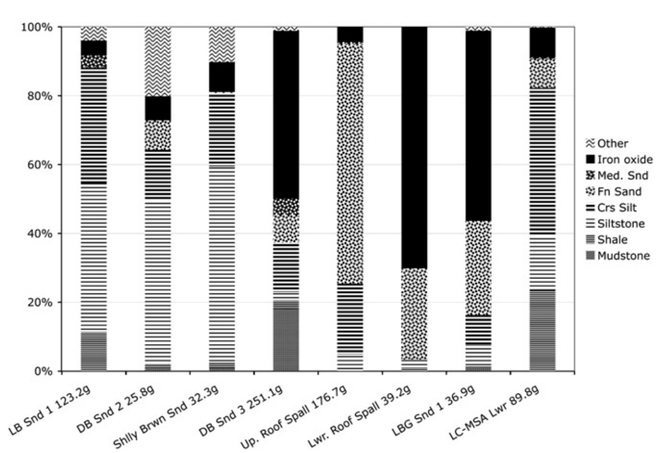

Fig. 4. Percentage bar chart of mass-based raw material profiles for stratigraphic aggregates dating to Marine Isotope Stages 6–5, arranged in approximate chronological order (oldest at right). Crs Silt = Coarse Siltston; Fn Snd = Fine Sandstone.

In the Western excavation, changes in grouped streak profiles across excavation aggregates (SOM Fig. 6) are fairly consistent with the changes in raw material profiles (Fig. 4 and SOM Fig. 5), with intermediate nuances characterizing the FGS dominated aggregates, and saturated/very dark nuances characterizing the iron oxide/fine-sandstone dominated aggregates. There is no such overall correspondence in the Eastern excavation, largely due to the influence of two distinct subgroups in Lower Roof Spall and Shelly Brown Sand.

In Lower Roof Spall ($n = 14$), despite a raw material profile dominated by iron oxide and fine sandstone, the frequency-based streak profile (SOM Fig. 6) is dominated by intermediate nuances (and the only appreciable representation of pastel nuances). The ten fine sandstone cases (with two additional cases in URS and three from section cleanings) share a close physical resemblance, and predominantly comprise small fragments of poorly chromatic, not very red material, with poor staining (two cases were appreciably more chromatic, hence the high chroma s.d. [SOM Table 8]). The subgroup largely accounts for the depressed chroma and substantially contributes to the low redness of fine sandstone as a whole (see above). Exclusion of the whole subgroup results in fine sandstone having an indistinguishable average streak to coarse siltstone (SOM 'stratigraphic aggregate samples'). Pre-empting discussion of utilization, none of this material was used; much of it could be considered candidate material for pigment processing waste, with a corollary categorization as 'possible pigment.'

Although Shelly Brown Sand ($n = 22$) predominantly comprises FGS forms, frequency and mass streak profiles are dominated by very dark, saturated, and very red values. Again, this is partly due to fragmentation of once larger pieces. Six of the 12 siltstone cases were a distinct subgroup of probably conjoining pieces containing crystalline pseudomorphs (with additional single cases in URS and DBS 2 [a second DBS 2 case fell below the weight/size parameters] and two cases in the Re-Deposited Disturbance). Relative to the overall siltstone sample (but not to other SBS siltstone), these were unusually dark, chromatic, and red (although both DBS 2 cases were much lighter and yellower). In addition, the three coarse siltstone cases were probable conjoins with 'very dark' nuances, while the two iron oxide were definite conjoins with 'very dark' nuances. In sum, three parent pieces probably account for half the SBS sample.

SBS and DBS 2 are broadly coeval, have similar raw material profiles, and the siltstone with crystalline pseudomorphs suggests a stratigraphic correlation. Yet, they have streak profiles and average streaks that could hardly be more different (respectively: 4543 Y69R, s.d. 12:13:7, $n = 22$; 3647 Y59R, s.d. 8:8:14, $n = 19$, see SOM Table 2). Both aggregates provide fairly small samples and fragmentation is a significant issue in SBS. The lightness and yellowness of the DBS 2 sample is partly attributable to three pieces of fine sandstone and a piece of mudstone. Two of the fine sandstone cases (probable conjoins) were considered possible pigment processing waste, while there was some doubt about the raw material categorization and pigment status of the 'mudstone' (see SOM). Nevertheless, even taking these mitigating factors into account, there remains a broader, underlying discrepancy that challenges any inference of meaningful temporal patterning to streak data or correlation with raw material profiles.

The discrepancy can, however, be explained. The Eastern sample as a whole is significantly darker than Western (Welch's t [307] = 2.132, p = 0.034) and Northeastern (Welch's t [108.9] = 2.572, p = 0.011) samples. Both by frequency and mass, Eastern Surface Deposits, SBS, and URS provide appreciably higher percentages of very dark nuances than any other aggregates (SOM Figs. 6 and 7). Of the six very dark nuances with ≥70% blackness, five came from Eastern aggregates (none of which were conjoins, probable conjoins, or shared identities to each other). Apart from two conjoining pieces of iron oxide from SBS, which had a layered, precipitate structure, 'very dark' streaked pieces were generally not otherwise distinctive. The spatial distribution is probably largely attributable to more pronounced heating of deposits in the Eastern excavation, inferred on the basis of magnetic susceptibility readings (Herries and Fisher, 2010) and microstratigraphy (Karkanas and Goldberg, 2010). Consistent with such an inference, magnetic pigment percentages were the highest in the Northeastern and Eastern excavations (SOM Table 2 and SOM 'Weathering assessments and magnetic pieces'), maghemite identifications were largely from these excavations (Herries, pers. comm.), while yellow ochre was disproportionately from the Western excavation (see below). That material from LC-MSA is not as dark as from the Eastern excavation, despite equally good proxy evidence for intensive heating, is probably due to subtle temporal raw material variation; notably, LC-MSA siltstone tends to be lighter, less chromatic, and less red even than samples where little heating is indicated (e.g., DBS 2 and LBS 1).

Yellow hues accounted for 9.8% of sample from the less heated aggregates ($n = 102$, predominantly in the Western excavation), compared to 5.9% of the sample among more intensively or repeatedly heated aggregates ($n = 189$, predominantly from the Eastern and Northeastern excavations; see SOM). This is consistent with some reddening and probable darkening of streaks through heating (Wadley, 2009); as the category disproportionately comprises small debris, this probably occurred incidentally. However, with yellow accounting for < 10% of pigments under the most favorable taphonomic conditions, most yellow being close to the cut-point with reddish-brown and no distinctively yellow ochre found in the local Bokkeveld exposure, it can be inferred that the great majority of pigment came into the site as red ochre.

Some final temporal observations concern the LC-MSA Lower sample. This appeared particularly homogenous in terms of raw materials grading into one another. The two 'very dark' values were maximally chromatic for their respective blackness, suggesting they may have been perceived as dark, saturated red, rather than as dark-brown or black. There were no extensively worn pieces and only one moderately worn, suggesting that pigments were not procured from exposures below present sea level.

The identification of six subgroups of conjoining, probably conjoining or otherwise identical material, each with ≥ 4 fragments and concentrated in particular aggregates, permitted some estimation of streak variability within the most homogenous samples (see SOM). This source of variance could potentially be subtracted from more heterogeneous samples.

Utilized material

Noting the high proportions of unutilized material in Watts' (1998) multisite MSA sample, Wadley (2005a: 599) has called for the reporting of both frequency and mass data and for "an investigation of the unmodified pieces from MSA sites," addressing whether they are unmodified "because they are unusable or because they were simply not used." In both the cited unpublished work and in published work (Watts, 1999, 2002, 2009; Henshilwood et al., 2001), I have addressed various factors affecting the relative representation of utilization (e.g., mesh size in sieving, proximity of a site to sources of pigment) and the attributes of utilized versus unutilized material (e.g., size, raw material, and streak). PP13B provides an opportunity to explore these issues in more detail.

Table 7 shows the frequency and mass percentages for the confidence assessments of utilization in the three excavations and the overall sample. Definite utilization accounts for 12.7% of the total. It is twice as frequent in the LC-MSA compared to the Eastern area (18% versus 9.2%). At the aggregate level, sample sizes are generally too small to evaluate rates of modification, but for primary context samples where $n \geq 14$, the highest rates of use occur in DBS 3 (27.7%) and LC-MSA Lower (18.8%); these are the largest samples and the 3 mm fraction was fully analyzed in each, so the percentages provide a reliable upper range. No Eastern aggregates exceed 13.6% (SBS). Discard of used pieces seems to have been less frequent in the forward, central portion of the cave than along the sides and the rear. By mass, 51.2% was utilized, slightly less than at Blombos (61.6%; Henshilwood et al., 2009; SOM). The weight outlier from URS (Cat. 29689, 104.8 g) accounts for 20% of utilized mass and explains why utilized mass percentage in the Eastern excavation is only slightly less than elsewhere.

Definitely utilized pieces ($n = 48$) have a mean weight of 10.7 g (s.d. 19.3 g), compared to 1.4 g for unmodified pieces ($n = 310$, s.d.

Table 7
Frequency and mass percentage distributions of the confidence assessments for the presence of use-wear by excavation area. (excludes a large chunk of 'possibly' ground fine sandstone from the crevice above LC-MSA)

	Definitely	Probably	Possibly	Not utilized		n
% of n						
West	14.5	3.6	1.2	80.7	100.0	166
East	9.2	3.7	2.5	84.7	100.0	163
LC-MSA	18.0	6.0	0.0	76.0	100.0	50
Total %	12.7	4.0	1.6	81.8	100.0	379
% of wgt						Total wgt
West	58.3	4.7	0.1	37.0	100.0	503
East	43.0	4.8	0.6	51.5	100.0	410.45
LC-MSA	49.6	1.0	0.0	49.4	100.0	90.35
Total %	51.2	4.4	0.3	44.0	100.0	1003.8

3.6 g; Welch's t [47.5] = 3.316, p = 0.002). This is comparable to the range of values reported at Blombos (Henshilwood et al., 2001: their Table 13) and similarly screened MSA assemblages (Watts, 1998: his Table 6.15; SOM). Clearly, the great majority of material from finely screened assemblages is unmodified small debris. The within form streak differences between smaller and larger pieces (Table 5b) suggested that much of the debris entered the deposit in a fragmentary state; speculatively, some of the debris may result from on-site processing to remove less desirable material (a hypothesis for future research).

The sample is too small to reliably indicate the lower size range for complete or near complete utilized pieces ($n = 10$), but the two smallest examples (Cat. 111498 and Plot 79414) were 21.8 mm and 30.7 mm in maximum dimension, a size comfortably held between forefinger and thumb. Grinding occurred on 93.7% of definitely used pieces, in six cases alongside other forms of modification (predominantly scraping, but with single cases of flaking and notching). The three non-ground cases were flaked, notched, and scraped. There were also 14 probably and five possibly ground, and one probable and two possible scraped cases. The rareness of very soft material (hardness < 3, see SOM Table 5) accounts for the low incidence of scraping relative to Blombos (Henshilwood et al., 2009). No pigment grinding stones were recovered, also in contrast to Blombos (pers. obs.); a speculative explanation is offered in SOM.

Exclusion of material < 10 mm and retaining the focus on definite utilization (SOM Table 9b) permits direct comparison with Blombos percentages (Henshilwood et al., 2009: their Table 2); the PP13B assemblage is less utilized (14.6%, $n = 309$; compared to 20%, $n = 1534$). Behind the overall Blombos figure lay considerable temporal variation (ranging from 33.3% in the Still Bay of M1 [$n = 254$] to 17% in M3 [$n = 1206$]), attributed to more intensive use of smaller quantities of non-local pigment in the younger phases and less intensive use of much larger quantities of locally procured material in M3 (Henshilwood et al., 2001; Watts, 2009). The PP13B figure is more consistent with local procurement.

To investigate past selective criteria, because utilized samples among the principal geological categories are fairly small, and with shale and siltstone having indistinguishable average streaks, it was decided to group definitely and probably utilized and to combine shale and siltstone (Table 8 [but see SOM and SOM Tables 9a and b]). In the overall sample and with the 10 mm cut-point, shale/siltstone is least utilized, followed by fine sandstone, coarse siltstone, and iron oxide. In weight-controlled samples shale/siltstone still provide the lowest rates of use, suggesting that this aspect of the ranking is not attributable to differential fragmentation between categories, but reflects past human choices. That coarse siltstone now provides the highest rates of use is partly due to small samples (particularly among material ≥1 g), partly to the low average redness of unutilized coarse siltstone (Tables 9b and c), and partly to the infrequency of iron oxide use among pieces >10 g—accounting for just two of the 15 'definitely and probably' utilized compared to five of the eight unutilized pieces (see SOM for discussion of all three factors). An exotic raw material would not be expected to predominate among large, unused pieces, suggesting that much of the iron oxide came from the same local source as the FGS forms.

Looking at grouped NCS profiles of utilized pieces among the principal raw materials (Fig. 5, see SOM Fig. 10 for the ≥1 g sample); shale/siltstone predominantly comprises intermediate reddish-browns (52.4%), coarse siltstone is distinguished from shale/siltstone by greatly reduced representation of intermediate nuances and 20% of the sample having 'very dark' nuances, fine sandstone predominantly comprises saturated reddish-browns (55.6%), while over 90% of utilized iron oxide provide very dark, saturated and/or very red streaks. This is a more pronounced version of the trend in grouped NCS profiles across the FGS spectrum in the overall sample (SOM Fig. 4), but now extending to fine sandstone. With saturated and very dark nuances apparently accounting for why coarse siltstone and fine sandstone were utilized at higher rates than shale/siltstone, iron oxide should provide the highest use rates (even among larger pieces). This is also suggested by utilization percentages across the three iron enrichment assessments (SOM Table 9c), with 'hematized' pieces consistently providing the highest rates of use (although in the ≥ 1 g sample, percentages are effectively indistinguishable). The anomaly regarding infrequent use of large pieces of iron oxide appears to be behavioral. With no significant darkness or hue differences between utilized and unutilized iron oxide samples (Tables 9a and c), it is as if the largest pieces (e.g., SOM Figs. 1g and 8a and e) tended not to be used precisely because they were valued. The reason can presently only be speculated upon (see SOM).

Just two of the 63 definitely and probably utilized pieces had < 60% redness. Catalog 111499 is the previously mentioned, partially leached, cortical siltstone (Fig. 7a), providing a poorly chromatic 'yellowish-beige' streak (3040 Y35R). The grinding extends well into the leached portion and is unusually coarse, possibly consistent with preliminary abrasion (testing streak properties or removing unwanted material?). Although this has to be considered part of the pigment assemblage, it is questionable whether the powder was used as pigment, being both poorly chromatic and 20% removed from the nearest utilized hue (Plot 21419, 3450 Y55R), which flags the approximate limit of desirable 'red ochre.'

With larger (≥ 1 g) pieces significantly redder and darker, and appreciably more chromatic than small (< 0.5 g) debris (Table 5b), utilized pieces would be expected to show similar streak traits relative to unutilized counterparts (Table 9a). Relative chroma differences in the two tables are comparable. The highly significant overall blackness difference in Table 5b is only marginally significant in the overall utilized/unutilized comparison (Welch's t [77.411] = 2.103, p = 0.039), where it may simply be a function of the weak correlation between redness and blackness—without implying selection for darker nuances (but see below). More revealing, however, is that while overall hue differences and their significance levels in the two tables are comparable, utilized raw material samples consistently show considerably lower hue variance than unutilized counterparts (for grouped shale/siltstone this only applies if the utilized siltstone hue outlier is excluded), whereas the weight-based comparisons provided similar standard deviations for small and large pieces. This is suggestive of hue selection.

When material < 0.5 g is excluded, most within form hue differences lose their significance, but overall, utilized pieces remain significantly redder (Table 9b). With everything < 1 g

Table 8
'Definite' and 'Probable' utilization percentages for the principal raw materials (shale and siltstone grouped together) for the total sample and under three different threshold conditions

	Overall		>10 mm		≥0.5 g		≥1 g	
	%	n	%	n	%	n	%	n
Shale/Siltstone	12.7	166	13.0	138	18.1	72	20.0	50
Coarse Siltstone	21.5	65	25.0	52	46.4	28	61.1	18
Fine Sandstone	16.4	55	22.0	41	29.0	31	37.5	24
Iron oxide	25.4	59	31.3	48	37.8	37	38.7	31
Major forms total	17.1	345	21.1	279	29.2	168	34.1	123
Overall total	16.6	380	19.1	309	28.3	187	33.8	136

Table 9
Average NCS values by geological form for grouped definitely and probably utilized samples compared to unutilized samples: for the overall sample, under different weight constraints, and with extreme case exclusions (*t*-tests are Student's *t* except where marked * [Welch's *t*])

Sample	Utilized			Unutilized			Hue *t*-tests	Chroma diff'
	n	NCS	s.d.	*n*	NCS	s.d.		
a) Overall sample								
Shale/Siltstone	21	3550 Y66R	07:10:10	144	3647 Y62R	07:09:11		2
Shale/Siltstone excludes Cat. 111499	20	3651 Y68R	07:10:07	“	“	“	* $t(35.93) = 3.59$, p = .001	4
Coarse siltstone	14	4144 Y68R	12:13:07	48	4143 Y61R	09:11:10	$t(60) = 2.304$, p = 0.025	1
Fine sandstone	9	4542 Y66R	07:13:05	44	4238 Y58R	09:10:08	$t(51) = 2.862$, p = 0.006	7
Iron oxide	15	5534 Y73R	14:17:04	44	5041 Y74R	10:12:05		−2
Total	63	4343 Y68R	13:14:08	310	4044 Y63R	10:11:11	* $t(121.4)$, 4.86, p = 0.000	2
b) Excludes material <0.5 g								
Shale/Siltstone	13	3551 Y67R	06:09:12	59	3747 Y64R	06:09:10		2
Shale/Siltstone excludes Cat. 111499	12	3552 Y69R	07:09:08	"	“	“		3
Coarse siltstone	13	4045 Y68R	11:13:08	14	4143 Y60R	10:12:09	$t(25) = 2.617$, p = 0.015	1
Fine sandstone	9	4542 Y66R	07:13:05	21	4241 Y60R	08:09:08	$t(28) = 2.029$, p = 0.052	4
Iron oxide	14	5337 Y74R	13:15:05	23	5338 Y75R	07:10:05		−1
Total	53	4343 Y69R	12:13:08	132	4244 Y65R	10:11:10	$t(183) = 2.361$, p = 0.019	
c) Excludes material <1 g								
Shale/Siltstone	10	3550 Y66R	07:10:13	40	3747 Y65R	06:09:10		1
Shale/Siltstone excludes Cat. 111499	9	3651 Y69R	07:10:07	“	“	“		3
Coarse siltstone	11	3848 Y68R	10:11:08	6	3748 Y59R	11:15:11		1
Fine sandstone	9	4542 Y66R	07:13:05	14	4342 Y61R	09:10:08		2
Iron oxide	12	5534 Y73R	13:15:04	19	5139 Y75R	08:10:05		−1
Total	46	4443 Y68R	12:13:08	88	4244 Y65R	10:11:11		1
Excl. Cat. 111499	45	4443 Y69R	12:13:07	“	“	“	* $t(126.04) = 2.27$, p = 0.025	1
Excl. Cat. 111499 & 5 unutilized pieces Iron oxide ≥10 g	“	“	“	83	4244 Y65R	10:11:11	* $t(124) = 2.50$, p = 0.014	1
d) Excludes material <1 g, but includes 'possible' pigments and treats non-abrasive utilization as part of unutilized								
Total	45	4442 Y67R	13:13:09	101	4244 Y64R	10:11:13	* $t(112.02) = 1.99$, p = 0.049	
Excl. Cat. 111499	44	4442 Y68R	13:14:08	“	“	“	* $t(123.44) = 2.56$, p = 0.012	
Excl. Cat. 111499 & 5 unutil' iron oxide ≥10 g	44	4442 Y68R	13:14:08	96	4144 Y63R	10:11:13	* $t(124.17) = 2.78$, p = 0.006	1

excluded (Table 9c), all comparisons become non significant. Among these larger pieces it initially appears fairly arbitrary as to which got used. However, for most forms, average hues of utilized samples remain consistently redder and nuances are relatively more chromatic. It only requires the exclusion of the utilized siltstone hue outlier for a significant (p = 0.025) overall hue difference to be restored, becoming more robust (p = 0.014) if the five, large, unutilized iron oxide chunks are also excluded (as presumptively high quality pigments). Even when controlling for weight, it can be inferred that MSA occupants of PP13B preferentially used the reddest pigments.

Would inclusion of 'possible' pigments alter this inference? Inclusion has no appreciable effect on the overall population or the principal raw materials (compare Table 9a with SOM Table 10a). It does remove the significant hue difference among pieces ≥ 0.5 g (SOM Table 10b). However, while all utilized pieces could be used as a rough proxy of desired pigment attributes in the more conservatively defined pigment sample (there being just two cases not involving abrasive utilization—one flaked and one notched), this is harder to justify with the enlarged sample, where the additional flaked and pressure release cases exert considerable influence. Incorporation of 'possible' pigments alongside a stricter proxy of desired pigment qualities (abrasive utilization, with or without other forms of modification), and treating exclusively non-abrasive modification as part of the background population, makes the hue selection more rather than less pronounced (Table 9d). A marginally significant (p = 0.049) hue difference is now obtained even among pieces ≥ 1 g, becoming robust if the utilized siltstone outlier is excluded (p = 0.012).

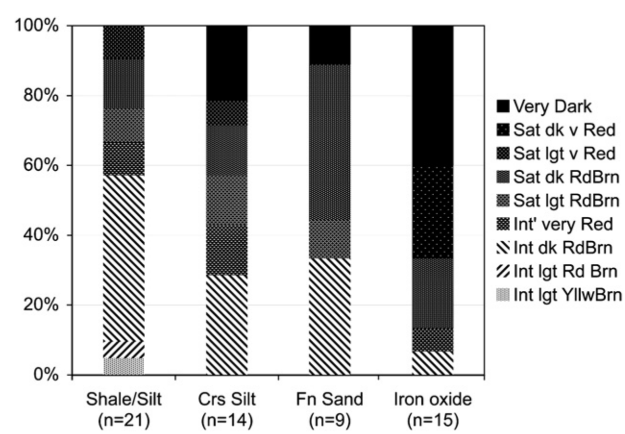

Fig. 5. Percentage bar chart of grouped NCS values for 'definitely' and 'probably' utilized pieces among the principal raw materials. Crs Silt = Coarse Siltston; Fn Snd = Fine Sandstone.

Figure 6, illustrating utilized percentages across nuance/hue groupings both for the overall sample and excluding small debris (< 0.5 g), indicates past selection for redness, saturation, and darkness (see SOM Tables 11a and b for full data, SOM text for hue selection within larger NCS groupings, SOM Table 11c for the distribution of utilized mass across nuance/hue groupings). The pigments most likely to be utilized were 'very red' (predominantly saturated) or 'very dark' (≥ 60% redness), followed by 'saturated reddish-brown,' while 'intermediate reddish-brown' provided acceptable red ochre. The lower rate of utilization among intermediate reddish-browns cannot be attributed to the predominance of small debris. To check that the difference in utilization rates between saturated and intermediate reds is not an artifact of the significant hue difference between the two groupings (see above), hue was controlled for (selecting 70% redness, see SOM). Twenty two percent of saturated reddish-browns ($n = 59$) were definitely/probably utilized, compared to 16.7% of

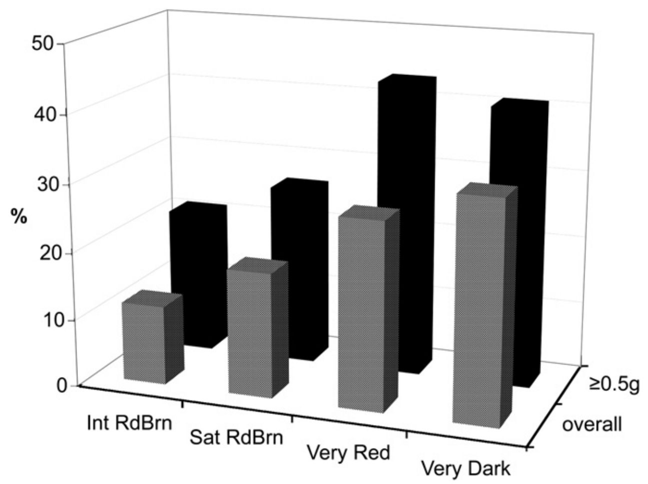

Fig. 6. Percentage bar chart of 'definitely' and 'probably' utilized pieces across grouped NCS values (grouping intermediate and saturated very red, and excluding groups where $n \leq 20$), for the overall sample and for the sample excluding pieces <0.5 g.

intermediate counterparts ($n = 42$): average blackness for the two samples was indistinguishable (38.5% and 39.2%, respectively), so the percentage difference in utilization supports selection for chroma independent of blackness and in addition to redness.

Unlike Blombos (Watts, 2009: his Fig. 4.5), 'very dark' nuances are not only well represented, but seem to have been at least as esteemed as 'very reds' (see SOM and SOM Table 12 for additional evidence of selection for darker reds). 'Very dark' nuances begin as a direct continuum of intermediate and saturated red groupings, but grade into streaks subjectively described as dark-brown, with one or two black values; three of the six cases with ≥ 70% blackness were utilized. So, in addition to some selection for darker reds, an interest in dark-brown/black pigments may be indicated. Utilized 'very dark' pieces are present from the earliest occupation, but they are more prominent from c. 100 ka, and cases with ≥ 70% blackness are restricted to these younger aggregates. That the group disproportionately comes from the Eastern excavation is consistent with evidence of relatively intense and/or repeated heating (Herries and Fisher, 2010), but this cannot account for the high utilization rate (27.3% utilized in the East [$n = 22$]; 40% in the West [$n = 10$]; one out of two in the Northeast). Beyond any incidental darkening of streaks, there seems to have been some deliberate roasting (also likely to have affected hue and chroma).

There is suggestive evidence that the intensity of utilization varied according to the same streak criteria of redness, saturation, and darkness (SOM Fig. 11). Sample sizes for 'intensively' ground ($n = 5$) and 'lightly' ground ($n = 9$) are too small for robust interpretation; nevertheless, the combined representation of saturated, very red, and very dark values doubles from 40.7% of unutilized pieces to 80% of intensively utilized. This is consistent with more robust data from Blombos (Watts, 2009: his Fig. 4.6).

Samples were generally too small to investigate color selection at the aggregate level. The only aggregate to provide a significant hue difference between utilized and unutilized pieces was LC-MSA Lower (see Marean et al., 2007 and SOM); particularly striking was how much more chromatic the utilized pieces were (+6%).

Intensively ground

Plot 22289 (Fig. 7b) is a large piece of hematized mudstone from DBS 3 (see SOM for further comment on geological form). It was utilized over > 90% of surface area with 14 facets. It has a vaguely pyramidal shape, as the principal facets converge to a snub-nose point. The proximal end is the least utilized, ground only over prominent surfaces, with a few, short scraping striae on a subface inaccessible to grinding. The piece would have required fairly prolonged processing to acquire this morphology, possibly over several episodes of use. The most remarkable feature is a large, scraped 'chevron' on a slightly concave, ground face (Fig. 7c). The two deeply scored, intersecting principal striae span the width of the facet along their alignments. Both have similar, broad, profiles, suggesting they were made with the same tool. The first is aligned with the nearest facet edge. The superimposed second line intercepts the first at an acute angle and overshoots it by c. 5 mm, extending right to the edge. It is flanked on either side by parallel, slightly shorter and narrower striae (see SOM for additional observations).

The scraping is not consistent with powder production; in the much larger Blombos sample (pers. obs., but see Henshilwood et al., 2001: their Fig. 8; Henshilwood et al., 2009: 39 *en passim*; Watts, 2009: his Plate 4.7), scraping striae generally share the same alignment and typically cover a large proportion of the worked face. Streak testing is implausible given the prior utilization. Use as a 'cutting board' is implausible because of the broad striae profiles and the inappropriate shape and size of the piece. The juxtaposition of striae is comparable to examples of 'converging lines' among the engraved pieces from Blombos (Henshilwood et al., 2009) and to several Klasies River examples (Knight et al., 1995: their Fig. 5; Watts, 1998: his Plates 6.28 and 6.91). It may be noted that 'simple converging lines' at Blombos were restricted to the M3 occupation phase, coeval with DBS 3. The inference that this piece was purposefully marked seems warranted. More speculatively, it may qualify as a simple geometric motif.

Plot 34783 is a chunk of fine sandstone, also from DBS 3, providing a dark-brown streak (6015 Y60R). It was estimated to be c. 75% complete and utilized over two thirds of its surface area. Prior to spalling or deliberate flaking, the utilized area would have been greater. In addition to being intensively ground, it was scraped and notched. The largest surface (Fig. 7d) was initially ground flat and then scraped over about two thirds of its area, creating a slightly concave facet in the centre. One edge of this facet shows three notches, one of which has a striation extending about 4 mm onto the ground face (a fourth indentation on this edge may be a natural fracture). The opposite side of this edge is also ground. On this face (Fig. 7e), two of the notches show small spall scars, while the third has a square-profiled striation extending c. 6 mm onto the remnant of the ground facet (spalled over much of its area). Notching is further discussed below. The third ground face has also lost much of its area to a large spall. The fourth ground face comprises three subfacets, together constituting a 'flat-bottomed trough,' as if ground against an angled surface. The extent of grinding and the use-wear biography of the piece are again suggestive of curation and use over several episodes.

The three other intensively ground pieces are described in the SOM. These five pieces comprise 11.9% of the definitely ground total ($n = 42$), considerably less than at Blombos (19.4%, Watts, 2009: his Fig. 4.6). The Blombos intensity of grinding data is not broken down by occupation phase, but the prediction would be that the PP13B percentage should most closely approximate that of M3—when pigment was primarily locally procured. Also in contrast to Blombos, there are no obvious 'crayons.' With some reservation (cf. SOM), I broadly concur with Wadley's (2005b) evaluation that 'crayons' are a typological category imposed by archaeologists on intensively ground pieces having a particular morphology and that no functional significance need be attached to the morphology, beyond what might be accounted for by manipulative affordances. The fundamental question remains, however: why were some

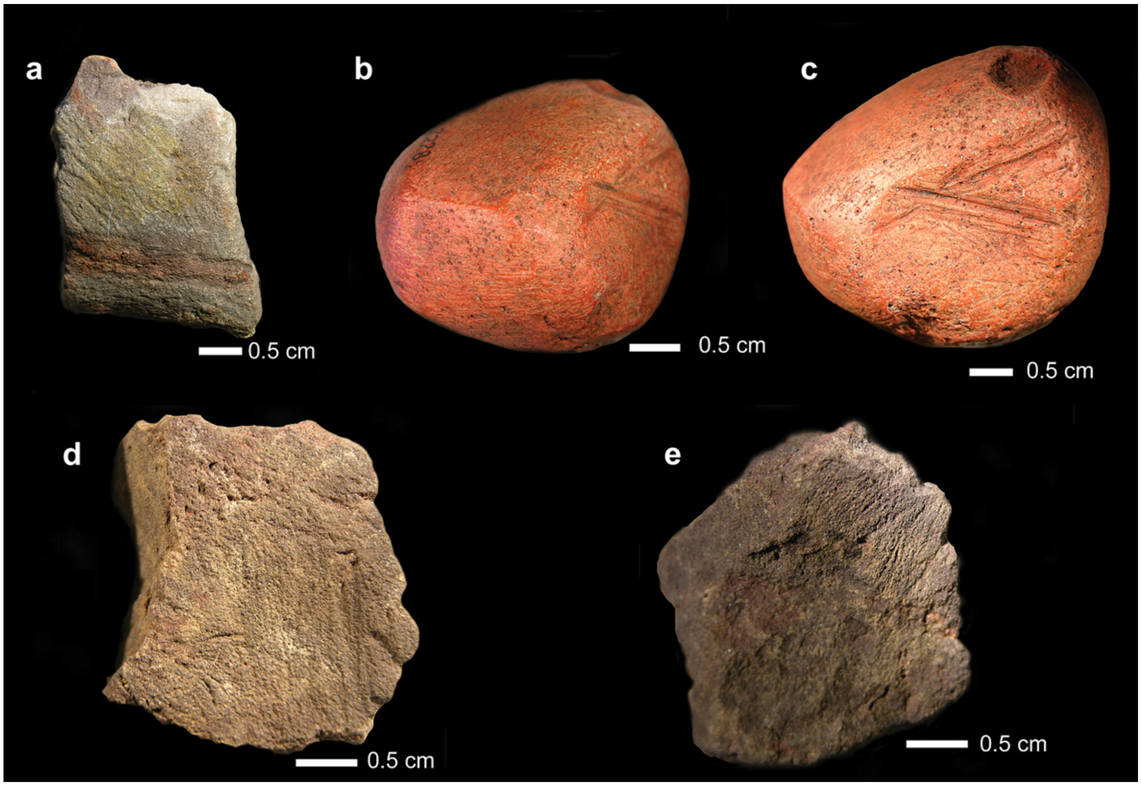

Fig. 7. Utilized pieces. (a) Partially leached, cortical siltstone, Western section cleanings, Cat. 111499, 4.1 g, 3040 Y35R (light intermediate yellowish-brown). Moderately ground. (b) Intensively ground, engraved piece, DBS 3, Plot 22289, 45.4 g, 3840 Y65R (dark intermediate reddish-brown). Categorized as moderately hematized mudstone, but highly altered, with abundant voids and fairly large quartz clasts (secondary mineralization?). Fourteen facets. (c) Plot 22289, the ground facet bearing the engraved 'chevron.' (d) Intensively ground, scraped, and notched fine sandstone from DBS 3. Plot 34783, 9.1 g, 6015 Y60R ('very dark'). This facet was initially ground, then lightly scraped over the central area of the facet, and at least three notches were cut into one edge (lower right hand side). (e) Plot 34783. Opposite facet to that shown in Figure 7d. The reverse of the three notches are in the upper right of the image, two showing spall scars, the third has a striation running from the point of inflection of the notch (one side of which is missing) to about 6 mm onto the ground facet.

pieces intensively ground and not others? The evidence from this study, Blombos (Henshilwood et al., 2001; Watts, 2009), and a multisite MSA sample (Watts, 2002) consistently points to redness and saturation; this study also tentatively implicating darkness as an additional subordinate criterion.

Moderately ground

Of the 22 moderately ground pieces (including three paired conjoins and the yellow-brown case), most were ground over one main surface, six were also edge ground, and four were categorized as 'ground tablets.' Three cases from LC-MSA Lower are illustrated elsewhere (Marean et al., 2007: their Fig. 2a–c, e, f).

Lightly ground

The lightly ground sample ($n = 9$) is too small for confident interpretation of the streak profile, but it more closely resembles the unutilized sample than any other category (SOM Fig. 9). On the other hand, unlike 'intensively ground' or 'ground fragments,' it includes both light and dark saturated very red cases. That there was sometimes a requirement for just small quantities of powder is suggested by a piece from LC-MSA Lower (Fig. 8a and SOM Fig. 1b). The facet on this edge ground, tabular piece of shale (maximum facet width 4 mm) is larger than required for streak testing. The junctures of both main faces with the facet are worn, indicating that it is not a post-utilization spall. It is one of the smallest, apparently complete utilized pieces, suggesting foreknowledge that grinding would produce a limited amount of powder. The most plausible use for small quantities of pigment powder would be for designs.

Notched

In addition to the ground, scraped, and notched piece from DBS 3, Western excavation section cleanings provided two other notched pieces (one below the sample size/weight parameters). The larger piece (Cat. 111498, Fig. 8b) is reddish-brown fine sandstone, with single, deep notches on opposite laterals, directly opposite each other. No use-wear was observed in the notches, but on one face grooves extend from both notches, almost meeting in the center. A speculative interpretation (requiring further cleaning and higher resolution microscopy to evaluate) is that the notches, together with the grooves, aided suspension of the piece. Catalog 111503 (Fig. 8c–d), categorized as hematized siltstone, was just 5.2 mm long and too small to streak. It can only have broken off a larger piece, but—judging by the thickness (1.9 mm)—this too was probably very small. One edge bore two minute but well-defined notches, much more delicate than the previous examples, and probably serving a different purpose. Apart from raising further interpretative challenges, this case highlights the need for low-power microscopy of even the smallest fragments. Notching is reported from several other South African late Pleistocene MSA contexts (SOM with references), with occurrences spanning the period from c. 100 ka to the Howiesons Poort industry. The likelihood is that these two unprovenanced pieces came from somewhere in the DBS 3 to LBS 1 sequence of aggregates.

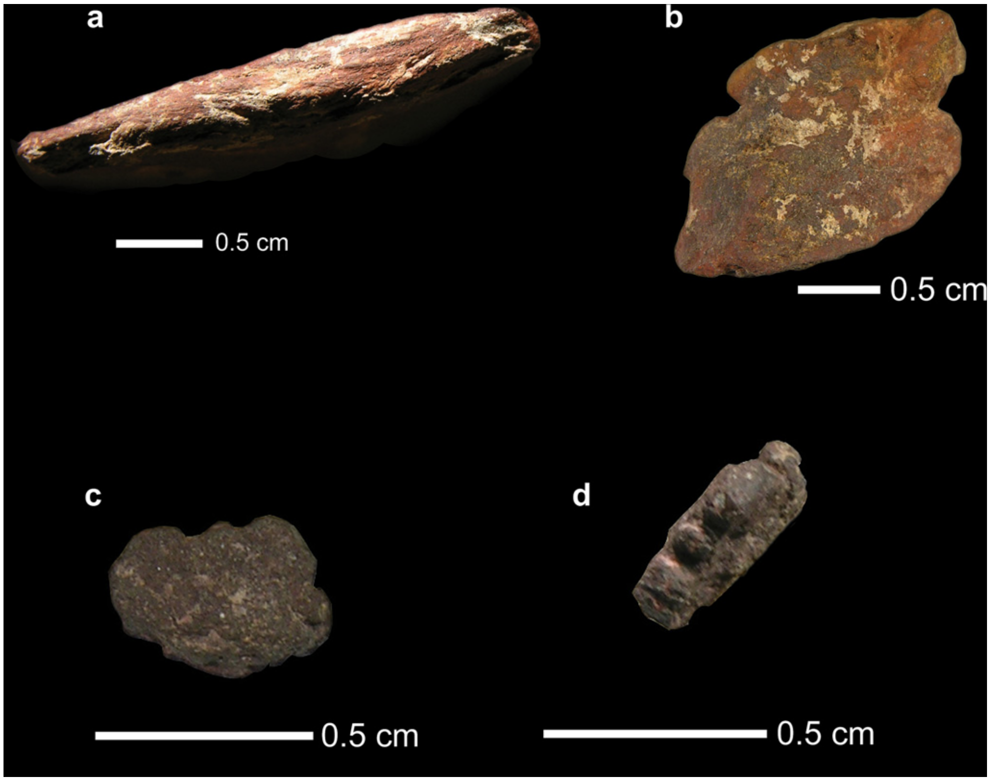

Fig. 8. Utilized pieces. (a) Lightly (edge) ground shale, LC-MSA Lower, Plot 79414, 2.6 g, 4630 Y60R (dark intermediate reddish-brown). See SOM Figure 1b for plan view. (b) Notched fine sandstone, Western section cleanings, Cat. 111498, 2.7 g, 4647 Y70R (dark saturated reddish-brown). (c) Plan view of notched hematized siltstone, Western section cleanings, Cat. 111503, < 0.1 g., length 5.3 mm. Too small to streak. (d) Cat. 111503, looking down on the notches.

Flaking

The few flaked pieces (including the two weight outliers categorized as 'possible' pigment) are discussed and illustrated in SOM and SOM Figure 12.

Summary and discussion

Everything that could potentially have served as earth pigment was evaluated. Pigmentaceous autochthonous materials—ferruginous quartzite and calcium carbonate concretions—were judged non-pigments; the former because of their hardness, poor pulverulence, and lack of use-wear, the latter because of post-deposition formation and the lack of use-wear. The carbonate concretions permit the inference that, had soft white or yellow earth pigments been used, they should be present (which they are not). There were 18 diverse pieces whose status as pigment was considered problematic prior to the analysis. Having generally unique forms, the most recurrent distinguishing attribute was poor pulverulence. While excluded from the overall analysis, these were taken into account when evaluating past selective criteria.

The remaining 380 cases were judged to be pigments, although in the course of analysis, some pieces (e.g., the fine sandstone subgroup concentrated in LRS, a couple of shale cases from Re-Deposited Disturbance, a couple of fine sandstone in DBS 2) were identified as possible pigment processing waste, primarily on the grounds of low chroma, relative yellowness, and lack of use-wear. Two partially leached pieces notwithstanding, the total mass of the 380 cases adequately reflects the amount of useable pigment. Geological categorization primarily rested on a textural gradient (with fabric distinguishing mudstone from shale). Iron oxide was largely defined as possible on the basis of subjective assessments of relative density, the presence of dense aggregates of dark material, and departure from normative attributes of the sedimentary categories. Much of the FGS material was not particularly iron enriched ('background' assessments). The histocity associated with high phyllosilicate content, together with the relative softness of FGS forms, accounts for the high proportions of small debris among shale and siltstone. High proportions of pieces of tabular shape and lustrous appearance were also attributed to histocity. Streaks of this material were typically fairly light and of moderately low chroma and redness. The lightness is probably a function of high mica content. Moving from finer to coarser textured forms, successively larger proportions showed signs of more developed secondary alteration—more pronounced iron enrichment, voids, and/or some crystalline expression. For sandstone and iron oxide, crystalline quartz clasts were also a fairly common attribute. More altered expressions also tended to be harder—and therefore—larger. That they tended to be less micaceous was tentatively attributed to hydrolysis of aluminosilicates frequently accompanying iron enrichment, rather than reflecting a different parent material. Streaks were typically darker, redder, and relatively more chromatic than non-hematized FGS expressions.

Shale and siltstone could have been grouped together without significant loss of information; the same may apply to coarse siltstone and fine sandstone. On the other hand, iron oxide might have been further categorized, distinguishing relatively soft, very dark material; mineralogical analysis of this subgroup is needed. The mass predominance of saturated reds over intermediate reds and yellowish-browns suggests that more hematized forms were the principal target of procurement. Iron oxide aside, whatever analytical utility the geological categories may have, they were probably not particularly salient to MSA people.

The similarity of average streaks among FGS forms $\geq$1 g suggests texturally variable expressions of the same outcrop. Fine sandstone, despite being significantly darker, also seems to be part of this spectrum. The distinctiveness of iron oxide is largely a function of secondary alteration and need have no sourcing implications. The only local potential pigment source is a fairly extensive Bokkeveld outcrop 5 km north of the site. Streaks and other physical attributes of field samples were comparable to the archaeological material. Circumstantial indications that iron oxide was also locally procured are: frequent similarities to FGS forms, that it accounts for a quarter of assemblage mass, has the highest mean weight among the principal forms (with collective entries multiplied up), that the most hematized field sample had a streak (5437 Y70R) closely resembling the iron oxide average (5139 Y74R), and its predominance among large ($\geq$ 10 g) unutilized pieces (contrary to expectations of an exotic material).

With little evidence for high-energy mechanical weathering—particularly in LC-MSA Lower—and in the absence of traces of colonization by marine organisms, it seems unlikely that the MIS 6 marine regression exposed ochreous Bokkeveld within the local foraging range.

The extent to which red hues predominate is comparable to Twin Rivers and Blombos (Barham, 2002: his Table 1; Henshilwood et al., 2001: their Table 14; Watts, 2009). As at Blombos (Watts, 2009: 83, his fn.11), most yellowish pieces (7.1% of the total) were within 10% of the cut-point with reddish-brown, suggesting they were brought back to the site as slightly yellower expressions of the target material (red ochre). That yellowish pieces (together with light intermediate reddish-browns) disproportionately comprised small debris is consistent with such an interpretation, and raises the possibility of some on-site processing to remove such material. It also counts against significant incidental reddening of yellow ochre, as this should principally have affected small debris. While yellows are better represented in less heated aggregates relative to intensively/repeatedly heated ones, they remain infrequent ($<$ 10%), suggesting there was little yellow in the first place. Conversely, very dark nuances, which do not appear for the most part to represent different forms, are disproportionately from intensively heated aggregates. This suggests that, in addition to any incidental reddening of yellowish-brown pigments, some red pigments were incidentally or deliberately darkened through heating. Archeometric investigation is clearly required.

Blombos and Pinnacle Point occur in similar geological settings, with Bokkeveld the only plausible local source of pigment. Despite this similarity, there are differences between the assemblages. PP13B provides considerably higher percentages of 'very red,' 'saturated,' and 'very dark' streaks. This is consistent with the suggestion that topographic differences between the Bokkeveld outcrops closest to the two sites resulted in differences in chemical weathering profiles, with more iron enriched profiles predicted of the higher elevation Mossel Bay outcrop.

Temporally, FGS forms predominate in LC-MSA Lower, while iron oxide and fine sandstone predominate in early Last Interglacial aggregates in Eastern and Western excavations. Over the remainder of the Interglacial, in both these excavations, there are successive increases in FGS representation. With variable expressions of ochre occurring as microfeatures in an outcrop extending over several kilometers and with ongoing mechanical weathering, the temporal changes need have no procurement implications. The difference between LC-MSA Lower and early Last Interglacial samples was speculatively attributed to prospecting of a rejuvenated weathering landscape following a long hiatus in procurement.

By mass, half the assemblage was definitely utilized, accounting for 12.7% of cases. Most pieces are unutilized small debris. Utilization percentages also tend to support local procurement. Among material $\geq$ 10 mm, the definitely utilized percentage (14.6%) is much closer to the Blombos value for occupation phase M3 (17%), when procurement is thought to have been predominantly local, than to the Still Bay phase (M1) percentage (31.7%), when regional procurement is inferred. Utilization is less common in the front of the cave (Eastern excavation) than at the sides and rear. If some material in Eastern aggregates was heated, the lower rate of use in this area might imply that heating occurred incidentally (but see below).

The overwhelming majority of utilization is grinding. Poor representation of scraping was attributed to the near absence of very soft material. Most ground pieces where the intensity of use could be assessed were 'moderately' ground, typically over one main face. That intensively ground pieces are less well represented than at Blombos was attributed to a local source remaining available throughout the occupations.

The most remarkable utilized piece is a multi-facetted ground chunk, with two convergent scraped striations dominating one facet, approximately 100,000 years old. The striations were inferred to have been deliberately juxtaposed, primarily because they were inconsistent with powder production and because of similar juxtapositions among the simpler Blombos engravings (Henshilwood et al., 2009), with additional examples from Klasies River. Whatever the purpose of such marking, it would be stretching credulity to suppose that similar markings were not made on human bodies. To this extent, indirect support is lent to Durkheim's prediction concerning geometric, body painted designs with red ochre, as the first 'art' (Watts, 2009). Another notable piece from the same aggregate was intensively ground, then lightly scraped on one face, and notched on one edge. Both these intensively ground pieces, with their variety of use-wear traces, are suggestive of multiple episodes of use and possible curation. Curation is also suggested by the apparent caching of one definite and one possible pigment in the crevice above the LC-MSA deposits, although when this occurred remains uncertain. At the other extreme, some lightly ground pieces are consistent with there sometimes having been a requirement for small amounts of pigment powder—itself suggestive of design. Larger samples are needed, but this too would accord with observations at Blombos (Watts, 2009). The presence of two other notched pieces, both unfortunately unprovenanced, is also notable, one for the minute scale of notching, the other for additional use-wear traces which, together with the notches, are suggestive of the piece having been suspended.

Even controlling for differential fragmentation, shale and siltstone were the materials least likely to be utilized. Despite not providing the highest utilization percentage in weight-controlled samples, several observations suggested that iron oxide was the most esteemed raw material. To this extent, the results are consistent with ethnographically documented criteria of esteem and corroborate findings from non-weight-controlled samples from other MSA contexts—most notably Blombos (Henshilwood et al., 2001: their Table 12, but see also Watts, 1999: 126; Barham, 2002: his Table 1). For some unknown, but apparently behavioral reason, the largest pieces of iron oxide tended not to be used.

The best predictor of the likelihood of any particular piece being utilized—and the attribute presumably underlying the ranking of raw materials and iron enrichment assessments—was hue. Even with small debris ($<$ 0.5 g) excluded, utilized pigments were significantly redder than non-utilized. Among material $\geq$ 1 g, a significant hue difference was obtained when a utilized streak outlier of questionable pigment status was excluded. Saturated nuances provided higher rates of use than equally red intermediate nuances. 'Very dark' nuances appear to have been as favored as 'very reds;' most are a direct continuum of intermediate and saturated reds but in a few cases from URS onwards, nuances were so dark and poorly chromatic as to be effectively black or dark-brown. With these possible exceptions, the arbitrarily defined categories of intermediate very red, saturated very red, and very dark (red), were probably treated by MSA people as one coextensive category focus, constituting 'ideal' red pigments. While some incidental heating was inferred in relation to very dark nuances, this cannot account for the high utilization percentage; it seems, therefore, that there was also some deliberate roasting of pigments, darkening streaks (and probably enhancing redness and chroma). Archeometric and experimental studies are needed to investigate this further. Less esteemed extensions to this focus were saturated reddish-browns, followed by intermediate dark reddish-brown. The focus appears not to have extended to intermediate light reddish-brown ($n = 23$, predominantly 'beige' streaked small debris, 1 probably utilized) or to yellowish-brown ($n = 27$, predominantly small debris and close to the cut-point with reddish-brown, 1 definitely utilized).

Incorporation of 'possible' pigments necessitated a stricter proxy criterion (abrasive utilization) for identifying desired pigment attributes in weight-controlled samples, but resulted in preferential use of the reddest materials becoming more pronounced. There was suggestive evidence that the intensity of grinding followed the same color selection criteria, as at Blombos (Watts, 2009).

With growing indirect evidence for language among early *Homo sapiens* (Botha and Knight, 2009), it is reasonable to postulate that this red focus was lexicalized. The hypothesized term would almost certainly involve nominal reference (Levinson, 2000; Deutscher, 2005), most probably to the red pigments themselves (e.g., Heider, 1972; Jones and Meehan, 1978) or to blood (e.g., Greenberg, 1963: 97, 118, 154; Berlin and Kay, 1969: 38; Blake, 1991: 84, 96; Dench, 1991: 236; Patz, 1991: 324; Everett, 2005: 627). There is no archaeological support for a stage of color lexicalization preceding the labeling of red (Sai Island notwithstanding), nor indeed for an initial lexicon of binary or triadic structure, as posited by the various versions of the BCT hypothesis. The most that can be said is that, within an overall focus on the reddest, most saturated pigment, PP13B indicates some additional selection for darker reds (which, from c. 100 ka, may have extended to rare dark-brown or black cases), while Blombos testifies to some interest (also from c. 100 ka) in very light, pastel nuances (Henshilwood et al., 2009).

Conclusions

The PP13B earth pigment assemblages—for the most part spanning intervals from c. 164 ka to c. 91 ka—almost exclusively comprise various forms of red ochre. A strong circumstantial case was made for these having been procured from a local outcrop of fine-grained sedimentary rock (Bokkeveld) about 5 km from the site. Controlling for fragmentation, the streaks of utilized versus unutilized pieces provided robust evidence for preferential use of the reddest material, and suggestive evidence for saturation and darkness being subordinate selective criteria, consistent with the most relevant ethnographic color lexical data (Heider, 1972). There is ambiguous evidence—requiring further investigation—that from c. 100 ka, pigments may sometimes have been roasted to enhance these streak qualities. In any event, 'very dark' values first become prominent at around this time. Also from around 100 ka, rare forms of utilization are encountered that appear unrelated to obtaining pigment powder, a probable simple engraving of one piece and notching of another (with two additional unprovenanced notched cases, one of which may have been suspended).

These findings suggest that the various initial stages of color lexicalization posited by the BCT hypothesis require further revision. A term for red can reasonably be inferred from at least c. 164 ka, terms for 'black' and 'white' or 'light/warm' and 'dark/cool' cannot. The selective focus among utilized pieces circumvents Wadley's (2009) objection that much MSA ochre may originally have been yellow, and denies any general explanatory power to the hafting hypothesis (Wadley, 2005a)—as does the persistent use of fine-grained materials. The findings are inconsistent with the suggestion (Kuhn and Stiner, 2007: 51) that—prior to the appearance of beads (c. 80 ka)—'pigment only' body ornamentation was primarily a means of expressing individual uniqueness: to the contrary, they are strongly suggestive of 'agreed upon canons of ornamentation' and of a medium for communicating about institutionalized relationships. The data are consistent with the predictions both of Durkheim's (1961) sociological theory and the Darwinian 'female cosmetic coalitions' model of the emergence of human symbolic culture (Power, 2009), which on theoretical grounds posit the centrality of 'blood-red' earth pigments in ritually defined cosmetic display.

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Appendix. Supplementary data

Supplementary data associated with this article can be found in the online version, at doi:10.1016/j.jhevol.2010.07.006.

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