

# Early Evidence for Brilliant Ritualized Display: Specularite Use in the Northern Cape (South Africa) between ~500 and ~300 Ka

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CA+ Online-Only Material: Supplemental Figures

Earth pigments figure prominently in debates about signal evolution among later *Homo*. Most archaeologists consider such behavior to postdate ~300 Ka. To evaluate claims for Fauresmith and Acheulean pigments in South Africa's Northern Cape Province, extending back 1.1 Ma (Beaumont and Bednarik 2013), we reexamined collections from Kathu Pan 1, Wonderwerk Cave, and Canteen Kopje. We report and describe materials where we are confident as to a pigment status. We found (i) compelling evidence of absence in all but the youngest Acheulean contexts, (ii) definite but irregular use in Fauresmith contexts from at least 500 Ka, (iii) widespread and regular use within this limited area by ~300 Ka, coeval with circumstantial evidence for pigment transport over considerable distances and use in fire-lit environments. These findings are used to evaluate predictions derived from two competing hypotheses addressing the evolution of group ritual, the "female cosmetic coalitions" hypothesis (Power 2009) and the "cheap-but-honest signals" hypothesis (Kuhn 2014), finding that the former accounts for a greater range of the observations. The findings underscore the wider behavioral significance of the Fauresmith as an industry transitional between the Acheulean and the Middle Stone Age.

Classical social anthropology and evolutionary ecology converge around the proposition that group ritual, with its formal characteristics of amplified, stereotypical, redundant display, established symbolic culture (Bulbulia and Sosis 2011; Durkheim 1912; Rappaport 1999). This convergence arises from evolutionary ecologists' application of signal evolution theory (see Maynard-Smith and Harper 2003)—particularly Zahavi's "handicap principle" (Zahavi and Zahavi 1997)—to demonstrate group ritual's adaptive value in securing cooperation between nonkin while deterring cheats (Sosis and Alcorta 2003). Internally, participants provide reliable signals of commitment, and the performance helps align emotional states and a focus for joint attention. Externally, it provides out-group observers with a reliable index of alliance quality.<sup>1</sup> These functions are

considered essential to creating the community-wide trust necessary for cheaper signals (e.g., language) to become evolutionarily stable (Knight 1998, 2014). Ritual's formal characteristics provide archaeologists with grounds for thinking that, if durable signaling media were used, ritual should leave a clear archaeological signature (Watts 2009).

Building on these insights requires models that generate interesting, refutable predictions as to the timing, form, and function of early group ritual. To this end, we present data from interior southern Africa significantly extending the previously assumed antiquity of earth pigment use. Addressing the timing, form, and function of early pigment traditions, we evaluate two explanatory hypotheses, both focused on group ritual and premised in signal evolution theory (Knight, Power, and Watts 1995; Kuhn 2014).

For scientists concerned with brute facts of nature, "symbolic culture" is enigmatic, literal falsehood being part of what social anthropologists mean by the term "symbol" (Sperber 1975), subjective fictions collectively accorded the status of objective facts (Knight 2014). As paleolithic archaeologist Phillip Chase observed, symbolic culture required "the invention of a whole new kind of things, things that have no existence in the 'real' world but exist entirely in the symbolic realm" (1994:628). On the basis of geometric engravings, beads, and elaborated burials (all directly or indirectly associated with red ochre), archaeologists are generally prepared to infer symbolic culture for our species from around 100 Ka (d'Errico and Stringer

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1. For a rare, nonhuman example of what is interpreted as individuals providing a synchronous motor signal of alliance quality, see Connor, Smolker, and Bejder (2006).

2011). Before this, earth pigments are the only recurrent archaeological evidence directly bearing on the evolution of signaling in the *Homo* lineage (Kuhn 2014; Watts 2014). Watts (2014) has argued that symbolic culture can be pushed back to our “speciation,” on the grounds that, in southern Africa, red ochre is found in virtually every rockshelter assemblage (sites primarily used as home bases) from ~170 Ka onwards. He considers this “a proxy for habitual collective ritual, transcending here-and-now contexts, with ritual performers across vast landscapes participating in shared fictions” (Watts 2014: 225). Earlier pigment occurrences would, however, still require explanation.

The prevailing view has long been that pigments can only reliably be inferred from ~300 Ka (d’Errico 2008; Kuhn 2014; Sagona 1994; Schmandt-Besserat 1980). Interpretation of early pigments has largely been a theoretically unconstrained field of speculation with little concern for generating refutable predictions (Watts 2015). However, with twenty years separating them, there are now two competing evolutionary hypotheses in play, sharing much common ground: the female cosmetic coalitions (FCC) hypothesis (Knight, Power, and Watts 1995; Power 2009, 2010, 2014; Power, Sommer, and Watts 2013) and Steven Kuhn’s “cheap-but-honest” signaling hypothesis (2014).

The time-consuming and extravagant nature of human collective ritual is generally considered a costly form of signaling (Sosis and Alcorta 2003). According to Zahavi, costly signals arise in contexts of strategic conflicts of interest between signalers and observers, where observers have selected a trait relevant to an underlying fitness quality (implying a causal or indexical connection between the form and meaning of the signal); signalers of different quality bear different levels of strategic cost, allowing observers to evaluate performance. Related debates in signal evolution theory concern manipulation and mind reading (Krebs and Dawkins 1984) and effects of shared versus conflicting interest in outcomes (Maynard Smith and Harper 2003). For example, where signaler and receiver share an overriding common interest in coordinating activity but there is low-level immediate conflict over the next move, low-cost, inconspicuous signals may evolve (Silk, Kaldor, and Boyd 2000).

The hypotheses considered differ in scope and purpose, but they agree that costly signaling can account for spectacular ritual displays in later prehistory (where symbolic culture is assumed), and both attach evolutionary significance to the establishment of a home base. In Europe and the Near East, this occurs between ~400 and ~300 Ka (Chazan 2009; Roebroeks and Villa 2011; Shimelmitz et al. 2014; Stiner, Gopher, and Barkai 2011). Although the strongest evidence concerns fire domestication, in both regions this associates with another fundamental technological change, where blades and/or points appear alongside—and eventually replace—bifaces (Shimelmitz, Barkai, and Gopher 2011; White, Ashton, and Scott 2011). African data are not as resolved, but a similar technological change is documented slightly earlier, from ~550 Ka (Johnson and McBrearty 2012; Wilkins and Chazan 2012), suggesting

that African home bases may be of similar antiquity. The hypotheses fundamentally differ over early ritual: the FCC hypothesis holds that here, too, conflicts of interest are analytically paramount (see fig. 12.1 in Knight 1999), whereas Kuhn emphasizes shared interest.

#### *FCC Hypothesis*

In the context of the Middle Pleistocene (780–130 Ka), with brain size increase and concomitant stress on maternal energy budgets, this hypothesis posits that coalitions of evolving females secured unprecedented levels of male investment and reduced their own travel costs by manipulating cues of impending fertility (i.e., menstruation). Pregnant or lactating females acted to prevent any male targeting a menstruant at other females’ expense by joining with her in scrambling and amplifying the signal with blood substitutes. The menstruant provided a reliable signal of commitment to the coalition, while all coalition members advertised coalition quality through cosmetic display in a “song and dance” performance. The idea is that humans came under sexual selection to show off their allies, with cosmetics the fundamental medium. The psychological finding that individuals appear more attractive when seen in a group (Walker and Vul 2013) suggests that, in this hypothesized context, individual and group levels of selection could pull in the same direction. Initially, ritual displays were reliably indexical of menstruation, organized on an ad hoc basis, using whatever materials came to hand, serving primarily to counter the would-be reproductive dominance of philanderers in favor of investors (for “counter dominance,” see Erdal and Whiten 1994). With further brain size increase, coalitions sought more regular and reliable investment, driving a regular routine of ritual performance—irrespective of actual fertility states. Sexual access was made conditional on males returning to a home base, surrendering the product of a collective hunt as “bride-service.” Investor males should choose females in cosmetically decorated coalitions, since they demonstrate rejection of philanderers (reducing male reproductive variance) and reliably advertise the support available to offspring born into that coalition. A runaway sexual selection process is posited for this final period of brain size increase and our speciation. Reproductive counter dominance becomes “reverse dominance” (Boehm 1999) as displays that were already—at different levels—both deceptive and honest (Power 2010) are no longer embedded in perceptible reality but—by their very generalization—become a shared fiction (“honest fakes”; Knight 2010), a pantomime performance that reverses the mate recognition system: “wrong species, wrong sex, wrong time” (Knight, Power, and Watts 1995).

#### *Cheap-But-Honest Signals Hypothesis*

Based on earlier work comparing the performance characteristics of pigments and beads (Kuhn and Stiner 2007; but see

Watts 2010), a premise of Kuhn's pigment hypothesis is that—applied to the body—pigments are “not well suited to expressing quantity or cost” (Kuhn 2014:45). A second premise is that early pigments (and early manifestations of much later signaling technologies) occurred in egalitarian social worlds with well-aligned fitness interests. Supporting this (although coming later in the argument), it is noted that archaeological evidence consistent with “small co-resident groups of cooperating non-kin” predate pigments (Kuhn 2014:47).<sup>2</sup> These premises inform the hypothesis that pigments “are most suitable for expressing honest, low-cost signals” whose initial use reflects efforts to coordinate action through small-scale rituals that promoted shared identity and cooperation (Kuhn 2014:46, citing Sosis and Alcorta 2003; Sosis, Kress, and Boster 2007; although Sosis treats group ritual as costly signaling).<sup>3</sup> This is considered “a response to increases in group sizes and cohesiveness” during the later Middle Pleistocene, resulting from the development of small, coresident groups of cooperating nonkin. Although fitness interests are presumed to be well-aligned, larger groups meant that members had “diverse but *potentially* congruent interests” (Kuhn 2014:47, emphasis in original). Much later increases in the size and/or differentiation of social groups led to more divergent interests and a need for costlier signals. The hypothesis significantly departs from Kuhn's earlier proposal that pigment use began as individual display (Kuhn and Stiner 2007). The predictions of the two models and how these align with the data to be presented will be considered in the “Discussion.”

## Early Pigment Use

That pigment use can only reliably be inferred from ~300 Ka largely rests on evidence from Terra Amata in France (de Lumley 1966), Hunsgi Locality V in southern India (Paddaya 1976), and GnJh-15 in Kenya (McBrearty and Brooks 2000). At Terra Amata, polish (“lustrée”) was reported on the ends of pieces of ochre, but this remains to be confirmed, and the ochre's manuport status has been questioned (Wreschner 1985); at Hunsgi, Bednarik (1990) described a ground facet on a “haematite” pebble; at GnJh-15, utilization rests on an undocumented claim for ochred grindstones. None of the evidence has been adequately published, but provisionally we consider the inference of pigment use at some or all of these sites to be reasonable. The estimate of 300 Ka is a minimum at Terra Amata and Hunsgi (Power, Sommer, and Watts 2013), GnJh-15 is >284,000 year ago (Deino and McBrearty 2002).

2. The literature cited by Kuhn to infer “co-resident groups of cooperating non-kin” is essentially the same we cite for the development of home bases.

3. Sosis, Kress, and Boster (2007) consider ritual body painting to be low in cost relative to permanent body marking (correlating with external warfare), not that it is intrinsically low in cost.

Pigment use >400 Ka has been suggested at Twin Rivers (Zambia; Barham 2002:183), but conservative interpretation of the dating and site formation processes supports an age  $\leq 266$  Ka (Barham et al. 2000:181). The predominance of specularite in this assemblage—a glittery form of hematite only known for visual display—leaves little doubt as to a pigment status. The only non-African claim for greater antiquity concerns Isernia la Pineta, Italy (~610 Ka; Coltorti et al. 2005), where some stones bore red coloration (Cremaschi and Peretto 1988:1,036).

GnJh-15 and Twin Rivers suggest that initial pigment use in Africa associates with the early Middle Stone Age (MSA), but there are numerous claims concerning probably coeval and earlier African Middle Pleistocene contexts (Chavaillon and Berthelet 2004:69; Watts 2009, table 4.2; see supplementary online material in Watts 2010 for missing bibliography).<sup>4</sup> Most lack radiometric dating, none of the materials have been described in detail, only one has been illustrated (Beaumont 1990a, fig. 4), and there are only three reports of modification consistent with pigment use (Beaumont 1990a; Beaumont and Bednarik 2013:11; Jones 1940:17). There is, therefore, generally little basis for evaluation. In this article, we present fresh observations that permit evaluation of some of the claims for Fauresmith and Acheulean pigments from South Africa's Northern Cape Province (Beaumont and Bednarik 2013:11–12; Beaumont and Vogel 2006:222), claims based on Peter Beaumont's fieldwork over the past 35 years. There are *prima facie* grounds for caution in several cases: reported scraped specularite in the Fauresmith at Kathu Pan 1 (Beaumont and Bednarik 2013:11) is not corroborated by the cited literature (Beaumont 1990b, 2004b), similarly with claims for specularite and red ochre in Late Acheulean contexts at Kathu Pan and Kathu Townlands (Beaumont and Vogel 2006:222, citing Beaumont 1990b); the most startling claim, that pigments at Wonderwerk Cave extend back ~1.1 Ma (Beaumont and Bednarik 2013:12), rests on the observation that material similar to hematite lenses above the cave (Beaumont 1990c:125) was encountered through most of the Acheulean sequence (Beaumont 2004b:33).

Recent and ongoing research in Northern Cape Province, following up on Beaumont's fieldwork, is reevaluating several contexts grouped together under the label Fauresmith, indicating a transitional status between the Acheulean of the Earlier Stone Age (ESA) and the MSA (Chazan 2015; Chazan and Horwitz 2009; Chazan et al. 2008, 2013; Porat et al. 2010; Wilkins 2013; Wilkins and Chazan 2012; Wilkins et al. 2012). There remain unresolved issues concerning the taxonomic validity of the Fauresmith and its designation as transitional (Underhill 2011; Wilkins 2013); nevertheless, particular significance is placed on the co-occurrence of prepared-core pro-

4. See Watts (2009), footnote 8, and Watts (2010), supplementary online material, pp. 10–12, for claims and suggestions for Lower Pleistocene pigments.

duction of blades and convergent (Levallois) points with biface manufacture (although questions remain about the association of bifaces in some contexts). The chronological resolution for Fauresmith-designated assemblages—including the top spits of stratum 2a at Canteen Kopje, stratum 4a at Kathu Pan 1, and excavation 6 at Wonderwerk Cave—remains the subject of ongoing research, but all indications point to an age range between approximately 600 and 300 Ka. The Fauresmith parallels similar developments in East Africa (Johnson and McBrearty 2012) and, at the younger end of the time-range, in the Levant (Shimelmitz, Barkai, and Gopher 2011); it also provides the earliest evidence for stone-tipped spears (Wilkins et al. 2012, 2015).

## Materials

We present the first detailed accounts of selected earth pigments from Kathu Pan 1 and Wonderwerk Cave and two previously reported pieces from Canteen Kopje (fig. 1).

## Geological Setting

The Vaal Drainage cuts through late Archean and initial Paleoproterozoic lavas. It also preserves relic Miocene (Upper Gravels) and Pleistocene (Lower Gravels) terraces. At Canteen Kopje, the Lower (“Younger”) Gravels are largely the colluvial fill of a paleo-loop of the Vaal (De Witt 2008). A

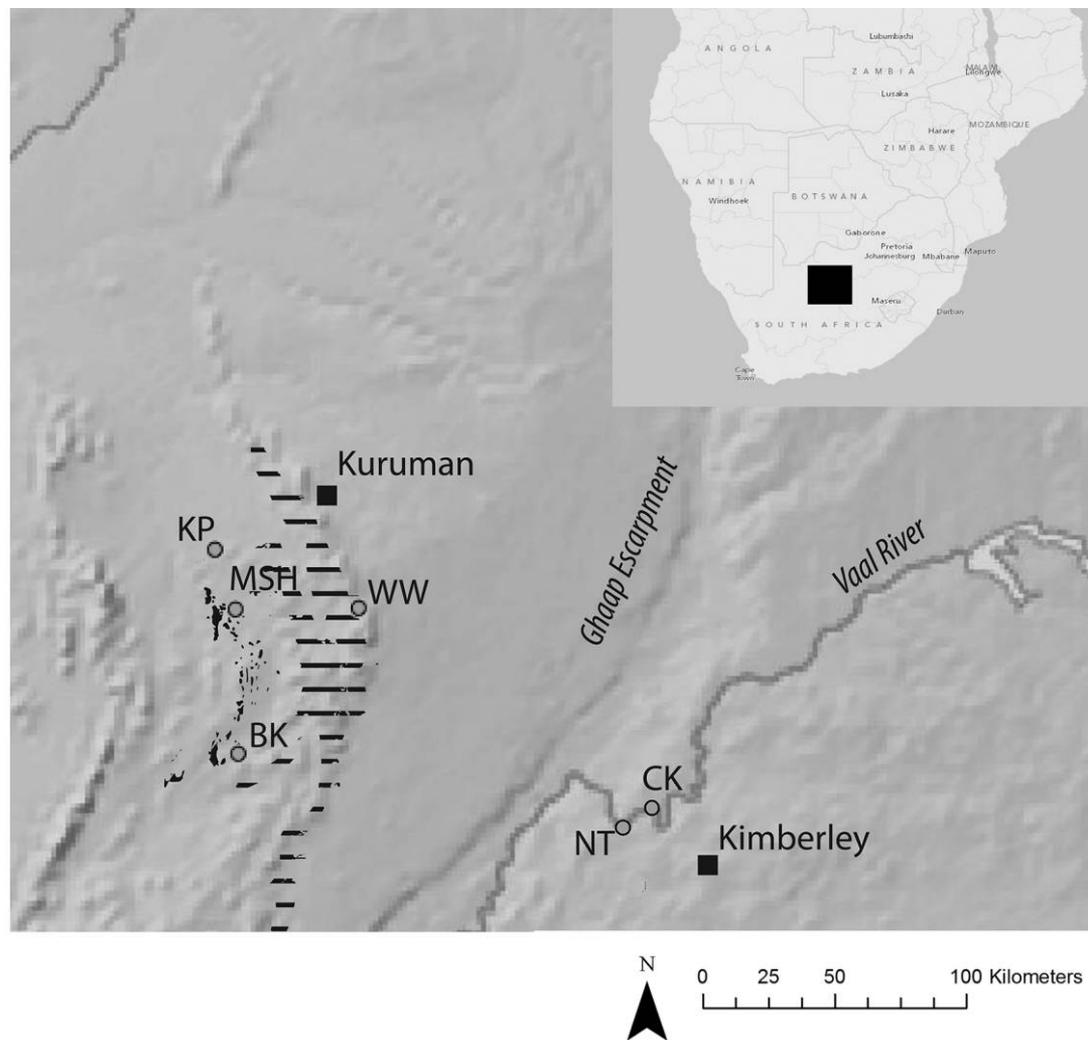


Figure 1. Topographic map of the study area (eastern portion of Northern Cape Province), showing the archaeological sites discussed in the text with selected geological outcrops. The shaded area shows the limits of the distribution of banded ironstone (Kuruman and Danielskuil Formations; Cambellrand dolomites and younger lavas within these limits are not shown). The black areas show outcrops of the Manganore/Wolhaarkop couplet. BK = Blinkklipkop (Tsantsabane); CK = Canteen Kopje; KP = Kathu Pan; NT = Nooitgedacht; MSH = Mashwening; WW = Wonderwerk Cave.

short distance northwest of the Vaal River rises the Ghaap Escarpment, giving onto the Ghaap Plateau, largely comprising Paleoproterozoic rocks of the Transvaal Supergroup—dolomite of the Campbellrand Subgroup and conformably overlying banded ironstone formations (BIFs) of the Asbesheuwels Subgroup (Kuruman and Danielskuil Iron Formations). The ironstone generally consists of alternating bands of iron (magnetite or hematite) and chert. The Kuruman Hills are a prominent feature on the plateau; their arced line delineates the eastern edge of a large anticline, the Maremane Dome. Dolomite's permeability has restricted the development of surface drainages, particularly to the east of the hills. Wonderwerk Cave is a solution tube on the hills' eastern flank.

Parallel to the western flank of the Kuruman Hills, forming an inner arc to the dome, lies one of the world's largest high-grade hematite deposits (Beukes, Gutzmer, and Mukhopadhyay 2003). Localized collapses of BIF into karstic erosion features in the dolomite led to the leaching of silica and supergene enrichment of hematite, with a siliceous breccia (Wolhaarkop Breccia) at the bottom, overlain by predominantly laminated and brecciated ores (Maremane Iron Formation). The Wolhaarkop Breccia is also associated with manganese (Moore et al. 2011; van der Merwe 2010). Subsequent erosion produced conglomeritic (detrital) iron ores in the lower portion of the overlying Gamagara Formation (Olifantshoek Supergroup). The ores (and other hard-rock geology) are widely masked by Tertiary calcretes and sands, outcrops are primarily isolated low hills or rises, arcing from Sishen in the north (close to Kathu Pan) to beyond Postmasburg in the south. The ore is generally hard microcrystalline hematite, unsuitable for use as pigment; however, later hydrothermal activity resulted in localized but widely distributed specularite in secondary veins throughout the Wolhaarkop, Maremane, and lower Gamagara succession (Beukes, Gutzmer, and Mukhopadhyay 2003; van Deventer 2010:28). Ancient specularite workings occur along the outcrop length of the Maremane/Wolhaarkop couplet (Beaumont 1973), the most significant being Tsantsabane or Blinkklipkop, near Postmasburg. Whether by direct procurement or trade, in the 1820s, specularite from this underground mine was said to be distributed over ~500 km (Burchell [1822–1824] 1953:256). Tsantsabane was also a source of soft, red hematite (Cambell 1815:230), which we equate with Wagner's (1928:183) "Eisenrham," a "fine purplish-red ochreous variety" of hematite.

An ancient pattern of north-trending drainage west of the Kuruman Hills (Haddon and McCarthy 2005) may have brought ore-body material into Kathu Pan but excludes transport toward Wonderwerk or the Vaal drainage. The only input of ironstone into the Vaal was in the Permo-Carboniferous glaciation, represented by isolated Dwyka deposits, with ironstone a minor component (De Wit 2004). An ethnohistorical account mentions a "fine red ochre" pigment procured near Danielskuil (Stow 1872:68), ~37 km south of Wonderwerk; this may have been an exceptionally weathered expression of

Kuruman Iron Formation. Protracted weathering of ironstone also produced a fine yellow ochre close to Wonderwerk (Bassett 2001:14).

## Archaeological Context

Materials from Beaumont's excavations are curated in the McGregor Museum (Kimberley, South Africa). New fieldwork, ongoing at Kathu Pan 1 and Wonderwerk, has been undertaken at all three sites (see above for the most relevant publications). Here we summarize the archaeological contexts, dating, and associated artifacts.

### *Kathu Pan 1*

This is an infill site within an erosional feature in Tertiary calcretes. Stratum 3 contains abraded MSA artifacts (poor in blades) in a dark brown gravelly unit, interpreted as a high-energy alluvial aggregate, and associated with an OSL estimate of  $291 \pm 45$  Ka. Stratum 4a has been observed both in gravelly spring vents and, in recent reexcavation, on a sandy horizontal surface. Both lithologies are yellow. The study of the geomorphological relationship between these contexts is in process, but lithic and faunal contents of the vents seem to rule out significant upward movement of material from stratum 4b. A combined U-series and electron spin resonance dating of an *Equus* tooth and OSL dating of sands, both directly associated with stratum 4a artifacts in a vent, produced ages of ~500 Ka (OSL provided a minimum estimate of  $464 \pm 47$  Ka; a weighted mean for the U-series and electron spin resonance results provided an estimate of  $542 + 140, -107$  Ka). The artifacts in stratum 4a are predominantly fairly fresh, characterized by prepared convergent flake and blade production. It remains to be demonstrated whether all bifaces in stratum 4a are unambiguously associated; a high proportion are worn and come from the lower spits (Wilkins 2013). Stratum 4b consists of two components: a Later Acheulean with some extraordinarily refined and symmetrical bifaces, and an underlying Early Acheulean (M. Chazan, personal observation). We currently have no age determinations, but abundant dental remains assigned to *Elephas recki* suggest an age >550 Ka (Faith et al. 2012).

The predominant lithic raw material throughout is locally procured ironstone (primary outcrops on Kathu Townlands, ~7 km east). A significant proportion of the stratum 3 ironstone and smaller amounts in stratum 4 has been severely weathered, sometimes resulting in an "ochreous" material, tentatively attributed to leaching of silica by alkaline groundwater (Beaumont 1990b:80; Wilkins 2013:100). The nearest outcrops of the Manganore, Wolhaarkop, Gamagara succession are ~11 km south (3 km into the Sishen property), on slightly rising ground (van Schalkwyk and Beukes 1986, fig.18b). Surface outcroppings on this and the adjacent property of Bruce have largely been quarried away, but specularite was presumably present; it is reported from core samples (Gutzmer et al.

2006), and ancient specularite quarries have been identified on all the farms immediately southeast of Bruce (Lylyfeld, Demaneng, and Mashwening), between 12.5 km and 26 km from Kathu Pan (Beaumont 1973; Beaumont and Bednarik 2013).

#### *Wonderwerk Cave*

This wide cave extends 140 m straight into a hill. Excavation 1, ~14 m from the current entrance, comprises ~5 m of Later Stone Age and ESA sequences. Contrary to Beaumont's description (Beaumont and Vogel 2006), we found no evidence in the upper levels of the ESA sequence for small bifaces and, more significantly, no evidence for blade production such as might be expected of a Fauresmith industry (Chazan et al. 2008). However, further analysis has found individual artifacts from upper stratum 8 and stratum 7 that might indicate a typological relationship to the Fauresmith (Chazan 2015). Bifaces predominate, but artifact density is extremely low throughout the Acheulean, suggesting that the front of the cave did not serve as a base camp at this time (Chazan and Horwitz 2009). Excavation 6 sampled up to 2 m of deposit over 25 m<sup>2</sup> right at the back of the cave, where it is very gloomy. There is no obvious functional reason for repeated use of this area. Analysis of these lithic assemblages is still in progress, but to date most material is consistent with the Fauresmith, with blade and point production associated with bifaces, nearly all in fresh condition. No underlying Acheulean has been identified, and no changes in the lithic industry have been detected. Artifact and faunal densities are considerably greater than in the ESA of excavation 1; preliminary taphonomic analysis indicates a high incidence of carnivore and porcupine activity. The paucity of primary flaking debris suggests that tools were made elsewhere (Chazan and Horwitz 2009), consistent with the poor illumination. The assemblages include numerous quartz crystals (only one with possible knapping scars)<sup>5</sup> and flaked ironstone slabs (one deliberately incised; Jacobson et al. 2012, fig. 4; see below and CA+ online supplement fig. S6B); both materials are obtainable from immediately outside the cave. Beyond attribution to the Fauresmith, there is limited chronological control. A U-series assay on a stalagmite (square CC148, stratum 3, 40–45 cm) of  $187 \pm 8$  Ka is reported as a minimum age (Beaumont and Vogel 2006, table 2).

#### *Canteen Kopje*

The sequence consists of Younger Gravels overlain by aeolian Hutton Sands. The gravels incorporate abundant Acheulean artifacts. The small "Fauremith" assemblage (which may equally be early MSA), characterized by blades, Levallois points, and retouched points, is restricted to the top 30 cm of the gravel and its surface. These are mostly in a fresh condition; two worn hand axes (one questionable) are not considered

5. Rubbed or struck together, quartz releases a luminescent glow (Whitley et al. 1999), possibly relevant to its collection at the back of the cave.

diagnostic (McNabb and Beaumont 2011). Single-grain OSL dating indicates that deposition of the Hutton Sands had begun by ~300 Ka, providing a minimum age for this assemblage (Chazan et al. 2013). Some artifacts are jaspelite, an ironstone variant lacking pronounced banding; some of these have round, white macrofossils (CA+ online supplement fig. S7B, S7C), similar to jaspelite exploited at the Late Acheulean quarry site of Kathu Townlands (Danielskuil Formation; Walker, Lukich, and Chazan 2014), ~175 km NW of Canteen Kopje. The closest primary outcrops of this Formation are ~90 km west.

#### Methods

Full accounts of potential pigments at Kathu and Wonderwerk are in preparation; here we report and describe those materials we confidently consider to be pigments (along with some of the most pertinent questionable cases). The grounds for such confidence were contextually arrived at, using guiding rather than formal criteria: (i) the material should be appropriate (eye-catching; in terms of color or reflective properties, soft or friable enough to readily produce a powder which should have staining power); (ii) ideally, there should be evidence for powder production (grinding or scraping); and (iii) in the absence of such evidence, there should be no grounds for confusion with lithic raw materials (even in a highly weathered state) or natural components of the deposit.

The descriptive procedures are those used in the analysis of MSA pigments from Pinnacle Point Cave 13B (Watts 2010). For Natural Colour System (NCS) notations of streak, a digital scanner (NCS Colour Scan 2) was used for preliminary assessments (providing readings to the nearest 10% intervals in blackness, chroma, and hue), with naked-eye revisions for more resolved notation. No color notation system captures specularite's glittery appearance (CA+ supplement fig. S8).

#### Results

Provenance and summary descriptive details of selected pigments from Kathu Pan 1 and Wonderwerk Cave and the two Canteen Kopje pieces are provided in table 1.

#### *Kathu Pan 1*

The square-by-square assignment of arbitrary 10-cm or 20-cm spits to stratigraphic units and industrial complexes follows J. Wilkins' assessments based on techno-typological traits preparatory to her thesis research, supported by her detailed analysis of materials from four squares (F21, F23, C21, and C23) and color changes in retained fine-sediment samples from five squares. Excavated volumes for stratum 3, stratum 4a, and stratum 4b were approximately 5.9 m<sup>3</sup>, 8.1 m<sup>3</sup>, and 18.4 m<sup>3</sup>, of which 45.8%, 97.5%, and 54.3%, respectively, were examined to identify potential pigments. Lithics were counted for most examined spits (for 42.4%, 88.9%, and 45.7% of total excavated volumes). Operationalizing the informal pigment criteria meant

Table 1. Provenience and selected descriptive details of definite pigments from pre-Middle Stone Age aggregates at Kathu Pan 1 (KPI) and Wonderwerk Cave (WW) and from a  $\geq 300$ -Ka context at Canteen Kopje (CK), together with two more equivocal cases from WW

Site, excavation	Square	Unit	Spit depth (cm)	Material	Mass (g)	Hardness <sup>a</sup>	Streak (NCS)	Comments	Pigment status
KPI, excavation 1:									
	F21	Stratum 4a	40–60	Specularite	34.5	4	7700 N	Intensively scraped over whole of one face	Pigment
	F21	Stratum 4a	40–60	Specularite	33.0	4	7502 R	Ground, 2 remnant striations	Pigment
	D20	Stratum 4a	80–90	Greasy hematite	14.5	2	5230 R	Unmodified	Pigment
	C20	Stratum 4a/4b	80–100	Weathered hematite	1.5	4	4050 Y60R	Ground, 1 facet	Pigment
	B20	Stratum 4b	120–140	Specular-hematite	103.5	4	6222 Y90R	Intensively ground, no clear striae, 7 facets	Pigment
	S29	Stratum 8a	0–5	Weathered hematite	0.4	4	4645 Y67R	Chip with remnant of edge-ground facet	Pigment
WW, excavation 6:									
	AA146	Stratum 3	125–130	Specularite	...	...	...	Scraped, 2 pairs of paired, deep striae	Pigment
	V148	Stratum 3	Unknown to 40	Specularite	30.0	4	7507 Y90R	Unmodified	Pigment
	X149	Stratum 3	175–180	Specularite	156.0	5	7005 R20B	Unmodified, abundant quartz	Pigment
	U151	Stratum 3	115–120	Specularite	104.5	4	7010 Y90R	Ground, no clear striae, 2 or 3 edge-facets	Pigment
	U151	Stratum 3	145–150	Iron-hydroxide?	2.0	3	6624 Y50R	Ground, clear striae, 1 facet	Pigment
	V151	Stratum 3	80–85	Greasy hematite	17.0	3	7213 Y70R	Possible large, deep gouge	Pigment
	U151	Stratum 3	80–85	Greasy hematite	12.0	3	5530 Y90R	Unmodified	Pigment
	W146	Stratum 4	30–40	Banded Ironstone	105.0	5	5035 Y70R	Incised and lightly ground, 1 surface	Possible
	U148	Stratum 4b	55–60	Weathered dolomite	14.0	2	5034 Y75R	Intensively scraped, 4 conjoining pieces	Possible
CK, area 2:									
	...	Stratum 2a	0–10	Specularite	76.0	4	6410 R10B	Unmodified	Pigment
	...	Stratum 2a	0–10	Specularite	63.5	4	7010 Y90R	Ground, no clear striae, 1 small edge facet	Pigment

Note. NCS = Natural Colour System.

<sup>a</sup> The qualitative ordinal scale of hardness is adapted from Mohs' scale; see supplementary online material in Watts (2010).

excluding dense but hard hematized material (typically hematized bands of BIF but probably including some laminar Manganore Iron Formation), “ochreous” weathered BIF, and indeterminate red materials softer than Mohs hardness 5 but not particularly dense (i.e., not obviously soft hematite). Examination of curated fine and coarse sediment fractions and field observations at nearby streambeds enabled an assessment of potential natural components of the deposits.

The largest category is specularite, present in the MSA (stratum 3,  $n = 10$ ), mixed stratum 3/4a ( $n = 3$ ), and Fauresmith (stratum 4a,  $n = 8$ ) horizons. It occurs as dense, glittery, more or less friable nodules. Depending on friability and particle size, it leaves either a dark red metallic residue on the fingers or a black and silver residue (the more friable pieces). Average streak was 6810 Y93R ( $n = 12$ ; standard deviation [SD]: 0706 Y06R), very dark, of low chroma and high redness (poorly perceptible owing to the darkness and low chroma).<sup>6</sup> The coarse, friable fabric means that original surfaces are rarely preserved (particularly in stratum 3). It seems unlikely that the most friable pieces could have washed into the pan from at least 11 km away, but the abraded state of most of the stratum 3 lithics suggests that specularite was washed in from hominin activities in the more immediate environment.

Of the eight specularite from stratum 4a, six came from the uppermost spit (40–60 cm) of one square (F21). Within Wilkins’ fully analyzed sample, material from spits of this depth (C21, F21) assigned to this stratum were unusual in having a high proportion (~19%) of rolled lithics (Wilkins 2013, fig. 11), a trait more consistent with overlying stratum 3. We therefore note that, in addition to the technological grounds for assignment to stratum 4a, sediment samples from C21 were brown in spit 20–40 cm and yellow in spit 40–60 cm (Wilkins 2013, fig. 6), consistent with geomorphological observations on the two strata. The two remaining pieces also came from the top spits assigned to this aggregate in their respective squares (F25 and D21). It is likely that these pieces are best associated with the Fauresmith, but the possibility remains that they are intrusive from the MSA.

Two stratum 4a specularite show definite utilization. One (fig. 2A; CA+ supplement fig. S1A) was scraped over most of one surface, resulting in a slightly concave facet that probably contributed to its preservation. Some initial points of entry of the scraping tool are visible (CA+ supplement fig. S1A). The second example (CA+ supplement fig. S1B) preserves a small remnant of an original surface with traces of two broad striations. Several other specimens, from both strata, had unusually flat surfaces in an otherwise rounded morphology, suggestive of ground facets (e.g., CA+ supplement fig. S1C).

Specularite sometimes grades into what we have designated “specular hematite,” a more finely specular expression that cannot be described as glittery, although fresh exposures glisten in bright light ( $n = 10$ ; 3 in stratum 3, 2 in mixed stratum 3/4a, 2 in stratum 4a, 1 in mixed stratum 4a/4b, and 2 in stratum 4b).

6. Mean NCS for KP1 specularite excludes five cases with no chroma and two where hue fell in the red : blue rather than yellow : red ratio.

This was recovered down to the upper spits of stratum 4b. Average streak (6812 Y87R, SD: 0608 Y10R,  $n = 9$ ) is indistinguishable from specularite. The most compelling case for utilization was from the top spit of stratum 4b in B20 (120–140 cm; fig. 2B; CA+ supplement fig. S1D). This large nodule lacked unequivocal aligned striations but appears intensively ground; 7 flat facets covered ~70% of the surface area. The overlying spit was assigned to stratum 4a, the only 4a spit in this square (spit 80–100 cm was designated “mixed stratum 3/4a”); given the arbitrary excavation units and lack of compelling supporting evidence from stratum 4b, admixture seems likely. The other piece from stratum 4b came from a spit in the top 30 cm. It was much smaller (4 g) and naturally worn; it could be a natural wash-in.

A third distinctive category was “greasy hematite,” dense, soft, and greasy to touch, with a submetallic luster and reddish-bronze color. This was recovered down to the middle of stratum 4a (5 in stratum 3, 1 in mixed stratum 3/4a, and 2 in stratum 4a). Of the two stratum 4a pieces, one (a mix of greasy hematite and specular hematite) came from the top spit in D21 (60–80 cm), and the other came from D20—with two overlying and two underlying 10-cm spits assigned to this stratum (CA+ supplement fig. S1E; see CA+ supplement fig. S8 for streak). Average streak (5426 Y84R, SD: 0811 Y09R, valid  $n = 7$ ) is appreciably lighter and more chromatic than previous categories, consequently appearing much redder.

A fourth utilized piece—categorized as ground “weathered hematite”—came from a mixed stratum 4a/4b spit (fig. 2C; CA+ supplement fig. S1F). As a vesicular, red material of only moderate density, it falls outside the criteria for confidently identifying pigments, but the broad (~0.8 mm) parallel grinding striations—covering most of one face—are unequivocal. These are brighter than most of the rest of the piece and bear some fine detail. Given the potential behavioral significance of grinding at this level in the sequence, the possibility that it occurred after excavation has to be considered. We therefore note that (i) ancient striations are sometimes brighter than the ground upon which they occur (d’Errico 2008, fig. 1b; Watts 2009, plate 4.7); (ii) the illustrated face shows recent scuffing (attributable to storage with lithics), which is brighter than the striations (CA+ supplement fig. S1F); (iii) if mischievously abraded (to make a case for ancient grinding), we might expect the piece to have been bagged separately (as done with some specularite) and for Beaumont to have drawn attention to the piece; and (iv) the general lack of sorting of potential pigments from lithics suggests that sorters were not alerted to the distinction, so streak-testing is unlikely. On balance, we consider this to be a fragment of fortuitously preserved, anciently ground red pigment.

Pigments in stratum 3 have not previously been reported. The stratum 3 dating estimate implies that they are among the oldest MSA pigments. The presence of pigments in the Fauresmith of stratum 4a is confirmed, predominantly specularite rather than “unmodified or flaked soft red haematite” (Beaumont 1990b:80). Although specularite is restricted to the topmost stratum 4a spits, specular hematite and greasy hematite

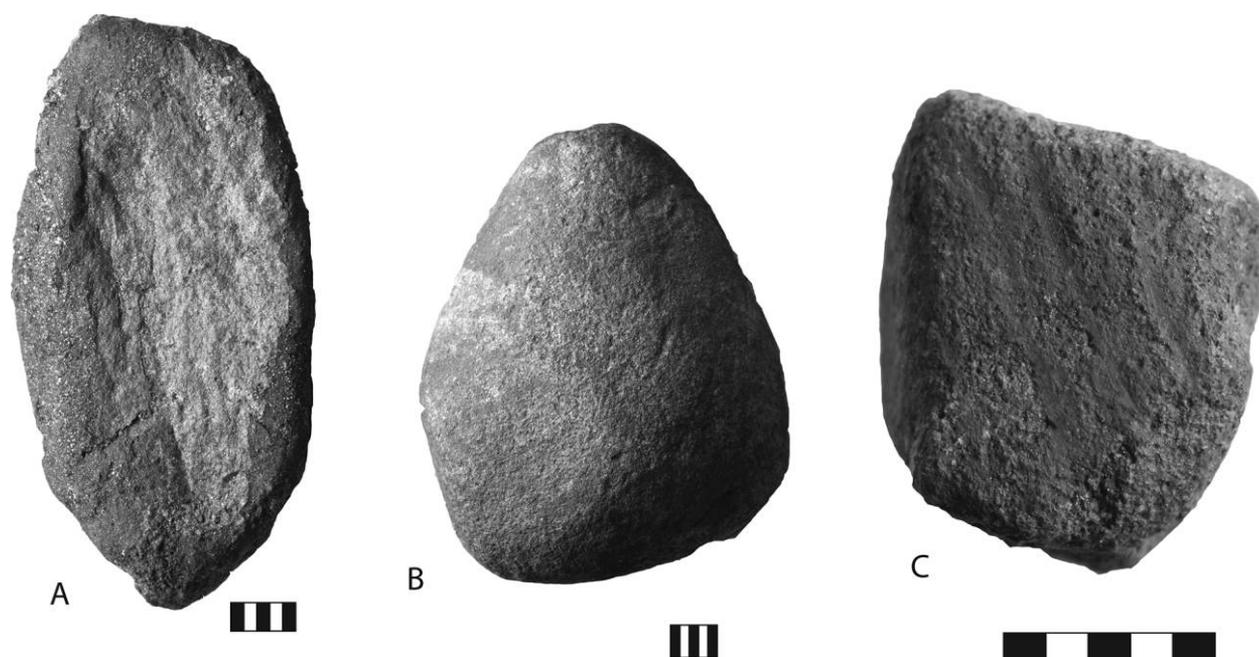


Figure 2. Kathu Pan 1 pigments. A, Scraped specularite, stratum 4a, F23, 40–60 cm, scraped over most of one main surface. B, Ground specular-hematite, stratum 4b, B20, 120–140 cm. No clear striations, but up to seven flat facets, at least four of which are represented here. C, Ground “weathered hematite,” mixed stratum 4a/4b, C20, 80–100 cm.

were encountered in deeper spits. The absence of specularite (and greasy hematite) from stratum 4b is striking. This visually arresting material was locally available and would have attracted the attention of anyone looking for eye-catching materials to augment a ritualized display. Over 15,700 lithics were counted for stratum 4b, compared to just over 12,000 for stratum 4a and ~5,900 for stratum 3; an absence in this context should be regarded as significant. Beaumont and Bednarik reported “half a dozen small and sometimes slightly rounded soft red haematite” in stratum 4b (2013:11); however, Beaumont sometimes used “haematite” inappropriately, including materials we categorize as iron hydroxides and probable cave sediments (see below). In the absence of diagnostic utilization, we see no basis on which to infer that such pieces were “pigment manuports” (Beaumont and Bednarik 2013), partly because of the ochreous state of some of the ironstone lithics (sometimes lacking signs of flaking) and the possibility of rare natural wash-ins from Sishen (e.g., possibly the small nodule of “specular hematite” from stratum 4b). That pigments may occasionally have been used in the youngest Acheulean cannot be ruled out, but the weight of evidence strongly suggests they are restricted to the Fauresmith and MSA, with most of the Fauresmith material coming from the upper spits, suggesting that Fauresmith use was initially irregular.

#### *Wonderwerk*

The “haematite lenses” in the dolomite above the cave (Beaumont 1990c:125) are nodules and horizontal veins of ferrugi-

nous material (CA+ supplement fig. S2). They occasionally stain the dolomite but are themselves almost invariably extremely hard to streak (6 in Mohs scale), suggesting a high silica content; the few streaks obtained were yellowish-brown or mid-brown, indicative of iron hydroxide rather than hematite. Comparable materials were encountered in excavation 1 and excavation 6 (e.g., CA+ supplement fig. S3D), but their hardness, streak properties (when obtainable), and the absence of any utilization provide no grounds for inferring a pigment status.

At excavation 1, pigments were identified in Beaumont’s strata 5 and 8. Stratum 5 provided two specularite and a small piece of “red ochre,” but mixing with LSA material (including ostrich eggshell beads) makes an ESA association insecure. Stratum 8 provided two pieces. One was a soft, dense, greasy piece of hematite from Q23, indistinguishable from the “greasy hematite” at Kathu Pan 1. However, LSA deposits immediately overlay stratum 8 in this square, so the piece must also be treated as probably intrusive. The second piece was a tiny fragment (10.5 mm × 7.6 mm) of weathered hematitic material, bearing small remnants of four parallel striations on a partially exfoliated edge facet, consistent with grinding (fig. 3; CA+ supplement fig. S3A). There were also traces of probable use on the edge of a main surface, although these are harder to interpret and may conceivably be due to trampling (CA+ supplement fig. S3A). The fragment came from the top spit (0–5 cm) of stratum 8 in square S29, where the stratum is overlain by a thin (~5 cm) presence of stratum 7. The context is within the top 10 cm of secure Acheulean deposits in this square. Displacement from the LSA cannot



Figure 3. Wonderwerk Cave, excavation 1, stratum 8a, S29, 0–5 cm. Edge-ground chip of pigment (indeterminate hematitic material), Acheulean context.

be ruled out, but we consider this to be the best evidence for pigment use toward the end of the Acheulean sequence at Wonderwerk.

Beaumont's stratum 9 is thought to contain the Brunhes/Matuyama magnetic reversal, placing it in the terminal Lower Pleistocene and initial Middle Pleistocene. Stratum 9b provided a scraped slab of superficially weathered dolomite (CA+ supplement fig. S3B). The aligned striations, covering one surface, are broad and square profiled. However, the powder is dull brown (4015 Y40R) with little staining power. A similar piece was recovered in a younger context at the back of the cave (CA+ supplement fig. S4A), also dolomite, with a distinct (precipitated) cortical layer, bearing broad scraping striations, providing a dull, light-grey streak (4010 Y30R). While the stratum 9 piece demonstrates powder manufacture by the early Middle Pleistocene (for purposes unknown), it cannot be considered good evidence for early pigment use.

The oldest Acheulean assemblage at Wonderwerk is from Stratum 11, with a cosmogenic age estimate of 1.17 Ma at its base. Some pieces of reddish-brown and bright red material were recovered, bagged by Beaumont respectively as "ochre" and "haematite." This material was extremely lightweight and friable, the powder having no staining power. Fourier transform infrared spectra for one specimen (CA+ supplement fig. S3C) showed absorptions of slightly altered clay, apatite, quartz, organics, and calcite, interpreted as probably cave sediment, possibly slightly burnt (Francesco Berna, personal com-

munication, July 1, 2014). There is no reason to consider this material pigment.

To date, less than half of the material from excavation 6 has been examined, providing a range of potential pigments, including seven pieces that we are confident about: four specularite (two utilized); a ground piece of weathered iron hydroxide; and two pieces of soft, greasy hematite (one possibly gouged). We reserve judgment on two further pieces: another scraped piece of weathered dolomite and an incised ironstone slab.

The specularite lacks the friable expressions of Kathu Pan 1; it comprises a cobble, two pebble-size worn nodules, and a large, angular chunk. Brown patination on the cobble and one of the smaller nodules suggests they were surface pick-ups. Both main surfaces of the nonpatinated nodule bear single pairs of deeply gouged striations; there is also at least one probably ground facet (fig. 4A; CA+ supplement fig. S4B). The cobble (fig. 4B; CA+ supplement fig. S4C) shows fairly extensive edge grinding (but no unequivocal striations); the largest ground area comprises two subfacets, and a small facet is on the opposite edge (CA+ supplement fig. S4C). The large chunk is fresh and angular; the specularite is intimately mixed with quartz (CA+ supplement fig. S4D), suggesting a Wolhaarkop Breccia derivation. The quartz makes grinding impracticable, but two faces have thin, more homogenous layers of specularite, which could potentially have been exploited. Beaumont and Bednarik (2013:11) state that Wonderwerk specularite "came

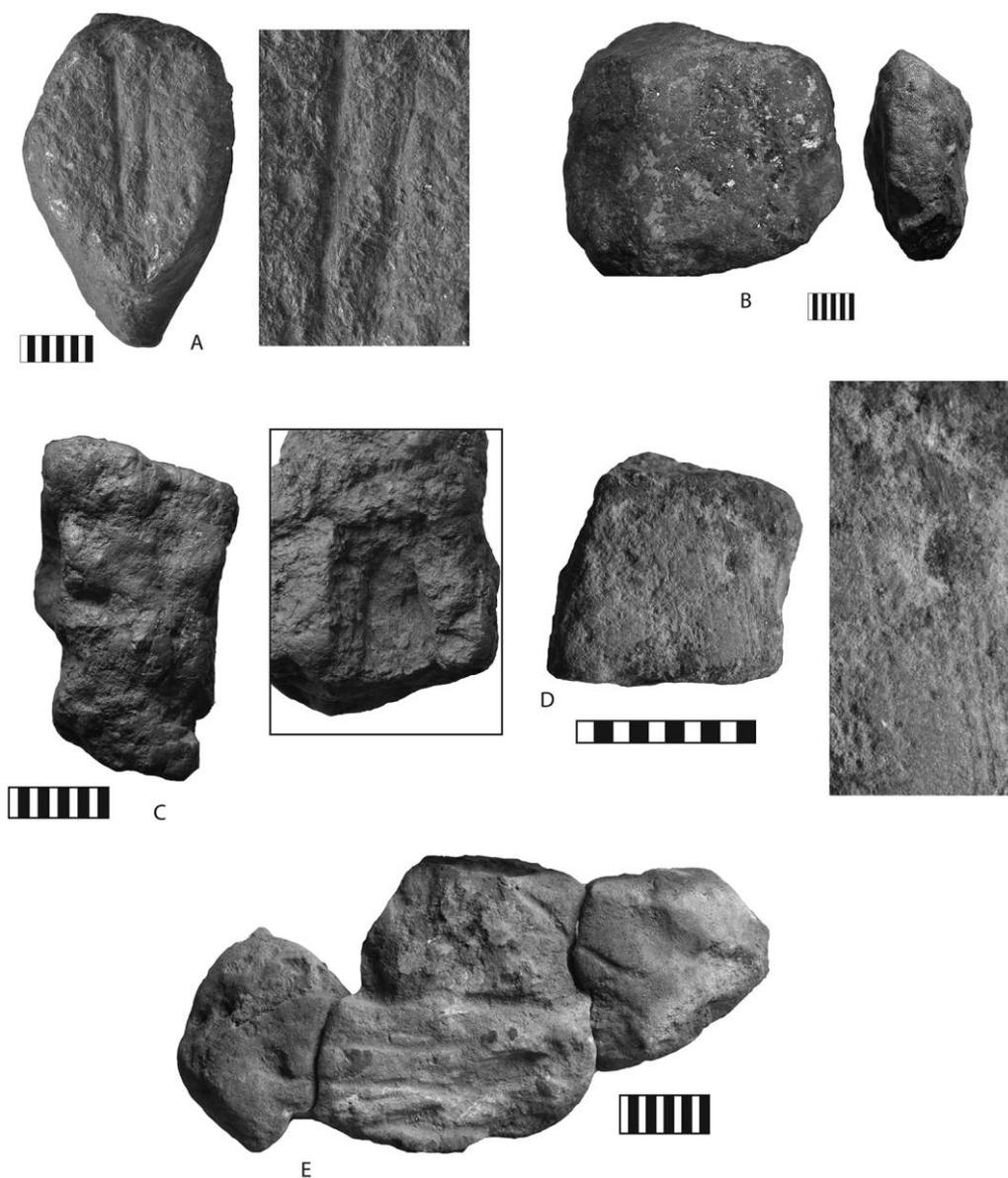


Figure 4. Wonderwerk Cave, excavation 6 Fauresmith pigments. *A*, Scraped specularite nodule, stratum 3, AA146, 125–130 cm. *B*, Edge-ground patinated specularite cobble, stratum 3, X149 175–180 cm. No clear striations. *C*, Possibly gouged soft, greasy hematite, stratum 3, V151, 80–85 cm. *D*, Ground “weathered iron hydroxide,” stratum 3, U151, 145–150 cm. *E*, Possible pigment (see text), scraped weathered dolomite, stratum 4b, U148, 55–60 cm.

from sources ~50 km to the east (*sic*)<sup>7</sup>. The closest mapped potential sources are small outcrops of the Manganore/Wolhaarkop couplet ~38 km to the southwest (van Schalkwyk and Beukes 1986, fig. 1). Mashwening, ~47 km west of Wonderwerk, is the closest identified prehistoric specularite working. A test trench adjacent to the workings provided a biface (Beaumont 1990b:81; Beaumont and Bednarik 2013:12).<sup>7</sup> A retained collection of substrate material (from the “Specularite”

7. Mashwening (MM 6896) comprises three strata (contra Beaumont and Bednarik 2013): “sand,” “specularite,” and “rubble.” The first two contain ceramics. The biface came from the “rubble” horizon.

stratum?) overwhelmingly comprised specularite, with tiny amounts of greasy hematite (CA+ supplement fig. S8). No natural agencies could have brought such material closer to Wonderwerk.

The two pieces of soft, dense hematite are greasy, with a submetallic luster, comparable to the “greasy hematite” at Kathu Pan 1 and Mashwening. One piece (fig. 4C; CA+ supplement fig. S5A) shows a deep, rectangular cavity that may have been gouged out. The streak of this piece (CA+ supplement fig. S8) was surprisingly dark, while the other (CA+ supplement fig. S5B) was appreciably lighter and more chromatic (CA+ supplement fig. S8).

We suspect that the ground piece of weathered iron hydroxide was originally hematite, hydrated to an iron oxide-hydroxide (e.g., goethite) after deposition. It was described as “slightly buttery,” resembling the greasy hematite, but not as dense. One face bears five or six aligned, worn striations (fig. 4D; CA+ supplement fig. S5C), predominantly in a yellow, heavily hydrated zone, but two small residual patches of dark-brown, harder material (comprising the bulk of the piece) emerge through the surface weathering, showing denser, finer striations. Our postdepositional weathering interpretation would suggest that the whole piece originally provided a redder streak.

The weathered dolomite (fig. 4E; CA+ supplement fig. S6A), from stratum 4b, comprises four deeply scraped, conjoining fragments (three illustrated). It is friable and leached, with two small nodules of ferruginous material resembling those in the dolomite above the cave (others are only distinguishable as dark-brown smudges). Unlike the previously discussed scraped dolomite, the color is consistent with use as a pigment and is unexpectedly chromatic and red but again has little staining power. Despite this failing, we would probably have categorized this as pigment but for the previously discussed brown cases. As it is, no unequivocal assessment can be made. If it were pigment, the stratigraphic provenance would imply processing from early on in the use of the back of the cave. It might also suggest that very local procurement of poor-quality red ochre preceded regional procurement of specularite and greasy hematite.

The incised slab of banded ironstone (CA+ supplement fig. S6B) from stratum 4 (W146, 30–40 cm) may also have served as pigment. Utilization occurs on a thin surface layer of slightly weathered hematite. It consists of a restricted area of polish together with aligned, very fine, “v”-profiled grinding striations and broader, more sinuous striations; a prominent sinuous striation runs parallel to an edge and appears to be the result of one incising action. The combined use-wear could only have produced a tiny amount of powder. If this served as pigment, it would lend weight to the tentative inferences concerning the previous piece.

#### *Canteen Kopje*

As originally reported (Beaumont 2004a:28), the small “Fauresmith” assemblage provided a “cache of specularite nodules.” Only two pieces were found in our examination (see also McNabb and Beaumont 2011:53), both fairly large, angular chunks in fresh condition, curated as having come from the surface of spit 0–10 cm. One has a previously unreported small, flat facet on an edge, indicating light grinding (fig. 5; CA+ supplement fig. S7A; see also CA+ supplement fig. S8 for streak). The nearest specularite outcrops are around Postmasburg, ~170 km west, with no known alluvial system capable of transporting clasts east (specularite is not reported in Dwykage glacial gravels at nearby Nooitgedacht, where weathering has removed all but well-rounded, siliceous pebbles; de Wit

2004). Although such a transport distance would be exceptional for this period, it is supported by the associated jaspilite blades, a raw material thought to come from at least 90 km west. Pigments are absent in the large Acheulean assemblages of units 2a and 2b (Beaumont and Bednarik 2013).

A fourth site in the region, Nooitgedacht 2, probably provides additional support for Fauresmith pigment use. Eleven kilometers downstream from Canteen Kopje, Beaumont (1990a) made a systematic collection of artifacts from trapped gravels on the Nooitgedacht Platform, exposed by diamond diggers’ removal of Hutton Sands (see de Wit 2004 for geological context). In an analysis of nine purported Fauresmith assemblages (not including Kathu or Wonderwerk), Nooitgedacht 2 was judged “the most likely candidate for a true occurrence” (Underhill 2012:165). Beaumont illustrated a ground piece of “haematite” (1990a, fig. 4)—the only previously published illustration of a pigment from an apparently pre-MSA context. Unfortunately, by 2009, this piece was missing (Underhill 2012:154).

#### Discussion

Beaumont’s long-standing claim that pigment use extends to the Fauresmith (Beaumont 1990a, 1990b) is confirmed. Caution dictates that we treat the ground piece of specular-hematite from a spit assigned to the top of stratum 4b at Kathu Pan as probably derived from stratum 4a. No other definite pigments were recovered from stratum 4b; given the large size of the examined lithic sample, this provides reasonably compelling evidence of absence, rather than absence of evidence. Most of the stratum 4a pigments came from the upper spits, but the piece of greasy hematite from the middle of the aggregate, the ground specular-hematite, and the ground “weathered hematite” from a mixed stratum 4a/4b spit suggest that the behavior goes back to the onset of systematic blade and point manufacture. Canteen Kopje, Wonderwerk, and probably Nooitgedacht 2 support the general coassociation. Two possible pigments from Wonderwerk excavation 6 stratum 4 suggest that pigment use may extend to initial (Fauresmith) use of the back of the cave. The only reasonably strong evidence that pigment use might extend to the Acheulean is the tiny fragment from stratum 8 of excavation 1 at Wonderwerk.

Specularite circumvents the objections most frequently raised about assigning a pigment status to ferruginous materials: its only use seems to have been for visual display, and it is unlikely to be a natural component of archaeological deposits. Natural inclusion is possible at Kathu, but the specularite’s friability, temporal distribution, absence in stream-beds, and archaeological sediment fractions make this unlikely, whereas utilization renders the issue fairly academic; natural inclusion was ruled out at Wonderwerk and Canteen Kopje. The inferred minimum transfer distance of ~38 km for the Wonderwerk specularite and greasy hematite is notable, whereas that for the Canteen Kopje specularite (~170 km) would be exceptional

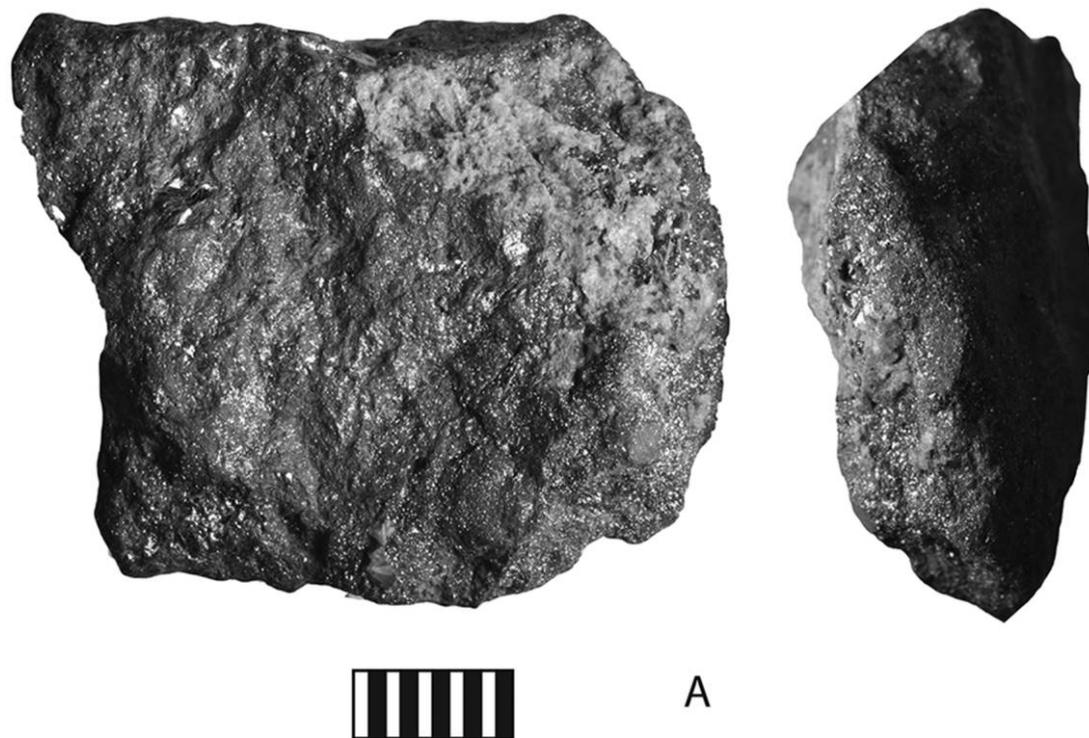


Figure 5. Canteen Kopje. Lightly edge-ground specularite, area 1, unit 2a, 0–10 cm. No clear striations.

for this period but seems to be supported by the jaspelite flakes.

The back of Wonderwerk is a unique find context, as is the suite of manuports (various pigments, quartz crystals, and ironstone slabs). Chazan and Horwitz (2009) propose that use of this space—more than 100 m deep inside the hill—was related to its unusual sensory characteristics. It is suggestive of a special place used for special occasions, consistent with characteristics of ritual performance (Rappaport 1999). We speculate that it was used for fire-lit, body-painted, song-and-dance performances, the performers glittering and red. The location counts against proposals that early pigments provided “badging” in intergroup encounters (Dunbar 1999; Sterelny 2011); it may be consistent with either a homogenous group of coritualists or the presence of an out-group drawn from coresidents (e.g., affines).

Contrary to Beaumont and Bednarik (2013), we found no good evidence for pigment use during the Acheulean at Kathu Pan (see above) or Kathu Townlands. For Kathu Townlands and adjacent Uitkoms, we examined large excavated samples from several trenches (MM 6714, 6890) without encountering any likely pigment; large-scale salvage excavations had similar results (Walker, Lukich, and Chazan 2014). The “in situ unmodified specularite lump” seen in 2009 (Beaumont and Bednarik 2013:12) concerns road-grading that exposed Hutton Sands and underlying deposits (Beaumont, personal communication, November 13, 2012). The technological character of the Townlands assemblages (Beaumont 1990*b*) makes a Late

Acheulean association plausible, but the similarity of geological context to Canteen Kopje and Nooitgedacht 2 alerts us to the possibility of a Fauresmith or early MSA association, or a palimpsest. At Wonderwerk, despite a fairly compelling pigment fragment from what is probably a secure context toward the end of the Acheulean sequence, we found no evidence to support the claim for the behavior extending far back into the Acheulean.

This evidence from the Northern Cape supports the idea that pigment use developed as part of a package of behaviors, which included the development of prepared core methods and hunting with hafted spears, in the context of a poorly defined Fauresmith transitional industry during the middle of the Middle Pleistocene. From a broader—Old World—perspective, this period (from ~550 to ~300 Ka) correlates with early evidence for home bases (see above).

The FCC hypothesis predicts early pigment use (i) not to predate Middle Pleistocene brain size increase, (ii) to associate with early evidence for home bases, (iii) to involve preferential use of reds, and (iv) to be characterized by initial, sporadic use of local materials. In the second stage, where a runaway sexual-selection process is posited, it predicts that, (v) where suitably red and saturated materials are locally unavailable, competition between female coalitions for more regular male investment should promote more costly regional or exotic procurement, and (vi) the last phase of brain size increase should associate with a rapid shift from a mosaic pattern of no use, irregular use, or localized regular use to a ubiquitous, regular

behavior. Predictions (i)–(iv) are directly relevant here, and prediction (v) may be relevant as regular use and costly procurement could occur regionally before the predicted explosive spread.

Paleoanthropologists have pushed back the onset of Middle Pleistocene brain size increase from ~500 Ka (Leigh 1992) to the early part of the epoch (780 Ka to ~600 Ka; Rightmire 2009). Nevertheless, prediction (i) would have been refuted if Beaumont and Bednarik's (2013:12) claim for pigments at ~1.1 Ma had been confirmed (it still could be if the "early Acheulean" at Hunsgi V proves of comparable age to Attirampakkan,  $\geq 1.07$  Ma; Pappu et al. 2011). The utilized chip from Wonderwerk stratum 8 of excavation 1 is intriguing. Accepting the context at face value, it presumably falls within the latter part of the period of brain size increase associated with the speciation of *Homo heidelbergensis*, suggesting that the positive aspect to prediction (i)—that earliest pigment use should occur during this period—also finds support. Speculatively, in predating widespread evidence for homebases, this piece may hint at a role for body-painted ritual display in their establishment. Although the Fauresmith aggregates discussed do not directly address the establishment of home bases, as previously noted, similar technological changes closely associate with this development, and the broad timing is consistent.

Any hypothesis concerning ritual display might predict use of brilliant or otherwise eye-catching materials, but surprisingly few explicitly predict selection for red (Durkheim 1912; Knight 1991). That locally available yellow ochre at Wonderwerk or manganese at Kathu Pan were not collected underscores the deliberate selection of several forms of hematite. The FCC hypothesis, as a model of the origin of symbolic culture, not only uniquely predicts a red focus on Darwinian grounds, but cosmological aspects of the model generate the additional prediction that redness and brilliance should associate with darkness (Knight 1991, 1997; Knight, Power, and Watts 1995; Watts 2005, 2015; see Watts 2010, supplementary online material, pp. 34, 35). Several observations are relevant here: (i) redness and brilliance are consistently associated with constructs of supernatural potency among southern African hunter-gatherers (Watts 1999), most consistently in menarcheal ritual (Knight, Power, and Watts 1995); (ii) among the simplest color lexicons studied in any detail (Heider 1972; Jones and Meehan 1978; Levinson 2000), perhaps the only common feature is the identification of specifically dark, saturated reds as particularly salient (Watts 2010, supplementary online material, p. 30);<sup>8</sup> (iii) in the MSA, in addition to preferential use of the reddest, most saturated materials (Hodgskiss 2012, 2013; Watts 2009, 2010), there is suggestive evidence that this focus extended to very dark values (rather than these

8. The salience of dark, saturated red is consistent with the naming centroid for English "red," where a dark value is expected owing to the presence of "pink" and "orange" terms (Kay and Regier 2003, figure 4b); it would not be predicted of simple color lexicons under the assumption that terms' significata jointly partition the color space (see Kay and Maffi 1999).

forming a distinct category focus; Watts 2010); and (iv) pigment use at the back of Wonderwerk implies that fire-lit darkness was a valued sensory quality of ritual performance.

There is no African evidence for significant further brain size increase until our speciation (Watts 2014, table 16.1), approximately when regular red ochre use in southern African rock shelters is thought to have become ubiquitous. The latter pattern remains to be confirmed by radiometric dating of several sequences but would be consistent with prediction (vi).

Kuhn's cheap-but-honest signals hypothesis requires that early pigments should be locally procured. If and when this might change is unspecified, but his argument implies that nonlocal procurement should not be seen before the Upper Pleistocene, possibly not before the Upper Paleolithic (when costlier signaling is identified). The tentatively inferred transfer distances for Wonderwerk and Canteen Kopje would, if confirmed by mineralogical analysis (see Kiehn et al. 2007a), contradict such an expectation.<sup>9</sup> With closely aligned fitness interests considered a precondition to honest, low-cost signals, the archaeological inference that home bases predate pigments may also be treated as an implicit prediction, one challenged by our data. The hypothesis makes no predictions of past selective criteria (beyond the use of eye-catching materials) and no connection between the medium and the message, nor does it make predictions about who was selecting and who was signaling. That body painting is cheaper than the thousands of beads in the Sunghir burials (~26 ka) is not contentious. But, in evolutionary terms, relative to the earlier absence of compelling evidence for materially mediated signaling, the procurement (local or otherwise), processing, and application of earth pigments represents unprecedented costs. Such de novo costs and the visual qualities of specularite hardly accord with the inconspicuous, private signals expected in coordinating action (Silk, Kaldor, and Boyd 2000).

Recalling that the comparison with beads (Kuhn and Stiner 2007) underpinned the premise that pigments do not express cost effectively, we note two neglected performance characteristics of body painting. First, it has to be executed afresh as the periodicity of ritual performance demands (a cost multiplier), making it intrinsically time-factored (suitable for marking out reproductive and environmental periodicities) in a way that donning beads is not. Second, anything but the crudest application requires a colleague, reliably signaling the presence of allies. The complexity or otherwise of early body painting can only be conjectured (see Durkheim 1912; Watts 2009), but demonstrating the presence of allies is critical to the conflict-driven FCC hypothesis, whereas in Kuhn's hypothesis all coresidents are allies, ritually reminding themselves of an overriding common interest, with no specified differentiating structure defining roles and obligations.

9. There are other early contexts where pigments appear to come from further afield than lithic raw materials (for Hunsgi V, compare Padaya 1976:761 with Shipton, Petraglia, and Paddayya 2009, fig.16.8; for Twin Rivers, compare Barham 2002:183 with Barham et al. 2000:190, 216).

Finally, for the FCC hypothesis, cosmetics may or may not indicate cost, but the time and energy spent on the entire ritual performance certainly does. This becomes the expensive religious packaging of “beauty magic,” as described by Malinowski (1929), the deployment of the ornamented body to invoke otherworldly powers (Power 2010). By contrast, Kuhn’s hypothesis expects both cosmetics and early ritual performance to be low in cost.

## Conclusions

We conclude that, for the sites discussed, there is (i) compelling evidence of pigment’s absence in all but the youngest Acheulean contexts, (ii) definite pigment use in a Fauresmith context from at least ~500 Ka, and (iii) regionally widespread and regular use by ~300 Ka, which probably included nonlocal raw material transfers. Additional work is needed (i) to improve stratigraphic and chronometric control, which may slightly push back initial use, but nothing like to the extent claimed by Beaumont and Bednarik (2013), and (ii) to assess the feasibility of “fingerprinting” archaeological and outcrop materials to address the provenancing issues raised.

The Fauresmith presents a novel package of behaviors that correlate with broader evidence for the generalization of a campsite-focused form of social organization. This suggests that initial pigment use, while localized and rare, associates with this process rather than following it, which is more consistent with the predictions of the FCC hypothesis than with the cheap-but-honest signals hypothesis.

The inferred transfer distance of specularite to Wonderwerk and, more emphatically, to Canteen Kopje would, if confirmed, seriously challenge cheap-but-honest signaling. Conversely, local procurement at ~500 Ka (Kathu Pan), with exotic procurement suggested at ~300 Ka (Canteen Kopje), could—at a regional scale—provide a time-frame for the FCC’s prediction concerning the emergence of competing coalitions (but see below). The predominance of specularite does not challenge the FCC’s predicted focus on “blood reds,” as the hypothesis also predicts an association between redness, brilliance, and darkness: specularite uniquely combines these properties, and red pigments coassociate with specularite at Kathu Pan, Wonderwerk, and Twin Rivers (Barham 2002; no significance can be attached to their absence at Canteen Kopje, owing to small sample size).<sup>10</sup>

In sum, a broader range of the new observations can be accounted for by the FCC hypothesis than by honest, low-cost signaling. In any event, the glittery nature of specularite and the find-context at Wonderwerk provide strong grounds for inferring fire-lit ritualized display, capable, in principle, of grounding shared fictions. If Watts (2014) is correct that pig-

ment use only became habitual throughout southern Africa around the time of our speciation, the question arises of why it took so long for shared fictions to stabilize at the level of a meta-population. This might be attributed to the interplay of geological contingency and demography: a restricted area of the Northern Cape providing a relatively rare, visually arresting material and relatively isolated population demes with little interconnectedness. On the other hand, precisely this temporal pattern is theoretically predicted by the FCC hypothesis, because the most pronounced increase in cranial volumes postdates ~300 Ka (de Miguel and Hennerberg 2001, fig. 1), placing renewed stress on maternal energy budgets, with concomitant pressure to compete for male investment. This, rather than the interval between ~500 and ~300 Ka, seems a more plausible context for invoking runaway sexual selection, where the periodicity of ritual performance by female coalitions could no longer be determined by the fertility status of individual members, and the reality-bound, partially deceptive displays of counter dominance tipped over into reverse dominance/reverse reality (Knight 2014; Power 2014), establishing symbolic culture.

## Acknowledgments

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## Comments

### Lawrence Barham

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It is well-known that human reasoning is affected by confirmation bias (Nickerson 1998). The bias may be deliberate in the form of selecting facts to suit a particular theory or unwitting with selectivity of a much less conscious kind. I am not sure which form is dominant here, but there is a definite agenda identifiable from the outset with the report of new finds of pigment cast as a test of a long-held theory. The theory (in summary) is that human society emerged from a collective female-based deception intended to subvert male dominance and to control reproductive rights. Menstrual blood as a signal of impending fertility was elaborated by female

10. Ethnohistorically, throughout the Setswana culture area, initiated men applied a mixture of specularite and red hematite to their hair, creating a glistening cosmetic “cap.” Both materials were procured from Tsantsabane (Shillington 2011:12, 32).

coalitions in the context of rituals that involved the use of red ochre as body paint and blood symbol that signalled the message to men that sex with women would be on their terms. The consequence was the emergence of cooperation from conflict, with cheaters controlled and a sense of group identity formed through shared rituals. The sex-strike hypothesis, as first proposed by Knight (1991), has since been developed into a more layered confection of contingent actions with associated predictions for the archaeological record (Knight et al. 1995; Watts 2014). Others will be better placed to assess the plausibility of this theory as an evolutionary model, but let me be up front about my own confirmation bias.

I struggle to accept models of causation that require a level of supposition that the archaeological record cannot support. As Kuhn (2014:42) observes, we can speculate on the kinds of messages encoded in artefacts, but the content of the messages will remain obscure. This is particularly true for the Middle Pleistocene African record, which is poorly resolved in terms of chronology and context. The idea of an ancestral female cosmetic coalition draws on ethnographic support for the association of red ochre with blood symbolism and, as interesting as these modern observations are, they simply highlight what we cannot know. Cousins (2014) emphasizes the contingency of culture as the product of meaning-making. When needs and goals change, then new meanings emerge through the process of generating symbolic references between signifier and signified. Granted, the female cosmetic coalition is not a static cultural entity, because it evolved, but the construct appears to deny agency to Pleistocene communities. They seem to be trapped in a normative social and cosmological structure that extends across time and space.

Why should, for example, evidence for pigment use in the Acheulean of India undermine prediction (i) of the hypothesis, unless it is assumed that the coalition was an effectively universal construct? Why should “suitably red and saturated materials” be deemed the only acceptable evidence of ritual based on pigment use when the archaeological (and ethnographic) record offers other materials (e.g., iron hydroxide and manganese dioxide) and colors (e.g., yellow and black) that could have conveyed meaning? A ground piece of iron hydroxide (yellow) is reported from excavation 6 at Wonderwerk Cave but is suspected to have been a redder material that has since weathered and changed its dominant color. Maybe so, but similar hints at confirmation bias are seen in the interpretation of scraped dolomite from Wonderwerk—one piece produced a red powder and so might have been a source of pigment, but another gave a light gray streak and a third produced a “dull brown” color. The latter two are dismissed as pigment sources, because they are not red and the first lacks the staining power of a true pigment. As an aside, the presence of scraped dolomite is of interest in its own right. These used materials occur at a time of technological change with blade making, prepared cores, and hafting as part of a much-expanded behavioral repertoire. The scraped and gouged surfaces may be

part of this technological variability—abraders, perhaps, used in blade core preparation or for grinding or rubbing other materials rather than or in addition to producing colored powders. The pigment selection criteria in place here deliberately reduce the options for interpretation in favor of the preferred theory and increase the “cost” of potential sources of pigment. Knight (1991) long ago anticipated the sceptics’ charge that mineral pigments might have other uses and so cannot be assumed to be primarily of symbolic value. That charge has gained momentum in recent years as new analytical methods have demonstrated the various qualities of red ochre as a preservative, sun block, and additive to adhesives used in hafting (see summary in Rifkin et al. 2015). Now is the time to examine the properties of specularite in a similarly dispassionate way. Perhaps this could be combined with the planned mineralogical analyses.

I agree with the authors and with Kuhn (2014) that mineral-based pigments represent the earliest durable evidence for materials that could have been used for body painting. Body painting, however, does not have to be linked with ritual to be effective as a signal of identity. The number of pieces of pigment reported here for the Fauresmith at both sites is small; do they constitute the required “clear archaeological signature” of ritual? I am not convinced, nor am I convinced of the association of the one fragment of weathered hematite with late Acheulean at Wonderwerk Cave. The authors are duly cautious in recognizing the uncertain provenance of this piece, but they still regard it as the “best evidence” for pigment use in this context. On a more general note, the presentation of the each site would have benefitted from section drawings to show the stratigraphic position of the pigment finds in relation to the archaeological industries.

I welcome the publication of this material from the Northern Cape. The description and images add to a small but important body of data on early mineral use in Africa. Their association with the technological transition from the Acheulean to MSA adds to what appears to be an expanded biocultural niche evolving in the Middle Pleistocene (Barham 2013). Ritual may have been part of that niche, but the evidence remains unconvincing.

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### Sheila Coulson

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Specularite, unlike ochre, is a pigment with no reported purpose other than visual display. The comparatively meagre literature on this pigment makes Watts, Chazan, and Wilkins’ contribution a most welcome addition. The authors are to be further commended, not only for introducing new well-documented and analyzed pieces of specularite to the archaeo-

logical record, but also for reexamining contexts and dates of previously reported specimens.

Specularite has been recovered from a range of predominantly MSA localities and some earlier sites. Unlike ochre it is not necessarily easily identified, as its natural steel-grey or bluish lustre belies its red color notation streak. Also, as noted by the authors, there is no color code that captures specularite's unique glittery appearance. While it is the red streak of specularite that is emphasized in this article, the equally eye-catching steel grey or blue lustre of this pigment should not be overlooked.

The attention-grabbing blue tint of specularite and its reflective and glittering nature, especially when applied to the hair, was first documented by nineteenth-century travellers to southern Africa. The following examples illustrate the ease of application and the outstanding visual effect. Burchell ([1822–1824] 1953:256–257) describes specularite, or “sibilo,” as “a shining powdery iron-ore of a steel grey or bluish lustre and soft and greasy to the touch, its particles adhering to the hands or clothes, and staining them of a dark-red or ferruginous color. The skin is not easily freed from these glossy particles, even by repeated washing; and wherever this substance is used every thing soon become contaminated, and its glittering nature betrays it on every article which the wearer handles. The mode of preparing and using it, is simply grinding it together with grease, and smearing it generally over the body, but chiefly on the head; and the hair is often so much loaded and clotted with an accumulation of it, that the clots exhibit the appearance of lumps of mineral. . . . Although the color of the sibilo be a brownish red, yet the micaceous particles give it a blueish tint in those places which reflect the light more strongly . . . the exact color together with that peculiar glittering which it would impossible to imitate by any other means.” Another traveller (Lichtenstein 1812:311) records an event where a woman's “hair was dressed with great care; it was divided into small bunches, which were well rubbed over with the shining ointment, and hung down from the crown of the head, looking like a profusion of silver thread or cord.” Finally, Methuen (1848:104) reported the use of specularite by members of a tribe who “often smear their bodies with fat and red ochre, and cover their hair with a paste consisting of black lead-ore, called sibilo, till their heads shine with it as if . . . they wore metal skull-caps.”

The value of specularite was perhaps enhanced by its rarity. As Burchell ([1822–1824] 1953:256) notes, the glittering ore is considered valuable and “constitutes in some degree an article of barter with the more distant tribes . . . so that the use of it extends over at least five degrees of latitude, or among every tribe I visited.” These historical descriptions strongly resemble the properties of specularite and the preparations for its use presented by the authors. Once specularite is ground and mixed with fat or grease, its application stains the body red, but when applied to the hair, it renders the wearer not only a lustrous blue-grey but also eye-

catchingly brilliant. It appears likely that the MSA or late Acheulean people using specularite were aware of these variant visual effects. Whether it was preferred for its red streak or its blue metallic lustre, specularite produces a costly cosmetic, which, if used in the fire-lit ritualized display suggested for the back of Wonderwerk Cave, would certainly have been attention grabbing.

A final point can be made regarding the authors' appeal for further investigations “to assess the feasibility of ‘fingerprinting’ archaeological and outcrop materials to address the provenancing issues raised.” Initial attempts to geochemically fingerprint specularite are encouraging (e.g., Kiehn *et al.* 2007; Smith and Fankhauser 2009). Once fully implemented, this technique would also assist in resolving the inferred minimum transfer distances for the period between ~500 and ~300 Ka. Results of investigations using geochemical fingerprinting for provenancing sources of silcrete (Nash *et al.* 2013a, 2013b, forthcoming) and obsidian (e.g., Ambrose 2012; Morgan *et al.* 2009; Negash *et al.* 2007; Negash and Shackley 2006; Vogel *et al.* 2006) are already essential in determining prehistoric mobility patterns and travel distances. Although these studies have focused mainly on MSA raw material acquisition, the straight-line minimum transfer distances indicate a common trend: fingerprinting techniques frequently reveal surprisingly long procurement distances. Determining transport distances for rare goods, such as specularite, from source to site would provide crucial insights into the social networks and behavioral practices of the later Acheulean of southern Africa.

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This article makes three main contentions. Based on a systematic examination of evidence for pigment use in South African Pleistocene sites, the authors argue that the earliest reliable evidence for intentional use of hematite pigment is associated with Middle Pleistocene Fauresmith assemblages at several localities. They further assert that this use of hematite is part of a complex of novel behavioral developments occurring in the second half of the Middle Pleistocene. The third contention concerns the evolutionary significance of pigment use among early hominins. Here, the authors promote a modified version of the so-called “female cosmetic coalitions” (FCC) hypothesis, placing it in opposition to a recent suggestion (Kuhn 2014) that early pigment use was part of low-cost “truthful” signaling systems.

I am not a geochemist, and I have no special knowledge about what has been identified as hematite in various sites in southern Africa. However, the authors' systematic and repli-

cable analysis of the various specimens is welcome. Even the most experienced archaeologist has learned over the years that field observations, whether about the nature of sediments or the unusual materials found in them, are often misleading. Techniques such as micromorphology and mass spectroscopy have demonstrated repeatedly that the sediments we dig through and the mineral inclusions they contain are often not at all what they first appear to be. I also agree completely that the Middle Pleistocene saw very significant developments in hominin technology, social behavior, and cognition, whether in Africa or Eurasia. Increasing research focus on this pivotal time period will only enrich our understanding of human behavioral evolution.

Not surprisingly, I find the authors's third contention a good deal less compelling. First, they seem to go out of their way to create an opposition between my recent article on systems of ornamentation in the Paleolithic and the FCC. In that article (Kuhn 2014), I claimed that pigments generally do not express investment or cost as effectively as do media such as beads. Following the lead of Maynard-Smith and Harper (2003), I argued that pigments were therefore better suited for low-cost, honest signaling systems where sender and receiver have similar interests. In that sense, my article seems to be consistent with the "coalition" part of the FCC. Here, however, the authors claim that the hematite evidence from southern Africa is more consistent with group rituals involving costly signaling. How this articulates with the FCC hypothesis is unclear; it is certainly not a necessary implication of the early stages of the model. Furthermore, the authors' claim is based on three main assertions: that group ritual is inherently costly, that some of the pigments used by Fauresmith people were self-evidently costly, and that these pigments were used in elaborate group rituals. None of these assertions is well supported.

Early in the article, the authors state that collective ritual is, by its very nature, "extravagant and time consuming" and therefore always indicative of costly signaling, citing an article by Sossis and Alcorta (2003). This is misleading. Sossis and Alcorta's article is concerned specifically with explaining the development of rigorous and costly religious observances using signaling theory. They claim, quite reasonably, that "Religious behaviors *often* entail significant proximate costs" (Sossis and Alcorta 2003:264, emphasis mine) but make no contention that *all* collective ritual, or all use of shared signals, is costly. There are countless ways in which people use body ornamentation to express group cohesion and solidarity that are anything but time-consuming and extravagant. A familiar environment such as a university campus is a virtual ocean of low-cost signals expressing group identity and social solidarity expressed in media such as T-shirts, temporary tattoos, make-up, and hairstyles. And every day, bearers of the signals organize themselves through routine social rituals such as meetings, prayer groups, and rallies.

As for the second assertion, I agree that, when procured from a distant source (whether directly or through social connec-

tions), pigments can express costliness effectively. However, here the Fauresmith evidence is equivocal at best. The authors themselves state that the claim that pigments at Wonderwerk and Kanteen Kopje come comparatively distant sources is "tentative" and unconfirmed. Moreover, we are talking about a very few small pieces of specular hematite, not large quantities. It is by no means obvious that these materials would have effectively communicated exoticness or cost to viewers.

And what about the elaborate ritual in which the specular hematite was used? Hematite from Wonderwerk comes from a dark part of the cave, where there is also evidence for fire. From this the authors imagine the existence of a "fire-lit ritualized display, capable, in principle, of grounding shared fictions." Of course, "fire-lit ritualized display" need not be elaborate or costly. Moreover, these same deposits also contain stone artifacts, including manufacture waste, as well as other sorts of humdrum debris. Were these also part of the ritual? I admit that I find it difficult to understand why hominins chose to light fires and conduct other activities in the dark recesses of Wonderwerk. However, there are many possible reasons for being there beyond creating a stage for elaborate and costly rituals. It is interesting that earlier deposits at the site, also "deep inside" the cave, contain traces of fire and domestic debris (Berna et al. 2012) but no evidence of hematite use.

In comparing the potentials of pigments and objects such as beads as signaling media, I have probably underestimated the potential of pigments. Clearly, there is a good deal more to be learned about the performance characteristics of various forms of "information technology." I also admit to not giving much space to the FCC, mainly because I was (and still am) uncertain about how it would work. And I would not be shocked if we eventually find evidence for costly signaling in material culture predating the Upper Paleolithic. However, the case made here for early use of hematite as evidence for costly signals and elaborate social rituals in the Fauresmith is poorly supported and unconvincing.

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#### Camilla Power

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Because pigments appear critical for understanding the emergence of symbolic behaviors in the Middle Pleistocene, detailed documentation of this South African material is invaluable. The authors make several significant contributions, first, in analyzing remains of possibly the earliest symbolic traditions of humankind—a collection of probable early pigment materials reported previously without substantiating detail. Second, their interdisciplinary stance draws on both classic social anthropology and modern evolutionary ecology to theorize

the role of this material in ritual performance. Third, they test competing models from a signal evolution paradigm on specific hypotheses about the social uses of this material as part of a general picture of major social developments in the mid-Middle Pleistocene.

The analysis yields a picture of pigments appearing in Fauresmith levels with little evidence for prior usage in the Acheulean. Fortunately, this cluster of sites in the Northern Cape provides us with clear messages. Glittery specularite is unambiguously used for display and not for any functional alternative. There are other colorants (yellow ochre and manganese) that are readily available, supporting definite selection of glittering and dark red materials. The special context of Wonderwerk makes it hard to imagine anything but some form of ritualized display in the gloomy cave. Transport distances inferred for specularite to Wonderwerk (~50 km) and especially Canteen Kopje (170 km) indicate the value set on this material by archaic humans.

The archaeological analysis therefore offers grounds for quite specific interpretations. While these are bound to appear speculative, the models being used, female cosmetic coalitions (FCC; Power 2009) and cheap-but-honest ritual coordination (Kuhn 2014), are theoretically constrained and, in principle, offer competing predictions. Both are premised in signal evolution theory, the main branch of behavioral ecology for understanding animal communication. The process of ritualization in animal signaling provides a certain continuity with emerging ritual performance in human culture and has been implicated in models for religion and symbolism by scholars across disciplines (Alcorta and Sosis 2005; Boyer 1994:189, 222; Deacon 1997:379–384; Huxley 1966; Power 2009, 2014; Rappaport 1999; Rossano 2015).

The FCC model sees sexual selection and sexual conflict over levels of investment in large-brained offspring as the driving force, stressing costly signaling. By contrast, the cheap-but-honest model assumes small-scale rituals coordinating egalitarian groups with no significant conflicts of interest, hence lower costs. But transport distances of specularite challenge the notion of “cheap” here.

FCC is intimately linked to the timetable of increasing brain size in the fossil record, because mothers experienced reproductive stress as brains increased in volume, requiring increased investment by males. Hence this hypothesis would be falsified by any significant pigment record prior to *H. heidelbergensis* encephalization 700–800 Ka. The Wonderwerk sequence running from Early Stone Age Acheulean into Fauresmith offers a good test.

The cheap-but-honest hypothesis is silent about particular color or display media, whereas FCC foregrounds choice of blood reds. Females who mount a strong coalition in resistance to advances of noninvesting males—visibly demonstrated through ritual cosmetic performance—should be attractive to discriminating investor males, who are willing to do bride service to get sexual access. So, FCC is linked directly

to home base strategies (females and their kin do not follow the hunt but demand that the proceeds come to them) and to increasing productivity of hunting. Again, the models compete on which comes first: ritual produces the social conditions generating home bases (FCC) or homebase strategies imply coresidential groups with aligned interests who need small-scale ritual to keep them coordinated (cheap-but-honest signaling). The latter suggests there could be a time lag in use of pigments relative to home bases, but that is challenged by present evidence.

Mithen (1999), Kuhn and Stiner (2007), Henshilwood and Dubreuil (2009), and others have questioned whether body painting is, in itself, “symbolic,” while Watts (2009) and Power (2010) have argued along Durkheim’s lines that body-painted dance and performance is the necessary and sufficient step into a symbolically demarcated world. Nonhuman animals perform coalitionary ritualized display, so we need to carefully distinguish the special features of human ritual.

At issue are shared or sociocentric fictions, which have no place in nonhuman ritualized display. The nonhuman world consists in “brute facts.” Institutional reality—our world—is made up of objective facts that depend on subjective belief (Searle 1995). Only through collective intentionality can a symbolic relationship that X stands for Y be agreed and effected. Durkheim taught us a century ago that ritual alone can generate such we-intentionality.

No great ape apart from ourselves ever begins to add paint to their faces or bodies. To intentionally add, or have added by another, design or color to oneself is to play with something “fake” which can only have value if the intention is shared with someone who joins in that game. As people become marked with identities that are collectively agreed and fictive, an individual is no longer just herself; she has created an intersubjective representation of herself for others, experiencing herself as others see her. For humans, there really can be no such thing as purely individualistic display. Self-decoration displays the individual in relation to the enduring social group to which she belongs. Cosmetic display, through ritual performance and collective intention, constitutes the social group beyond the here and now.

If we do have evidence of symbolic capacity and performance in the period from 500–300 Ka, the question becomes, why did it take so long subsequently to establish full-scale symbolic culture? The authors hint at specific local conditions and demographic factors which might engender a pioneering symbolic enclave at these early dates. We need to consider the ratchet effect of cultural transmission and accumulation among small populations. FCC argues that sexual selection will act as a stabilizing force, but intensification and regularization of the emergent ritual cosmetic strategy is expected in relation to increases of brain size (and concomitant female reproductive stress). Because the final stage of encephalization in the lineage of modern *Homo sapiens* occurs after 300 Ka, FCC predicts pigment usage to spread and stabilize after that date.

## Reply

We are very grateful to all the commentators. Sheila Coulson draws attention to the regional ethnohistorical record of specularite use, emphasizing its visual properties, restriction to displays, and high esteem. We add that the most frequently recorded ritual context of use was the treatment of adolescent initiates (male and female) on their emergence from seclusion (Engelbrecht 1936:160–61, 167; Moffat 1842:250–251; Willoughby 1909:242). We would also correct a misapprehension: we drew attention to specularite's dark, glittery properties, addressing whether these contradicted the FCC's predicted focus on reds.

Camilla Power expands on the FCC hypothesis, stressing that “we-intentionality” and sociocentric fictions distinguish human ritual from nonhuman counterparts, that classic social anthropological theory provides a secure foundation for Searle's philosophy of the symbolic, and that the behavioral ecology of signaling allows us to chart a route from nonhuman ritual to “we intentionality.”

We were particularly gratified by the measured tone of Kuhn's comments. Readers could be forgiven for thinking we had an ax to grind with Kuhn's hypothesis. Far from it; informed by the most relevant body of theory, we consider this hypothesis the most significant contribution to the interpretation of early pigments in over a decade.

Nevertheless, fundamental disagreement remains about early group ritual. In common with ritualized signals in general, characteristic traits of group ritual include amplified, stereotyped, redundant display, traits more indicative of signaller sales pitch and receiver sales resistance than shared interest (Krebs and Dawkins 1984). In this context, we treated early group ritual as “extravagant”—having evolved through a competitive arms race, in contrast to the “conspiratorial whispering” predicted of cooperative signals. Not all religious behaviors are costly, but Sosis and Alcorta are unequivocal that “communal participation in costly ritual” is one of four “cross-culturally recurrent features of all religions” (Alcorta and Sosis 2005:325). Modelling the variability of these costs in given social contexts does not remove the centrality of cost for establishing group commitment in the first place.

Secondary disagreements include the following. First, we were not discussing “a very few small pieces.” For Kathu Pan, we provided streak data for 28 pieces. For the 16 weighed pieces in table 1, from all three sites, average weight ( $\pm$ SD) was  $47.9 \pm 47.6$  g, more than for any MSA assemblages (Watts 2002, table 1). More importantly, Kathu, Wonderwerk, and Twin Rivers show repeated specularite use over long periods. Second, the evidence for fire “deep inside” Wonderwerk Cave at ~1 Ma concerned excavation of a naturally well-lit zone, not comparable to the very gloomy conditions of excavation 6. Despite this evidence, it is not thought that Wonderwerk served as a base camp at this period (Chazan 2015).

Kuhn points out that the early stage of the FCC model does not predict exotic procurement. There may be grounds for

confusion here. We treated all three sites as providing early evidence for pigment use (between ~500 and ~300 Ka)—evidence consistent with local procurement associated with the oldest dating estimates—at Kathu, where the high quality of local materials gave no grounds for anticipating change. The tentative evidence for regional or exotic procurement at Wonderwerk and Canteen Kopje appears to fall at the younger end of the temporal range.

Barham's criticisms are that we wittingly or unwittingly brought a confirmation bias to our research; that the FCC hypothesis draws on ethnographic support, but this only highlights something that cannot be known about the deep past; and that the hypothesis traps agents in “normative sociological and cosmological structures” extending across time and space.

Having identified what we considered a significant behavioral pattern (earlier pigment use than generally presumed, correlating with a suite of important behavioral changes), we wanted to promote discussion about the interpretation of this pattern. Drawing on theoretically informed models generating refutable predictions is standard procedure. The important issue is not whether we, or the lead author, had another “agenda,” but whether readers can distinguish between purported testing and confirmation bias. Popperian falsifiability remains a fair criterion for whether a proposition is scientifically grounded. The attraction of investigating some of the pigment predictions of the FCC hypothesis in the Northern Cape was that the region offered the opportunity to refute its first prediction, that pigment use should not predate early Middle Pleistocene brain size increase. Beaumont and Bednarik (2013) claimed that, at Wonderwerk, pigment use extends back ~1.1 Ma. The color selection prediction could potentially be refuted, because yellow ochre and black manganese were locally available at Wonderwerk and Kathu, respectively.

Are we engaging in confirmation bias when suggesting that the ground piece of “iron hydroxide” at Wonderwerk may have been redder at deposition? This piece provided a hue of Y50R (table 1), brown rather than red or yellow. We provided observations to support the inference of some postdepositional hydration. We should also have noted that there is localized evidence for standing water during the deposition of the excavation 6 sediments (Chazan and Horwitz 2009:530, citing unpublished observations by P. Goldberg). The other cited cases of possible confirmation bias are the three scraped, weathered dolomite with poor or no staining power. Given the brain's neurological biases (Deacon 1997), there is no compelling reason for thinking that the dull brown and grey powders of two of the pieces were used for signalling. Classifying the case from excavation 1 as pigment would add ~300,000 years to the behavior, solely on the basis of powder production. We were trying to avoid such poorly warranted inferences. As for the red specimen, most analysts would probably have classified this as pigment; we withheld definitive judgement because of our caution concerning the other two pieces, and because poor staining power contradicted one of our guiding criteria. We agree that this

leaves unanswered what purpose(s) weathered dolomite powder served, an interesting research project beyond the scope of this article.

Far from revealing a confirmation bias on our part, we think Barham's comments reflect his own view, based on his analysis of Twin Rivers, that a wide color palette was employed in the early MSA (2002:188). Although widely repeated (d'Errico et al. 2003:4, 2008:169; Wadley 2005:2, 2009:166), this view has been criticized as an overinterpretation of the available data (Watts 2010, supplementary online material, pp. 13–19). Barham misrepresents us as claiming that only “suitably red and saturated materials” provide “acceptable evidence” of ritual use of pigments. Our main finding was the repeated use of dark, glittery specularite, alongside the collection and use of redder forms of hematite; we pointed out that other, locally available colors were ignored. Globally, only one site testifies to yellow pigment use in the Middle Pleistocene, also providing the only reasonable evidence for a black pigment in this epoch (van Peer et al. 2004). Yellow and black pigments are essentially Upper Pleistocene phenomena, while the latest research on Neanderthal use of black manganese suggests it was more likely used as a fire lighter (Heyes et al. 2016). Black and yellow could have conveyed meaning; the pertinent question is why they scarcely seem to have done so for the first 400,000 years of earth pigment use.

The FCC hypothesis does not posit female coalitions as a “universal construct.” It proposes that they may have arisen wherever later *Homo* mothers experienced the energetic burdens of further encephalization (qualified by the degree of birth seasonality, a natural constraint on male philandering; see Power et al. 2013), so the hypothesis is indeed potentially applicable to all daughter lineages of *H. heidelbergensis* (*sensu* Stringer 2012). This is why we noted that Hunsgi could also potentially refute the hypothesis's first prediction.

Regarding the role of “ethnographic support,” the FCC hypothesis was developed on Darwinian theoretical grounds, not as a model based on ethnographic analogy, but a model of the origin of symbolic culture needs symbolic data to test it. The hypothesis generated expectations concerning the dynamics of ethnographic cosmetic usage (Power 1999:102). Literature reviews of Bushman use of pigments and dyes indicated that cosmetics were primarily used in ritual contexts, red pigments being used most consistently in girls' menarcheal rituals (Knight et al. 1995; Watts 1999), a finding fully consistent with the model. Initiation rituals, whether male or female, are central to cultural transmission among all hunter-gatherers. Social anthropologists have long been identifying some kind of “blood symbolism” at the core of symbolic culture, invariably invoking menstrual blood (Durkheim 1897; correspondence of George Frazer to Henry Jackson, 1887, in Fraser 1990:74–80; Knight 1991; Testart 1986). Archaeology alone cannot support the interpretative load of the FCC hypothesis, but the hypothesis distributes that load across evolutionary theory, archaeology, and ethnography.

This leads to the most intriguing issue raised by Barham, that the FCC hypothesis denies human agency by positing

normative cosmological structures across space and time. The hypothesis does claim such structures, but at the level of an underlying syntax to the mobilization of ritual power rather than at the level of historically contingent meaning. We agree with Cousins (2014) and Barham that people had to keep their signifiers relevant to changing needs and goals. What Barham omits is that such a process was guided by prior understandings of adaptive demands (Cousins 2014:185), analogous to “descent with modification.” Religion, mythology, and fairy tales are deeply conservative at the level of formal structure (Lévi-Strauss 1970; see also da Silva and Tehrani 2016). For anyone familiar with the syntactical, ethnographic predictions of the FCC hypothesis, we draw attention to southern Setswana historical practice, where the key ritual events of boys' initiation, from circumcision and smearing with red ochre, to the adornment with specularite at reintegration, were all timed to occur at the new moon (Willoughby 1909:233–234, 242). As so often where men monopolize paramount forms of ritual power, they (secretly) acknowledge that this was a power stolen from women (Knight 1991:451–452; Willoughby 1909:229).

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