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Dating, archaeology and human fossils from the Middle Stone Age levels of Die Kelders, South Africa

Die Kelders Cave 1, on the southwestern coast of South Africa, preserves a rich Later Stone Age (LSA) occupation and a thick series of Middle Stone Age (MSA) layers below. Limited excavation of the MSA layers has yielded numerous lithic artifacts and faunal remains, and nine human teeth. Sedimentological and faunal evidence suggests that the MSA levels accumulated under comparatively cool, mesic conditions, probably at the beginning of the Last Glaciation (isotope stage 4). The MSA artifact assemblage consists overwhelmingly of quartzite *débitage*. Elongate flakes are fairly common; systematic retouch is extremely rare. The high frequency of silcrete artifacts in some of the lower units may signal the Howiesons Poort variant of the MSA, although diagnostic backed and truncated pieces are absent. The animal bones come from rodents, insectivores and other small creatures that were probably introduced mainly by owls, as well as from larger mammals and seabirds that were probably introduced mainly by humans. This latter component resembles the Klasies River Mouth MSA fauna in the abundance of eland relative to wild pigs, the dominance of penguins over flying birds, and the absence of fish. At both Die Kelders and Klasies River Mouth these features tentatively suggest that MSA hunter-foragers exploited animal resources less effectively than their LSA successors. Although the Die Kelders MSA human teeth tend to be somewhat larger, they are morphologically similar to modern African homologues, and they exhibit several features that tend to distinguish modern Africans among other populations. These teeth may be added to the small fossil sample that attests to the morphological modernity of the MSA inhabitants of southern Africa.

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Introduction

The site of Die Kelders (34°32'S, 19°22'E) consists of a pair of contiguous caves situated at sea level on the southwestern coast of South Africa (Figure 1). The larger cave, Die Kelders 1 (DK1), and an adjacent chamber (DK2) were formed at the base of a 12 m high sea cliff by wave action and fresh-water seepage at the nonconformity between the Paleozoic quartzites of the Table Mountain Sandstone Series and the overlying Neogene limestones of the Bredasdorp Formation. Excavations in DK1 by F. R. Schweitzer between 1969 and 1973 revealed a rich Late Stone Age (LSA) occupation separated by sterile strata and at least two depositional hiatuses from a thick series of Middle Stone Age (MSA) layers below.

The LSA layers accumulated between 2·0 and 1·5 kyr BP as indicated by C¹⁴ analyses on charcoal (Schweitzer & Scott, 1973; Schweitzer, 1979). Like most other local LSA occupations that postdate 2·0 kyr, these strata contain both stone and bone artifacts, the skeletal remains of indigenous animals, as well as potsherds and the bones of introduced domestic stock (Schweitzer & Scott, 1973; Deacon *et al.*, 1978; Schweitzer, 1979; Deacon, 1984a,b; Klein, 1986a).

The MSA levels at DK1 have yielded reasonably large samples of lithic artifacts and faunal remains even though only a small portion of the deposit has been excavated. It is necessary at the present time to infer the geological age of the MSA layers from the artifacts, fauna and sediments themselves. These data, coupled with the dating of MSA sites elsewhere in southern Africa (Volman, 1984; Grün *et al.*, 1990a,b) indicate that the entire DK1 MSA

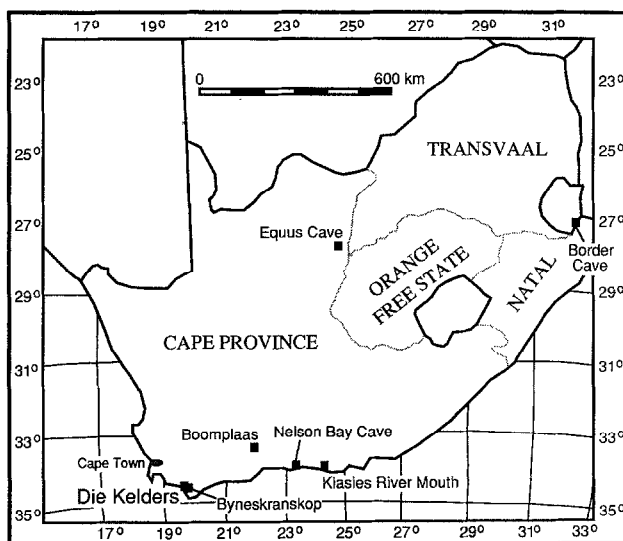


Figure 1. Location of Die Kelders and other archaeological sites mentioned in the text.

sequence probably lies beyond the 40 kyr BP limit of conventional radiocarbon dating. The MSA faunal sample can be used to check inferences about human behavior that have been drawn from other southern African sites, especially Klasies River Mouth (Singer & Wymer, 1982; Deacon, 1989; Klein, 1989).

Several adult human bones and the partial skeleton of a child have been excavated from the LSA layers at DK1. These remains are fully modern (Rightmire, 1979a).

The MSA layers at DK1 have yielded nine human teeth. Although this sample is admittedly paltry, the scarcity of human fossils of this age from sub-Saharan Africa (Leakey *et al.*, 1969; Rightmire, 1979b; Singer & Wymer, 1982; Grine & Klein, 1985; Bräuer & Mehlman, 1988; Rightmire & Deacon, 1991) lends significance to the DK1 specimens. At issue is the anatomical modernity of the MSA inhabitants of sub-Saharan Africa, and whether these populations subsequently replaced non-modern people elsewhere (Stringer & Andrews, 1988; Wolpoff, 1989). It is in this context that the descriptions and analysis of the DK1 human fossils are offered here.

Geology and dating of the MSA deposits

DK1 and DK2 were formed by wave action and fresh-water seepage. A patch of breccia with MSA flakes that adheres to the wall of DK2 above the present floor suggests that wave action flushed an earlier fill from the caves. This same wave action may have produced the deep strike-passage in the quartzite floor of DK1 that contains the deposits excavated by Schweitzer (Figure 2). Following Tankard and Schweitzer (1974, 1976) and Tankard (1976), these excavations exposed the following major units from bottom to top (Figure 2):

Layer 17

At least one meter of quartzite cobbles and boulders in a quartz and sand matrix. This layer is archaeologically and paleontologically sterile.

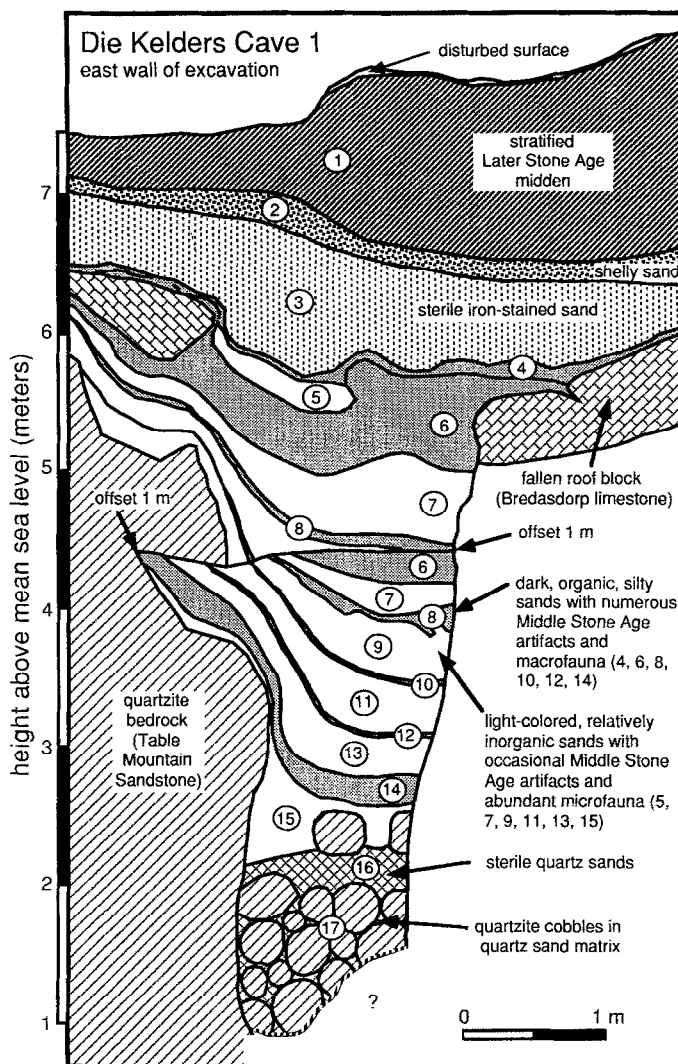


Figure 2. Profile of Die Kelders Cave 1 along the east wall of the excavation by Schweitzer. Baseline is 1 meter above sea level. Redrawn after Tankard & Schweitzer (1976, fig. 4).

Layer 16

10 to 15 cm of quartzose sands. This layer is archaeologically and paleontologically sterile.

Layers 15–4

4 to 5 m of iron-stained sands. Dark, organic, silty bands (layers 14, 12, 10, 8, 6 and 4) that are relatively rich in bone and MSA artifacts alternate with lighter-colored, inorganic bands (layers 15, 13, 11, 9, 7 and 5) that are relatively poor in artifacts and larger bones, but rich in microfauna. Flat, angular limestone fragments interpreted as *eboulis secs* occur throughout this unit, especially near the bottom in layers 15 and 14. A subcontinuous spread of large, heavily weathered limestone blocks occurs near the top of this unit.

Layer 3

30 to 70 cm of laminated, iron-stained sands that are capped by a very thin, weathered horizon. This layer is both archaeologically and paleontologically sterile save for the occasional microfaunal element.

Layer 2

10 to 15 cm of coarse, rounded, shelly quartzose sands containing numerous eolianite fragments. This layer is archaeologically and paleontologically sterile.

Layer 1

1.0 to 1.5 m of well-stratified, mainly culturally accumulated shell layers and intercalated bands of ash and sandy silt rich in animal bones and LSA artifacts.

Textural analyses by Tankard & Schweitzer (1976) indicate that the sands comprising MSA layers 15 through 4 were wind-deposited, and that the sharp, angular limestone fragments (*eboulis secs*) are best explained by frost-fracturing of the cave roof. The large limestone roof blocks near the top of the MSA sequence may reflect an earthquake, and their weathered surfaces imply a prolonged period during which there was little if any sediment accumulation. The overlying, laminated sands of layer 3 were deposited in water, probably when a temporary pond formed between the cave wall and the quartzite bar in front. The microsoil horizon that caps layer 3 reflects a second, significant depositional hiatus, perhaps when the cave mouth was sealed temporarily by a massive dune.

The rounded, shelly sands of layer 2 indicate renewed eolian deposition during an interval of relatively high sea level. The eolianite fragments in this layer derive from the cliff face above, and probably accumulated as talus at the base of a dune that stood near the cave mouth. The structure and contents of the LSA deposits indicate that they accumulated under essentially modern circumstances, which is in keeping with their dating.

The only suitable source for the eolian sands that comprise layers 15 through 4 is the continental shelf, which implies that the MSA occupation occurred during a marine regression. At the same time, the frost-fractured roof debris within the sands indicates that the climate was moist and very cool by historic standards. Thus, the sediments clearly place the MSA occupation within a cold "glacial" interval. Determination of the interval in question depends on interpretation of the underlying cobble bed.

Tankard & Schweitzer (1976) argued that the layer 17 cobble bed was formed by wave action during the closing phase of the Last Interglaciation (= global oxygen-isotope substage 5a) because they believed that sea level at that time stood at or near its present level. From this, it follows that the overlying MSA deposits would have accumulated during the early part of the Last Glaciation (isotope stage 4, or perhaps stage 4 and part of 3), i.e., sometime between 74 kyr and 35 kyr.

In a subsequent study, however, Hendey & Volman (1986) argued that the last time sea level was high enough to produce the basal cobble beach was at the very beginning of the Last Interglaciation (substage 5e). If this is correct, then the MSA sequence could conceivably date from one of the pronounced cold phases (substages 5d and 5b) centered on approximately 110 kyr and 92 kyr within the Last Interglaciation. Alternatively, the MSA deposits could still date from the early part of the Last Glaciation, depending on how much time is represented by the thin sterile sand layer that lies between the basal beach cobbles and layer 15. As discussed below, the MSA artifacts suggest that they date to the earlier part of the Last Glaciation.

Table 1

Percentage frequencies of raw materials utilized in artifact manufacture at Die Kelders Cave 1. Artifacts include only those pieces > 10 mm. Level 7 has been omitted because most of the Middle Stone Age artifacts in it probably derive from the base of level 6. See text for further explanation of level 6 samples. Quartzite includes wall rock that appears to be artifactual. Quartz representation in and especially below level 6 is somewhat inflated due to quartz derived from wall rock, some of which may not be artifactual

Level	Artifact <i>N</i>	Raw material (%)		
		Quartzite	Quartz	Silcrete
4	23,252	94.5	3.5	2.0
5	1063	95.3	1.2	3.5
6A	14,267	83.7	15.5	0.8
6C	6959	71.7	28.2	0.1
8	6134	46.7	52.3	0.9
9	461	51.6	34.5	13.9
10	866	52.4	25.3	22.3
11	111	29.7	17.1	53.2
12	367	33.2	6.0	60.8
13	155	64.5	29.0	6.5
14	2583	60.2	38.8	0.9
15	698	61.6	37.4	1.0

Moreover, the MSA deposits at DK1 may date from only a portion of the Last Glaciation, perhaps nearer the beginning (stage 4) than the middle (stage 3), insofar as evidence from other local sites (e.g., Boomplaas) suggests that the middle was relatively dry, whereas the DK1 sediments imply moist conditions (Tankard & Schweitzer, 1976). As discussed below, the faunal evidence also indicates that the MSA layers at DK1 accumulated under comparatively mesic conditions. Firmer dating of the Die Kelders MSA is clearly desirable, but this probably can be achieved only by employing thermoluminescence or electron spin resonance methods, which would require renewed excavation.

MSA archaeological record

As at most other sites, formal bone artifacts are not present in the MSA levels at DK1. The stone artifact collection, which comprises roughly 200,000 pieces, is composed mainly by small (< 30 mm) quartzite *débitage* and fragments of poorer quality quartzite wall rock. Cave wall rock, which was occasionally used for artifact manufacture, is especially abundant below level 6. Comparisons of the abundant smaller materials are not particularly instructive because they were not always systematically collected; thus, the present discussion omits pieces smaller than 10 mm and all quartzite wall rock that is not obviously artifactual.

Approximately half of the MSA artifacts derive from the level 6 complex, which was partitioned in various ways during the course of the excavation. Only those artifacts that could be attributed with confidence to units 6A and 6C (unit 6B is a thin parting with very few artifacts) are considered here.

Quartzite, quartz and silcrete are virtually the only materials that were used for tool production, and quartzite predominates throughout most of the sequence (Table 1). The major exceptions are levels 11 and 12, which together yielded a small collection of some 478

definite artifacts larger than 10 mm, and in which silcrete is the most common raw material (Table 1). It should be noted, however, that level 11, like most of the other inorganic bands, probably contains artifacts that are best attributed to adjacent levels that evidence much more intensive human occupation.

At other MSA sites in the southern Cape Province where quartzite was the most abundant raw material, quartz and cryptocrystalline siliceous rocks (e.g., silcrete) generally were available only as small cobbles, and these often had irregularities that precluded the production of large, regular flakes. This was not the case, however, at DK1. Some quartz flakes are 50 to 60 mm long, and there are numerous silcrete flakes, mostly from levels 4 and 6, in the 50 to 70 mm range, with some up to 80 or 90 mm in length. In contrast to other MSA sites, where quartz and silcrete cobbles may have been selected despite their small size (perhaps because they produced sharp-edged flakes or could be more finely trimmed than quartzite), quartz and silcrete appear to have been treated in the same manner (both technologically and typologically) as quartzite at DK1. Thus, unlike many MSA sites, DK1 does not preserve quartz as battered core-reduced pieces or as shattered debris. The quartzite and quartz that were used for artifact manufacture at DK1 are available in the immediate vicinity, whereas the silcrete would have come from farther away, perhaps from sources on the now inundated continental shelf.

Elongated flakes with parallel, sub-parallel and occasionally convergent dorsal scars are fairly common (Figure 3). The sequence (Table 2) shows a shift in quartzite flake size from longer and relatively narrower flakes below (levels 10–15), to shorter and comparatively broader flakes in the middle (levels 6–9), then back to longer and relatively narrower flakes at the top (levels 4 and 5). Because of the small sample sizes in many of the levels, the most reliable contrast is top and bottom (levels 4, 14 and 15) versus the middle (levels 6 and 8).

Radial cores predominate throughout the sequence. There is also an absence of cores that could have produced any of the large, elongate pieces. This suggests that the cores were reduced to well below their original size. Perhaps they were converted from single and double platform types to radial and change-of-orientation types in the process.

Systematic retouch is extremely rare at DK1, occurring on fewer than 1% of pieces larger than 30 mm, including those from level 12. This is similar to most other MSA collections from southern Africa, especially those in which cryptocrystalline raw materials are rare (Volman, 1984). At DK1, retouch consists mainly of varied, irregular damage to all or part of one or more edges on a flake. This retouch may result in fairly regular denticulation, but it commonly consists of irregular notching and lighter removals that in some cases cannot be readily distinguished from utilization or even postdepositional damage. There is no evidence for the existence of any trend or discontinuity in the kinds of retouched pieces that were produced throughout the sequence.

Several dozen pieces, principally from level 6, possess edges with continuous, fairly regular removals that are concentrated enough to qualify as scraper retouch (Figure 3). Only one piece even minimally qualifies as a retouched point; this is a triangular silcrete flake from level 12 that has convergent dorsal scars and some trimming near the tip on one edge (Figure 3).

Small quantities of ocher, often in the form of crumbled fragments from disintegrated pieces, occur throughout the MSA levels at DK1. The largest pieces, which range up to about 100 mm reveal ground surfaces and abundant striations. These pieces presumably served as sources for powdered ocher, but there is no evidence for how the powder may have been used.

The MSA sequences at Klasies River Mouth and Border Cave contain Howiesons Poort levels that are characterized by distinctive backed pieces and the increased utilization of

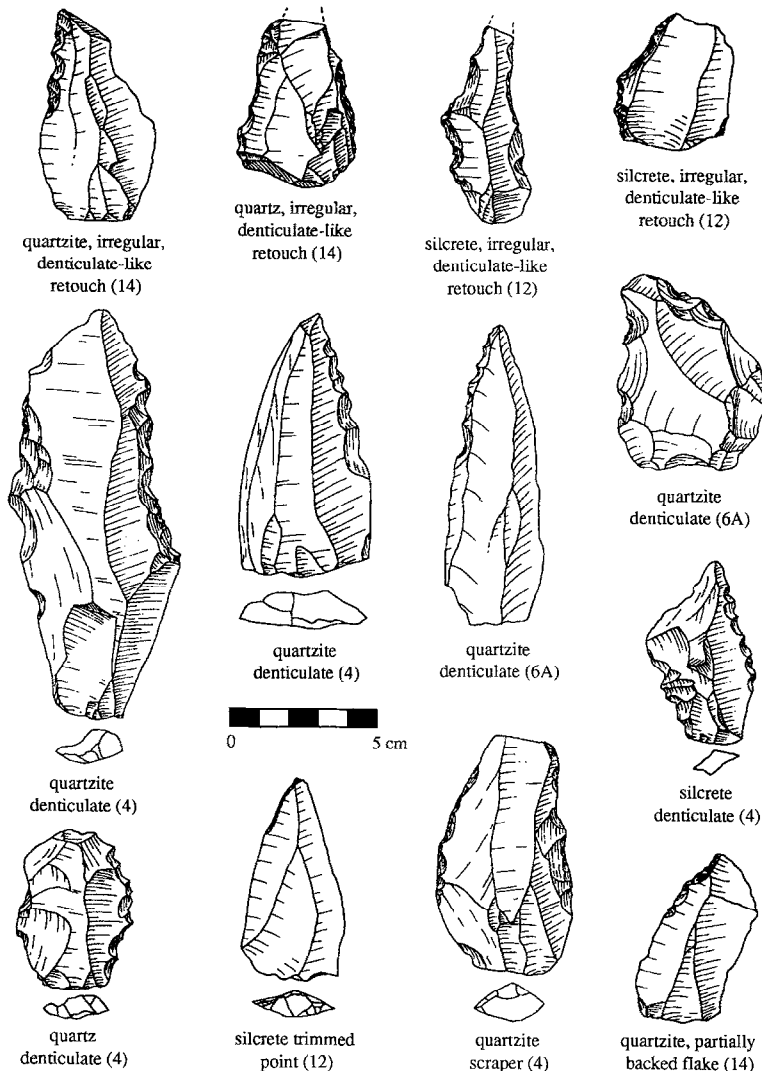


Figure 3. Examples of MSA stone artifacts from Die Kelders Cave 1. The numbers in parentheses are the stratigraphic layers from which the artifacts derive.

cryptocrystalline raw materials. Although dating of the Howiesons Poort at these sites is problematic, it clearly exceeds 45 kyr, and it may be 75 kyr or older (Grün *et al.*, 1990a,b). At DK1, backed and truncated pieces like those that occur in the Howiesons Poort at other sites are absent, although the level 12 artifacts are formed predominantly on silcrete. The lack of Howiesons Poort artifact types, in conjunction with the geological and faunal evidence may indicate that the entire MSA sequence at DK1 antedates the Howiesons Poort, and thus accumulated during one of the cold phases of the Last Interglaciation (i.e., stage 5d or 5b). On the other hand, the predominance of silcrete artifacts in level 12 may mark a Howiesons Poort occupation, and small sample size may account for the lack of typologically characteristic pieces. If this is the case, then the entire DK1 sequence above level 12 could be assigned to

Table 2 Breadth/Length ratios and lengths for quartzite flakes from Middle Stone Age levels at Die Kelders Cave 1. Level 7 has been omitted here because most of the artifacts in the level probably derive from the base of level 6. See text for further explanation of the level 6 samples

Level	Number of complete quartzite flakes larger than 30 mm	Breadth/Length mean	Breadth/Length standard deviation	Length mean (mm)	Length standard deviation
4	1677	0.83	0.41	48.4	20.9
5	29	0.79	0.51	43.6	18.3
6A	856	0.95	0.43	38.3	13.4
6C	263	0.96	0.44	38.8	14.7
8	146	0.99	0.39	39.1	13.4
9	14	0.98	0.39	38.2	19.0
10	41	0.80	0.31	45.0	16.0
11	2	1.14	—	31.0	—
12	12	0.72	0.22	48.6	11.6
13	1	0.79	—	34.0	—
14	206	0.81	0.36	45.6	15.6
15	70	0.81	0.40	47.6	16.1

the MSA 3 of Volman (1984). At Klasies River Mouth and Boomplaas Cave A the MSA 3 overlies the Howiesons Poort and clearly dates to the earlier part of the Last Glaciation (Deacon, 1989). The presence of MSA 3 at Die Kelders would support the geological dating proposed by Tankard & Schweitzer (1974, 1976), and it is consistent with observations from faunal and sedimentological evidence that the deposits could have formed under moist conditions at the beginning of the Last Glaciation.

A decrease in the size of flakes made on coarse-grained raw materials characterizes the post-Howiesons Poort levels at both Klasies River Mouth and Border Cave (Beaumont *et al.*, 1978; Singer & Wymer, 1982). The decrease in flake size in the middle of the DK1 sequence may correspond to some portion of the sequence at these other sites. The shift back to larger flakes in level 4 at DK1 may be idiosyncratic, but it also may represent a technological shift that occurs in MSA levels which are younger than any at Klasies River Mouth or Border Cave. It possibly corresponds to the youngest MSA levels at Boomplaas, which are characterized by large flake blades and which arguably date to 40–32 kyr (Deacon, 1989).

MSA faunal remains

The fauna from the MSA levels at DK1 consists of micromammals (<0.75 kg adult weight), macromammals, birds and tortoises. Micromammalian bones, mainly those of insectivores and very small rodents, occur throughout the sequence, but they are especially abundant in those layers that are relatively devoid of artifacts and large mammal bones. This suggests that the micromammal remains were accumulated principally by owls (e.g., *Tyto alba* and/or *Bubo capensis*) or small carnivores that inhabited the cave when people were absent. Avery (1982) has observed that while there is evidence that some of the layers were “rather warmer and drier” than others, the micromammalian fauna points to generally moist and cool climatic conditions. This is consistent with the sedimentological evidence noted above.

The macromammal fauna (Table 3) may be used to infer aspects of the ancient environment and of the behavior of the MSA bone accumulators. The presence of hippopotamus and

southern reedbuck probably indicates a comparatively moist climate, since there are no bodies of standing water large enough to support them near the cave today. Similarly, very moist conditions are indicated by the large average size of the Cape dune molerats. The MSA individuals from DK1 were, on average, 10–15% larger than their local modern counterparts, and today, larger average size correlates closely with higher rainfall throughout the species range (Klein, 1984, 1991).

At the same time, the presence of grazing ungulates—especially quagga, black wildebeest and southern springbok—that are unknown in local “interglacial” faunas from the southern and western Cape (Klein, 1983a), implies that the vegetation contained more grass than the sclerophyllous scrub and bush (Cape macchia or “fynbos”) that characterized the region historically. The abundance of Cape hare relative to Cape dune molerat in the lower as well as the higher MSA levels (e.g., levels 15–12 and 6A–4) may imply that grasses were especially prevalent near the beginning and end of the MSA occupation. This is also suggested by the microfaunal evidence (Avery, 1982).

As noted by Klein (1986b), cooler-than-historic conditions are implied by the large size of the grey mongoose in the MSA levels at DK1, based upon its tendency to show an increase in size with a decrease in temperature today.

Interpretation of the macrofauna in terms of human behavior is complicated by uncertainty as to the mode of accumulation of many of the smaller animals, especially the superabundant dune molerats. This species dominates the fauna throughout the MSA (and LSA) sequence, reaching a density of about 100 individuals per square meter in MSA layer 8, where it comprises nearly 99% of the sample. With regard to the fauna as a whole, the next most common taxa are the Cape hare and small antelopes—grysbok/steenbok, klipspringer and vaalribbok. Additionally, these small bovids are represented mainly by very young individuals with unworn deciduous teeth. Cape dune molerats, Cape hares and very small young antelopes are all within the prey-size range of the Cape eagle owl (*Bubo capensis*), which is known to focus on colonial species (e.g., Cape dune molerats) when they dominate a prey community (Avery, 1990). Although Cape eagle owls have not been observed to roost in coastal caves today, their use of caves in the mountainous regions to the east and north suggests that they could have inhabited DK1 in the past, especially when the climate was much cooler and people were less abundant. The DK1 dune molerat sample comprises mainly those skeletal elements—maxillae without braincases, complete mandibles and whole limb bones—that characterize Cape eagle owl collections today (Avery, 1990). However, it is conceivable that this pattern of skeletal part representation reflects a combination of human butchering and postdepositional destruction. Surface damage from stone tools, which might be expected from skinning and/or butchering, and damage from gastric acid, which affects at least a few bones in modern owl assemblages (Avery, 1990), was not observed during sorting of the DK1 bones. It is possible, however, that postdepositional corrosion of the DK1 bone surfaces has obscured damage from tools or gastric acid (Avery, 1990), and that such damage might be detectable only under high magnification (Andrews, 1990).

With regard to the remains of large mammals that were more surely accumulated by humans, the MSA assemblages from DK1 and Klasies River Mouth Cave 1 (KRM1) are similar in that eland is the most common species, despite the fact that it was probably the least common large ungulate in the environment (Klein, 1983a, 1989). At both DK1 and KRM1, eland outnumbers Cape buffalo, while wild pigs (bushpig and/or warthog) are rare or absent. Fauna from the MSA at KRM1 contrasts sharply with the prepastoralist LSA fauna (only prepastoralist LSA fauna [i.e., prior to 2.0 kyr BP] can be compared meaningfully

<i>Arctocephalus pusillus</i> , Cape fur seal	6977/76	119/3	5/1	188/3	71/2	1/1	9/1	29/1	96/2	18/2	7/1	3/1	16/2	9/2
<i>Monachus lemnus</i> , elephant seal	2/2	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Proavia capensis</i> , rock hyrax	255/22	255/13	4/2	783/24	322/11	7/1	72/3	9/1	19/3	2/1	16/1	3/1	53/3	9/1
<i>Loxodonta africana</i> , elephant	22/1	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Diceros bicornis</i> , black rhinoceros	5/1	79/2	—	20/1	—	—	—	—	—	—	—	—	1/1	2/1
<i>Equus quagga</i> , quagga	—	—	—	1/1	—	—	—	—	—	—	—	—	—	—
<i>Hippopotamus amphibius</i> , hippopotamus	1/1	5/1	—	15/1	86/2	1/1	3/1	1/1	—	—	—	—	1/1	—
<i>Polanchoerus porcus</i> , bushpig	1/1	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Taurotragus oryx</i> , eland	—	39/3	—	64/3	10/3	1/1	—	2/1	10/1	16/1	3/1	—	15/1	15/1
<i>Tragelaphus streptoceros</i> , greater kudu	—	2/1	—	2/1	2/1	—	—	—	—	—	—	—	—	—
<i>Tragelaphus scriptus</i> , bushbuck	3/1	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Hippotragus leucophaeus</i> , blue antelope	—	2/1	—	12/2	7/1	—	—	—	—	—	—	—	—	—
<i>Redunca arundinum</i> , southern reedbuck	—	9/3	—	10/2	9/1	—	—	—	—	—	1/1	—	—	—
<i>Redunca fulvorufa</i> , mountain reedbuck	—	1/1	—	1/1	—	—	—	—	—	—	—	—	—	—
<i>Pelea capreolus</i> , vaalribbok	—	18/3	—	74/8	15/2	—	1/1	2/1	—	—	—	—	—	—
<i>Alcelaphus buselaphus</i> , hartebeest	10/1	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Damaliscus dorcas</i> , bontebok	2/2	—	—	—	—	—	1/1	—	—	—	—	—	—	—
<i>Connochaetes gnou</i> , black wildebeest	—	20/3	—	12/2	4/1	—	—	—	—	—	—	—	1/1	—
<i>Antidorcas australis</i> , southern springbok	—	4/2	—	—	1/1	—	2/1	5/1	2/1	—	—	—	—	—
<i>Raphicerus</i> sp.(p), grysbok/steenbok	214/102	11/7	—	20/11	11/4	—	2/2	—	2/2	—	—	—	3/2	—
<i>Oreotragus oreotragus</i> , klipspringer	6/2	38/2	—	86/5	42/3	1/1	4/1	—	—	1/1	—	—	1/1	2/1

Table 3 (Continued)

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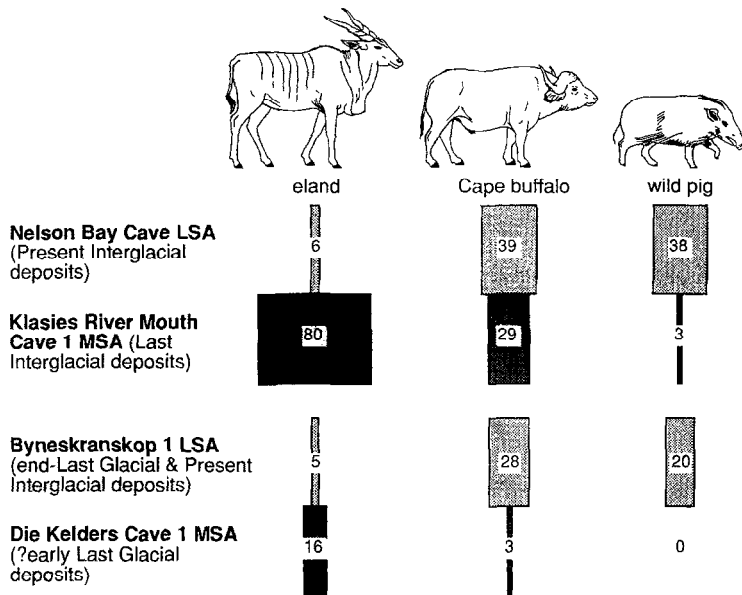


Figure 4. Comparisons of the minimum numbers of individuals by which eland, Cape buffalo and wild pig (bushpig and/or warthog) are represented in the MSA layers of Klasies River Mouth Cave 1 and Die Kelders Cave 1, and in the prepastoralist LSA layers of Nelson Bay Cave and Byneskranskop Cave 1. For background information on Klasies River Mouth (Singer & Wymer, 1982; Deacon, 1989; Klein, 1989); Nelson Bay Cave (Deacon, 1984b); Byneskranskop Cave 1 (Schweitzer & Wilson, 1982).

because the introduction of domestic stock reduced the representation of indigenous species in occupation sites) at nearby Nelson Bay Cave (Figure 4), perhaps because LSA people possess more sophisticated weaponry (e.g., bow and arrow) that would have allowed them to obtain dangerous prey such as Cape buffalo and pig (Klein, 1989). While the MSA fauna from DK1 contrasts with the prepastoralist LSA fauna from nearby Byneskranskop 1 in the same way (Figure 4), the same explanation need not apply. Whereas the KRM1 and Nelson Bay faunas were accumulated under similar (interglacial) conditions, the DK1 and Byneskranskop assemblages were accumulated under contrasting climatic conditions—cool “glacial” conditions at DK1 and mainly warm “present Interglacial” conditions at Byneskranskop (Klein, 1989). Moreover, the DK1 MSA faunal sample, while suggestive, is rather too small to permit definitive statements concerning changes in human behavior from the MSA to the LSA.

The MSA faunal sample from DK1 should be increased by renewed excavation, particularly in the lower levels, where bone preservation is excellent and where small mammals, the probable prey of owls and small carnivores, are much less abundant. With larger samples it might also be possible to construct mortality profiles for eland, Cape buffalo and other large species in order to determine how the MSA peoples acquired them. At KRM1, for example, eland exhibit a catastrophic mortality profile that is suggestive of human hunting by driving, while the Cape buffalo shows an attritional profile, which suggests an inability to hunt prime-age adults (Klein, 1983b). It could even imply scavenging of naturally dead animals.

The MSA fauna from DK1, like that from KRM1, also contains the bones of seals, dolphins and marine birds (Table 3). This indicates that the coast remained within the

Table 4 Human remains from Middle Stone Age deposits at Die Kelders

Specimen	Element	Level	Co-ordinate
DK1 AP 6244	Rdm ²	4	E-5
DK1 AP 6245	Rdi ²	4	E-5
DK1 AP 6242	RM ₁	6	F-4
DK1 AP 6243	Rdm ²	6	F-4
DK1 AP 6246	Ldm ₁	6	F-4
DK1 AP 6247	Ld ₁	6	F-4
DK1 AP 6248	Rdi ₂	6	C-5
DK1 AP 6250	Rd ^c	14	D-5
DK1 AP 6249	Rdi ¹	15	H-4

catchment of the cave, despite the lower sea level during that time. The faunal assemblage, however, contains no fish remains, and the avian component is dominated by penguins (*Spheniscus demersus*) as opposed to flying birds such as the Cape cormorant (*Phalacrocorax capensis*) and Cape gannet (*Morus capensis*) (Avery, 1990). This situation, which is encountered also in the MSA levels at KRM1, is in sharp contrast to the assemblages from local LSA coastal sites (Klein, 1986a). The implication may be that MSA peoples lacked the fishing and fowling technology of their LSA successors.

Unfortunately, there are too few seals from the MSA of DK1 to determine whether their mortality profile resembles those from local LSA sites, in which seasonally harvestable 9-month-olds dominate heavily, or whether it is similar to that from the MSA of KRM1, where individuals of all ages are more evenly represented (Klein, 1989). The latter pattern may imply a limited awareness of seasonal variability in resource availability (Klein, 1989). The establishment of seal mortality profiles, and the determination of the fishing and fowling capabilities of the MSA humans at DK1 require renewed excavations.

Finally, the MSA fauna from DK1 definitely differs from local LSA assemblages in the size of the tortoises. The remains of the angulate tortoise (*Chersina angulata*) are abundant in both, but they tend to be much larger in the MSA (Klein & Cruz-Urbe, 1983). Because cool climatic conditions almost certainly did not promote faster tortoise growth, their larger size likely resulted from less intense human predation. This, in turn, may reflect lower human population densities in MSA than LSA times.

In sum, the MSA artifacts and fauna from DK1 tentatively support evidence from KRM1 that MSA people were behaviorally primitive by LSA standards. Since LSA people were fully modern in behavioral terms, the implication is that MSA people were not.

MSA human fossils

The human remains from the MSA levels comprise nine isolated teeth. All but one are deciduous, and most derive from level 6 (Table 4). As a group, they probably represent between four and six juvenile individuals.

The descriptive terminology employed here follows that of Grine (1989). The teeth were examined by low-power binocular microscopy, and all measurements were taken using a dial-equipped vernier caliper and recorded to the nearest 0.1 mm. The mesiodistal (MD) diameters of worn crowns are provided, and in those instances where it was possible to

estimate the pristine value with reasonable accuracy this is recorded as MD est. The maximum buccolingual (BL) diameter was recorded perpendicular to the MD axis of the crown. Values provided in parentheses indicate low confidence for estimated diameters for worn and/or damaged specimens (Table 5).

The descriptions that follow are grouped by stratigraphic level, and specimens are arranged in numerical order for each level except in those instances in which teeth are considered to have derived from a single individual.

Level 4 specimens

This sample comprises two teeth—DK1 AP 6244 (a Rdm²) and DK1 AP 6245 (a Rdi²)—that probably derive from a single individual. Both are heavily worn, of compatible ontogenetic status, and they derive from the same square.

DK1 AP 6245 Rdi² (Figure 5a). This is an intact, heavily worn crown with a short segment of root. The cervically tapered labial crown face has a shallow depression in its center; there is no cervical enamel prominence. There are two small, deep hypoplastic pits at the distal edge. Lingually, the moderate cervical prominence is skewed distally. There is no tubercle; the lingual face is dominated by a moderate median swelling. Distally, a small, shallow triangular fossa separates the swelling from a weak distal marginal ridge. There is no lingual shovelling.

DK1 AP 6244 Rdm² (Figure 5b). This is a complete, heavily worn crown with a short segment of the root neck. Occlusally, the crown has a nearly square outline. It is slightly broader across the trigon than the talon, and the distobuccal corner is more obtuse than the others. It is apparent from the occlusal outline and fissure remnants that all four principal cusps were well-developed. The protocone was clearly the largest; the paracone appears to have been larger than the metacone, and the hypocone was the smallest. The buccal surface has a shallow, broad depression between the paracone and metacone. The crown displays no apparent hypoplasia or pathology.

Level 6 specimens

This sample consists of five isolated teeth. Two of the specimens, DK1 AP 6246 (Ldm₁) and DK1 AP 6247 (Ld_c), almost certainly come from one individual. They were recovered from the same grid square, they are similarly worn and, most importantly, the distal interproximal contact facet (ICF) of the d_c and the mesial ICF of the dm₁ match one another in size and shape. A third specimen, DK1 AP 6242 (RM₁), may also come from the same individual. It was recovered from the same square, and its faint occlusal wear and nearly complete root development are compatible with this association.

The fourth tooth, DK1 AP 6243 (Rdm²), was recovered from the same grid square as the three foregoing teeth, but it may not be from the same individual. It is only slightly worn compared to the d_c and dm₁, and the distal ICF of the dm₁ is better developed and noticeably larger (3.2 mm BL; 2.1 mm CO) than the mesial ICF of the dm² (2.6 mm BL; 0.5 mm CO). The dm₂, which would have erupted synchronously with the dm², should display similar degrees of both occlusal and interproximal wear as its occlusal partner, and it is evident that the dm₂ that would have belonged to the individual represented by the d_c and dm₁ would

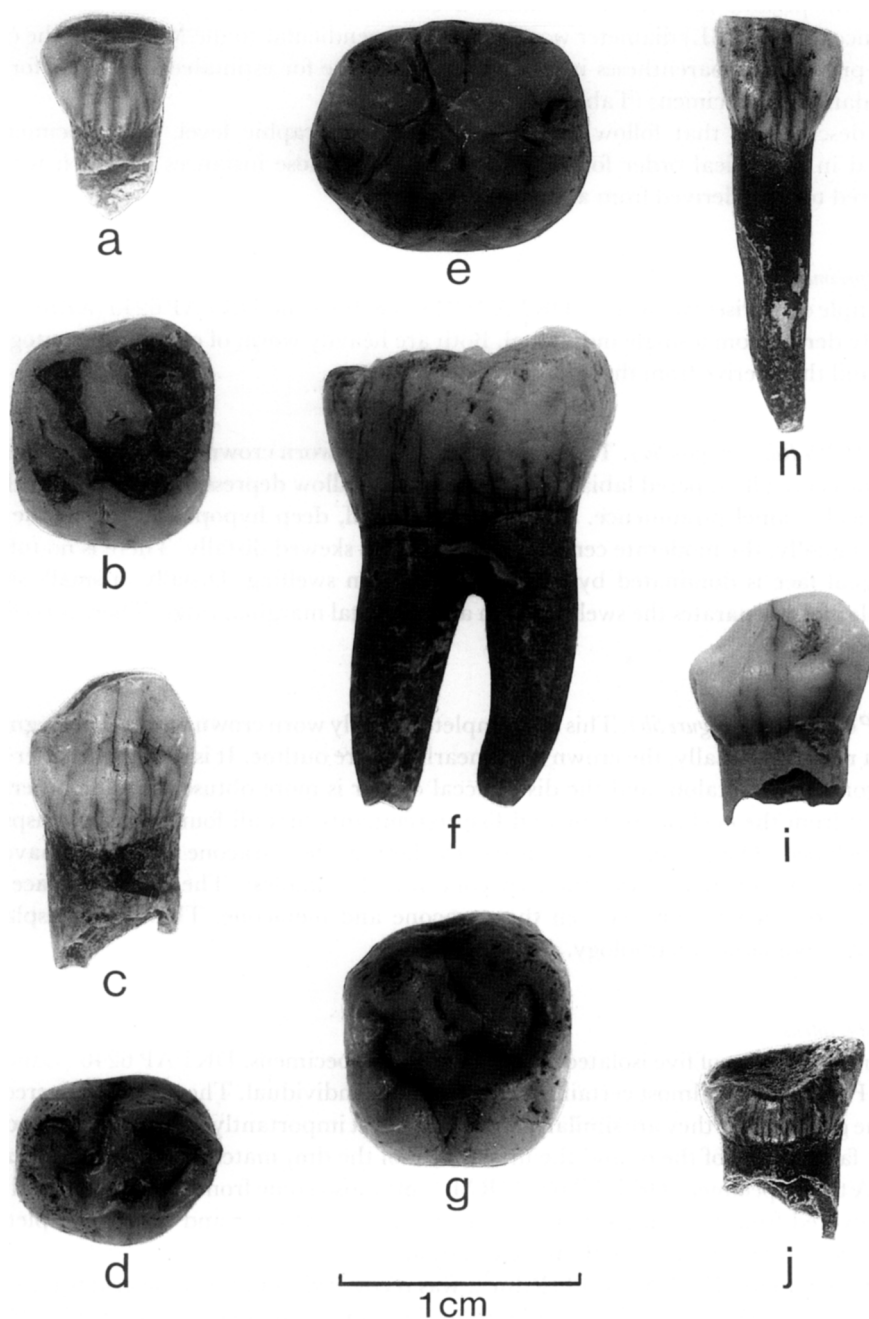


Figure 5. (a) Lingual view of DK1 AP 6245 Rdi². (b) Occlusal view of DK1 AP 6244 Rdm². (c) Lingual view of DK1 AP 6247 Ld₁. (d) Occlusal view of DK1 AP 6246 Ldm₁. (e) Occlusal view of DK1 AP 6242 RM₁. (f) Buccal view of DK1 AP 6242 RM₁. (g) Occlusal view of DK1 AP 6243 Rdm². (h) Lingual view of DK1 AP 6248 Rdi₂. (i) Lingual view of DK1 AP 6250 Rd¹. (j) Lingual view of DK1 AP 6249 Rdi¹.

Table 5 Crown diameters of human teeth from MSA deposits at Die Kelders

Element	Specimen	MD meas	MD est	BL meas
di ¹	DK1 AP 6249	7.2	(7.5)	5.3
di ²	DK1 AP 6245	5.8	5.8	5.2
d ^c	DK1 AP 6250	7.5	7.7	6.0
dm ²	DK1 AP 6243	9.4	9.4	10.5
	DK1 AP 6244	8.5	(8.8)	9.6
di ₂	DK1 AP 6248	5.6	5.7	4.5
d _c	DK1 AP 6247	6.9	7.1	6.3
dm ₁	DK1 AP 6246	9.0	9.1	7.9
M ₁	DK1 AP 6242	12.2	12.2	10.0

have had a better developed mesial ICF than that which is possessed by the DK1 AP 6243 dm².

The fifth tooth, DK1 AP 6248 (Rdi₂), comes from a different grid square. Its degree of wear suggests that it could be compatible with either the proposed DK1 AP 6242/6246/6247 composite or the DK1 AP 6243 dm². Because neither possible association can be determined with certainty, and because its provenience differs from the other specimens, DK1 AP 6243 is regarded as probably representing a separate individual.

DK1 AP 6247 Ld_c (Figure 5c). This is an intact, moderately worn crown with a short segment of root. The crown and root display a number of very small pits that were probably produced by postmortem acidic erosion. Viewed buccally, the crown has a somewhat trapezoid outline, with a reduced disto-occlusal corner, and barely projecting mesial and distal angles. There is no evidence of hypoplasia. Lingually, the moderate cervical prominence is skewed distally. There is no tubercle. The slight, albeit broad median lingual ridge is delimited mesially by a very faint depression and distally by a somewhat deeper fossa. The mesial marginal ridge is weak; the distal marginal ridge is somewhat better developed. Shovelling is absent.

DK1 AP 6246 Ldm₁ (Figure 5d). This is an intact, moderately worn crown with a very short segment of the root neck. Viewed from its occlusal aspect, the crown has a trapezoid outline that is BL broader across the trigonid than the talonid. Four principal cusps are present; the protoconid is notably the largest. The metaconid and hypoconid are equivalent in size, and the entoconid is slightly smaller. There is no evidence of a hypoconulid. There is no mesio-style. The moderate mesial marginal ridge courses distolingually from the mesial end of the protoconid to the mesial end of the metaconid. The fovea anterior is a completely enclosed oblique groove. The distal trigon crest is complete, and the metaconid is set distal to the level of the protoconid. The distal marginal ridge is moderate; there is no fovea posterior. The tuberculum molare is moderately convex buccally and cervically. The buccal groove is moderately broad but shallow. The lingual surface is unremarkable.

DK1 AP 6242 RM₁ (Figure 5e,f). This is a complete, very slightly worn crown with intact, nearly complete roots. The lingual crown surface has some enamel etching. The apical margins of the mesial and distal root plates are damaged, but their thinness (especially the

mesial aspect of the mesial root) suggests that although the apices had not yet been completed, the roots were very close to having been fully formed at time of death.

Viewed occlusally, the crown has an ovorectangular outline with a slight distal taper. All five principal cusps are well-developed. The protoconid is slightly larger than the hypoconid and metaconid, which are equivalent in size. They are larger than the hypoconulid and entoconid, which are equal in size. There is no tuberculum sextum (C6); a very large tuberculum intermedium (C7) is present. The mesial marginal ridge is formed by two cuspidals adjacent to the protoconid; these are separated from metaconid by a shallow depression. The fovea anterior is a moderately deep furrow that is open mesial to the metaconid; it has a short, oblique limb between the protoconid and the mesial marginal ridge. The distal trigonid crest is broadly incised. The distal edges of the protoconid and metaconid are in the same transverse plane, but the latter contacts the hypoconid by a distally elongate deflecting wrinkle.

Buccally, the mesial and distal grooves are very shallow; both terminate in a small pit. There is no protostylid development. Lingually, two short vertical furrows delineate the tuberculum intermedium. There is no indication of hypoplasia.

The root system is comprised by a moderate neck (*ca.* 2.5 mm buccally) and separate mesial and distal plates, each with a single cavity. The distal root is 11.5 mm long; the mesial is 13.4 mm.

DK1 AP 6243 Rdm² (Figure 5g). This is a complete, very slightly worn crown with much of the mesiobuccal root and short segments of the distobuccal and lingual roots.

Viewed occlusally, the crown has a nearly square outline. All four principal cusps are well-developed. The protocone is the largest, followed by the paracone and metacone, which are equal in size. The hypocone is slightly smaller. The moderate mesial marginal ridge is incised by several shallow furrows that partially delineate incipient accessory cusps. An incipient epicrista runs between the paracone and mesial marginal ridge, forming the distal boundary of the fovea anterior, which is continuous distally with the trigon basin. The moderate crista obliqua (=distal trigon crest) is complete; two shallow grooves partially incise its distal aspect. The distal marginal ridge is complete; it is crossed by a shallow, narrow furrow. The fovea posterior is a broad transverse furrow.

The buccal groove is broad and shallow. The buccal surface has very shallow, faint vertical depressions near the mesial and distal edges. There is no hypoplasia. Lingually, a distinct, V-shaped Carabelli pit does not interrupt the contour of the protocone.

The root system is composed of a moderate neck (*ca.* 2.5 mm high buccally) and three separate roots. The lingual root is dominant. The two buccal roots are MD compressed in cross-section.

DK1 AP 6248 Rdi₂ (Figure 5h). This is an intact, moderately worn crown with a nearly complete root. Viewed labially, the crown has a slightly tapered outline with a curved distal margin. The cervical enamel prominence is very slight. The distal half of the labial face is flattened in comparison to the more convex mesial moiety. There is no hypoplasia.

Lingually, the slight cervical eminence is very slightly skewed distally. There is no tubercle. The median ridge is barely perceptible; there is no mesial marginal ridge, and the distal marginal ridge is weak. The mesial half of the lingual face is slightly convex; the distal half is slightly concave. There is no shovelling. The root is 12.3 mm long. The mesial surface is convex; the distal surface has a narrow longitudinal furrow.

Level 14 specimens

An isolated Rd^c , DK1 AP 6250, is known from this stratigraphic level.

DK1 AP 6250 Rd^c (Figure 5i). This is an intact, moderately worn crown with a short segment of the root. There are two mesial ICFs: it is likely that one resulted from contact with the di^2 , while the other resulted from a short period of contact with the I^2 .

Viewed from its buccal aspect, the crown has an asymmetric outline; the distal crown angle is situated more cervically than the mesial angle, which projects to a greater degree. There is a moderate cervical enamel prominence. Buccal marginal ridges and styles are absent. A large area of hypoplastic enamel covers almost the entire mesial half of the buccal surface. A large, deep hypoplastic pit is located at the distal end of the distal apical edge, and a vertical band of hypoplastic enamel is located near the distal edge of the lingual face.

Lingually, the moderate cervical eminence is strongly skewed distally; there is no tubercle. The median ridge is broad. There is a small, shallow fossa near the distal crown edge, and a slightly larger fossa near the mesial edge. The mesial marginal ridge is barely perceptible. There is no lingual shovelling.

Level 15 specimens

An isolated Rdi^1 , DK1 AP 6249, is known from this stratigraphic level.

DK1 AP 6249 Rdi^1 (Figure 5j). This is an intact, heavily worn crown with a short segment of root. The labial surface is featureless insofar as it is preserved. There is a slight labial cervical enamel prominence. Lingually, the moderate cervical eminence is skewed distally. The mesial marginal ridge is separated from the cervical eminence by a small, shallow fossa.

Metrical comparisons

The principal crown diameters of the DK1 teeth are recorded in Table 5. Mensurational data recorded by Jacobson (1982) and Grine (1986) for southern African Bantu-speaking blacks are compared to the DK1 values in Figures 6 and 7. Also compared are data for penecontemporaneous Neandertal teeth from Europe and the Levant (Table 6). While metrical comparisons with Late Pleistocene African samples would be perhaps more satisfactory than those with Neandertals, such data for reasonably large African samples do not exist at this time.

In most instances, the MD and BL diameters of the DK1 teeth fall within the 95% fiducial limits of the modern South African population samples; in all cases they fall within the fiducial limits for the Neandertal samples. In four instances the DK1 values are at the very upper end of the 95% fiducial limit for the modern African sample ($MD\ di^1$; $MD\ d^c$; MD and $BL\ dm_1$), and in three cases they exceed this limit ($MD\ di_2$; $MD\ d_c$; $BL\ d_c$). In general, the Die Kelders tooth diameters tend to fall above the corresponding modern African sample means (Figures 6 and 7). The MD diameters of the di^1 , d^c and all mandibular teeth, and the BL diameters of the d_c and dm_1 from DK1 are more similar to Neandertal than to the modern sample means. In several instances (most notably the BL diameters of the di^1 and d^c), however, the DK1 values are closer to the means for the modern human sample.

In view of the age of the DK1 specimens, it is not surprising that they tend to be larger than some modern human teeth. Large tooth size is plesiomorphic in *Homo*, and temporal reduction in tooth size has been documented from even comparatively recent (e.g., Mesolithic and Neolithic) archaeological samples to living populations (Frayer, 1977; Smith, 1982; Brace & Vitzthum, 1984; Lukacs, 1988). Moreover, the human deciduous tooth diameters used here

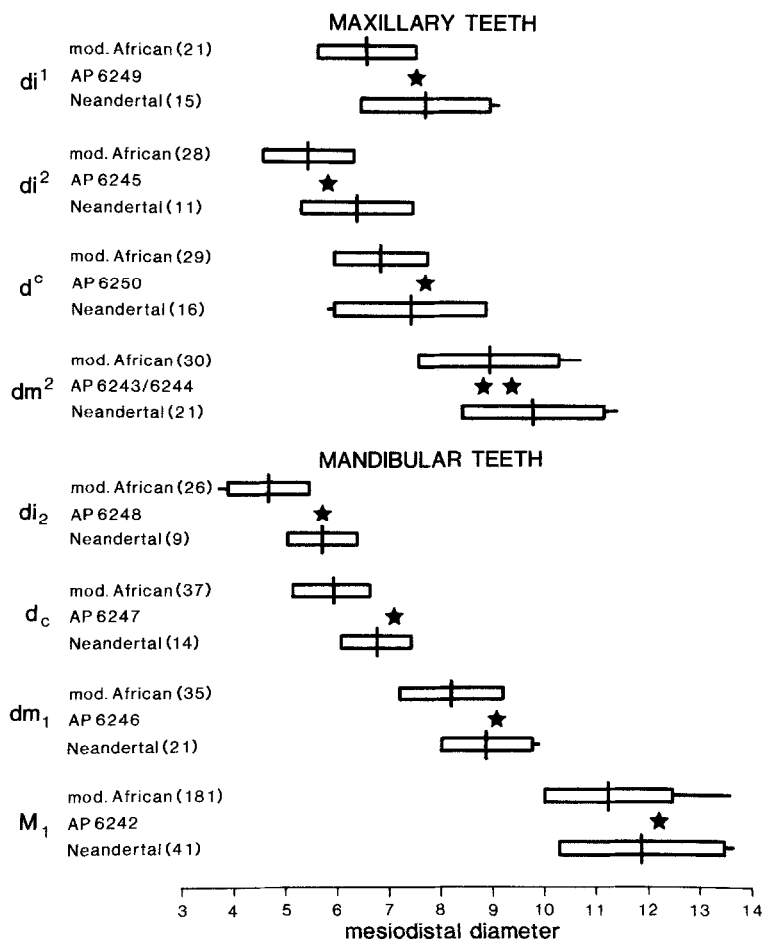


Figure 6. Comparison of mesiodistal diameters of Die Kelders, modern black South African, and Neandertal teeth. Vertical line=sample mean; horizontal rectangle=sample mean \pm 2 SD; horizontal line=observed sample range. Numbers in parentheses=sample sizes. Modern African sample data from Jacobson (1982) and Grine (1986). Neandertal sample data from Table 6.

are not the largest that have been recorded for modern African populations (Grine, 1986). Thus, the South African means for the MD diameter of the di^1 , di^2 , dm^2 , di_2 and dm_1 , and the BL diameter of the di^1 , dm^2 and di_2 are exceeded variously by averages recorded for Kalahari San (Grine, 1984), Liberian blacks (Moss & Chase, 1966) and Rwandan blacks (Brabant, 1963).

In sum, the MSA teeth from DK1 tend to be larger than those of some modern Africans (i.e., modern South African blacks). They are metrically similar to homologues of pencon-temporaneous Neandertals from Europe and the Levant. This, however, does not necessarily signify a closer relationship of the DK1 people to Neandertals than to modern Africans. This is because large tooth size is plesiomorphic, and because tooth size reduction has been demonstrated to have occurred even from comparatively recent archaeological samples to living populations.

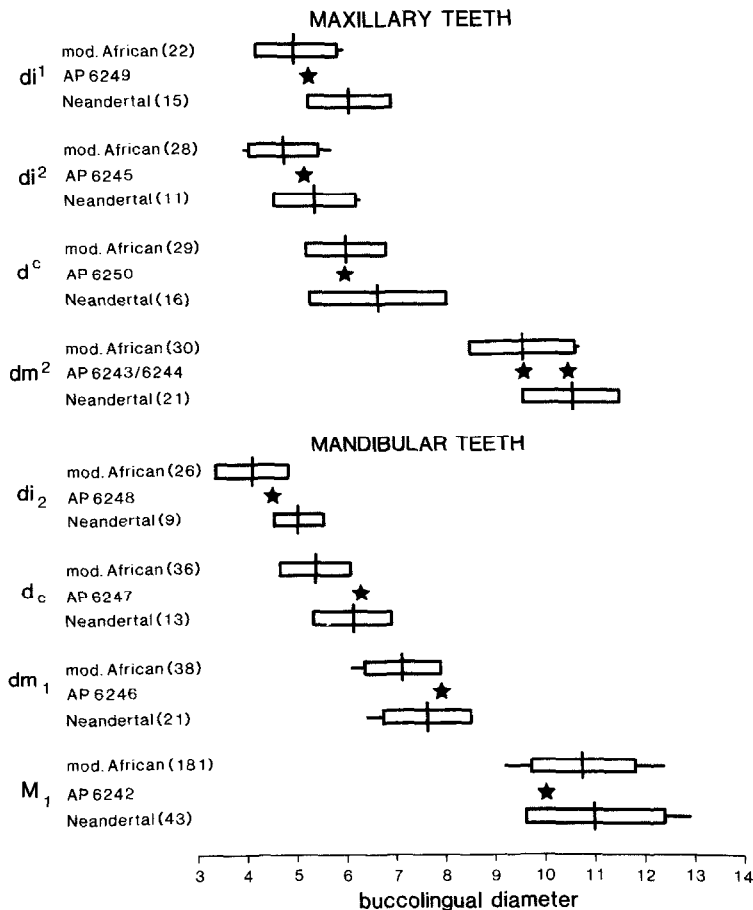


Figure 7. Comparison of buccolingual diameters of Die Kelders, modern black South African, and Neandertal teeth. Legend as for Fig. 6.

Non-metrical comparisons

With regard to the deciduous incisors, the di^1 and di^2 from DK1 possess a moderate, distally skewed lingual cingulum, whereas modern San and black South Africans tend to have weaker, symmetrically disposed cingula. Thus, only 10% of San di^1 s and 2% of San di^2 s have a moderate cingulum (Grine, 1990); this was not observed in a sample of black South African di^1 s, and it is possessed by only 4% of di^2 s (Grine, 1986). Some 28% of San di^1 s and 34% of San di^2 s have a distally skewed cingulum (Grine, 1990); 14% of di^1 s and 15% of di^2 s of South African blacks evince it (Grine, 1986). Similarly, the median lingual ridge of the upper and lower lateral incisors from DK1 tends to be better expressed than on the majority of San and South African homologues (Grine, 1986, 1990). Thus, a moderate ridge was not encountered in a sample of South African black di^2 s, and it was observed on only 2% of San di^2 s (Grine, 1986, 1990). Some 12% of San and 4% of South African black di_2 s possess a weak median ridge (Grine, 1986, 1990). At the same time, however, the absence of a lingual tubercle, the absence or weak development of the mesial and distal marginal ridges, and the concomitant

Table 6 **Tooth diameters of Neandertal samples**

		<i>N</i>	\bar{X}	SD	SE	Obs. range
Maxillary teeth						
di ¹	MD	15	7.68	0.63	0.16	6.5-9.1
	BL	15	6.11	0.42	0.11	5.4-6.9
di ²	MD	11	6.35	0.55	0.17	5.7-7.4
	BL	11	5.40	0.43	0.13	4.9-6.3
d ^c	MD	16	7.41	0.75	0.19	5.8-8.4
	BL	16	6.68	0.69	0.17	5.3-7.6
dm ²	MD	21	9.81	0.70	0.15	8.9-11.4
	BL	21	10.59	0.49	0.11	9.8-11.5
Mandibular teeth						
di ₂	MD	9	5.72	0.35	0.12	5.1-6.0
	BL	9	5.03	0.25	0.08	4.6-5.5
d _c	MD	14	6.75	0.35	0.09	6.2-7.3
	BL	13	6.13	0.40	0.11	5.5-6.8
dm ₁	MD	21	8.91	0.45	0.10	8.3-9.9
	BL	21	7.63	0.45	0.10	6.4-8.5
M ₁	MD	41	11.90	0.80	0.13	10.3-13.6
	BL	43	11.00	0.70	0.11	9.6-12.9

Sample for di¹ includes: Chateaufneuf (Tillier, 1979), Engis, Kebara and Tabun (Smith & Arensburg, 1977), La Ferrassie (Heim, 1982), Hortus (de Lumley, 1972), Krapina (Wolpoff, 1979), Lazaret (Ferembach, 1959), Neussing (Abel, 1937), Pech de l'Aze (Legoux, 1970), Roc de Marsal (Genet-Varcin, 1974), Shanidar (Senyurek, 1959), Staroselje (Roginskii, 1954), Subalyuk (Thoma, 1963).

Sample for di² includes: Chateaufneuf, Engis, Kebara, La Ferrassie, Krapina, Shanidar, Staroselje, Subalyuk.

Sample for d^c includes: Baume des Peyrards (Genet-Varcin, 1974) Chateaufneuf, La Chaise (Genet-Varcin, 1974), Engis, La Ferrassie, Kebara, Le Portel (Brabant & Sahly, 1964), Krapina, Pech de l'Aze, Roc de Marsal, Shanidar, Staroselje, Subalyuk.

Sample for dm² includes: Amud (Sakura, 1970), Chateaufneuf, Engis, La Ferrassie, Gibraltar (Tillier, 1982), Kebara, Krapina, Kulna (Genet-Varcin, 1974), Pech de l'Aze, La Quina (Genet-Varcin, 1974), Roc de Marsal, Shanidar, Tabun, Staroselje, Subalyuk, Teshik-Tash (Gremyatskij, 1949).

Sample for di₂ includes: La Chaise, La Ferrassie, Kebara, Krapina, Pech de l'Aze, Roc de Marsal, Shanidar, Staroselje.

Sample for d_c includes: Archi (Ascenzi & Serge, 1971), Chateaufneuf, Combe Grenal (Genet-Varcin, 1982), La Ferrassie, Kebara, Krapina, Le Moustier (Genet-Varcin, 1974), Pech de l'Aze, Rigabe (Genet-Varcin, 1974), Roc de Marsal, Shanidar, Staroselje, Teshik-Tash.

Sample for dm₁ includes: Archi, La Chaise (Genet-Varcin, 1974, 1982), Chateaufneuf, Combe Grenal, Engis, La Ferrassie, Gibraltar, Kebara, Krapina, Kulna, Molare Shelter (Mallegni & Ronchitelli, 1989), Pech de l'Aze, Roc de Marsal, Shanidar, Staroselje, Taubach (Genet-Varcin, 1974), Teshik-Tash.

Sample for M₁: data from Bermudez de Castro (1986: table 8).

lack of lingual shovelling on the DK1 incisors finds correspondence with the vast majority of San and black South African homologues (Grine, 1986, 1990). Patte (1962) and others have commented on the strong lingual shovelling exhibited by Neandertal permanent incisors, and while deciduous crowns do not present the same degree of shovelling as their permanent

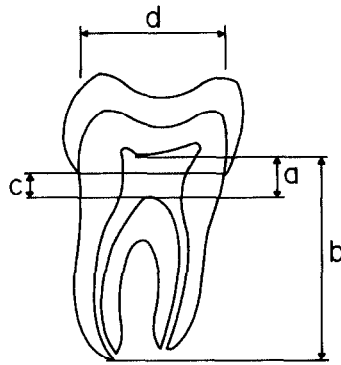


Figure 8. Longitudinal cross-section of mandibular molar showing the four variables measured. Line between mesial and distal cervical margins forms horizontal base. Variable a: perpendicular distance from lowest point on roof of pulp chamber to highest point on floor of chamber. Variable b: perpendicular distance from lowest point on pulp chamber roof to apex of longest root. Variable c: perpendicular distance from cervical base line to highest point on pulp chamber floor. Variable d: MD diameter of root neck at level of cervical margin. Variable a corresponds to variables "Y" of Keene (1966) and "1" of Shifman & Chanannel (1978). Variable b corresponds to "Z" of Keene (1966) and "2" of Shifman and Chanannel (1978). Variable c corresponds to variable "3" of Blumberg *et al.* (1978). Variable d corresponds to variable "2" of Blumberg *et al.* (1978).

successors, it would appear that they tend to display stronger marginal ridges (see Table 6 for references) than the DK1 teeth.

With reference to the deciduous canines, the DK1 crowns have a moderate, distally skewed lingual cingulum, whereas most San and South African black homologues possess a weak cingulum; it is symmetrically disposed on most of their d's (Grine, 1986, 1990). Thus, 100% of South African black d's that were examined evince a weak cingulum, and it is moderately developed on only 4% of San d's; only about 18% of San and South African d's have a moderate cingulum. Similarly, the cingulum is distally skewed on only 18% of San and 11% of South African black d's (Grine, 1986, 1990). At the same time, however, the absence of a lingual tubercle, the weak or moderate development of the marginal and median lingual ridges, the absence of lingual shovelling and the absence of mesial and distal styles from the DK1 canines finds correspondence with the vast majority of modern San and South African black homologues (Grine, 1986, 1990).

The dm₁ from DK1 has a complete, high mesial marginal ridge and a complete distal trigonid crest, while on the majority of San and South African black homologues the mesial marginal ridge is open at the base of the metaconid and the distal trigonid crest is incised (Grine, 1986, 1990). Thus, only 4% of San and 8% of South African black dm₁s have a complete mesial marginal ridge, and only about 10% of these crowns display a complete distal trigonid crest (Grine, 1986, 1990). In all other attributes, including occlusal crown outline, the presence of only four principal cusps, and the development of accessory cuspidals, the DK1 molar finds correspondence among the majority of modern southern Africans. Indeed, the presence of only four cusps on the majority of African dm₁s serves to differentiate them from other modern population groups (e.g., Europeans and Asians), in which five-cusped crowns appear in significantly higher frequencies (Grine, 1986, 1990).

In the few morphological features that are preserved by the dm₂ from DK1 level 4 (AP 6244), it resembles the majority of San and black South African homologues. The tooth

from level 6 (AP 6243) is similar in these attributes. Thus, four, well-developed cusps are possessed by about 90% of San and South African black homologues, and about 70% of these have a shallow buccal groove without a terminal pit (Grine, 1986, 1990). The dm^2 from level 6 differs from the majority of modern African crowns in its moderate, albeit incised mesial marginal ridge, and in its moderate distal trigon crest. Most San and South African black dm^2 s possess thinner ridges, and most do not reveal a deeply incised mesial crest (Grine, 1986, 1990). In all other features, including principal cusp and accessory cuspule development, the form of the buccal groove, and the configuration of the Carabelli trait, the morphology of the DK1 crown finds correspondence among the majority of modern San and black South African homologues (Grine, 1986, 1990).

With reference to the M_1 , the DK1 crown has a large tuberculum intermedium and a distinct deflecting wrinkle, whereas the majority of San and South African homologues lack these features (Grine, 1981). Thus, only 15% of San and 20% of South African M_1 s have a tuberculum intermedium, and only about 20% have a true deflecting wrinkle (Grine, 1981). The DK1 M_1 also possesses a shallow buccal groove that ends in a small pit, whereas the groove is shallow on about 27% of black South African homologues, and most (*ca.* 90%) lack a pit. In all other morphological variants, however, the fossil resembles the majority of modern African first molars.

Thus, almost all of the morphological traits displayed by the DK1 MSA teeth occur in the majority of modern peoples from southern Africa. The only noteworthy exceptions pertain to the tendency for the lingual cingula of the deciduous incisors and canines to be better developed on the DK1 crowns, the well-developed mesial marginal ridge on the dm_1 , and the tuberculum intermedium and a deflecting wrinkle on the M_1 . However, while these variants are comparatively uncommon, they certainly are not unknown among modern Africans. Indeed, in several features (e.g., incisor and canine shovelling, principal cusp development on the dm_1 , and Carabelli trait expression on the dm^2), the resemblances between the DK1 fossils and modern African teeth serve to differentiate modern Africans from populations in other geographic regions (e.g., Europe and Asia) (Grine, 1986, 1990).

The morphological similarities between the DK1 fossils and modern southern African populations, however, do not necessarily indicate modernity of the fossil sample. These same morphological manifestations may also have characterized the teeth of the Early Stone Age (ESA) populations from which the MSA inhabitants of southern Africa may have derived. Unfortunately, the relevant samples are not adequate to determine this possibility.

Pulp chamber dimensions

Interest in the relative size of the molar pulp chamber dates to Gorjanovic-Kramberger's (1907, 1908) descriptions of the Krapina Neandertal sample. The roots of these teeth commonly display an enlarged pulp cavity, a condition referred to by Keith (1913) as taurodontism.

Shaw (1928) defined three categories of taurodontism (i.e., hypotaurodont, mesotaurodont, and hypertaurodont) that have been employed in several qualitative and quantitative analyses of modern human populations (e.g., Brabant & Kovacs, 1961; Keene, 1966; Blumberg *et al.*, 1971; Shifman & Chanannel, 1978). Lateral radiographs were obtained for all DK1 molars, but because of damaged roots, the relative size of the pulp cavity could be defined quantitatively according to the definitions supplied by Keene (1966) and Shifman & Chanannel (1978) only for the M_1 . Nevertheless, a qualitative assessment of the deciduous molars indicates that some are, at most, "hypotaurodont" (AP 6243 and 6244).

Four variables (Figure 8) were measured on the radiograph of the M_1 . Diameter "a" is 3.4 mm; "c" is 3.0 mm, and "d" is 9.9 mm. Because the roots of this tooth are not fully formed, variable "b" cannot be measured directly, but it can be estimated with a reasonable degree of certainty. Insofar as the root is developed, variable "b" is 13.0 mm, and when allowance for further apical formation is made, it increases to 15.0 mm. According to Keene's (1966) classification, which is based solely on the value of a "taurodontism index" (TI) that compares variables "a" and "b", the Die Kelders M_1 is cynodont. Even if the *incomplete* length of the root is used for variable "b", the resulting TI value places this tooth just within the lower limit of the hypotaurodont category. According to the scheme of Shifman & Chanannel (1978), which employs the absolute value of diameter "c" together with different delineations of the TI categories, the DK1 molar is marginally hypotaurodont.

Molar pulp chambers are not commonly enlarged in modern human populations (Shaw, 1928; Keene, 1966; Blumberg *et al.*, 1971; Shifman & Chanannel, 1978), and according to the criteria employed in these studies, none of the DK1 teeth would be regarded as being more than hypotaurodont. They certainly do not display the taurodontism that has been recorded for some penecontemporaneous Neandertals, e.g., those from Krapina (Gorjanovic-Kramberger, 1907, 1908; Kallay, 1963). While a high incidence of taurodontism has come to be regarded as a characteristic of Neandertals (Stringer *et al.*, 1984), not all exhibit this variant. Unfortunately, quantitative data are not available for a large, representative Neandertal sample, but a preliminary qualitative assessment of radiographs of some 30 specimens with permanent and/or deciduous molars has revealed 13 that display moderate to extreme taurodontism (Robert Tompkins, pers. comm.). When the Krapina remains are excluded from this sample, about 70% of Neandertals with deciduous molars and about 30% with permanent molars display noticeable taurodontism (Robert Tompkins, pers. comm.). Taurodontism seems to have been comparatively rare among earlier *Homo sapiens* specimens in MSA or even late ESA contexts. While the M_1 in the Cave of Hearths mandible has been described as mesotaurodont by Tobias (1971), the teeth in other early specimens (e.g., those from Kabwe, Florisbad, and the Ngoloba Beds) do not appear to manifest this condition.

Thus, the absence of taurodontism from the DK1 sample is not necessarily an indication of its modernity. While a high incidence of taurodontism within a sample of Last Glacial age may be suggestive of Neandertal affinities, its absence does not necessarily indicate a closer relationship to modern southern African populations than to the earlier MSA or even ESA inhabitants of sub-Saharan Africa.

Discussion

The origin of anatomically modern humans is one of the more hotly contested issues in hominid palaeontology. The central issue, which was enunciated clearly by Howells (1976), continues to be whether anatomically modern people arose from a common source population and then spread through migration and replacement (Stringer, 1984, 1989; Bräuer, 1984a,b, 1989; Jones, 1986; Cann *et al.*, 1987; Stringer & Andrews, 1988), or whether modern populations arose polycentrically through multiregional evolution (Thorne & Wolpoff, 1981; Wolpoff *et al.*, 1984; Wolpoff, 1989). Increasingly, proponents of the former (the so-called "Garden of Eden") hypothesis have focused on Africa as the source for anatomically modern humans because the differentiation of nuclear DNA among living populations (Jones, 1986), and the evolution of mitochondrial DNA (Cann *et al.*, 1987) suggests an origin

during the Penultimate Glaciation or Last Interglaciation. Also, a number of studies indicate that African fossils from or shortly postdating the Last Interglaciation possess manifestly modern morphologies (Leakey *et al.*, 1969; Beaumont *et al.*, 1978; Rightmire, 1979*b*, 1984, 1986; Singer & Wymer, 1982; Bräuer, 1984*a,b*; Smith, 1985, 1991; Stringer, 1989).

As noted by Wolpoff (1989), however, the genetic evidence is not wholly unambiguous. While it must be conceded that the fossil evidence is hardly overwhelming, the African record is certainly no worse than those for Europe and Australasia upon which arguments for regional continuity have been based (Thorne & Wolpoff, 1981; Wolpoff *et al.*, 1984; Wolpoff, 1989).

Among the northern and eastern African specimens are two crania from Jebel Irhoud and two crania and a mandible from Dar es Soltan, Morocco (Stringer, 1974; Debénath *et al.*, 1986), the Omo 1 cranium and partial skeleton from the Kibish Formation, Ethiopia (Day & Stringer, 1982), and three molars from Mumba Rock Shelter, Tanzania (Bräuer & Mehlman, 1988). Relevant South African fossils include eight isolated teeth and a fragmentary mandibular corpus from Equus Cave (Grine & Klein, 1985), an incomplete cranium, two mandibles, a partial infant skeleton and a few postcranial fragments from Border Cave (de Villiers, 1973, 1976; Rightmire, 1979*b*, 1984; Bräuer, 1984*a,b*; Morris, 1991), and several mandibles, cranial pieces, teeth and postcranial bones from Klasies River Mouth (Singer & Wymer, 1982). Recently, a partial maxilla, several teeth and an ulna have been added to the collection from Klasies River Mouth (Rightmire & Deacon, 1991).

Amongst the southern African specimens, those from Klasies River Mouth and Border Cave have figured most prominently in arguments over the origin of modern humans. The Klasies River Mouth fossils are perhaps the most securely dated of all the African specimens referred to above (Deacon *et al.*, 1986; Deacon & Geleijnse, 1988; Deacon, 1989; Grün *et al.*, 1990*b*; Rightmire & Deacon, 1991). In general, the Klasies River Mouth remains fall within the range of modern anatomical variation, although some specimens evince slightly more primitive morphology. Thus, the zygomatic (KRM 16651) is typically modern in the disposition of its inferiolateral margin, the frontal (KRM 16425) is characteristically modern in the distinct separation of the supraorbital swelling and superciliary arch, and, as noted by Smith *et al.* (1989), while two of the mandibles (KRM 16424 and 41815) are clearly modern in form, two others (KRM 21776 and KRM 13400) have rather vertical symphyses with little development of the mental eminence. Wolpoff & Caspari (Wolpoff & Caspari, 1990*a,b*; Caspari & Wolpoff, 1990) have recently attempted to dispel the notion that the Klasies River Mouth hominid sample is generally modern through comparisons with very limited archaeological samples from the southern Cape which can hardly be taken to represent the range of variation even for modern southern African peoples. Although some of the Klasies River mandibles may be robust in comparison to modern African corpora, this should not be surprising in view of their considerable antiquity. It certainly does not alter the fact that the fossils evince derived morphological features that are generally regarded as being characteristic of modern humans.

The modern aspect of the Border Cave remains has been elucidated by numerous investigators (de Villiers, 1973, 1976; Beaumont *et al.*, 1978; Rightmire, 1979*b*, 1981, 1984, 1986; de Villiers & Fatti, 1982; Bräuer, 1984*b*; Smith, 1985; Fatti, 1986; Smith *et al.*, 1989). Several multivariate statistical studies, however, have questioned the affinities of the Border Cave 1 (BC-1) cranium. Thus, Campbell (1984) and Ambergen & Schaafsma (1984), who employed Rightmire's original data in their analyses, indicated that BC-1 is statistically atypical for the modern southern African samples that were employed by Rightmire. Van

Vark *et al.* (1989), who included larger samples of modern humans from different geographical regions, concluded that although BC-1 may look modern, it is "quite different from recent *Homo sapiens*". However, this same study led to the suggestion that BC-1 is perhaps "only slightly more distinct from Asiatic *Homo erectus* than it is from recent *Homo sapiens*" (van Vark *et al.*, 1989; p. 54)! Such a patently bizarre conclusion cannot but detract from the credibility of this kind of analysis.

Corruccini (1990) has also reported that BC-1 falls "far outside the 'morphometric' envelope of all modern African populations". His conclusion that "the fossil in no way can be equated with living *H. sapiens*" is difficult to accept in view of its manifestly modern appearance. Not only does it lack any Neandertal apomorphies, it also possesses weaker browridges and an arguably more vertical frontal than the slightly older Ngaloba and Florisbad crania. The principal difference between the Border Cave 1 cranium and the skulls of the modern inhabitants of southern Africa appears to be one of size, and the comparatively large size of BC-1 may be at least partially responsible for some of the recent multivariate results (G. P. Rightmire, pers. comm.). The incomplete nature of the specimen adds to the problem of interpreting its affinities on the basis of multivariate statistics alone. Despite the fact that the BC-1 vault is fragmentary, various workers who have reported conflicting results have employed quite different sets of measurements, in addition to having used different multivariate statistical methods. As was aptly observed by Smith *et al.* (1989), the total morphological pattern of the Border Cave material justifies its designation as modern human.

The geochronological age of the Border Cave hominids is a matter of real dispute. It has been argued at length that they are in an MSA context and between about 85 kyr and 100 kyr old (Beaumont *et al.*, 1978; Butzer *et al.*, 1978a; Beaumont, 1980; Butzer, 1984). Klein (1983b), however, has cited several factors regarding the "excavation" of BC-1 and BC-2, and the state of preservation of BC-3 and BC-5 indicating that the purported ages of these specimens should be treated with some circumspection. The provenance of the postcranial pieces described by Morris (1991) is even more problematic, since they were recovered from sediments that clearly have slumped over the last four decades into a hole that was excavated in the early 1940s. The recently reported ESR dates for the Border Cave sequence (Grün *et al.*, 1990a) do not resolve the problem, as they are based on animal teeth from the MSA sediment layers rather than on the human remains themselves. Nevertheless, the Border Cave evidence for anatomically modern humans in the early Late Pleistocene *might* gain some support from the securely provenanced fossils from Klasies River Mouth.

Morris (1991) has recently argued that Equus Cave can no longer be considered as a site that bears upon modern human origins because of its supposedly young age. According to him, "fieldwork revealed that the [artifacts] were washed into the cave from an MSA open site upslope", palynological analysis by Scott (1987) suggests that the basal layers may represent the "last major cold phase of the Pleistocene and the beginning of the Holocene", and "most recently a radiocarbon date of $16,300 \pm 160$ years before present (PTA 4409) was obtained on collagen from a bone sample just above the base of the sediments in Upper Stratum 2B".

These assertions, however, are not completely accurate. While it is conceivable that the MSA artifacts could have been washed into the site, fieldwork has not demonstrated this; nor could it. Such a scenario would also require an *ad hoc* explanation of how artifacts from an upslope MSA site could have contaminated the lower but not the upper units of Equus Cave. In any case, the antiquity of Equus Cave relies most heavily on geological inference, rather

than on the sporadic occurrences of MSA artifacts in what was clearly an hyena-accumulated assemblage of bones (Grine & Klein, 1985; Klein *et al.*, 1991). The pollens reported by Scott (1987) from coprolites in Unit 2B are consistent with his earlier (1984) conclusions to the effect that unit 2B probably represents the coldest phase of the depositional sequence, with annual temperatures perhaps 4°C lower than those of today. As noted by Grine & Klein (1985), "the palaeoenvironmental parameters adduced from the faunal remains correspond closely to the vegetational indications derived from palynological analysis". On the basis of the pollen alone there is no reason to suspect that unit 2B was more likely to have accumulated during the close of the Last Glaciation (i.e., during isotope stage 2) than during some earlier phase (e.g., isotope stage 3 or 4). With reference to the radiocarbon data of *ca.* 16 kyr for unit 2B, this is based on organic residue that is not demonstrably collagenous (Klein *et al.*, 1991). The organic residue could derive partly or wholly from soil microorganisms that substantially postdate the bone.

Under the circumstances, there is still a strong possibility that the human teeth and mandible antedate 40–30 kyr (Butzer *et al.*, 1978b; Butzer, 1984; Grine & Klein, 1985; Klein *et al.*, 1991). The teeth and mandibular fragment closely resemble modern African homologues (Grine & Klein, 1985), and if the older dating is correct, they are consistent with the evidence from Klasies River Mouth and other Late Pleistocene sites in sub-Saharan Africa.

The human teeth from the MSA levels at Die Kelders tend to be large by comparison with some modern African homologues, while they are metrically similar to the teeth of penecontemporaneous Neandertals. Tooth size, however, does not attest to a closer biological relationship to Neandertals than to modern Africans. Large tooth size is plesiomorphic, and dental reduction has been demonstrated to have occurred from comparatively recent archaeological samples to living populations. While a few of the non-metrical traits evinced by the DK1 teeth are infrequently encountered among modern southern Africans, most of the variants displayed by the fossils are shown also by the majority of modern Africans. Significantly, there are several morphological resemblances between the DK1 specimens and modern Africans that serve to differentiate the latter from modern populations in other geographic regions (e.g., Europe and Asia). These same features, however, may also have characterized the teeth of the ESA inhabitants of southern Africa and, as such, the resemblances between the DK1 and modern African samples do not necessarily indicate modernity of the MSA peoples. The cynodont to hypotaurodont molars from DK1 resemble modern human teeth in contrast to some Neandertals, but here, too, the absence of taurodontism does not necessarily indicate the modernity of the MSA sample because the teeth of earlier inhabitants of southern Africa may also have been characterized by small pulp cavities.

Thus, while the fossil teeth from the MSA levels at DK 1 differ from those of the modern inhabitants of southern Africa in several respects, these differences are overshadowed by their similarities. Notwithstanding the manifestly incomplete nature of the human remains that are currently available from the MSA levels at DK 1, they are not inconsistent with the evidence from other sites for the presence of morphologically modern people in southern Africa during the Last Interglacial.

The MSA artifacts and fauna from DK1, like those from KRM1, suggest that MSA people were behaviorally primitive by LSA standards. Despite the anatomical modernity of the MSA inhabitants of sub-Saharan Africa, the behavioral limitations implied by their occupation debris may explain why they were unable to spread into Europe until roughly 40–45 kyr ago. Unfortunately, the nature and timing of the MSA/LSA transition remains

obscure, mainly because late MSA and early LSA occupation sites are very rare. The reason for this rarity may be hyperaridity and consequent low population densities over much of Africa during the mid-Last Glacial interval when the transition occurred.

Both the potential for dating the MSA at Die Kelders, and the quality of the MSA bone preservation are at least as good as at Klasies River Mouth, but Die Kelders has been much less extensively excavated. Thus, DK1 is an obvious choice for renewed excavation designed to further our understanding of later Pleistocene human evolution in Africa.

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