

# Implications of Border Cave Skeletal Remains for Later Pleistocene Human Evolution<sup>1</sup>

by G. Philip Rightmire

EXCAVATIONS AT BORDER CAVE, situated on the boundary between Swaziland and Zululand (South Africa), have yielded extensive evidence of prior human occupation. Sediment analyses undertaken by Butzer, Beaumont, and Vogel (1978) suggest that the cave was first inhabited sometime prior to the Last Interglacial, while the main period of use spans four protracted periods of accelerated frost-weathering, all of which are older than 35,000 B.P. Quantities of stone artifacts have been recovered, along with human bones and a moderate sample of faunal material (Klein 1977). The human remains include a partial adult cranium, the first fragments of which were found by W. E. Horton in 1940. Horton removed some of the cave deposit while digging for guano, and more of the cranium together with a mandible and postcranial pieces were located in his dump during 1941–42. Thought to be associated with a Middle Stone Age industry, this cranium was originally described as quite different both from African Negroes and from Bushmen, though Cooke, Malan, and Wells (1945) did recognize a resemblance to two other supposed Middle Stone Age men from Springbok Flats (Transvaal) and Fish Hoek in

the Cape. The broad frontal, projecting glabella, and rugged superciliary eminences also invited comparison with Florisbad, which was said to show similar if more massive supraorbital development. Later reports (Wells 1969, 1972) have continued to emphasize similarities between Border Cave and Springbok Flats or even Rhodesian man (Brothwell 1963), while ties with living South African populations have been regarded as remote. Application of Mahalanobis's generalized distance ( $D^2$ ) to a small set of cranial measurements has most recently led de Villiers (1973) to claim that neither Border Cave nor Springbok Flats can be related closely to modern Negroes or Bushmen, though a role of more generalized "protonegriform" ancestor is considered. My own study of the fossils, based on statistical treatment of additional measurements, leads to a rather different conclusion, and there is metric evidence which links the Border Cave adult cranium directly with modern African populations. The implications of this finding depend heavily on the dating and provenance of the human remains, which are uncertain pending full publication of radiocarbon determinations, racemization assays, and nitrogen and uranium contents of hominid and faunal bone samples.

The adult cranium consists of most of a frontal, parts of both parietals and temporals, an occipital fragment, and a right zygomatic bone, all of which have been set in a plaster reconstruction by A. R. Hughes. If landmarks on plaster and dimensions bridging large gaps between bone (e.g., of the base) are avoided, then 11 measurements may be taken on the original fossil, located in the Department of Anatomy, University of the Witwatersrand, Johannesburg. Most of the measurements relate to frontal form, supraorbital development, or projection of the nasal root. Full descriptions of the technique may be found elsewhere (Rightmire 1975).

The measurements provide a basis for comparison of Border Cave with crania drawn from recent African populations. One multivariate statistical approach which permits assignment of single fossils to one or another of several test groups is discriminant analysis, as discussed recently and comprehensively by Howells (1973). In simple terms, multiple discriminant analysis treats simultaneously several measurements or characters, each of which has been recorded for skulls drawn from comparative populations. The technique permits conversion of the original measurements to a smaller number of functions or axes along which the positions of the various groups can be plotted. The result is a multidimensional statistical space within which each group can be represented as a mean (centroid) surrounded by a probability contour depicting an expected range of variation. Some groups may overlap, making exact assignment of individuals difficult, while others may be

<sup>1</sup> I wish to thank Q. B. Hendey, J. J. Oberholzer, and P. V. Tobias for access to skeletal remains. K. W. Butzer, P. B. Beaumont, and R. G. Klein provided much helpful advice. The work was supported by Grant No. BNS 75-02679 from the National Science Foundation.

G. PHILIP RIGHTMIRE is Associate Professor of Anthropology at the State University of New York at Binghamton (Binghamton, N.Y. 13901, U.S.A.). Born in 1942, he was educated at Harvard College (B.A., 1964) and the University of Wisconsin-Madison (M.S., 1966; Ph.D., 1969). He has been Research Associate in the Department of Zoology of the University of Wisconsin (1969) and Research Fellow of the Osteological Research Laboratory, University of Stockholm (1973). His research interests are Pleistocene hominids and human evolution, particularly in Africa, the later prehistory of eastern and southern Africa, and measurement and statistical approaches to the study of human diversity. He has conducted extensive studies of human skeletal remains in southern and eastern Africa since 1966 and is now engaged in the study of Middle and Upper Pleistocene African hominids. His publications include "Problems in the Study of Later Pleistocene Man in Africa" (*American Anthropologist* 77:28–52), "Human Skeletal Remains from the Southern Cape Province and Their Bearing on the Stone Age Prehistory of South Africa" (*Quaternary Research* 9:219–30), "Florisbad and Human Population Succession in Southern Africa" (*American Journal of Physical Anthropology* 48:475–86), and "*Homo erectus* and Human Evolution in the African Middle Pleistocene," in *Current Argument on Early Man*, edited by L.-K. Königsson (in press).

The present paper, submitted in final form 4 iv 78, was sent for comment to 50 scholars. The responses are printed below and are followed by a reply by the author.

distant from one another, so that their respective members do not mingle at all. Single skulls may then be inserted into this framework and their affinities examined. This use of the functions in assignment is the role for which discriminant statistics were originally designed by Fisher in 1936. Where proper care is taken with data collection and when the individuals to be classified do not differ greatly (e.g., at the species level) from specimens included in the initial calculations, there is little doubt that the analysis is reliable, even given the formal parametric criteria which must theoretically be met in the application of multivariate statistics.

Such statistics are used here to explore the affinities of Border Cave with eight groups of modern Bushman, Hottentot, and South African Negro crania, all of which have been carefully documented by sex and tribal membership (Rightmire 1970a, 1975). Analysis of 11 measurements yields seven discriminant functions, the first six of which account for more than 99% of total variation. This framework assigns 129 of

the original 227 skulls to the correct groups, while 98 are mis-assigned (lie closer to some centroid other than their own) if all errors of both sex and tribe are counted. This figure of 57% successful identifications is about what might be expected, given the small number of measurements available. However, if the test materials are viewed simply as constellations of related peoples rather than as distinct populations, results improve substantially. Only 14 Bushmen or Hottentots are misassigned as Negroes, while 17 Zulu, Sotho, or Venda crania are incorrectly labeled as Bushman or Hottentot. This more liberal reading of discrimination raises the number of acceptable assignments to 196, or more than 86% of the total.

Correlations and scaled weights for each measurement on the first three functions are given in table 1, and this information together with the plot (figure 1) suggests that Function I is both size- and sex-related. Biorbital and frontal chords are emphasized, and discrimination is closely associated with mastoid length, generally a good sex indicator. Separation by

TABLE 1  
CORRELATIONS AND SCALED WEIGHTS OF 11 MEASUREMENTS FOR THE FIRST THREE  
DISCRIMINANT FUNCTIONS COMPUTED IN AN EIGHT-GROUP ANALYSIS

MEASUREMENT	CORRELATIONS			SCALED WEIGHTS		
	Function I	Function II	Function III	Function I	Function II	Function III
Glabella protrusion . . . . .	-0.32	-0.10	0.02	-3.15	-6.08	-1.16
Supraorbital projection . . . . .	-0.29	-0.09	-0.07	3.02	-10.97	-2.68
Biorbital chord <sup>a</sup> . . . . .	-0.77	0.64	-0.00	-23.43	25.92	-6.58
Nasion subtense . . . . .	-0.45	0.32	0.35	6.09	-9.61	-2.13
Nasion angle . . . . .	-0.26	0.17	0.40	-5.71	10.29	5.64
Malar height . . . . .	-0.42	0.03	-0.31	5.05	-10.62	-3.49
Frontal chord . . . . .	-0.63	0.33	0.26	-21.18	13.86	7.75
Frontal subtense . . . . .	-0.00	-0.00	0.01	7.07	-18.56	-4.61
Frontal angle . . . . .	0.26	0.03	-0.12	-3.48	13.86	-0.71
Orbit breadth <sup>a</sup> . . . . .	-0.43	0.17	0.67	4.23	-10.19	14.40
Mastoid length . . . . .	-0.87	0.40	-0.20	-25.59	3.02	-3.81

<sup>a</sup> These measurements depend partly on reconstruction of the right lateral supraorbital margin, which seems accurate. Other dimensions should be reliable even if there are faults in the plaster portions of the specimen.

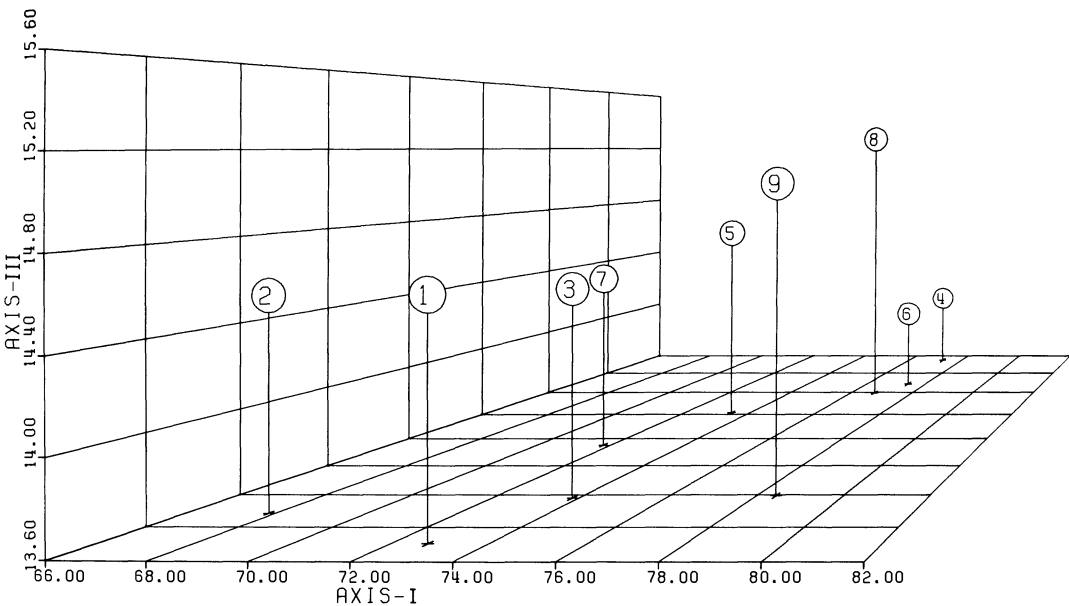


FIG. 1. Positions of eight modern African groups and the Border Cave adult on the first three discriminant axes computed from 11 cranial measurements. Bushman males and females (1) and (2); Hottentot males (3); Zulu males and females (4) and (5); Sotho males and females (6) and (7); Venda males (8); Border Cave (9). Scale of Axis II (not labeled) is the same as that of Axis III. Diameters of group markers have no relationship to actual dispersion, and in fact there is some overlap of population distributions.

sex within each population is well marked, and the Border Cave skull lies toward the end of this axis, where its score is roughly comparable to those of Negro males.

Function II seems to distinguish Bushmen and Hottentots from Negro crania of either sex, and upper facial breadth is again important. The high correlation of mastoid length may reflect a generalized size component to discrimination, though this is not so clear. Also, the scaled weights for frontal angle as well as frontal chord and subtense indicate that these measurements are important, though neither subtense nor angle is related to actual variation in individual discriminant scores. On this function, Border Cave falls close to the Hottentot mean but is not far removed from Bushmen. A different pattern appears on Function III, which opposes Venda males to other Negro males, while Bushmen and Hottentots are intermediate. This function is associated with orbit shape and facial flatness as measured at nasion, relative to the orbital rims. It is less important than the first two axes, and on it the fossil falls about midway between the Venda and the Bushmen.

When all (six rather than just three) discriminants are considered, Border Cave in fact lies closest to the Hottentot centroid and is contained within the .05 limits of this distribution. The fossil also approaches the Venda and Bushman male centroids but falls beyond the .05 limits of these groups. This is new information, not principally because of the Hottentot identification, which is dubious,<sup>2</sup> but because Border Cave is shown emphatically to be well within the range of modern African variation for the measurements used. The cranium is heavily constructed, but it is hardly archaic in the fashion of Florisbad or Broken Hill.

The significance of these results is tempered by doubt as to the provenance of the fossil cranium. With the exception of a new adult mandible recovered in 1974 (de Villiers 1976), all of the adult skeletal material was dug out of the cave by Horton, and its original position in the deposits was not directly verified. Cooke, Malan, and Wells (1945), who followed Horton at the site, have argued that soil from small cracks in the cranium is best matched with dark earth from the top of a "normal Pietersburg occupation zone," and an infant skeleton was excavated by them from this same level. More recent work (Beaumont and Boshier 1972, Vogel and Beaumont 1972, Beaumont 1973) has helped to clarify the cultural and stratigraphic sequence, but association of the partial cranium with either the first mandible or the postcranial bones cannot be proved, and contemporaneity of any of the adult remains with the infant burial is still uncertain.

The facts available do suggest considerable antiquity for the infant and probably for the Border Cave adult as well. If the opinion of the original excavators is reiterated by Wells (1972) is accepted (and there is no substantial reason to question this view), then the skeletons are associated with what Beaumont (1973) now calls a Final Middle Stone Age or Epi-Pietersburg industry, and this sort of stone work occurs early in the occupational sequence, where it is dated at >48,700 B.P. (Pta-489). Such an age would be unexpected for relics of fully modern man, and the implications are far-reaching. It is thus important not only to consider Border Cave in local South African perspective but also to assess its relevance to a larger question, i.e., the way in which modern humans have evolved from archaic ancestors in the Upper Pleistocene.

This larger problem has been discussed recently by Weiss and Maruyama (1976) and by Howells (1976), who review the

controversy surrounding two principal hypotheses of human origins. One view, originally that of Weidenreich and Coon, is referred to as "phyletic" by Weiss and Maruyama, while a temporally restricted but still geographically uniformist version of the same idea is dubbed the "Neanderthal-phase" hypothesis (after Hrdlička) by Howells. In various forms, this view holds that *Homo sapiens* has evolved over a long period of time throughout the Old World. There has been an in situ transition in many places from archaic to more modern man, without much dispersal or replacement. An alternate hypothesis suggests that present human variation is the result of relatively recent migration of populations outward from a common source. Presumably less advanced peoples were replaced or swamped genetically by this expansion, which must have occurred sometime prior to 35,000 B.P. However, the "Garden of Eden" (Sarich 1971) or "Noah's Ark" (Howells 1976) in which modern man originated has not been located. Weiss and Maruyama have attempted to test the phyletic viewpoint on genetic grounds, using estimates of gene flow and population dispersion drawn from contemporary hunter-gatherers. Their model shows that there has been ample time for diffusion of advantageous traits and cline formation in a species evolving during the mid-Pleistocene, and therefore a phyletic view is not ruled out. The replacement hypothesis is equally compatible with the genetic findings, however, and neither can be preferred on the evidence available.

If the Border Cave cranium is not ancient, then it has no special relevance to this controversy. But if the case for its antiquity is regarded as firm, then the skeletons suggest the presence of *H. sapiens sapiens* in southern Africa before 50,000 B.P. and perhaps as early as 115,000 B.P., if Butzer, Beaumont, and Vogel's (1978) interpretation of cave sediment analyses, radiocarbon dates, and available microanalytical data is correct. Something like this has been argued by Protsch (1975), although his treatment of the fossils is unfortunately quite superficial and his case suffers accordingly. Protsch would lump Border Cave with Florisbad, Fish Hoek, and Springbok Flats, all of which are said to represent "*H. sapiens capensis*" and to be associated with Middle Stone Age industries. In fact none of these specimens has been securely dated, though there is some evidence that Florisbad is not only old (>100,000 B.P.?) but also more archaic in appearance than the other crania (Rightmire 1978a). Fish Hoek is anatomically modern and probably terminal- or post-Pleistocene in age (Rightmire 1978b). Springbok Flats is simply not dated, and here as with the other fossils cultural associations are uncertain (Klein 1970). In spite of these obvious difficulties, "*H. sapiens capensis*" is claimed as earliest modern man, arising first in southern Africa. Migration into East Africa and eventual dispersion into Europe and Asia are postulated, so Protsch is firmly in the replacement school. He also contends that the "African Neanderthals" (e.g., Hopefield, Broken Hill) are contemporaries of or a later offshoot from "*H. sapiens capensis*," so that these former hominids presumably died off without issue. This is certainly debatable, and new information places Hopefield (Butzer 1973) and probably also Broken Hill (Klein 1973) in later Middle Pleistocene rather than Upper Pleistocene context. These hominids are not Neanderthal-like, but they are decidedly archaic in morphology (Rightmire 1976), and it would make better sense to view them as ancestral to the later, more modern populations.

Whether Border Cave represents a population descended from mid-Pleistocene *H. sapiens rhodesiensis* cannot be determined without further fossil evidence. Statistical results show, however, that the Border Cave adult cranium is certainly within the range of recent human variation, and this also holds for the two adult mandibles, one of which was apparently recovered directly from Middle Stone Age deposits (de Villiers

<sup>2</sup> Because of long-standing difficulties in differentiating between the Bushmen (San) and Hottentots (Khoikhoi) of history, and because of the relatively small numbers of representative skeletons available to this analysis, the assignment of the Border Cave cranium should not be interpreted in a strict sense to exclude it from all Bushman populations. It should also be understood that no tie is implied between "Hottentot" status in the statistical analysis and a particular language or pastoralist economy.

1976). Elsewhere in southern Africa, skeletal remains of undoubted Middle Stone Age association have come mainly from Klasies River Mouth (Singer and Wymer n.d.), where some of the Cave I material is probably older than 90,000 years (Bada and Deems 1975, Butzer 1978). This material is very fragmentary, but there is little or no indication of the robust anatomy of Broken Hill, and a Klasies frontal fragment is lightly built even in comparison with Florisbad. If this assessment is correct, then Border Cave need not mark the only or necessarily the earliest appearance of fully modern man in the African Upper Pleistocene. However, Border Cave is important in that the cranium can be linked, albeit tentatively, with a recent African population. This implies that Hottentot or large Bushman-like people may have inhabited southern Africa for a long time, as would be consistent with a phyletic view of human evolution. Whether migration and replacement were occurring elsewhere is of course another question, and there is no reason to exclude this as a possibility on a local level even if waves of replacement did not sweep the Old World shortly before 35,000 B.P. The course of evolution outside of southern Africa cannot be determined from the evidence considered here.

## Comments

by PETER B. BEAUMONT

*McGregor Museum, Kimberley 8300, South Africa.* 31 VII 78  
Rightmire's important finding can be more fully appreciated in terms of the chrono- and culture-stratigraphy at Border Cave. This may be summarized as follows (Beaumont 1973, 1978; Butzer, Beaumont, and Vogel 1978; Beaumont, de Villiers, and Vogel 1978):

a) 1BS.UP stratum,  $^{14}\text{C}$  age  $\sim 200\text{--}600$  B.P. Rare Iron Age objects in the upper reaches of this level suggest only sporadic use of the cave then. The pottery consists largely of unincised black matt and burnished sherds which are similar to modern Swazi wares (Beaumont 1973).

b) 1BS.LR-1WA strata,  $^{14}\text{C}$  age  $\sim 33,000\text{--}38,000/45,000$  B.P. Artefacts fall within the typological definition of the "Early" Later Stone Age (Beaumont and Vogel 1972). Minute scaled pieces based on quartz and chalcedony are particularly distinctive (van Noten 1977). Flake platforms are preponderantly plain, but a few polyhedrals do occur. Also present are ground-bone arrow points and small bored stones. Ostrich-eggshell beads are similar to those still being made by the San. A number of bone and wood fragments show incised "non-notational" ritual(?) markings (A. Marshack, personal communication).

c) 2BS.UP-2WA strata,  $^{14}\text{C}$  age  $> 49,000$  B.P., inferred age  $\sim 60,000\text{--}85,000$  B.P. Tools represent two distinct phases of the Post-Howieson's Poort complex, which terminates the Middle Stone Age succession in South Africa (Sampson 1974). Blades grade with time from large and robust to short and squat forms. Triangular flakes are infrequent and in the lower levels often show butt reduction from the ventral to produce Emireh-type points (Garrod 1955). Backed pieces are limited to occasional specimens of exclusively trapezoidal shape. Of note are ground-bone "daggers" based on split warthog-tusk fragments. *Acacia karroo* thorns with damaged tips appear to have served as awls.

d) 3BS-3WA strata, inferred age  $\sim 85,000\text{--}100,000$  B.P. Implements refer to the Epi-Pietersburg variant of the old Second Intermediate (Malan 1949, Sampson 1972). Blades are abundant and include a consistent proportion of autochthonous punched specimens (Clark 1970). Also present are a variety of backed elements, some of which approximate to Châtelperron or Abri Audi knives. Amongst the few bifacial forms are small

pressure-flaked triangular points which may well be arrowheads (Cooke, Malan, and Wells 1945).

e) 1GBS.UP-BACO.D strata, inferred age  $\sim 100,000\text{--}125,000$  B.P. These contain various middle-late Pietersburg assemblages which equate broadly with those from Cave of Hearths Beds 5-8 (Sampson 1972). Untrimmed flake classes in all raw-material categories show progressively decreasing dimensions with time (Mason 1957, Sampson 1972). Retouched pieces are uncommon and typified by a variety of bifacial, unifacial, and laterally trimmed points.

Provenances of the human remains probably or certainly associated with the Stone Age levels at this site are as follows:

a) The BC-1 and BC-2 fragments were displaced from their original contexts in 1940 during the removal of "guano" from Horton's pit (Cooke, Malan, and Wells 1945). Observations made in 1942 indicated that the surface of the 4WA stratum, which immediately underlies the 1GBS (see *e* above), was intact over the entire floor of that area, thereby providing a lower dating limit for the hominid bones (Archaeological Survey File B20/1/2, University of the Witwatersrand). It was claimed at the time that the soil adhesions in small interstices of BC-1 were only matched by a distinctive "chocolate-coloured" layer corresponding to the base of our 1GBS.LR (Cooke, Malan, and Wells 1945). That view is supported by the BM and UCLA nitrogen values, which suggest that BC-1 (0.41%) and BC-2 (0.28%) are similar in age to in situ finds BC-3 (0.44%) and BC-5 (0.48%) but certainly older than the Iron Age hominid BC-4 (0.93%) (Beaumont 1978). Discriminant analysis confirms the latter deduction by showing that BC-1 differs in size (particularly breadth) from recent South African, Negro, and Khoisan population values (de Villiers 1973). Our conclusion is thus that BC-1 is very unlikely to be younger than the "Early" Later Stone Age, with a minimum age of  $\sim 33,000$  B.P., while other concordant lines of evidence would support an association of BC-1 and BC-2 with some post-4WA level of the Pietersburg dating to  $\sim 115,000$  B.P. An antiquity of that order would then be in good accord with the marked  $D^2$ -derived affinities of BC-1 with Tuinplaats (de Villiers 1973), which was found in *F*-supported association with macrofauna (Oakley and Campbell 1967) underlying typical "advanced" Pietersburg (van Riet Lowe 1929, Inskeep 1969).

b) The BC-3 infant skeleton was found straddling squares F12 and G12 during systematic excavations in 1941 (Cooke, Malan, and Wells 1945). It came from a shallow but indubitable grave with a maximum length of  $\sim 38$  cm, breadth of  $\sim 30$  cm, and depth of  $\sim 24$  cm (Archaeological Survey File B20/1/2). Associated was a perforated *Conus* shell, presumably an ornament or amulet, which must have come from the coast, at least 82 km to the east (Cooke, Malan, and Wells 1945). Some of the bones show reddish-brown stains (de Villiers 1973) that appear to result from the perhaps ritual application of haematite powder (Dart 1968). The grave lip is recorded as lying  $\sim 5$  cm below the base of an intact brown sand and black ash layer marking the lower limits of the Epi-Pietersburg (Archaeological Survey File B20/1/2). It follows from these facts that the burial refers to the upper reaches of the Pietersburg, with an inferred age of  $\sim 105,000$  B.P.

c) The BC-5 adult lower jaw was recovered by C. Powell, in my presence, on April 10, 1974 (de Villiers 1976). The specimen was found just above the base of the undisturbed 3WA (see *d* above) in the northwest corner of square T20 (Beaumont 1978). Associated artefacts represent a middle phase of the Epi-Pietersburg, with an inferred date of  $\sim 90,000$  B.P.

The four hominid fragments just discussed are all unequivocally ascribable to anatomically modern *H. sapiens*, traits typical of the Neanderthals being entirely absent (de Villiers 1973, 1976). Indeed, a number of morphological similarities to modern indigenous peoples already exist, as has been clearly

shown by the statistical data of Rightmire. The fossil series may thus, in view of the present dating evidence, be regarded as an already partly differentiated basal stock from which the Khoisan peoples, amongst others, ultimately arose (Beaumont and Vogel 1972).

It may be mentioned here that the association of fairly advanced anatomically modern *H. sapiens* forms with Middle Stone Age aggregates showing many Upper Palaeolithic features, at time-levels dating back to well within the Last Interglacial, is not at all incompatible with revised physical and temporal evaluations of certain other hominids that have been linked by some to the Middle Stone Age and/or early Upper Pleistocene (e.g., Protsch 1975). The detailed evidence in this connection is discussed elsewhere, and salient findings are as follows (Beaumont, de Villiers, and Vogel 1978):

The facio-calvarial fragment from Florisbad has no clear analogues outside of Africa and appears to represent an "early" *H. sapiens* variant (Howells 1974, Rightmire 1978a). An upper dating limit for it is provided by an estimated age of ~115,000 B.P. for the Middle Stone Age aggregate of Mazelspoort type (Clark 1959) which occurs in the upper reaches of the overlying Green Sand (Sampson 1972). The sample of long retouched lava and lydianite blades, which Dreyer (1938) associated with the skull, is best ascribed to the terminal Acheulian/Fauresmith (Beaumont 1978), which would imply a minimum age of ~170,000 B.P. on the basis of the Th/U reading for Rooidam (see comments by Butzer).

The Elandsfontein skull lies close to and perhaps on the nether side of the *sapiens-erectus* morphospecies divide (Coon 1962, Bilsborough 1973). The associated fauna is particularly comparable with the animal remains from Olduvai Bed IV (Cooke 1964, Klein 1973), which accumulated between ~600,000 and ~800,000 B.P. (Hay 1975). It is therefore likely that a minimum age of about 400,000 B.P. may be attached to the Saldanha skull. This estimate is compatible with the finding that South African faunal aggregates of Last Interglacial age have an extinct-species proportion of ~10% (Klein 1976, 1977) as compared to ~46% for Elandsfontein (Klein 1973, 1974).

Despite Rightmire's ultimate line, it would seem to me, on the basis of minimum hypothesis, that present Old World evidence is best interpreted in terms of a Presapiens scheme, in which the donor area for anatomically modern *H. sapiens* is seen to have been sub-Saharan Africa. It is on the "satisfying and hospitable hearth" (Howells 1974) formed by the game-rich savanna landscapes (Bourlière 1963) south of the Saharan environmental barrier (e.g., Kukla 1976) that the emergence of anatomically modern *H. sapiens* appears to have taken place (Vogel and Beaumont 1972), by way of Middle Pleistocene forms such as Omo and Florisbad (Beaumont, de Villiers, and Vogel 1978). However, it is patent that much still remains to be done to corroborate and amplify the as yet sparse present evidence, which forms but a first step in the exploration of those hitherto unperceived and formative phases in the physical and cultural evolution of our own kind.

by ALAN BILSBOROUGH

Department of Physical Anthropology, Downing St., Cambridge CB2 3DZ, U.K. 7 VIII 78

Rightmire's paper makes a most useful contribution to the study of human evolution in sub-Saharan Africa during the later Pleistocene. I should like to make the following comments:

1. Discriminant analysis is a valuable tool for depicting the relationships of the Border Cave specimen and reference groups and for evaluating the contribution of the original characters to the separation achieved. However, reference to only the first three axes does omit an (unrecorded) proportion of the available information. It would be useful to have a matrix of generalised distances for the groups, based upon all the variation, and to

know how Rightmire's  $D^2$  separation compares with that of de Villiers (1973).

2. It would also be useful for workers to have access to Rightmire's original measurements for the Border Cave specimen and the modern groups. To what extent are the results of the multivariate analysis—especially the relative roles of characters as discriminants—predictable by appropriate univariate statistical analysis of the original data? For example, is Border Cave similar to Zulu, Sotho, and Venda males in biorbital and frontal chords and mastoid development, as suggested by their positions on Axis I?

3. As Rightmire notes, accurate dating of the Border Cave specimen is crucial to an assessment of its relevance for human evolution. I hope that Butzer's sedimentological studies, referred to above, can be published in full in the near future.

4. Like Rightmire (1976 and this paper), I consider that Broken Hill and Saldanha are not "African Neanderthals" and that to label them as such dilutes the term "Neanderthal" to such an extent as to make it virtually meaningless. My own work indicates that they have a quite distinctive morphology compared with other populations of *H. sapiens*, but one that is "decidedly archaic" (Rightmire) and in many respects reminiscent of Middle Pleistocene *H. erectus*. Indeed, in terms of phenetic affinity they might equally well be considered a subspecies of *H. erectus* as of *H. sapiens*. Butzer and Klein's work, cited by Rightmire, effectively undermines the common practice of placing these specimens in the later Upper Pleistocene as contemporaries of the Eurasian Neanderthals. Such placement, with its implication of isolated development and the retention of a relict cranial morphology long after its disappearance elsewhere in Eurasia and Africa, seems inherently improbable, given our knowledge of human mating patterns and the interaction of hunter-gatherer groups. The earlier dating therefore clarifies rather than confuses our view of human phylogeny in the later Pleistocene, and, like Rightmire, I regard Protsch's (1975) suggestion that Broken Hill/Saldanha are derived from his "*H. sapiens capensis*" as implausible and *contra* the relevant evidence.

5. As Rightmire notes, the available fossil specimens do not permit a definitive choice between "phyletic" and "replacement" interpretations of the later stages of human evolution. For various reasons I tend to prefer a modified phyletic interpretation, at least on the larger scale. However, the two theories should be thought of as complementary rather than mutually exclusive. Evolutionary change in most small communities probably results from a compound of natural selection, gene flow and migration; and (in the short term) drift, and the most realistic reconstructions of human phylogeny would consequently incorporate a reticulate pattern.

When considering geographically restricted fossil specimens separated from each other by only a few thousand years—a not uncommon situation in the later Pleistocene—one is, in effect, focusing on the fine detail of population interaction and evolution, and unifactorial interpretations will almost certainly be inadequate to explain the observed variation. Given fluctuations in group size, the mobility of hunter-gatherer communities, and their response to environmental change, limited numbers of specimens may well suggest a replacement interpretation at the parochial level and yet accord with a phyletic framework at (say) the continental or supracontinental level. This view seems similar to that hinted at by Rightmire in his final paragraph.

6. Like many workers, I am suspicious of spectacularly early dates attributed to morphologically modern specimens. I would include Rightmire's suggestion that Border Cave may be "as early as 115,000 B.P." in this, to my mind, shady category. We need more information about the criteria upon which this assignment is based. However, it is perhaps worth noting that

such a date would accord with a special case of the replacement interpretation—Thorne's (1977) recently enunciated "centric hypothesis." Thorne suggests that new variants are most likely to occur initially at the centre of a species distribution and that populations in that region will show correspondingly enhanced variability.

7. The investigation of the later stages of human evolution in southern Africa, after having undergone a period of relative stasis, is currently in a state of flux. I find Rightmire's article valuable not only in its own right, but in drawing my attention to several important references; I also find it frustrating that several of the most critical are not generally available. I should like to request that Rightmire and (say) Butzer and Klein consider the possibility of a collaborative review article surveying recent developments in this important field. Such an article—ideal for publication in *CURRENT ANTHROPOLOGY*—would be invaluable.

by KARL BUTZER

*Departments of Anthropology and Geography, University of Chicago, Chicago, Ill. 60637, U.S.A. 17 vii 78*

The full import of the Border Cave fossils, so competently analyzed in Rightmire's paper, can only be appreciated in the light of the detailed geo-archaeological information.

At Klasies River Mouth, it has been possible to show that the Middle Stone Age spans deep-sea isotope stages 5e to 4, ca. 125,000–60,000 B.P. (Butzer 1978). The argument is based on an almost complete sedimentary sequence in which sands are of littoral origin and their grain size is inversely proportional to distance of the cave from the seashore; particle-size parameters record all the minor details of the glacial-eustatic stratigraphy for the complex climato-stratigraphic span known as the Last Interglacial. The first phase of Middle Stone Age occupation, immediately following a +7-m sea level, can be unequivocally dated to isotope stage 5e on the basis of  $O^{16}/O^{18}$  analyses of a molluscan suite by Shackleton (n.d.). Furthermore, the sophisticated Howieson's Poort industry, with its small, slender blades, backed crescents, and trapezoids, is dated to a minor sea-level regression, with an  $O^{18}$  deviation intermediate between that of a full interglacial and a full glacial (Shackleton n.d.); this places the so-called Howieson's Poort in the cool isotope stage 5b, ca. 95,000–90,000 B.P.

At Border Cave (Butzer, Beaumont, and Vogel 1978), detailed lithostratigraphic and sedimentological work identifies eight Pleistocene sedimentary cycles, including six major cold phases, marked by grit-rubble horizons or well-developed roof-spall zones, interrupted by sedimentary breaks or chemical-weathering horizons noted by striking, authigenic clay formation or gypsum mobilization. The two youngest cold phases, associated with the Later Stone Age, have eight  $C^{14}$  dates between 38,600 and 13,300 B.P. By gauging sedimentation rates in finer and coarser sediments and duration of sedimentary breaks, and allowing for differential compaction, one can safely extrapolate the excellent and unprecedented radiocarbon framework provided by 28  $C^{14}$  dates to the six cold intervals and two paleosols that are older than 50,000 B.P. This also serves to place the Howieson's Poort horizon (Third White Ash of Beaumont 1973) in a cold phase ca. 95,000 B.P., demonstrating synchronicity with Klasies River Mouth. The major paleosol at Border Cave, recording a long period of warm, moist climate, is equivalent to isotope stage 5e and the minor paleosol to isotope stage 5c, ca. 125,000 and 110,000 B.P. respectively. This leaves two complex sedimentary cycles at Border Cave prior to 125,000 B.P., evidently spanning all of isotope stage 6 and resting on the strongly weathered cave floor. The base of the Middle Stone Age sequence is therefore dated at ca. 195,000 B.P.

This stratigraphic framework, placing the Middle Stone Age between 195,000 and 50,000 B.P., is substantiated at other

South African sites. At Bushman Rock Shelter, the top of the undisturbed Middle Stone Age is associated with a major roof-spall horizon dated greater than 51,000 B.P. (Butzer and Vogel n.d.); two-thirds of the Middle Stone Age sequence predates a major period of chemical alteration that can be correlated with isotope stage 5e. At Rooidam, the terminal Acheulian (Fauresmith) is linked to an ancient lakeshore, substantially older than a subsequent lacustrine phase that has a uranium-series assay of  $174,000 \pm 20,000$  B.P. (Szabo and Butzer n.d.). In other words, the Middle Stone Age technocomplex, which only a decade ago was thought to be younger than 40,000 B.P., began almost 200,000 B.P. The microlithic Howieson's Poort industry, once thought to be of terminal Pleistocene age, now proves to be older than 90,000 B.P.

The Border Cave hominids fit comfortably in this context. The derivation of the incomplete mandible (BC-2) and the cranial fragment (BC-1) from Horton's pit is less uncertain than Rightmire implies: the youngest stratum present in this part of the cave is Level 7b (Third White Ash, isotope stage 5b) and Cooke, Malan, and Wells (1945) identified the attached matrix with that of (our) Level 10 (isotope stage 5d). The infant skeleton (BC-3) was from a burial, contemporary with (our) Level 9 and cut down into (our) Level 10, a fact indubitably recorded by H. B. S. Cooke's detailed, unpublished geological section, which shows the burial. The 1974 mandible (BC-5) was removed intact from Level 8 by reputable witnesses. Finally, the large suite of microanalytical data (courtesy of T. Molleson and J. L. Bada) shows that BC-1, -2, -3, and -5 (with nitrogen levels of 0.28–0.48%) are substantially more leached and mineralized, although not charred, than Iron Age bone (0.93–0.95%) or Later Stone Age bone (0.62–0.83%) in the cave. There is, then, no question at all that BC-3 comes from Level 9, BC-5 from Level 8, and that BC-1 and -2 can be no younger. This places BC-5 at 90–95,000 B.P. and BC-1, -2, and -3 at ca. 115,000 B.P. This is compatible with a late Middle Pleistocene age for Peat I and the more archaic fossil cranium at Florisbad (Butzer n.d.).

Evidently the presence of *H. sapiens sapiens* in an incontrovertible early Upper Pleistocene context requires radical reassessment of the evolution of anatomically modern people, presumably as an example of punctuated equilibrium in the peripheral continental setting of southern Africa in response to long-term, cyclic environmental change (Butzer 1977).

by OLIVER DAVIES

*Natal Museum, Pietermaritzburg, South Africa. 29 vi 78*

Rightmire is premature in submitting his view that *H. sapiens sapiens* originated in southern Africa perhaps as much as 115,000 years ago. His view rests on several hypotheses which are at present very shaky. We have for years awaited Beaumont's full publication of his excavations at Border Cave (and at other sites), and some remarkable statements have been made in preliminary reports and especially in the press. We require full publication of Butzer's sediment analysis to check his view that the cave was occupied in pre-Eem times (apparently from 195,000 B.P.), as the chronological sequence and nomenclature of the Early Würm and Eem stages are widely disputed; some of his other work in South Africa has been much questioned. Rightmire admits that the stratigraphic position of the human remains is unknown.

Beaumont has told me that he considers that the industry of Middle Stone Age type from Border Cave goes back to Eem I (usually dated about 122,000 B.P.; it is not clear where the figure 115,000 comes from). Despite the claim that an industry of admittedly Middle Stone Age type from Ethiopia (Wendorf and Schild 1974:55) is older than 181,000 B.P. (on the basis of potassium-argon analysis, which is suspect under 1,000,000 years), I see no reason yet to suppose that the Middle Stone Age from Border Cave is older than Eem II, i.e., rather older



than the date of 89,000 obtained on the skeleton by amino-acid racemisation (Protsch 1976:200). This method is still on trial and has yielded unexpected results from South Africa, e.g., dating the Hopefield skull at 42,000 B.P. If the date of 89,000 is anywhere near correct, the adult skeleton must have lain far down in the Middle Stone Age stratum, as the child from the top of this layer is dated 60,000 B.P.

The correlation of Eem shorelines in South Africa has been much confused. It has been assumed that a beach at about +8 m is Eem I, because this is calculated to be the worldwide absolute sea level of this stage; but I am investigating two levels of warm-water fauna in the South Cape (Davies 1972), and it may transpire that owing to emergence of the sub-continent through the Quaternary our Eem I beach is at +18 m and our +8 m beach is Eem II. This affects particularly the date of Klasies River Mouth.

The locality would be better described as on the border of Swaziland and Kwa-Zulu, or of Swaziland and Tongaland. The location is lat. 27°01'S long. 31°59'E.

by ISAAC J. GILEAD

*Archaeological Division, Ben-Gurion University of the Negev, P.O. Box 653, Beer-Sheba, Israel. 16 VII 78*

The cradle of modern man is still moving—to paraphrase Breuil. Rightmire and others are now looking for it in southern Africa, reexamining old finds with statistical procedures and refined dating techniques. It seems to me that the interesting conclusions concerning the antiquity of modern man should be accompanied by two reservations.

Since the relevance of the Florisbad, Fish Hoek and Springbok Flats remains is rejected by the author, and the Klasies River Mouth remains have not yet been thoroughly studied, the Border Cave sample is the sole subject of discussion. One should therefore bear in mind that the origin of *H. sapiens* is inferred from some cranial fragments, a mandible, and a postcranial bone—some excavated in 1940 and some found later in dumps. To illustrate how poor this sample is, one can compare it with finds from the Middle East. Work in Israel in the last 50 years has revealed remains of more than 25 individuals in clear-cut Middle Palaeolithic association. This large sample, especially the Carmel and Qafza caves specimens, of which many have modern traits, has long been considered proof of the antiquity of modern man in the Levant. This may also serve as an example of the amount of work—especially fieldwork—that will be required in southern Africa to validate these inferences from the Border Cave remains.

The importance of the Border Cave skeletal remains—along with that of other potential finds—will be fully appreciated only when the nature and chronology of the South African Middle Stone Age are better understood. The limits of this period have been pushed back considerably in recent years but are not yet clearly defined. An age which Rightmire defines as “before 50,000 B.P. and perhaps as early as 115,000 B.P.” is not sufficiently determined to support the suggested hypothesis. Moreover, as the date attributed to the Border Cave remains is beyond the range of C<sup>14</sup>, its validity is still problematic.

Rightmire should be congratulated on his contribution—the support he gives to the view that moderns originated outside Europe earlier than has been supposed. Despite its tentativeness, Border Cave is another case to be considered in any fruitful discussion dealing with the possible origins of modern man in general and certain autochthonous populations in particular.

by COLIN P. GROVES

*Department of Prehistory and Anthropology, Australian National University, Canberra, A.C.T. 2600, Australia. 31 VII 78*

Multiple discriminant analysis is a method which arranges the samples being compared in a multidimensional space, as

Rightmire correctly notes. Any specimen or sample subsequently interpolated into the analysis is therefore placed with respect to those samples on which the multidimensional space was erected; it cannot “strike out on its own,” inventing new parameters of variation. Rightmire cannot, therefore, conclude that “Border Cave is shown emphatically to be well within the range of modern African variation,” even merely “for the measurements used”: it was compared only with modern African samples, and who knows, if “Rhodesoids” had been used to add a further element of dispersion in the original analysis, whether Border Cave might not tend away from the moderns towards the “Rhodesoids”? All that can be said is that, if Border Cave is modern, it is closest to Hottentots; but it has not been shown to be modern, as Rightmire has given it no chance to be anything else.

It is a pity to have to criticise in this way the worker who has done most to reintroduce common sense into the study of human geographic variation in Africa by substituting original analysis for the inbuilt inertia which tends to have characterised this study in the past. But in this instance Rightmire has slipped from his usual rigour.

I would register a mild protest at the use in the penultimate paragraph of “*H. sapiens sapiens*” to denote the whole of modern humanity; and I am aware here that Rightmire is only following a common trend. The use of the trinomial gives a spurious impression of exactitude: it implies that someone has done an analysis of modern human populations to see whether the geographic variation of the species is susceptible of a subspecific interpretation. In the absence of such an analysis, it is as misleading to lump all populations together under one subspecific head as to allot them to a set number of cut-and-dried subspecies in the manner of Coon or John Baker.

by W. W. HOWELLS

*Peabody Museum, Harvard University, Cambridge, Mass. 02138, U.S.A. 31 VII 78*

I would amplify Rightmire's point as to the significance of the Hottentot association found for Border Cave. It should be recognized that, since only sub-Saharan populations are entered in the analysis, a test skull can only be classed as “African,” having no options to appear as European, Australian, etc. But the specific allocation is persuasive. With such broadly similar populations, a first discriminant function is the more apt to emerge as one of size (secondarily of sex), as is the case here, with Border Cave departing from the other populations mainly on this score. Further functions reflect shape differences, usually contrasting specific populations, again as is the case here. Therefore the maximum number of functions used simultaneously to classify will best damp the factor of size and should give the best reading of shape. Hence Rightmire's finding that Border Cave lies within the 5% centour of the Hottentot population based on six functions should indeed be better information than its position in figure 1, based on three discriminants only.

I likewise agree that analyses such as this one are the best way to advance matters step by step. As Rightmire suggests, nothing is gained simply by classing Border Cave, Fish Hoek, and Springbok Flats together with Florisbad as “*H. sapiens capensis*.” If, however, Border Cave can be objectively associated, i.e., by multivariate analysis, with “Hottentot,” and if in a comparable analysis by myself (1973), in this case also using non-African populations, Fish Hoek can be placed within a similar distance of “Bushman,” then something is done to argue a projection of this general Bushman-Hottentot population, though in a more robust form, well back into the past in South Africa.

by F. J. IRSIGLER

*P.O. Box 271, Krugersdorp 1740, South Africa. 26 vi 78*

The cranial fragments dug up since 1940 at Border Cave were originally thought to be related to Rhodesian man, Florisbad, and other "archaic" South African deposits, with no or only remote ties with modern Negroes and Bushmen. Rightmire's multidimensional statistical approach to metric affinities, however, links the Border Cave cranium directly with modern African populations. It is associated with the Final Middle Stone Age (in the terminology of Beaumont 1973) or the Upper Middle Pleistocene, if one accepts (as is generally the case) that the beginning of the Eemian Interglacial coincides with the end of the Middle Pleistocene, some 125,000 years ago (Klein 1973). In a wider context, this means that *H. sapiens* has evolved over a long period of time in the Old World, with in situ transition in various places from archaic to modern man. The suggested antiquity of the Border Cave cranium, furthermore, would indicate that *H. sapiens sapiens* lived in southern Africa as early as 115,000 years B.P. (Beaumont [1972] has put the transition to "modern" man at about 88,000 B.P.). Also, it implies that Hottentot and related Bushman-like people have inhabited southern Africa for a long time.

Interpretation based exclusively on quantitative morphometric measurements of cranial fragments, as in this study, is likely to render the establishment of ramifications into lineages more complicated than it really may be. A welcome complement to the morphometric approach is provided by morphogenetic consideration of the cranial contents in cases where endocranial casts are available, as in the Taung, Rhodesian, and SK 1585 (a robust *Australopithecus* from Swartkrans) specimens. The hallmark here is the palaeocephalic invagination and subsequent emergence of the Sylvian (lateral) fossa of the vertebrate brain. Using this criterion, one is led to the phyletic lineage Rhodesian, Australian Aborigines, Bushman, Neanderthal, European.

by KUBET LUCHTERHAND

*Department of Anthropology, Roosevelt University, 430 S. Michigan Ave., Chicago, Ill. 60605, U.S.A. 9 viii 78*

Rightmire's conclusion that the Border Cave skull is "well within the range of modern African variation" makes good sense in terms of the rest of his argument about its place in the phylogeny of late Pleistocene hominids in South Africa. My own work on mid-Pleistocene hominid radiations (Luchterhand 1974, 1978, n.d.) lends some support to the idea that late Pleistocene hominids in various parts of the world evolved from mid-Pleistocene hominid populations that were already widely distributed throughout the Old World. I favor an interpretation of hominid evolution after the mid-Pleistocene that sees all the various hominid populations as part of a single, large, heterogeneous species with sufficient gene flow throughout it to maintain the mutual interfertility that characterizes that species at the present time. Thus, I too prefer to see Middle Stone Age hominids of South Africa as derived from mid-Pleistocene hominid populations represented in South Africa by the Broken Hill and Hopefield remains. I also agree with Rightmire in being skeptical of the conclusion that the Middle Stone Age hominids in South Africa mark the "cradle" of *H. sapiens*, because I believe that the idea of such a "cradle" is ill-conceived to begin with.

I am skeptical, however, that Rightmire's discriminant analysis shows quite what he says it does. Since the populations among which the analysis discriminates are all modern African ones, and since (as the author carefully points out) the Border Cave skull is similar enough to "not differ greatly (e.g., at the species level) from specimens included in the initial calculations," it doesn't seem at all surprising that the discriminant functions would place the Border Cave skull within the range of the modern African populations studied; the analysis is

designed to do precisely that. A much more interesting use of discriminant analysis than the one discussed here would be one in which both modern African skulls and as large a collection of mid- and late Pleistocene hominid material from South Africa and elsewhere as could be gathered were used as the "known" material. If such an analysis placed the Border Cave specimen among the modern African sample rather than among the older fossil material, a rather stronger case for its modern aspect would be made. I do not disagree that the Border Cave specimen is modern in aspect—I have no informed opinion on that issue; I simply do not agree that the discriminant analysis described here could demonstrate that it is.

Another interesting point is suggested by the author's discussion. If one can improve the performance of the present analysis by viewing the original populations "simply as constellations of related peoples rather than as distinct populations," why not run a discriminant analysis with only two "known" populations—Bushman and Hottentots in one group, Negroes in the other? This would allow the statistical apparatus to be used directly to measure the affinities of the Border Cave skull to these two groups. Both the results of such an analysis and the comparisons that could be made with the present analysis and with those Rightmire (1970a, b; 1975) has previously reported would be very interesting.

Rightmire's work suggests one further point. Given that one can safely assume that the Border Cave skull was either male or female, it would be very interesting to see it run against only male and only female specimens to see whether it would conform more to one set of discriminant functions than to the other; Rightmire (1970a) reports that the discriminant functions to separate males in modern South African populations used somewhat different sets of measurements as the most important factors in the functions than did the discriminant functions to separate females in the same populations. Such analyses might provide either a hint as to the sex of the Border Cave skull (or any other specimen) or a way of eliminating sexual variation as a consideration in arguments about its modernity.

I would also have been interested in seeing a table of the ranges, standard deviations, and mean values of each of the 11 measurements used in the study for each of the "known" populations and for the Border Cave specimen itself. Such a table would make it much easier for anyone reading the article to determine whether the discriminant analysis is telling us anything that less elegant statistics might not have revealed more simply.

by HARRY V. MERRICK

*Department of Anthropology, Yale University, New Haven, Conn. 06520, U.S.A. 13 vii 78*

The demonstration that the Border Cave skull has an essentially modern morphology (in available measurements) and shows closer resemblance to Bushman and Hottentot crania than to Zulu, Sotho, and Venda crania certainly adds a new dimension to our knowledge of the potential affinities of the skull. However, I hope that we have not witnessed the premature birth of a Bushman/Hottentot ancestor some 50,000 years ago. I greatly fear that Rightmire's admittedly tentative suggestion that the Bushman/Hottentot morphology has a much greater antiquity than previously thought—based solely on the Border Cave skull, whose provenance is clearly uncertain—will be accepted as proven *fact* by the incautious reader. Given that "the implications of this finding depend heavily on the dating and provenance of the human remains, which are uncertain pending full publication of radiocarbon determinations, racemization assays, and nitrogen and uranium contents of hominid and faunal bone samples," he might have been well advised to wait for these results and to have replaced speculation with a more definitive statement.



My comments are from the viewpoint of a prehistorian specialized in Upper-Pleistocene-to-early-Holocene times in West Eurasia and Africa. The author has studied affinities of late Mid-Pleistocene to Holocene skeletal remains with earlier and with historical populations in Africa, making use of objective and thorough anatomical and quantitative methods. His findings are basic for anthropologists interested in biocultural events relating to the emergence of modern hominids within and outside Africa.

Research in allied disciplines during the last decade shows how much has been accomplished at the level of concepts, methods, and evidence. Attempts at explaining Pleistocene culture changes by reference to greater genotypic fitness may now appear naive. Human biologists and prehistorians will collaborate more fruitfully when investigating overlapping phenomena, for example, identifying mechanisms inducing cultural stability or change, isolation or dissemination, gene flow or deme formation and detecting adaptive traits in the phenotypes of ancient and recent human populations (e.g., Hiernaux 1968, Yellen and Harpending 1972). The notions of polyphyletic origins of *H. sapiens* (Coon 1962) and of sub-Saharan Africa's becoming an evolutionary and/or cultural backwater after the Middle Pleistocene (Clark 1960:321; 1970: chaps. 4, 5) are being reconsidered in view of new chronological, bioanthropological, and archaeological evidence (Vogel and Beaumont 1972; Klein 1973; Clark 1975; Rightmire 1976, 1978a). Prehistoric research by H. and J. Deacon, R. Klein, and P. Carter, among others, emphasizes the importance of cultural developments occurring at that time in southern Africa.

Before concluding that modern hominids appeared first in sub-Saharan Africa, however, it should be kept in mind that (a) estimates for Upper Pleistocene chronology in Europe are being revised downwards (van der Hammen, Wijmstra, and Zagwijn 1971:374); (b) the evolutionary position of Last Glacial Neanderthals (who are *sapiens* sensu lato) remains controversial (Brose and Wolpoff 1971); and (c) the postulated linkage between Neanderthals and fully *sapiens* hominids, with Middle and Upper Palaeolithic assemblages respectively, is more complex in reality (Vandermeersch 1972, Bordes 1972). A polycentric hypothesis for the emergence of the Advanced Palaeolithic (i.e., Upper Palaeolithic and early Late Stone Age) is now conceivable (Bricker 1976:134-43).

Until standardized and objective systems can be applied for the comparative analysis of tool-making habits of Upper Pleistocene populations in both Eurasia and Africa, it cannot be determined conclusively whether (a) Advanced Palaeolithic industries also developed earlier in Africa and (b) the otherwise real regional idiosyncrasies of the African Middle Stone Age have not been overstated at the expense of more basic similarities with the Eurasian Middle Palaeolithic. Application of the Bordes system to assemblages in Nubia (Marks 1968), the Egyptian Sahara (Schild and Wendorf 1975), and Ethiopia (Wendorf and Schild 1975) provides a more realistic common denominator.

Finally, it might prove informative if late Middle and early Upper Pleistocene hominid remains from sub-Saharan Africa were compared with those in Europe variously described as "late *erectus*," "early *sapiens*," or "archaic Neanderthals" (e.g., l'Arago, Swanscombe, Steinheim, La Chaise, Fontéchevade, Saccopastore, Ehringsdorf, and Krapina).

by MILAN THURZO

Slovenské Narodné Múzeum, Vajanského nábr. 2, 885 36 Bratislava, Czechoslovakia. 12 VII 78

Prínosom predloženej práce je ďalší pohľad na význam dospelého crania z Border Cave pre neskoropleistocénny vývoj

človeka. Pozoruhodné je najmä zistenie, že nález z Border Cave je svojimi 11 metrickými znakmi lebky blízky súčasným Bushmenom a Hottentotom, takže nemožno vylúčiť evolučné vzťahy medzi Border Cave a súčasnými africkými populáciami.

Na tomto mieste by som chcel upozorniť na jednu dôležitú skutočnosť – protirečenie medzi nedávnymi zisteniami de Villiers (1973) a novými poznatkami autora predloženej práce. Autorka de Villiers použila menší počet mier a inú štatistickú metódu, Mahalanobis's generalized distance ( $D^2$ ). Čo je príčinou rozdielnych poznatkov oboch autorov o vzťahu crania z Border Cave k moderným africkým populáciám? Je to počet použitých mier alebo iná štatistická metóda? Možno konštatovať, že metóda  $D^2$  je tak isto vhodná pre spracovávaný problém; niektorí autori, napr. van Vark (1976), uprednostňujú použitie metódy  $D^2$  v tom prípade, ak je počet prípadov vo vzorkách malý alebo ak sa jedná o izolovaný specimen neznámej afinity (za taký možno považovať i nález z Border Cave). Ak je príčinou spomínaných rozdielov medzi výsledkami oboch autorov kvalita, resp. kvantita metrických znakov, potom existuje teoretická možnosť, že tretí bádateľ dospeje za použitia iných mier na tom istom materiáli opäť k odlišným záverom.

I keď sú moderné multivariačné štatistické postupy veľkým prínosom, ich význam nesmieme preceňovať. Môže sa stať, že diskriminačná analýza alebo iné metódy rovnakej bioštatistickej úrovne potvrdia metrickú podobnosť takých súborov, kde ju nemôžeme logicky očakávať alebo môžeme metrickú podobnosť a priori vylúčiť. Ako príklad uvediem štatistické porovnanie súčasnostredovekých kranologických sérií z Európy, severnej Afriky a z Blízkeho Východu, ktoré vykonali Rösing et Schwidetzky (1977) pomocou metódy Penrose's approximate generalized distance. Títo autori porovnali 157 kranologických sérií (do úvahy brali série väčšie ako 10 jedincov a porovnávali 10 lebečných rozmerov), zistili jednotlivé Penrose's distances ( $PD$ ) medzi sériami. Z dendrogramu ako i z hodnôt  $PD$  vychádzajú najavo niektoré kuriózne skutočnosti, napríklad skupine stredoeurópskych slovanských pohrebísk z 9. storočia (Séria No. 115) sa najviac približuje lebečnými rozmermi talianske langobardské pohrebisko (No. 133), datované do 5.-8. stor. ( $PD = 0,04259$ ). Iným príkladom je slovanské pohrebisko Nitra-Lupka z 9. stor. n.l. (No. 114), ktorému je hodnotou ( $PD = 0,08047$ ) najbližšie arpádovské pohrebisko z územia Maďarska Szatymaz, datované do 9.-12. stor. n.l. (No. 102). Podobná je i situácia medzi skupinou troch slovanských pohrebísk z územia Československa, Poľska a Juho-slávie a k tejto skupine najviac sa približujúcim pohrebiskom z Dolnej Núbie (!), datovanom do 6.-13. stor. n.l.

Ak by sme chceli dôsledne interpretovať hodnoty  $PD$  z článku Rösing et Schwidetzky, museli by sme hľadať evolučné alebo príbuzenské vzťahy medzi napr. stredoeurópskou slovanskou skupinou a talianskou langobardskou populáciou alebo medzi skupinou európskych slovanských pohrebísk a pohrebiskom z Dolnej Núbie. Súčasný historicko-archeologický poznatky o týchto pohrebiskách nás však k tomu neoprávňujú.

Neúplne zachované a nie celkom presne datované dospelé cranium z Border Cave nemusí byť okrem toho typickým predstaviteľom populácie, žijúcej kedysi v okolí spomínanej jaskyne. Zaujímavé by tiež bolo súčasne s nálezom z Border Cave porovnať s modernými africkými populáciami za použitia tej istej metódy i vyššie spomínané podobné pleistocénne nálezy z Južnej Afriky.

[Rightmire's study presents a reassessment of the significance of the adult cranium from Border Cave for later Pleistocene human evolution. It is an interesting contention that in 11 skull measurements the Border Cave find is similar to present-day Bushmen and Hottentots, implying evolutionary links between Border Cave and some modern African populations.]

I would like to call attention to the important discrepancy between the recent findings of de Villiers (1973) and those of Rightmire's study. De Villiers used a smaller number of measurements and a different statistical method, Mahalanobis's generalized distance ( $D^2$ ). Is the disagreement in their findings due to the different number of measurements used or the difference in statistical methods? It is my contention that the  $D^2$  method is equally suitable for the task in question; some authors, for example, van Vark (1976), find application of the  $D^2$  method preferable in cases where there is only a small number of specimens available or an isolated find of unknown affinity (the Border Cave find may be so classified). If the reason for the disagreement lies in a lack of uniform quality or quantity in the measurements, it is theoretically possible for a third scholar, using yet other measurements, to arrive at other conclusions on the basis of the same material.

The importance of modern multivariate statistical analysis should not be overestimated. Discriminant analysis and other methods of similar biostatistical relevance sometimes assert metric similarities that are not logically anticipated or can even be ruled out. For example, Rösing and Schwidetzky (1977) have made a statistical comparison of early medieval cranial materials from Europe, North Africa, and the Near East through application of Penrose's approximate generalized distance. They compared 157 cranial series (each containing more than ten specimens) on ten measurements and determined the Penrose distance ( $PD$ ) between the series. Some curious findings are apparent from the resulting dendrogram: A group of Central European Slavonic cemeteries from the 9th century (Series No. 115) is very similar to an Italian Langobard cemetery (No. 133) dated to the 5th–8th century ( $PD = 0.04259$ ). Again, there are similarities between the Slavonic cemetery of Nitra-Lupka, from the 9th century (No. 114), and the Arpadian cemetery of Szatymaz in Hungary (No. 102), dated to the 9th–12th century ( $PD = 0.08047$ ). Similarly, links can be perceived between three Slavonic cemeteries in Czechoslovakia, Poland, and Yugoslavia and a cemetery from Lower Nubia (!) dated to the 6th–13th century.

To interpret the  $PD$  data contained in the Rösing and Schwidetzky article consistently, we would have to look for evolutionary similarities and other related characteristics between, for example, the Central European Slavonic group and the Italian Langobard population or between the group of European Slavonic cemeteries and the Lower Nubian one. Contemporary historico-archeological findings regarding these cemeteries would not justify such a contention.

The single adult cranium from Border Cave, incompletely preserved and not precisely dated, may be not at all representative of the population that once inhabited the area of the cave. Further comparisons would be desirable and interesting. In addition to the Border Cave find, other South African Pleistocene finds might be profitably compared with the data on modern African populations by the same method.]

by S. R. WILSON

*Department of Statistics, Australian National University, P.O. Box 4, Canberra, A.C.T. 2600, Australia. 25 vii 78*

The main conclusions of this paper appear to be based on a statistical analysis the validity of which is dubious. Firstly, the author claims that "one multivariate statistical approach which permits assignment of single fossils to one or another of several test groups is discriminant analysis." This statement may be true *only* if it is *known* that the fossil belongs to one of the populations (and certain distributional assumptions hold). Secondly, the populations from which one has sampled should be *a priori* distinct, *clearly* defined, and nonoverlapping, in other words, not amenable to manipulation such that "results improve substantially." Thirdly, the claim that "there is little

doubt that the analysis is reliable, even given the formal parametric criteria which must theoretically be met" is false (for "parametric" one should read "distributional"). The analysis may be sensitive to deviations from the assumption of homogeneity of the variance-covariance matrices for the groups, and deviations from normality do greatly affect the allocation to groups (see Lachenbruch, Sneeringer, and Revo 1972). Fourth, "analysis of 11 measurements yields seven discriminant functions" should read "analysis of eight groups. . . ." Also, to remove confusion with the term "linear discriminant functions," the discriminant functions in this context could be termed canonical variates. Fifth, the author gives no details as to how the skulls have been reassigned to their groups, and most standard computer packages use biased techniques (see, for example, Lachenbruch and Mickey 1968). Also, for small sample sizes the odds for an individual's belonging to one population compared with another may be grossly in error using the discriminant-function technique (Aitchison, Habbema, and Kay 1977). Sixth, the percentage of successful identification bears no relation in general to "the small number of measurements available." Seventh, in the statement about the location of Border Cave with regard to the Hottentot centroid, it would make more sense to replace .05 by .95. Finally, the conclusion that "Border Cave is shown emphatically to be well within the range of modern African variation for the measurements used" does *not* necessarily follow from this particular statistical analysis.

Further discussion of these and other points is given by Corruccini (1975). Overcoming all the difficulties involved with handling data of the type discussed in this paper may be impossible. A first step towards overcoming some of them is made by Thorne and Wilson (1977).

by J. J. WYMER

*17 Duke St., Bideston, Ipswich, Suffolk IP7 7EW, England. 27 vi 78*

The apparent early date of the Border Cave human remains has caused Rightmire to consider the question of phyletic evolution or replacement, and he suggests that the former is more likely in this part of Africa, if not elsewhere. The archaeological evidence from Klasies River Mouth in the Eastern Cape Province, which Ronald Singer and I excavated in 1966–68, supports this view. Some of the human fragments from Klasies River Mouth are associated with the earliest phase of occupation, dated to the equivalent of the Last Interglacial in European terms, on the evidence of sea levels, oxygen isotope analysis, and molluscan fauna. They are accompanied by a Middle Stone Age industry typified by quartzite flake-blades and unifacial points. At least one mandible is fully *H. sapiens sapiens*.

The sequence of occupation at Klasies River Mouth is the longest unbroken one in the Late Pleistocene of southern Africa; Middle Stone Age hunting communities exploited the caves and rockshelters from the middle of the Last Interglacial to the time when the sea eventually receded because of the worldwide fall in ocean level in the Last Glacial. There is thus a record of at least 50,000 years of continuous occupation, in the sense that the site was never vacated long enough for soils to form on the midden surfaces or erosion to take place between one series of levels and another. The significant point is that during this immense span of time, apart from minor traits such as a reduction in flake-blade size, the same industrial tradition persisted. The strong implication is that only one population was involved. If *H. sapiens sapiens* had arrived as a replacement, it is inconceivable that the stone industries would not have altered. Only in one phase, before the sea had receded but after a vast series of deposits 15 m high had accumulated, was there a marked and sudden change in the industrial typology: a Howieson's Poort industry is wedged between Phases Middle

Stone Age II and III. This presumably represents an intrusive population. Unfortunately, no human remains were found in these levels. It could have brought a genetic change into the existing population, but it does nothing to alter the inference that *H. sapiens sapiens* was evolving slowly without major external influences during the Late Pleistocene in this highly favoured part of the African coast.

## Reply

by G. PHILIP RIGHTMIRE

Binghamton, N.Y., U.S.A. 3 x 78

Divers colleagues in anthropology and related disciplines are never likely to reach a unanimous verdict concerning papers circulated for CA☆ treatment. Given this climate of healthy skepticism, I am pleased that my short article has drawn comments from a number of informed scholars, most of whom are willing to agree at least in part with what I have to say.

I am especially glad to have Butzer's summary of litho-stratigraphic and sedimentological work done at Border Cave, as the significance of the hominid remains is very much dependent on their position in the sequence at the site. Butzer's analysis with reference to oxygen isotope stages and radiocarbon dates helps to clarify the stratigraphic framework, and micro-analytical results point toward an early Upper Pleistocene provenance for the adult cranium. Beaumont's discussion of archaeological material excavated in the cave is also helpful, but I suspect that our views concerning Florisbad, the Omo skeletons, and the pattern of human evolution in Africa are diverging rapidly. Wymer's evidence that people of a single Stone Age industrial tradition were present over a long span of Upper Pleistocene time at Klasies River Mouth is intriguing, and a complete report on this important Cape coastal site will be most welcome.

Other generally supportive comments include those of Howells, Bilsborough, and Luchterhand. The latter workers both indicate that a list of measurements taken on Border Cave and the modern comparative skeletons would be useful, and this information is presented in table 2. Luchterhand also outlines ways in which the discriminant statistics might be modified or extended. I do not see how a group of Pleistocene fossil crania could be included in the analysis along with the samples of living African populations. Middle Pleistocene hominid remains are rare in sub-Saharan Africa, and a group comprising all of the known specimens would still be very small. And I do not think that it would make good biological

sense to lump archaic hominids from all over the Old World into a single mixed assemblage, even to provide wholesale contrast to variation in recent *H. sapiens*.

Gilead and Rolland urge caution in dealing with fragmentary human fossils and argue that additional anatomical studies and fieldwork will be needed before we can make real sense of the later Pleistocene prehistoric record. I agree broadly with these sentiments and second Rolland's call for fresh comparison of the African remains with those unearthed in Europe. This should be done systematically, and Bilsborough speaks to the dangers of treating all of the specimens simply as variations on a Neanderthal theme. Gilead and Rolland attribute to me, and express reservations about, a conclusion that modern hominids appeared first in southern Africa. This I have not said, although my discussion is purposely limited to African evidence. While dating is generally problematical, I am quite happy to concede the antiquity of fully human skeletal remains found elsewhere.

Davies and Merrick suggest that the stratigraphy of the Border Cave deposits and the provenance of the human material are incompletely documented, but Butzer's and Beaumont's comments should help to fill the gaps in my own presentation. Davies also refers to amino-acid racemization-deduced ages for the Border Cave adult and infant skeletons. These dates of 89,000 B.P. and 60,000 B.P. are provided by Protsch (1975), but there is some question as to how they were obtained. According to J. L. Bada (unpublished), samples of the hominid bones were analyzed in his laboratory in 1973, but because of uncertainties in the results no racemization ages were determined. Given these circumstances, the dates cited by Protsch should be ignored.

Three commentators criticize my work on statistical grounds or at least question whether I have used discriminant analysis appropriately. Some of the issues raised are important ones, although there is scant agreement even among statisticians as to how they may best be settled. Thurzo, for example, suggests that Mahalanobis's generalized distance ( $D^2$ ) would provide a better classification of the Border Cave cranium with respect to the African populations used in the analysis. To support this contention, he cites van Vark (1976). Van Vark argues that  $D^2$  can be used for assessing the affinities of single skulls provided that one or more reference samples is available. Distances can be calculated with the variance-covariance matrix taken from such a reference group, but there is a major difficulty. According to van Vark, a reference data set should consist of measurements obtained from a "very large" number of individuals of known sex and age, all drawn from a single homogeneous modern population. So far, information of this sort is lacking. A different

TABLE 2

MEASUREMENTS OF BORDER CAVE AND EIGHT COMPARATIVE SERIES OF MODERN AFRICAN CRANIA

MEASUREMENTS	BORDER CAVE	BUSHMEN		HOTTENTOT	ZULU		SOTHO		VENDA
		N=22 Males	N=17 Females	N=18 Males	N=40 Males	N=32 Females	N=35 Males	N=30 Females	N=33 Males
Glabella protrusion.....	6	4.77	3.47	5.16	5.12	4.50	5.11	4.13	5.18
Supraorbital projection.....	10	6.72	5.52	6.72	6.20	5.56	6.14	5.40	6.24
Biorbital chord.....	112	97.86	93.52	98.55	101.87	98.37	101.91	95.96	101.63
Nasion subtense.....	15	16.36	15.52	16.16	17.57	15.68	16.71	15.76	18.78
Nasion angle.....	15	18.22	18.17	17.83	19.00	17.53	18.08	18.13	20.27
Malar height.....	21	19.45	17.05	19.44	19.85	18.56	20.51	19.10	19.51
Frontal chord.....	116	110.54	105.47	112.38	112.35	110.56	113.25	109.30	113.45
Frontal subtense.....	32	29.36	29.41	28.61	27.72	28.34	28.62	28.23	27.93
Frontal angle.....	32	31.09	33.11	30.00	30.17	30.87	30.28	31.43	29.63
Orbital breadth.....	45	39.40	37.70	39.11	38.97	39.03	39.34	38.13	40.51
Mastoid length.....	26	24.59	20.29	24.88	28.05	24.53	28.28	23.73	27.30

stance is taken by other authors, e.g., Corruccini (1975), who declare  $D^2$  unsuitable in the very situations in which Thurzo claims it should be employed, cases in which samples are relatively small and isolated individuals must be dealt with.

Groves and Wilson both suggest that I have erred in attempting to place a Pleistocene cranium within a discriminant framework made up of recent African populations. Theoretically their point is correct, in that the use of discriminant functions to allocate new individuals should be restricted to cases in which it is known that the specimens to be classified belong to one of the groups included in the analysis. This principle was made explicit 30 years ago by Rao (1948). In the same paper, however, Rao employs discriminant analysis to assign an excavated British skull to an Iron Age rather than a Bronze Age population. In this example, archaeological evidence suggests that the Highdown skeleton should belong to one or the other of the two test series, although this cannot be established with absolute certainty. Since 1948, discriminant statistics have been employed in many similar situations, apparently with good results. More recently, Rao (1973) has discussed reasonable criteria for determining whether discriminant assignments of individuals are justified (see also Campbell 1978). In practical terms, it may be important that a fossil to be classified resembles some subset of the possible parent populations, but especially in biological work one can hardly insist on a priori proof of membership in one of the test samples. If the functions are constructed so as to identify the important directions of between-group variation and to provide an interpretable scale for group separation in the discriminant space, then the position of a fossil on these axes should be meaningful, even if the individual lies somewhat beyond the boundaries of the samples on which the analysis is based.

Wilson seems to feel that I have committed additional sins and complains that the method of allocating crania to groups is not spelled out. The problem of inferring group membership from an individual's discriminant scores is fairly complex, though chi-square can be used as an index relating skulls to the several group centroids. These classification chi-squares are computed by pre- and postmultiplying the inverse of a sample dispersion matrix by a vector of an individual's deviation scores (Cooley and Lohnes 1962). The figures resulting for each skull are used as the basis for assignment, and the distance of a particular individual from each of the population centroids may be tested for significance. It is important to emphasize that where such individuals are dissimilar to populations included in the analysis, they may be excluded statistically from membership in any group. My results in fact show that the Border Cave cranium lies closest to the Hottentot centroid and that it is not excluded from membership in the Hottentot distribution of skulls.

Some of Wilson's other comments regarding my approach are not very helpful and a few offer little more than gratuitous corrections to my statistical language. Certainly multivariate procedures can be abused by nonspecialists. However, one has to strike a balance between using techniques such as discriminant analysis inappropriately as all-purpose tools and never using them at all because distributional assumptions made about the data may not be met precisely. Different points of view have been argued in the recent literature (see Corruccini 1975 and a response by Campbell 1978). The aim of such statistical methods is only to extract as much information as possible from the data available, and my own feeling is that some insight concerning Border Cave can be obtained from multiple discriminant analysis applied with a degree of caution. Where measurements are complete for all individuals, sample sizes are adequate (greater than the number of measurements in each case), and the populations and individuals being compared are all closely related (members of one species or subspecies), then there is some basis for confidence in the results.

## References Cited

- AITCHISON, J., J. D. F. HABBEMA, and J. W. KAY. 1977. A critical comparison of two methods of statistical discrimination. *Applied Statistics* 26:15-25. [SRW]
- BADA, J. L., and L. DEEMS. 1975. Accuracy of dates beyond the  $^{14}\text{C}$  dating limit using the aspartic acid racemisation reaction. *Nature* 255:218-19.
- BEAUMONT, P. B. 1973. Border Cave: A progress report. *South African Journal of Science* 69:41-46.
- . 1978. Border Cave. Unpublished master's thesis, University of Cape Town, Cape Town, South Africa. [PBB]
- BEAUMONT, P. B., and A. K. BOSHIER. 1972. Some comments on recent findings at Border Cave, northern Natal. *South African Journal of Science* 68:22-24.
- BEAUMONT, P. B., and J. C. VOGEL. 1972. On a new radiocarbon chronology for Africa south of the Equator. *African Studies* 31:65-89, 155-82. [PBB]
- BEAUMONT, P. B., H. DE VILLIERS, and J. C. VOGEL. 1978. Modern man in sub-Saharan Africa prior to 49,000 years B.P.: A review and evaluation, with particular reference to Border Cave. *South African Journal of Science*. In press. [PBB]
- BILSBOROUGH, A. 1973. A multivariate study of evolutionary change in the hominid cranial vault and some evolution rates. *Journal of Human Evolution* 2:387-403. [PBB]
- BORDES, F. 1972. "Du Paléolithique moyen au Paléolithique supérieur: Continuité ou discontinuité?" in *Origine de l'homme moderne*. Edited by F. Bordes, pp. 211-18. Paris: UNESCO. [NR]
- BOURLIÈRE, F. 1963. "Observations on the ecology of some large African mammals," in *African ecology and human evolution*. Edited by F. C. Howell and F. Bourlière, pp. 43-54. Chicago: Aldine. [PBB]
- BRICKER, H. M. 1976. Upper Palaeolithic archaeology. *Annual Review of Anthropology* 5:133-48. [NR]
- BROSE, D. S., and M. H. WOLPOFF. 1971. Early Upper Palaeolithic man and Late Middle Palaeolithic tools. *American Anthropologist* 73:1156-93. [NR]
- BROTHWELL, D. R. 1963. Evidence of early population change in central and southern Africa: Doubts and problems. *Man* 63:101-4.
- BUTZER, K. W. 1973. Re-evaluation of the geology of the Elandsfontein (Hopefield) site, southwestern Cape, South Africa. *South African Journal of Science* 69:234-38.
- . 1977. Environment, culture, and human evolution. *American Scientist* 65:572-84. [PBB]
- . 1978. Sediment stratigraphy of the Middle Stone Age sequence at Klasies River Mouth, Tzitzikamma Coast, South Africa. *South African Archaeological Bulletin* 33(2). In press.
- . n.d. Geomorphology and stratigraphy of paleontological and archeological sites at Florisbad and Vlakkrail, Orange Free State, South Africa. MS. [KWB]
- BUTZER, K. W., P. B. BEAUMONT, and J. C. VOGEL. 1978. Lithostratigraphy of Border Cave, Kwa Zulu, South Africa: A Middle Stone Age sequence beginning ca. 195,000 B.P. *Journal of Archaeological Science* 5(3). In press.
- CAMPBELL, N. A. 1978. Multivariate analysis in biological anthropology: Some further considerations. *Journal of Human Evolution* 7:197-203.
- CLARK, J. D. 1959. *The prehistory of southern Africa*. Harmondsworth: Pelican. [PBB]
- . 1960. Human ecology during Pleistocene and later times in Africa south of the Sahara. *CURRENT ANTHROPOLOGY* 1: 307-24. [NR]
- . 1970. *The prehistory of Africa*. London: Thames and Hudson. [PBB, NR]
- . 1975. Africa in prehistory: Peripheral or paramount? *Man* 10:175-98. [NR]
- COOKE, H. B. S. 1964. "Pleistocene mammal faunas of Africa with particular reference to South Africa," in *African ecology and human evolution*. Edited by F. C. Howell and F. Bourlière, pp. 65-116. Chicago: Aldine. [PBB]
- COOKE, H. B. S., B. D. MALAN, and L. H. WELLS. 1945. Fossil man in the Lebombo Mountains, South Africa: The "Border Cave," Ingwavuma. *Man* 45:6-13.
- COOLEY, W. W., and P. R. LOHNES. 1962. *Multivariate procedures for the behavioral sciences*. New York: Wiley.
- COON, C. S. 1962. *The origin of races*. New York: Knopf. [PBB, NR]
- CORRUCCINI, R. S. 1975. Multivariate analysis in biological anthropology: Some considerations. *Journal of Human Evolution* 4:1-19. [SRW]
- DART, R. A. 1968. The birth of symbology. *African Studies* 27:15-27. [PBB]
- DAVIES, O. 1972. Pleistocene shorelines in the southern and southeastern Cape Province (Part 2). *Annals of the Natal Museum* 21(2): 225-79. [OD]

- DE VILLIERS, H. 1973. Human skeletal remains from Border Cave, Ingwavuma District, KwaZulu, South Africa. *Annals of the Transvaal Museum* 28:229-56.
- . 1976. A second adult human mandible from Border Cave, Ingwavuma District, KwaZulu, South Africa. *South African Journal of Science* 72:212-15.
- DREYER, T. F. 1938. The archaeology of the Florisbad deposits. *Archeologische Navorsing, Nasionale Museum, Bloemfontein* 1:65-77. [PBB]
- GARROD, D. A. E. 1955. The Mughareh el-Emireh in Lower Galilee: Type-station of the Emiran industry. *Journal of the Royal Anthropological Institute* 85:141-62. [PBB]
- HAY, R. L. 1975. Olduvai Gorge: Stratigraphy, age and environments. *Journal of the Geological Society of London* 131:545 [PBB]
- HIERNAUX, J. 1968. *La diversité humaine en Afrique subsaharienne*. Bruxelles: Université Libre. [NR]
- HOWELLS, W. W. 1973. *Cranial variation in man*. Papers of the Peabody Museum 67.
- . 1974. Neanderthals: Names, hypothesis and scientific method. *American Anthropologist* 76:24-38. [PBB]
- . 1976. Explaining modern man: Evolutionists versus migrationists. *Journal of Human Evolution* 5:477-95.
- INSKEEP, R. R. 1969. "The archaeological background," in *The Oxford history of South Africa*, vol. 1. Edited by M. Wilson and L. Thompson, pp. 1-39. Oxford: Clarendon Press. [PBB]
- KLEIN, R. G. 1970. Problems in the study of the Middle Stone Age of South Africa. *South African Archaeological Bulletin* 25:127-35.
- . 1973. Geological antiquity of Rhodesian man. *Nature* 244:311-12.
- . 1974. Environment and subsistence of prehistoric man in the southern Cape Province, South Africa. *World Archaeology* 5:249-84. [PBB]
- . 1976. The mammalian fauna of the Klasies River Mouth sites, southern Cape Province, South Africa. *South African Archaeological Bulletin* 31:75-98. [PBB]
- . 1977. The mammalian fauna from the Middle and Later Stone Age (Upper Pleistocene) levels of Border Cave, Natal Province, South Africa. *South African Archaeological Bulletin* 32:14-27.
- KUKLA, G. L. 1976. Around the Ice Age world. *Natural History* 85(4):56-61.
- LACHENBRUCH, P., and M. R. MICKEY. 1968. Estimation of error rates in discriminant analysis. *Technometrics* 10:1-11. [SRW]
- LACHENBRUCH, P. A., C. SNEERINGER, and L. T. REVO. 1972. Robustness of the linear and quadratic discriminant function to certain types of non-normality. *Communications in Statistics* 1:39-56. [SRW]
- LUCHTERHAND, KUBET. 1974. Mid-Pleistocene hominid distribution and adaptation in eastern Asia. Unpublished Ph.D. dissertation, University of Chicago, Chicago, Ill. [KL]
- . 1978. "Late Cenozoic climate and mammalian evolutionary patterns and Middle Pleistocene hominid adaptation in eastern Asia," in *Views of the past*. Edited by L. G. Freeman. The Hague: Mouton. [KL]
- . n.d. "The distribution and palaeoecology of mid-Pleistocene hominids in eastern Asia." *Proceedings, IX Congrès de la Union Internationale des Sciences Préhistoriques et Protohistoriques, Nice, France, 13-18 September 1976*. In press. [KL]
- MALAN, B. D. 1949. Magosian and Howieson's Poort. *South African Archaeological Bulletin* 4:34-36. [PBB]
- MARKS, A. E. 1968. "The Mousterian industries of Nubia," in *The prehistory of Nubia*, vol. 1. Edited by F. Wendorf, pp. 194-314. Fort Burgwin and Southern Methodist University Press. [NR]
- MASON, R. J. 1957. The Transvaal Middle Stone Age and statistical analysis. *South African Archaeological Bulletin* 12:119-43. [PBB]
- OAKLEY, K. P., and B. G. CAMPBELL. 1967. *Catalogue of fossil hominids. Pt. 1. Africa*. London: Trustees of the British Museum (Natural History). [PBB]
- PROTSCH, R. 1975. The absolute dating of Upper Pleistocene sub-Saharan fossil hominids and their place in human evolution. *Journal of Human Evolution* 4:297-322.
- . 1976. "Comparison of absolute dates by radiocarbon and amino-acid dating on Upper Pleistocene hominids." *IX Congrès de la Union Internationale des Sciences Préhistoriques et Protohistoriques, Colloquium I*, pp. 180-211. [OD]
- RAO, C. R. 1948. The utilization of multiple measurements in problems of biological classification. *Journal of the Royal Statistical Society B10*:159-203.
- . 1973. *Linear statistical inference and its applications*. New York: Wiley.
- RIGHTMIRE, G. P. 1970a. Iron Age skulls from southern Africa reassessed by multiple discriminant analysis. *American Journal of Physical Anthropology* 33:147-67.
- . 1970b. Bushman, Hottentot, and South African Negro crania studied by distance and discrimination. *American Journal of Physical Anthropology* 33:169-96. [KL]
- . 1975. New studies of post-Pleistocene human skeletal remains from the Rift Valley, Kenya. *American Journal of Physical Anthropology* 42:351-69.
- . 1976. Relationships of Middle and Upper Pleistocene hominids from sub-Saharan Africa. *Nature* 260:238-40.
- . 1978a. Florisbad and human population succession in southern Africa. *American Journal of Physical Anthropology* 48:475-86.
- . 1978b. Human skeletal remains from the southern Cape Province and their bearing on the Stone Age prehistory of South Africa. *Quaternary Research* 9:219-30.
- RÖSING, F. N., and I. SCHWIDETZKY. 1977. Vergleichend-statistische Untersuchungen zur Anthropologie des frühen Mittelalters (500-1000 n.d. hr Z.). *Homo* 28:65-115.
- SAMPSON, C. G. 1972. *The Stone Age industries of the Orange River Scheme and South Africa*. National Museum, Bloemfontein, Memoir 6. [PBB]
- . 1974. *The Stone Age archaeology of South Africa*. New York: Academic Press. [PBB]
- SARICH, V. M. 1971. "Human variation in an evolutionary perspective," in *Background for man*. Edited by P. Dolhinow and V. M. Sarich, pp. 182-91. Boston: Little, Brown.
- SCHILD, R., and F. WENDORF. 1975. "New explorations in the Egyptian Sahara," in *Problems in prehistory: North Africa and the Levant*. Edited by F. Wendorf and A. E. Marks, pp. 65-112. Dallas: Southern Methodist University Press. [NR]
- SHACKLETON, N. J. n.d. Stratigraphy and chronology of the Klasies River Mouth deposits: Oxygen isotope evidence. MS. [KWB]
- SINGER, R., and J. WYMER. n.d. *The archaeology of Klasies River Mouth*. Chicago: University of Chicago Press. In preparation.
- SZABO, B. J., and K. W. BUTZER. n.d. Uranium-series dating of lacustrine limestones from pan deposits with final Acheulian assemblage at Rooidam, Kimberley District, South Africa. *Quaternary Research*. In press. [KWB]
- THORNE, A. M. 1977. The centre and the edge. Paper given at the VIIIth Pan-African Congress of Prehistory and Quaternary Studies, Nairobi, Kenya. [AB]
- THORNE, A. G., and S. R. WILSON. 1977. Pleistocene and recent Australians: A multivariate comparison. *Journal of Human Evolution* 6:393-402. [SRW]
- VAN DER HAMMEN, T., T. A. WIJSTRA, and W. H. ZAGWIJN. 1971. "The floral record of the Late Cenozoic of Europe," in *Late Cenozoic glacial ages*. Edited by K. K. Turekian, pp. 391-424. New Haven: Yale University Press. [NR]
- VANDERMEERSCH, B. 1972. "Récentes découvertes de squelettes humains à Qafzeh (Israel): Essai d'interprétation," in *Origine de l'homme moderne*. Edited by F. Bordes, pp. 49-54. Paris: UNESCO. [NR]
- VAN NOTEN, F. 1977. Excavations at Matupi Cave. *Antiquity* 51:35-40. [PBB]
- VAN RIET LOWE, C. 1929. Notes on some stone implements from Tuinplaats, Springbok Flats. *South African Journal of Science* 26:623-30. [PBB]
- VAN VARK, G. N. 1976. A critical evaluation of the application of multivariate statistical methods to the study of human populations from their skeletal remains. *Homo* 27:94-114. [MT]
- VOGEL, J. C., and P. B. BEAUMONT. 1972. Revised radiocarbon chronology for the Stone Age in South Africa. *Nature* 237:50-51.
- WEISS, K. M., and T. MARUYAMA. 1976. Archeology, population genetics, and studies of human racial ancestry. *American Journal of Physical Anthropology* 44:31-49.
- WELLS, L. H. 1969. *Homo sapiens after Linn.: Content and earliest representatives*. *South African Archaeological Bulletin* 24:172-73.
- . 1972. Late Stone Age and Middle Stone Age tool-makers. *South African Archaeological Bulletin* 27:5-9.
- WENDORF, F., and R. SCHILD. 1974. *A Middle Stone Age sequence from the Central Rift Valley, Ethiopia*. Wrocław: Polska Akademia Nauk. [OD, NR]
- YELLEN, J., and H. HARPENDING. 1972. Hunter-gatherer populations and archaeological inference. *World Archaeology* 4:244-53. [NR]