All these papers illustrate nicely the potential of collaboration between paleoanthropology and relevant natural sciences. As an interesting intellectual exercise, the reader might wish to read each of the papers twice, ignoring all data and conclusions about environmental context and lifeways derived from the natural sciences at the second reading. In every case, the variation in readings will cause a considerable difference in the interest and utility of the articles. This is not just a reflection of the title and focus of the symposium. It is a result of the impossibility of deriving useful conclusions about prehistoric human lifeways without understanding their natural context. That, in itself, is perhaps the moral of our story, as presented in these papers, and the significance of the separation of paleoanthropology from traditional prehistory. In our attempt to understand man's physical and behavioral evolution, we are at long last learning to distinguish Evolution from the concept of Progress and to equate it, as rightfully must be done, with Adaptation.

NOTE

[1] Unfortunately four participants in that symposium (L. G. Freeman, G. L. Isaac, A. J. Jelinek and E. N. Wilmsen), were unable to include their papers with those presented here.

REFERENCE CITED

Clark, J. D., and F. C. Howell, eds.
1966 Recent studies in Paleoanthropology. American Anthropologist 68 (Pt. 2):1-394.

Another Look at the Australopithecine Cave Breccias of the Transvaal[1]

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A reexamination of sediments from the Transvaal Australopithecine cave breccias suggests that at each site accumulation took place under relatively dry conditions. The sediments themselves do not *support the hypothesis of alternating occupations under different climatic and vegetational conditions by australopithecines with distinct dietary adaptations.*

THE DIETARY HYPOTHESIS OF AUSTRALOPITHECINE DIFFERENTIATION

IN MOST DISCUSSIONS of australopithecine phylogenies, considerable emphasis is placed on the contrasts of dentition between gracile, robust, and hyper-robust forms. One body of thinking, most lucidly championed by J. T. Robinson (1963, 1967), explains these differences by dietary adaptations, suggesting that the relatively small anterior teeth and relatively massive premolars of the robust australopithecine would be most suited to a vegetarian. On the other hand, the dentition of the gracile form, with well-developed incisors and canines, is believed to indicate an omnivorous diet, including substantial proportions of meat and other animal protein. One of the key arguments used by Robinson to support this dietary hypothesis is that of the sediments in which the different australopithecine "populations" were found embedded. In the case of the Transvaal cave breccias there seem to be foolproof arguments that the robust australopiths were present—exclusively so according to

Robinson—during relatively wet periods with more luxuriant vegetation, while gracile australopiths completely replaced the robust forms during drier phases.

This theory of ecological differentiation was anchored on the meticulous sediment studies of C. K. Brain (1958, 1967). Not only were Brain's interpretations used to infer that the gracile and robust australopiths exploited different environments, but they were variously applied to establish a sequence of so-called pluvial and interpluvials during the early Pleistocene. This paleoclimatic "curve," in turn, was employed to support Robinson's (1963) hypothesis of adaptive radiation amid the environmental vicissitudes of the South African Plio-Pleistocene, by supporting a purported sequence of wet and dry climates that provided repeated periods of ecological stress. At the same time this "curve" was further used as a stratigraphic tool to interrelate the cave breccias of the Transvaal, e.g., by Brain (1958), Robinson (1967, with earlier references) and Cooke (1963).

BACKGROUND AND PURPOSE OF THIS PAPER

Brief examination of Sterkfontein and Swartkrans in 1969 and 1970, and of Makapansgat and Kromdraai in 1970, suggested to me that the premises to Brain's interpretations were more ambiguous and, in certain instances, more debatable than I had realized. Laboratory examination of a very limited sample suite corroborated Brain's analytical results, but at the same time supported misgivings I had about some aspects of interpretation of the sediment bodies examined at the various sites. My reactions were framed with reference to extended and intensive study of comparable deposits on coastal limestones of the Balearic Islands (Butzer and Cuerda 1962; Butzer 1963). There, in the Mediterranean region, red detrital sediments, derived from residual soils, are well represented in complex stratigraphic relationships with interglacial beaches, cave breccias, alluvial bodies, and eolianites. Known as *limons rouges*, or red silts, these deposits vary widely in facies, allowing more perspectives as to their overall interpretation (see Butzer 1971:306ff). At the same time, their dating—with respect both to assemblages of marine mollusca and to isotopic dating by the thorium-uranium technique—provides both a firmer internal stratigraphy and a crude means of estimating rates of sedimentation (see Butzer and Cuerda 1962; Stearns and Thurber 1965, 1967).

The present paper does not aim to contradict Brain's conclusions; instead it hopes to show that the sedimentary evidence from the australopithecine breccias is still problematical and that further work and reevaluation will be necessary. In order to do so, the stratigraphic column at each site must be amplified, to obtain estimates of cumulative sediment thickness, and to permit tracing of more objectively defined facies, both horizontally and vertically. At the same time the laboratory evidence needs to be reconsidered in comparison with the Balearic parallels. Consequently, this paper aims to discuss a problem, and urge further field study, rather than to present a body of analytical data. In this connection I would like to emphasize that I have profited greatly from repeated discussions with C. K. Brain (The Transvaal Museum), who not only facilitated but welcomed my visits to the sites. Appreciation is also due to Alun Hughes (Witwatersrand University), who introduced me to Makapansgat, and provided further opportunity for critical discussion.

THE NATURE OF THE AUSTRALOPITHECINE BRECCIAS

The australopithecine sites of the Transvaal form part of old cave fills. These caves were developed in dolomitic limestone as a result of karstic solution, while the deposits within were derived from several sources: (a) blocks of dolomite, fallen from the roof and walls of interior caverns, vertical shafts, or sink-holes; (b) insoluble residues of oxides, quartz and chert left by the breakdown of dolomite; (c) carbonate precipitates, mainly flowstones; (d) colluvial detritus, derived from outside of the cave and by rainwash and mass-movements, ranging from reddish decalcified soils to crude dolomite scree, accumulating by gravity at the base of rock outcrops or washed down the hillsides. The great bulk of the fossiliferous deposits consist of colluvial detritus, admixed with collapsed blocks of dolomite. The resulting sediments were impregnated by carbonates during and after deposition and now form typical *limons rouges*. Only at Makapansgat are there appreciable deposits constituted in the main part of insoluble cave residues and precipitates. At or near each of the sites karstic pools, seeps, or springs were probably available in early prehistoric times, providing sources of water for hominids and other animals, and presumably favoring a more luxuriant plant cover at the local level.

Brain (1958, 1967) was able to show conclusively that the calcareous cement was precipitated from percolating solutions, and that it had not been introduced as a fine, eolian lime dust with the original soil wash. Furthermore, "typical" eolian quartz or loess-like components were found to be absent. In fact, all of Brain's textural data on the non-calcareous soil residual indicate sandy silts, poorly sorted according to grain size. This conforms well with the known sedimentology of analogous *limons rouges* developed in limestones of the Mediterranean region (see, for example, Butzer and Cuerda 1962). However, Brain (1958) does deduce a number of climatic changes on the basis of three major criteria: (a) *Angularity of quartz sand grains*. Examination of such grains in dolomite soils from different South African environments indicated that quartz sand tends to be most rounded in shape with a rainfall of 400-750 mm., most angular with rainfall in excess of 900 mm., and intermediate in areas with less than 350 mm. rainfall. The apparent reason for this pattern is that the quartz residue within the dolomitic rock is angular, and a wet climate rapidly releases large quantities of fresh quartz. In drier settings, weathering of the dolomite is slower, so that the released grains are altered and smoothened with time. In a very dry climate, the rounding process is retarded by calcite cement adhering to the quartz grains. (b) *Ratio of chert to quartz sand*. After determining the ratio of chert and quartz grains in the bedrock and in the local soil residues today, any "excess" of quartz grains in the sedimentary column is attributed to foreign quartz sand of eolian origin, admixed with the soils. (c) *Sediment color*. Humid hillside dolomite soils in South Africa tend to be brownish, drier counterparts reddish.

From this kind of evidence, Brain (1958) suggested that during the australopithecine time-range the local rainfall at the cave sites varied from less than 500 to greater than 1000 mm. per year, compared with a central value of about 750 mm. today. The hypothetical rainfall curve that was constructed inferred dry conditions for the accumulation of the Sterkfontein and Makapansgat fills (with their *africanus* fossils), and moist conditions for Swartkrans and Kromdraai (with *A. robustus*).

I am of the opinion that Brain's analyses have little bearing on the environments actually contemporary with active deposition at the different sites. All of the finer detritus was deposited under identical geomorphologic conditions: a rupture of the equilibrium between soil formation and soil erosion. Under such circumstances residual products of many ages, reflecting accumulation on hillsides and foot-slopes over long periods of time, are all swept into the same colluvial wash. Consequently, the statistical results would seem to have limited environmental significance and no true quantitative applications. In each case the *limons rouges* indicate no more than an incomplete or ineffective vegetation mat, since rainfall intensity today is far greater than anywhere in the Mediterranean region. Such conditions must, therefore, in the South African case, be interpreted either by a drier climate or a less reliable or less well-distributed rainfall. The same applies for the Taung site, where the red, sandy cave-fill was thought to be essentially eolian and derived from the Kalahari Sands (Peabody 1954). The soil matrix from the Taung skull cast is, however, quite similar to that of the *limons rouges* from Sterkfontein or Swartkrans.

SOME TENTATIVE CONCLUSIONS

Several inferences can be made by way of conclusion:

(1) Except for the carbonate precipitates in general and some intermediate beds at Makapansgat, the sediment matrix of the australopithecine caves is typical of *limons rouges*. The fact that such reddish soil products were repeatedly washed into the caves indicates that the vegetation mat was, at times, incomplete, and that high intensity rains were no less common than today. At such times the grass cover was certainly less dense than it was at the arrival of the European settlers in the mid-nineteenth century. Consequently the cave breccias do not provide convincing evidence of a fluctuating climate through time, at least not contemporary with active sedimentation. This does not negate the possibility that the rates and modes of soil formation on the hillslopes, outside of the caves, varied through time; but it is unlikely that such soil formation was contemporary with the periods of active erosion responsible for removing and transporting materials, and ultimate accumulation in the cave interiors. The crucial thing, then, is the time lag between external soil development by weathering and eolian accretion on the one hand, and internal sedimentation on the other.

The great bulk of the sediments at *each* site implies accumulation under relatively dry conditions, either with a lower rainfall, or with a less equitable distribution of rains. As such, the sediments do *not* argue for alternating occupation by gracile and robust australopithecines under different environmental conditions. Any paleo-climatic deductions will have to be based primarily on biological data. Some 80% or 90% of the fauna represented at each site is gazelle or antelope (Brain, personal communication), which is suggestive of fairly uniform grassland settings. Until these bovidae have been studied in detail, inferences based on other, rather rare forms are possibly meaningless.

(2) The sediments at the different sites have no *ex ipso* implications for dating or any stratigraphic purposes. Any correlations must be made from faunal criteria, in the absence of materials suitable for isotopic dating (see Tobias and Hughes 1969). I feel strongly that the hypothetical rainfall curve given initially by Brain (1958) and subsequently modified and reproduced by Cooke (1963) and others is unwarranted not only as a paleo-climatic construct but also as a stratigraphic framework for the various sites. In fact, the former cluster of caverns at Sterkfontein and the neighboring sites of Swartkrans and Kromdraai are all found at median elevations of 1452-1454 m., suggesting a broadly contemporaneous origin in relation to essentially a single watertable.

(3) Although no accurate cumulative, maximum thicknesses can yet be offered for the australopithecine breccias, a *minimum* of 12 m. of sediment is represented at Sterkfontein (see Butzer 1971:427 ff), of 13 m. at Swartkrans and, according to Brain (1958), of as much as 45 m. at Makapansgat. These geologic columns all exceed the total sediment accumulation in limestone caves and depressions on the Balearic Islands that postdate the Tyrrhenian II/III (ca. 115,000-75,000 B.P.), and broadly matches that postdating the Tyrrhenian I ($\geqq$250,000 B.P.). It would therefore appear that the Transvaal cave fills record, at the very least, several tens of thousands of years (x. 10^4 years) and, quite possibly, several hundreds of thousands of years (x. 10^5 years). This raises the question whether or not some parts of the stratigraphic column at two or more sites are, in fact, coeval.

(4) In view of the preceding reservations or conclusions, it would seem that the australopithecine breccias, as such, provide no support for the dietary hypothesis of australopithecine differentiation. Both here, in terms of paleo-ecological interpretation,

as well as in the matter of internal and external stratigraphy, the paleontological materials will necessarily be decisive.[2]

NOTES

[1] The field and laboratory studies referred to here were made possible by a Wenner-Gren grant-in-aid (No. 2344, 1969) and further facilitated by NSF grant GS-3013 (1970) and the Department of Anthropology of the University of Chicago.

[2] A further note by Butzer presenting specific site data together with a commentary by Dr. C. K. Brain on some aspects of the interpretation of the australopithecine breccias will be presented in a forthcoming issue.

REFERENCES CITED

Brain, C. K.
1958 The Transvaal Ape-Man-Bearing Cave Deposits. Pretoria: Transvaal Museum, Memoir 11.
1967 Procedures and Some Results in the Study of Quaternary Cave Fillings. *In* Background to Evolution in Africa. W. W. Bishop and J. D. Clark, eds. Chicago: University of Chicago Press. pp. 285-301.

Butzer, K. W.
1963 Climatic-Morphologic Interpretation of Pleistocene Sediments in the Eurafrican Subtropics. *In* African Ecology and Human Evolution. F. C. Howell and F. Bourlière, eds. Viking Fund Publications in Anthropology 36.
1971 Environment and Archeology: An Ecological Approach to Prehistory. Chicago: Aldine Publishing Co.

Butzer, K. W., and J. Cuerda
1962 Coastal Stratigraphy of Southern Mallorca and Its Implications for the Pleistocene Chronology of the Mediterranean Sea. Journal of Geology 70:398-416.

Cooke, H. B. S.
1963 Pleistocene Mammal Faunas of Africa, with Particular Reference to Southern Africa. *In* African Ecology and Human Evolution. F. C. Howell and F. Bourlière, eds. Viking Fund Publications in Anthropology 36.

Peabody, F. E.
1954 Travertines and Cave Deposits of the Kaap Escarpment of South Africa. Bulletin of the Geological Society of America 65:671-706.

Robinson, J. T.
1967 Adaptive Radiation in the Australopithecines and the Origin of Man. *In* African Ecology and Human Evolution. F. C. Howell and F. Bourlière, eds. Viking Fund Publications in Anthropology 36.
1967 Variation and Taxonomy of the Early Hominids. *In* Evolutionary Biology. Vol. II. T. Dobzhansky, M. K. Hecht and W. C. Steere, eds. New York: Appleton-Century-Crofts.

Tobias, P. V., and A. R. Hughes
1969 The New Witwatersrand University Excavation at Sterkfontein. South African Archaeological Bulletin 24, No. 95:158-169.

Environment and Activity Patterning at Isimila Korongo, Iringa District, Tanzania: A Preliminary Report [1]

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Two differing fluvial environments from Sands 3, Isimila, yielded distinct lithic assemblages. One occurrence, on the sands of an occasionally active channel flat, indicates occupation of the anastomose channel with associated shrubby vegetation by a group whose lithic artifact inventory is dominated by large cutting edge tools.