Académie royale
des Sciences coloniales

SECTION DES SCIENCES NATURELLES
ET MÉDICALES

Mémoires. — Collection in-8°.
Tome XXV, fasc. 4.

Koninklijke Academie
voor Koloniale Wetenschappen

SECTIE VOOR NATUUR- EN
GENEESKUNDIGE WETENSCHAPPEN

Verhandelingen. — Verzameling in-8°.
Boek XXV, aflev. 4.

Outlines of Prehistory and Stone Age Climatology in the Bechuanaland Protectorate

BY

E.-J. WAYLAND

LATE DIRECTOR OF THE GEOLOGICAL SURVEYS OF
THE UGANDA AND BECHUANALAND PROTECTORATES,
MEMBER OF THE ACADÉMIE ROYALE
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Avenue Marnix, 25
BRUXELLES

Marnixlaan, 25
BRUSSEL

1954

PRIX :
PRIJS : F 70

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Mémoire présenté à la séance du 19 juin 1954.

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(SUMMARY IN FRENCH : by J. LEPERSONNE, in *Bulletin de l'Institut Royal Colonial Belge*, 25, 1954, pp. 1189-1196).

If the following considerations are wide and general, rather than local and deep, they will nonetheless achieve their purpose if they serve as an introduction to a little-known country of great significance in the history of Early Man in Southern Africa.

A. General (1946).

About eighty per cent of the 275 thousand square miles of land that comprise the Bechuanaland Protectorate are sand-covered, and by nature waterless, except of for short spells after summer rains. The solid geclogy of this vast area is almost entirely masked by more or less superficial deposits among which red desert sand is the most widely developed. Indeed, except for some of its derivatives, it is practically everywhere present.

Anybody who has looked at a map of Africa will know where the Bechuanaland Protectorate is situated and that most of it is comprised in what is called the Kalahari desert, the southern counterpart, it might be supposed, of the great Sahara. But this is not so at the present day, though, during more than one period of the past, the parallel has most probability held. Even now, with its sand dunes, its internal drainage and its pedimented hills the Kalahari has the morphology of a desert, and is thereby cut of tune with its biology and climate. Indeed, as VAN DER MERWE points out :

« ... its rainfall is considerably higher than that associated with desert conditions ; in fact other stretches of the Union ... are more of a desert from a rainfall and vegetal point of view than the Kalahari itself ».

Of the vegetation this same writer says :

« The Kalahari is fairly densely covered by vegetation. The floral belts traverse this region with a north-west-south-east trend coinciding with the rainfall intensity, and the distribution of the soils. In the north-eastern section « mopane » *(Capaifera mopane)* and several species of *Commiphora* are often dominant, being commonly associated with the « Boabab » *(Adansonia digitata)*, *Acacia senegal* and others. South of this belt, *Terminalia*, a tree characteristic of the heavy sand dominates, followed by the shrub *Rhigozum* (« Driedoring ») further towards the south.

» The latter grows almost entirely on the shallow phase (Sand on Lime) soils. The flora of the Kalahari from south to north varies from a fairly dense growth of low bushes and shrubs to bush and tree steppe and finally to luxuriant tropical flora and open forest. The swamp lands of the Okavango and Linyanti possess in addition to Acacias various species of *Ficus* and water loving trees, palms, papyrus and water lilies. Apart from the arboreal vegetation described above the Kalahari sand is well covered by grass » (1).

For most of the year the Kalahari is completely waterless, but game is plentiful and some species, such as springbok and wildebeeste, can be seen in enormous herds. Given sufficient surface water, experts seem agreed the so-called Kalahari desert would be one of the finest ranching countries in the world.

The Kalahari lies roughly between latitudes 21° and 27° S. Thus much of it is north of the tropic of Capricorn. It is in the zone where the southern deserts should normally occur. Its morphology therefore is in

(1) VAN DER MERWE, C. R., Soil Groups and Sub-Groups of South Africa (*Sci. Bull. 231, Dept. Agric. and Forestry*, Dec. 1940, pp. 55 and 56).

keeping with its geographical position and as already stated, out of keeping with its present biology and climate. These considerations, and others to be written of later, leave no room for doubt that at a time, or times, in the past the Kalahari has really been a desert, and that its present relatively high rainfall (1) represents either a climatic shift back to pre-desert conditions, or a superimposition upon an arid climate appropriate to this part of Southern Africa. In this regard there are three significant facts.

(a) Outliers of Kalahari sand, in Rhodesia, the Transvaal, Angola and elsewhere indicate that the desert has been vaster than the present accepted limits of the Kalahari would lead one to expect (2).

(b) The few hills of the Kalahari rise from pediments (see B. below). These are denudational features of thirst-land topography and must have taken many millions of years to develop. It is to be noted, too, that they occur far beyond the present geographical limits of the desert.

(c) Indubitable evidence can be produced to show that within Pleistocene times the climate of the Kalahari has periodically varied between two opposites — dry and wet ; and that these periods have each in their turn been of long duration, according to human time standards. They have not been mere changes of weather, nor ordinary oscillations. They represent a succession of climatic regimes.

(1) The characteristic feature of the rainfall in the Bechuanaland Protectorate (in common with that of many semi-arid lands) is its erratic nature, it is thus impossible to strike a mean of any value, therefore I provide no figure here. It is only by a study of all relevant available figures that some picture of the comparative quantities of rainfall emerges, but vegetation is helpful in this regard.

(2) Du Toit, A. L., The Kalahari and some of its Problems (*S. Af. Jour. Sci.*, Vol. XXIV, Dec. 1927, p. 90).

The most probable explanation of these facts would appear to be that normally the Kalahari, and much of the country surrounding it, is a desert ; a desert with an extremely long past, upon whose arid climate certain wet periods of relatively short duration compared with that of the desert, but long sustained by human time standards, were superimposed during Pleistocene times. Some of the effects of the latest of these are still with us. The desert dunes are for the most part still fixed by vegetation.

B. Topographical considerations (1946).

The hills and mountains of the Bechuanaland Protectorate are in the main clustered about its eastern (and to some extent about its western) borders. From a distance many of these eminences appear imposing, and to scale them, one might imagine, would be quite an undertaking ; yet when their bases are reached they have, it seems, lost half their height ; nor is this an optical illusion. It results from the fact that one has been coming up the pediment, that is, the very gently graded slope surrounding each (or a cluster) of these hills, and from which they rise abruptly. The pediments merge into, and indeed form part of the Bechuanaland plateau.

In Africa there are several plateaux, one above another, and geologists have named them (1). Their height, and degree of denudation parallel their antiquity. The lowest and youngest is known as the end-Tertiary peneplain, and in spite of what has been held to the contrary (2), the Bechuanaland plateau, in the writer's

(1) Dixey, F., Erosion Cycles in Central and Southern Africa (*Trans. Geol. Soc. S. Africa*, vol. XLV, 1943, pp. 151-181).

(2) du Toit, A. L., Geology of South Africa (London and Edinburgh, 2nd Edition, 1939, pp. 418-423).

opinion, is part of it. Some geologists are of opinion that this erosion surface was formed when the land stood at a much lower level, others do not favour this view. Be the truth of this matter as it may, there can be no doubt that the peneplain is still developing, for upon it there is every gradation between remnants of higher plateaux (monadnocks, Inselberge and Bernhardts) and small piles of exfoliating boulders crumbling to grit and sand destined to be spread around by sheet flow when the rain falls, and blown afield by the winds during dry weather.

The Protectorate is far from well watered. Such rivers as it has, are nowadays dry for nearly the whole year, many are ephemeral run-off channels transporting for a few days mud and sand, some never flow at all ; but evidence provided by their ancient gravels, boulder beds, extinct cataracts and fossil waterfalls leaves no room for doubt that in former times the rivers were perennial.

On the eastern side of the Protectorate a number of comparatively short ephemeral streams are tributary to the Crocodile or Limpopo river. The Mopolo river on the South, together with its tributaries, is fossil ; and for a great part of its length is the Nosop which joins the Molopo, in the extreme south-west of the Protectorate, seldom carries water and never for long, or so I was informed by the Bushmen. For the rest the drainage, such as it is, is internal.

After leaving the eastern border of Bechuanaland the Limpopo descends some 3,000 feet in its journey to the ocean, which should thus be the base level of erosion for at any rate the eastern part of the Protectorate, and yet the Bechuanaland plateau, as such, is virtually undissected. Surely the cutting power of the rivers in the past must have always been downward, and should have done much to dissect the country into flat-topped hills and gorges; but this was last achieved during a previous cycle of erosion that produced the end-Tertiary peneplain itself (the Bechuanaland plateau). During the periods of heavy rainfall in the past streams gouged their way more or less along the thalweg of the almost flat-sided, senile valleys of the ancient and already dead peneplain rivers; but this erosion was intermittant and the streams, having cut their channels, proceeded more or less simultaneously to fill them up again. This process was repeated with the coming and going of a subsequent wet period, and yet again with that of another. Though locally there are some exceptions, the rivers have not in their various periods of renewed activity continued the down-cutting role of pre-existing rivers. They have started anew much the same channels; but, it can be shown, with power that decreased with each succeeding wet period. The rejuvenated courses were not everywhere entirely coincident, with the result that they cross and recross, each crossing by the present-day channel being marked by the bottom-bed boulders of a pre-existing stream, where these deposits do not lie markedly above or below the present stream bottom.

The present-day ephemeral streams are generally poor in tributaries, and their lack of power compared with that of the pre-existing streams, with whose courses their own roughly coincide, is evidenced by:

(a) Their relative narrowness;

(b) Their steep banks (about vertical in many cases) cut into earlier riverine sediments. These steep-sided channels look amazingly young, but that is in great measure because river erosion is effective for only a few days each year. Thus these channels are perhaps forty times older than they seem;

(c) Their lack of waterworn gravels of their own;

(d) Their tendency to dwindle in size downstream after reaching a maximum (the earlier rivers increased in width and depth downstream) ;

(e) Although in their upper courses they may expose earlier river gravels and cut a foot or two below them, for considerable lengths the old bottom gravels and the present river bottoms coincide in level, but in the lower reaches present river bottoms are well above the boulder and gravel beds that floored the pre-existing river.

The ancient bottom gravels are rich in stone artifacts. The great majority are palaeoliths, but a significant proportion is comprised of older tools (Kafuan). Practically all are waterworn and, in spite of some rare exceptions, it is true to say that, on the whole, the older the type of tool the more waterworn it is. In these situations Middle Stone Age material is very rare and does not belong to the gravel. A fact of much significance. These ancient rivers that produced strong bottom-gravels and boulder beds were all pre-Middle Stone Age in date.

C. Stone Age Research (1952).

The Kalahari, it seems, is a terrain of very long duration. Its normal expression is probably that of a Saharan desert ; but in Pleistocene times, if not in any others, its deadly aridity was banished, more than once, by halcyon regimes. Those were the pluvial periods, during which its erstwhile fossil rivers became perennial and its sand dunes, a heritage from desert days, forest-clad. Climatically between these extremes lies the present thirstland, with its appropriate flora, disharmonious alike with that of rainier days and with that of the desert land-forms within its grip. The fauna, too, shows similar disharmony. Moreover, in many cases the ancient dunes are misaligned with regard to the prevalent winds of today.

The Pleistocene climatic episodes in the Kalahari provide a sequence of contrasts, the impressive evidences of which can hardly be bettered, if indeed equaled, anywhere in Southern Africa. They provide part of an unfinished pageant wherein the present is an inexorable consequence of past events and a formative factor for shaping the future.

The appreciation of status in any field of endeavour, at any given time, can only be achieved in the light of preceding relevant events ; nor can future possibilities be judged in the absence of such a background, and attempts thus to do so, with a view to long-term planning, may court disaster. Realising this, and the fact that groundwater supplies in Bechuanaland are bound up with past climatic influences, and because of more than half a lifetime's practical interest in the Stone Age, the present writer, during his nine years work in the Protectorate, paid much attention to the prehistory of the territory. Prehistory, that is, with a strong geological bias, geoarchaeology it might be called.

The results of this research may be grouped thus :

(a) Those of essentially scientific interest.

(b) Those of economic application.

They are interdigitated, and in important measure some have proved unexpected. The lithic cultures so far discovered by the writer may be listed in downward order of increasing antiquity, considering the main divisions only, and excluding as yet unidentified groups, as follows :

Iron Age ;
Neolithic ;
Wilton ;

Magosian ;
Still Bay ;
Middle Stone Age Group ;
Sangoan ;
A Bambesi-like Culture ;
Chelles-Acheul Group ;
Pre-Chellean ;
Developed Kafuan ;
True Kafuan.

Some Kafuan, and some pre-Chellean types of tools tend to be astonishingly large, and in gravels of early date there are boulders (some weighing over 100 pounds each) from both faces of one end, both faces of one end and of a contiguous part of one side, and both faces of one end and of contiguous parts of both sides of which large intersecting flakes have been removed, thus producing sharp, more or less zigzag edges. Were these worked boulders a twentieth, or less, of their actual bulk, they would be generally accepted as pebble implements.

Can these enormous artifacts be reasonably regarded as tools ? Even double-handed ones ? Common sense shies at the idea. If they were tools surely they must have been made by giants ? But in the absence of evidence of the past (or present) existence of such beings in Southern Africa, it is prudent to regard these remarkable flaked boulders as cores. They could of course have been « fixed tools » in the sense that an anvil is a fixed tool. Some gigantic hollow scrapers fall into this possible category.

Another type of utilised boulder is one supporting several complete cones of percussion with basal diameters of about two and a half inches. They tend to be grouped on one side of a boulder (the present writer has counted as many as six of these cones so situated), and from the bottom of each fractures splay out almost horizontally, thus detaching wedge-section slivers.

Associated with these boulders are others from which large flakes have been removed more or less indiscriminately. This may have been achieved by flinging, with great force, one boulder upon another. Thus, it would seem, was the flung boulder flaked and the « anvil » boulder coned. Giants or no giants the men who produced these huge cones must have had prodigious strength. Suspending a boulder by a thong and swinging it on to a stationary boulder proved unavailing.

Writing of cones, calls to mind the large percussion rings (over-sized chatter marks) one sees on many quartzite boulders in the ancient gravels. The largest rings are nearly one inch in diameter. They are cross sections of once incipient cones which have been *developed by weathering* as the boulders have gradually lost size by attrition in one-time torrentiel rivers. Clearly, the diameters of these rings gives a measure of the thickness of the material removed, and it is noteworthy that these boulders do not individually display upon their surfaces, as one might expect them to do, percussion rings of every size-gradation between diameters of nearly one inch to these of circles of pin-head dimensions. The historical significance of this seems obvious.

The huge cones referred to above are not, as are the percussion rings, incipient strain phenomena, weather-developed ; they are the direct and immediate results of fracture.

There is in the writer's collection, a piece which has all the appearance of a titanic proto-levallois flake with a prepared striking platform. This artifact is (I speak from memory) quite ten inches long, about half as wide and roughly three inches thick. It is composed of dolerite, and consequently very heavy.

There are, too, some specimens fashioned in the style of the more or less lunate, sharp-edged pebble-artifacts (biflakes they might be called) of the Mfongosi industry of Zululand. They consist of large pebbles, or small boulders, each with a sharp edge along the junction of two opposing flakes removed from one end or side, but with no percussion bulbs. This absence has caused considerable doubt in the minds of some observers with regard to man's participation in the making of these supposed artifacts. But if they are pseudo-artifacts, how could nature have produced them ?

Assuming that the biflakes are humanly made, it might be supposed that the first bulb was removed by the blow that detached the second flake ; but, if so, where is the trace of the second bulb ? This is like looking for the body of a supposedly murdered person who has, in fact, clandestinely bolted to America. There is no dead body. Similarly, there is no bulb.

Experiment shows that the method of producing these curious implements, or cores whichever they may be, is this :

Take a large flat-sided pebble or boulder and, by means of other stones, wedge it in a position such that its approximately parallel sides are vertical, and one of the primary axes, preferably the major axis, slightly inclined toward you (this inclination is not essential, but it is convenient). Collect another boulder ; the roundest you can find and the heaviest you can lift above your head with two arms without much inconvenience, and from that position fling it with all your might, at the topmost point of the wedged boulder (namely that at which the major axis would emerge). Your first attempts will probably smash the wedged boulder in any but the desired way ; but with a little practice you will be able, by this means, to remove two opposing flakes simultaneously, and thus produce a Mfongosi-type biflake. A small batter-point may in some cases be found where the blow was struck, but there is no percussion cone or bulb.

Some biflakes are of ordinary pebble size, and it might be supposed that the flakes have been removed by striking the stone on an « anvil », but the present writer has been unable to produce any that way. They could probably be produced by striking a pebble appropriately with a heavier one.

Biflakes have been made from dolerite or quartzite boulders, but in the case of the latter the flakes tend to be longer and the cutting edge straighter than when dolerite is used. The biflake technique has been employed in the production of some cleavers.

The percussion bulb is to the archaeologist what the hall mark is to the collector of silverware, insofar as each in its way is considered to guarantee the genuine article. But there is silver plate without hall marks and man-made flakes without percussion bulbs.

In addition to those already considered, there are flakes without bulbs not because they have been removed, but because they were never there.

Fifth from the bottom of the list of Stone Age cultures given above is one described as Bambesi-like. The artifacts are found on and in a rubble deposit, with some pebbles, strongly cemented by ironstone. It appears to have been a pediment cover.

From this deposit a decidedly large collection of artifacts was made, and among them very thick, often rather long, flakes and flake-tools are conspicuous. They display a surprising absence of percussion bulbs. There can be no shadow of doubt that this feature is original and not a result of removal. Rare examples of excellent bulbs are to be found ; faint bulbs are not very uncommon, but a great many of the flakes are quite bulbless. One might take this to indicate a special striking-method ; but such is not the case, for it requires but little experiment to show that the bulblessness of the flakes results from the nature of the material used, not from the technique employed. Nor are bulbless flakes confined to a single culture.

The material in question is a very fine grained purple-red quartzite ; but this is not the only material from which bulbless flakes can be made. Some other fine-grained quartzites react similarly to a sharp blow. The same is true of some very coarse grained quartzites, some felsites, and some tough silicious ironstones.

Objection has more than once been raised to what has been called the « humanity » of some Kafuan artifacts on the grounds that many of them display no bulbs. This judgment is characteristically passed with an air of complete finality, but had the critics who made it attempted to split comparable pebbles by means of a hammer-stone no doubt they would have been disillusioned ; and although they would have been able to make a few Kafuan-like artifacts, they would not have found it easy to produce one with the (to them) hall mark of human handicraft, had they used « comparable pebbles », which does not include flint.

In passing, it may be recalled that NEVILLE JONES [1] writing of the Hope Fountain culture, remarks that the artifacts are made of a very hard « limonitic chert of jasper », and that they show « neither butt nor bulb of percussion and appear to have been fabricated on naturally detached fragments of rock » ? The present writer knows very little, at first-hand, of the Hope Fountain material, but he is tempted to suggest that in it we have another example of bulbless flakes. Very few of the artifacts mentioned in the last paragraph but two are bulbless, but the writer has collected bulbless

[1] JONES, N., The Prehistory of Southern Rhodesia (*Nat. Mus. S. Rhodesia*, Mem. 2, 1949, p. 71).

and bulbless flakes from the surface of a highlevel wave cut bench of a vanished lake in Ngamiland.

From some materials it seems practically impossible to remove a flake by means of a direct blow without producing a bulb. One of these is flint.

Be the part played by the Kalahari in modern history what it may, it palls to insignificance beside the long eventful and inexorable panorama unfolded by the study of its prehistory and the pointers that emerge therefrom. But of these there is no space to write.

Our knowledge of the Kalahari in this regard has been obtained of recent years. Its acquisition has been in no small measure a one-man job ; a defect which, in the near future, it is hoped to remedy.

The first stone tools recorded from Bechuanaland were those recovered by the Vernay Lang Kalahari Expedition (March to September 1930). According to RIET LOWE (1) the specimens were collected in the Ghanzi district, south west of the dry lake Ngami. They were all found either on top of or in the Surface of Limestone which occurs so abundantly in the area.

The implements comprised of some upper Stellenbosch (Acheul-type) *coup de poing* with the remains of a striking platform at the butt-end (2). Middle Stone Age and Smithfield-type tools were also collected.

NEVILLE JONES found some implements of Bambesi type at the Samedupi drift near Maun a good many years ago (3).

One of the Managers of the Tati Company (Headquarters at Francistown) collected a large number of

(1) *Annals. Transvaal. Mus.*, Vol. XVI, Part. 3, 1935.

(2) A number of these and some cleavers in mint condition were found by the present writer, under deposits of a one-time extension of Lake Ngami, in 1944.

(3) Notes on a Bambesi culture at Inyazura. *Occas. Pap. S. Rhod. Nat. Mus.* No 11, pp. 39-46. From what appears to be the same site the present writer recovered large numbers of stone tools of various cultures from Chellean-type to what may be the local Sangoan, in 1943 and later.

prehistoric artifacts, presumably selected surface material, and despatched them to the *Archaeological Survey* at the University of the Witwatersrand. That, too, was a long time ago, they have never been described.

Between June, 1943, and October, 1952, the present writer collected a very large number of stone implements, nearly 9,000 of which were retained.

In the great majority of cases the artifacts were discovered *in situ*, and full notes of their stratigraphy were made. The invariable practice is (and will remain) to « collect everything », including the « rubbish », for in no other way can one obtain a balanced appreciation of a Stone Age so-called culture. Often enough the rubbish and second-rate stuff proves illuminating. Selective collecting, therefore, is to be most strongly deprecated.

Beginnings have been made in the matters of area site-grouping, particularly with regard to watersheds, and to plotting Stone Age sites, of which I have investigated about 100 (the number of deposits is, of course, greater than this), in places scattered all over the Protectorate.

The whole of what is now known as the *Wayland Collection* of Bechuanaland stone tools, together with the catalogues, etc., has been transferred to the *National Museum* in Bulawayo for safe keeping and study.

Special studies are being made (none is as yet complete) of the nature and mineral content, etc., of geoarchaeological deposits, and the writer and D^r^ A. POLDERVAART, now Professor of Petrology at *Columbia University*, but chemist and petrologist to the Geological Survey of the Bechuanaland Protectorate at the time when he undertook and wrote up his work, have collaborated in an as yet unpublished paper dealing with the sands of the Kalahari. On the petrological and physical side generally this work is being continued by others, if and when possible ; and the present writer hopes to enlarge his studies of the geological history of the deposits which constitute what is often called the Kalahari cover (sands, calcrete, silcrete, ferricrete, etc., see below).

SUMMARY.

Stone Age relics discovered in the Bechuanaland Protectorate when studied not only typologically but also, and particularly, in the light of those physiographical controls whose operations are reflected in the Pleistocene and perhaps somewhat older deposits, lead to seven main conclusions :

1. In certain periods man has inhabited, as distinct from taking occasional excursions into, the Kalahari.

2. The periods of human occupation were those of relatively high rainfall when now fossil rivers were perennial, dunes and many of the flatter expanses were forested, while the rest of the country was presumably fertile prairie and natural parkland.

3. The climates of the intervening periods were : drier to very much drier and in one period at least (the inter-pluvial between the 3rd and 4th pluvials) wind appears to have played an important part.

4. The Pleistocene climates of Bechuanaland belong to the past only in the sense that they are pre-recent. They do not comprise a vanished and completed sequence. The end of the epoch is not yet. It has the wholeness of a superimposed complex, and any phase lying between the beginning and the end of that complex is as a child of past events and as a progenitor of those to follow.

5. Therefore, an adequate understanding of the pre-

sent position in this region should form, within reasonable limits, a basis for prognostigation of future climatic trends, and of all that depends upon them.

6. It is not to be supposed that Pleistocene climatic changes were confined within the territorial boundaries of the Protectorate, and there is sound evidence that, *mutatis mutandis*, contemporaneous sequences were manifested over very wide areas.

7. The Kalahari and its borderlands were, and are, singularly responsive to vicissitudes of climate ; a fact which, from an environmental angle, has rendered the investigation of the Pleistocene deposits of Bechuanaland unusually *fruitfull*. Moreover, it has indicated lines of approach to several economic problems, among which those pertaining to groundwater are of vital consequence.

D. The Samedupi artifacts : their climatic significance (1946, slightly revised 1948).

Samedupi is the name of a spot in the Bechuanaland Kalahari on the Botletle river, an affluent from the Okovango swamp area of Ngamiland, running (if and when it does run nowadays) toward the now dry lake Dow and the still partly watered Makarikari depression. At Samedupi, about 11 miles approximately south-east of Maun, is a drift where the river has cut into pre-existing deposits which were long ago called the Botletle beds by PASSARGE [1]. These, as represented at Samedupi, are chiefly hard, buff to honey-coloured, highly siliceous and easily flaked rocks with a conchoidal fracture. In places where their surfaces have not been smoothed by attrition, (e. g. the sides of the holes shortly

[1] PASSARGE, S., Die Kalahari (Berlin, 1904, chap. XXXIV). Since PASSARGE's day the Kalahari Sand has been grouped (mistakenly in the present writer's opinion) with his *Botletle Schichten* and the whole renamed the *Kalahari beds* (DU TOIT, A., Geology of South Africa, 2nd, Ed., London and Edinburgh 1939, p. 419).

to be described) examination with a lens shows the stone to be made up of tiny, rounded grains (essentially quartz sand), cemented together. Under the microscope petrographic slides reveal the cement to be chalcedonic silica and some opal, and the grains to be significantly similar to those of the Kalahari sand.

Among sand-rounding agencies wind attrition is the most efficient. It will reduce, round and polish, or frost with little pits, quartz grains to a degree far beyond the powers of any other natural physical agency. River sand tends to sharpness. This, because of water cushioning, is particularly true of very small grains. Rivers, even in powerful flood, cannot mechanically abrade grains below about 0,5 mm ; but wind rounded grains no larger than 0,25 mm are common.

Those of the Kalahari sand dunes and those of the Samedupi sand-rock are commonly about 0,15 mm in diameter and rounded.

Whatever the Kalahari sand is, so was the Botletle sand-rock, or *silcrete* [1] as it is named. The Kalahari sand is a desert sand, so was that of the Botletle silcrete.

But the one-time Botletle sand accumulation is much older than the present Kalahari dune deposit, for where they contact the latter overlies the former with marked unconformity. The Botletle silcrete is not, therefore, the cemented base of the Kalahari sand, as some have thought [2], but a silica-cemented desert sand of earlier days.

(1) Silcrete is a term introduced by W. G. LAMPLUGH (*Geol. Mag.*, Vol. IX, 1902, p. 575). In this communication LAMPLUGH also advocated the use of the terms *calcrete* and *ferricrete*, the obvious meanings and utility of which keeps them in employment. Silcrete is often called surface quartzite, chalcedonic or Surface Limestone quartzite. The term *ferricrete* is ambiguous. It has been made to include not only ordinary ferruginised sands but lateritic ironstones which have resulted, in no small measure, from leaching.

LAMPLUGH, W. G., The Geology of the Zambesi Basin around the Batoka Gorge (Rhodesia) (*Q. J. G. S.*, Vol. LXIII, 1907, p. 198).

(2) WAYLAND, E. J. (*Geogr. Journ., Vol. CXIX, Part. I*, 1953).

PASSARGE believed the Botletle silcrete to be of oligocene date [1], but all the evidence I have been able to gather militates against this. Though older than the sands it supports, it may well be early Pleistocene or late Pliocene.

The Samedupi quartzite locally displays steeply inclined bedding, recalling that of sand-dunes, and is a much-holed rock. The holes are of two types :

(a) Irregular cavities generally varying in size between that of a fist and that of a cauliflower, and

(b) Tubular holes approximately circular in section (except where they flatten out and become lenticular, with one extended lateral axis and one diminished one like the cross section of a bean).

Three hundred and seventy two of these diameters were measured ; 57 % of them were from 5 to 10 mm inclusive ; over 40 % 3 mm and less, the majority of these being of very small diameter. It should be pointed out that the measured holes were in artifacts, but it would not appear that those in the local mother rock would have been significantly different. Measurements of hole-diameters in silcrete of another area show somewhat different and commonly larger averages. But they appear never to have been used for hafting (see Plate I).

What is their significance ? They do not suggest the work of any known physical agent ; organic activity must therefore be considered. The fact that they are, nearly all of them, unfilled, at least for much of their length, together with the absence of any hint of a lining that could have halted silicification at their peripheries shows the tubes to have been occupied by a substance, or substances, other than sand when cementation occurred. Moreover, the sharpness of the axils

(1) *Op. cit.*, Chap. XXXVI.

between the branches, the diameters of the largest tubes, the broad flattenings already referred to and the extremely silicious nature of the original sand preclude worm burrows and the like, thus leaving us with nothing but plant growth by way of explanation.

The tubes then, are consequent upon the disappearance of *(a)* roots, or *(b)* branches. It is important to decide which (both of course could be present, theoretically, but one or the other would probably prove dominant), for if the holes were made by roots it is a fair assumption that the plants grew in the sand, thus showing them to be subsequent to that deposit, but if many of the tubes are indicative of branches it would appear that the sand submerged them.

The character of the branching (downward and outward), the intimate association of tiny thread-like holes, now mostly filled, with the larger tubes, the complete absence of any impression of bark, leaves, boles or nodes, the comparatively narrow limits in variation of the larger tube diameters and the great probability that the silcrete was formed underground, as we shall see later, combine to turn the scale in favour not merely of roots of some sort, but of those of trees such as are commonly encountered in excavations at depth. (I have seen such roots between fifty and seventy feet below surface) and when one recalls the abundance of the tubes, and the strong local false bedding of the rock in which they occur, there arises in the mind a picture of forested dunes, recalling those of the present Kalahari — that more than one-time desert, now reclaimed by vegetation [1].

It would therefore appear that in the Botletle sand of ancient time, in the later but far from recent Kalahari Sand and in the vegetal covers to these we have a repeti-

[1] WAYLAND, E.-J., From an Archaeological Note B ok (*S. Afr. Arch. Bull.*, Vol. V, Nº 17, March 1950, p. 9).

tive double regime (arid, seasonal, arid, seasonal) [1], and there can be little doubt that these regimes were climatically conditioned. But the sequence is far from complete, not only because, as we shall see, the Botletle beds are not the beginning of the story, nor the accumulation of the Kalahari sands the end of it, but also because the time-gap between the formation of these two aeolian deposits can be shown to be long. The main lines of evidence for this statement are :

(1) The very gradual development of end-period hand axes, and

(2) The beginning of an important part-flake culture (recalling the early Sangoan) during this period, together with the astonishingly large number of artifacts in places where they occur, and the remarkably thick calcrete deposits that lie between the older Palaeolithic gravels and the Kalahari Sand in some parts of the thirstland.

Moreover, the Kalahari sand at Samedupi is a reblown deposit ; there is another Kalahari sand younger than the silcrete and older than the local sand but it is not represented here.

The specimens figured on plate I, and a great many others in the B. P. collection [2], show that early hand axe-making man appeared in Ngamiland after the early days of dune reclamation that followed the Botletle arid-

(1) I write *seasonal* rather than *wet* because however high (relatively) the rainfall, it can hardly have been other than markedly seasonal. During arid times the seasonal effect doubtless diminished almost, perhaps, to vanishing point. The term *wet* conveys, I believe, a misguided or exaggerated idea, so, I think, does *pluvial*.

(2) Bechuanaland Protectorate Government collection housed at the Geological Survey headquarters, Lobatsi. [Now removed to the National Museum, Bulawayo (E. J. WAYLAND, 1952)].

period, for the implements were made of local root-holed silcrete, and the fact that this rock is silica-cemented desert sand indicates the coming of the seasonal period in which he lived.

The roots would hardly have grown in the environment provided by the silicifying solutions that converted the loose sand to silcrete, but that the roots were living when this process started is indicated :

(1) By the fact that they were in no known instance petrified or carbonized, as dead material might well have been, and

(2) Because many of the hollow tubes show, a short way from their peripheries, a narrow encircling zone (a ring in section, but actually a sheath, Pl. I, fig. 2), consequent upon reaction between the silica-bearing solution and certain decomposition products of a decaying plant members. These reaction-zones are evidenced by bleaching. The root-enclosing sand was therefore coloured, doubtless by iron oxides consequent upon the gradual breakdown (weathering) of ferromagnesian and other iron-bearing mineral grains originally present in the sand. This in turn indicates that the accumulated sand had been static for a considerable time, perhaps a very long time, before silicification occurred. We may provisionally infer then that a forest, or at least an established scrub regime, rather than a short vegetal episode followed desert conditions.

Discussion of the knotty and related problems of silcretes, calcretes and ferricretes will be deferred for another occasion, but an explanation of the tubular Botletle quartzite must here be attempted, if only in a general way.

So far as my observations have as yet gone (they need verification), the Botletle silcrete (quartzite) rests not upon hard bed rock, but on a dark-grey to almost black clay. Whether this is entirely riverine or in part lacustrine is not yet known, but in either case it is seemingly indicative of a regime quite other than that of the one-time Botletle sand. Elsewhere in the Protectorate there is evidence in plenty, in my opinion, of a long, seasonal period, during which Kafuan man appeared, before Palaeolithic times, and separated from them by a dry period (the Botletlean I propose to call it). Pending discovery of evidence against this view, the black clay is presumed to belong to that seasonal period which, it may be noted, corresponds chronologically, so far as it is possible to determine the point at present, with some part or other of what is known as the Kageran of East Africa. It followed the long desert period of the pre-human Kalahari and culminated in the First Pluvial Period ; if not in two of them.

As the pluvial, less dry, moist or seasonal periods of the Plio-Peistocene and Pleistocene go, the Kageran was long and characterised by great riverine erosion, on the one hand, and correspondingly extensive sedimentation on the other ([1]).

In favourable circumstances much rock weathering occurred and deepened as toward the end of the period the water table fell. Although slow at first, the fall accelerated upon the subsurface weathering (itself declining) with the coming of the Botletle desert, and was eventually re-established at about the pre-Kageran level (commonly — 100 m, ± 3 m it would seem). The desert

([1]) In my view the erosion of part of the Batoka gorge and of the Molopo valley, the accumulation of the so-called Kalahari beds (at one time considered to be Eocene) that underlie the Botletle quartzite and of extremely thick deposits in the Albertine rift valley of Uganda and the Belgian Congo (to mention a few examples) are, unlike the Kalahari Sand as generally understood in Bechuanaland, all pre-Palaeolithic, Kageran events. It should be pointed out, however, that at least one of the major valleys (that of the Lower Molopo) is extremely old, for it contains Karroo deposits, including Dwyka.

came, and stayed until the aridity that caused it waned to the van of less parching years that banished ephemeral spates, like those of today, and heralded the running rivers of Kamasian times and the halcyon days of Palaeolithic man.

But a desert is not all death, and even at its peak rain will sometimes bless it. At its beginning, and toward its end, meteoric waters have their rôle. It was in such times as these that the extensive calcretes and diatomites of the Kalahari, and the much less conspicuous surface ironstones of that area were formed. Silcrete, usually green or white and commonly concretionary, is apparently forming today in many Kalahari pans, but it is of little consequence compared with the thick, wide sub-surface sheets of that substance in the thirstland, and the same may be said *(mutatis mutandis)* of calcrete, which according to DU TOIT, « must underlie an enormous region » (1). Either this is true or optimum conditions for its formation have in the past existed in numerous localities throughout a vast area. In an attempt to explain these astonishing sheets of sub-surface materials, so largely chemical in origin, attention must be directed to six issues :

1) Microscopic examination of the Botletle silcrete reveals the absence of corrosion from sand grains such as would result from local solution. The silica cement of the silcrete zone was therefore of extraneous origin.

2) It is chalcedonic and opaline, and unlikely to have arisen from a deep-seated (hydrothermal) source ; moreover, its complete lack of crystalline continuity with the silica grains may well be consequent upon replacement of an original cementing medium.

3) Turning to the superficial characters of the silcrete

(1) DU TOIT, A.-L., The Geology of South Africa (2nd ed., London and Edinburgh, 1939, p. 408).

(exemplified by the two implements shown on Plate I) it must be noticed :

a) That tiny out-of-the-way patches are very commonly brightly polished (the arrow, Plate I, points to one of these). Some of the tools show polish more or less all over one or both sides, but again the brightest gloss is in tucked away surface spots. Comparison reveals that very many of the Botletle artifacts were at one time brilliantly polished, as those of the Victoria falls area still are ; and that they have lost, or are losing, their lustre. Secondly, polish is invariably absent from the lining of the root-holes whether they pierce the stone or lie in part along its surface. On the other hand some of the tools (Plate I, fig. 2, for example) show no signs of ever having been polished ; they exhibit only the characteristic sheen of the calcrete.

4) PASSARGE's long and wide experience of the Kalahari and its geology led him to believe that silcrete is a siliceous replacement of calcrete (1). This in many cases can be shown to be true.

5) Climate has a marked control of chemical accumulations (evaporites, saline crusts, etc.) and is widely admitted by geologists and soil experts to play an important part in the formation of calcrete, silcrete and ferricrete (including laterite).

6) Were the Kalahari sand as absorbent as some observers suppose (2), the vast depression it occupies

(1) Die Kalahari (chap. XXXV).

(2) For example, Prof. F. DEBENHAM writes : « There is of course, a great deal of underground water since the sand absorbs up to 90 per cent of the rainfall », and again « There remains, however, the vast central arid division which has few stream beds... Here it is the sand itself which is the conservator and below that large area there *must be* large quantities of water ». (The italics are mine. How many our own development problems would be simplified were this but true) « Report on the Water Resources of the Bechuanaland Protectorate .. » (H. M. Stationery Office, London, 1948).

would almost certainly be a swamp or lake, resembling, possibly the sudd areas of the Sudan, or a second Victoria-Nyanza (1), it would hardly be the thirstland that it is.

Much of the shower rain, after a short period ofrapidly decreasing percolation, runs off as sheet flow to relative depressions where it evaporates, or is swallowed by herds of thirsting game. A great deal of the remainder is returned to the air by plant transpiration, and a little perhaps, where the sand contains much very fine material, by capillarity. Long-continued rain goes deeper. If, then, the Botletle silcrete was not of hypogene origin the cementing silica must have reached its resting place by downward percolation to a level where lay the cause of its release from solution, for it the sand itself had induced this deposition, cementation would have occurred at high levels and inhibited percolation almost from the start.

PASSARGE'S view of the origin of the Botletle silcrete beds, which I accept, is that alkaline carbonates and soluble silica accumulated in the ground in a region of internal drainage during an arid regime, but in a succeeding period of greater rainfall silica was dissolved by alkaline solutions which when they contacted $Ca\ CO_3$ replaced it by SiO_2. This is a perfectly reasonable hypothesis, and there is much field evidence to support it.

From these facts and speculations, and from the now certain knowledge that climatic changes have taken place in the Kalahari region during Pleistocene time, we may hypothesise as follows :

In what may vaguely be called the Samedupi area, and doubtless beyond it, for it is hard to believe that

(1) The Victoria-Nyanza, a lake about the size of Ireland, is a titanic puddle. Indeed, it is not even that, for if reduced to scale so that its longest axis measured about four and a quarter feet its maximum depth (N. E. side) would be little more than one hundreath of an inch — a mere damp patch.

the events to be recorded were purely local (unless, indeed, the evidence has been misinterpreted), there was a time before the arrival of the Botletle sands (which later became the silcrete) when the climate was less dry than it is today ; but the present Kalahari is not the Botletle desert more or less reclaimed by vegetation, because between Botletle times and the coming of the Kalahari sands fell the palmy days of handaxe man. But even this propitious period was not, it seems, uninterrupted, for the one-time polished implements strongly suggest the work of sand-laden wind rather than that of siltladen water [1], and we know that the Kalahari sand of this area has been reblown, and in either case a regime quite different from, and almost certainly less moist than that immediately preceding and that immediately following the polishing times.

The above, then, would appear to be the story in outline ; but the critical reader will point to the Okovango swamps as almost the only source of the Botletle waters today and declare their flow to be dependent upon the uncertainties of that extraodinary delta. Thick papyrus belts, for instance, can choke a channel and, by slowly filtering sediments from a running stream, block its passage ; or again, hippopotami may clear a channel and keep it open by their tramping. We must therefore look afield for confirmation or disproof of our hypotheses.

If, then, evidence from widely separated areas is in support (and I hold that it is) are we to assume that the influence of the Okovango swamps was negligible ? Or must we conclude that in pre-Kalahari days it was not there ? With this problem are bound others of singular significance ; and not the least of these relates to the history of the upper Zambesi.

[1] This matter is, however, debatable.

E. Outlines of Stone Age Climatology (1952).

From the geoarchaeological viewpoint significant evidence of past climatic changes, and of the nature of the regimes that inevitably followed, is to be obtained by critical field studies of :

Geological accumulations.

1. *Windblown sands* of which the following are at present well known to the author.

(a) Pre-Palaeolithic red sand. Remnants of very much more extensive deposits are to be found in well-protected places.

(b) Post-Palaeolithic pre- (or early) Middle Stone Age red sands of the dunes and of many of the extensive flats of Bechuanaland.

(c) Dark grey-brown (nearly black and very slippery when wet) sand-stuffed flat deposits with a microlith-carrying industry at its base (*e. g.* Maun-Toteng area, etc.).

(d) Buff to cream-coloured dunes (Wilton) (*e. g.* Tsabong ; Kuis, etc.).

(e) Nearly white dunes (Neolithic ?) (*e. g.* Lake Ngami, etc.).

2. *Bedded calcrete* (so-called Surface Limestone, locally known as Kalk) (*e. g.* Lephepe ; Ghanzi ; etc.).

3. *Silcrete* (usually a silicious replacement of 2) (*e. g.* Mosna Laagte gorge, N. W. of Moldpolde ; Tsane, etc.).

4. *Ferricrete* (that form of it generally known as lateritic ironstone) (*e. g.* Lobatsi area ; W. of. Khwebbe hills, etc.).

5. Thick extensive *diatomite deposits* (*e. g.* Rakops, etc.).

6. Some riverine *red sands and grits* with a bouldery horizon (*e. g.* between Palapye and Serowe).

7. Some *high-level boulder beds* (*e. g.* Ramontsa, etc.).

8. *Low-level boulder beds* (*e. g.* Gaberones, etc.).

9. Some more or less *buff-coloured arenaceous deposits* (*e. g.* Notwani river).

10. Some black earths (so-called black cotton soil or turf) (very widely distributed).

11. *Chemical deposits* such as dripstone, etc. (*e. g.* Drodsky's cave, etc.).

As with blown sands, there are calcretes, silcretes, and ferricretes of different and distinct ages. Further research will most probably prove this to be true of diatomite and chemical deposits.

Erosional effects.

1. *Fossil rivers.*

2. Some *valley and stream-bed features.*

3. High wave-cut benches, in association with vanished, and in some cases long forgotten, lakes of large size.

4. Certain *limestone caves.*

It has not been overlooked that some of the above phenomena might result from causes which are not climatic. Fossil rivers, for example, might not be « fossil » after all, since they could owe their dryness to regional earth-tilt or river capture, but all the cases investigated have been dealt with on their merits, and the chronological correlation of events has been established by the use of stone tools as fossils, a practice long in use by the writer, and one which can be confidently adopted not only throughout the territory considered, but also for the purpose of age-correlation with geoarchaeological discoveries in the Rhodesias, Angola, the Transvaal (and probably in most of the Union of South Africa) and South West Africa. The same practice coupled with the nature and succession of the major climatic sequences, can be extended with confidence to the East African field.

Climatic changes and regimes.

In countries which normally enjoy high rainfall, indications of higher precipitation in the past tend to be obscured, on the other hand former dry periods (supposing there had been any) are by contrast more obviously evidenced. The reverse holds for arid and semi-arid lands. In addition to exposed boulder beds and gravels in generally waterless places in many parts of the Protectorate, we have similar implementiferous deposits beneath as much as 70 feet of surface limestone telling of the superimposition of near-arid conditions in the past ; on the other hand we have the fossil rivers aready mentioned, and in the north-west of the territory near S. 20° 2′, E. 21° 25′ we have a very striking three-halled limestone cavern containing great stalactites and stalagmites, now bone-dry and dust covered, beside a waterless river (the Khnihabe) in a setting of great sand dunes, which, it can be shown, are of later date than the cave (1). Then again the very dunes themselves provide evidence of a past climatic setting differing from that of today, not merely because they are now fixed by vegetation, but also because, to quote DU TOIT, their orientation « does not fit with present day wind directions and sug-

(1) WAYLAND, E.-J., Drodsky's Cave (*Geogr. Journ.*, Vol. CIII, n° 5, May 1944, pp. 230-233).
Aerial investigation reveals the probability of other caves in the N. W. of the Protectorate.

gests a former southerly displacement of the climatic girdles » (1).

These are among the most obvious indications of past climates of Bechuanaland that differed from those of today—some having been drier, some wetter. Already we have seen reason to believe that the « normal » climate of this part of the continent is that of a desert, and that the wetter periods are superimpositions upon that regime. Taking this, then, as a working hypothesis it becomes necessary, if we are desirous of understanding this matter as best we may (and this is desirable for the economy of the Protectorate depends in no small measure on the effects of its past climates), to enquire, so far as we can, into the nature and duration of the Pleistocene wet periods, and to learn when they had sway — clearly a matter for prolonged research to be conducted over wide areas. First we shall do best to enquire into age.

It is widely believed that the red Kalahari sand, and the surface limestone which it so frequently overlies, belong to the Pliocene, if not to earlier times, but such evidence as I have been able to collect during nine years in various parts of the Protectorate does not support this view, neither does the palaeontological evidence, so far as we have any. In a number of places where I have observed junctions of the Kalahari sand with the rocks beneath it and have discovered artifacts thereon, I have found that stone tools at bedrock may be of any antiquity up to the end of the older Stone Age (Plate 2).

The early Stone Age artifacts are all worn or weathered and generally more or less patinated, while associated with these are unweathered unpatinated (or extremely little patinated) smaller flake-artifacts that extend up into the bottom part of the red sand. Moreover, as alrea-

(1) Du Toit, A.-L., The Geology of South Africa (Edinburgh and London, 1939, p. 509).

dy related, the implement-bearing gravels of the ancient rivers are pre-Middle Stone Age. It should be noted too, that the dunes themselves have all the appearance of modernity, and it is hard to believe that they have suffered the climatic vicissitudes that followed the close of the Pliocene epoch.

In this line of research we have to consider topography and the implications of six main sorts of deposits.

a) Riverine, to which considerable reference has been made above ;

b) Lacustrine (the ancient beds of Lake Ngami for example), such sediments may include deposits of diatomite. Ancient wave-cut benches and boulder fans of the Mababe depression, and of Lake Dow, etc. ;

c) Aeolian : the Kalahari sand ;

d) The so-called surface deposits of which there are essentially three kinds : calcrete, silcrete and ferricrete (laterite variety).

There are also some important problems relating to soil. It is necessary to discover the conditions under which these deposits were severally laid down. The first three classes (*a* to *c* of the above list) do not as a rule present any great difficulty ; the last three are more problematical. They have two characters in common. In this country they tend immediately to underlie the Kalahari sand and their typical habitat is that of flat ground. Laterite, however, appears to be uncommon compared with the other two sorts of surface deposit in the Bechuanaland Protectorate wherein they are extremely well developed. But extensive laterite deposits may be found beneath the Kalahari sand. Calcrete (surface limestone, kunkar or kalk, as it is variously called) can apparently form in certain soils, first as little pellets which, as they grow, may join and anastomose and push out the soil, until a bed of little more than calcium carbonate results. In some cases this substance accumulates around roots. It is hard to believe, however, that deposits a hundred feet thick can have been so formed. Nor can the widely held belief that the carbonate of line is derived by decomposition of the underlying rocks be everywhere substantiated. Indeed there are numerous cases in which such derivation is out of the question. There can be little doubt that some deposits of calcrete were laid down under water — like diatomite into which they sometimes pass. It may be noted here that thick deposits of these substances do not of necessity indicate the past existence of deep waters for their accumulation. Indeed in many instances it would seem that the deposits grew in thickness as the containing lake or « pan » (to use a well understood South African term), always more or less shallow, expanded, in response to a rainfall which, extremely sparce initially, gradually increased on balance with time.

Calcrete and silcrete are inter-related, and PASSARGE held, as already stated, that beds of silcrete are the results of the replacement of $CaCO_3$ of the calcrete by SiO_2 (1).

An example of this sort of replacement can be seen in sections exposing a calcrete deposit with a silicified top covered by a later calcrete near Maun in Ngamiland for instance.

If PASSARGE's hypothesis is right, silicification (silcrete), where it occurs on a large scale, should characterise an early phase of a wet period, and calcrete the declining phase. Some evidence can be produced in support of this from Samedupi as already explaned.

Much remains to be learnt about surface deposits. They deserve a closer study than has been accorded them.

(1) PASSARGE, S., Die Kalahari (1904, p. 622).

My own work in this regard is as yet very incomplete and I shall not further refer to it here, except to say that calcrete, silcrete, laterite (and diatomite) as we know them in this Protectorate are, all of them, forming today, but in a weak fashion. In the Pleistocene optimum conditions for their formation occurred, and have done so more than once during that epoch of that period.

What were those optimum conditions ? Internal drainage was probably helpful, but not perhaps essential. Sources of lime carbonate and silica must of course exist, but these are extremely widespread and none is in any way peculiar to Bechuanaland. The essential factors are clearly climatic, and it seems certain from regional studies, here and in other countries, that neither very wet nor extremely dry (Sahara-like) conditions favour the formation of calcrete and silcretes. Long droughts and little rain in a hot land seem to be the essentials for calcrete formation, as PASSARGE thought, and it would appear that his explanation of the origin of the silcrete beds is not far from the truth.

As to ferricrete, lateritic ironstones or laterites, the general opinion, for which there is a good deal of evidence, favours the view that it was generally formed under tropical conditions with strongly marked wet and dry seasons which have led to the leaching of the more soluble substances from the soil. I tentatively subscribe to that view. Laterites are formed on areas of low relief and, according to PRESCOTT and PENDLETON, under conditions of high watertables (1).

I have said that there are silcretes, etc., of more than one age in this Protectorate. This is quite certain. It is also certain that the Kalahari sand has blown more

(1) PRESCOTT, J.-A. and PENDLETON, R.-L., Laterite and Lateritic Soils, *Comm. Bur. Soil. Sci.*, *Communication* n° 7, 1952.

Some evidence from Uganda suggests that in certain days lateritisation starts from scattered centres, in a concretion-like manner (E. J. WAYLAND, 1953).

than once during Pleistocene times. It is similarly indubitable that the rivers flowed abundantly between the arid and semiarid periods evidenced by the desert sands, and as we have seen by the calcretes and silcretes, it is clear that in all this we have evidence of climatic changes and regimes, the story of which reveals not only the environmental background but in considerable measure the controlling factors of early man's strivings in and about the Kalahari.

Sequences.

One may establish a sequence of geological or climatic events at one place and an apparently similar sequence at another place — say 500 miles away. We must ask were the seemingly parallel events really similar in nature ; and if so, were they contemporaneous ? In Palaeoclimatic work it is of the highest importance to establish these points, for certain stratigraphical and some other phenomena may be brought about either by a climatic change or by one or other different physical causes, among which river capture and earth movement are the most potent ; and while the first is more or less local, the second may be regional in its operation. Thus, as I have explained elsewhere (1), supposed climatic effects in one area must be checked up in others where positive results of earth movement in the first area would be negatived, reversed or non existent, as the case may be.

As to contemporaneity : when one is dealing with Pleistocene deposits the use of stone tools as zone fossils is usually possible, provided that the sequences to be compared are not too far apart ; but the wideness of the areas over which this test is applicable is astonishing. It is

(1) WAYLAND, E.-J., Desert versus Forest in Eastern Africa (*Geogr. Journ.*, Vol. XCVI, No 5, November 1940, p. 338).

found that the Stone Age sequences of Africa, though not exactly the same, are closely similar, and of not very different date over thousands of square miles. In Pleistocene palaeoclimatic research, therefore, this is our clock. I do not say chronometer. I have used this clock in the checking up of sequences at many places in the Bechuanaland Protectorate, which is a territory considerably vaster than the largest country in Europe, and the results are illuminating.

Repetition of climatic regimes of the Kalahari have already been referred to, and it is clear therefore that some sort of sequence has obtained ; this, with the aid of our stone-tool clock, will now be briefly examined.

The oldest silcrete I have been able to discover in widely separated places in the Bechuanaland Protectorate is essentially a silica-cemented sand. Except where interaction has taken place between contents and matrix, its grains have the character of those of the oldest unconsolidated Kalahari sand in that they are well sorted and rounded ; there are few millet-seed grains, but even the smallest of them (about a tenth of a millimetre long) exhibit abrasion. Locally, as at Samedupi in Ngamiland (as already described), the silcrete is full of root holes, in other places very ancient silcretes are pebbly especially toward their bases — among these stones are early Kafuan pebble tools ; all of which are derived. With regard to this material two points should be noted :

a) Early palaeolithic man frequently used it for the manufacture of his tools ;

b) I have never yet seen a Kafuan tool made from a silcrete pebble, but I have seen silcrete pebbles, split or flaked and trimmed, in association and contemporaneous with Acheulean-type artifacts. This suggests that the early silcrete, where it has been studied by me in

Bechuanaland, is post-Kafuan and pre-South African Chelleo-Acheulean in age.

Locally it is represented by calcrete. But older silcretes could occur. The next silcrete in order of decreasing antiquity is post-Acheulean and pre-Fauresmith I. Gravels containing Acheulean tools, and certain deposits above them, are calcified sometimes through a thickness of seventy feet. Locally the deposit is silicified, but the silcrete thus formed is not known to form massive beds like its predecessor. From this time onwards silcrete diminishes in importance. Calcrete appears again in Fauresmith II times, and again later, but only, as far as I know, in nodular form in certain black fills of late date. A little is forming today.

The Kalahari sand sequence is as follows :

The great antiquity of the Kalahari desert proper suggests that vast quantities of sand must have accumulated before the beginning of Pleistocene days. How much has been added to this during human times it is impossible to say ; it may have been comparatively little; but since the typical long-period desert regime was interrupted by the first Pleistocene wet phase (Pluvial I = Kageran), the Kalahari sand has blown in at least three periods :

c) About Magosian times ;

b) About Middle Stone Age ;

a) Pre-Palaeolithic.

The dunes of (*a*) appear to have been mostly destroyed but some sand patches can be found that may belong here. They were the source of the sand in silcrete. Most of the dunes and other Kalahari sand deposits we see today are of early Middle Stone Age date, but some, especially those in the S. W. of the Protectorate, are of about Magosian age.

These are light coloured, and some occur in the beds of extinct rivers (e. g. Lower Molopo). The dunes in the west and particularly the south-west of the Protectorate are on the move again. This is not only obvious on the ground, but most conspicuous from the air.

With regard to riverine, lacustrine, and swamp regimes, the position is this : the first Pleistocene Kalahari sands (oldest silcrete) were preceded by a strong riverine wet phase, evidenced by part of what is known as the Kalahari Beds. Under this term was embraced everything from and including the Kalahari sand (the separate blowings were not recognised) down to and including marl, arenaceous deposits and conglomerates of pre-silcrete I age. Here it is proposed to restrict the term Kalahari Beds to the pre-silcrete I post-Karroo aqueous deposits of the Kalahari area. « There can be no doubt », says DU TOIT, « that this widespread deposit, with its occasional conglomerates, resting on the most diverse of rock groups, is largely of *fluviatile origin*, though some aeolian action is not excluded » (1). No fossils have been found in these beds, save those of a few modern genera, and there seems no reliable evidence of the very great antiquity claimed for them by several authors. They apparently correspond to the Kageran deposits of Uganda, which are regarded as early Pleistocene, and here provisionally I propose to place them. This accepted, they could be regarded as the major deposits of the first wet period (Pluvial I). If this is so, then in the Kalahari, as in Uganda, Pluvial I was the longest of the three pluvials and may well be complex.

It was agreed, at the *XVIII[th] International Geological*

(1) DU TOIT, A.-L., Geology of South Africa (2nd Edition, Edinburgh and London, 1939, p. 419).

Congress, held in London in 1948, that the Plio-Pleistocene boundary is to be drawn at the bottom of the Kageran in Africa, and at the base of the Villafrankian in Europe (¹). The world over, so far as is known, this horizon provides evidence of a climatic change. This is a welcome decision, for it has been my opinion for many years that in the accepted view the Pleistocene has been greatly foreshortened. There has, I think, been a kind of unconscious conspiracy to minimise the denudational and other changes that have taken place since man was evolved. Some researchers have shown that in middle Pleistocene times there seemingly existed a species of *Homo* closely allied to our own. Indeed, I think we can see this in the stone age industries of that time. The skill and beautiful workmanship exhibited by of some the late Acheulean handaxes, for example, renders it perfectly clear that their makers were artists, carrying their technique far beyond the bounds of mere utility. True, there may have been ape-men then (just as there are apes today), but the makers of these exquisite artifacts were not of them. They were essentially sapient. From their day it is a very far cry indeed back to the beginning of the Stone Age (early Kafuan times).

After the dry period that followed the first Pluvial (my Kageran), came another pluvial (LEAKEYS Kamasian — my second pluvial) during which many of the deposits of Pluvial I, which chanced not to be covered by wind blown sand or silcrete or otherwise protected, were early destroyed and their constituents incorporated in the accumulations of Pluvial II. These were the days of Chellean man, who established a hand-axe culture which was destined to last throughout the succeeding pluvial (although man was driven, by encroaching drought, to vacate the area of our present study), and

(¹) *Nature*, Vol. 163, nº 4135, 1949, p. 186.

to advance in Pluvial III (the Kanjeran) to its Acheulean peak, only to decline rapidly to its virtual end. During the last part of this period, Fauresmith and Sangoan tools appear.

The fourth and latest pluvial (the Gamblian) saw the development of the Sangoan culture and the Middle Stone Age complex of South Africa. The Sangoan people, it seems, were highlanders, while the Fauresmith folk were people of the plains.

The pluvial deposits provide, in places, evidence of complexity (1) ; nor were the interpluvials without their phases. That which fell between Pluvials III and IV, although most strongly characterised by the red sand of the Kalahari dunes was not unaccompanied by calcrete and silcrete formation. In the Samedupi area, as we know, and near the present Victoria Falls, many stone tools were naturally polished, either by sandblast or by sand and silt-laden waters, such as those of ephemeral rivers. But the Kalahari sand, as we know it in Bechuanaland, itself re-blown, was again in part, and more than once, redistributed, as reference to *E. Geological Accumulations* will show (see p. 30).

After the re-building of the dunes and before the present time, there were two periods in which black turf (so-called black cotton soil) was intensively produced in low lying areas. The older of carries calcium carbonate concretions and sometimes pellets of ferricrete, usually more or less globular, the younger deposit apparently does not. At some places the junction between these two

(1) According to SOHNGE, VISSER and VAN RIET LOWE (Geology and Archaeology of the Vaal River Basin, Mem. 35, Geol. Surv. S. A., 1937) there were two oscillations toward drier conditions during Pluvial II (first wet phase of these authors) in the area they investigated. LEAKEY does not regard the main climatic interruption in Pluvial II as an oscillation, but as an interpluvial so that what he originally called upper Kamasian incomes the Kanjeran Pluvial. A view that there were only two pluvials, each with a strong intrapluvial and some oscillations, and one true interpluvial is worthy of consideration.

deposits is very sharp, at others they merge into each other. They represent conditions of considerable water and bad drainage (swamps in fact) and the carbonate concretions in the lower of the two appear to indicate a period of drying out, with long dry seasons and summer rains, before the second black turf was deposited. These two relatively short moist periods seemingly correlate with my epipluvials of East and Central Africa.

Judging by stream development, the present day conditions have not been long established. They go back perhaps a very few thousand years; perhaps not so much.

F. Correlations and consequences (1952).

The world over, Pleistocene time was punctuated by a series of meteorological events which COTTON has called climatic accidents (1). In the high latitudes these comprise the Great Ice Age with its glacial and interglacial period; near the equator and on it, however, ice sheets did not develop; but it can be shown that equatorial mountains that rise well above the snow line today had longer and larger glaciers in Pleistocene times, while some mountains (Mt. Elgon, near the Uganda-Kenya border for example) that now have no permanent snow were glaciated. Today we are credibly told that, the world over, glaciers are shrinking. This can hardly result from mere coincidence, and if, as would seem most likely, some world factor controls this shrinkage it is a fair presumption that a world factor controlled glacial developments in the Pleistocene days. At any rate this idea provides a good working hypothesis, which suggests that, although there can be no such thing as a world climate so long as this globe retains its atmosphere, there may be world control effecting all the climates of the

(1) COTTON, C.-A., Climatic Accidents in Landscape-Making (1942).

earth, one way or another. Indeed there is one such control, albeit indirect of which we know, and that is solar energy. Let us suppose that the mean quantity of solar heat this earth receives were doubled, or halved, all terrestial climates would alter greatly in response. Solar heat is likely to be fundamental and astronomical cases may well produce modifying effects. Surface relief must also play an essential and modifying part (1). BROOKS was the first to prophesy that glacial periods of the higher latitudes would in many parts of the tropics be times of heavier rainfall than those of today and these pluvial periods would be separated by exceptionally dry interpluvial phases (2). Before World War I, I was able to produce evidence from Ceylon that appeared to support BROOKS view ; and between World Wars I and II, I secured better and more detailed evidence in East Africa (3). There is a test for this theory of glacial and pluvial coincidence, it is that of contemporaneity. If one glacial period of the Great Ice Age in high latitudes was contemporaneous with a pluvial period in the tropics, and another glacial period of that epoch was synchronous with a desert period in that same tropical area, our theory falls to the ground, but if, on the other hand, a succession of glacial periods is reasonably parallel in time, number and intensity with distant pluviations, the theory has much to recommend it, and there are many reasons for supporting this positive correlation, but it must be remembered that local influences must modify climates. Assuming the general truth of this hypothesis, and accepting the commonly held view that we are not

(1) WAYLAND, E.-J., Causes of Ice Age (*Geol. Mag.*, Vol. LXXXV, nº 3, 1948, pp. 178-181).

(2) BROOKS, C. E. P., The Meteorological Conditions of an Ice Sheet and their bearing on the Desiccation of the Globe (*Q. J. Roy. Nat. Soc.*, Vol. XL, nº 169, January, 1914).

(3) I have produced several papers dealing with this matter, and a memoir embracing the whole subject, and the Pleistocene generally so far as Uganda is concerned, is being prepared.

yet quite out of the Ice Age we must expect climatic change, for half-size ice caps, such as we have today, are unstable, they must either disappear or grow larger, what are the implications regarding the future ? Surely this : if we are not in an interglacial period, earth climates will gradually return to normal, and the Kalahari will once more be a desert. Such indications as we have today seem to favour this view.

The detailed work of LEAKEY in Kenya (1) and of the *Geological Survey of the Union of South Africa* in collaboration with Professor VAN RIET LOWE, in the Vaal Basin (2), has shown that the parallelism of Pleistocene climatic events in East Africa and the Transvaal is indicatively striking ; and as might be expected, the results of my work in this regard in the Bechuanaland Protectorate, so far as it has gone, fit in closely with those obtained in these widely separated areas of East and Southern Africa. Indeed the parallel can be taken much further afield than this (3), so that it is very difficult to disbelieve that these climatic phenomena were not, as the Great Ice Age was, a result of world climatic control ; and it is but a short step from this conclusion to another ; namely that BROOKS was essentially right when he correlated glacial and pluvial periods. Moreover, as research into these matters proceeds in various parts of the globe, the more likely does this conclusion become.

We are left, then, with the hypothesis that our climate is very slowly changing, and evidence of accelerating erosion in areas where man's influence cannot be invoked to account for it is in support (4). There is evidence in

(1) LEAKEY, L. S. B., The Stone Age Cultures of Kenya Colony (1931, pp. 6-17).

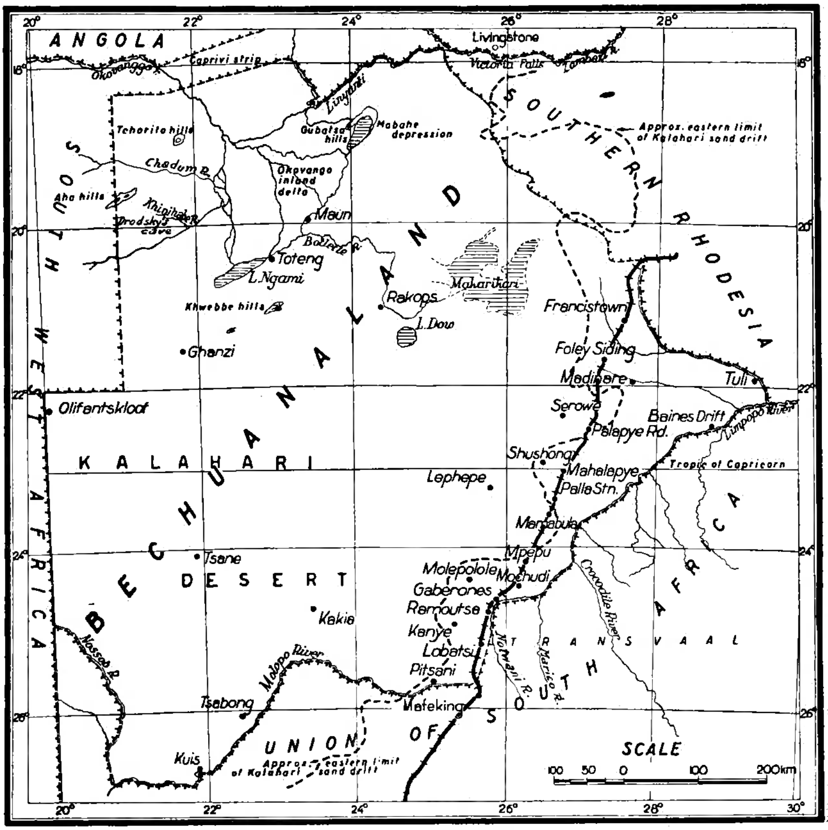
(2) *Memoir* 35 (1937).

(3) PATTERSON, T. T., A World Correlation of the Pleistocene (*Trans. Roy. Soc. Edinburgh*, Vol. LX, Part. II, No 11, 1940-1941).

(4) On the other hand, it would appear that in Ankole (Southern Uganda) the natural soil erosion is slowing up (E. J. WAYLAND, 1953).

plenty that in Pleistocene time the Kalahari and its marginal areas were the scene of long sustained climatic regimes alternating between wet and dry, and that this highly remarkable succession of climates with decreasing intensity towards the present day, together with some wider considerations, leads to the view that the wet periods of the Kalahari during the Pleistocene were superimpositions upon the normal climate of a very long existing desert. Paralleling this succession of changes, synchronously it would appear, were the Ice Ages of the Glacial Period of the higher latitudes, and if we correlate pluvials with glacials, and there seems little alternative to this rational view, it would seem in the fitness of things that here, in Bechuanaland, the essential desert should return unto its own unless, of course, these are interglacial days, in which case that return will be postponed for ages. The presence of polar ice caps shows that we are not yet out of the Glacial Period, and the indications, as far as we know them and can read them at present, are that the last of its constituent Ice Ages is drawing to its end, and with it the palmier days of the Kalahari. But it is unthinkable that the change will be an entirely one-way process ; moreover these climatic mergings take time — geological time.

Written in 1946 and 1952.
Introduced Nsongezi camp,
Kagora river, Ankole,
Uganda, the 23rd of May 1954.



— Map of the Bechuanaland Protectorate.

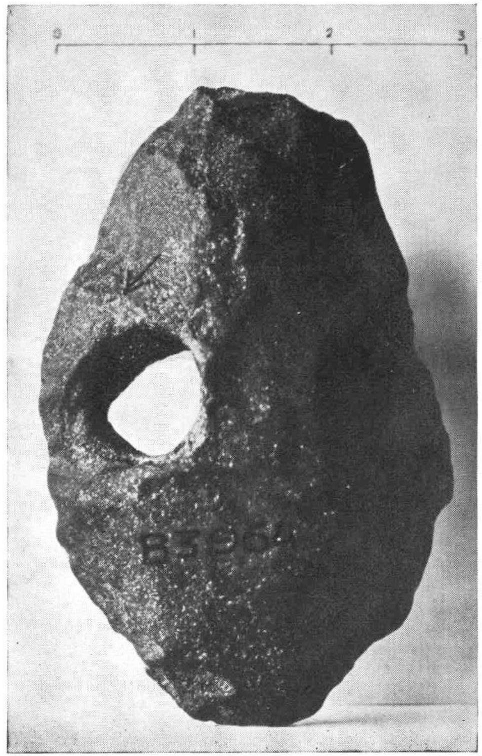


Plate 1. — Samedupi artifacts showing fossil root notes.

FIG. 1. — Small handaxe losing its natural polish.

FIG. 2. — Small cleaver (never polished) showing reaction ring (sheath) round « fossil » root-hole.

(Scale = inches).

Plate 2. — Kalahari sand (9 feet thick) overlying calcrete. On the somewhat lateritised top of the calcrete tools of Fauresmith cum Sangoan types are found. Twenty miles east of Serowe.

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