The Palaeogeography of the Middle Kalahari of Northern Botswana and Adjacent Areas

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The Okavango Delta is but part of what Wellington (1958), himself following Passarge (1904), labelled the “Middle Kalahari”. This comprises the end drainage basin of the Okavango River itself, together with those of the Chobe and upper Zambezi, and includes the whole Makgadikgadi internal drainage system. The Delta’s evolution and present character cannot be studied in isolation from this whole region of which it is an integral part. This paper therefore concerns itself with the palaeogeography of the region as a whole.

Throughout this middle Kalahari region the Kalahari sand is almost ubiquitous, though scattered outcrops of older rocks rise like islands from the sea of sand. This extensive sand-covered surface is however, by no means uniform or monotonous in detail. Land forms include the islands, channels and lagoons of the swamps; the variegated surfaces of the ancient lake beds of Makgadikgadi, Ngami, and Mahabe; the wide flood plains of the rivers; ancient fossil valleys; innumerable small pans; alkali and barchan type dunes and puzzling sand ridges like that of Magwickey; and flat sandy plains. Massey (1974) in a study of the relatively small area of the southern Makgadikgadi and its margins recognized eight major and quite distinctive geomorphic units in this area alone. Even a superficial survey of the region reveals many puzzling problems. What is the cause of the drying up of the former considerable lakes of Makgadikgadi, Ngami, and Mahabe? Why do desert sand dunes exist side by side with humid climate landforms such as river valleys and solutinal caves in dolomite outcrops? Why do the Okavango and distributaries, the Chobe, and the upper Zambezi abruptly turn to flow north-eastwards and eastwards or south-westwards from their more or less parallel south-east oriented upper courses? Why does the Okavango spread out into a vast deltaic swamp where most of its water is lost to the atmosphere by evaporation and transpiration, leaving only a relatively small flow to continue in good rain years via the Boteti River to the Makgadikgadi Pans? Answers or at least partial answers to these and similar problems lie in two separate fields. Firstly, in the nature of the climate and the way in which this has changed in the past, changes which have had a marked effect on the nature and development of the landforms. Secondly, in the fact that crucial movements appear to have taken place which have seriously interfered with the river courses, radically altering them from what they may have been in the past. Each of these subjects must be examined in turn, and earlier ideas reviewed.

A great deal of controversy has surrounded the question of climatic change in Southern Africa as a whole, but a powerful body of evidence has by now been gathered and set down in its favour. E. J. Wayland, sometime Director of the Bechuanaland Protectorate Geological Survey, in a very important paper (Wayland, 1954) made detailed reference to the evidence he had gathered on landforms, geological accumulations, and early human occupation in the Kalahari, and its relation to climatic change. He concluded as follows: “...in Pleistocene times the Kalahari and its marginal areas were the scene of long sustained climatic regimes alternating between wet and dry, and 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 long-existing desert.”
A. T. Grove in another important paper (Grove, 1969) reviewed the landforms of the Kalahari in detail. He drew attention particularly to typical arid climate landforms such as the extensive systems of sand dunes now stabilised by vegetation, and the evidence for the existence of former lakes in for example the ancient strandlines and lacustrine deposits of the Mokgadi-Kgadi area, and of former flowing rivers in the existence of fossil valley systems orientated towards this depression, which indicate wetter climates at sometime in the past. The present writer from evidence in caves and adjacent landforms in western Ngamiland (Cooke, 1975) has postulated an alternating series of wet and dry climatic phases, with one prolonged wet phase dated from 14C determinations on cave sinter, occurring between 17 000 and 14 000 B.P. Rainfall may have varied from less than 250 mm per annum to over 1 500 mm per annum overall. Much evidence of similar changes has been gathered in South Africa and Rhodesia, for example by Brain (1958) from studies of dolomite cave deposits in the Transvaal, by Burrell et al. (1973) from an ancient lake bed near Kimberley, by Bond and Flint (1968) from studies of slab sand dunes in western Rhodesia, and by Van Zinderen Bakker and his associates from palynological studies in South Africa (e.g. Van Zinderen Bakker, 1957). There are now some workers however who doubt the reality of climatic change in Southern Africa or at least feel the evidence to be inconclusive. Kokot (1948) went so far as to state that there is little to support and much to contradict the idea of marked pluvial phases during the Pleistocene in Southern Africa, and concluded that it was highly certain that at no time was rainfall much more than it is now for any length of time. More recently Partridge has spoken of "... the flimsy nature of the evidence, and the questionable relationships between cause and effect from which the majority of supposed climatic changes in South Africa have been inferred (Partridge, 1969 p. 115). Whatever the nature of the evidence from Southern Africa as a whole, most workers who actually travelled and studied in the Kalahari region with which we are here concerned, accept the fact of climatic changes in that area, and 14C dates are now beginning to give added meaning to the evidence. In the present writer's view the judgement of Wayland quoted above stands supported.

The nature of the crustal movement and its effect on drainage development in this region has likewise been a subject of debate, though recent findings have served to clarify certain aspects of the problem. To make the nature of this problem clear, it is necessary first to describe briefly the present-day pattern of drainage. Below the rapids at Katima Mfolo the upper Zambezi flows across a flat sandy plain where the river's gradient drops to between 1:13 000 and 1:20 000, and when the river is in flood much water spills southwards from this section through a swamp zone and into the Chobe, which then enters the Zambezi about 14 km below a second set of rapids at Mambwe Boys. The Zambezi then flows on through a wide valley with many islands in the river, across further rapids at Katombo and then 60 km further on plunges over the Victoria Falls. The Chobe (also known as the Linyanti and the Kwando), in its upper course in Angola has a gradient of about 1:13 000, but as it enters the Caprivi Strip and then Botswana its gradient flattens, and enters an extensive swamp zone, and it turns abruptly north-eastwards. This swamp zone is sharply defined to the south-east against a low sand rise. This parallels the continuation of the Magwile sand ridge between the Gabasaa Hills and Kachikau, though separated from this by a shallow depression in which old flood channels lie parallel to and against the Magwile sand ridge continuation. As already noted, between Kachikau and its junction with the Zambezi the Chobe receives much floodwater from that river through a swamp zone. Wellington remarked on the very interesting fact that between Leghiwe just south of the Lianmbezi Lake and the abandoned Savuti offtake upstream the gradient along the Chobe River bed steepens to 1:7 000 compared with
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at least in part to downdrafting which has resulted in a sharp slackening of gradient along the rivers leading to increased rates of sedimentation and to interference with drainage in the east. The Chobe is ponded back sharply along fault lines, but its waters escape laterally eastwards to the Zambezi through a swamp zone to which both rivers contribute. The question of whether the Chobe and/or the Zambezi could flow southwards to join the Okavango remains unresolved on present knowledge, and Wellington's river capture hypothesis also remains open to debate. Also still unresolved is the question of whether a link ever existed between the Okavango-Boeti-Maqgadigkadi system and the Limpopo. The discovery of Kimberlite minerals in the upper Macloutie Valley, and of Kimberlite pipes around Lebuhzane to the west and on the other side of the present watershed has lent strong support to the idea. Furthermore, air photographs reveal the existence of fossil valleys and associated geomorphic features in the area between Macloutie and the watershed. Recent survey for 150,000 map sheets however, shows that the only break in the rise is a low 20 km wide gap below 1,090 m altitude 14 km south of the fossil valleys and immediately adjacent to the upper Macloutie. This gap however appears to be a flat and largely featureless sandy plain. Again the matter lies unresolved and awaits further fieldwork.

There remains the question firstly of the present nature of the Okavango Delta and how this has arisen from former patterns, and secondly of the former existence of a large lake in the Maqgadigkadi depression. It is here that the two factors of climatic change and crustal movement seem to be most closely linked. In the writer's view the idea that the Okavango Delta is simply the result of the darning back of the drainage by downdrafting is only part of the truth. A dam fills up from a spillway, whereas the perennially flooded part of the Delta is well upstream towards the apex. Furthermore there is the 'as yet admitted' sanny' evidence that the Delta sediments do not fill up from upstream. From the perennially flooded zone the annual floods move south-eastwards and on to sheet floods and partly in channels to the north-eastwards and south-westwards, but now almost entirely in the latter direction along the fault-defined valleys which constitute the bed of the Delta.

If we accept Wayland's basic hypothesis that the Kalahari is a nuclear or ancient arid and semi-arid zone that has been affected from time to time by more humid climatic phases, then the Okavango may be typical of a river rising in humid highlands and invading a terrain dominated by arid climateplanation and aggradation, which is precisely what most of the Kalahari in fact is. In such circumstances rivers diminish in volume, their velocity decreases and their transporting power is reduced. The deposition of sediment follows. Channels become blocked and divide, the ends of channels and spreading out. Periodic sheet floods degenerate into mud-flows. A characteristic fan-like area of deposition results, with a pattern of shifting braided courses. Eventually, with increasing aridity, all flows may cease, and vegetation die out. In such conditions, strong winds may deflake the finer fractions of sediment from the unprotected surfaces, further obscuring the pattern of drainage that may once have existed.

With the onset of more humid conditions and an increase in precipitation, both in the upper catchment and locally, this pattern might be expected to change. Such a change of climate would create increasingly large run-off amounts, especially in the early stages of change before vegetation had again colonised wide areas. In such circumstances flows are likely to be in the form of what Garner (1967) calls quasi-sheet floods. Under these, flows may be laminar rather than turbulent especially on the shallower flanges of the floods. Laminar flow does not transport sediment so that can it erode. Where the water is deeper however, streaming flow may develop, and such turbulent flow can then erode channels which may progressively deepen, though flooding may continue during periods of high discharge. The typical result in such conditions is the development of an anastomising channel system. Bretz (1923), quoted by Garner, showed that such multiple-channel drainage systems are inherently unstable, and because of the changes in store, discharge, and geometry of the network, erosion will be more effective in deepening some distributaries than others. Thus eventually a single channel may develop. Flow beyond the arid period fan may then become exorctic or if a topographic low or basin exists downstream, a lake may result.

This could be the origin of the great Maqgadigkadi Lake. Du Toit thought the rise along the Rhodesian axis took place in the Pliocene, thus pre-dating the climatic fluctuations of the Pleistocene with which we are concerned. Drainage from the eastern watershed and from river systems draining the Kalahari from the south and flowing during wet climatic phases would complete the pattern of centripetal drainage.

A succession of dry and wet periods would obviously, in terms of what has been described above, result in a complex situation with a chaotic conglomeration of dry and humid landform relics, and a highly dergened and unstable pattern of drainage. Earth movements along faults athrow the major topographic gradients might be expected to further complicate the landscape, especially if they took place contemporaneously with climatic fluctuations. There is evidence that this has been the case, and that movement within the southwestern to north-west rift zone in which the Delta lies has continued into upper Pleistocene to recent times. The fault running south-west from near Gomare on the western edge of the Delta very strikingly truncates alluvial sand dunes which must date from the last major arid period, whilst in the Kwiwane hills further to the west, faulting has affected camera in valleys which transgress and thus postdate the dunes, and large-scale erodes within the cave in the hills fracture domolonic, and sixteen years date from a major Pleistocene event period (Cohee, 1975). A series of earthquakes was experienced in the Delta in 1952 (Reeves, 1972), whilst the recent study made by Schotz and associates (1975) revealed continuing earthquake activity at the present day along the major faults which define the base of the Delta. If the downdrafting of the lower reaches of the Delta preceded a major wet period then it is feasible to suppose that a large lake may have formed as Du Toit suggested. There is very clear evidence of at least nine swamp conditions having existed over a large area further north-east and south-west of the present swamp areas. Ngami and Mahave might thus be regarded as the latest remnants of such a lake to contain open water up to recent times. Drainage to Maqgadigkadi would be effectively blocked, and that lake would slowly shrink, drying up completely in the more arid period.

The situation at the present day may be that we are in a transitional arid to humid or humid to arid phase. In favour of the former is the fact that the flow in the Delta swamps does seem to be concentrating towards a central line in the Boro, with the outer distributaries of the Thogwe and the northern Nkhoma channel losing flow. This may indicate that the River Okavango is acquiring what Du Toit picturesquely called 'single-biocentred' in the manner postulated by Bretz for such systems and referred to above. It is also possible however, though somewhat speculative, to suggest that downdrafting across the major axis of the rift may have had something to do with this. For 130 km below the Botswana-Caprivi border the Okavango Swamp is sharply confined within a downdrafted trough aligned north-west to south-east, and the long axis of Chobe's Island follows closely the same line with the Boro flowing roughly parallel to this on its south side.

In conclusion, it is clear from the foregoing description that although the picture has become clearer in recent years, no firm and final conclusions can yet be drawn regarding the exact nature of this land and its surface form in the past, nor of the
processes working on it. The Middle Kalahari remains a place of utmost fascination with a tremendous amount of geomorphological and hydrological fieldwork still to be done. The findings of such research will not simply be of academic interest. An understanding of the history of landform and climatic evolution and change in this area is vital to an assessment of the present situation, which is the context for current short and long term planning of this country’s precious water resources.

REFERENCES


