Fluctuations in the level of Lake Ngami: the historical evidence

1983

Periodicity ..

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Introduction

Lake Ngami plays an important part in the economy of northwest Botswana. It supports a small, but growing commercial fishing industry, whilst visitors come to observe, or in some cases, to shoot, the abundant bird life. The surrounding lake flats support in excess of 30 000 cattle (U.N.D.P./F.A.O. 1977). All of these activities are dependant on the presence of water in the lake bed. Lake Ngami, like many of the shallow lakes of Africa, is notoriously ephemeral by nature, liable to rapid fluctuation in both area and depth.

For the purposes of prediction, therefore, it is helpful to know as much as possible of the history and regime of the lake. Data collection can be approached on three time scales. On a short time scale (less than ten years in the case of Ngami) this involves estimation of the water balance based on accurate periodic observations of the lake level and inflow. Measurements of this type have been made intermittently since 1973 by the Departments of Water Affairs and Fisheries, but the results so far are neither sufficiently accurate nor long-term to be of more than indicative value.

On a long timescale (up to 50 000 years) it is possible to study the geomorphology of the late Quaternary Ngami basin and its relationship to the Okavango-Makgadikgadi system as a whole (Cooke 1980), yet such studies are still at an early stage.

Between the two approaches lies the possibility of reconstructing the history of the lake over the last two centuries from observations or inferences made by early travellers, administrators and engineers, supplemented for the last three decades by aerial photography, and, more recently, satellite imagery.

Many summaries of early, particularly 19th Century accounts, have already been published[1] in response to public interest in the grandiose schemes of Professor Schwarz (1920), who believed that the interior of Southern Africa has undergone progressive dessication. The remedy proposed by Schwarz was the reconstitution of the lakes of northern Botswana, and the transfer of water to the Orange River system. The idea of dessication within human experience was not new at the time, having been expressed by Livingstone (1858a) and subsequent visitors to the region, but the controversy generated by these proposals was far-reaching. Schwarz' schemes were investigated by the Department of Irrigation of the Union of South Africa (Du Toit 1926) and found to be impractical. However, vestiges of Schwarz' ideas can be found in subsequent investigations of the Okavango system (MacKenzie 1946) (Brind 1955) and of South Africa as a whole (Kokot 1948).

Thus the principal documents relating to Ngami can be divided into those who believed that dessication had occured since the mid-19th Century (e.g. Stigand 1923, Kokot) and those that expressed a belief in a stable, but fluctuating, lake level (e.g. Du Toit, MacKenzie, Brind). The evidence of the early travellers, some of whom never actually saw the lake, has been selectively interpreted according to the opinion of subsequent authorities. Evidence for and against the existence of higher lake levels in the 19th Century that have been suggested by some reviews will be examined in this paper.

Physical Background

Lake Ngami occupies the northeast part of shallow sedimentary basin (Fig. 1) bounded to the southeast by a low escarpment of Karoo and Ghanzi Formation rocks along an extension of the Kunyere Fault (Reeves 1978). To the west a 25 km compound sand ridge separates the Dautsa Flats from the present basin, although it is probable that both parts were inundated as part of greater Lake Ngami in the past. To the north a series of old shoreline features and minor sand ridges separate the basin from the abandonned swamp and fill topography of the Thaoge system.

The present Lake Ngami is fed by the Kunyere and Lake (Nghabe) Rivers, which join at Toteng, and flow into the northeast extremity of the lake by way of a well-defined channel. The Kunyere is currently the more reliable source; the water in the Lake River is derived via the Thamalakane and a major share, perhaps as much as from fifths (Kraatz 1976) is drawn off by the Boteti River some 63 km upstream of Toteng.

During the 19th Century the Thaoge also flowed into the lake, drying up between the 1870's (Stigand 1923) and 1898 (Drotsky in Kokot 1948), but most probably about 1884 (Wilson 1973). The failure of the Thaoge is generally attributed to blockage by papyrus and, despite occasional attempts at clearance[2], water has not passed beyond Makakung, 16 km north of the lake, during this century.

Reliable estimates of the extent of the lake show it

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to vary from a series of small pools close to the Lake River inflow, with a water level at 919,5 metres a.s.1., to a maximum extent of 250 km² (length 34,5 km, width 8 km, circumference 80 km). This represent a water level of approximately 923,5 m.a.s.1., with the water reaching past Sehitwa to the sand bar running across the lake in the direction of Bodibeng Village (Figs. 2 & 3). This level was attained in 1969, causing damage to the Moshu woodland on the Bodibeng Flats (Mr P Smith — personal communication). The flood reported for 1925 (Du Toit), considered to be the highest this century, has been estimated by Brind at 923,7 metres.

Past higher levels of the lake are indicated by strandline features. A 926-927 metre strandline is seen along the north shore east of Sehitwa and in the Bodibeng Flats. Water at this level would pond back to the Kunyere-Lake River confluence. A more prominent feature occurs at 930-931 metres (Grove 1969) around the basin perimeter, enclosing an area of 810 km². This marks the level at which backflow would occur on the Lake River as far as the Thamalakane junction, leading to an outflow of Lake Ngami into the Boteti River. Earlier levels, including the Dautsa Flats, encompass an area of 1,800 km² and are thought to exceed 940 metres a.s.1.

The lake derives approximately 80% of its water from inflow, the remainder from local precipitation. Thus the seasonal rise of the lake follows the arrival of water in the Kunyere and Lake River feeders in June of an average year, with maximum inflow usually reached in August. The lake level tends to fall during the period from October to May, except for high-flow years, such as 1978, when limited inflow occurs in all months.

The influence of precipitation on the lake is limited, which is not suprising considering that the rainfall records for Sehitwa in the decade 1973-83 show only five months in which the monthly rainfall has exceeded evaporation.

This regime has two important consequences. First, the lake is out of phase with local climatic conditions, reaching a seasonal peak during the dry season, and a low during the summer rains. Second, the behaviour of the lake does not directly reflect long-term climatic changes in the locality, for the variation of the inflow is dependant on periodic rainfall fluctuations in the headwaters of the Cubango and Cuito Catchments, and on changes of hydrological conditions within the Okavango Delta itself.

The Lake Levels

Variations in the lake level for 1849-1983 are summarised in Fig. 4, together with associated river flows for the same period. The flows for the Boteti River at Rakops are also shown, for not only does the Boteti have a more complete record, but the flow itself is considered more reliable than that of its sister distributary, the Lake River at Toteng, and can be used as a doublecheck for early accounts of the latter river [3].

It is necessary to point out the limitations of Fig. 4 as follows:—

(1) It has been assumed that lake levels for 1849-1862 are comparable to those of the present. This assumption may not be correct (see next section) as the Thaoge flowed into the lake at this time and the regime may have been different. There are no records for the critical period 1863-1883.

(2) Annual lake levels have been ascribed on the basis of statements of lake extent, depth and relation to prominent features, and are thus dependant on the objectivity and accuracy of the observers [4] The levels themselves may vary considerably within the annual cycle (for example, Brind reports a fluctuation from dry to 20 miles extent and back to dry in 1951) and consideration must be given to the time of year at which the observations were made. Thus the record is not necessarily complete for any year before 1973.

(3) The river flow diagram refers merely to the presence of water in the channel and does not indicate the duration or rate flow for the year. For example, the Boteti reached Rakops in 1981, but the flow was negligible.

Taking these limitations into account it is possible to identify five periods within the last eighty years during which the lake bed has been dry for two consecutive years. These periods of dessication naturally coincide with reduced flow in the feeder rivers. On these grounds it is reasonable to suggest that the years 1934-36 and 1938-47 also experienced low levels, if not complete dessication. Likewise, during the years 1905-09 and 1911-20 the lake did not extend further than 7 miles from Toteng (Stigand, Du Toit). Thus it would appear that, as far as the 20th Century is concerned, low levels are the norm.

Maximum levels, with the water reaching between Sehitwa and Bodibeng, appear to have been attained in 1898 (Stigand, Du Toit), 1899 (Scolefield and Lugard in Kokot)[5], 1904 (Stigand), 1925 (Du Toit, Westgate 1976), 1926 (Westgate), 1968-69 and 1978-79. In most cases the high levels were maintained for one or two years before gradually declining.

1849-1863: A Higher Level?

When Livingstone and his companions arrived at the northeast end of the lake on August 1st, 1849, they beheld a "fine-looking sheet of water" (Livingstone 1858b:75). Subsequent visitors in following years were less enthusiatic; Andersson, arriving at the western end of the lake in July 1853, expressed disappointment (Andersson 1857:417) and Chapman (1886), a regular visitor, chronicle with alarm the decrease in the lake size over a period of nine years. Yet the idea has grown, encouraged in the early decades of the twentieth century by the controversy over Schwarz bizarre schemes, that the lake of this period, receiving inflow from the Thaoge River, was of greater extent, possibly attaining the 930 metre level at which overflow into the Boteti system would occur. The evidence for and against this hypothesis can be summarised as follows:

(1) **Lake Size and Shape:** Livingstone (p.66) estimated the circumference of the lake from native reports as 75 miles. Chapman gave the length as at least 50 miles, with a width not exceeding 10 miles, whilst his companion in 1861, Baines, shows a width of 8 to 10 miles on his map (Baines 1864-224). Andersson (p.425) gives the following description:

> The whole circumference is probably about sixty or seventy geographical miles; its average breadth is seven miles, and not exceeding nine at its widest parts. Its shape, moreover, is narrow in the middle and bulging out at the two ends; and I may add, that the first reports received many years ago from the natives about the lake, and which concurred in representing it of the shape of a pair of spectacles, are correct.

In this context it is interesting to note that Brind, who carried out the first accurate topographic survey of the lake in 1951, states that the lake consists of two basins separated by a narrow channel (1954:30). Brind maintains that Oswell's (1900) description of the lake in 1849 ("What was an expanse of water eight miles across is now, just below, but a moderately broad river".) applies to this channel, and concludes that the lake observed by Livingstone, Oswell and Murray to be actually smaller than in 1925.

Early attempts at cartographic representation of the lake capture the outline of the basin. Baines shows a lake of 750 km², incorporating the Thaoge mouth. Stigand's map of 1912 identifies a basin of 600 km², whilst his more speculative effort of 1923 shows a lake basin of 850 km² (including the Dautsa Flats) and a representation of the 1898/1904 flood area of 430 km².

These dimensions, both descriptive and cartographic, are somewhat larger than the area of the lake at the 923,5 metre level, but smaller than the area enclosed within the 930 metre shoreline. The evidence, however, is inconclusive. Due allowance must be made for the inacuracies in the method of survey and the fact that none of these visitors actually circumnavigated the lake shore. Particularly difficult to assess is the dimension of the lake looking from the south shore in the direction of Sehitwa. At the other extreme, the 60 mile width attributed to Livingstone by Schwatz (1920:132) is clearly an exaggeration.

Considerable earlier variations in the lake level were noted at the time. Andersson refers to the presence of submerged tree stumps (p.426) and was shown places, covered in vegetation, that were previously the haunt of hippoptami. Baines indicates on his map flats that were previously inundated. The pre-European record is also supplemented by Stigand's (1923-404) conversations with Mokwati, a descendant of chief Zankotse, who related tales of both higher levels and a dry lake bed, thus corroborating Andersson's observations.

(2) **Lake Depth:** The present lake has a gentle shelving shoreline and is shallow in all but a small area in the northeast of the basin, The gentle gradient of the lake flats means that a larger lake would also be shallow for some distance offshore, so perhaps little significance should be placed on the recurring references to the shallowness of the lake by early travellers. However, Chapman records the average depth of the lake as six feet in November 1853 (p.128) and only three and a half feet in June 1855 (p.163). Livingstone also observed (p.76):

> a native punting his canoe over seven or eight miles of the northeast end;...during the months preceeding the annual supply of water from the north the lake is so shallow that it is with difficulty cattle can approach the water through the boggy, reedy banks. These are low on all sides, but on the west there is a space devoid of trees, showing that the waters have retired thence at no very ancient date.

Accepting Stigand's (1923:405) average length for a *mokoro* pole as eleven feet, this would mean that the average depth of water in the deepest part of the lake was no greater than nine feet, or equivalent to the 922 metre level. Again it is worth noting that punting remains the dominant form of propulsion at the present day.

(3) **Lake Outflow:** Both Livingstone and Adersson commented on the imperceptible motion, of the Zouga (Lake) River at its junction with the lake, which could be interpreted as backflooding to the Toteng junction (i.e. a 927 metre level). Andersson believed the Zouga to be an outflow of Ngami, as did Oswell and Leyland, who visited the area in June 1851. Chapman, however, states:

> Andersson and Livingstone have called the Botletlie River an outlet of Lake Ngami, but they are mistaken. This was the case 30 or more years ago, when the Lake was perhaps twice its present size. Since then it has two feeders but no outlet. (Vol 2:175)

(4) **Lake Inflow:** As already noted, Livingstone's party had heard of a northern inflow to the lake from local inhabitants. This is presumed to be a branch of the Thaoge River. Chapman attempted to cross this stream close to its junction with the lake in 1855 and found difficulty in extricating his waggons (Vol 2:177). Andersson gives the following account:

> The Lake is fed by the Teoge at its northwest extremity. The river never, perhaps, much exceeds forty yards: but it is deep, and, when at its greatest height, contains a large volume of water... The main course of the Teoge is north-

west, but it is so serpentine that, in thirteen days when I ascended it, travelling on average five miles per day, in thirteen days when I ascended it travelling on average five miles per day, and reckoning two and a quarter miles to the hour, I only made about one degree of latitude due north of the Lake. As far as I proceeded, however, it was navigable with smaller craft; for only in three places that I can remember did I find less than five feet of water, and generally speaking, the depth was considerable. It must be recollected, however, that it was then at its greatest height." (p.427)

Green (1857) attempted the same route in August 1855 and found rowing difficult against a current he estimated at three to three and a half m.p.h.

There is no doubt that such an inflow existed and probably contributed the bulk of Ngami's water, On the north shore a number of old channels are terminated by the old shoreline/sand ridge system. In 1951 Brind surveyed down the main Thaoge channel and found that it terminated at 930,6 metres, some 16 km WNW of Sehitwa. Of this Brind says:

> A remarkable feature about the lake near the Thaoge mouth is that there is not a sign or vestige of a channel or old drainage line anywhere along the margin of the lake floor to indicate the entry of large volumes of water in the past, despite the fact that there is a thirty foot fall from the margin into the hollow of the lake.
>
> Whereas water from the Thaoge used to enter the lake at its highest point (full supply level) and thereafter find its way towards the hollow of the lake floor without leaving a trace of a drainage line, the Lake River, in marked contrast, not only enters at a much lower level but also continues into the lake along a well-defined waterway. (p.33)

Taken at face value this would be conclusive evidence that the lake formerly stood at the 930 metre level. However, Brind's channel, as already stated, is one of many, although it has significant dimensions. It is possible that the Thaoge at a late stage followed an alignment directly to the north of Sehitwa, where both the 930 and 927 metre shorelines have been dislocated. This possibility remains to be investigated.

Conclusions

The evidence for higher lake levels in the mid-nineteenth century is, to say the least, ambiguous. If there is a solution to the various lines of documentary evidence it lies in future geomorphological studies. Two conclusions, however, can be drawn. First, the regime of the lake was no more constant in the nineteenth century than it has been in the twentieth. Second, any overall changes that may have occured in the regime of the lake result from changes in the hydrology of the Okavango network, not from shifts in climate.

The twentieth century evidence suggests that the condition of the lake is much more marginal than previously thought; low levels are common irrespective of theories of climatic or hydrological change. This must become a basic assumption in future land and water use planning for the Ngami region.

The fluctuations of the lake appear to have a cyclical basis. There is a reamarkable coincidence between low lake levels and the quasi-twenty-year summer drought cycle proposed for southern Africa by Tyson (1979), although there is no correlation either with rainfall patterns in Ngamiland, or with Okavango inflows. As prediction is an essential part of the exercise, these potential cycles must be investigated further.

FOOTNOTES

1 The most readable summaries of the hydrological history of the Okavango region are those of Du Toit (1926), Brind (1954) and Wilson (1973).

2 Summarised in Wilson (1973).

3 The ratio of flows to the Boteti and Lake Rivers has been fixed since 1969 by the establishment of an earth bund 2 km downstream of the Thamalakane bifurcation. Reasonable correlation between the flows of the two rivers, however, predates this structure.

4 Kokot (1948) believes that some early travellers, such as Leyland, did not give authentic first-hand accounts. Generally it would seem that diaries and journals form the most reliable sources, eyewitness recollections the most unreliable. This is apparent from studies of the Boteti flow by Lund (1969) and Gibb (1969).

5 The lake appears to have fluctuated greatly in level in the years 1898-99, much as it did in 1951.

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FIGURE 1. THE LAKE NGAMI BASIN.

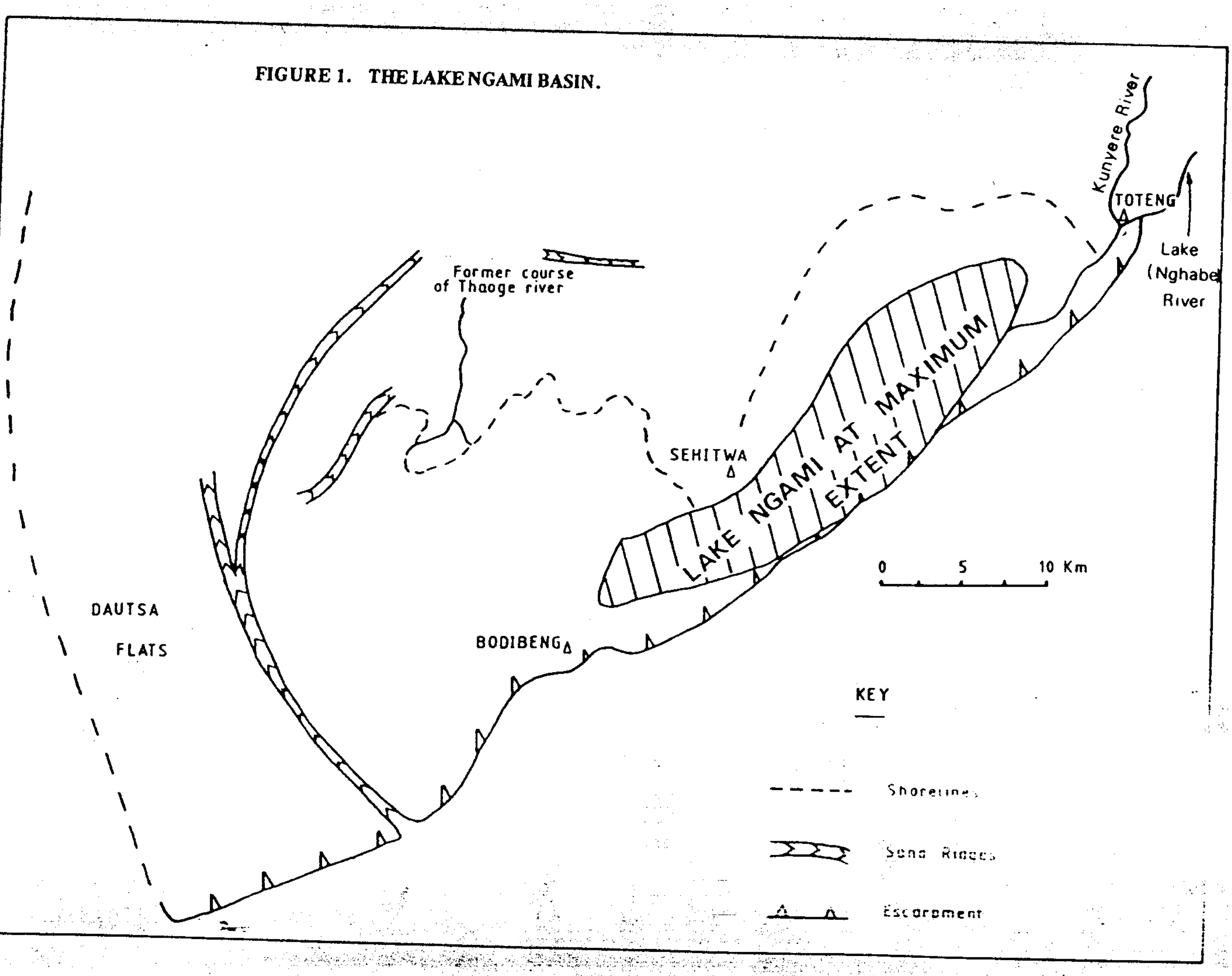

Figure 2: Lake Ngami on 15th September 1972. The lake bed is dry—thr dark areas shown are grass fires. Flow in the Kunyere and Lake Rivers terminates some distance from the lake (LANDSAT 1. Scale 1:1 million.)

Figure 3: Lake Ngami on 27th October 1976. The lake stands at 922.8 metres above sea level, extending to the west of Sehitwa. There is flow in both Kunyere and Lake Rivers. (LANDSAT 2. Scale 1:1 million.)

FIG. 4 LAKE LEVELS AND RIVER FLOWS 1849 - 1983