

STUDY METHODS APPLIED IN THE INVESTIGATION OF KALAHARI GROUP SEDIMENTS

P.I. DU PLESSIS

De Beers Prospecting, Botswana, P.O. Box 90, Lobatse, Botswana.

The selection of an area of interest in Botswana is followed by a study of Landsat TM images of that particular area. Certain features on the images are highlighted for investigation in the field. The study area is then traversed and outcrops and borrow-pits are logged in detail. Boreholes in the area are logged by means of chips or cores and a geophysical borehole logger. Since most of the work in the Kalahari is done above the water table, Natural gamma and density are the most useful geophysical logs. The geophysical logs are useful in defining contacts and small upward fining and coarsening sequences in the Kalahari Group, which are often difficult to recognize with chip-logging. The upward fining and coarsening sequences are in turn useful in the interpretation of the depositional environment for the sediments.

A geological map of the area is then compiled, digitized and entered into a GIS (Geographic Information System). The GIS is used to compare and overlay different sets of data in order to better understand the data. For example, the geological map can be superimposed on the Landsat TM images or topographic maps and even moulded to the topography for a 3-D view. Prospecting results are also superimposed on the geology to aid in the understanding of those results.

Considerable attention is given to Kalahari Group sediments as an understanding of their depositional environments is imperative in order to prospect for deposits hidden under the Kalahari Group.

EVOLUTION OF THE EAST HERERO HYDROGEOLOGICAL REGIME

C.R. LOMBERG

P.O.Box 9, Cape St. Francis, South Africa.

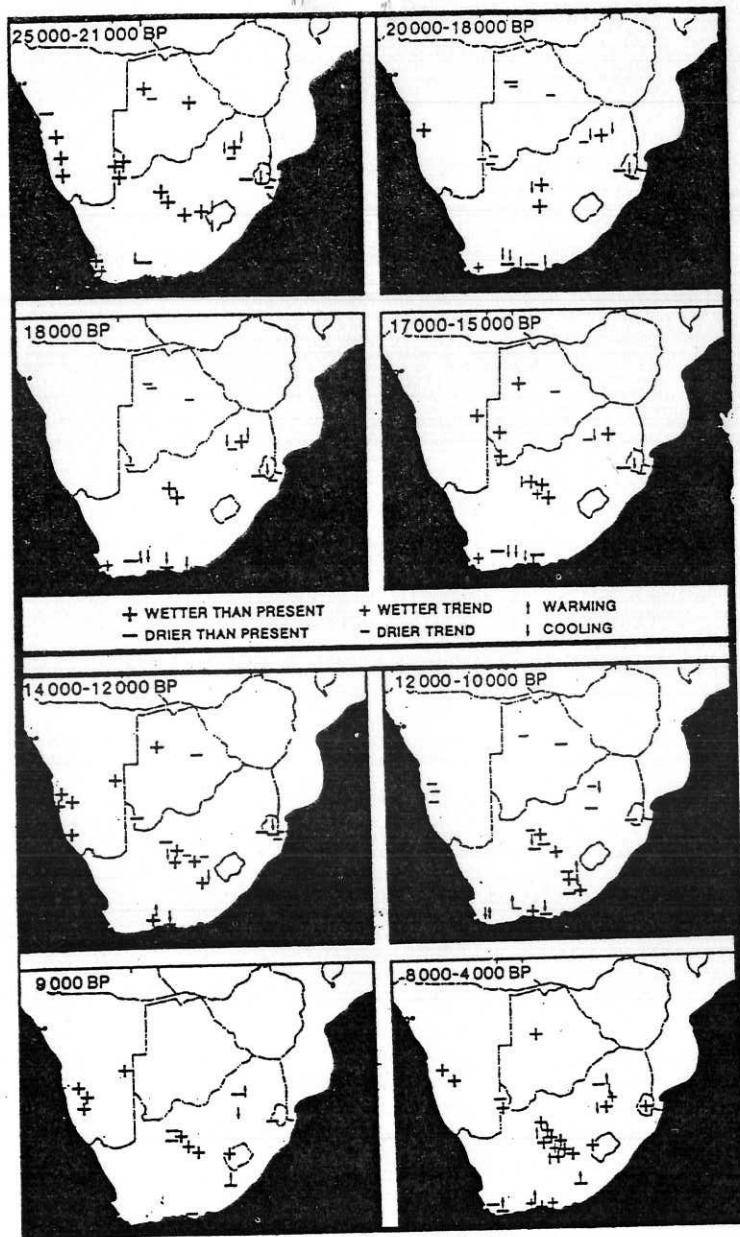
Many of the hydrogeological, topographical and Kalahari Group phenomena that are evident today are inconsistent with the current hydrological and hydrogeological regime.

Some of these phenomena include:

- the size and courses of the omurambas;
- the apparent contradiction in groundwater age, chemical quality and distribution;
- the formation of thicknesses of calcretes in the Middle Kalahari formations;
- the incision of the omurambas through these calcretes and in some cases into bedrock.

These phenomena are explained in terms of the evolution of the groundwater regime. It is apparent that the area has been subject to significant climatological and environmental change over the last 40,000 years (Figure 1) after the Upper Kalahari Quarternary dunes were emplaced. Heavy rainfall periods saturated the Kalahari formations to within metres of the surface probably more than once during this period. Further evidence for near surface saturation are stalacmites and stalactites in caves in the Tsodilo Hills in Botswana.

Due to the extreme wavelength of the upper dune system, unconfined aquifer water levels in these sands would mimic topography. Groundwater flow directions were then controlled by the dune and regional topography. Internal drainage after rapid infiltration of rainfall was toward local base levels defined by interdune corridors which carried and controlled surface flow (Figure 2).



PALEO-CLIMATIC CHANGES OVER THE LAST 30 000 YEARS

REPRODUCED FROM 3 MILLION YEARS OF CHANGE - CLIMATIC HISTORY OF SOUTHERN AFRICA

Stage 1. Regional hydrologic base level was the paleo-Ngami lake in Botswana. When climatic conditions become dry and hot, and internal drainage reduced groundwater levels to a point where direct recharge by precipitation through significant thicknesses of Kalahari sands was no longer possible, the phreatic surface continued to drop under natural groundwater head and hydraulic gradient conditions.

Stage 2. As water levels dropped, the topographically lowest interdune area would begin to drain a greater volume of water derived from lateral internal flow captured from topographically higher interdune areas. These dried up as the water table dropped below their base. Flow volumes in these proto-omurambas increased and significant erosion and downcutting began. (Figure 2).

Stage 3. When hydraulic gradients and groundwater flow velocities decreased regional calcrete formation took place in the Middle Kalahari layers. Drilling evidence indicates an increase in the calc content of the sands with depth until the regional duricrust layers are intersected. These tend to mimic both surface and bedrock topography as evidenced by the exploration drilling profiles. These duricrust layers were formed at the water table interface and achieved thicknesses of 40-60m as the phreatic surface slowly subsided.

Stage 4. As dewatering of the Kalahari beds progressed, a combination of surface flow during wet episodes, lateral internal drainage, and uplift resulted in downcutting of the omurambas through the pedogenic duricrust layers as evidenced east of the 20° meridian.

Stage 5. With further dewatering and the latest dry period waning flow conditions in the omurambas deposited fluvial sediments fining upward toward zones where infiltration into bedrock structure occurred.

It is probable that this sequence of events occurred partially several times before complete dewatering of the Kalahari Group formations occurred.

Once the Kalahari formations had been dewatered, recharge to the basin continued predominantly by throughflow from the southwest and to a lesser extent the north and south. Low permeabilities of the bedrock formations around the basin

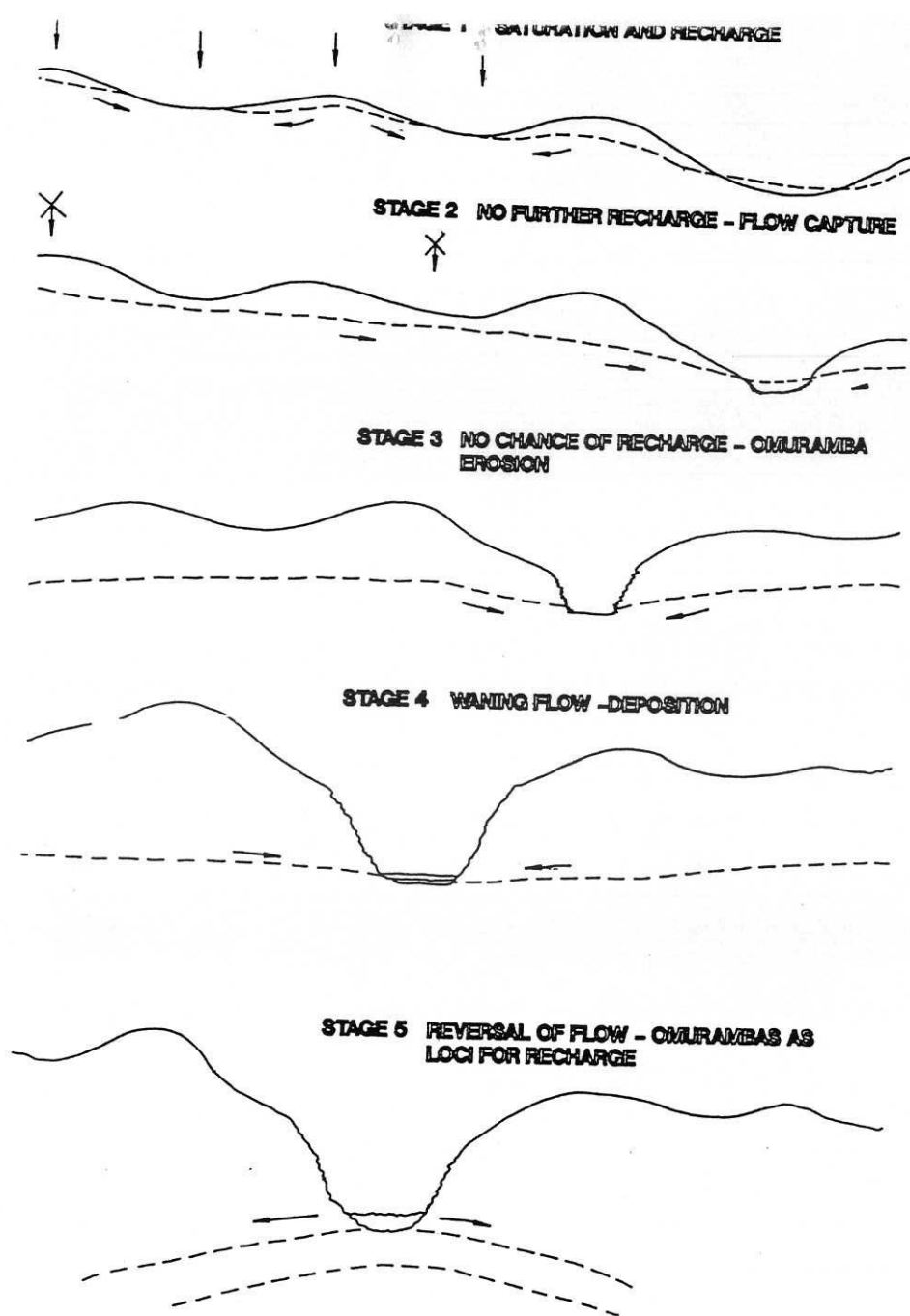


Figure 2: Omuramba development.

margins and higher outflow rates into Botswana resulted in a declining water level in the centres of the basin. This is largely the situation today, with steep groundwater gradients around the basin margins where throughflow is taking place and a central portion which has dewatered under natural residual hydraulic head.

This conceptual model explains the rather erratic distribution of groundwater ages and chemistry. Most water was introduced into the basin over relatively short intense periods. Major age groups as identified by Vogel (1979) correlate broadly with the major wet periods identified by paleo-climatic studies. In this case we would expect to have an age stratification with depth and unless hydrochemical and isotopic sampling could accurately ascertain the source of the sample, random sampling could produce a confusing picture.