PROCESSES IN THE FORMATION OF THE OKAVANGO FAN DELTA.

T.S. McCARTHY
University of the Witwatersrand, South Africa.

Over the last six years, a multidisciplinary team from the University of the Witwatersrand has been carrying out research to establish the nature of the processes which underpin the Okavango Delta. From this work it has become evident that the environmental factors controlling the Delta can be divided into two broad categories:

(i) External variables, which include graben faulting, which is the ultimate reason for the Delta's existence; the geology of the catchment area of the Okavango River, which controls water quality and the nature of the particulate sediment; the semi-arid nature of the environment, which is responsible for the high evapotranspirational rate; and groundwater leakage which prevents the accumulation of hypersaline groundwater;

(ii) Internal processes which operate within the constraints imposed by the external variables and have produced the present form of the Delta. Biotic processes dominate this latter category, with specialized plant communities fulfilling specific functions. These various communities regulate the dispersal of particulate sediment and water. They also control water loss through transpiration, thereby regulating chemical sedimentation, which is the dominant aggradational process in the Delta at present. The action of biological agencies induces even aggradation of the land surface and shapes the topography of the Delta, ensuring widespread distribution of water, and localizing, and hence minimizing the impact of, the accumulation of toxic salts. Far from being catastrophic, changes in water distribution are actually brought about by plant communities and constitute an essential self-renewal strategy in the system.

CHRONOSTRATIGRAPHY IN THE KALAHARI GROUP - RELEVANCE TO INTRACRATONIC BASIN MODELLING.

P.R.Siegfried
GeoAfrica Prospecting Services, P.O.Box 24218, Windhoek, Namibia

Tertiary age strata of the Kalahari Group occur as largely semi- to unconsolidated sediments in southern and central Africa. These terrestrial sediments have a mixed fluvial and lacustrine origin and are covered by aeolian sands. In Namibia the Kalahari Group is present in the eastern, northern and southern parts of the country. Two broad basins are present in the north - the Owambo Basin (Miller, 1990) and the Herero Basin (Albat, 1978). The southeastern parts of the country are separated from the north by the Ghanzi Ridge which extends from Witvlei through to Maun in Botswana. This prominent topographic high formed during the Damaran Orogeny and appears to have been an important boundary since then.

Three units of formational status are recognised to comprise the Kalahari Group in the Owambo Basin. Post-Karoo sediments such as the Nanzi Formation underlie these units and can also be considered to be part of this sequence. The Kalahari sediments are from the base upwards; the Beiseb Formation which consists of red clays, gravels and grits; the Olukonda Formation, which consists of red and brown calcareous sandstones; and the Andoni Formation consisting of green, usually non-calcareous clay-rich sands and sandy clays (SACS, 1980).

Similar units were identified in the Herero Basin (Albat, 1978). These are the Tsumkwe Formation consisting of reddened gravels, grits and sand; the Eiseb Formation consisting of silcretized quartz sands and the Omatako Formation consisting of ferricretes. All are overlain by recent, unconsolidated aeolian sands of the Gordonia Formation (SACS, 1980).

In the Kavango region red clay is usually noticed below fluviatile sandstones and grits which are discontinuosly covered by green clay-rich sands possibly

equivalent to the Andoni Formation. A calcrete horizon is usually encountered at the junction with the overlying unconsolidated aeolian sands.

A single formation, the Weissrand Formation, is recognised in the southeastern parts of the country (SACS, 1980) and consists of calcretised gravels. Reddened sandstones and calcretised siltstones do, however, underlie parts of this unit. A variable thickness of unconsolidated dune sand again covers the sequence.

All these divisions are based upon significant changes in lithology, however, few actual exposures exist in the Kalahari and most data is sourced from hydrological percussion drilling. Local divisions have therefore often been based upon calcretes or other duricrusts. Traditional sedimentary analyses should therefore be considered with care as;

i. the pervasive presence of duricrusts severely alters the nature of the sediments. Chemical expansion as well as alteration can severely change the nature of the original rock.

ii. The rarity of fossils and dateble remains severely limits correlation of units identified.

Chronostratigraphy or sequence stratigraphy has had a large amount of success in the oil industry in delineating stratigraphic sections to a great degree of accuracy. Most of the work is based upon seismic sections, however, units have been well constrained using microfossil dating. Correlation is therefore a well developed tool.

Of primary importance in utilizing sequence stratigraphy is the identification of unconformity bounded surfaces or UBS's combined with hierarchical ranking. This effectively enables one to subdivide the entire sequence into correlatable units. In the majority of cases the unconformity bounded surface will constrain an age to the overlying sequence.

Recently the applicability of chronostraphic analysis has been succesfully applied to the Witwatersrand Basin (Winter, 1990). Understanding of the continuous structural dynamics of this basin has been well advanced through this

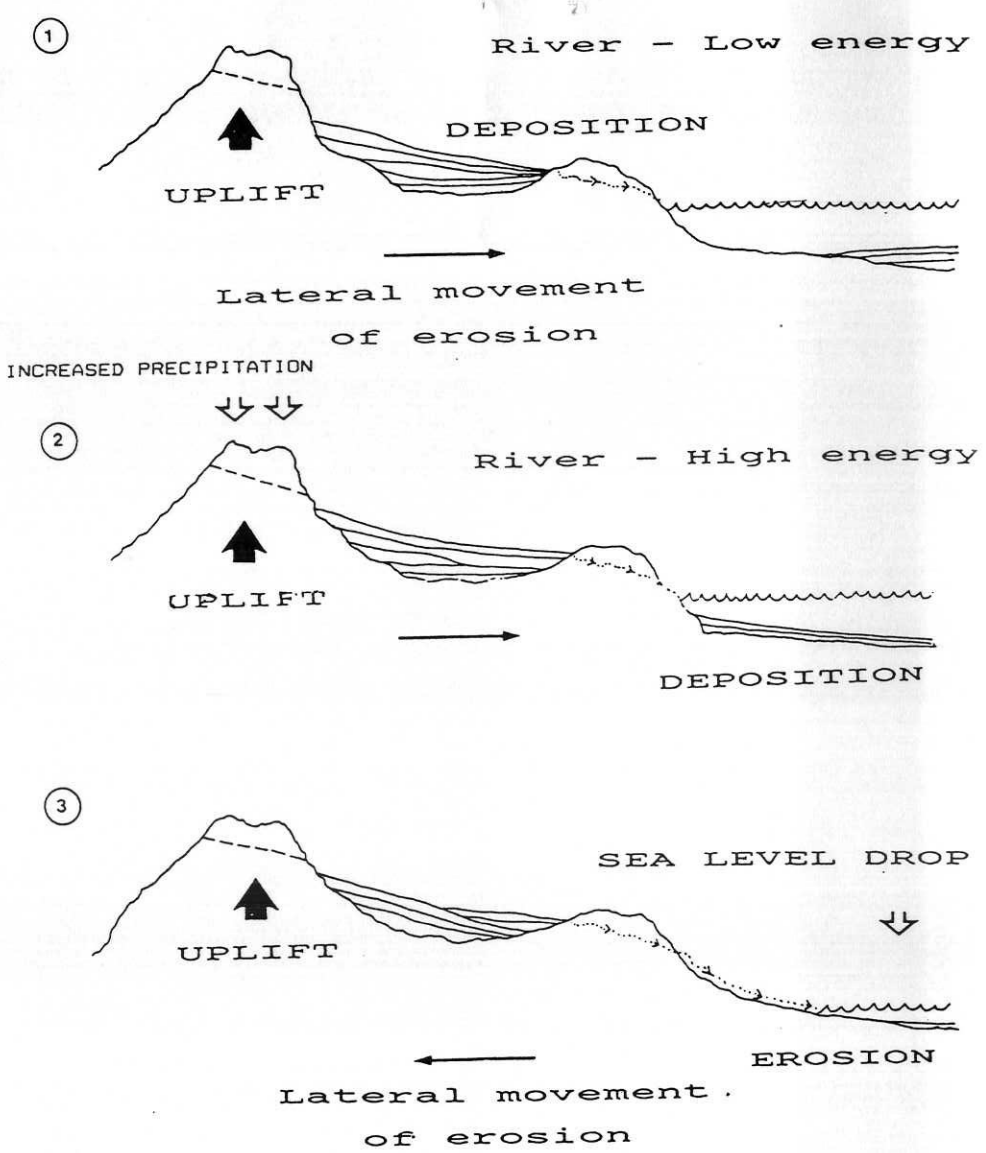

Figure 1: Erosion and deposition changes.

technique. The Witwatersrand is well suited to chronostratigraphy as detailed borehole logging, seismic surveys and mining development has constrained UBS divided units very well. Importantly the Witwatersrand Basin is devoid of any fossiliferous material. The Kalahari Group/Basin with it's limited exposures is therefore well suited to chronostratigraphic interpretation and identification of Unconformity Bounded Surfaces will depend on:

i. Major lithological changes - here the protolith must be properly identified as a duricrust overprint could severly alter the appearance of the rock.

ii. Identification of the local or regional nature of the duricrusts identified. Are they recognisable as aquifers/aquacludes? This could also have important consequences with respect to palaeoclimatic interpretation.

iii. Reworked calcretes. These are important to identify and are often masked by the recementation and formation of nodular and concretionary calcretes.

iv. Correlation with off-shore sediments. Gaps, breaks and hiatuses must have terrestrial equivalents on the grand scale.

The Kalahari Basin began to form immediately after the break-up of Gondwanaland when isostatic rebound caused margin uplift to produce an intracratonic depocenter. This depocenter rapidly filled up with material eroded from the continent's edges. The effect of this is well illustrated by the narrow drainage system flanking the Namibian coastline. However, in times of increased uplift, elevated precipitation or major regression the base level would have been radically dropped and major rivers would have flowed out of the basin eroding and transporting material to the coast. The Orange River was the major conduit for sediments being eroded and transported from the western parts of this interior basin.

The lower Orange River has well developed gravel terraces which can be correlated on grounds of their elavation and relative distance from the mouth as well as tribuataries of the river. These gravels have been dated at their oldest to be mid-Miocene in age (Corvinus and Hendey, 1978). The terrace tops also represent UB surfaces. It should be possible to correlate these units with major events in the

offshore sediments of the Orange Basin. Oil exploration off the coast of Namibia will soon enable accurate subdivision of these sediments and hopefully chronostratigraphic subdivision of the offshore sediments will enable correlation of the major UBS's occurring in the Kalahari Group itself.

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