

THE ETJO AND KALAHARI SEDIMENTS OF THE OWAMBO BASIN

R. McG. Miller
 NAMCOR, Private Bag 13196, Windhoek

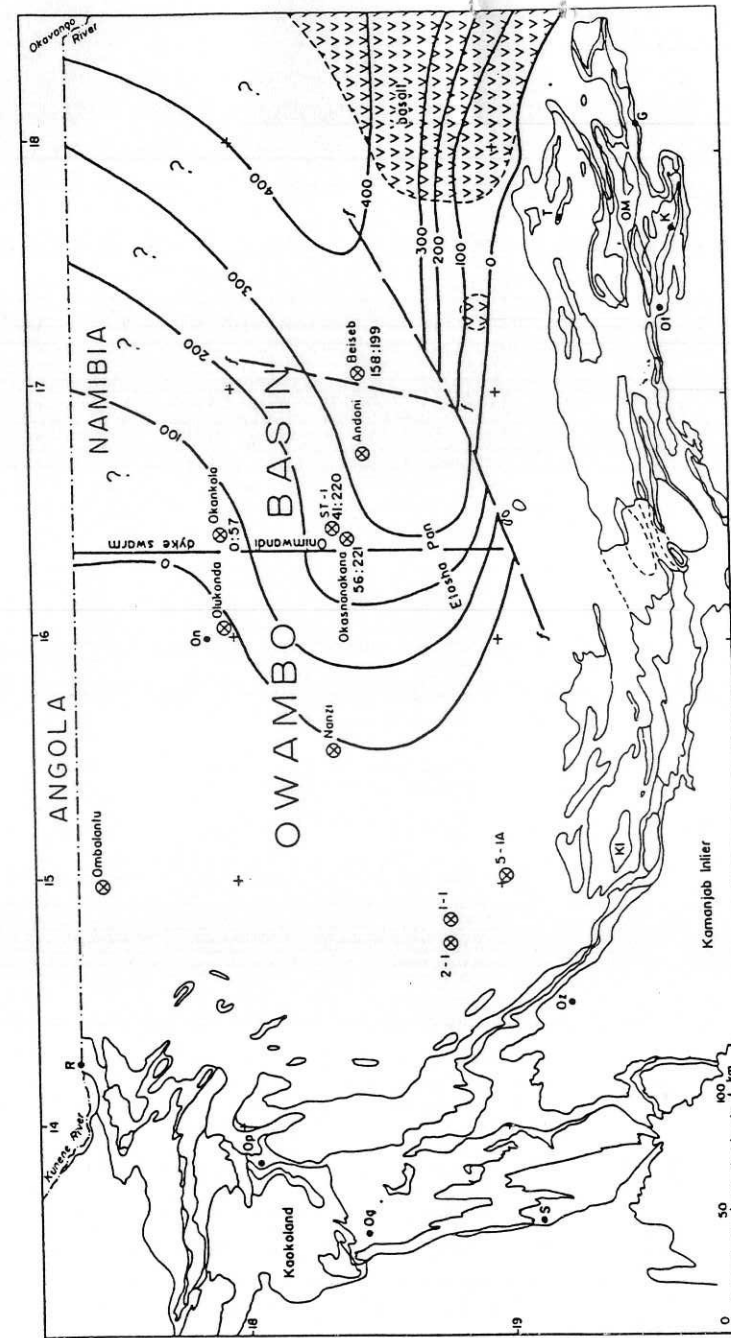
This analysis of the post-Karoo succession in the Owambo Basin is based largely on a reinterpretation of the cores of the following deep boreholes drilled in the late 1960s: ST-1 (Hedberg, 1979); Nanzi (borehole no. 9074), Olukonda (9124), Okankolo (9197), Ombalantu (9262), Beiseb Pan (9296) and Okasnanakana Pan (9563) (Hugo, 1969). The late Proterozoic Owamboland Formation forms the pre-Karoo basement within the Owambo Basin. Figure 1 shows the distribution of Dwyka, Prince Albert and Etjo Formations as well as basalt of the Karoo Sequence.

Etjo Formation

Hugo (1969) correlated a succession of red beds and hard light grey to yellowish, well-bedded sandstone which overlies the Prince Albert and Owamboland Formations in the central and northwestern parts of the Owambo Basin with the Stormberg Series of the Karoo Sequence, i.e. with the Etjo Formation of central Namibia. However, the hard, light grey, well-bedded sandstone which occurs between the depths of 257 and 394 m in the Nanzi borehole and which has a well-developed 7 m thick basal conglomerate is quite distinct from the red beds that occur at similar depths in the other boreholes. The light grey sandstones in the Nanzi borehole are the only rocks that can be correlated with the Etjo Basin. The red beds belong to a totally different formation.

Kalahari Sequence

The Kalahari Sequence is subdivided into four formations: a basal, red, fine-grained Ombalantu Formation, a conglomeratic Beiseb Formation, a red Olukonda Formation and an upper Andoni Formation. The thickness of the Kalahari Sequence is shown in Figure 2.

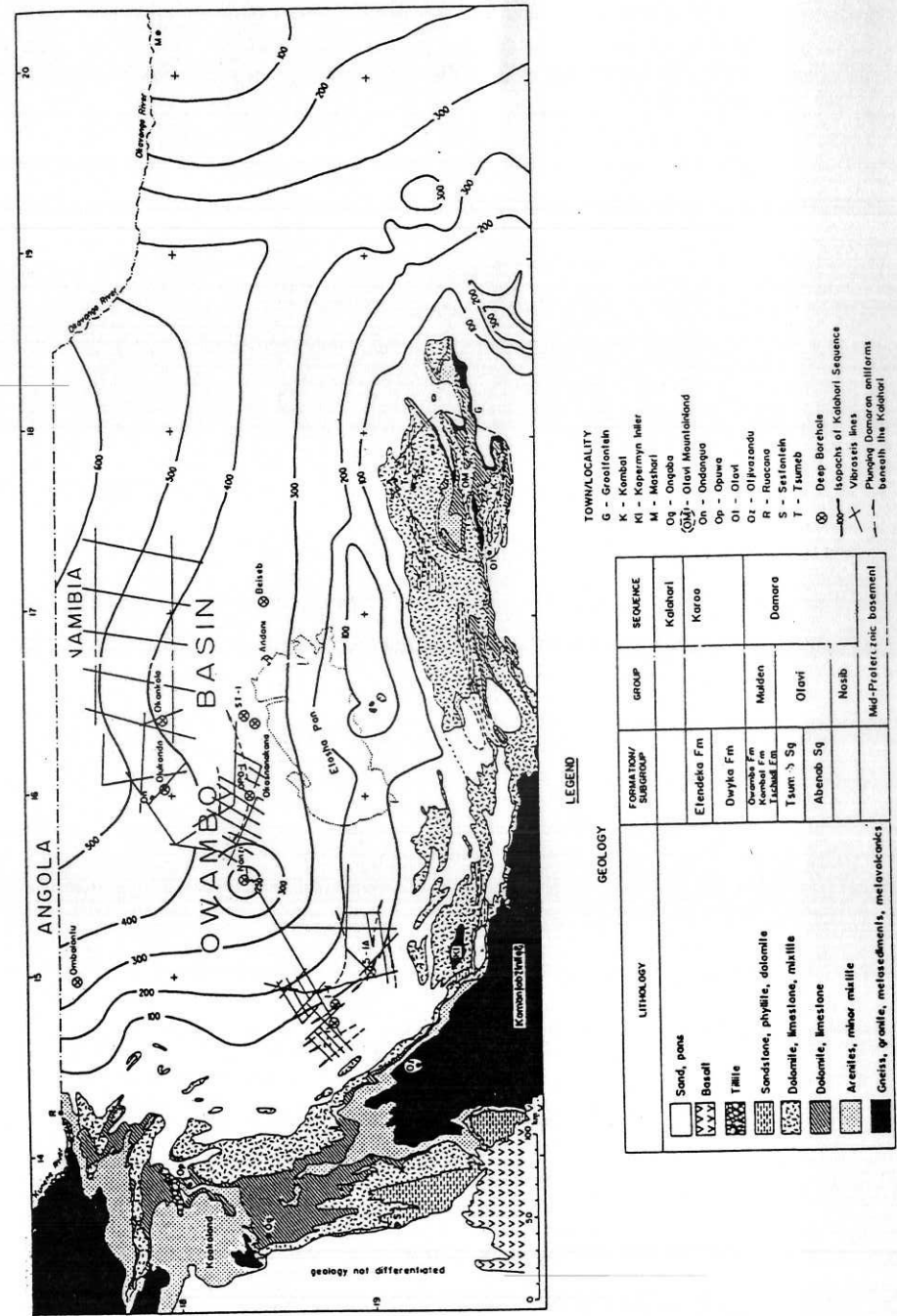


1. Isopach map (in metres) of the Karoo Sequence below the Kalahari succession in the Owambo Basin (137 m of Etjo Formation sandstone in the Nanzi borehole excluded). Numbers below each borehole give the respective thickness of the Dwyka Formation and overlying Prince Albert Formation. Basalt (v symbol) distribution based on borehole and aeromagnetic survey data. See Figure 2 for legends for localities and pre-Kalahari outcrops along the western and southern margins of the Owambo Basin.

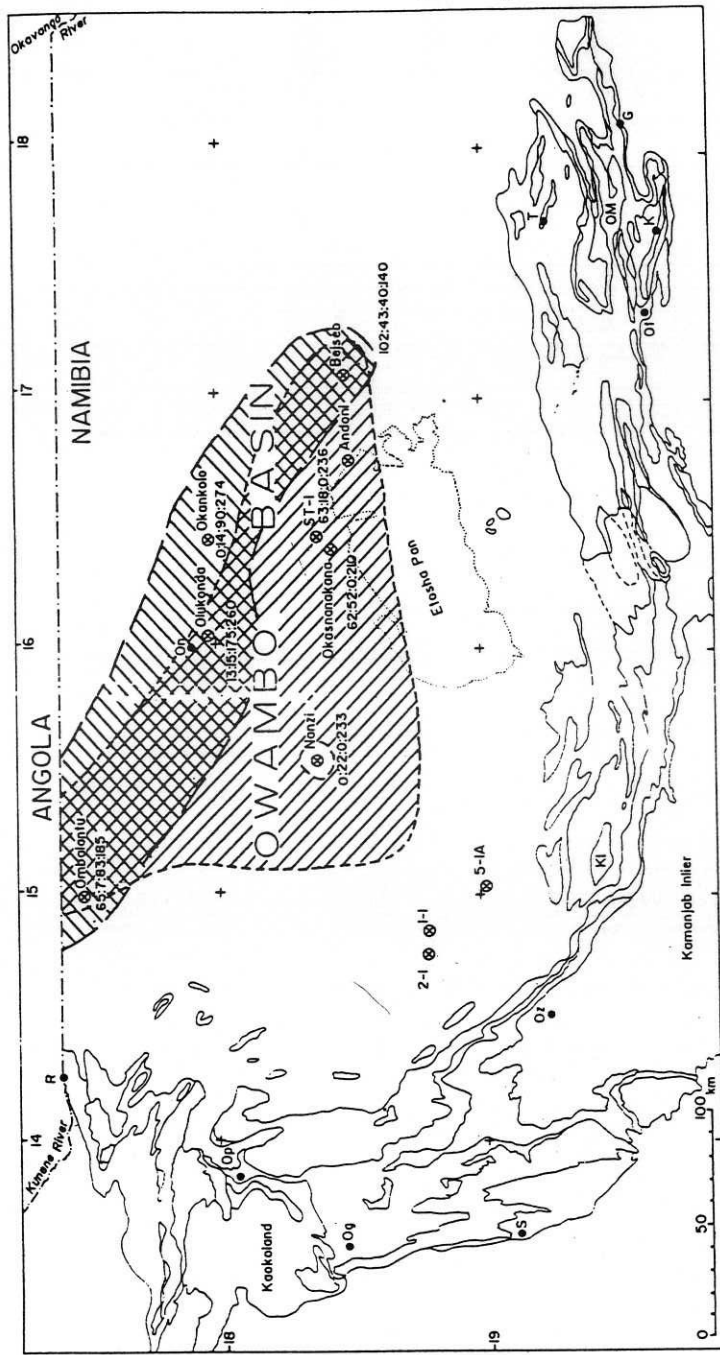
Ombalantu Formation

The logs given by Hugo (1969) name the various red lithologies encountered immediately above definitive Karoo and Owamboland rocks as sandstone or siltstone with varying amounts of clay, shale, clay and unconsolidated sand. The log of the Okasnanakana Pan borehole (9563) describes the red shale as having a gritty appearance due to abundant spherical centres of silicification. These are between 1 and 2 mm in diameter and are a common feature of all the red cores described as "sandstone" or "siltstone". In some cores these silicification centres occur within a fine filigree latticework of silicification veinlets, in other only the filigree latticework is present. The so-called red sandstones, siltstones and shales are finely laminated in places with small-scale, well-developed crossbedding being common. In places there are a few, small, irregular patches up to 10 cm thick in which the red colouration is reduced to a light grey colour. Close examination shows, however, that most of the red "sandstones", "siltstones" and "shales" are in fact red semiconsolidated but friable, variably silicified mudstones consisting almost entirely of clay. Even the silicification centres can be ground down with the fingers to a clay-sized powder. Some of the mudstone contains variable amounts of silt and sand-sized grains.

These mudstones are not sufficiently indurated to warrant use of the term shale. The lack of induration and the presence of interbedded red unconsolidated sands in the Ombalantu borehole which were washed out in abundance with the drilling water clearly indicate that this succession is younger and less lithified than the Karoo Sequence. It is tentatively referred to in this paper as the Ombalantu Formation and apart from the above unconsolidated sands and local interbedded units described below consists largely of red mudstone. The basal two metres are pebbly in the Beiseb Pan borehole. In most holes, sections of the mudstone contain scattered angular fragments up to 2 cm across of pink to white very fine-grained limestone or siltstone. Thin layers of light brown sandstone and siltstone and white nodular pan limestone up to 20 cm thick are present in places, particularly in the Beiseb Pan borehole. Irregularly-shaped nodules of white calcrete up to 4 cm across are present in places. Gypsum crystals and casts of gypsum crystals occur in the upper part of the formation in the Ombalantu borehole. Not known from outcrop, it is suggested that the Ombalantu Formation forms the base of the Kalahari Sequence, is Cretaceous in age and is possibly equivalent to the red,



2. Isopach map (in metres) of the Kalahari Sequence in the Owambo Basin.



62:52:0:210 - Respective thicknesses of Ombalantu, Beiseb, Olukonda and Andoni Formations

3. Distribution of the Ombalantu and Olukonda Formations.

cross-bedded Kwango sandstone beds of Zaire and Angola (Furon, 1963; Haughton, 1963).

The Ombalantu Formation has a broad elongate suboutcrop extending from the Andoni-Beiseb area in the southeast to Ombalantu in the northwest (Fig. 3). The beds may also occur west of the Etjo inselberg of the Nanzi borehole because the overlying Kalahari succession also contains abundant clay in this region. Deposition of the Ombalantu Formation consisted mainly of the accumulation of fine clastics in a shallow, low-energy, deltaic environment in a restricted continental basin in which there was sufficient evaporation to produce gypsum. In the Beiseb Pan area, gritty and pebbly material was introduced at an early stage from the basin margins. Thick aeolian sands accumulated marginal to the lake in the northwest.

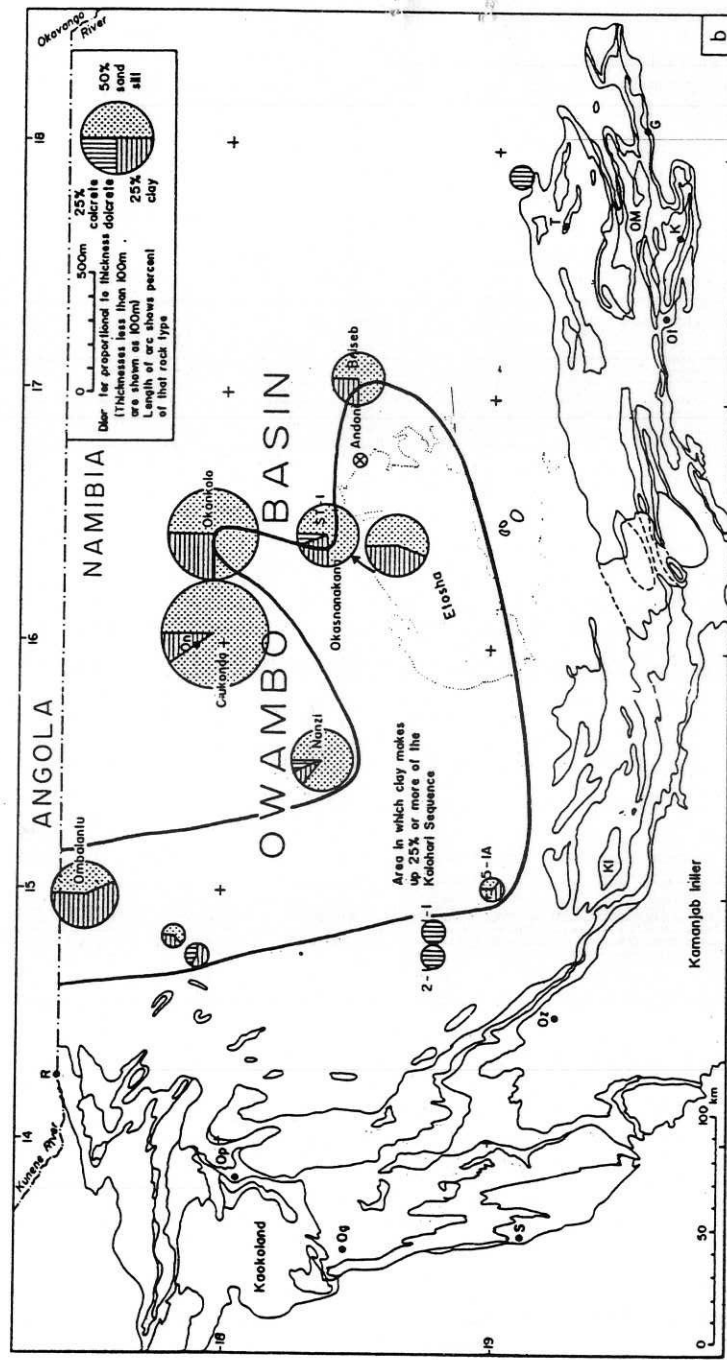
Beiseb Formation

The Beiseb Formation reaches a maximum thickness of 30 m, is widespread, was intersected in all boreholes and represents a period of rapid and extensive input of material from the basin margins into the basin. It is generally reddish in colour but light green to white in the Nanzi and Okasnanakana boreholes. The formation consists of well-rounded clasts of brown and grey sandstone and mudstone and grey and black chert (some oolitic) up to 12 cm in diameter that are set in a matrix of fine- to medium-grained, argillaceous, calcereous to dolomitic sandstone which is very hard where well-cemented by carbonates or silica. Dolomite layers are interbedded in the ST-1 borehole. The lowest 5 m of the Ombalantu borehole contain gypsum crystals up to 5 cm long.

The calcrete-cemented basal parts of the Kalahari Sequence that outcrop in the Tsumkwe-Gam area and along the Weissrand of southern Namibia may be equivalent to the Beiseb Formation.

Olukonda Formation

The Olukonda Formation is a friable, poorly consolidated, reddish brown, poorly sorted, massive sand and sandstone up to 120 m thick that contains a few thin gritty and pebbly layers. In the Ombalantu borehole, 35 m of dark red sticky clay that becomes progressively more sandy upwards overlies the red sands. The formation has only a limited distribution and, like the Ombalantu Formation, has



4. Distribution of that part of the Kalahari Sequence containing more than 25% clay.

a broad elongate suboutcrop extending from Beiseb in the southeast to Ombalantu in the northwest (Fig. 3).

Andoni Formation

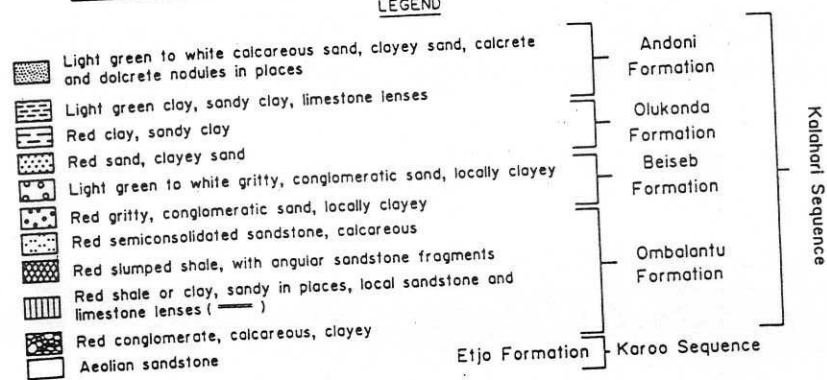
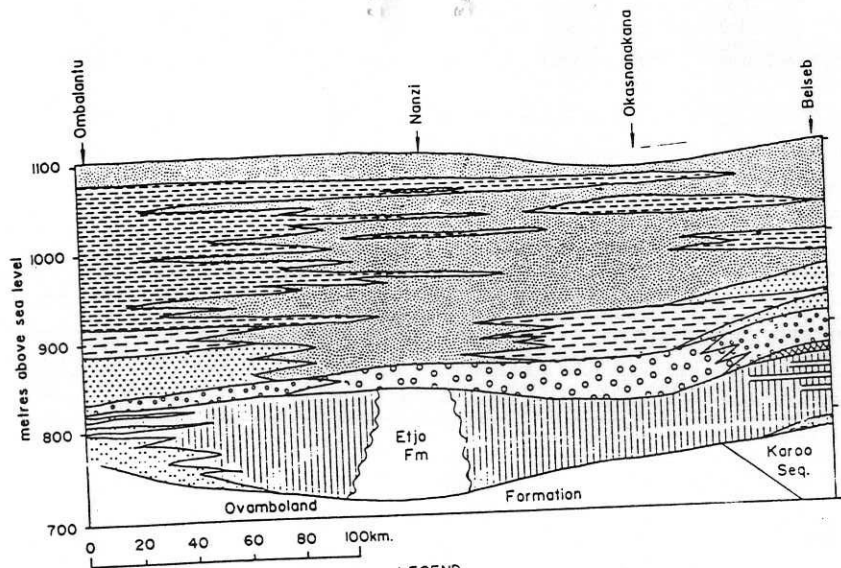
The Andoni Formation occurs throughout the Owambo Basin as a cover to all underlying units and consists of interbedded white medium-grained sand, light greenish clayey sand and green clay. The sand, in zones between 10 and 200 m thick, is unconsolidated, slightly pyritic or hematitic and, near the top of the section, contains numerous irregularly shaped dolcrete and calcrite nodules up to 30 cm across. Silcrete nodules occur in the east and become more abundant in the northeastern part of Namibia. Sorting improves upwards in the sequence. Polished and frosted, angular to subrounded grains of quartz make up 90% of the sand; chalcedony, feldspar and chert are minor components. Burrows occur in cemented sand of the Beiseb borehole.

The clay layers interbedded in the sand are between a few centimetres and 155 m thick (Ombalantu borehole). They are often sandy or silty and calcereous and are generally pyritic. Thin limestone layers up to 10 cm thick, some of which are laminated, occur interbedded in the clays. Oolitic layers between 2 and 10 cm thick and ostracod shells and impressions occur in the clays of the Beiseb and ST-1 boreholes. Unidentified bone fragments were found in clay from the Nanzi borehole.

Calcrite lenses occurs locally at or near the top of the Andoni Formation.

A thin cover of reddish brown aeolian sand in the west and southeast may be Recent in age (SACS, 1980).

More than half of the Andoni Formation consists of light green clay or sandy clay over a broad region that extends due south of Ombalantu for some 200 km. The section underlying the present-day Etosha Pan contains more than 25% clay (Fig. 4). The clay-rich parts of the Ombalantu, Olukonda and Andoni Formations falling within the triangle defined by Ombalantu, Beiseb and borehole 5-1A may therefore define the Cretaceous and Tertiary limits of an inland lake that resembled the Okavango swamps of Botswana. The Olukonda lake appears to have been



5. Schematic section of the Kalahari Sequence between the Beiseb and Ombalantu boreholes.

located slightly north of the position of the Ombalantu lake but during deposition of the green Andoni clays the lake was located further south and beneath the present-day Etosha Pan. A schematic section of the Kalahari Sequence between the Beiseb and Ombalantu boreholes is shown in Fig. 5.

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