THE GEOLOGY OF THE SPRINGBOK AREA

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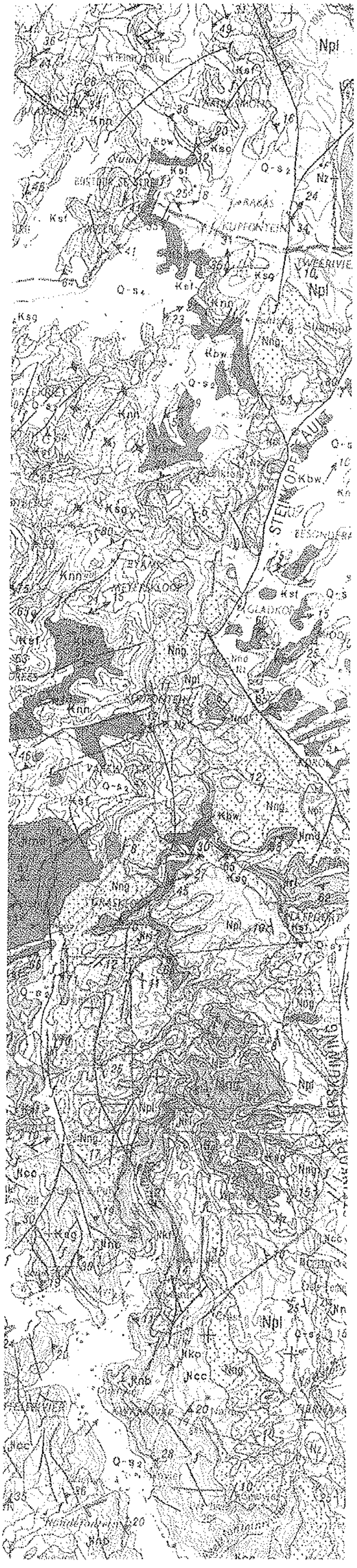

EXPLANATION:
Sheet 2916
Scale: 1:250 000

Council for Geoscience

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SOUTH AFRICA

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1. INTRODUCTION

The Springbok sheet comprises an area of 11 000 km^2, bounded by latitudes 29°S and 30°S, and stretching from longitude 18°E to the Atlantic coastline. The area encompasses large portions of the magisterial districts of Springbok and Port Nolloth, and also includes the communal Coloured People's Reserves of Concordia, Komaggas, Steinkopf and the Richtersveld.

Mining has historically been the mainstay of the region's economy. The towns of Springbok, Nababeep, Okiep, Carolusberg, Steinkopf and Concordia have served the administrative and infrastructural needs of the copper mining industry since 1854. The harbour facilities at Port Nolloth provide a base for offshore diamond-recovery operations, while onshore operations have produced more than ten million carats of high-quality diamonds since 1926 from raised marine and alluvial gravel deposits. Wolframite was recovered in the Komaggas-Nababeep-Concordia tract up to 1955, when known reserves became exhausted. Lithium-, beryl-, tantalum- and rare-earth-bearing minerals have, in the past, been recovered on an ad hoc basis by small operators in the area north of Steinkopf.

Despite the interest shown by Governor Simon van der Stel of the Dutch East-India Company in the mining potential of Namaqualand as early as 1688, and the fact that large-scale copper mining began at Springbok in 1852, methodical geological investigation of the area lagged behind until 1854, when A.G. Bain reported the results of his geological surveys to parliament. He was followed by Wiley (1857) who visited, mapped and reported on all the then existing mines and prospects in Namaqualand. Rogers (1915) submitted a report and a reconnaissance map, which included the Springbok map area, and pioneered the first lithostratigraphic subdivision.

Kingsbury (1919) submitted an unpublished map and report to the Cape Copper Company in which a five-fold division of the rocks in the Copper District was proposed. Further subdivisions were proposed by Strauss (1941), who also produced a map of the Copper District. Shortly afterward Wiid (1951) remapped the area. His map was the first application of a stratigraphic subdivision first introduced by Söhnge (1949) as part of an unpublished report. This subdivision endured for some 26 years and was largely retained by Joubert (1971), who first proposed a comprehensive synthesis of the stratigraphy and structural development of Namaqualand.

Detailed geological mapping of the region generally known as the Copper District was initiated by the exploration department of the O'okiep Copper Company in 1946 under guidance of E.N. Pennebaker. Orthophotos on a scale of 1:12 000 were used during the period 1954 to 1984. The regional mapping information gathered by company geologists was gradually released from 1975 onwards, when the O'okiep Copper Company became actively involved in sponsoring and cooperatively organising the sixteenth congress of the Geological Society of South Africa with the theme "Mineralization in Metamorphic Terranes". Most of the company's regional geological information was subsequently released as its contribution towards unravelling the geology of the Northwest Cape under aegis of the National Geodynamics Project. As part of the University of the Orange Free State's participation in this project, Van der Merwe (1986) and Van Aswegen (1988) mapped the transition zone between the Namaqua and Richtersveld domains. An adjacent strip, stretching from Spektakel Mine in the south to the Groendoring area, was mapped by Theart (1980).

The programme of reviewing and integrating the available geological data and maps, with a view to the publication of the 1:250 000-scale geological map, was initiated in 1985. Field work required to cover unmapped areas was done by staff of the Council for Geoscience (Upington), with J.A.H. Marais acting as coordinating consultant. All the regional geological maps produced by the O'okiep Copper Company, as well as those of research institutes and universities, were reviewed in order to obtain uniformity in approach.

2. PHYSIOGRAPHY

The Springbok map area includes parts of the low-lying western coastal plain, the western escarpment and the inland Namaqua-Bushmanland plateau.

The morphology of the coastal area of low relief is typical of a mature landscape. Since the Miocene, it has been benchmarked by several wave-cut terraces associated with sea-level standstills ranging from -120 to +90 m, relative to present sea level. These transgressions and regressions are related to glacial periods which occurred during Pliocene and Pleistocene times. When traced southwards the elevated palaeolittoral zone widens from 3 km in the Cliffs area north of Port Nolloth to 8 km at Julies Hoogte, narrowing to 4 km opposite White Point. In the Dreyerspan and Sandkop areas it widens to 8 and 6 km respectively, narrowing to a mere 2 km in between. From Brazil southward the marine terraces are about 3 km wide.

The 100-m contour line roughly delineates the upper limit of marine transgression during the Pleistocene. Within 3 km beyond this limit, the topography rises to 150 m above mean sea level, an elevation which remains constant in the central portion of the map area for the next 50 km inland. More resistant quartzite hills locally reach heights of 250 m. The 150-m land surface probably represents the remains of an ancient coastal plain, which had already developed mature morphological features in the Cretaceous. The trace of the 250-m contour line broadly defines the inland limit of this protocoastal plain.

Green, glauconitic sand covers the wave-cut terraces. The terraces are in places preserved under a thin calcrete layer, but in general they are covered by windblown white sand of marine derivation. This sand occurs far inland, where it is piled up into high moving dunes by the prevailing southwesterly winds. On the inland side of the coastal plain, red-coloured terrestrial sand buries the old Tertiary landsurface. The red sand is considered to be a younger, redistributed equivalent of the Kalahari-type sand deposits present in the eastern part of the map area. Owing to the arid climate prevailing in the coastal area, only the Buffels River occasionally flows into the sea. The Kamma River never flows much beyond a point just below Julieshoogte.

The gap in the quartzite hills at Gemsbokvlei represents the only outlet of the extensive sand-filled depression lying along the route of the old railway track up to the foot of Aninaus Pass, into which all the ephemeral streams from the adjacent elevated terrains drain. The lowland known as Soetwater se leegte branches off to the north at Komaan. The entire depression is a typical piedmont plain with a coarse sand cover up to 60 m thick, as measured in boreholes near the Gemsbokvlei homestead on Oograbies 149.

The upper edge, or fall line, of the Little Namaqualand escarpment can broadly be traced from the top of the Wildeperdehoek se Pas in the south through the Komaggas highlands, Witberg's Kloof 185, Harras 182, Klipfontein at the top of Aninaus Pass, Knie Brand 142 and northwards to the Sabieboomrante. The inland plateau rises from an average height of 700 m above sea level along its western edge to 1 100 m in the east. A few mountains such as Voëlklip se berg (1 303 m), Nababeep Mountain (1 313 m) and Narrap Mountain (1 322 m) rise above the general level of the plateau.

A northwesterly trending topographic high between Carolusberg Mine and trigonometric beacon 31, near the Chabiesies homestead, divides the region's drainage into two domains: streams northeast of this watershed drain to the Orange River, whereas those to the southwest drain to the Atlantic Ocean. River patterns are generally dendritic, but the impact of northerly striking faults and fracture zones is reflected by the numerous northerly and north-northwesterly striking valleys noticeable on aerial photographs. The meandering pattern of the Schaap River canyon in the Nama sediments, between Spektakel and Nababeep, points towards the antecedent nature of this river, which was rejuvenated by upliftment of the inland Nama-covered plateau.

The coastal plain of this region, generally referred to as the Sandveld, has an extremely low rainfall of 60 mm per annum which falls essentially during the winter and is inadequate to promote flowage of water to the coast. Despite the fact that the Buffels River drains an inland area of 621 000 hectare, which includes the Kamieskroon Mountains with an average annual precipitation of 305 mm, the river flows into the Atlantic Ocean only once every three years on average.

Remnants of gravel-covered river terraces are preserved along the Kamma River some 5 km south of the Vredefontein homestead on Korridor 21. Lying at different elevations, these terraces mirror the inland morphological effects of sea-level movements during the Pleistocene. No diamonds have been found in these gravels. Relicts of the palaeochannel of the Buffels River, along which diamondiferous deposits are preserved, occur 30 to 35 m above the present elevation of the river. Upstream, at places like Buffelsbank and on Grace's Puts 201, the inland trace of this ancient flood plain is sporadically exposed as relics of diamondiferous gravel deposits at Bontekoei, Nuttabooi, Wolfberg, Langhoogte and Buffelsbank.

Along the Gari River, some 20 km northeast of Steinkopf, a vertical embankment cut into slightly indurated aeolian red sands reflects incision in the wake of the general rejuvenation during recent times (Fig. 2.1).

3. LITHOSTRATIGRAPHIC FRAMEWORK

Although isotopically determined ages are used to establish the age sequence of various events and rock units, in the face of some puzzling and conflicting isotopic results not satisfactorily explained or understood as yet, researchers have leaned heavily on the significance of contact relationships as observed in outcrops. These relationships are often exposed in exfoliation domes and other large areas of fresh bare outcrop, and leave little room for ambiguity in respect of the relative ages of the various rock units.

The lithostratigraphy involves five main groups of rocks, viz.:

(a) Mokolian metasediments for which no depositional base has been recognised in the field.
(b) Proterozoic granitic to granodioritic igneous rocks which intrude the Mokolian metasediments.
(c) Early Namibian sediments of the Gariep Supergroup resting unconformably on the older metasedimentary and igneous rocks.
(d) Weakly metamorphosed and slightly deformed strata of the Nama Group (600–700 Ma; Germs, 1972) which also rest unconformably

Table 14.2 – ORE PRODUCTION FROM NAMAQUALAND WOLFRAM MINES, 1941–1956

	Period 1941–1949			Period 1950–1956		
	Ore grade %WO_3	Concentrates		Ore grade %WO_3	Concentrates	
		Tonnes	Grade %WO_3		Tonnes	Grade %WO_3
Kliphoogte Mine	2,50	352,8	66,0		31,75	±65,0
Tweedam Mine	0,83	406,3	65,0	0,64	753,70	±66,3
Tweedam Tailings	0,51	26,5	62,1	0,53	73,78	54,7
Narrap Mine	0,60	105,0	70,3	-	-	-
Ezelsfontein Prospect	1,0	16,5	68,8	-	-	-
Nababeep Mines	0,88	1238,2	66,8	0,29	318,8	63,2
Biesies Workings	-	-	-	±1,50	32,8	±69,0

crystallise as enveloping rims of fine sugary crystals around larger wolframite phenocrysts. Scheelite is treated as a penalty when mixed with wolframite, and some ore deposits were abandoned because of a persisting high scheelite/wolframite ratio. At Biesies (Sannagas 269) the narrow width and piebald distribution of the small mineralised lenses made economic exploitation impossible, despite a prospecting programme involving 15 boreholes totalling 824 m.

Small wolframite-bearing quartz bodies amenable to one-man operations were found and exploited in the high-lying biotite-sillimanite schists between Biesies and Komaggas. They were mined out, but not explored at depth.

Down-dip diamond drilling on mineralised zones failed to reveal signs of new ore bodies. Exploration was abandoned in the face of the high expenditure and insignificant returns. There is little hope for renewed interest in wolfram mining in Namaqualand.

15. GROUND WATER

Despite the low average annual rainfall, as recorded over many years in parts of the Springbok region, i.e. 305 mm in the Kamieskroon catchment area of the Buffels River, 102 mm in the western Bushmanland and 178 mm in the Springbok mountainous area, small springs are widely distributed and are sufficient for stock watering purposes and domestic use. The names of many occurrences ending in "-fontein" and "-water" testify to the widespread availability of shallow or surface water.

Many boreholes with a strong yield are found along the fault-related north–south-striking valleys. The holes are drilled into the fractured zones bordering on the main faults, which tend to decompose into clayey impermeable core zones. Good-quality fresh water with a reliable and reasonably strong yield is typically found in displacement zones where the latter intersect inclined quartzite beds, such as at Modderfontein 215, and the municipal site northeast of the school rugby field in Springbok. These holes adequately provided in Springbok's domestic requirements from 1946 to the late fifties, when the Buffels River Scheme was inaugurated. At Kanonkop, just north of Steinkopf, artesian water was struck in the Nama sediments. Unfortunately this supply is also being utilised for irrigation purposes, which will be detrimental in the long term. Other artesian holes drilled at Eselsklip near Carolusberg Mine and in Springbok ceased flowing after prolonged utilisation. This confirms the fact that ground-water supplies are limited and should be exploited with caution.

15.1 SPEKTAKEL AQUIFER

The largest reserves of ground water are confined to the sand-filled basin of the Buffels River on the farm Drie Rivier 268. The Spektakel Water Scheme was developed at this locality in 1947, and provided in the industrial and domestic needs of the local mines and towns until 1974, when the Orange River Water Scheme was brought into production to meet increasing demand.

The aquifer consists of a sand-filled basin extending 16 km upstream from a point near the old Spektakel Mine. The basin, carved into fresh granite, measures 700 m in width with a depth ranging from 4 to 20 m. When fully saturated with water the sand holds an impounded supply of 20,8 million m^3. The scheme is fed mainly by ephemeral streams from a catchment area of 621 000 hectares, which comprises the Kamieskroon Mountains with an average annual rainfall of 305 mm, the western Bushmanland with 102 mm and the Springbok mountainous terrain with 178 mm per annum.

The Buffels River flows on average once every three years. Drilling has disclosed that the straight section of the flood plain follows a fault. This east-dipping fault zone has a highly sheared middle portion, is fringed by well-jointed and brecciated borders, and varies up to 70 m in width. Its vuggy nature adds to its permeability and capability of yielding 12,63 litres per second from boreholes drilled into it. The basin is filled with sand of variable grain size, with occasional pebbles up to 25 mm in diameter down to about one or two metres from the bedrock. Loose boulders in the order of 1,5 m in diameter, in poorly consolidated gravel, comprise the bottom layer (Fig. 15.1).

The average porosity was experimentally determined at 3,1 per cent and the average effective porosity at 20 per cent. With evaporation being effective to a depth of one metre, the available volume has been calculated as 11,33 million m^3 of water when the aquifer is fully replenished. The fault zone serves as sump, draining the last of the water from the overlying sand when final depletion occurs.

Ideal replenishment requires oversaturation of soils in the catchment area. This is normally achieved after unbroken precipitation of more than 76 mm over a period of at least a fortnight. Subsequent slow flowage of the main stream normally accomplishes complete replenishment. Periods of significant replenishment observed from 1947 to 1974 were spaced as much as six years and nine months apart. A sustainable withdrawal limit was therefore calculated as 2 000 000 m^3 per annum.

Routine sampling and chemical analysis of water from 51 monitoring sites during the period 1953 to 1963 showed that the quality of impounded ground water in the Spektakel Scheme varied from good (1 000 ppm total dissolved solids) in the main production upstream sector to poor (6 700 ppm) in the unutilised downstream sector. Improvement in quality directly follows on periods of substantial replenishment. Fluorine content increased from 0,6 ppm to values between 1,5 and 6,0 ppm when boreholes in the granite were brought into production to augment supplies.

15.2 GEMSBOKVLEI BASIN

This palaeovalley is surrounded by hills bordering on the coastal plain and has a single outlet at the Gemsbokvlei farmhouse on Oograbies 149. The compartment drains the eastern and surrounding highlands and absorbs the runoff water into a thick succession of coarse sand.

The catchment area exceeds 130 650 hectares. The depth of the sand cover varies up to 70 m in places and towards the interior it is similar to the sand found in the Buffels River, with an average porosity of 30 per cent and estimated effective porosity of 20 per cent. The high porosity renders the Gemsbokvlei basin an excellent source of ground water. With an annual rainfall estimated at 5 cm over the coastal area, ground-water supplies are mainly dependent on runoff from the escarpment with its precipitation of some 30 cm per annum. Precipitation finds its way to the Gemsbokvlei water gap along the buried channels of the palaeolandscape. During pumping tests conducted at Gemsbokvlei, pumping at a rate of 12,08 kilolitre per hour lowered the watertable from 49,07 to 51,3 m below surface, where it remained stable during twelve hours of pumping. Further draw-down to cylinder intake depth was not possible owing to the inadequate capacity of the pumping equipment. At a monitoring station some 200 m west of the test hole, no change in the watertable was measurable. Water samples from the test hole remained stable at the following values:

	Total dissolved solids	Total alkalinity	Total hardness	Total Cl	Total F
ppm	1 400	100	490	760	0,6

In terms of volume and effective porosity, the water-yielding capacity of the Gemsbokvlei compartment is three times that of the Spektakel compartment.

Downstream of the Gemsbokvlei water gap the coarse fluvial sand is gradually replaced by very fine aeolian sand of coastal backshore derivation. The fine sand has a much lower porosity, so that the drainage channel spreads out towards the coastal stretch between Port Nolloth and White Point, where water often seeps out at springs. The quality of the water deteriorates towards the shoreline. At Julieshoogte, three municipal boreholes revealed a water column of 1,83 to 6,70 m above bedrock, the watertable being 12,89 to 17,49 m below surface. A total yield of 32,20 kilolitre/hour was measured during June 1965. Despite an estimated average production of 4,45 kilolitre per hour over a period of 3 years, the average water level did not subside more than 27 cm; in fact during the period 1st June 1962 to 4th May 1965 it rose by 52 cm. Total dissolved solids increased from 1 774 to 1 806 parts per million during this period. Poorly installed supply pipelines, rather than decreasing ground-water reserves, resulted in a deteriorating water situation at Port Nolloth which was finally solved by piping fresh water from the Orange River. The ground-water supplies contained in the inland fluvial gravels remain virtually untouched.

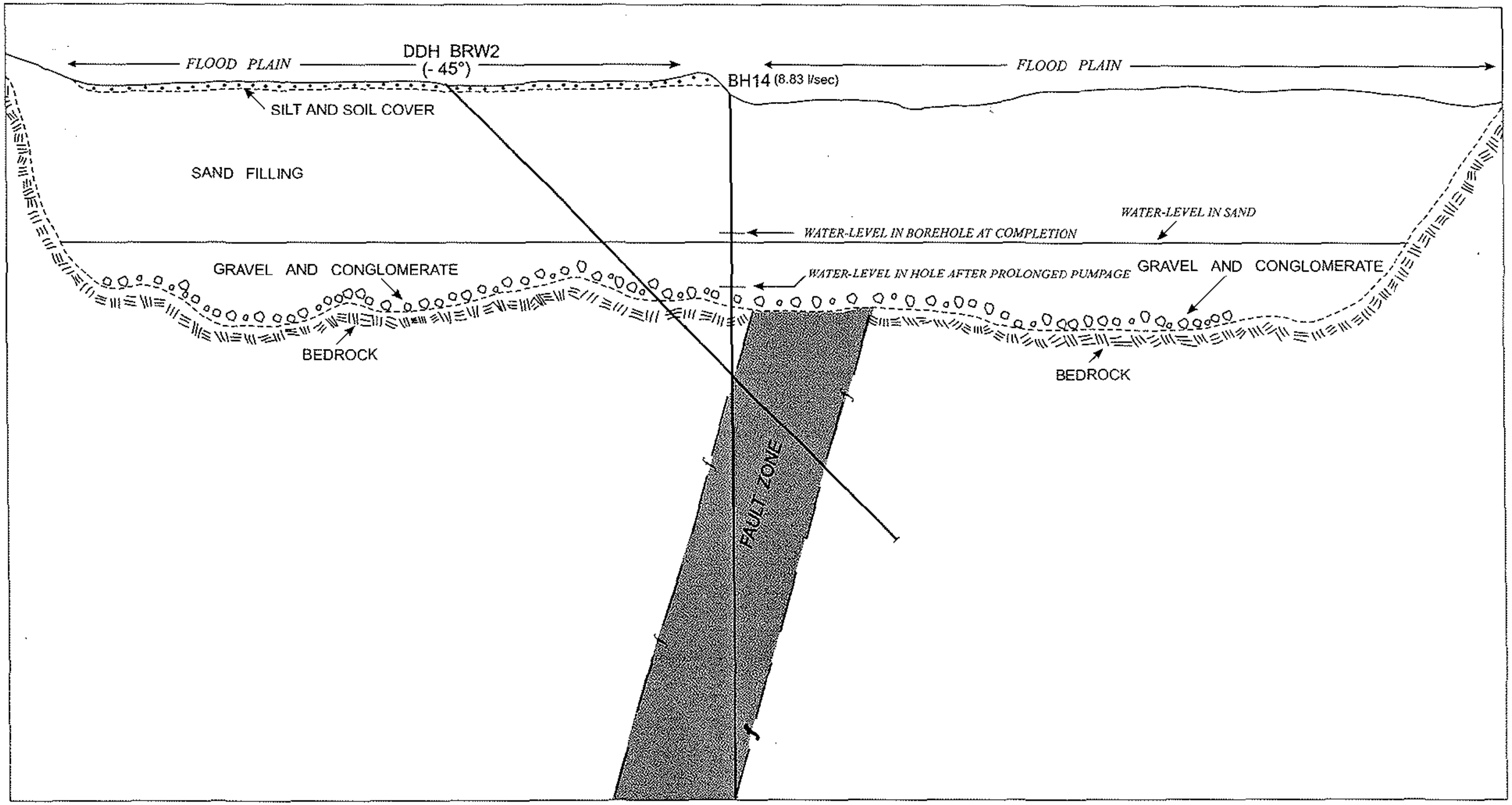

Fig. 15.1 – Schematic cross-section through the Spektakel water reservoir (not to scale).