

GROUND-WATER REGIONS AND SUBREGIONS

OF

SOUTH AFRICA

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MARCH 1990



2.2 (107)

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ABSTRACT

The currently accepted lithostratigraphic subdivision of South Africa's geological strata, physiography and climate provide the basis for the identification and demarcation of ground-water regions and subregions. Of the sixteen proposed regions thirteen have been subdivided into 82 subregions, i.e. 84 separate hydrogeological units have been recognised, plus an unfixed number of Tertiary-Quaternary primary aquifer systems.

GROUND-WATER REGIONS AND SUBREGIONS OF SOUTH AFRICA

1. Introduction

The Co-ordinating Committee for Geohydrological Research of the Water Research Commission has identified the characterisation of the ground-water resources of South Africa as one of the primary research goals needed for promoting their optimal utilization. X

Characterisation entails determining

- the water-bearing properties of the geological formations
- the hydraulic properties of aquifers
- the volumes of ground water held in storage
- the recharge
- the natural discharge and loss
- the chemical quality of ground-water
- the current state of and the potential for development.

Much has already been done towards the attainment of this goal. Over the past 50 years the Geological Survey initially, and the Directorate of Geohydrology, Department of Water Affairs subsequently, have carried out very many local ground-water investigations as well as a number of regional surveys and studies.

Although a large volume of data, information and reports have thus accumulated and ground-water resources have been identified and characterised at a number of places, considerable gaps in knowledge, areally and in detail, still exist. These gaps can be resolved only by a long-term programme of investigations and surveys, data collection, storage, evaluation and interpretation, resulting in repeated updating and refinement of the ground-water picture.

As yet however, no attempt has been made to compile and synthesize all available information and data in a conspectus. The continually increasing demand on the country's limited water resources and the need for protecting them from contamination and pollution, calls for a comprehensive overview. A conspectus is not only urgently required by the practising hydrogeologist or geohydrologist, but there is also a serious need to inform and educate water supply engineers, planners, managers, administrators, users and the general public. X

To describe the ground-water conditions in South Africa, it is necessary to divide the country into regions and subregions. Each of the subregions at least, should have as far as possible more or less uniform characteristics.

2. Criteria for subdivision in ground-water regions and subregions

The concept of interstices - the open spaces that form receptacles and conduits of ground-water - is fundamental in ground-water hydrology. Openings are produced by a number of geological processes. Two main types of openings may be distinguished.

Primary openings originate contemporaneously with genesis that is during the deposition of sediment and the solidification and (re) crystallisation of igneous and metamorphic rocks. Primary openings in igneous and metamorphic rocks may however be disregarded as of little or no consequence in South African ground-water hydrology.

During the lithification of sediments primary openings are reduced in size by the physical-chemical processes of consolidation, compaction, cementation, (re)crystallisation etc. The degree of diagenesis and metamorphism determines to what extent a sedimentary rock retains primary porosity and permeability.

Geological formations capable of yielding water to boreholes principally by virtue of primary openings are termed primary aquifers. Apart from alluvial deposits which occur in narrow strips in and along surface-water courses and Quaternary coastal sands, very few consolidated sedimentary rocks in South Africa qualify as primary aquifers. They are restricted to Tertiary and Cretaceous sandstones which have a very limited distribution and localised occurrences of some Karoo sandstones. Semi-permeable pores are however important as storage space.

Secondary openings originate in hard-rock formations through tectonic deformation, weathering and unloading by erosion. They are planar where formed along joint, bedding and fault planes etc but also consist of pores in disintegrated and decomposed rock. Geological formations capable of yielding water to boreholes through secondary openings are termed secondary aquifers.

Over approximately 90 per cent of the area of South Africa ground-water occurs only in secondary openings, that is in weathered and fractured hard-rock formations ranging from Earliest Pre-Cambrian to Jurassic in age and comprising sedimentary, metamorphic and extrusive and intrusive igneous rocks.

With the overwhelming preponderance of hard-rock formations in mind, division of the country into ground-water regions on the basis of primary and secondary aquifers only, is ineffective.

Whereas the mapping of the larger, if not all, primary aquifers presents little difficulty, the delineation of secondary aquifers country-wide is impossible at least for the present. Secondary aquifers are not confined to particular hard-rock types (although some may be more conducive to transformation into secondary aquifers than others) or to discernible structural features. Within a particular hard-rock formation, the water-bearing properties can vary considerably. Delineation of secondary aquifers requires detailed investigation often including geophysical survey and exploratory drilling. The occurrence and distribution of secondary aquifers is therefore only known where

detailed investigations have been carried out.

Under these circumstances the second best alternative as basis for delineating ground-water regions and subregions is to use the lithostratigraphic subdivision of the country's geologic strata.

The occurrence and availability of ground-water at any locality is, however, not only determined by the capacity of strata to store and transmit water but also by

- 1) the volumes and frequency of periodic recharge or rate of continuous recharge by infiltrating precipitation and surface water;
- 2) the rate of ground-water movement;
- 3) the rate of discharge and/or loss by evapo-transpiration.

The factors controlling natural recharge namely

rainfall - volume, intensity, frequency and distribution;
availability of surface water;
land surface configuration;
soil and vegetative cover;
moisture retention and evapo-transpiration;

can be grouped under climatic conditions and physiography. Besides transmissivity, ground-water flow is governed by hydraulic gradient which in turn depends on topographic relief. Surface configuration is also one of the factors controlling the loss of ground-water through spring flow and effluent seepage and by evapo-transpiration. In delineating ground-water regions and subregions the aim has therefore been to obtain as far as possible uniformity in respect of lithostratigraphy, physiography and climate.

A unique answer is not possible. A large degree of discretion has to be exercised and compromises have to be made. Obviously other schemes/subdivisions are possible.

Hopefully the proposed subdivision presented here, may nonetheless prove, with little or no change, acceptable as a first attempt and a starting point for a conspectus.

3. Ground-water Regions

In the case of eleven out of the sixteen regions that have been identified and delineated, major lithostratigraphic unit and/or geologic structure has been the prime factor. Physiography was the main consideration in the case of three and a combination of physiography-geology in the remaining two cases. Climate has not played a role in the major subdivision.

The major divisions are

| <u>Region</u> | <u>Main consideration</u> * | <u>Principal Characteristics</u> |
|--|-----------------------------|---|
| I Limpopo Lowland | P | Lowland adjoining major eastward flowing river. Major part occupied by Swazian granites and metamorphic rocks; east-west grabens with Karoo strata; |
| II Limpopo Highland | P | Source of Limpopo tributaries. |
| III Bushveld Basin | G | Prominent basin-like geologic structure. |
| IV Witwatersrand Basin | G | Contains all major exposures of West Rand and Central Rand Groups. |
| V Trans-Cape Highveld | G | Extrusive rocks of the Dominion Group, Ventersdorp Supergroup and correlates. |
| VI Transvaal Lowveld | P/G | Situated below Great Escarpment and solely underlain by Swazian granite and metamorphic rocks. |
| VII Transvaal Middleveld | P/G | Situated below Great Escarpment but higher elevation than Lowveld. Underlain by volcano-sedimentary Swaziland and Pongola Supergroups. |
| VIII Lebombo belt | G | Basalt and rhyolite range |
| IX Kalahari | P | Interior physiographic basin and nearly ubiquitous sand cover. |
| X Griqualand West | G | Elevated tract composed of rocks of Griqualand West and Olifantshoek Sequences. |
| XI Namaqua-Bushmanland Metamorphic Complex | G | Metasedimentary, metavolcanic and gneissic intrusive rocks. |

| | | |
|----------------------|---|---|
| XII Karoo basin | G | Occupies about 50 per cent of South Africa contains practically continuous succession of Carboniferous to Jurassic sedimentary rocks. |
| XIII Natal Monocline | G | Important major structural feature. |
| XIV Cape Fold Belt | G | Orogenetic belt; fold mountain ranges. |
| XV West Coast Tetrad | G | Geosynclinal Gariep Complex and Malmesbury Groups and platform Nama Group sediments all of Namibian age. |
| XVI Coastal deposits | G | Primary aquifers. |

* G Geological; P Physiographical.

4. Description of Ground-water Regions and Subregions.

In the following sections the boundaries of the different regions will be described under the heading "Configuration". Under "Aspect" some of the physiographic features will be outlined. Some remarks on rainfall and natural vegetation (according to Acocks, J.P.H. 1953. Veld types of South Africa, Botanical Survey Memoir No 28) are made under "Precipitation" and "Natural Vegetation". Apart from the Karoo Basin Region, subregion boundaries are not being described. They are shown on the accompanying map. Subregion boundaries are of a diverse nature: geological contacts, waterdivides, rivers, the Great Escarpment and political boundaries.

The geological map of South Africa, Transkei, Bophuthatswana, Venda and Ciskei and the Kingdoms of Lesotho and Swaziland (scale 1:1 000 000) published by the Geological Survey of South Africa in 1984 has been used as basis for the delineation of regions and subregions. Stratigraphic nomenclature in the text is in accordance with the geological map and handbook "Lithostratigraphy of the Republic of South Africa, South West Africa/Namibia and the Republics of Bophuthatswana, Transkei and Venda" of the Geological Survey published in 1980.

In all but a few cases no reference has been made to alluvial deposits which to a greater or lesser degree are present in most of the subregions. Although some are mentioned, no attempt has been made to give a full account of the most important ones. Alluvial aquifers are considered integral components of the subregions in which they occur. A separate category in the proposed subdivision has not been provided.

I LIMPOPO LOWLAND REGION

(a) Configuration

The region consists of an elongated strip of country about 600 km long and 80 km at its widest.

The northern boundary is the international one with Botswana and Zimbabwe from near Ramoutsa Gate in the west to Pafuri in the east. The southern boundary is as follows: the base of the Chuniespoort Group from Ramoutsa Gate to a point north of Thabazimbi; the contact of the Aasvoelkop Formation (Waterberg Group) with Bushveld granite, Chuniespoort Group strata and the overlying Sandriviersberg Formation (Waterberg Group); the contact between Karoo strata and the Sandriviersberg Formation and the Villa Nora Bushveld Complex rocks; hence the northern limit of the Waterberg and Soutpansberg Groups cutting across the northern extremity of the Lebombo Range to the Mocambique border at Pafuri.

(b) Aspect:

Flat country with isolated hills. The elevation ranges from 1100 m a.m.s.l. in the west to 300 m a.m.s.l. in the east. Northward-flowing tributaries joining the Marico-Limpopo are the Crocodile, Matlabas, Mokolo, Lephala, Mogalakwena, Sand and Nzhelele.

(c) Precipitation:

Summer; ranging from an average annual of over 500 mm in the far west to less than 400 mm in the east; peaks in December-January.

(d) Natural Vegetation (Acocks)

Mopani Bushveld east of Baines Drift; mixed Bushveld on the southern higher-lying areas;

Arid Sweet Bushveld along the Marico and Limpopo Rivers;

Patch of Turf Thornveld in the surroundings of Dwaalboom.

(e) Subregions

Boundaries are geologic except where stated otherwise.

The region is subdivided into

| Subregion | Geological Strata |
|--|---|
| I A Crocodile-Marico Lowland (Derdepoort-Rooibokkraal-Dwaalboom) | Swazian granitic and metamorphic rocks; minor occurrences of Randian intrusives and extrusives and Early Vaalian sediments and lava, Bushveld granite |
| I B Matlabas catchment | Aasvoëlkop Formation sandstone and mudstone (Waterberg Group) The southern limit is a waterdivide. |

| | | |
|-----|----------------------|---|
| I C | Waterberg Coal basin | Karoo sandstone, siltstone, shale, mudstone, basalt. |
| I D | Beauty-Messina belt | Swazian granitic and metamorphic rocks. |
| I E | Limpopo Karoo basin | Karoo sandstone, siltstone, shale, mudstone, basalt. |
| I F | Waterpoort trough | as for I E |
| I G | Tshipise trough | as for I E |
| I H | Masisi strip | Upper Cretaceous calcareous sandstone and conglomerate. |

Note that water-bearing alluvial deposits occur along the Limpopo and its tributaries.

II LIMPOPO HIGHLAND REGION

(a) Configuration

The region is almost rectangular with ^{an} east-west dimension of 240 km and a north-south one of 120 km. The eastern Soutpansberg provides a handle to it. The Limpopo Lowland Region adjoins it in the west and north. Its eastern boundary is the Great Escarpment from Elim in the north to the Wolkberg. In the southwest the boundary is the base of the Waterberg Group; it curves northwards in the Hanglipberge west of Potgietersrust in order to excise the northerly trending tongue of Bushveld Complex and Transvaal Supergroup rocks. East of Steilloop Bridge the boundary is the southerly and easterly trending contact between the Swazian granitic and metamorphic and Bushveld Complexes and Wolkberg Group. Bushveld Complex rocks in the vicinity of Villa Nora have also been cut out.

(b) Aspect:

From the point of view of both physiography and geology the region consists of three separate areas:

- a rugged territory built by horizontally disposed sedimentary rocks known as the Waterberg and the centre of which is called the Palala Plateau and which has an average altitude of about 1 500 m. The plateau ends to the north, east and south in escarpments. The highest point of nearly 2 000 m a.m.s.l. is made by the Kransberg north of Rooiberg. To the northeast across the Mogalakwena River lies the imposing Blouberg. South of the Palala Plateau and north of Warmbaths and Nylstroom lies hilly country. The isolated Kranskop rises from the sand-covered plain a little southeast of Nylstroom.

- the Soutpansberg built by tilted sedimentary rocks where strike faulting produced repetition of strata and triplication of ridges. Within the mountains deep valleys have been carved. The highest elevation is 1 470 m.

- the Pietersburg Plateau, a plain underlain by granitic rocks which declines northwards from about 1 350 m to about 900 m a.m.s.l. Along its southern margin Swazian greenstones, banded ironstone, magnetic quartzite build the Ysterberg, the Mount Mare range and the Rhenosterkoppies.

The Limpopo Highland is the source of the Mokolo, Lephalala, Sand and Nzhelele Rivers. It is crossed by the Mogalakwena whilst the Matlabas catchment lies immediately to the west.

(c) **Precipitation:**

Summer; in the higher-lying parts of the Waterberg an average of between 600 to 700 mm per annum decreasing in a northerly direction to below 500 mm per annum and in an easterly direction on the Pietersburg Plateau to less than 400 mm/a. On the escarpment rainfall rises to over 800 mm/a. Rainfall on the Soutpansberg depends strongly on elevation - increasing from about 500 mm at the foot to more than 1 750 mm on the highest part.

(d) **Natural Vegetation (Acocks):**

The eastern Soutpansberg: Mountain Sourveld. The western Soutpansberg, Blouberg, Magabene and Waterberg: Higher-lying areas Sour Bushveld with Mixed Bushveld in lower-lying parts.

On the Pietersburg Plateau the veld ranges south to north from False Grassveld to Mixed Bushveld to Arid Sweet Bushveld.

(e) **Subregions**

The region comprises three subregions. The Waterberg subregion is all but separated from the Pietersburg Plateau by the tongue of Bushveld Complex rocks.

Geology determines the boundary between the Pietersburg Plateau and the Soutpansberg subregion.

| Subregion | Geological strata |
|---|---|
| II A Waterberg (including Palala Plateau, Magabene, Blouberg; Nylstroom to Ellisras; Bulge River to Blouberg) | Waterberg Group sandstone, siltstone, grit, shale, mudstone conglomerate, trachyte. |
| II B Soutpansberg Range | Soutpansberg Group sandstone conglomerate, shale, basalt and tuff. |
| II C Pietersburg Plateau | Swazian granitic and metamorphic rocks. |

Note alluvial deposits along Sand and Mogalakwena Rivers.

III BUSHVELD BASIN REGION

This pear-shaped basin-like feature which occupies the Central Transvaal is about 500 km long. It stretches from west of the Botswana border to the Transvaal Drakensberg in the east. Its north-south dimension averages about 150 km. Excepting sections between Thabazimbi and Graskop and in the southeast, the boundary is defined by the basal contact of the Black Reef Formation. The region as far as South Africa is concerned terminates against the Botswana border between Ramoutsa and Schilpad Gates. In the southeast between Kempton Park and Carolina, its boundary is the irregularly dentated edge of Karoo strata. In the northeast between a point just east of Potgietersrust, past Haenertsburg to just south of Graskop, the base of the Wolkberg Group underlying the Black Reef Formation, is the boundary. North of Potgietersrust where the Bushveld Complex transgresses the Pretoria and Chuniespoort Groups, Swazian granite forms the boundary up to a point east of Steilloop Bridge. From here to Thabazimbi in the west, the zig-zagging basal contact of the Waterberg Group is the boundary. Granite and mafic rocks in the Villa Nora area are taken as an outlying part of the Bushveld Basin Region.

(b) Aspect:

The rim of the Bushveld Basin Region consists of Chuniespoort and Pretoria Group strata, which build the higher-lying engirdling ground, particularly in the northeast and east. Here, in places, the Strydpoort and Drakensberg ranges composed of Wolkberg sedimentary rocks, Black Reef quartzite and Chuniespoort dolomite and ironstone reach elevations in excess of 2 000 m a.m.s.l. The resistant quartzites and relatively easily erodible shales of the Pretoria Group are responsible for the scenery termed Bankeveld, which consists of long ridges separated by longitudinal valleys. The most familiar part of the Bankeveld is the succession of ridges about Pretoria, the Magaliesberg, Daspoort and Timeball Hill ranges which stretch east-west. In the far west this trend is continued by the Enzelberg. The northwestern rim is built by the Dwarsberg, the Witfontein Ridge (Chuniespoort dolomite) and the eastward trending Gatkop range near Thabazimbi. In the east the Pretoria Group makes a wide strip of elevated ground with relief approaching 1 000 m and building the Sakun, Tokane and Steenkampsberg ranges. The latter culminates in 2 333 m a.m.s.l.

Apart from the prominent Pilanesberg north of Rustenburg, the Matlapynsberg to the west of it, the Boshofs and Elandsberg southeast of Thabazimbi, the Koedoeskop hills at the confluence of the Pienaars and Crocodile Rivers, and a chain of detached norite koppies and hills, the western two-thirds of the inner basin is topographically relatively little diversified. It lies at an elevation of 1 000 to 1 500 m a.m.s.l. except for the lower reaches of the Crocodile and Olifants Rivers which drop to below 1 000 m a.m.s.l. Karoo rocks underlie the extensive Springbok Flats.

In contrast with the west and central parts where the mafic rocks of the Complex are largely characterised by slightly undulating ground with black turf soil, norite and associated rocks build the Leole and Marona mountains in the northeast, stretching from the Olifants River as far as Magnet Heights. Further southwards to Roosenekal the continuation is a hilly tract covered by koppies.

An elevated plateau 1 200 to 1 500 m a.m.s.l. between Roodeplaas Dam in the west, Loskop Dam in the northeast, and Middelburg in the southeast consists of sedimentary rocks of the Waterberg Group and Loskop Formation, in places covered by patches of Karoo strata.

The westward-sloping Pokwani plateau which lies further to the north, terminates in the eastward-facing escarpments of the Sekhukhune Mountains (highest point 1 900 m a.m.s.l.), and the Bothasberg. Both are built by Rooiberg felsite and Lebowa Granite and stand some 900 m above the Steelpoort River valley. Between Sterkwater, northwest of Potgietersrust, and Nylstroom, Rooiberg felsite and Lebowa granite form the high ground west of Moorddrif and the Swaershoek Mountains north of Naboomspruit. The Hoekberg west of Warmbaths consists of the same rocks. North of Brits granite forms gently rolling country relieved by isolated koppies.

Rivers crossing the Bushveld Basin from south to north are the Marico and Crocodile and towards the northeast the Olifants River joined by its important Steelpoort tributary. The Nyl drains the hilly country north of Warmbaths, Nylstroom and Naboomspruit. It leaves the Bushveld Basin via the northerly trending tongue of the Bushveld Complex at Potgietersrust. Rivers like the Blyde, Sabie, Crocodile (Eastern Transvaal) the Elands and the Nkomati rise in the Drakensberg.

(c) Precipitation:

From the Drakensberg which receives 1 000 mm/a on average and more - localised maxima of 2 000 mm/a - precipitation decreases westward to an annual average of between 500 and 600 mm/a. The engirdling higher ground receives more than the inner basin - over 600 mm/a. Rainfall is the least over the lower reaches of the Olifants River - less than 500 mm/a. Months with the highest rainfall are December and January. Over the Drakensberg escarpment the peak rainfall period lasts from November to February.

(d) Natural Vegetation (Acocks):

West of an imaginary line from Ohrigstad to Witbank, the greater part of the Bushveld carries a Mixed and Sourish Mixed Bushveld with some Sour Bushveld on the highest areas. Turf Thornveld is encountered on the western turf soils and on the Springbok Flats basalt. East of the imaginary line vegetation ranges from Bankeveld in the Middelburg area and around Lydenburg, to Themeda grass to Northeastern Mountain Sourveld with Lowveld Sour Bushveld along the eastern slopes of the Drakensberg.

(e) Subregions

Note that the Chuniespoort dolomite along the southwestern and southern rim of the Basin has been accorded the status of a subregion because of its large ground-water resources, whereas that in the northwest, northeast and east has been included in the different Bankeveld subregions. Except in the vicinity of Thabazimbi, the dolomite of the northwest has relatively little significance as an aquifer. That along the Drakensberg although an important source of surface streams, being in mountainous terrain,

~~important source of surface streams, being in mountainous terrain, is unfavourably situated for development of ground-water.~~

The region is composed of the following subregions. All boundaries between subregions are geological.

| Subregion | Geological strata |
|---|---|
| III A Northwestern Bankeveld (Ramoutsa-Thabazimbi) | Conglomerate, sandstone (Black Reef); dolomite, chert, iron formation, shale (Chuniespoort Group); shale, quartzite, diamicrite, andesite (Pretoria Group); diabase. |
| III B Marico Bushveld (Nietverdiend-Ruighoek) | Shale, quartzite (Pretoria Group) intruded by bronzitite, harzburgite and norite. |
| III C Southern Bankeveld (Schilpad Gate-Swartruggens-Pretoria-Dryden) | Pretoria Group rocks as for III A above. |
| III D Karst belt (Schilpad Gate-Lichtenburg-Tarlton-Verwoerdburg-Delmas) | Quartzite, conglomerate, shale (Black Reef) dolomite and chert (Chuniespoort Group). |
| III E Western Bushveld Mafic Lobe including Pilanesberg Complex | Bronzitite, harzburgite, norite, gabbro, anorthosite, magnetite gabbro of the Rustenburg layered Suite and foyaite, syenite lava and tuff of the Pilanesberg. |
| III F Western Bushveld Felsic Lobe including roof and floor rocks. | Rashoop granophyre Suite Lebowa Granite Suite; dolomite iron formation and quartzite (Chuniespoort Group), quartzite and shale (Pretoria Group), rhyolite/felsite (Rooiberg Group). |
| III G Springbok Flats | Karoo shale, mudstone, sandstone, siltstone and basalt. |
| III H Northern Lobe of Bushveld Complex (Potgietersrust "tongue" and Villa Nora inlier) | Norite, anorthosite, gabbro, magnetite gabbro of Rustenburg Layered Suite; granite of Lebowa Suite and Rooiberg rhyolite/felsite. |
| III I Middelburg Basin | Shale, sandstone, conglomerate and volcanic rocks of Loskop Formation and Waterberg Group sandstone and conglomerate with patches of Karoo rocks. |
| III J Eastern-Southeastern Felsic lobe of Bushveld | Rashoop granophyre Suite, Lebowa granite Suite, |

and floor rocks.

schist, gneiss, andesite, quartzite and shale; Chuniespoort dolomite and chert, Pretoria shale and quartzite, Rooiberg rhyolite/felsite.

III K Eastern Mafic Lobe of Bushveld Complex

See III E above.

III L Eastern and Northeastern Bankeveld

Pretoria and Chuniespoort Groups see III A overlying Wolkberg Group shale, quartzite, conglomerate and basalt.

IV WITWATERSRAND BASIN REGION

(a) Configuration

With exception of outcropping Witwatersrand strata south of Ottosdal, this region includes all the major outcrops of the West Rand and Central Rand Groups strata. From Ventersdorp eastward to the vicinity of Springs the region adjoins the Bushveld Basin region. In the west the boundary is an irregular line separating Witwatersrand strata, Dominion Group rocks and Swazian granite from the Rietgat Formation of the Ventersdorp Supergroup. It runs from Ventersdorp to a point southwest of Hartbeesfontein then eastward to Klerksdorp and southwards to Orkney. The southern and southeastern limit is the irregular edge of blanketing Karoo strata.

(b) Aspect:

The region lies at an elevation of between 1 400 to 1 900 m a.m.s.l. Topographic relief is subdued over most of the region, the maximum being about 300 m.

The more important physiographic features are

- the Witwatersrand, a major water divide;
- the Suikerbosrand in the Heidelberg area;
- the Gatsrand along the northern limb of the Potchefstroom synclinorium;
- the Losberg near Fochville;
- the Witwatersrand quartzite ridges encircling the northwestern half of the Vredefort Dome;
- the valleys on Chuniespoort Dolomite of the Koekemoer and Wonderfontein Spruits and the Mooi and Klip Rivers, all tributaries of the Vaal in the south of the region.

(c) Precipitation:

Excepting the far west around Klerksdorp where the rainfall is somewhat below 600 mm average per annum, most of the region enjoys between 600 to 700 mm of precipitation. On the Witwatersrand rainfall exceeds 700 mm per annum. Rainfall peaks during December to February.

(d) Natural Vegetation (Acocks):

Bankeveld and Cymbopogon-Themeda veld.

(e) Subregions

On geological ground the region may be divided in

| Subregion | Geological strata |
|---|--|
| IV A Halfway House Dome | Mainly Swazian gneiss, migmatite granodiorite; subordinate basic and ultrabasic metavolvanic rocks and remnants of layered ultrabasic intrusions; Witwatersrand sedimentary rocks, Klipriviersberg andesite. |
| IV B Central Rand (Randfontein-Benoni) | Witwatersrand shale quartzite lava, conglomerate; Klipriviersberg andesite and tuff; small inlier of granite gneiss west of Randfontein. |
| IV C Ventersdorp-Hartebees= fontein-Klerksdorp area | Swazian granite gneiss; Dominion Group lava and quartzite; Witwatersrand sedimentary rocks; Ventersdorp Supergroup lava and sedimentary rocks. |
| IV D Karst Belt (Orkney- Carletonville-Alberton- Vereeniging) | Chuniespoort dolomite and chert, Black Reef quartzite conglomerate, shale; patches of Karoo sedimentary rocks overlying dolomite especially in the Meyerton-Vereeniging area. |
| IV E Potchefstroom Bankeveld | Witwatersrand shale, quartzite, lava, conglomerate; Klipriviersberg andesite and tuff; Chuniespoort dolomite and chert; Pretoria Group shale, quartzite andesite. |
| IV F Suikerbosrand (Meyerton- Greylingstad; Vaal Dam - Nigel) | Witwatersrand and Klipriviersberg rocks as described above. |
| IV G Vredefort dome | Swazian granite gneiss. |

V TRANS-CAPE HIGHVELD REGION

(a) Configuration

From Schilpad Gate on the Botswana border to Ventersdorp, the boundary is the base of the Black Reef Formation - the adjoining

~~boundary is the base of the Black Reef Formation - the adjoining~~ subregion on the north being the Karst Belt subregion III D. From Ventersdorp to Orkney, the region is bounded by the Witwatersrand Basin Region, the limit very approximately following the Schoon Spruit. From Orkney to Warrenton the region is demarcated by younger Karoo strata. From Warrenton to approximately Pudimoe, the limit is the eastern edge of the Harts Valley. Between Pudimoe and a point about 20 km west of Stella, the region is defined by the base of the Black Reef Formation in the south and by the contact between Zoetlief Group strata and Allanridge lavas in the north. Further northwards to the Botswana border, north of Ramatlhabama, the Kalahari sand cover is the boundary.

(b) Aspect:

The region has a slightly undulating surface practically all of it lying at an elevation of between 1 200 and 1 500 m a.m.s.l. and sloping from the north down to the Vaal River. The highest part, the Platberg between Hauptsrus, Ottosdal and Hartebeesfontein, attains an elevation of over 1 600 m a.m.s.l. The other important topographic feature is the Makwassie Hills.

The region is drained by tributaries of the Vaal which, in parts, forms its southern boundary. The most important tributaries are the Harts River, the Bamboes, Makwassie, Leeudoorn, Rhenoster and Schoon Spruits, of which the latter only is perennial.

(c) Precipitation:

Rainfall decreases from just below 600 mm/a in the east to just above 400 mm/a in the west. In the east the peak rainfall period is December-January. In the west it is January to March.

(d) Natural Vegetation (Acocks):

The vegetation changes from Cympobogon-Themeda Veld in the east to Dry Cympobogon-Themeda Veld to Kalahari Thornveld in the west.

(e) Geology

The region is not subdivided into subregions. Geologic strata principally comprise extrusive rocks - andesite, dacite, trachyte, quartz porphyry, tuffs, agglomerate - as well as sedimentary rocks - sandstone, shale, chert, grit, conglomerate, all belonging to the Ventersdorp Supergroup.

Inliers of older rocks appear in the Ventersdorp Supergroup:

- 1) Between Coligny and Wolmaransstad Swazian granite gneiss, Dominion Group volcanics and Witwatersrand sedimentary rocks.
- 2) Swazian granite gneiss between Delareyville and Broederput.
- 3) Swazian granite gneiss, chert, iron formation, jaspillite, schist and lava southwest of Schweizer-Reneke.
- 4) Dominion Group volcanics and granite north of Mafikeng.

Reneke.

VI TRANSVAAL LOWVELD REGION

(a) Configuration

The region lies below the eastern Escarpment from Thohoyandou in the north to just south of Nelspruit. It is bound in the north by the eastern Soutpansberg and in the west by the Pietersburg Plateau subregion and the eastern edge of the Bushveld Basin Region. The southern limit is the northern contact of the volcano- sedimentary strata of the Barberton Sequence running from Kaapse Hoop to Hectorspruit. From Hectorspruit the boundary is the southeastern side of the mountainland up to the Swaziland border. The eastern boundary is formed by the base of overlying Karoo strata and lavas of the Lebombo belt.

(b) Aspect:

Except for a narrow zone along the escarpment which widens in the Hazyview-Witrivier-Nelspruit area, the Lowveld lies below 900 m a.m.s.l. In the east along river valleys elevations drop to below 300 m. The greater part of the region lies at elevations of between 300 to 600 m a.m.s.l. Its surface is mostly a gentle rolling one falling gently eastward to the Lebombo.

Prominent landmarks are the Murchison and so-called Sutherland ranges respectively situated in the Leydsdorp and Giyani areas. Elsewhere isolated single or clumps of koppies typical of granite areas are seen. The Lowveld is crossed from west to east by the Shingwidzi, Letaba, Olifants, Sabie and Crocodile Rivers and a number of tributaries.

(c) Precipitation:

Along the escarpment annual rainfall averages between 600 and 1 000 mm/a. Over the northern half of the Lowveld the average annual precipitation is less than 500 mm. In the south rainfall is higher - 600 to 700 mm/a. Rainfall peaks in January.

(d) Natural Vegetation (Acocks):

- (1) Northern Lowveld (north of Olifants River) : Lowveld Sour Bushveld on the escarpment slopes changing eastward to Arid Lowveld and into Mopani Veld.
- (2) Southern Lowveld
South of the Olifants the Mopani veld is absent. Further south (from Acornhoek) the transition is from Lowveld Sour Bushveld to Lowveld to Arid Lowveld vegetation.

(e) Subregions

On the basis of precipitation this region may be divided into

Subregion

Geological strata

VI A Northern Lowveld

Swazian ultramafic, mafic and acid lava, tuff, schist quartzite, conglomerate, banded gneiss (Murchison Range, and Giyani) migmatite and leucogranite as well as various younger granites.

VI B Southern Lowveld

Swazian granite, granodiorite, migmatite, younger tonalite.

VII TRANSVAAL MIDDLEVELD REGION

(a) Configuration

The Transvaal Middleveld extends southwards for a short distance into Northern Natal. In the north it adjoins the southern Lowveld. Its western boundary from Kaapse Hoop southwards follows the base of the Black Reef Formation to a point just east of Carolina. From here past Lothair, Sheepmoor, east of Dirkiesdorp, Paulpietersburg, to Zungweni north of Vryheid, to Louwsburg, to a point north of Nongoma on a prominent north-south fault, the boundary is the extremely irregular edge of Karoo strata. The prominent fault forms the eastern boundary against the southern Lebombo belt up to the Swaziland border. The remainder of the eastern boundary is the Swaziland border to a point just east of the Barberton mountainland.

(b) Aspect:

The Middleveld lies below the Escarpment at elevations of between 600 and 1 500 m a.m.s.l. It is a highly dissected region with considerable relief crossed by the following eastward flowing rivers the Nkomati, Usutu, Ngwempisi, Assegaai, Pongola and Mkuze.

(c) Precipitation:

Rainfall exceeds an average of 800 mm/a almost throughout the region. Over the Barberton Mountainland precipitation is above 1 500 mm/a. In the Nongoma-Louwsburg area rainfall amounts to between 600 - 700 mm/a.

(d) Natural Vegetation (Acocks):

The natural vegetation changes with elevation from grassveld (Near Highlands Sourveld) to grass and scrub forest (Piet Retief Sourveld) and Natal Tall Grassveld to Zululand Thornveld.

(e) Geology

No subregions have been identified.

The geology comprises the following:

Metamorphosed volcano-sedimentary Swaziland Supergroup consisting of lavas, pyroclastic rocks, sandstone, shale, conglomerate,

serpentinite, amphibolite; older potassic granite, granodiorite; Pongola Supergroup basalt, andesite, dacite, rhyolite, conglomerate, sandstone, quartzite, shale; younger granites; Usushwane intrusive Suite of various gabbros, serpentinite.

VIII LEBOMBO BELT REGION

(a) Configuration:

The region consists of two parts, separated from each other by Swaziland. The northern section stretches over a distance of about 400 km from Pafuri southwards along the Mocambique border to the Swaziland border. The western boundary is the base of Karoo sedimentary rocks resting on Swazian basement rocks.

The southern section extends from Pongola and Golela in the north to Empangeni in the south. Its western boundary runs along N-S faults, west of which Swazian and Ordovician-Silurian strata make their appearance. The eastern boundary is defined by the base of overlying Cretaceous strata. A narrow strip of the belt lies in South African territory east of Swaziland and north of Golela for a distance of about 60 km up to the Mocambique border.

(b) Aspect:

In the northern sector the Lebombo Belt straddles the South African-Mocambique border. It consists of a narrow N-S elevated tract, built by Karoo rhyolite with the low ground to the west lying at less than 300 m a.m.s.l. and underlain by Karoo sedimentary rocks and basalt. The highest point on the Lebombo Range (802 m a.m.s.l.) is at the triple junction of South African, Swaziland and Mocambique borders. Northwards the height decreases to between 500 and 300 m a.m.s.l. Rhyolite is absent within South Africa for the northernmost 100 km.

In the southern sector the height of the Lebombo mountain varies between 600 and 700 m a.m.s.l. As the rhyolite thins southwards and eventually disappears north of Hluhluwe, so the range dwindles until it disappears about 25 km south of Ubombo. The lowland immediately west of the mountain has an elevation of less than 300 m. Further westward the belt of Karoo sedimentary rocks occupies dissected country attaining elevations of up to 600 m.

(c) Precipitation:

Northern sector

Immediately north of the Swaziland border the mountain receives over 800 mm/a and the country directly to the west 600 - 700 mm/a. Rainfall falls off in a northerly direction to less than 500 mm/a at Pafuri.

Southern sector

Precipitation is over 800 mm/a over much of the sector. West of the Lebombo range rainfall is somewhat lower - about 700 mm/a.

(d) Natural Vegetation (Acocks):

Northern sector

From the Swaziland Border northwards the veld changes from Lowveld Bushveld to Arid Lowveld to Mopani Veld.

Southern sector

The veld type on the high-lying areas is High Altitude Zululand Thornveld with Lowveld at lower elevations and Arid Lowveld in the lowest valleys.

(e) Subregions

The region consists of two separate entities.

VIII A Northern Lebombo

Karoo sandstone, mudstone, shale and coal followed by Clarens sandstone, siltstone, basalt and rhyolite south of the Olifants River. Northwards Clarens sandstone and siltstone and basalt only.

VIII B Southern Lebombo

Complete succession of Karoo strata from Dwyka upwards to Clarens Formation, basalt and rhyolite; Bumbeni Complex northwest of Lake St Lucia. East and northeast of Hlabisa some small outcrops of Natal Group sandstone.

IX KALAHARI REGION

(a) Configuration

The Kalahari Region borders on the Trans-Cape Highveld in the east. The common boundary as described under that region runs from north of Ramatlabama on the Botswana border to a point northwest of Vryburg where it meets the Vryburg Formation. From this point the southern boundary follows the base of that Formation past Bothithong and continues further west, just north of the outcropping-from-beneath-the-sand Vryburg, Schmidtsdrift and Ghaap Plateau Formations to the northern extremity of an Asbestos Hills Formation outcrop, just south of the Mashowing River.

From here the boundary skirts the western side of the Asbestos Hills as far south as Kathu where it turns westwards to the Koranna Range, runs northwards west of Dibeng to the northern end of the Korannaberg and continues southward west of the Koranna and Langberg ranges to near Boegoeberg. This interfingering pattern is repeated with decreasing amplitude westward: firstly with Groblershoop Formation outcropping in the Scheurberg, Kareeboom and Kamkuip Hills and further north to beyond Kuiepan; again with Wilgenhoutdrif Group outcrops extending as far north as Kakoup and Jebeko; and finally with the Koras Group and Dwyka outcrops on

Vrede, north of Upington. From here westward the boundary follows the contact between the older Namaqualand Metamorphic Complex and overlying younger Nama and Dwyka sedimentary rocks to the Namibia border about 20 km south of Nakop. The western and northern boundaries of the region are the Namibia and Botswana borders.

(b) Aspect:

It is a flat sand-covered area with virtually no relief except for northwest-southeast trending dunes in the west, the Makhubung-Pomfret-Senlac hills jutting through the sand and the dry sandy riverbeds of the Auob, Nossob, Molopo, and Kuruman and in the east the Setlagoli Phepani, Kgokgolo and Mashowing laagtes. The altitude of the region ranges from just over 1 200 m in the east to somewhat less than 900 m a.m.s.l. in the southwest.

For convenience sake, the area with Karoo and Nama outcrops along the southeastern Namibia border has been included in the Kalahari Region. To the east of it lie numerous pans in the so-called Salt Block.

(c) Precipitation:

Rainfall decreases from about 500 mm/a average in the east to less than 200 mm/a in the west. January, February, March are the months with the highest rainfall in the east. Rainfall peaks during February-March in the west.

(d) Natural Vegetation (Acocks):

Except for some Sourish Mixed Bushveld in the far northeast, the veld type is Kalahari Thornveld ranging from *Acacia giraffae* Savannah with some grasses of Dry Cymbopogon-Themeda veld in the east, to a very open savannah of *Acacia haematoxylon* and *Acacia giraffae* and desert grasses.

(e) Subregions

Subdivision as follows:

| Subregion | Geological Strata |
|---|---|
| IX A Northeastern Kalahari | Kalahari beds less than 15 metres thick overlying Swazian granite gneiss, Kraaipan chert, iron formation, jaspillite schist and lava; younger granite and Zoetlief volcanics. |
| IX B Makhubung-Pomfret-Senlac-Morokwen outcrop area | Campbell Group dolomite and chert; Griquatown iron formation and jaspillite. |
| IX C Central Kalahari | Kalahari beds from 15 to more than 180 m thick overlying granite gneiss; Kraaipan metamorphics; Campbell Group dolomite and chert; Griquatown Group iron |

formation, jaspillite; Ongeluk andesite; Voëlwater dolomite, jasper and lava; Lucknow quartzite, limestone and Dwyka tillite and shale.

IX D Lower Kuruman

Waterbearing Kalahari beds overlying Groblershoop quartzite Prince Albert shale and Dwyka tillite.

IX E Southwestern Kalahari

Kalahari beds overlying Groblershoop quartzites; Wilgenhoutdrif greenstone, quartzite and phyllite; Koras basic and acid lavas and sandstone and Dwyka tillite.

IX F Mier-Gemsbokpark

Kalahari beds underlain by Dwyka tillite and shale, Prince Albert shale and dolerite sills.

IX G Southwestern Hardeveld

Dwyka tillite and shale and Nama quartzite and shale in places covered by dune sand.

X GRIQUALAND WEST REGION

(a) Configuration

The region is bounded on the west and north by the Kalahari Region of which the boundary has already been described. On the west the region includes the Scheurberg, Kareeboom and Kamhuip hills built by Groblershoop Formation. The western boundary runs from beyond Kuie Pan in the north to Grootdrink on the Orange River.

The southwestern limit has been chosen to include only strata of the Groblershoop Formation and the Volop and Campbell Groups. From Grootdrink the boundary runs in a southeasterly direction west of Uitdraai and Groblershoop, making a dog-leg towards Boegoeberg Dam and following from there the southeasterly trending faulted edge of the Doringberg to near Omdraaisvlei south of Prieska, where it makes a 160 degree turn back towards Prieska. From Omdraaisvlei to Pudimoe in the north the eastern limit is the ill-defined contact between the Campbell Group and Dwyka Formation and in places extrusives and sedimentary rocks correlated with the Ventersdorp Supergroup. From Pudimoe to a point northwest of Vryburg the region shares a common boundary with the Trans-Cape Highveld.

(c) Aspect:

Physiographically as well as geologically the region consists of two parts:

- the eastern Ghaap plateau underlain by nearly horizontally disposed Schmidtsdrift and Ghaap Plateau Formations - an

elevated flat area lying between 1280 and 1 500 m a.m.s.l.

- the western fold belt comprising the Asbestos-Kuruman Hills with elevations ranging from 1 300 m a.m.s.l. in the extreme north to 1855 m a.m.s.l. south of Kuruman and 1 350 m a.m.s.l. near the Orange River; the Korannaberg-Langberg Range with height varying from 1 370 m in the north, to 1 830 m near Olifantshoek to 1 500 m a.m.s.l. near the Orange River and the Scheurberg in the west which rises to 1 400 m a.m.s.l. Between the Asbestos-Kuruman hills and the Langberg the area is undulating to hilly at an elevation of mostly over 1 200 m a.m.s.l. except south of Postmasburg where the Groenwater River has cut down to below 1 200 m a.m.s.l.

The tongue of the Kalahari Region which lies between the Langberg and Scheurberg hills has an elevation of less than 1 200 m a.m.s.l.

(c) Precipitation:

Rainfall decreases from an annual average of about 450 mm in the northeast in a westerly as well as southerly direction to about 250 mm. January, February and March have the highest rainfall in the northeast. In the southwest March is the peak rainfall month.

(d) Natural Vegetation (Acocks):

On the Ghaap plateau : Tarchonanthus Shrub Bushveld.
On the Asbestos-Kuruman hills: Mixed Tarchonanthus Shrub Bushveld.
On the Langberg: Mixed Tarchonanthus-Rhus-Croton Shrub Bushveld.
Kalahari Thornveld with Acacia haematoxylon and Acacia Giraffae with desert grass on the sandy soils.

(e) Subregions

Two are distinguished:

| Subregion | Geological formations |
|--|--|
| X A Ghaap plateau and Maremane anticline | Vryburg Formation shale, sandstone, andesite; Campbell Group dolomite, chert, limestone shale. |
| X B Griqua fold belt | Griquatown Group consisting of Asbestos Hills Banded Ironstone Formation, and Koegas Jaspillite Formation; followed by the Gamagara Shale Formation, the Makganyeni Diamictite Formation, the Cox Group comprising the Ongeluk Andesite Formation and the Voëlwater Jasper Formation overlain by the Olifantshoek Sequence: Mapedi Shale Formation; Hartley Andesite Formation; the Volop Quartzite Group and the Groblershoop |

Schist Formation.

XI NAMAQUA-BUSHMANLAND METAMORPHIC COMPLEX REGION

(a) Configuration

The region is bounded on the west by the Atlantic Ocean between Baai Vals 15 km north of the Olifants River mouth and Kleinsee. From Kleinsee the boundary runs inland to Sendelingsdrif on the Orange River, skirting the Stinkfontein mountains on their eastern side. From Sendelingsdrif to 20° longitude the Orange River defines the northern limit. After a short dog-leg up the 20° longitude line (Namibia border), the boundary is shared with the Kalahari Region as far as Grootdrink, east of Upington. At Grootdrink the boundary crosses the Orange River and becomes common to the Griqualand West Region to near Omdraaisvlei southeast of Prieska. (see also description under Kalahari and Griqualand West Regions).

Starting at Omdraaisvlei in the east the southern limit, defined by the edge of the Karoo Basin Region is a tortuous line around the southeastern extremity of the Brakbospoort Hills running in a northwesterly direction and passing south of Copperton and Kenhardt, to a point some 65 km west-northwest of Kenhardt. At this point the edge of the Karoo Basin Region swings in a southwesterly direction towards Bitterputs, passing east of Stofkloof and Platbakkies to about 7 km north of Kliprant. From here the edge forms a huge irregular amphitheatre-like bend to the east meeting the faulted contact with Nama rocks on the farms Waterval and Jobskraal about 30 km west-southwest of Loeriesfontein.

From these two farms the boundary follows northwestwards the contact with downfaulted Nama strata. Owing to repeated downfaulting the contact has a saw-tooth appearance to about 45 km north of Bitterfontein. The boundary is continued along a north-south fault passing close to Bitterfontein and Nuwerus. Further south to Lutzville it is jagged as the result of oblique northwesterly trending faults. The demarcation is completed by a line joining Lutzville and Baai Vals.

Within the outlined Namaqua-Bushmanland Metamorphic Complex Region, Nama beds form a N-S strip 65 km long from about 25 km south of NababEEP to about 15 km north of Steinkopf, known as the Steinkopf plateau. Further north, immediately south of the Orange River lies the Neint NababEEP plateau built by Nama strata and covering an area of about 600 km².

(b) Aspect:

The greater part of this region consists of flat or gently undulating country. The strip occupied in the far east by the low northwesterly trending Brakbospoort hills lies at an elevation of just more than 1 000 m a.m.s.l. To the west the area drained by the HartebEes River and its tributaries the Mottels, Tuins and Sout Rivers lies between 600 and 900 m a.m.s.l. for a distance of up to 80 km from the Orange River. From the Augrabies Falls downstream to Violsdrif the distance from the Orange river to the 900 m

contour line averages 50 km. Northwest of Pofadder the 900 m contour comes to within 5 km of the river, the bed of which lies at about 300 m a.m.s.l. The result is a dissected mountainous tract bordering the Orange downstream from the Falls. Between the relatively high ground in the vicinity of Pofadder (about 1 150 m a.m.s.l.) and the Namaqua Highlands, lies the broad sand-choked Koa valley which starts near Bosluissoutpan on the waterdivide with the Krom River. The latter joins the Olifants via the Doring and Sout Rivers. The Koa Valley debouches in the Orange a few kilometres west of Goodhouse dropping 120 m over the last 5 1/2 km.

Most of the Namaqua Highlands has an elevation of a little over 1 200 m a.m.s.l. The high ground extends as a belt of varying width but of not more than 25 km wide from Steinkopf in the north past Concordia and Springbok making a broad sweep to the east round Gamoep. It extends south almost as far as Kliprant and to the west as far as the Kamiesberge where the highest elevation is 1 708 m a.m.s.l.

A belt of dissected mountainous country at elevations of 600 to 1 000 m a.m.s.l. lies to the west of the Garies-Vioolsdrift main road. It has been carved out by the Buffels, Spoeg and Swartlintjies Rivers. The former rises in the vicinity of Gamoep and is the reason for amphitheatre-like retreat of the Highland between Springbok and Kamieskroon.

(c) Precipitation:

The line indicating equal distribution of rainfall between summer and winter runs roughly through Goodhouse and Bosluispan. West of the line lies the winter rainfall region. The average annual rainfall on the Namaqua Highlands is between 100 and 200 mm. The highest areas around Springbok and the Kamiesberge receive over 200 mm/a. East of the Highlands to beyond Pofadder the annual rainfall is less than 100 mm/a. In the far east along the Brakbospoort hills the average annual rainfall is just over 200 mm. March is the peak rainfall month. In the winter rainfall area June, July and August have the highest rainfall.

(d) Natural Vegetation (Acocks):

Apart from a narrow zone along the northern edge of the Karoo Basin and the Koa valley, which is classed as Arid Blomkoolganna Veld, the eastern part is Orange River Broken Veld with a transition to Namaqualand Broken Veld (variation Rhigozum trichotomum and Desert False Grass Veld) in the mountainous tract bordering the Orange River below the Augrabies Falls.

The Namaqualand Broken Veld is typically developed in the mountainous Namaqualand areas except for the highest ground between Sendelingsdrif and Steinkopf with Western Mountain Karoo Veld and the Kamiesberge with Mountain Renosterbos Veld. Vegetation along the coast is Strandveld grading inland in Succulent Karoo. False Succulent Karoo Veld has developed as a result of over-grazing in the area between Springbok-Pofadder-Kliprant which receives less than 100 mm/a of precipitation on average.

(e) Subregions

Topographically the following units may be distinguished:

| Region | Geological formations |
|---|--|
| XI A Brakbospoort Hills belt | Marydale Group composed of conglomerate, grit, volcanoclastics, metalavas, amphilolite, banded ironstone; Kaaien Group: quartzite, quartz-sericite schist, phyllite. |
| XI B Bushmanland plains |) Pretectonic metasedimentary and |
| XI C Mountainous Lower Orange River tract |) metavolcanic rock units referred to under various names Orange River, O'Okiep, Bushmanland |
| XI D Namaqua mountainous tract |) Groups and Korannaland Sequence composed of a variety of |
| XI E Coastal sand belt |) gneisses, schists, amphibolite metaquartzite etc; and syn-tectonic intrusive rock units consisting of granites, gneisses also basic and ultrabasic intrusives. |

XII KAROO BASIN REGION

(a) Configuration

The kidney-shaped region measures 1 250 km from Carolina in the northeast to Matjiesfontein in the southwest and 575 km across from Kimberley to East London. It is bounded by the Indian ocean in the southeast between MBoty 30 km north of Port St John and the Great Fish River Mouth. The Cape Fold Belt is the boundary in the south and west. In the south the basal Dwyka Formation overlies Witteberg Group whilst in the west the Dwyka Formation successively transgresses on to Bokkeveld and Table Mountain Groups and Knersvlakte Formation (Nama) finally coming to rest on rocks of the Namaqua Metamorphic Complex west of Loeriesfontein. From this point the Karoo Basin Region adjoins the Namaqua-Bushmanland Metamorphic Complex Region as far as Omdraaisvlei southeast of Prieska. From Omdraaisvlei northwards to Pudimoe Dwyka strata rest on mainly extrusive igneous rocks which are correlated with the Ventersdorp Supergroup and appear as inliers. The western boundary in this zone is the Campbell Rand Scarp a pre-Karoo topographic feature.

Between Pudimoe and Orkney the Karoo Basin Region adjoins the Transvaal-Cape Highveld Region (see description V). From Orkney on to Carolina in the northeast, the region skirts the Witwatersrand Basin and Bushveld Basin Regions. Between Carolina and MBoty the region adjoins the Transvaal Middleveld and the Natal Monocline Region.

(b) Aspect:

About 2/3rds of the Karoo Basin region lies in the inland plateau. Most of it has an elevation of between 1 000 m and 1 500 m a.m.s.l. The western pan and "vloer" country lies lower than 1 000 m a.m.s.l., while the Southeastern Transvaal and the country along the Lesotho border rises to above 1 500 m a.m.s.l. The elevation of the Great Escarpment averages about 1 600 m in the Hantam, Roggeveld and Komsberg in the west. That of the Nuweveld is about 1 900 m. The Kompasberg in the Sneeuberge rises to 2 504 m a.m.s.l. The (Agter) Renosterberg Suurberg, Bamboesberg and Stormberg average about 2 200 m whereas the Natal Drakensberge stand above 2 400 m with the highest point 3 483 m a.m.s.l. Below the escarpment elevations vary from sealevel to over 1 500 m a.m.s.l. Most of the country however lies between 600 - 1 000 m. The higher elevations are found in the foothills of the Drakensberg.

(c) Subregions

In view of its size, it was considered, contrary to the other regions, necessary to describe each of the subregions in greater detail than was done in the case of the other regions.

XII A Highveld

(i) Configuration

Its boundary is as follows:

Bloemhofdam to Orkney: Trans-Cape Highveld Region.
Orkney to Carolina: Witwatersrand Basin and Bushveld Basin Region.
Carolina to Sheepmoor: Transvaal Middleveld Region.
Sheepmoor to Oliviershoekpass: Drakensberg Escarpment (Natal Middleveld).
Oliviershoekpass to Ooreenkoms siding on the Arlington-Bethlehem railway line: the base of the Molteno Formation.
Ooreenkoms siding to Bloemhofdam: Watershed between the Vals and Vet Rivers.

(ii) Physiography

The area contains the headwaters of the Vaal and tributaries, the northerly draining Olifants and tributaries and the easterly flowing Nkomati, Usutu and Pongola Rivers. East of the line Vaal Dam-Heilbron-Edenville-Steynrus the area lies above 1 500 m a.m.s.l. Precipitation ranges from just below 800 mm/a along the Escarpment in the east to 500 mm/a at Bloemhof Dam.

The natural vegetation varies from Sour to Mixed and Sweet Grassveld.

(iii) Geology

Dwyka Formation comprising tillite, reworked tillite, conglomerate and sandstone has a very limited exposure along the edges. The subregion is occupied over about 60 per cent of its area by Ecca Group (shale sandstone and coal) and by Beaufort Group (mudstone,

shale and sandstone) over the remainder. The strata have been intruded by dolerite in the form of dykes and sheets.

XII B Pudimoe-Omdraaisvlei Dwyka - Lower Ecca belt

(i) Configuration

The subregion is bounded on the west by the Griqualand West Region; from Pudimoe to Windsorton and back to east of Warrenton by the Trans-Cape Highveld and from Warrenton to Omdraaisvlei by the top of the Whitehill and Prince Albert Formations.

(ii) Physiography

The area comprises the lower ends of the Harts, Modder and Vaal, the confluence with the Orange River as well as the area between the Orange and the lower end of the Brak River. It has an elevation of between 1 000 - 1 200 m a.m.s.l.

Precipitation varies from about 450 mm/a average in the north to 250 mm/a in the south.

Natural vegetation comprises largely Kalahari Thornveld in parts invaded by Karoo, some Orange River Broken Veld and Central Upper Karoo and the False types of the last two.

(iii) Geology

Dwyka Formation tillite and shale, Prince Albert Formation shale and Whitehill Formation carbonaceous shale overlying extrusive igneous and sedimentary rocks belonging to the Sodium Group, the Ritchie and Hereford Formations and the Ventersdorp Supergroup. The Karoo strata have been invaded by dolerite in the form of sheets.

XII C Central Pan Belt

(i) Configuration

The subregion adjoins the Trans-Cape Highveld region between Warrenton and Bloemhof Dam in the northwest and the Highveld subregion between Bloemhof and Riebeeckstad. The southeastern boundary follows the contact between the Tierberg Formation (Ecca Group) and the Adelaide Subgroup to south of Britstown. From here to Waaipunt siding on the Hutchinson-Carnarvon railway line, the boundary follows the contact between Tierberg Foundation and overlying Carnarvon Formation (Ecca Group). The western boundary is the watershed between the headwaters of the Ongers River and the Carnarvonleegte, which runs from Louwsplaas siding through Vosburg to the contact between the Tierberg and underlying Whitehill Formations. The northwestern boundary is the contact between the Tierberg and underlying Whitehill/Prince Albert Formations.

(ii) Physiography

The subregion is one with low relief in the form of flat-topped hills and dolerite ridges. It is characterised by numerous pans.

Elevations along the southeastern boundary range between 1 500 and 1 200 m a.m.s.l. Along the northwestern boundary elevations vary from 1 200 to 1 100 m a.m.s.l. The Vet, Modder, Orange, Brak and Ongers Rivers traverse this longitudinal subregion perpendicularly from east to west and in the case of the Ongers from south to north.

Rainfall decreases from an annual average of just under 600 mm/a in the northeast to about 250 mm/a in the southwest.

The natural vegetation (Acocks) changes from Dry Cymbopogon-Themeda Veld and Themeda Veld Turf/Highveld around pans in the northeast to Turfveld invaded by Karoo to False Arid Karoo in the southwest.

(iii) Geology

Tierberg Formation shale only with dolerite intrusions.

XII D Northeastern Free State Highland

(i) Configuration

The subregion lies against the northern and northwestern border of Lesotho i.e. for the greater part against the Caledon River. The encircling extremely tortuous northern boundary which is the base of the Molteno Formation, lies confined within the polygon formed by Maseru-Excelsior-Marquard-Hibernia-Paul Roux-Ooreenkoms siding-Bethlehem-Kestell-Witsieshoek-Swinburne-van Reenen-Oliviershoek Pass-Mont-Aux-Sources.

(ii) Physiography

The mountainous subregion lies above 1 500 m a.m.s.l. with the Korannaberg reaching a height of 1 927 m, the Witberg west of Fouriesburg 2 409 m, the Rooiberg north of Clarens 2 477 m and the mountains surrounding Witzieshoek 2 330 m a.m.s.l. The elevation of Mont-Aux-Sources is 3 302 m a.m.s.l.

The Vet, Sand, Vals and Wilge Rivers have their headwaters in this subregion. Annual precipitation averages 750 mm in the southwest around Ladybrand; rises to over 800 mm/a in the north and reaches a maximum of more than 1 500 mm/a near Mont-Aux-Sources.

Natural vegetation (Acocks) consists of Southern Tall Grassveld in the east, Highland Sourveld grading into Cymbopogon-Themeda Veld in the north and northwest with Transitional Cymbopogon-Themeda Veld in the southwest.

(iii) Geology

The geology consists from the base upwards of Molteno, Elliot and Clarens Formations - sandstone, shale, mudstone and siltstone - capped by Drakensberg basalt on the mountain tops. Adelaide Formation is exposed in a few valley bottoms. Dolerite is present.

XII E Southeastern Free State

(i) Configuration

The western boundary between Orange River and Riebeeckstad is shared with subregion XII C the Central Pan Belt. It is namely the contact between the Tierberg and Adelaide Formations. In the north the subregion adjoins subregion XII A, the Highveld, along the waterdivide between the Blomspruit - tributary of the Vals River - and the headwaters of the Sand, as far as Ooreenkoms siding. From Ooreenkoms to the Lesotho border at Maseru the eastern limit is the base of the Molteno Formation. The Lesotho border is the boundary as far as Saphapo s Gate. From this point the boundary again follows the basal contact of the Molteno Formations reaching the Orange about 17 km upstream from Aliwal North. The Orange River is the southern boundary downstream to P.K. le Roux Dam.

(ii) Physiography

The Wepener, Van Stadensrus, Zastron, Rouxville area stands above 1 500 m a.m.s.l. A zone of less than 1 500 m lies along the Orange and Caledon Rivers. West of the Caledon and running more or less parallel to it lies a strip of country with elevation exceeding 1 500 m a.m.s.l. which slopes northwestward so that the northwestern third of the subregion again lies below 1 500 m a.m.s.l.

Rivers rising west of the Caledon and flowing in a westerly-northwesterly direction are the Groot Vet, the Modder, the Kaffer and the Riet Rivers.

Rainfall varies from an annual average of about 700 mm along the eastern boundary to 550 mm in the northwest and 450 mm in the southwest.

The natural vegetation (Acocks) varies from Cymbopogon-Themeda Veld in the east through Transitional Cymbopogon Veld to dry Cymbogopon-Themeda Veld (Central Variation) and False Upper Karoo in the southwest.

(iii) Geology

The area is underlain by Adelaide and Tarkastad Subgroups - mudstone, shale and sandstone.

The strata have been intruded by dolerite. Notable are the circular features of dolerite in the southern Free State.

XII F West and East Bushmanland Pan Belt

(i) Configuration

From a point more or less 30 km NNW of Loeriesfontein to the southeasternmost exposure of Skalkseput granite immediately south of the Doringberg fault i.e. about 5 km south of Omdraaisvlei, this subregion adjoins the Namaqua-Bushmanland Metamorphic Region. From 30 km NNW of Loeriesfontein to Loeriesfontein the southwestern

boundary follows the waterdivide between tributaries of the Krom River flowing westward, and northeastwards. Further to the southeast the waterdivide between the westward-flowing Hantam and Koedoe Rivers, on the one hand and the northerly directed drainage to pans and to the Vis River on the other hand, defines the southwestern limit of the subregion. This waterdivide meets the contact between a dolerite sill and the Carnarvon Formation some 20 km SSW of Downes siding on the Calvinia-Kootjieskolk railway line. The contact between the Tierberg and Carnarvon Formations is the southern boundary as far east as Louwsplaas siding, between Carnarvon and Victoria West. From Louwsplaas siding the eastern limit, runs along the watershed between tributaries of the Carnarvonleegte and the Ongers River through Vosburg to a point 5 km south of Omdraaivslei.

(ii) Physiography

Except for some hills along the southern boundary north of Williston stretching towards Carnarvon and the Grasberg northeast of Carnarvon, the subregion is devoid of relief being characterised by pans and so-called "vloere". Its average elevation is about 1 050 m a.m.s.l.

Annual rainfall averages less than 200 mm. In the far west it is less than 100 mm/a. March is the peak rainfall month.

The natural vegetation (Acocks) changes from False Arid Karoo in the east to Arid Karoo to False Succulent Karoo to Western Mountain Karoo in the West.

(iii) Geology

The geology consists of tillite and shale of the Dwyka Formation, shale of the Prince Albert and Tierberg Formations with intervening shale of the Whitehill Formation. The strata have been intruded by dolerite sheets.

(iv) Further division

In view of its size and 50 percent decrease in rainfall from east to west, division along the waterdivide between the Sak River and the Koa valley is shown on the map.

XII G Hantam Subregion

(i) Configuration

From a point 30 km NNW of Loeriesfontein (see description subregion XII F Bushmanland Pan Belt) to Waterval/Jobskraal (see description Namaqua-Bushmanland Metamorphic Complex Region) the Hantam subregion is contiguous to the Namaqua-Bushmanland Metamorphic Complex Region. Between Waterval/Jobskraal and a point about 6 km north of Nieuwoudtville the boundary is the contact of Dwyka Formation and the Knersvlakte Formation (Nama), and to about 10 km south of Nieuwoudtville the contact with Table Mountain sandstone. From here southwards to the Brak River the boundary follows the contact with the Ceres Subgroup. Eastwards the waterdivide between the northward flowing tributaries of the Koedoe River and those of

the southward flowing Wolf River forms the southern boundary to a point 20 km south of Downes siding on the contact between a dolerite sheet and the Carnarvon Formation. The southwestern boundary of the Bushmanland Pan Belt is common to the Hantam subregion.

(ii) **Physiography:**

The eastern third of the subregion lies above 900 m a.m.s.l. with the Hantamberge north of Calvinia higher than 1 200 m and culminating at 1 673 m a.m.s.l. To the south hills rise above 1 200 m. This is also the case around Loeriesfontein. The rest of the subregion lies between 600 and 900 m above m.s.l. The subregion is drained by tributaries of the Krom, the Hantam, the Koedoe, Brak and Wolf Rivers.

The average annual rainfall is around 200 mm - the higher ground receiving more and the lower-lying areas less. Between 60-70 percent falls during the winter months April to September especially in the months of May and June.

The natural vegetation (Acocks) is mostly Western Mountain Karoo with subordinate Mountain Renosterbos Veld and Namaqualand Broken Veld in the lower-lying valleys of the Krom and Hantam Rivers.

(iii) **Geology:**

The area is underlain by Dwyka, Prince Albert, Whitehill and Tierberg Formations (tillite, shale and carbonaceous shale), intruded by dolerite.

XII H Tanqua Karoo Subregion

(i) **Configuration**

This region adjoins the Hantam on the south. Its western boundary is defined by the contact of Dwyka Formation firstly with the Ceres Subgroup in the north, thereafter in southerly direction successively with the Bidouw Subgroup (Bokkeveld Group), the Weltevrede Subgroup, the Witpoort Formation and the Lake Mentz Subgroup from the Groot River south and eastwards to Matjiesfontein. The eastern boundary runs from Matjiesfontein northwards to the Great Escarpment (Komsberg) south of Sutherland. The boundary follows the watershed between the tributaries of the northwestward draining Groot and Tanqua River and of the southward flowing Buffels River. The eastern limit follows the Escarpment northwestwards. Except for the first 25 km the lower contact of the Koedoesberg Formation and further north that of the Carnarvon Formation is taken as the boundary.

(ii) **Physiography**

The bounding Roggeveld and Komsberg Escarpment in the east reaches up to 1 700 m a.m.s.l. Below the escarpment the watershed between the Groot and Tanqua and Buffels River reaches a maximum of just under 1 500 m a.m.s.l. The bordering mountainous terrain in the west is generally lower than the Roggeveld Escarpment.

Along the northern watershed and boundary, elevations range from less than 900 m to over 1 200 m a.m.s.l. A considerable portion in the centre of the subregion lies below 600 m, the lowest point of just under 300 m a.m.s.l. being where the Tanqua River leaves the area at Elandsvlei. Over the southeastern half rainfall averages between 100 to just over 200 mm/a. Being situated in the rainshadow of the Seder and Skurweberge rainfall over the rest of this subregion is less than 100 mm/a average. Sixty to seventy percent of the precipitation falls during the winter; May-June being the peak rainfall months.

Natural vegetation according to Acocks : Succulent Karoo in the lower-lying areas with Western Mountain Karoo on the eastern mountain slopes and the Klein Roggeveld mountains, south of the Komsberg.

(iii) Geology

The geology consists of Dwyka Formation tillite and shale; Prince Albert Formation shale; Whitehill Formation carbonaceous shale; Tierberg Formation shale; in the southwest it is followed by Skoorsteenberg Formation shale and sandstone, and Kookfontein Formation shale with Koedoesberg Formation shale and sandstone changing to Carnarvon Formation shale and sandstone in the north. With the exception of a few dykes, dolerite intrusions are limited to the area north of the Tanqua River. In the south the strata have been affected by the Cape foldings.

XII I West and East Central Karoo Subregion

(i) Configuration

Starting south of Downes siding on the Calvinia-Kootjieskolk railwayline, the northern boundary is the contact between the Tierberg and Carnarvon Formations as far east as a point 40 km south of Britstown. From here onwards to the P.K. le Roux Dam, the boundary which passes close to De Aar, Philipstown and Petrusville, is the contact between the Tierberg and Adelaide Formations. In other words, the West and East Central Karoo Subregion adjoins the West and East Bushmanland and the Central Pan Belts. The Orange River is the northeastern limit from P.K. le Roux Dam to about 17 km upstream from Aliwal North where Molteno beds are encountered. The base of the Molteno Formation is the eastern boundary southwards to the Escarpment about 17 km east of Steynsburg. The western and southern boundary of the subregion is the Great Escarpment starting with the Roggeveld in the west followed by Komsberg, Nuweveld, Sneeuwege, Renosterberg Agter-Renosterberg and Suurberg.

(ii) Physiography

An indication of the elevation of the Escarpment which forms the southern limit has already been given in the paragraph "Aspect" dealing with the Karoo Basin as a whole.

As a result of strong headward erosion by the Krom, Sout, Kariega and Buffels Rivers, the escarpment is not a very distinctive

feature between Beaufort West and Aberdeen, as it makes a big bend northwards. The result is that the watershed between northerly and southerly drainage does not lie very far south of Victoria West and Richmond, in fact it is situated about 100 km north of a line connecting Beaufort West and Aberdeen. Both towns are situated close to the foot of the Escarpment.

Starting in the west, the northerly flowing rivers are the Vis, Renoster, the Groot and Klein Riet all of them tributaries of the Sak River which rises further east, the Ongers, the Brak, Seekoei and Oorlogspoort Rivers.

The subregion slopes northwards to the Orange River. A deviation from this trend is the waterdivide stretching from Williston in the west to beyond Carnarvon in the east. It consists mainly of the Kareeberge which lie to the north of a line joining the two towns. Practically the whole subregion lies higher than 1 200 m a.m.s.l. The exception is the drainage area of the Sak River up to 70 km east and southwest of Williston and the lower section of its western tributaries, the Vis, Renoster and Riet Rivers.

Precipitation on the edge of the Escarpment exceeds 200 mm/a on the Roggeveld and Nuweveld. A part of the Roggeveld receives more than 300 mm/a. The rainfall on the mountains north of Aberdeen exceeds 400 mm/a. Further northeastwards the escarpment is not featured as a higher rainfall strip on the Weather Bureau's map. On the plateau itself precipitation decreases from 500 mm/a in the northeast (Aliwal North, Burgersdorp) westwards to about 300 mm/a at De Aar and Richmond and to less than 200 mm/a west of Carnarvon.

According to Acocks the natural vegetation on the Roggeveld, Komsberg and Nuweveld is Mountain Renosterbos Veld with Western Mountain Karoo to the north. Eastward the escarpment has a Karroid *Danthonia* vegetation.

On the plateau the vegetation changes from Dry *Cymbopogon*-*Themeda* Veld on the eastern fringe to False Upper Karoo as far west as De Aar and Victoria West to Central Upper Karoo to False Arid Karoo to Arid Karoo west of Carnarvon.

The considerable range in rainfall from less than 200 mm/a in the west to 500 mm/a in the east may warrant division of this subregion into a western and eastern section. The waterdivide between the headwaters of the Sak and Ongers in the north and the Sak and Krom Rivers in the south could feature as a dividing line. It runs southwards from Louwsplaas siding to a point on the Nuweveld Escarpment about 20 km northeast of Beaufort West.

(iii) Geology

The subregion is underlain by Carnarvon Formation shale and sandstone along the western half of the northern boundary. For the rest by Adelaide Subgroup mudstone and sandstone. The strata have been invaded by dolerite.

XII J Eastern Cape-Transkei Highland

(i) Configuration

The subregion flanks the southern part of Lesotho from Saphapots border gate south of Wepener to the triple junction of Lesotho, Natal and Transkei borders south of Ha Paulus in the east. From just south of Saphapots Gate the western southern and eastern boundary follows the base of the Molteno Formation. This tortuous line lies within the polygon described by the following localities Saphapots Gate-Rouxville-Steynsburg-Hofmeyr-Queenstown-Lady Frere-Engcobo-Tsolo-Luyengweni-Matatiele-Sehlaba Thebe (Lesotho).

(ii) Physiography

This deeply dissected mountainous tract lies above 1 500 m and rises to elevations above 2 500 m a.m.s.l. south and east of Barkly East. The Witberg east of Lady Frere culminates at 2 770 m a.m.s.l. The subregion straddles the Escarpment though most of it lies inland. Drainage is to the Orange River. The Kraai River and tributaries comprise most of the drainage. Numerous streams rising on the southern and eastern side discharge towards the Indian Ocean. Precipitation varies from 500 mm/a in the lower lying areas to over 1 000 mm/a on the highest mountains. The natural vegetation (Acocks) comprises various types of grassveld, ranging from Karroid Danthonia Mountain Veld in the southwest through Cymbopogon-Themeda, Stormberg Plateau Sweet Veld to Themeda Estuca Alpine with Highland Sourveld in the foothills of the Drakensberg.

(iii) Geology

The geology consists of sandstone, shale, mudstone and siltstone of the Molteno, Elliot and Clarens Formations capped by Drakensberg basalt. The basalt covers a more or less rectangular area, centred on Barkly East, about 6 000 km² in extent.

XII K West and East Great Karoo Subregion

(i) Configuration

The subregion is about 450 km long in an east-west direction. Its width varies between 60 and 100 km. In the west it borders on the Tanqua Karoo. The northern boundary is the Great Escarpment from Komsberg to the Koueveldberge with its Wynberg and Suurberg spurs west of Graaff-Reinet. From this point eastwards the Great Karoo is adjoined by the Cape Midland subregion in the north. The limit is the Tandjiesberg, the Coetzeeberge and Groot Bruintjieshoogte between Pearston and Somerset-East. The eastern boundary is the watershed between the Voël River - tributary of the Sundays River - and the Klein Vis River rising in the Swaershoek Mountains. The southern boundary is the contact between the Dwyka Formation and the underlying Lake Mentz Subgroup.

(ii) Physiography

In the south the gently folded Karoo strata make for weak ridges

and valleys paralleling the Cape Fold Mountains. Northwards the terrain is one of undulating rough plains, abutting against the Escarpment. The Great Karoo is crossed from north to south by the Buffels, Dwyka, Gamka, Sout, Kariega and Sundays Rivers. The latter has two big tributaries the Kamdeboo and the Voël. Most of the Great Karoo lies between 600 to 1 000 m a.m.s.l. In the southeast the elevation drops to between 600 and 300 m as do the valleys of the Dwyka and Gamka Rivers on approaching the Cape Fold Mountains. Lake Mentz on the Sundays River lies less than 300 m a.m.s.l.

The western half receives less than 200 mm/a rainfall on average. From approximately Aberdeen eastwards rainfall averages between 200 and 300 mm/a. In the west the months with the highest average rainfall are March, May and June. The peak rainfall months at Beaufort West are November, December and March. In the east rainfall peaks in December and again in February/March.

Mountain Renosterbos Veld is found on the Klein Roggeveld in the far west. East thereof as far as Beaufort West and Rietbron, Acocks designates the vegetation as Karroid Broken Veld. The eastern half of the Great Karoo is characterised by a patchwork of Karroid Broken Veld, Central Lower Karoo and Succulent Mountain Scrub-Spekboom Veld with Noorsveld in the southeast.

(iii) Geology

The geology comprises Dwyka Formation tillite, Eccca Group shale and sandstone and Adelaide Subgroup mudstone and sandstone. The combined outcrop width of the Dwyka and Eccca is mostly less than 20 km. Consequently most of the Great Karoo is underlain by the Adelaide Subgroup. Dolerite intrusions are absent west of a line running from Beaufort West to Klipplaat.

(iv) Further division

In view of its length further subdivision along the waterdivide between the Gamka and Sout River drainages could be considered as shown on the map.

XII L Eastern Cape Middleveld Subregion

(i) Configuration

The Great Escarpment is the western and northern boundary of this subregion; from west of Graaff-Reinet to east of Steynsburg i.e. the Central Karoo is the bordering subregion in the north. East of Steynsburg the base of the Molteno Formation becomes the boundary to a point 17 km north of Lessayton where it crosses the Transkei border. The eastern limit of the Cape Middleveld is the Transkei border down the Kei River to the confluence of the Thomas River east of Cathcart. The 1 000 m a.m.s.l. contour is taken as the southern boundary, as it runs along the southern foot of the Winterberge, Amatole and Xolora. Somerset-East, Bedford, Adelaide, Keiskammahoeck, Stutterheim and Bolo lie just south of this line.

(ii) Physiography

Most of the subregion lies at elevations of between 1 000 to 1200 m a.m.s.l. However the south is mountainous and appears to be a continuation or spur of the Escarpment, decreasing eastward in elevation. In the west, the highest point on the Tandjiesberg has an elevation of 2 431 m, that in the Winterberg 2 371 m, the Amatole rises to over 1 500 m and north of Toise River station high ground reaches 1 360 m a.m.s.l. Apart from the small catchment area of the Sundays River above Graaff Reinet, the rest of the subregion is taken up by the upper catchment of the Great Fish and the western half of the Kei River. Precipitation over the mountainous terrain ranges from 4 00 mm/a to more than 1 000 mm/a on the higher ground. Southwest of Stutterheim rainfall exceeds very locally 1 500 mm/a.

North of the mountains and west of Tarkastad rainfall averages 350 to 400 mm/a. It increases eastward to over 500 mm/a.

Natural vegetation (Acocks) is Karroid *Danthonia Veld* on the mountains between Graaff-Reinet and Somerset East. Further east it is *Dohne Sourveld*.

In the north the vegetation changes in an north-easterly direction from Karroid *Danthonia* invaded by Karoo to False Karroid Broken and False Upper Karoo Veld. Higher-lying ground in the Sterkstroom-Queenstown-Lady Frere area carries *Dohne Sourveld*; lower-lying areas *Dry Cymbopogon-Themeda Veld*. Valley Bushveld is found in the lower river valleys.

(iii) Geology

The subregion is occupied by sedimentary rocks belonging to the Adelaide and Tarkastad Subgroup which consists of sandstone and mudstone, intruded by dolerite.

XII M Eastern Cape Lowlands Subregion

(i) Configuration

This subregion occupies topographically the same position as the Great Karoo. Situated between the Cape Fold Belt in the south and the Eastern Cape Middleveld in the north it may be considered the eastern more humid extension of the Great Karoo Subregion. Its northern boundary the 1 000 m contour has already been described under XII L. The Great Kei River from the Thomas River confluence down to its mouth is the northeastern boundary. To the southeast lies the Indian Ocean from Kei mouth to the Great Fish River mouth. The contact between the Kommadagga Subgroup and the Dwyka Formation is the southern limit from the Great Fish River mouth to about 40 km east of Lake Mentz. The western boundary is the waterdivide between the Sundays and Fish River catchments (see XII M).

(ii) Physiography

Relief is subdued. West of Adelaide a strip of country about 25 km wide lies above 600 m. Apart from this and narrow belts bordering the mountains further east and in the south, most of the subregion

lies at an elevation of between 300 and 600 m a.m.s.l. The 300 m contour line averages a distance of about 25 km inland.

Precipitation ranges from an average of about 300 mm/a in the west to over 800 mm/a between East London and the Lower Kei River.

In the west the vegetation (Acocks) is False Central Lower Karoo and False Karroid Broken Veld. From Bedford eastward the area bordering on the mountains in the north carries False Thornveld and Sour Dohne Veld in the far east. Valleys of the Fish, Keiskamma and Kei are characterised by Valley Bushveld. Along the coast a strip of Coast-belt Forest occurs.

(iii) Geology

The Dwyka Formation tillite and the Ecca Group shale and sandstone which have been folded build a narrow strip of hilly terrain. Most of the subregion is occupied by Adelaide Subgroup sandstone and mudstone; patches of Tarkastad Subgroup are found along the coast. The strata have been intruded by dolerite.

XII N Southern Transkei Subregion

(i) Configuration

The Eastern Cape-Transkei Highland lies across the subregion's northwestern boundary (see XII J). Its southwestern boundary is the border between Transkei and South Africa (see XII L and M). On the southeast it is the coastline between Great Kei River mouth and the watershed between the Mngazi and Mzimvubu Rivers. The northern boundary is the watershed between the Mngazi, Mtakatye, and tributaries of the Mtata to the south and the Mzimvubu and its tributary, the iTitsa River to the north. The watershed meets the northern boundary - the base of the Molteno Formation - 20 km west of Tsolo.

(ii) Physiography

Excepting some higher-lying country around Lady Frere, Cala and Cofimvaba in the northwest of the subregion, most of the remainder lies between 600 and 1 000 m a.m.s.l. There appears to be a distinct break in the topography along the 600 m contour line which runs about 30 km inland and parallel to the coast. From it the surface has a steeper slope down to the coast.

The subregion is well-watered receiving from 600 to over 1 250 mm precipitation per annum. Apart from the bounding Kei and Mzimvubu Rivers, the other bigger rivers are the Bashe and Mtata.

The natural vegetation grades from Highland Sourveld furthest inland, through Southern Tall Grass, and Thornveld to Coastal Forest.

(iii) Geology

The geology comprises Adelaide and Tarkastad Subgroup sandstone and mudstone over most of the subregion. Some distance north of Qora mouth underlying Ecca Group shale makes its appearance. Between

the Great Kei Mouth and Mngazi River the coast is cut by many faults. These are responsible for the occurrence of blocks of Dwyka Formation and Adelaide Subgroup along the sea front.

XII O Southern Natal Middleveld Subregion

(i) Configuration

The subregion is bounded on the west by Lesotho from Giants Castle to the triple junction of territorial borders south of Ha Paulus, and from there southwards by the Eastern Cape-Transkei Highland to a point 20 km west of Tsolo where the northern boundary of subregion XII N meets the base of the Molteno Formation. Its southern boundary is shared with subregion XII N. The waterdivide between the Mkomazi in the south and the tributaries of the Tugela, Mvoti and Mgeni in the north as well as the headwaters of the Mlazi and Lovu in the vicinity of Richmond defines the northern limit. From the vicinity of Richmond the southeastern boundary follows the contact between the Pietermaritzburg and Volksrust Formations as far as Harding. South of Harding the Ecca Group is undivided. Thus further south the boundary is taken as the base of the Ecca Group to the waterdivide between the Mzimvubu and Mngazi Rivers.

(ii) Physiography

The lowest elevation of about 300 m a.m.s.l. is in the southeast. In the northeast, near Richmond, the elevation is about 1 200 m a.m.s.l.

From the basal shale of the Ecca Subgroup along the southeastern boundary the country rises westward attaining elevations in excess of 3 000 m on the Lesotho border in the north. South of the triple junction of territorial borders, elevations along the western boundary range between 1 200 to 1 700 m a.m.s.l. Most of the subregion lies above 1 200 m. Elevation drops to below 1 200 m only in the southeast. Notable elevations within the subregion are 2 085 m close to Bulwer, the Swartberg 2 322 m, the Nungi range south of Matatiele and Cedarville 2 322 m, the Insizwa south of Kokstad 1 924m, the Ngele Mountain east of Kokstad 2 269 m a.m.s.l. The Insizwa, Ngele and Tabankulu are crowned by a thick differentiated dolerite sheet. Major rivers are the Mkomazi, Mzimkhulu, Mtamvuma and Mzimvubu.

Precipitation exceeds 900 mm/a average over most of the subregion. On the Drakensberg and some other high peaks as well as near Port St Johns precipitation is more than 1 250 mm/a average.

Vegetation (Acocks) ranges from the coast inlandwards from Coastal Forest and Thornveld to Coastal Plateau Sourveld (Pondoland) to Ngongoni to Tall Grass to Highland Sourveld.

(iii) Geology

The geology of the northern half of the subregion comprises the complete succession of Karoo strata from the base of the Ecca Group to the Drakensberg basalt at the top. As strata from the Molteno Formation upwards occur high up the Drakensberg Escarpment they are of little consequence as far as ground-water is concerned. In the

southern half of the subregion strata consist of Ecca Group and Adelaide and Tarkastad subgroups only. The strata have been intruded by Karoo dolerite.

XII P Northern Natal Middleveld Subregion

(i) Configuration

The subregion is bounded by Lesotho between Giant's Castle and Mont-Aux-Sources, by the Northeastern Free State Highlands (i.e. the Natal-Free State geographical boundary) between Mont-Aux-Sources and Oliviershoek Pass (see XII D), by the Highveld subregion between Oliviershoek Pass and Luneberg (Natal-Free State and Natal-Transvaal borders - see XII A) and by the Transvaal Middleveld subregion from just north of Luneberg to Zungweni on the Piet Retief-Vryheid railway line.

From here southwards to near Richmond the boundary with the Natal Monocline Subregion follows the base of the Pietermaritzburg Formation. The subregion adjoins the Southern Natal - Northern Transkei Middleveld subregion in the south, between Richmond and Giant's Castle.

(ii) Physiography

Topographically three sections may be distinguished.

- A triangular area in the northwest with its apex south of Volksrust and a baseline from van Reenen via Dundee to Vryheid. The elevation is in excess of 1 200 m. Within this triangle Biggarsberg south of Glencoe rises to 1 790 m a.m.s.l.

- A second triangular area in the south with its apex at Mont-Aux-Sources and base Richmond to Greytown with elevation in excess of 1 500 m.

- In between lies the oval-shaped drainage basin of the Tugela lower than 1 200 m dropping to 600 m a.m.s.l. at Tugela Ferry near the eastern boundary of the subregion.

Precipitation on the higher ground encircling the Tugela basin averages between 800 to more than 1 000 mm/a. In the lower-lying Tugela Basin rainfall drops to below 700 mm/a.

Vegetation (Acocks) consists of Highland Sourveld on the eastern slopes and foothills of the Drakensberg with various False Grassveld types to the east. The Tugela Valley carries Valley Bushveld. Mist Belt Ngongoniveld is found in a strip of country between Richmond and Greytown.

(iii) Geology

The geology comprises the complete succession of Karoo strata with the exception of the Dwyka Formation tillite and the Pietermaritzburg Formation shale which are incorporated in the Natal Monocline Subregion as they are also affected by the faulting which characterises the monoclinial structure. Westwards the overlying Vryheid Formation sandstone and shale, is followed by

Volksrust Formation shale, Escourt Formation mudstone and sandstone, Molteno, Elliott and Clarens sandstone, mudstone, shale and siltstone capped by Drakensberg basalt. The strata have all been invaded by dolerite. Strata above the Tarkastad Subgroup occur high up the Drakensberg slopes and have little groundwater significance.

XIII NATAL MONOCLINE REGION

(a) Configuration

The region lies against the Indian Ocean between Port St Johns in the south and Mtunzini in the north. North of Mtunzini the boundary is defined by Cretaceous strata overlain by younger coastal deposits as far north as Teza on the northern Natal railway line. From Teza the boundary is that of the Lebombo Belt Region. It passes just north of Empangeni in a westerly direction to Nkwalini, after having made two 90° turns west of Teza. From Nkwalini, the boundary between the Lebombo Belt and the Natal Monocline region runs along north-south trending faults, west of which, Swazian and Ordovician-Silurian strata make their appearance as inliers. With the exception of the localised appearance of Natal Group sandstone and granite in a highly faulted section north and east of Hlabisa, only Karoo strata are present east of the line of faulting. There is also a step in the topography along this line, the area to the west being at a higher elevation. The region abuts against the Transvaal Middleveld Region north of Nongoma-Louwsburg-Vryheid. On the west the region is adjoined by the Northern Natal and Southern Natal-Northern Transkei Middleveld Subregions and in the far south for a very short distance by the Southern Transkei Subregion.

(b) Aspect:

North of the Tugela thrust fault which passes through Tugela Ferry and Nkwalini, the region has an elevation of 600 - 1 000 m above sea level. South of the fault, the elevation ranges from sealevel to about 1 000 m a.m.s.l. along the western boundary except in the south where it approaches the coast of Port St Johns. The region is crossed by many streams perpendicular to the coast making for mostly highly dissected terrain.

(c) Precipitation:

Precipitation exceeds 800 mm/a over most of the region and 1 000 mm/a along the coast. Northwest of Empangeni rainfall drops to less than 700 mm/a locally.

(d) Natural Vegetation (Acocks):

The natural vegetation is Coastal Forest changing inland in the south to Pondoland Sourveld to Ngongoni Veld. To the north in the vicinity of Pietermaritzburg the Coastal Forest gives away inland to Ngongoni to Mist Belt Ngongoni Veld. North of Nkandla and Melmoth, Highland Sourveld and Northern Natal Tall Grassveld is encountered.

(e) Geology

The core of the monoclinial structure is occupied by Precambrian rocks overlain by Ordovician-Silurian Natal Group sandstone, arkose and shale, Dwyka Formation tillite and Pietermaritzburg Formation shale (south of Harding the Ecca Group strata have not been subdivided into Formations.) The monoclinial structure is oriented obliquely to the coast with the result that the western limb only is present directly north of Port St Johns. The complete structure is exposed north of Amanzimtoti although the Dwyka and Pietermaritzburg Formations are present only as a narrow strip along the coast.

A four-fold subdivision of the monoclinial structure is possible based on the Precambrian core (see Thomas R.J. 1989a and b):

North of the Tugela Thrust Front (i.e. Tugela Ferry - Nkwalini line) the Precambrian rocks consist of Archeozoic Swazian granite and granodiorite and Nsuze lavas and quartzite.

South of the thrust front the core consists of Proterozoic formations. Three tectonic-stratigraphic terranes have been distinguished.

The Tugela Terrane between the Tugela Thrust Front and Mapumulo thrust south of Eshowe. The strata occurring here are the amphibolitic Tugela Group, the pelagic Mfongosi Group and a shelf facies sedimentary Ntingwe Group.

The Mzumbe Terrane between the Mapumulo thrust and Melville shear zone about 10 km north of Port Shepstone and running northwestwards in the direction of St Faith. It comprises:

- (a) supracrustal Mapumulo Group consisting of quartzite, various gneisses, migmatite, amphibolite and calc-silicate rocks.
- (b) pre-, syn- and post-tectonic granitoids (different granite and gneiss Suites).

The Margate Terrane south of the Melville shear zone consisting of:

- (a) Supracrustal Mzimkulu Group comprising metabasite, migmatite, marble.
- (b) pre-, syn- and post-tectonic granitoids (different granite and gneiss Suites).

(f) Subregions

Subdivision into three ground-water subregions is possible:

XIII A Northern Monocline Subregion

XIII B Tugela Subregion

XIII C Central and Southern Monocline Subregion

XIV CAPE FOLD BELT

(a) Configuration

This region stretches southwards from the mouth of the Berg River and from north of Nieuwoudtville respectively to Cape Hangklip and Inverdoorn (55 km northeast of Ceres) and from these two places eastward to the mouth of the Great Fish River. Measured along strike the distance is about 1 250 km. The belt is at its widest between Inverdoorn and Cape Agulhas - about 190 km. Eastward its width decreases as the belt disappears under the Indian Ocean. In the north between the Berg River mouth and a point somewhat south of Nieuwoudtville its width is 90 km.

It is bounded in the northwest by the contact between Table Mountain Sandstone Group and the informally designated Vanrhynsdorp Group of Namibian age. Commencing at Cliff Point north of the Berg River mouth the contact runs inland encircling Vredendal and Vanrhynsdorp and northward around the northern extremity of the Bokkeveldberg, to a point west of Brandkop. From here to the Great Fish River mouth the boundary on the east and north is defined by the base of the overlying Dwyka Formation. The subregions of the Karoo Basin Region adjoining it are therefore the Hantam, Tanqua Karoo, West and East Great Karoo and the Eastern Cape Lowland.

The southern boundary is the Indian Ocean between Cape Hangklip and the Great Fish River mouth except for stretches of coastline between Mossel River and Die Kelders, Cape Agulhas and Cape Infanta, Witsand and Vleesbaai, Sundays River mouth and Port Alfred where extensive stretches of Tertiary to Quaternary sediments are encountered and the boundary has to swing away from the coast.

The western limit from Cape Hangklip to Elandsbaai is the contact between Table Mountain Group on the one hand and Malmesbury Group strata and Cape Granite on the other. Its course is more or less described by the following localities: Gordons Bay-Wellington-Saron-Porterville-Het Kruis-Piketberg-De Hoek-Aurora-Elandsbaai. The Atlantic Ocean between Elandsbaai and Cliff Point completes the picture.

(b) Aspect:

West of a line connecting Graafwater-Sandberg-Het Kruis-Aurora most of the area lies below 300 m a.m.s.l. and is sand-covered. Northeast of Aurora the isolated mass of Piketberg rises to 1 450 m. Elevations in the hills north of Het Kruis and west of the Olifants River drop from the 1 314 m Kriedoukrans to just more than 600 m north of Heerenlogement. North of Clanwilliam and east of the Olifants River the highest point is on the table-topped Matsikamma. The Bokkeveld mountains further north stand at about 1 000 m a.m.s.l. and over 300 m above the Knersvlakte.

In contrast to the north where the Table Mountain Group alone is involved, both the Table Mountain and Witteberg Groups build the mountainous terrain as far south as the Hex River Mountains. Highest points on the Seder, Skurwe and Kouebokkeveld Mountains have elevations of more than 2 000 m a.m.s.l.

Matroosberg on the Hex River Mountains has an elevation of 2 252 metres. The Olifants River which rises in the Kouebokkeveld follows a northerly-trending syncline partly underlain by Ceres Subgroup. The riverbed lies below 300 m from about 30 km above Citrusdal. In the north the Doring River crosses the mountainous terrain in a gorge that is more than 300 m deep before joining the Olifants.

The north-south trending mountainous fold belt terminates against the Hex River Mountains. The intermontane Tulbagh-Wolseley-Worcester-Robertson-Ashton valley, is followed by the Bree River from Wolseley southeastwards. South of the valley Table Mountain Group strata build the Du Toitskloof, Hottentotsholland, Riviersonderend, Kleinrivier and other mountains. Maximum elevations are more than 1 500 m.

The east-west trending fold belt is characterised by two main chains of mountains. The northern chain commences east of Worcester with Kwadousberg, followed by the Witteberg east of Touwsrivier, the Klein Swartberge, the Groot Swartberge, the detached Slypsteen and Antoniesberg southwest and south of Willowmore respectively, the Baviaanskloof and the Groot Winterhoek mountains terminating at Uitenhage. Excluding the Witteberg which consists of Witteberg Group strata, the others are all built by Table Mountain Group quartzitic sandstones.

The southern mountain chain also commences east of Worcester and comprises the Langeberg, Outeniqua Langkloof and Tsitsikamma Mountains ending at Cape St Francis. In between these two mountain chains more important ranges are the Rooiberg southwest of Oudtshoorn, the Kammanassie and Kouga ranges. All mentioned above are built by Table Mountain strata.

Elevations of the mountains are generally above 1 500 m a.m.s.l., the highest point in the Klein Swartberge being 2 327 m a.m.s.l. The lower ground in between is occupied by the mainly argillaceous Bokkeveld Group and north of Oudtshoorn by Cretaceous strata. The lower ground containing the Groot, Touws and Brak in the west, the Olifants and Kammanassie in the east, all tributaries of the Gouritz, lies below 300 m a.m.s.l.

Another east-west range built by Witteberg Group strata, starts north of Willowmore and is called the Grootrivierhoogte and Klein Winterhoekberge. It passes south of Lake Mentz and is known as the Suurberg further east. Beyond the Suurberg the high ground continues eastwards south and north of Grahamstown. Elevations drop from over 1 500 west of Miller Station to between 600 and 800 m a.m.s.l. in the vicinity of Grahamstown.

To the south of the Suurberg lies the Algoa basin with an arm shooting west between the Groot and Klein Winterhoekberge. It is underlain by Cretaceous sediments. A smaller Cretaceous Basin is traversed by the Gamtoos River downstream of the Paul Sauer Dam. Both basins lie at elevations below 300 m a.m.s.l.

Between a north-south line connecting Bonnievale-Stormsvlei-Bredasdorp-Cape Agulhas in the west and Plettenberg Bay in the

east, the area south of the Langeberge-Outeniqua ranges lies at less than 300 m a.m.s.l. Apart from the argillaceous Bokkeveld Group which underlies most of the undulating area west of Mossel Bay known as the Ruensveld, the area contains an inlier of Kaaimans quartzite, phyllite, schist and granite between Groot Brak and Wilderness as well as several patches of Enon conglomerate along the foot of the Langeberge. The Tertiary deposits in the Bredasdorp and Stilbaai areas which lie in this coastal belt are not considered part of the region.

(c) **Precipitation:**

Precipitation is directly related to elevation and distance from the ocean. The mountain ranges in the west between Clanwilliam and Somerset West, the Riviersonderend, the Langeberge and its eastwards continuation to Humansdorp, the Klein Swartberg, the Baviaanskloof, the Groot Winterhoek and the Suurberg are the loci of highest rainfall - generally in excess of 700 mm/a to more than 1 000 mm/a and over 1 500 mm/a on the Outeniqua and Hottentotholland mountains. East of the Sederberge rainfall drops to below 100 mm. Between Touwsriver and Van Wyksdorp and in the Calitzdorp-Oudtshoorn Valley rainfall averages less than 200 mm/a. From less than 200 mm/a in the vicinity of Willowmore rainfall increases to over 400 mm/a in the region of Addo in the Algoa Basin. In the Alicedale-Grahamstown-Port Alfred area precipitation varies from an average of 500 to more than 600 mm/a.

The Ruensveld south of the Langeberge receives about 400 mm/a.

The line of equal distribution of precipitation between summer and winter runs approximately through Laingsburg and Swellendam to the coast south of Riversdale. To the west of it lies the winter rainfall region which includes all of the northwestern Fold Belt. The preponderance of summer over winter rainfall over the Fold Belt east of Swellendam does not exceed 10 percent.

(d) **Natural Vegetation (Acocks):**

False Macchia is characteristic of the mountain ranges lying in the all-season rainfall area whilst Macchia is found on the mountains receiving mostly winter rainfall. Along the south coast forest occurs south of Alexandria and between Plettenberg Bay and George. The Algoa Basin and Gamtoos valley carry Valley Bushveld. West of Mossel Bay and south of the Langeberge and also between the West coast and the northerly trending mountains as far north as the Verlorevelei, Coastal Macchia and Coastal Renosterbos Veld is found. Further north Strandveld takes over.

Thornveld occurs on hilly terrain north of Alexandria. The lower-lying and semi-arid areas north of the Langeberge and other east-west mountain ranges are Karroid Broken Veld and Succulent Mountain Scrub Veld. Between Willowmore and Steytlerville Succulent Karoo Veld is present.

(e) **Subregions**

The Cape Fold Belt is divided into the following subregions

| Subregion | Geological Formations |
|---|---|
| XIV A Sandveld | Piekenierskloof, Graafwater and Peninsula Formations: conglomerate, sandstone, shale, partly under cover of coastal sand. |
| XIV B Northern Mountainous terrain | Table Mountain Group sandstone conglomerate, subordinate shale and diamictite; Bokkeveld Group: shale dominant and sandstone. Witteberg Group sandstone and shale. |
| XIV C Southwestern Mountain Ranges | As for XIV B. |
| XIV D Intermontaine Tulbagh-Worcester-Ashton Valley | Malmesbury phyllite, greywacke, conglomerate, sandstone, limestone; Cape Granite Suite; Dwyka tillite; Prince Albert sandstone and shale; Enon conglomerate. |
| XIV E Worcester-Algoa Mountain ranges | As for XIV B and locally narrow strips of older phyllite, quartzite limestone etc. |
| XIV F Oudtshoorn basin | Kango sandstone, shale, conglomerate, limestone; Enon conglomerate sandstone. |
| XIV G Groot Brak-Wilderness inlier | Kaaimans quartzite, phyllite, schist; biotite granite. |
| XIV H Ruensveld | Bokkeveld Group shale, sandstone and siltstone; isolated occurrences of Table Mountain Group sandstone and of Witteberg Group sandstone and shale; Enon conglomerate at several localities at the foot of Langeberge. |
| XIV I Sundays to Great Fish River | Witteberg Group quartzitic sandstone, sandstone, shale, diamictite; Bokkeveld shale (at Alexandria only). |
| XIV J Algoa Basin | Suurberg Volcanics; Uitenhage Group conglomerate, sandstone, mudstone and shale. |
| XIV K Gamtoos Basin | Enon Conglomerate. |

XV WEST COAST TETRAD

The name has been given to four separate occurrences of strata which have been assigned an Namibian age. They are situated south of the Orange River mouth; on the Neint Nababeep and Steinkopf plateaux; in the Vanrhynsdorp area and the Southwestern Cape.

(a) Configuration

A Richtersveld

This subregion has a triangular form. It is bounded on the west between Kleinsee and the Orange River mouth by the Atlantic Ocean; in the north by the Orange River and in the east from Sendelingsdrif to Kleinsee by a curved line skirting the eastern side of the Stinkfontein mountains.

B Neint Nababeep and Steinkopf plateaux

The subregion consists of two separate units:

(i) the Neint Nababeep plateau which stretches southwards from Kotzeshoop on the Orange River for a distance of 40 km and is about 17 km at its widest.

(ii) A narrow strip at its widest 10 km and 65 km long stretching from 25 km south of Nababeep to about 15 km north of Steinkopf.

C Knersvlakte

The subregion is bounded by the Namaqua-Bushmanland Metamorphic Complex Region on the north, the Hantam subregion for a short distance in the east and by the Cape Fold Belt Region in the south. The boundaries have been described in detail under Regions XI and XIV and subregion XII G.

D Southwestern Cape

The subregion lies west of the Cape Fold Belt region from Elandsbaai in the north to Gordon's Bay in the south (see XIV for a more detailed description of the boundary). For the rest it is bounded by the Atlantic Ocean, excepting coastal stretches where water-bearing Tertiary to Quaternary sand is present.

(b) Aspect:

A Richtersveld

The subregion occupies the Central and Western parts of the Richtersveld. In the Central Richtersveld the Stinkfontein mountains rise to 1 378 m a.m.s.l. These mountains have a convex curvature to the east and extend over N-S distance of about 60 km. West of the Stinkfontein mountains the Black Hills reach 1 200 m. The high ground terminates some 40 km northeast of Port Nolloth. From here to Kleinsee the country is largely sand-covered and is part of the coastal belt which stretches also northwards west of the Stinkfontein mountains and Black Hills, up to the Orange River. Rainfall over the mountainous tract is between 100 to 200 mm/a; along the coast it is less than 100 mm/a. The subregion gets its rain largely during the winter.

West Mountain Karoo Veld (Acocks) is present on the crest of the Stinkfontein Mountains; lower down the vegetation is Namaqualand Broken Veld. On the flats down to the coast Succulent Karoo occurs which changes to Strandveld near the sea.

B Neint Nababeep and Steinkopf plateaux

The Neint Nababeep plateau covers an area of about 600 km² and lies at an elevation of 600 to 1 000 m above sea-level.

The Steinkopf plateau has an elevation of over 1 000 m north of Steinkopf. To the south its elevation is between 600 and 1 000 m a.m.s.l.

The Neint Nababeep plateau receives less than 100 mm/a of rainfall on average. The vegetation is classified as Namaqualand Broken Veld. In the vicinity of Steinkopf rainfall locally exceeds 300 mm/a; to the south it is between 100 - 200 mm/a. North of Steinkopf the veld type is Western Mountain Karoo; to the south Succulent Karoo and Namaqualand Broken Veld.

C Knersvlakte

The Knersvlakte lies at an elevation below 300 m a.m.s.l. In the vicinity of Lutzville, the Sout, Geelbek and other tributaries from the encircling high ground on the east and north join the Olifants River. Streams originating on the Matsikamma in the south and to the southeast join the Olifants above Vredendal. Average annual rainfall is between 100 and 200 mm/a, the bulk falling during the winter months. The vegetation is Succulent Karoo.

D Southwestern Cape

The subregion has an undulating surface lying at less than 300 m a.m.s.l. Table Mountain and the rest of the Peninsula, Tygerberg, Paarl Mountain, Riebeek Kasteel, the hills around Malmesbury, Darling and Saldanha and others stand out above the plain. Elevations range from 600 to over 1 000 m.

Drainage is principally by the Berg River which flows from south to north not far from the mountain ranges in the east. Except for hilly terrain which receives more, precipitation averages about 300 mm/a, the bulk falling in the winter.

The natural vegetation is Coastal Macchia and Coastal Renosterbos Veld.

(c) Geology

A Richtersveld

The geological strata are assigned to the Gariep Complex which has been intruded by the Kuboos, and Swartbank granite plutons.

The Gariep Complex is composed of

(a) In the Central Richtersveld

Numees Formation diamictite, dolomite, arenite; Hilda Suite arenite, dolomite, diamictite, schist and phyllite;

Stinkfontein Formation quartzite, arkose, dolomite, phyllite,

diamictite, lava, tuff.

(b) In the Western Richtersveld and Coastal area
Holgat Suite schist, gneiss, arenite, limestone;
Oranjemund Suite schist, phyllite, dolomite;
Grootderm Suite schist; andesite, basalt.

Tertiary to Recent river terrace gravels, raised beach deposits,
alluvium and windblown sand.

B Neint Nababeep and Steinkopf plateaux

More or less horizontally disposed Kuibis Formation quartzite and
Schwarzrand limestone and shale.

C Knersvlakte

The deformed geological strata correlated with the Nama Group
consist of

Klipbak Formation sandstone shale
Knersvlakte Formation shale, siltstone, sandstone, limestone
Flaminkberg Formation quartzite
Gifberg Formation schist, limestone, dolomite; and
Tertiary to Recent fluvial deposits.

D Southwestern Cape

Steeply folded and faulted Malmesbury shale, greywacke, quartzite,
limestone, schist, phyllite and greenstone, intruded by
Cape Suite biotite granite plutons.

Tertiary to Recent fluvial, lacustrine and beach deposits.

XVI COASTAL DEPOSITS

Deposits of Tertiary to Recent age varying in expanse and thickness
are present along the South African coastline. Although studies
have been undertaken in certain areas, the extent to which these
deposits are water-bearing has not been completely determined.
Apart from indicating major occurrences of these deposits no
attempt will be made at describing the configuration, physiography,
precipitation and vegetation as has been done with the other
regions.

Major occurrences are

In the Kosi - Richards Bay area (Cretaceous sedimentary rocks are
included on map);

Between Port Alfred and Sundays River Mouth;

In the Vleesbaai - Stilbaai - Witsand area;

Between Cape Infanta and Cape Agulhas;

In the Die Kelders - Mossel River area;
On the Cape Flats;
In the Melkbosstrand - Silwerstroom area;
Between the Modder River and Ysterfontein joining up with
The Lower Berg River area;
The Lamberts Bay - Graafwater palaeovalley.

Future investigations may result in redefining these aquifer systems and/or identifying more.

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deur J.R. Venter, Mende 1990

| REGION | SUBREGION | PRINCIPAL ROCK TYPES | LITHO- OR CHRONOSTRATIGRAPHIC UNIT(S) |
|--|---|--|---|
| Limpopo Lowland | A Crocodile-Marico Lowland | Granitic and crystalline metamorphic rocks | Swazian |
| | B Matlaba Catchment | Sandstone and mudstone | Waterberg Group |
| | C Waterberg Coal basin | Sandstone, siltstone, shale, mudstone, basalt | Karoo Sequence |
| | D Beauty-Heasling belt | Granitic and crystalline metamorphic rocks | Swazian |
| | E Limpopo Karoo basin | Sandstone, siltstone, shale, mudstone, basalt | Karoo Sequence |
| | F Waterpoort trough | Sandstone, siltstone, shale, mudstone, basalt | Karoo Sequence |
| | G Thlipsie trough | Sandstone, siltstone, shale, mudstone, basalt | Karoo Sequence |
| | H Hasluis strip | Calcareous sandstone, conglomerate | Cretaceous |
| Limpopo Highland | A Waterberg | Sandstone, shale, conglomerate, lava | Waterberg Group |
| | B Soutpansberg Range | Sandstone, shale, conglomerate, volcanics | Soutpansberg Group |
| | C Pietersburg Plateau | Granitic and crystalline metamorphic rocks | Swazian |
| | | | |
| Bushveld Basin | A Northwestern Bankeveld | Dolomite, quartzite, shale, andesite, diabase | Black Reef Formation, Chuniespoort and Pretoria Groups |
| | B Marico Bushveld | Shale, quartzite and mafic intrusives | Pretoria Group, Bushveld Complex |
| | C Southern Bankeveld | Shale, quartzite, andesite, diabase | Pretoria Group |
| | D Karst belt | Norite, (magnetite) gabbro, anorthosite, syenite, foyaitite | Black Reef Formation, Chuniespoort Group, Ecce Group |
| | E Western Bushveld Mafic Lobe | Granophyre, granite, dolomite, quartzite, shale, trachyte | Bushveld and Pilanesberg Complex |
| | F Springbok Flats | Shale, sandstone, mudstone, siltstone, basalt, dolerite | Bushveld Complex, Chuniespoort, Pretoria and Rooiberg Groups |
| | G Northern Bushveld Complex | Norite, gabbro, granite, rhyolite/felsite | Karoo Sequence |
| | H Middleburg Basin | Shale, sandstone, conglomerate, volcanics | Bushveld Complex, Rooiberg Group |
| | I E/SE Bushveld Felsic Lobe | Granophyre, granite, volcanics, quartzite, shale, dolomite | Looskop Formation, Waterberg Group, Ecce Group |
| | J E/NE Bushveld Mafic Lobe | Norite, (magnetite) gabbro | Bushveld Complex; Groblersdal, Chuniespoort, Pretoria, Rooiberg Groups |
| | K Eastern/Northeastern Bankeveld | Dolomite, quartzite, shale, andesite, diabase | Bushveld Complex |
| | Mtwatersrand Basin | A Halfway House Dome | Gneiss, migmatite, granodiorite |
| B Central Rand | | Shale, quartzite, conglomerate, andesite | Swazian |
| C Ventersdorp-Hartebeesfontein-Klerksdorp area | | Granite, lava, quartzite, shale | Mtwatersrand Supergroup, Klipriviersberg Group |
| D Karst belt | | Dolomite, chert, sandstone, shale | Swazian, Dominion Group, Mtwatersrand and Ventersdorp Supergroups |
| E Potchefstroom Bankeveld | | Shale, quartzite, conglomerate, andesite, dolomite | Chuniespoort Group; Ecce Group |
| F Suikerbosrand | | Shale, quartzite, conglomerate, andesite | Mtwatersrand Supergroup, Klipriviersberg, Chuniespoort and Pretoria Groups |
| G Vrededorst Dome | | Shale, quartzite, conglomerate, andesite | Witwatersrand Supergroup, Klipriviersberg Group |
| | | Granite, gneiss | Swazian |
| Trans-Cape Highveld | | Andesite, sandstone, conglomerate, granite gneiss, various volcanics, quartzite, shale | Ventersdorp Supergroup; Swazian; Dominion Group; Mtwatersrand Supergroup |
| | | | |
| Transvaal Lowveld | A Northern Lowveld | Lavas, tuff, schist, quartzite, gneiss, migmatite, granite | Swazian |
| | B Southern Lowveld | Granite, granodiorite, migmatite, tonalite | Swazian |
| Transvaal Middleveld | | (Meta)lavas, quartzite, sandstone, shale, conglomerate, serpentinite, amphibolite, gabbro, granite | Swaziland and Pongola Supergroups |
| | | | |
| Lebombo Belt | A Northern Section | Sandstone, mudstone, shale, siltstone, basalt, rhyolite, dolerite | Karoo Sequence |
| | B Southern Section | Tillite, sandstone, shale, mudstone, siltstone, basalt, rhyolite, dolerite | Karoo Sequence |
| Kalahari | A Northeastern Kalahari | Granitic and crystalline metamorphic rocks, lavas, pyroclastics | Kalaharibeds, Swazian, Soetlief Group |
| | B Makhubung-Pomfret-Senloc-Morokwe area | Dolomite, chert, iron formation, jaspillite | Campbell and Griquatown Groups |
| | C Central Kalahari | Sand(stone), clay, gravel, granite and metamorphics, dolomite, tillite | Kalaharibeds; Swazian; Campbell, Griquatown and Cox Groups, Dwyka Formation |
| | D Lower Kuruman River | Sand(stone), clay, gravel, quartzite, shale, tillite | Kalaharibeds; Dwyka and Prince Albert Formations |
| Criqueuland West | A Ghaap Plateau | Shale, sandstone, andesite, dolomite, chert, limestone | Vryburg Formation, Campbell Group |
| | B Griqua Fold belt | Banded ironstone, jaspillite, shale, diamictite, quartzite, shale, quartz-sericite-schist | Griquatown Group, Gamaara and Makanyeni Formations |
| | | Andesite, iron formation, jaspillite, lava, dolomite, quartzite, tillite | Cox Group, Olifantshoek Sequence |
| | | Metaquartzite, various gneisses and schists, granulite, amphibolite, granites, adamellite | Namaqua Metamorphic Complex |
| Namaqua-Bushmanland Metamorphic Complex | A Drakbospoort Hills | Metaquartzite, various gneisses, and schists, amphibolite, lava, granites, adamellite | Namaqua Metamorphic Complex |
| | B Bushmanland Plain | Metaquartzite, gneisses, schists, granites | Namaqua Metamorphic Complex |
| | C Mountainous Lower Orange tract | Metaquartzite, gneisses, schists, granites | Namaqua Metamorphic Complex |
| | D Namaqua tract | Metaquartzite, gneisses, schists, granites | Namaqua Metamorphic Complex |
| | E Coastal sand belt | Tillite, sandstone, shale, mudstone, dolerite | Namaqua Metamorphic Complex |
| | A Highveld | Tillite, shale, carbonaceous shale, lava, volcanoclastic, quartzite, dolerite, shale, dolerite | Dwyka Formation, Ecce and Beaufort Groups |
| | B Pudiwoe-Oudraaisvllel belt | Shale, dolerite | Dwyka, Prince Albert, Whitehill Formations; Randian Ventersdorp Supergroup, etc |
| | C Central Pan belt | Sandstone, shale, mudstone, siltstone, basalt, dolerite | Tierberg Formation |
| | D Northeastern Free State Highland | Sandstone, shale, mudstone, dolerite | Molteno, Elliott, Clarens, Drakensberg Formations |
| | E Southeastern Free State | Tillite, shale, carbonaceous shale, dolerite | Adelaide and Tarkastad Subgroups (Beaufort) |
| | F W and E Bushmanland Pan belt | Tillite, shale, carbonaceous shale, dolerite | Dwyka, Prince Albert, Whitehill, Tierberg Formations |
| | G Bantam | Tillite, shale, carbonaceous shale, sandstone, dolerite | Dwyka, Prince Albert, Whitehill, Tierberg Formations |
| H Tanqua Karoo | Shale, sandstone, mudstone, dolerite | Kookfontein, Koedoesberg and Carnarvon Formations | |
| I W and E Central Karoo | Sandstone, shale, mudstone, siltstone, basalt, dolerite | Carnarvon Formation, Adelaide Subgroup | |
| J Eastern Cape-Transkei Highland | Tillite, shale, sandstone, mudstone, dolerite | Molteno, Elliott, Clarens, Drakensberg Formations | |
| K W and E Great Karoo | Sandstone, mudstone, dolerite | Dwyka Formation, Ecce Group, Adelaide Subgroup | |
| L Eastern Cape Middleveld | Sandstone, mudstone, dolerite | Dwyka Formation, Ecce Group, Adelaide Subgroup | |
| M Southern Cape Lowland | Tillite, shale, sandstone, mudstone, dolerite | Ecce Group, Adelaide and Tarkastad Subgroup | |
| N Southern Transkei | Shale, sandstone, mudstone, siltstone, basalt, dolerite | Ecce Group, Adelaide and Tarkastad Subgroups | |
| O Middleveld | Shale, sandstone, mudstone, siltstone, basalt, dolerite | Ecce Group, Adelaide and Tarkastad Subgroups | |
| P Northern Natal Middleveld | Shale, sandstone, mudstone, siltstone, basalt, dolerite | Ecce Group, Adelaide Subgroup, Molteno, Elliott, Clarens and Drakensberg Formations | |
| Natal Monocline | A Northern Monocline | Granite, granodiorite, lava, quartzite, tillite, shale | Swazian; Neuze Group, Dwyka and Prince Albert Formations |
| | B Tugela | Amphibolite, gneiss, schist, conglomerate, mudstone, limestone | Tugela, Mfongosi, Ntingwe Groups |
| | C Central and Southern Monocline | Quartzite, gneisses, migmatite, metabasite, amphibolite, calc-silicate rocks, granitoids, granite | Mpumulo and Mzimkulu Group |
| Orange Fold Belt | A Sandveld | Sandstone, shale, sand | Plekeniera, Graafwater and Peninsula Formations |
| | B Northern Mountainous terrain | Sandstone, shale, diamictite | Table Mountain, Bokkeveld and Witteberg Groups |
| | C Southwestern Mountain ranges | Sandstone, shale, diamictite | Table Mountain, Bokkeveld and Witteberg Groups |
| | D Intermontane Tulbagh-Lahton Valley | Phyllite, greywacke, conglomerate, sandstone, limestone, tillite, shale | Malmesbury Group, Cape Granite Suite, Dwyka and Prince Albert and Enon Formations |
| | E Worcester-Algoa Mountain Ranges | Sandstone, shale, diamictite | Table Mountain, Bokkeveld and Witteberg Groups |
| | F Oudshoorn Basin | Sandstone, shale, conglomerate, limestone | Kango Group, Enon Formation |
| | G Groot Brak-Wilderness Inlier | Quartzite, phyllite, schist, biotite granite | Kaaimans Group |
| | H Ruensveld | Shale, sandstone, siltstone, limestone, dolomite, quartzite | Table Mountain, Bokkeveld and Witteberg Groups, Enon Formation |
| | I Sundays-Great Fish River area | Quartzitic sandstone, shale, diamictite | Witteberg and Bokkeveld Groups |
| | J Algoa Basin | Lava conglomerate, sandstone, mudstone, shale | Saarberg and Uitenhage Groups |
| | K Gamtoos Basin | Conglomerate | Enon Formation |
| East Coast Tetrads | A Richtersveld | Diamictite, dolomite, arsenite, schist, phyllite, lava, tuff, granite, sand, gravel | Gariep Complex |
| | B Neint Nababeesp-Steinkopf plateau | Quartzite, limestone, shale | Kulbia and Swartvlei Formations |
| | C Kneravilakte | Sandstone, shale, siltstone, limestone, dolomite, quartzite, schist, fluvial deposits | Gilberg, Flamingberg, Kneravilakte, Klipbak Formations |
| | D Southwestern Cape | Shale, greywacke, quartzite, limestone, schist, phyllite | Malmesbury Group, Cape Granite Suite |
| Coastal Deposits | | Fluvial, lacustrine, coastal sand, sandstone, etc | Tertiary to Recent |
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