SOUTH WEST AFRICA

DEPARTMENT OF MINES

Memoir No. I

THE GEOLOGY

OF THE

WESTERN REHOBOTH

An Explanation of Sheet F. 33—W. 3 (Rehoboth)

By

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CHAPTER I.

INTRODUCTORY.

Area.

The sheet under description is bounded on the south and north by the 24° and 23° parallels of S. latitude respectively while the 16° and 17° meridians of E. longitude form its western and eastern limits. It thus comprises an entire degree sheet with an area of 1,130,933 hectares (4366.5 sq.miles). Except for a small portion of the north-western corner which falls in the Windhoek district the entire area lies in the Rehoboth district and roughly one half is Baster Gebiet which is a semi-reserve occupied by the Basters (coloureds) prior to the German settlement of 1885.

The area except in the extreme western desert portion is, for South West, well populated by pastoral farmers. The grazing is good and climatic conditions favourable, while stock disease, apart from horse-sickness, is practically unknown.

The survey was done on field sheets provided by the Surveyor General's office and these were compiled from the available topographical data such as farm surveys, the geological map of E. Rimann, etc. For the north-eastern area two 20' field sheets of the German topographical survey were available. These two sheets are almost perfect in every topographical detail, and are on the scale of 1:100,000. Although this seems a large scale for geological work, and is in fact too large for the simpler areas, it is by no means large enough for the very complicated north-eastern corner and also the middle east, where the complex folding and faulting jumbled a highly altered assemblage of rocks of different ages together.

Previous Work.

The first known reference to the geology of this area is by Stapff (1)*, Gurich (2), Dr. E. Stromer von Reichenbach (3). In 1904 Voit and Stollreither mention the area of the lower Kuiseb valley and the Gansberg (4).

In 1910 and 1911 Dr. E. Rimann made a geological survey of the Baster Gebiet for the Hanseatische Minen-Gesellschaft (D.K.G.). His map together with an explanation was published in 1915 (5). A short paper by the same author anent the alkali rocks of the Baster Gebiet appeared in 1914 (6).

* Numbers in brackets refer to the list of literature references given at the back.

In 1916 Wagner's memoir on the Geology and Mineral Industry of S.W.A. was published, in which are references to this area (7).

Reuning in 1923 published his geological map of the middle South West, accompanied by a short paper (8).

In 1925 Reuning's description of the Natas mine accompanied by a geological map of the surrounding area, comprising just over one 20' field sheet, was published (9).

These, with the exception of Rimann's work, are all very brief and not very helpful for the purpose of detailed mapping and study. Rimann's work on the Baster Gebiet was very hurriedly done, and in consequence suffers in accuracy. This is especially true of his tectonic interpretations which in many places cannot be reconciled with the evidence of more detailed mapping.

The author has freely used the above works wherever possible, but the survey and conclusions are entirely his own.

The survey took two field seasons, 1930—31, of approximately 4½ and 5 months respectively.

The work was prolonged by the complex nature of the north-eastern section, and the inaccessibility of the western desert section lying below the escarpment, which in places is an arid desert for hundreds of sq.miles where neither man nor beast can live for long. This inaccessibilty was further accentuated by the prevalence of horse-sickness in the low veld and desert during the rain months, making animal transport impossible when water and grass can be obtained.

CHAPTER II.

PHYSICAL GEOGRAPHY.

The area under description is one of geological, structural, topographical and scenical contrasts. Some of the finest desert and mountain scenery can be witnessed from the heights of the imposing Gansberg, while the endless rolling chain of undulating hills that can be seen from the escarpment at Us westward along the Kuiseb valley reminds one of the "Valley of a Thousand Hills" in Natal, in a different setting.

(1) *MORPHOLOGICAL FEATURES.*

The area as a whole presents marked topographical features, for whereas the greater part belongs to the highveld and lies above the 1500 m. (4920 ft.) contour the western strip below the escarpment already falls within the scope of the coastal plains or Namib desert. The escarpment is very marked, so much so that in the whole area under description there is only one descent at Us that can be undertaken with a vehicle, and that is partly out of the sheet. Bridle paths are few and far between, and even descent on foot is not always possible.

The most marked physical feature of this area is the Gr. Gansberg (Gans — Nama, meaning high plateau), 2332 m., the Table Mountain of South West. For sheer flatness it is even more like a table than Table Mountain. On the western side there is a fall of 1332 m. (4,370 ft.) in 22 km. (13½ miles) to the valley of the Gaub river, 1000 m.

"Inselberge" are common on the plateau or highveld, the most prominent of these being the quartzite mountains of Charlottenberg and Marienhof, (Plate I, 1 and 2) and the phonolite-capped Duruchas hill, Plate XIII. The tors of typical woolsack-weathering granite are grouped together, while the massive quartz-porphyries of the Nuckkopf range weather in steps and bastions, forming imposing mountain chains.

Table of Altitudes.

These are taken from our maps and German diagrams; aneroid checking was attempted wherever possible, but this was not successful owing to the poor class of instrument available:—

	Metres.		*Metres.*
Great Gansberg	2332	Noasfelsen	1784
Alberta Mt.	2221	Nukurus	1775
Charlottenberg	2144	Nauchas police stn.	1750
Kristallgestein	2090	Garis trig. beacon	1720
Zwischenpunkt A.	2059	Duruchaus Spitzkop	1715
Steinfeld	2049	Kosspitze	1634
Nuckkopf	2028	Aroams homestead	1630
Swartfontein, near fountain	2006	Kobus homestead	1612
Biedersfarmberg	1994	Doppelkopf	1602
Tsebriseb Mt.	1974	Achaub trig. beacon	1583
Ninais beacon	1963	Komasis homestead	1562
Luderitzberg	1958	Nauzerus homestead	1551
Tantusspitze	1939	Narebis homestead	1526
Arnamberg	1931	Abendroth trig. beacon	1452
Marienhof Mt. (Chilkopf)	1892	Natas mine	1402
Meilenrucken	1885	Us berg	1362
Rote Kuppe	1882	Eisgaubib homestead	1142
Schafweiden	1874	Chausib werf	1090
Nebenpunkt B.	1834	Ubib waterhole	1084
Gurumanasberg	1826	Chaibis spring	1042
Hohe Kante	1804	Lower Kuisib Valley	989
		Lower Gaub Valley	980

(2) *ROADS.*

The main roads are marked on the map. These are mostly bad and communication in and over the area is in consequence much hampered. The sandy valleys and flats have the best roads, while the schists, especially of the Khomas Series, are on account of the irregular wear and abundance of quartz rubble the worst. The

Basters have numerous roads radiating from each "werf", and it is often impossible to travel from place to place without a reliable guide. As already stated the low veld or Namib section is without any road whatsoever, except the Us—Donkersan road which is hardly traversable by car beyond Eisgaubib.

(3) *GENERAL.*

To the north lies the Khomas highland, an almost endless stretch of schist hills which slope to the north, the dip side, and are more or less sharply terminated to the south. In the stretch north and east of the Hakos mountains where the Gomab river has serrated the schists in sharp ridges with deep rugged kloofs the local farmers call it "Gramadulas", a collective name for difficult country. This name also applies to the section between the Gansberg and the Hakos mountains and to the valley of the Gaub.

The Khomas highland is terminated by the steep and rugged mountains which are formed of a pitching anticline of quartzites standing up from underneath the schists. To the east there is the range of quartzites and marbles forming the Ninais mountain, Charlottenberg and Arnamberg range, while further east on the boundary of the map are the typical 'inselberge' of phonolite with the Duruchaus Spitzkop the most prominent.

The Tsebriseb mountains rise some 400 m. above the surrounding flat country, due mainly to a very strong fault line since utilised by the western tributary of the Twee river. The country around Marienhof is flat, with in places 'inselberge', such as the white Marienhof quartzite mountain and some of the more prominent black amphibolite 'koppies'. (Plate II, 1 and 2.)

From Marienhof to Hoornkranz and Gamsberg the country is flat and grass-covered with only occasional low hills breaking the monotony. On Gamsberg (or Groendoorn) is situated the Gansberg referred to above, the most prominent of the eminences of this area. Immediately to the north of Gansberg lies the deeply incised valley of the Djab a tributary of the Kuiseb river. To the south and west lie the valley of the Gaub, and where the latter leaves the map the lowest altitude is recorded. South of Hoornkranz and the Gaub lies the massive block of red granite stretching beyond Kobus and Morgenroth, tors and ramparts of solid rock tailing off into round hillocks and 'koppies' to the north. On Areb and Alberta lie the massive brown-black ridges of amphibolite and diabase rising to 2221 m. in the Alberta mountains, the second highest point on the map. U-shaped valleys lie between the various ridges.

The country round Nauchas, Borodino, Namibgrens, Swartfontein and Namakorabis is largely highveld flats with granite ridges, tors and hillocks as far as the escarpment. In the immediate neighbourhood of the escarpment there is an abundance of narrow dykes of diabase, which stand out from the light coloured granites of this area as so many black ridges weathering in piles of round boulders. (Plate X.)

Below the escarpment at Swartfontein lie the endless stretches of Namib sand and deflation residue, usually covered with waving white grass and teeming with game. These sand flats sweep round with the escarpment to Koireb and Ababis and cover about 800 square miles of waterless desert country.

The country south of Marienhof shows typical granite scenery, round smooth-faced krantzes and occasional tors with typical woolsack-weathering in places. This granite massif extends to Groendraai on the eastern boundary and from there through Grundorn and Homeib to Noatis where its place is taken by the quartz-porphyries of the Nuckkopf range. To the south of this granite, the younger sedimentaries of the Nama extend in vast rolling grass-covered plains from which well-marked flat dark ridges of Schwarzkalk limestones and Schwarzrand quartzites stand out with shelving valleys of mudstones in between.

Westward from Rokskeur through Garis, Nauzerus and Noab the Schwarzkalk plateau is a prominent feature terminated in the south against the Maltahohe plains by the strong faulting of the Bullspoort line. To the west the plateau ends in outliners of limestone and grits on the Steinfeld range and the mountains round Ababis where it forms the escarpment from the highveld to the Namib.

(4) *HYDROGRAPHY.*

There are no perennial streams in this area, and for the greater part most of them flow for only a few hours, or at most a few days after heavy showers.

The river courses drain into two large rivers; (1) the Kuiseb, which eventually reaches the Atlantic Ocean at Walvis Bay, and (2) the Orange via the Fish river. Then there is the Tsondap which must once have reached the Atlantic somewhere near the present Conception Bay, but is now entirely dammed by the dune belt of the west coast and forms a large drowned vley.

The western or Kuiseb drainage system consists of the following rivers:— The Gomab draining the area immediately north and east of the Hakos mountains and flowing into the Kuiseb at Eisgaubib. The Djab draining the area between the Hakos and the Gansberg with the Obus and the Natas rivers draining the western slopes of the Hakos anticline, all three separately joining the Kuiseb. The Chauchab rising on the western and north-western slopes of Gansberg passes through Chausib and flows into the Kuiseb. Further to the south the country from Isabis, Areb, Alberta and Weener is drained by numerous tributaries of the Gaub which in its upper reaches has a steep gradient. The numerous amphibolite dykes and the harder quartzite bands which it traverses form numbers of good waterholes.

The country round Swartfontein and Namibgrens is drained by the numerous rivulets which eventually join the Ubib river, another tributary of the Kuiseb.

The Tsondap river mentioned above has its origin in the mountains between Noab and Nauzerus and is joined at Ababis by tributaries from Zais in the south and Namakorabis to the north. It flows through a bed of lime-cemented boulders and sand-covered schists leaving the area north of Swartkop.

The south-eastern or Fish river system rises on the water-shed which runs roughly diagonally across the sheet from the north-east corner to somewhere south of Nauzerus near the south-west corner of the sheet.

In the extreme north-east corner the rivers of Krumneck and Gurumanas which combine at Quaggas drain the country, to be joined south-east of the Charlottenberg by the combined rivers from Naos and Choaberib to form the Twee river which leaves the sheet a little below the farm Tweerivier to become the Rehoboth river. This system incidentally has not a clear run to the Fish river, but after passing Rehoboth it meanders to a certain extent in the vleys of Heide and Oas and is partly blocked by the Kalahari sand coming from the east. It is, however, certain that part of its water at any rate, reaches the Schaf river and via that the Fish River. In the flat granite country south of Marienhof the drainage system consists of shallow watercourses which eventually drain into the Tsumis river via Kamkam.

Further south the larger courses of the Augagams or Homeib-Schlip river and the combined Kam rivers drain the flat country of the lower Nama beds and the foothills of the Nuckkopf range, respectively.

In the extreme south there is the Achaub river flowing due south and draining the Achaub hills and flats.

(5) *RAINFALL.*

This on the whole is very good for South West, but not very regular. There is a belt below the escarpment and especially in the south, with a rainfall of under 200 m.m. (7.9 inches). The flat country round Marienhof and from there southward to Tsumis averages 200—250 m.m. (8 to 9.8 inches). The mountainous country of the north-east corner and the tract round Nauzerus average from 300—350 m.m. (12 to 14 inches). Then there is a central area comprising the farms Gollschau, Hohenheim, Isabis, etc., with the high average of from 450 to 620 m.m. (17.5 to 24.4 inches).

List of Rainfall Normals for this Area.

Ababis	200 m.m.	7.9 inches.
Marienhof	200 m.m.	7.9 „
Rehoboth	240 m.m.	9.5 „
Nauchas	248 m.m.	9.8 „
Nauzerus	300 m.m.	11.8 „
Naos	300 m.m.	11.8 „
Isabis	430 m.m.	17.0 „
Hohenheim	500 m.m.	19.7 „
Gollschau	620 m.m.	24.4 „

(6) *SPRINGS.*

These are not very numerous in the area under description, but some of them are of some importance from the geological point of view. The row of springs which issue on the Kuiseb from Elsgaubib to Dromunab are important in that they are copious and highly mineralised. Hydrogen sulphide, free sulphur, magnesium sulphate, common salt and lime are the chief solids in solution. Some of these springs, e.g., Tantus and Swartmodder are so highly charged with sulphur that free sulphur is deposited at the outlet. The springs rise on a definite geological horizon. The massive Hakos quartzites (Damara System) are overlain by a varying thickness of graphitic schist and phyllites which in turn are overlain by the massive Khomas schists. It is on the junction of the porous quartzites and the impervious graphite schists that the line of springs have their origin. There are more than 20 of these springs, between the two points mentioned, of which Chaibis, Tantus and Swartmodder are the most important.

On the farm Naos (Florida) there are some typical solution-caverns in the Marble Series of the Damara System. The entrance is only a few metres in diam. and the windings can be followed for over 100 m. with beautiful stalactites and stalagmites in most of the chambers. At the end of the cave there is a plentiful supply of crystal-clear water.

The transverse fault on Tsebris is the cause of the very strong spring issuing on the side of the river. In the Gaub river on Weener there are several strong springs issuing on master-joints in the highly folded schists; these may be partly caused by the compact amphibolite dykes which penetrate the schists at short intervals in this vicinity. The Auros spring is the most important of these.

The Swartfontein spring on the farm of that name is one of the best known springs, has a copious flow and has never been known to cease. The springs in the upper reaches of the Tsondap river on Noab issue from the Schwarzkalk on joints and solution fissures. Those lower down on Stolzenfels rise on hard barriers of diorite in the granite.

In the Basal Beds of the Nama there are also a number of springs, especially on the coarser, more porous conglomerates and pebbly beds. The most important is that on Campbells Aub, Klein Aub and Nauzerus.

There are also springs well known 10 or 20 years ago that have since ceased entirely. The Natas spring is one of these. During the field season 1930, and again 1931, there was not even a seepage, notwithstanding the very good rains during the latter year.

(7) *VEGETATION.*

The scant growth of this area varies between that of the West Coast Desert* and the Desert-Grassland Transition belt, with a

*"South Africa and Science". Chapter X, by Dr. I. B. Pole Evans, 1929.

small portion of Karroo Semi-desert in the south,viz: the Maltahohe plains. The middle granite country with its rich growth of forage grasses can be classed as S.A. Savannah popularly known as Western Savannah. The Coast Desert belt represented on the map is roughly that portion below the escarpment, with a low rainfall and scant vegetation. The sand dunes are often barren of any growth whatsoever. After good rain years, however, the sand flats are covered with an abundance of Silvergras and Blinkaargras with occasional bushman candle (Sarcocaulon Burmanni). Twaa gras (Aristida brevifolia) and Voëlstruisgras (Eragrostis spinosa) are not uncommon and sometimes abundant. The river courses support a fair growth of Kameeldorn (Acacia Giraffae) which seldom grows into big trees. On the bare rock outcrops in places Kokerboom (Aloe Dichotoma) and an occasional Gifboom (Euphorbia Virosa) are to be found. Tsamma (Citrullus vulgaris) is not uncommon in some of the sandy places and is especially abundant in the plains of the Ubib river. In the courses of the Tsondap and especially the Gaub and Kuiseb beautiful specimens of the Wilde Vyeboom are to be found. In the valley of the Obus and all over the Hakos mountains and its surroundings and also on the slopes of the Noab river and surroundings there grows on the practically barren rock ledges an abundance of the veld tea or Resurrection Plant.

The Desert-Grassland Transition belt is marked by more grass and larger trees, and merges almost imperceptibly into the Savannah. The grasses represented are: Bushman grass (Aristida Obtusa); Steekgras (Aristida congesta) and (Aristida ciliata); also Kalkgras (Fingerhuthia africana) with (Penisetum cenchroides) and a few other rare kinds. The other vegetation is divided into shrub with Haakdoorn (Acacia detinens); Sikkeldoorn (Dichrostachys nutans); Soetdoorn (Acacia horrida); and trees proper such as Kameeldoorn (A. Giraffae) and Annaboom (A. albida), these frequenting the river courses and omurambas. Besides these several other plants such as Witgatboom (Boscia pechuelli) and the common Vaalbos (Tarchonanthus camphoratus) are found throughout the highveld. The Karroo semi-desert, as already remarked, covers only a small area of the sheet, viz: the Maltahohe flats. Except for the river courses the country is covered by typical shrublets and what is commonly known as "bossies weiveld". The shrubs are represented by Brosdoorn (Phaeoptilum spinosum), Klapperbos (Nymania capensis), Kraalbos (Galenia africana), Ganna (Salsola aphylla), and various species of Mesembrianthemum (Vyebos). The commonest trees are Doornboom (Acacia Karroo) and Witgat (Boscia albitrunca).

(8) *SOILS.*

Owing to the comparatively low rainfall and the great preponderance of granite and arenaceous sedimentary rocks the soils of this area are shallow, sparsely distributed and lean. Really good humus soils are not represented. The best soil and incidentally the only soil on which agriculture is practised is the river soil. When

these rivers are locally in spate they overflow their banks in the wider valleys and deposit a heavy silt, usually fertile, but inclined to be dense and easily caked. The granite soils, owing to lack of phosphate and their great porosity, do not lend themselves to horticulture with any success. The schists of the Khomas highland are heavily strewn with quartz rubble, the valleys have a very scant deposit of highly micaceous loams in which hardly anything can be grown without an inordinate amount of water. The soils of the marble and graphite schist areas like that round Tsebris are usually so highly mineralised with lime and other salts that their undoubted good properties tend to become obscured.

CHAPTER III.

LIST OF GEOLOGICAL FORMATIONS.

The geological formations represented on the map are, in descending order:—

			Sign on Map
Recent	Surface deposits, sand, surface lime, Namib deflation residua, and River Gravels (R)		
Nama System	Schwarzrand Series	Upper shales	N 5
		Quartzites	N 4
		Lower shales	N 3
	Schwarzkalk Series	Impure limestones, marls, etc.	N 2
	Basal Beds	Pebbly grits, sandstones, quartzites	N 1
Damara System	Khomas Series	Biotite, chlorite and amphibole schists with micaceous quartzites and the Red band and Auas quartzites	K
	Tillite	Chuous tillite, pebbly limestones, grits, etc.	T
	Marble Series	Crystalline limestones, graphitic phyllites, etc.	Ma
	Quartzite Series	Quartzites and basal conglomerates	Q
Pre-Damara Beds	Duruchaus Series	Biotite, muscovite and sericite schists with impure limestone bands	S
		Crystalline and Talcose marbles	Na
		Micaceous quartzites	Mg
	Marienhof Series	Phyllites	ph.
		Quartzites	qt.
	Mixed rocks	Ortho-, Para-, — Lit-par-lit gneiss	M.
		Metamorphic rocks	

Intrusive Igneous rocks	Phonolite, Limburgite and Trachyte	pPo, pL, pTo.
	Diabase dykes	d
	Quartz-porphyry dykes	p
	Massive Quartz-porphyry	P
	Pegmatite dykes	Pe
	Older granites	—
	Diorites, quartz-diorites	Di
	Amphibolite and Hornblendite	A
	Serpentine	Se
	Amphibolite dykes	A
	Pre-Damara gneiss	gn.

CHAPTER IV.

GENERAL GEOLOGY AND STRUCTURE.

The geology of this area, owing to its highly complex nature, its abundance of ancient and eruptive rocks and its promise of mineral deposits, is a subject of absorbing interest.

HISTORICAL.

There is evidence at the Natas and Jan Jonker mines that the Jan Jonker Hottentots some 70 to 80 years ago exploited the surface copper deposits and the serpentine mouth-piece of an old bellows used in the smelting of the ore was found at Natas by the miners of the Deutsche Kolonial Gesellschaft in 1911. Furthermore it is possible that the discovery of copper ore and the hot spring at which the expedition under Willem van Reenen in 1792* camped, refers to this area. There is a legend among the Namaquas of the area, about a white man with ox waggons who long, long ago passed through there, that might also refer to this expedition. Some 50 years ago an Englishman by the name of Donkin led a prospecting expedition through the area. On the farms Areb and Alberta there is still evidence of their activities.

The Hanseatische Minen-Gesellschaft had part of the area geologically surveyed and prospected in 1910—11, without however locating any important mineral deposits.

GENERAL GEOLOGY.

The greater part of this area is covered by pre-Nama beds, collectively known as the Fundamental Complex and composed of schists, marbles and quartzites with vast bodies of granite and gneiss intrusive into them. There are moreover large tracts covered by rocks which are neither entirely instrusive nor sedimentary in

*G.M. Theal. "History of S.A. before 1795" page 257.

a light-green colour and pitted surface. It is mostly foliated, but locally, as to the west of Gurumanas, massive bodies occur. It is this material that the Hottentots use for making their bellow heads and occasionally pipe bowls.

Titanium Ores.

The deposits of copper ore at the Duruchaus Spitzkoppies and near Gelkopf contain small admixtures of rutile, while the deposits at Kabiras and Auchas contain small quantities of titanite intermixed with the gangue minerals.

On the farm Eisgaubib some 3 km. from the homestead on the south bank of the Kuiseb, Mr. G. Schurz has opened up a deposit of titanium ore. The ore is of pegmatitic origin and occurs together with quartz, felspar and calcite in a number of highly anastomosing veinlets, in which quartz predominates. The country rock is mica schist with local developments of amphibole schists. The ores consist of rutile in prisms and knee-shaped twins, and as idiomorphic crystals embedded in the pegmatite and sometimes in the country rock. A feature of this deposit is the development of massive titanite (sphene) of a yellowish-green colour. A lump of this massive titanite contains idiomorphic crystals of felspar, scales of biotite, grains of quartz and needles of rutile. Occasionally idiomorphic crystals, of this green titanite can be picked out of the pegmatite.

A sample of titanite analysed in the Government Chem. Laboratory, Windhoek, returned 28% of TiO_2.

The deposit has been opened up by means of shallow pits and trenches. The ores pinch out and make within a metre from surface and are most sporadically distributed. They will possibly pinch out altogether within 5 metres of the surface. From what has been done a few tons of titanium ores can be extracted but hand sorting and cleaning to any degree of purity will be a costly business. Everything considered, there is little hope of this deposit ever being worked.

CHAPTER XIII.

WATER SUPPLY.

A. *SPRINGS AND WATERHOLES.*

The better known springs and waterholes have already been referred to in Chapter II.

B. *UNDERGROUND WATER-SUPPLY.*

Owing to the irregular rainfall and the prevalence of recurring droughts the question of underground water-supplies becomes all-important for the successful settlement of the area.

An endeavour will be made to point out the chances of, and the difficulties which confront the successful boring and digging for water.

Scheelite.

The Scheelite of the Natas mine has been so well and broadly described by Reuning (9) that no detailed description will be attempted here. The scheelite occurs in pegmatite veins and lenses through which it is more or less evenly distributed to form 2—3% of the mass and occasionally as much as 10% and in some lenses 30%. The scheelite in rich pockets is scarce and irregularly distributed, but was found to be payable at the high pre-war and war prices. To-day, however, this deposit is not worth working.

From a cursory examination of the mine in 1930 and 1931, the writer has come to the conclusion that the main body of scheelite-containing pegmatite, has been taken out, leaving only the poorer ore, and pillars of rich ore. If anything comes of the gold mining proposition at present being floated it is possible that some scheelite might be extracted as a by-product, but alone, there is very little likelihood of its being mined, for in addition to reasons set out above, the ore has to be transported over partly impossible roads or tracks for 100 miles to railhead at Windhoek, or 90 miles to Karibib over even worse tracks. Reuning also reports scheelite from the Jan Jonker mine, but a prolonged search by the author failed to reveal any scheelite in this vicinity.

Serpentine.

In the highly metamorphosed limestones on Samaubes there occurs a dull whitish-green body of massive serpentine which has been used by Mr. Schultz of Nauzerus for the manufacture of small ornaments such as sugar basins, ash trays, ink stands, etc. The finished products are of pleasing appearance.

The serpentine on Marienhof is an altered pyroxenite. It was examined for possible veins of chrysotile with negative results.

Sulphur.

Crystalline sulphur is found in the graphitic schists at Guru-manas in conjunction with the numerous pyrite crystals.

The springs of Tantus and Swartmodder, especially the former, have deposited beds of sulphur in the ash-like rock powder and fine muds at and round their orifices. The sulphur is golden-yellow in colour, and locally handfuls of pure sulphur can be scraped together.

Talc.

The marbles of the Natas area, and the Duruchaus Series in general are often highly altered, so much so that locally they become talc with some calcite crystals embedded therein. In the Natas river near the new well sunk by Mr. Bassingthwaighte the entire thickness of marble of about 40 to 50 m. contains talc scales of a beautiful silver colour, and of a quality that could be used for the most delicate preparations such as face powder, etc. The Khomas Series contain many beds and lenses of talc schist of

No attempt is made to give the possible depths at which supplies might be expected, because of the great diversity of local conditions. Each selection has to be considered on its own merits.

Owing to the fact that about half the area is occupied by Basters, and a great deal of the other half is unfit for human occupation, very little boring has been done.

During the extensive boring campaign of the years 1927-30 several holes were drilled by Government machines. These are listed below. Of the boring during the German Regime, and by private machines on several of the farms no records are obtainable. The following list of boreholes has been taken from the records of the Irrigation Department and have been amended as regards the formation, where the writer has definite knowledge of the site:—

Year	Farm	Formation	Total Depth ft.	Water Struck at ft.	Water rises to ft.	Yield in galls per diem	Remarks
1927	Mahonda	Khomas Schists	427	265	180	240	Suitable for domestic use
„	„	„ „	301	—	—	—	Dry
„	Hoornkranz	Granite and Diabase	189	130	103	1680	Slight taste but potable
„	Swartfontein	„ „	298	265	85	240	Good for domestic use
1928	„	Granite	168	150	66	15,200	Good water but yield has since diminished
„	„	Sheared diabase in Granite	216	60 206	50	86,400	Yield diminished to almost nil
„	Namibgrens	Granite and Diabase	240	—	—	—	Dry
„	„	„ „	210	—	—	—	Dry
„	Alberta	Mixed Rocks	99	50	18	7200	Good for domestic use
„	Areb	Schists and Limestone	136	109	80	29,602	„
1929	Isabis	Granite with Sedimentaries	260	50 83	48	2000	„
„	„	Granite	157	60 82	50	23,000	„
„	„	„	202	175	45	33,000	„
„	Verdwaal	Khomas Schists	292	—	—	—	Dry

The above list could be supplemented by the record of wells dug on the various farms, but these are even more unsatisfactory than one would expect, especially in the nature of the formation and the approximate yield. It must be noted that the yield given in the table above is based on pumping or bailer tests of at most 9 hours. This time is too short, and the method too primitive for good results. It has happened, for instance in the case of one of the holes drilled on the farm Swartfontein, that the yield per diem has fallen to almost nil, although the test showed 86,400 gallons per diem.

A brief resumé of the various formations and their underground water possibilities follows:—

The Marienhof Series.

The extent of these beds is really too small to be considered in this connection, and besides their compact nature is against the possibility of strong water supplies.

The Duruchaus Series.

The schists of this Series are bad water carriers and the micaceous quartzites little more favourable, but the thicker marble bands have been proved to be fairly good sources of water. The four wells sunk to the south and south-east of Natas prove this, also the well on Swartmodder to the north of Natas.

The Khomas Series.

This on the whole is one of the worst water carriers of the whole area, and since some good pastoral farms are located on these schists it is a great drawback. The boreholes on Mahonda and Verdwaal cited above prove this. Boreholes have also been sunk on Hartelust, Naos, Friedental, Hefner, Hohenheim and Choaberib with varying degrees of success. Where the boreholes have been successful as on Naos and Choaberib there is always a contributary cause, such as the presence of a band of sandstone or marble in the compact schists. The same applies to wells sunk in this formation. The very productive wells on the upper reaches of the Djab river sunk by the Bassingthwaighte brothers in 1930 are located on a porous sandstone band in the schists. The porosity is increased by the fact that a certain percentage of calcite and pyrite has been leached out of the sandstone. Nowhere to the knowledge of the writer has a decent supply of water been tapped in the compact schists of this Series. If water is found, however, it can be reckoned on to be of good quality.

The Marble Series.

This is the best formation for sources of underground water, and where a moderately thick band of this formation crosses a strip of land it is practically certain that water can be obtained by means of a well or borehole. The wells on Hakskeen, Gurumanas, Vaalgras, the boreholes on Naos, the caves on Naos, the

wells to the west of Tsebris, some wells and boreholes on Choaberib, the well on Doornboom, and the borehole on Weissenfels are all on this band of marble. So are the borehole and wells on Portsmut, and the twenty or more Kuiseb springs mentioned in the opening chapters of this report all originate on this horizon or its equivalent, the graphite schists.

The quality of water from this Series suffers in comparison with that obtained from the schists. It is usually hard, and contains quantities of $MgSO_4$, and where the site is located in the graphitic schists, or when these are encountered in the borehole or well, the water usually smells of H_2S and rarely of SO_2 which makes it quite unpotable. The supplies from these marbles are usually copious, and in several cases, for instance at the Naos homestead, the water level has never been known to fall appreciably even after the severest droughts, and with day and night pumping.

The Quartzite Series.

Wherever this Series is developed to any thickness it is almost always overlain by the Marble Series, and has on this account seldom been tapped for its underground water-supply. It is not an unfavourable formation, in fact the extensive development of the basal conglomerates north of Aroams, and the fault lines of Tsebris with its thick tillitic grits should form very favourable sources of underground water.

Where the quartzites have been subjected to intense mechanical stress and consequent partial recrystallisation, the mass becomes too compact to be a reservoir for underground water.

The Nama Formation.

(1) *The Basal Beds.* These Beds must be classed with the best as far as water finding possibilities are concerned. In the first place they were deposited on an uneven surface, and secondly they consist for the greater part of coarse sandstones, pebbly grits and conglomerates, and in the lower layers of ground agglomerate. The occasional bands of mudstone and shale are beneficial rather than detrimental to the conservation of water. Unfortunately no boring has been done on these beds, and the few wells in existence are too shallow to be any criterion of the above theoretical views.

(2) *The Schwarzkalk* is another favourable formation for water finding. The intercalcated sandstone and shale beds act relatively as porous and impervious layers for the ground water while the shales of the Schwarzrand Series act as an impermeable layer for the limestones themselves. Again, the lack of boring and the very few wells chosen at suitable places prevents us from testing these observations. The fault lines of Rokskeur—Bullspoort, and the lesser faults north of Rokskeur can all be exploited to advantage.

The water obtained from these beds is usually hard and slightly brackish, but once used to it is not unpotable, and locally believed to be very healthy. The best supplies obtained by wells in this formation are on Uikans, Garis, Nauzerus and Noab and the springs of Kanbis, Noab and Garis.

(3) *The Schwarzrand Series.* The shales are too impervious to be good water carriers, and the quartzites are very compact and hence not very favourable. Supplies of good water have been tapped in these quartzites on Achaub and also to the west of Achaub. At both localities the water issues from master joints and fractures in the quartzite on the axes of local folds.

The Mixed Rocks.

These rocks have been proved to carry supplies of underground water where the schistose sedimentary mixture, or the gneiss, approaching granitic composition, is not too much in evidence. These mixed rocks usually contain crush-zones, and these are favourable. Strong supplies of good water have been obtained from these rocks on Areb, Alberta, Namibgrens, Nauams and Morgenroth, and also on Kabiras and Auchas. The shelving debris-covered valleys, underlain by these mixed rocks, would with judicial selection yield good supplies of water.

Granite.

The massive granite should always be avoided, and even the decomposed granite, although it might yield an enormous supply on opening up, is not a permanent source, for instance the one borehole on Swartfontein. The valleys filled by granite debris usually yield good and lasting supplies, provided the subsoil is deep enough, and replenishment takes place from time to time. The borehole near the homestead on Morgenroth is an example of this sort. The granite, even in its most compact zones usually contains lines of crush or fracture, dykes of sheared diabase or lenses of incorporated sedimentary rock on which small supplies of water can be obtained. The boreholes on Nauchas, Swartfontein and Isabis and the numerous wells on Namakorabis and throughout the Baster Gebiet, testify to the correctness of this. The supplies are of excellent quality, but dependent on the rainfall to such an extent that in the winter of 1930 the majority of them dried up.

Recent Deposits.

The water holes of the Namib are storage rather than underground supplies, and are all of a temporary nature. The wells on Ababis in the lime-cemented Namib detritus yield good and fairly constant supplies, but are undoubtedly being fed by a subflow in the Tsondap river.

C. *STORAGE DAMS.*

Projects suitable for small farm dams abound in this area, and many dams have been constucted under the Government-

aided schemes. The dams built in schist areas are usually of cheap construction owing to sharp V-shaped valleys, but they have been found liable to silting-up. The dams in the large granite areas have been more expensive but more successful on the whole. As the result of dam construction, wells and bore-holes in the immediate vicinity have in many cases been made to yield permanent supplies where formerly they dried up after the rainy season. Shallow barrages across stream beds and spruits thrown up at little cost, can in this way do much to relieve the acute distress often caused by water shortage.

D. *TEMPORARY SUPPLIES.*

The sandy bottoms of the rivers and the occasional pans yield temporary supplies of drinking water after the rainy season and occasionally, as for instance, at Gurumanas, permanent supplies.

CHAPTER XIV.

AGRICULTURAL AND PASTORAL PROSPECTS.

The agricultural prospects of this area are almost nil, for apart from local horticulture and the growing of maize and pumpkins along the larger rivers, there is no agriculture being practised, neither is the soil or rainfall favourable.

The farmers are all pastoral, and the area is eminently suitable for the raising of various kinds of stock.

Horse breeding was once a profitable and flourishing occupation both in the Baster Gebiet and outside. Nauchas and Areb were the stud farms of the Imperial German Government, while Ababis was famous once for its thorough-breds, and is today the only farm in this area where horse breeding is still practised on a small scale. The coming of the motor car has practically ended this industry.

Cattle raising with its subsidiary cream-production, has been the mainstay of the greater number of inhabitants. Lately some of the more progressive farmers have introduced full-blood stock to improve their herds both as regards the milking and beef qualities. Swiss, Shorthorn, Aberdeen Angus, Simmenthalers and a few Frieslands have been noticed. What is needed for this area of rough veld and long distances to water is a type combining the milking qualities of the Swiss with the hardiness and beef qualities of the Afrikander.

Afrikander sheep and goats thrive exceedingly well in this area, and both Basters and white settlers produce an excellent quality of mutton and lamb.

Karakul breeding has become popular in the last few years, and the quality of pelt produced is second to none in South West Africa. Moreover, it is found that the cross between the Afrikander and Karakul produces a type well suited to the exacting climatic conditions and in quality of mutton equal to the pure-bred Afrikander.

The pasture on the Khomas highlands is of a very good quality for cattle and sheep, but the abundance of quartz rubble and consequent "sharp" veld coupled with the sparsity of watering places results in part of the farms not being used, and the other part overstocked. This overstocking also applies to the other areas, and has the detrimental effect of destroying the good forage grasses followed by a spurious growth of "steekgras" and other hard grasses of little feed value.

The grazing on the granite veld is the best in this area, and were it not for the scarcity of water and the difficulty of "making" water most of these farms could carry far more stock than at present.

On the whole this area represents one of the best and healthiest farming districts in South West Africa, and it is a great pity that the best portion of it should belong to a people with such a lack of enterprise as the Rehoboth Basters.