UNION OF SOUTH AFRICA

DEPARTMENT OF MINES

GEOLOGICAL SURVEY

THE GEOLOGY

OF THE

COUNTRY AROUND POTCHEFSTROOM AND KLERKSDORP

An Explanation of Sheet No. 61 (Potchefstroom).

BY

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II.—THE AREA AND ITS PHYSICAL FEATURES.

The area described here is one of 2,128 square miles and extends from latitude 26° 30′ to 27° south and from longtitude 26° 30′ to 27° 30′ east. The larger part of the area is in the Transvaal and includes only a small part of the Orange Free State south of the Vaal river which serves as the provincial boundary. On the Transvaal side of the Vaal river the sheet includes most of the Potchefstroom district, the eastern half of the Klerksdorp district and a little of the Ventersdorp district. South of the river the country embraces parts of the districts of Vredefort and Bothaville.

The region is comparatively well populated. Potchefstroom and Klerksdorp, the two oldest settlements in the Transvaal, and Parys and Vredefort are the principal villages. According to the 1936 census the first three have European populations of 10,774, 4,561, and 2,905 respectively, while Vredefort has under 2,000. Outside urban areas the closest settlements, as may be expected, are mostly along some of the rivers or minor streams. The rural community is chiefly occupied with cattle rearing and maize farming, but various other crops are also raised on narrow alluvial flats under irrigation along the banks of the principal streams.

The means of communication are good. The main railway line from Johannesburg to the Cape passes through Potchefstroom and Klerksdorp. Fochville on the eastern border of the map is the terminal station of a branch line from Potchefstroom, and Vredefort on the southern boundary is the terminal of another branch line passing through Parys on to Dover where it joins the main railway line between Johannesburg and Bloemfontein. The national road from the Cape runs across the area from south-west to north-east through both Klerksdorp and Potchefstroom. The various towns or villages are further linked up by good main roads and a large number of farm roads traverse the country in all directions.

For the greater part the area is covered with grass diversified by occasional clumps of shrubs and trees. Bare grassy plains or uplands, however, give place to moderately thick growths of scrub and bush in hollows and valleys or along the lower slopes of ridges. In some valleys especially, of which that of the Vaal river affords a fine example, unusually fine thorn trees give the country a well-wooded aspect. Hills and prominences of quartzite usually support a thin growth of sugar bush and, not infrequently, some formations or the approximate junction between two formations tend to be more thickly studded with bush or scrub. (L.T.N.)

Elevation and Relief.

The country, which forms part of the High Veld of the Transvaal, has an average elevation of roughly 4,500 feet above sea level. Various heights of trigonometrical stations, railway stations and sidings are given below.

LIST OF HEIGHTS OF TRIGONOMETRICAL STATIONS, RAILWAY STATIONS AND SIDINGS.

	Eng. Feet.
Witkop II (B–4)	5534
Bakenkop (B–4)	5524
Baviaanskranz (B–4)	5396
Witrand (B–4)	5368
Schoemansdrift (B–3)	5324
Rietpoort (B–4)	5249
Naauwpoort (A–3)	5178
Grootfontein (B–4)	5133
Platberg (A–1)	5130
Rooderand (B–3)	5120
Bulskop (A–2)	5111
Rietfontein I (A–4)	5080
Rooipoort (A–2)	5065
Rustig (B–3)	5051
Goedgevonden (A–2)	5047
Hartbeestfontein (A–4)	5029
Potchefstroom (A–2)	5017
Vaalkop (A–3)	4981
Leeuwfontein (A–2)	4977
Fochville station (A–4)	4929
Witpoort (A–4)	4913
Roodekraal (B–3)	4893
Enzelspoort (A–4)	4841
Reebokfontein (B–1)	4822
Rietkuil (A–2)	4819
Townlands (Potchefstroom) (A–3)	4812
Vyfhoek (A–3)	4800
Kaffirkop (B–4)	4781
Benekraal (B–1)	4760
Vaalkop (A–1)	4738
Parys (B–4)	4737
Paradys (B–2)	4731
Losberg siding (A–4)	4726
Rietfontein II (A–4)	4717
Oudedorp (A–3)	4683
Rooikoppies (A–4)	4679
Frederiksstad station (A–3)	4670
Walkraal (B–3)	4656
Parys D.R.C. (B–4)	4639
Scandinavia (B–3)	4629
Parys station (B–4)	4609
Enselspruit siding (A–4)	4601
Boskop station (A–3)	4591
Rietfontein (A–2)	4584
Lubbe (A–1)	4543
Droogespruit (B–2)	4539
Klington siding (A–3)	4536
Bonanza siding (B–1)	4535
Loopspruit siding (A–4)	4522
Southleigh (B–1)	4489
Welgevonden (B–3)	4488
Townlands (Klerksdorp) (B–1)	4485
Klipdrift siding (A–4)	4471
Zandpan (B–2)	4466
Klerksdorp (B–1)	4456
Tarentaal siding (A–3)	4454
War Memorial (Potchefstroom) (A–3)	4434
Cachet siding (A–3)	4418
Kareerand (B–2)	4406
Potchefstroom station (A–3)	4398
Afrikander station (B–1)	4396
Machavie station (B–2)	4382
Koekemoer station (B–2)	4365
Klerksdorp station (B–1)	4309
Milner Bridge siding (B–1)	4256
Ariston siding (B–1)	4247
Eastleigh junction (B–1)	4239

Map reference to localities given in brackets.

The present shape of the ground is partly the effect produced by pre-Karroo denudation on folded and dislocated strata and partly the result of the renewed action on these rocks by processes of weathering and corrasion following the removal of the covering of Karroo beds. This is proved by the disposition of the more or less horizontally bedded Karroo beds. The various outliers of these beds as a rule lie at a lower level than the surrounding ground occupied by older formations and, just beyond the southern limit of the accompanying map, the older rocks gradually disappear under the great expanse of Coal Measures in the Orange Free State, the ragged fringes of which extend into valleys and encroach upon the ridges carved out of older rocks in the hilly country about Vredefort until, finally, there only remain as inliers a few of the more prominent peaks of a former landscape. It is possible that certain ridges and prominences of Witwatersrand rocks around Klerksdorp may also be remnants of a former landscape but dating back to an even earlier perod than that immediately preceding Karroo times. Drilling operations in the cover of Ventersdorp beds and the relation of these beds to those of the Witwatersrand system show that the former were laid down on a surface of the latter that possessed strong relief in places.

The distribution of high and low ground is closely related to the underlying rocks and to the denudation to which they have been subjected. As the area under review presents a considerable variety of formations, the distribution of each of which is often marked by some characteristic topographic feature, it is advisable to discuss the physical features consequent on the nature of each type of rock separately.

Older Granite scenery, whether near Klerksdorp or around Parys and Vredefort, is that of fairly level or gently undulating ground occasionally relieved by low dome-shaped masses and hummocks of exfoliated rock or small stacks of rounded blocks. Often over large stretches of ground the granite is covered with a light sandy soil.

In striking contrast to the gently rolling granite plain on which Parys and Vredefort are located is the mountainous aspect of the highly inclined Witwatersrand rocks encircling it. The Witwatersrand system there is built up of a series of quartzites, shaly and hornfelsic rocks with intrusive diabases, and their differential weathering produces an interesting type of rugged scenery. Ridge upon ridge of quartzite, of varying elevations up to a thousand feet above the level of the Vaal river, sweep round in broad concentric curves separated from one another by deep valleys or shallow depressions carved out of shaly beds or intrusive diabase sheets. Abrupt terminations of these features are generally due to the presence of transverse faults or igneous intrusions. Many ridges, especially those forming the inner ranks, are sharply crested due to the steep or vertical dip and the narrow width of some quartzites. On many of them, too, beautiful dip slopes are frequently seen which, because of inversion of the beds, face towards the central granite. The rugged nature of the country is especially evident about the little village of Venterskroon where, from the top of any of the bold ridges in the vicinity, fine and extensive views can be obtained across the numerous closely ranked parallel ranges. (L.T.N.) The most striking feature, however, of the Venterskroon country, and one which is unfortunately too rare throughout the greater part of South Africa, is the association of mountain scenery with fine stretches of water formed by the wide reaches of the Vaal river, which traverses the greater part of the mountain region. (E.T.M.)

The Witwatersrand system in its topographic expression is much less impressive in the country about Klerksdorp. There these rocks, largely belonging to the lower portion of the system, are responsible for a series of parallel ridges with intervenient valleys, the trend of which corresponds to the general N.E.–S.W. strike of the formation. The differences in level between the crests of quartzite ridges and the floors of valleys or depressions occupied by shales or diabase sheets are seldom as much as 200 feet. North-east of Klerkdorp these features become less and less prominent as one passes from the base upwards in the succession of Witwatersrand rocks to where they pass underneath later Ventersdorp beds showing little relief. Along the strike south-westwards Witwatersrand quartzite ridges also flatten out until the quartzites eventually disappear under amygdaloidal lavas of the Ventersdorp system in comparatively low, flat ground. On the western border of the map a patch of irregular hilly ground marks another emergence through Ventersdorp lavas of lower Witwatersrand quartzites and shales. (L.T.N.)

Outside the very rough and hilly zone occupied by the Witwatersrand system to the south-east of Potchefstroom, and between it and the low-lying Dolomite zone, lies that occupied by the volcanic rocks, mainly amygdaloidal diabase of the Ventersdorp system. These rocks occupy a well-marked belt of country, of a very uniform breadth of about three and a half miles, easily recognised by its physical characters. It rises into broad swelling hills forming a more or less continuous range extending from near Lindeque's Drift (off the eastern boundary of the map) to beyond De Wet's Drift (B–3) and constituting the watershed between the tributaries of the Loop spruit and Mooi river, and the smaller streams flowing southwards to join the Vaal more directly. These hills reach a considerable elevation, only slightly below that of the massive quartzite ridges of the Witwatersrand system. They are usually broadly rounded at the top, very smooth in outline, and without any prominent surface features. (E.T.M.)

Around Klerksdorp, on the other hand, the lavas do not rise into any conspicuous ridges or hills but, instead, occupy wide expanses of comparatively level or gently undulating ground. Features that do stand out in areas underlain by Ventersdorp beds are built of quartz porphyry, coarse volcanic breccias or boulder beds and, to a lesser extent, of tuffs and other sediments.

The dark ridge overlooking the valley of Schoon spruit at Klerksdorp is formed by a sheet of Ventersdorp quartz porphyry gently inclined to the west. The extension of this sheet northwards is also responsible for some detached pyramidal kopjes on both sides of the Schoon spruit and for an irregular mass of low bushy hills in the north-eastern corner of Kafferskraal 36 (B–1). One of the most prominent features in the landscape of the country around Klerksdorp, Platberg (A–1), is capped by a sheet of quartz porphyry. There this rock lies on the axis of a large shallow syncline or basin-shaped fold. The even crest line of Platberg is about 500 feet above the general level of the plain extending from the north-west round to south-west. Below the quartz porphyry cap, bounded by vertical cliffs or kranzes, is a succession of lavas and diabase sheets, tuffs and volcanic breccias, the differential erosion of which has engraved a well-marked terraced character in the western slopes of the hill.

The coarse volcanic breccias or agglomerates about Platberg either build isolated bushy hummocks or hillocks of large blocks rounded by weathering or give rise to rough uneven ground. Where this rock occurs in flat ground its presence may be revealed by rounded outcrops that project slightly above the surface of the ground. Tuffs and other sediments generally show no special configuration distinct from those of the other members of this formation, but occasionally they do rise into low eminences or bults. (L.T.N.)

On the western border of the sheet, however, is a prominent south-north trending escarpment of almost horizontal beds of sedimentary rocks belonging to the Ventersdorp system which dominates the wide rolling plain, largely underlain by granite and amygdaloidal ava, east and north-east of it. On Buisfontein 27 (A–1) the northerly trend of this upland suddenly ceases and the escarpment bends round to continue in a westerly direction without losing its dominant aspect. Streams on Lapfontein 35 (A–1), Buisfontein 27 and elsewhere have made deep incisions into the otherwise resistant cherts, shales and calcareous deposits forming the escarpment, and have in places produced very rugged scenery. On the last-mentioned farm especially, the drainage channels are truly canyon-like in character. (J.W.)

The continuous zone of Dolomite which extends in a wide curve from Modderfontein 52 (A–4) in the east across the Vaal river at Grootedrift 16 (B–3), sixteen miles due south of Potchefstroom, to France 671 (B–3) in the Orange Free State, where it leaves the area in question, has a characteristic effect upon the surface topography. It forms a belt of country usually lying at a comparatively low level between the broad hills of amygdaloid on the one hand and the sharp ridges and escarpments of the Pretoria series on the other. As a rule the country is thickly grassed and dotted over at intervals with small but dense clumps of trees. These are frequently particularly numerous and tend to form a continuous and thick belt of timber along the outcrop of the Black Reef series along its junction with the amygdaloid, a feature especially noticeable where the junction is crossed by the main road from Potchefstroom to Ventersdorp. Although the Dolomite area usually forms comparatively low-lying country, certain portions of it, in which strong bands of chert form a prominent constituent of the rock, frequently give rise to small but prominent ridges and kopjes, distinguished by the extreme roughness of the outcropping chert and its debris. Such ridges are most abundant near the junction of the Dolomite with the Pretoria series where, on the uppermost portions of the Dolomite, cherty beds are strongly developed.

To the north and west of Potchefstroom, beyond the margin of the Pretoria series, lies a second zone of Dolomite similar in character to that already described to the south-east of the town. (E.T.M.) Over a large part of this gently undulating country outcrops of massive "olifantsklip" or dolomite either lie flush with the general surface of the ground or the rock is covered by only a thin layer of soil, a type of scenery which is locally known as the "Klipveld". This is especially the case in the occurrence of this zone in the Orange Free State just before it disappears towards the south under the sandy soil resulting from the disintegration of the rocks of the Coal Measures. In the Transvaal the monotony is to a certain extent relived by the presence of an outlying belt of Karroo sediments on the Dolomite in the vicinity of Koekoemoer station and also by the presence of the Koekoemoer or Kromdraai spruit which traverses this zone in a southerly direction. On the west this Dolomite region is demarcated by a belt of bushy ground so typical of areas occupied by rocks of the Black Reef series. (J.W.)

The tongue of Dolomite country which extends southwards from Witstinkhoutboom 146 and Oude Dorp 25 (A–3) differs in many ways from the main body. It is traversed in part by the fine stream of the Mooi river, the narrow alluvial flats under irrigation along the banks being among the most productive land in the Transvaal. Several strong springs are discharged into the Mooi river along this portion of its course. From Witstinkhoutboom southwards the tongue of Dolomite frequently rises into rough ridges of considerable elevation which terminate near the railway to the south-west of Potchefstroom.

The junction between the Dolomite and Pretoria series is usually marked by conspicuous ridges formed partly by the thick beds of resistant chert occurring near the top of the former, and partly by the lowermost quartzite of the latter. In the south-eastern part of the region these rocks form an almost continuous line of ridges, usually double in character, extending from beyond the eastern border of the sheet to near de Wet's Drift (B–3). (E.T.M.) In the Orange Free State the chert component of the ridge is more or less continued but the quartzite becomes less conspicuous. (J.W.) The ridge forms one edge of the very wide belt of country occupied by the Pretoria series.

This belt, which has an average width of 15 to 20 miles, forms the central part of the broad syncline, the major structural feature of the area, with many minor synclines and anticlines, lying between two parallel belts of Dolomite country as shown on the map. From that on the south it is separated by the ridge above alluded to, while its northern edge is formed by the prominent and well-known range of the Gatsrand, which lies for its greater part beyond the limits of the area included in the present description. The Gatsrand which forms so prominent and continuous a feature in the country between Johannesburg and Potchefstroom is interrupted to the north of the latter town by the folding and faulting which brings in a tongue of the Dolomite to the west of the railway. Beyond this interruption the range is, however, continued from Witstinkhoutboom 146 towards the south-west as a pronounced line of hills as far as Machavie station, beyond which point the quartzites at the base of the Pretoria series cease to give rise to any conspicuous surface features, although the upper portion of the Dolomite is usually represented by prominent ridges.

The broad belt of country occupied by the Pretoria series shows more diversity within its limits than the other zones already referred to. Geologically the series consists for the most part, as elewhere in the Transvaal, of shales and intruded diabases, with quartzites well developed at three different horizons. The shales and diabases usually form the valleys and depressions, while the quartzites give rise to more prominent surface features, usually in the form of sharp and well-defined ridges. Where, however, the quartzites are very highly inclined or vertical they frequently give rise to no surface features at all while, on the other hand, if horizontal, or nearly so, they produce broad flat-topped hills of the "Tafel-kop" type—such as the Los berg in the north-eastern part of the area at the head of the Loop spruit, Paarde kop to the east of Boskop station (A–3), Spits kop (A–2) to the west of Potchefstroom, and the small raised platform to the south of Potchefstroom on the farm Prinsloosrust 93 (B–3).

The broad flat-topped Los berg dominates the upper portion of the Loop spruit and is one of the most conspicuous features of the Potchefstroom district. It lies between two arms of the Loop spruit and is a typical example of circumdenudation. In addition, it is situated on the axis of the main syncline in the Pretoria series and consists for the most part of beds of the uppermost quartzites which, dipping at low angles towards the centre of the mountain, have successfully resisted the denuding forces which have excavated the broad valley in which it stands.

Of similar structure and origin is the hill known as Spits kop which from its symmetrical shape forms a conspicuous and easily recognised landmark to the west of Potchefstroom. This kop like the Los berg occupies the centre of a synclinal fold, the "Spits-kop" syncline, in the Pretoria series, the synclinal structure giving rise to a characteristic elevated area of about fifty square miles in extent surrounded on three sides by the lower ground of the Dolomite. Around the margin of this area run the parallel ridges formed by the upper cherty bands of the Dolomite and the lowest quartzites of the Pretoria series within which extend the higher and broader ridges formed by the extensive sheet of amygdaloidal andesite which occurs at this horizon and which rises at its northern extremity into the heights of Vaal kop. In the midst of the lower ground in the centre of the syncline stands the miniature peak of Spits kop consisting of a base of shales capped by the remains of the middle quartzites of the Pretoria series. This small synclinal area around Spits kop is cut off to the south by a series of faults whose course corresponds with the depression followed by the Klerksdorp railway line between Potchefstroom and Machavie.

Along the south-eastern limb of the major syncline quartzites of the Pretoria series, many times repeated owing to a complicated series of folds, give rise to several roughly parallel ridges whose distribution will be best understood by reference to that of the corresponding quartzites on the map. In some instances the folding of the quartzites causes their outcrops at the surface to give rise to prominent ridges disposed in circular fashion, which form a somewhat peculier feature in the topography of the district. Examples of these curved ridges are those indicated by the quartzites shown circling round the south-western beacon of Palmietfontein 109 (A–4), on Syferfontein 154, on the eastern boundary of Elandsheuvel 123 (A–3), on Welgevonden 39 (B–2), and round the trigonometrical beacons Scandinavia (B–3) and Paradys (B–2) in the Orange Free State. (E.T.M.)

On the southern side of the Vaal river and west of longtitude 27° the predominantly sandy nature of the soil is a noteworthy feature, a phenomenon due in places to the presence of underlying Karroo rocks and in other localities due to the incomplete removal of the products of disintegration of such rocks from the extensive area which they have occupied. (J.W.)

Climate and Rainfall.*

Climatic records have been kept at Potchefstroom and Klerksdorp for periods of 25 and 12 years respectively. At Potchefstroom these records show a mean annual temperature of about 62·7° Fahrenheit with a range from 72·8° F. to 49·2° F. between the hottest and coldest months of the year. At Klerksdorp the corresponding figures are 63·8° Fahrenheit with a range from 73·4° F. to 50·0° F.

* Meteorological data supplied by the Chief Meteorologist, Division of Meteorology, Irrigation Department of the Union of South Africa.

The average rainfall at various places within the area is shown in the following table :—

Station.	Longitude.	Latitude.	Period in Years up to end of 1935.	Mean Annual Rainfall in Inches.
Boskop	27°08′	26°33′	29–31	23·85
Brakspruit	27°00′	26°44′	19–20	23·48
Doornfontein	26°40′	26°38′	2–3	25·85
Doornfontein	26°44′	26°34′	8–9	20·21
Eleazar	26°51′	26°41′	20	21·20
Frederikstad	27°09′	26°31′	23–26	21·45
Hartebeestpoort	27°18′	26°45′	10–11	23·13
Klerksdorp	26°40′	26°52′	38–40	22·88
Klipdrift	27°19′	26°35′	18–20	24·71
Koekemoer	26°49′	26°50′	29–31	22·62
Koppieskraal	27°22′	26°54′	26–31	23·25
Leinster	27°06′	26°58′	22–24	21·58
Limerick	27°04′	26°57′	11–12	23·21
Machavie	26°58′	26°47′	30–32	23·84
Mooibank	27°07′	26°41′	31–32	23·34
Parys	27°27′	26°54′	26–32	25·31
Potchefstroom (station 1365)	27°05′	26°43′	32–33	25·38
Potchefstroom (station 1366)	27°05′	26°44′	33	23·76
Potchefstroom railway station	27°05′	26°43′	27–31	23·84
Potchefstroom Reservoir	27°06′	26°41′	16–18	25·10
Request (Welgegund)	26°45′	26°45′	15–16	22·08
Rietfontein	27°24′	26°34′	3	23·56
Rooipoort	26°49′	26°36′	6–7	23·96
Smithfield	27°06′	26°47′	9–12	22·37
Tygerfontein	27°13′	26°52′	6–7	24·92
Vredefort	27°22′	27°	27–29	26·40
Vyfhoek	27°08′	26°41′	14–15	21·92
Waterford	26°54′	26°58′	16–19	20·29
Welgegund	27°00′	26°35′	6–7	22·69
Wildebeestlaagte	27°02′	26°31′	3–4	21·22
Witkop	26°42′	26°58′	17–19	18·31

Most of this precipitation falls during the summer months, usually as thunderstorms.

Drainage.

The Vaal river with its branches drains the whole area. Its principal tributaries are the Mooi river, the Schoon spruit and, on the Orange Free State side, the Rhenoster river. A striking feature of the Rhenoster river is the narrowness of its channel between steep vertical walls 25 to 30 feet high.

The Vaal river flows practically across the entire length of the southern part of the area. Its course, often meandering, trends normal to the strike of the formations, thus suggesting a superimposed drainage sytem. Its banks, generally consisting of alluvium variable in extent according to the bend in the channel, are usually thickly overgrown with bush. Up to now this section of the river has not been exploited for irrigation purposes since the cost of raising the water from its present level to that of the irrigable land on the relatively high banks would be very great. For watering stock, however, it constitutes a never-failing supply. (J.W.)

Between the ranges of hills formed by the quartzites on the northern and southern margins of the broad belt occupied by the Pretoria series, a particularly wide and open valley extends for nearly 40 miles from Los berg, south-westwards to the junction of the Mooi and the Vaal rivers, and has an average width of about eight miles. Near the middle of its length lies Potchefstroom. This valley, which forms one of the main physical features of the area, approximately coincides with the axis of the big syncline in the Pretoria series. It is traversed in the upper portion by the Loop spruit, and in its lower portion by the joint stream of the Loop spruit and the Mooi river which, above the junction, occupies a much less conspicuous valley than that of its tributary.

The fine perennial stream of the Mooi river, which determined the position of one of the earliest settlements in the Transvaal and of the ancient capital Potchefstroom, is derived almost entirely from strong springs in the Dolomite, and is many times greater than the ordinary discharge of Loop spruit.

Both the main valley of the Loop spruit and that branch of it traversed by the Klein Loop spruit or Rooikraal spruit are remarkable for the broad extent of almost flat land which occupies the greater portion of the valley. These two spruits, although occupying such large valleys and draining such extensive areas, discharge but a very small quantity of water. For a considerable portion of the year they do not flow, but consist of numerous disconnected pools.

Both the Loop spruit and the Mooi river below Potchefstroom have a very low gradient and pursue meandering courses between the steep banks of alluvium many feet in depth. The erosive power of these streams is practically nil, and the whole aspect of the broad valley which they traverse is that of one which belongs to a drainage system which has almost attained a base level of erosion.

Those areas occupied by the Dolomite are characterised by a rapid absorption of surface waters and although usually forming a portion of the low-lying parts of the country they are rarely traversed by well-defined and continuous valleys and spruits and are without the numerous channels of surface drainage common to other geological formations. Where a definite channel does exist as, for example, the Kromdraai or Koekemoer spruit, the channel carries no running water except shortly after rain. A striking exception is the Mooi river above Potchefstroom which carries a large volume of water for a considerable distance over dolomite. The existence of considerable bodies of water in the Dolomite is, however, shown by the frequent occurrence of exceptionally strong springs where the elevation of the surface is sufficiently low, such springs, spruits, and rivers usually rising either close to or but a short distance from the banks of the main spruits and rivers. As examples may be mentioned the springs on Buffelsvallei 87 (A–3)* near Boskop and on Oudedorp 25 and Witstinkhoutboom

* Erroneously spelt Buffelsvalei on the degree sheet issued by the Surveyor-General and on the geological map. Given as Buffelsvley on the original diagram of the farm in the office of the Surveyor-General of the Transvaal.

146 (A–3), discharging into the Mooi river, and that on Hartbeestfontein 41 (B–2) discharging into the Koekemoer spruit. In the last-mentioned case the water disappears before reaching the Vaal into which it probably finds its way below the surface together with other waters from the Dolomite area.

Caverns occur in the Dolomite and are especially interesting on account of their connection with the behaviour of the surface and underground waters in Dolomite areas, and their obvious connection with local subsidences of the surface frequently met with. A very striking example of such subsidence occurs on Modderfontein 52 (A–4) near the middle point of the northern boundary of the farm. It consists of a hollow, about 150 yards in length and 50 yards in width, with a depth of about 30 feet, and with steeply inclined or overhanging sides. There is no alteration of the surrounding surface, so that the presence of the hollow cannot be detected at a distance. A small spring, said to be permanent, rises near one end of the depression, the water of which after flowing a few yards disappears. At the deeper end of the subsidence there are a number of vertical fissures and small caves in the chert. Although there is no obvious entrance, the extent of the surface subsidence points to the existence of a considerable cavern in the vicinity.

A similar origin must be attributed to the still more extensive depressions occasionally met with in Dolomite areas, an example of which occurs just west of the Ventersdorp road, about nine miles north-west of Potchefstroom. The depression lies in the centre of the farm Welgegund 84 (A–2). It is about a quarter of a mile in diameter and 20 feet below the general level, resembling a pan in general form. Although, however, a considerable quantity of water is brought into it by the drainage of the surrounding ground, there is no tendency to form a swamp, and even after heavy rain there is no accumulation of surface water, which disappears rapidly into the Dolomite below.

Caverns are more likely to be discovered in the cherty zones. Owing to the resistant character, the massive cherts prevent the falling in or crushing together of the formation after the solution of the more calcareous beds, and also render the entrance to such caverns more easy of discovery and entrance. Such caverns occur on the farms Eigenaarsfontein 116 (A–4) and Modderfontein 52 (A–4). The cavern on Eigenaarsfontein is very characteristic. It is situated at the base of a small kopje of chert about one mile N.N.W. of the south-east corner of the farm. The entrance, an obscure opening scarcely two feet in diameter, opens almost vertically into a fissure between chert walls, leading downwards at a very steep angle, necessitating the use of rope in places. The general slope of the descent is towards the north, and the main fissures run east and west between flat or curved walls of rough chert, often much brecciated, originally interbedded with thin beds of limestones, 4 to 6 inches in thickness, which have been almost entirely removed by solution. From the descending fissure several chambers of considerable size open laterally. A descent was made to about 100 feet below the surface, beyond which the passages, partially filled with bat guano, become too small to be easily followed. (E.T.M.)

Like the Mooi river, the Schoon spruit—also a perennial stream—derives most of its water from strong springs in the Dolomite beyond the northern limits of this area. In this country the Schoon spruit, with its principal tributary the Jagd spruit, flows mostly through a slightly undulating plain occupied by the Ventersdorp amygdaloid, except in the north-western corner of the sheet where it traverses flat land underlain by the Older Granite. (L.T.N.)

The spruits which rise in the Ventersdorp amygdaloid country south-east of Potchefstroom are few in number and small in size, although usually rising in broad catchment areas. Such streams as exist are, however, fairly permanent in character. (E.T.M.) Streams that rise in Witwatersrand rocks do not flow for a large part of the year, though the deeper pools often retain their water, occasionally even during periods of fairly severe drought. (L.T.N.)

With the exception of the supplies already mentioned the Potchefstroom district is characterised by the comparative poorness of springs and streams, the smaller kind of spring such as is of frequent occurrence in other districts being rare. A few are found in the heavy deposits of sand which accumulate round the broad flanks of the Los berg from the weathering of the quartzites above. Most of the ridges formed elsewhere by the Pretoria quartzites in the district afford insufficient catchment to give rise to permanent springs. (E.T.M.)

III.—GEOLOGICAL SUCCESSION AND STRUCTURE.

Geologically speaking, the country around Potchefstroom and Klerksdorp is one of the most varied districts in the Transvaal for, with the exception of the Waterberg system, all the principal geological formations from the Witwatersrand system up to the Coal Measures are represented. The Swaziland system, however, is represented by one or two small patches only of highly altered rocks that occur as inclusions in the Older Granite in the south-east corner of the area. Moreover, at different times these formations were invaded—sometimes extensively—by igneous rocks. The igneous rocks are mostly gabbroid or doleritic rocks in the form of sheet-like and dyke-like bodies, but the presence of diorite, various syenites, a younger granite and an enstatite granophyre has also been established and, very likely, additional types not mentioned here will be disclosed by a closer examination of the intrusive rocks in this region.

The Older Granite is the foundation rock upon which the Witwatersrand system and other later formations rest. The following table gives a complete list of the various formations :—

the greenish light-coloured rock near the drift across the Rooikraal spruit. (J.W.)] In size, shape and mode of distribution they correspond with the amygdales of calcite and other secondary products which occur in the country rock.

These small lodes of bornite do not appear to be connected with any distinct lode. The mode of occurrence is unusual and suggests an impregnation of the country rock with copper ores, which have been mainly deposited in pre-existing vesicles corresponding to the amygdales in other neighbouring portions of the intrusion. Near the surface the vesicles are empty or partially occupied by coatings of malachite and azurite. (E.T.M.)

IRON.

Reference has been made to the highly ferruginous shales occurring in the Daspoort group above the amygdaloidal lava. Wagner distinguishes two horizons to the north-east of Potchefstroom: an upper or main horizon and a lower one of no economic significance. According to him the total estimated reserve on the main Daspoort horizon from Gerhardminnebron 4 and Buffelsvallei 87 (A–3) southwards past Paardekop, and through Boschhoek 159 (A–3, 4) and Deelkraal 63 (A–4) in an easterly direction as far as Wildebeestkuil 3 some five miles east of the easterly margin of the map, is of the order of 1,000,000,000 tons. The bulk of this should average 45 per cent. of iron and between 15 and 20 per cent. silica. Excluding the ore on Gerhardminnebron 4 and Buffelsvallei 87, which is probably for the most part potential, some 42,000,000 tons of the total are exposed on the surface or can be obtained by open-cast or adit mining.* (J.W.)

XII.—UNDERGROUND WATER RESOURCES.

By F. C. TRUTER.

Since agriculturists have already taken full advantage of the excellent, although localised, perennial supplies of surface water, it must be obvious that the future development of the area under review will depend mainly on the extent to which the underground water resources can be exploited. Methods and cost of recharging, conserving and recovering the groundwater, its depth, quality and adequacy for the growing needs of rural and industrial development have therefore become questions of primary economic importance. In view of the rapid expansion of agricultural and mining industries in the area, a preliminary survey of its ground-water resources has been undertaken. The results of this investigation are incorporated in the present account which is based partly on valuable information furnished by well and borehole records and partly on data collected in the field.

* For more detailed information the reader is referred to: "The Iron Deposits of the Union of South Africa, by P. A. Wagner." *Mem. geol. Surv. S. Afr., No.* 26, 1928, *pp.* 105–111.

I.—The Older Granite.

The Older Granite is exposed only in the extreme north-western and south-eastern portions of the area. It is traversed in both localities by basic dykes or sills.

A.—Klerksdorp–Ventersdorp Area.

The north-westerly occurrence comprises an even-textured, medium-grained granite which is mostly concealed under a porous cover of sandy soil or surface drift. It is confined to the valley of the Schoon spruit and thus intercepts the drainage of a large catchment area. Along this major drainage line surface run-off is reduced to a minimum by the low hydraulic gradient of the peneplain and the high permeability of its overburden. The annual recharge of the subsurface supply is therefore enormous and the granite is usually decomposed to a porous material from which large quantities of water can be recovered at moderately shallow depths.

(a) *Seepage Supplies.*

The low surface relief and the spongy nature of the weathered granite cause the groundwater to be discharged as seeps rather than as well-defined springs. The seeps occur over wide areas along drainage channels and depressions and are usually small and often intermittent. In many cases considerable volumes of water can nevertheless be obtained from this source by the construction of underground barriers or by trenching along contours.

(b) *Supplies from Wells.*

In the low-lying parts where the granite is thoroughly weathered and saturated, wells are usually the most efficient means of tapping the underground storage. Farmers have availed themselves of this fact and derive most of their supplies from this source. The information in regard to depth and yield is unfortunately too vague and conflicting to be of statistical value. The general impression created is, however, to the effect that in most places water can be struck at shallow depths and that the yield is high and fairly constant.

(c) *Borehole Supplies.*

Boreholes are comparatively scarce and are found mostly on the more elevated parts where conditions are unfavourable for well-sinking. The hydrological conditions reflected by the records of thirty-nine boreholes are as follows:—

Average total depth of boreholes in feet	89
Average depth at which water is struck	59
Average depth to which water rises	26
Average daily yield in gallons per day pumping	30,058
Percentage of failures	5
Percentage of holes deeper than 300 ft.	nil.

The unsuccessful boreholes include one with an insufficient yield, i.e., less than 1,000 gallons per day, and another which has been sunk to an insufficient depth. The quality of the water has in all cases been described as " good".

Igneous rocks intrusive into the Older Granite are limited to two fairly persistent diabase dykes which occur on the farm Palmietfontein 124 (A–1). Since these dykes are oriented at right angles to the drainage direction, it is quite probable that large supplies of groundwater will be arrested on their upstream side.

B.—THE VREDEFORT–POTCHEFSTROOM AREA.

The Older Granite in the south-east occupies the peneplaned core of the Parys–Vredefort "dome" and is only exposed where its cover of Karroo sediments has been denuded by the superimposed drainage system of the Vaal river. It consists of even-grained to porphyritic varieties of granite and gneiss and is cut by a multitude of quartz veins and dykes or sills of gabbroid composition. The occurrence exhibits in varying degrees the effects of cataclastic deformation which has resulted from updoming. In some localities the Older Granite is perfectly fresh and undisturbed whilst in others it has acquired a platy or sheet structure or has been converted into a quartz-sericite schist.

The present granite-landscape possesses the physical features of a dissected peneplain. The deeply excavated channel of the Vaal river constitutes the principal drainage and maintains a perennial flow. Its tributaries are ephemeral streams and follow broad valleys or deep gullies etched out along crush-zones in the granite. The divides and more elevated remnants of the pre-Karroo peneplain are usually sand-covered and occasionally studded with bare, dome-like tors. In general, the effects of sculpturing are most pronounced where the gradients are steepest and both diminish with the distance from drainage lines.

(*a*) *Supplies from Springs and Seepages.*

The groundwater is discharged by pressure produced by gravity and issues from openings which may be described as barrier and depression springs. The latter are usually confined to those stretches of the streams which intersect the upper limits of the zone of saturation. On account of the crushed condition of the granite the water percolates from capillary interstices. The supplies are small and inconstant and are usually distributed over wide and poorly defined areas. A typical example of a barrier spring occurs on the farm Elim 497 (B–4). The water is returned to the surface by a diabase dyke and the supply is perennial and moderately strong.

(b) Supplies from Wells and Boreholes.

The fragmentary nature of the granite along valleys renders it very susceptible to weathering and the porous products of decomposition are generally well saturated by constant percolation from the slopes. Where the gradients are not too steep water can be struck at depths ranging from 15 feet upwards. In these localities groundwater is most profitably recovered from wells. At higher altitudes groundwater often occurs at considerable depths and is usually confined to fissures or joints in fresh or only slightly decomposed granite. The cost of well-sinking is therefore prohibitive and the underground supplies can only be tapped by means of boreholes. In the absence of official records it is impossible to assess the specific utility of boreholes in this part of the Older Granite terrain although it is safe to assume that large supplies can be obtained from structurally favourable localities.

(c) Quality of the Water.

A sample of water from a borehole in the Older Granite at Parys station was tested and gave the following results:—

Electrical resistance.................. =850 ohms,
PH value.......................... =7·3

These figures indicate that the water contains about 23 parts of dissolved matter per 100,000 and that alkali carbonates are absent. The water is therefore pure enough to be used for any desired purpose.*

2. The Witwatersrand System.

The rocks of the Witwatersrand system repose on the peneplaned archaean basement of Older Granite. They are restricted in areal distribution to two concentric belts which are separated from one another by a broad synclinal basin occupied by younger sediments. A small patch of Witwatersrand rocks is also exposed in the Potchefstroom townlands north of the Witrand Institute.

In view of its great thickness the Witwatersrand system has been subdivided conventionally into a lower and an upper division each of which includes rocks of diverse origin, texture and composition. The lower division is characterised by a rapid alternation of argillaceous and arenaceous sediments interspersed with acid and basic igneous rocks. The sediments consist of an almost infinite variety of sandstones, quartzites, flagstones and shales or slates. These are sandwiched with frequent intercalations of grits and conglomerates and two more or less persistent bands of tillite. The igneous rocks comprise extrusive and hypabyssal types. The former are represented by amygdaloidal andesites, rhyolites and tuffs, and the latter by dykes and sills of gabbroid composition. With the exception of an interbedded sheet of amygdaloidal lava and one persistent horizon of slates the upper

* For the performance of tests on the quality of water, the writer is gratefully indebted to Messrs. H. H. Cornell and Viljoen, both of the Potchefstroom School of Agriculture.

division is predominantly arenaceous and consists of a great thickness of quartzites, grits and conglomerates. These are traversed occasionally by diabasic sills or dykes.

A.—THE NORTH-WESTERN BELT.

The Witwatersrand system in the Klerksdorp and Ventersdorp districts is represented mainly by rocks of the lower division. The less resistant shales and diabase usually occupy the floors of longitudinal valleys and depressions whilst the more durable quartzites give rise to a series of parallel ridges. In consequence of the moderately low dips the gradients and differences in elevation are never very pronounced and the run-off is comparatively small. The infiltration and underground concentration of water are further promoted by the permeability of the sandy layers, the abundant surfaces of discontinuity and the alternation of porous and confining beds. The formation is therefore a good and fairly consistent water-bearer.

(*a*) *Supplies from Springs and Seepages.*

On account of the low relief and the absence of artesian conditions strong springs are entirely absent and the subsurface water is discharged only along the floors and slopes of the principal valleys. The water usually percolates from permeable material (seepage springs) but in some places, as on Goedgevonden 20 (A–1), it issues from small fissures and fractures (fracture springs) or from the contacts of pervious and impervious beds (contact springs). The supplies are usually small but can often be augmented by trenching along contours or across the strike of the rocks.

(*b*) *Supplies from Wells and Boreholes.*

In the valleys and depressions which are underlain by shales, soft sandstones and decomposed igneous rocks, water is often recovered from wells at fairly shallow depths. In the absence of reliable information the yields from this source cannot be assessed. The water-bearing properties of these rocks can, however, be gauged from the results of boreholes which have been drilled in the more elevated parts. The averages are as follows :—

Total number of holes	56
Average total depth in feet	104
Average depth at which water is struck	72
Average depth to which water rises	34
Average daily yield in gallons per day pumping	30,379
Percentage of holes deeper than 300 feet	0
Percentage of holes with exceptional supplies	0
Percentage of holes with acid or sulphuretted water	0
Percentage of total failures	7
Percentage of holes not deep enough	5
Percentage of holes with insufficient water	2
Total percentage of failures	14

(c) Mine Supplies.

For the following information concerning the water supplies of the existing gold mines in the Klerksdorp district the writer is gratefully indebted to the respective mine managers :—

(i) *Buffeldoorn Mine (New Machavie Gold Mining Co. Ltd.).*—The manager, Mr. P. H. Maasdorp, states that the yield from this mine is approximately 36,000 gallons per day.

(ii) *Afrikander Mine (Afrikander Lease, Ltd.).*—According to the information of Mr. J. Johnson, the manager, the main sources of water supply are as follows :—

Source.	Formation.	Total Depth.	Depth at which water is struck.	Yield.	Remarks.
		Feet.	Feet.	Gals p.d.	
Vertical shaft	Quartzite..	85	55	18,000	Potable.
Borehole in inclined shaft	,,	135	—	22,000	Potable.
Vertical shaft	,,	85	60	10,000	Potable.
Fault fissures underground	—	—	—	50,000	Acid. Increases to 80/90,000 after a succession of heavy rains.

Total—100/140,000 gallons per day.

(iii) *New Mines Limited.*—The water supply is obtained partly from the Klerksdorp Municipality and partly from shafts. The manager, Mr. S. E. Poole, estimates the yields from the latter source as follows :—

Ada May Shaft......	50,000 gallons ger day.
Union Jack Shaft....	50,000 gallons per day.
Main Shaft..........	75,000 gallons per day.
TOTAL...........	175,000 gallons per day.

(iv) *Babrosco Mines (Pty.) Limited.*—The manager, Mr. F. C. W. Ingle, reports that the water supply is derived from two boreholes which are located in quartzite of the Government reef series. The yield is 23,000 and 43,000 gallons per day respectively and the water is suitable for domestic use.

B.—THE SOUTH-EASTERN BELT.

The Witwatersrand system in the south-eastern portion of the area forms the north-western quadrant of a broad zone which engirdles the circular mass of " Vredefort or Older Granite". It embraces the entire sequence from the basal amygdaloid to the top of the Elsburg series and is invaded extensively by igneous rocks. The latter comprise stock-like bodies of alkali granite, dykes of syenite and keratophyre and complex sheets of basic and ultra-basic rocks. The exposures of the younger alkali granite are surrounded by a large, crescent-shaped aureole of intensely metamorphosed rocks.

The high inclination of the strata, their parallelism to the principal drainage directions and the steepness of the gradients render the Witwatersrand of this region an extremely poor and erratic water-bearer. On account of the irregular surface configuration the recoverable groundwater is mostly confined to the compact and poorly pervious shales of the valleys. The yields from boreholes are therefore small and failures are frequent. This is borne out by the averages of eleven borehole records :—

Average total depth in feet....................	153
Average depth at which water is struck........	94
Average depth to which water rises............	59
Average daily yield in gallons pumped.........	9,793
Percentage of absolute failures................	9
Percentage of holes with insufficient water......	9
Percentage of holes not deep enough...........	27
Total percentage of failures...................	45

3. The Ventersdorp Sysiem.

The rocks of the Ventersdorp system are stratigraphically interposed between those of the Transvaal and Witwatersrand or older formations and are exposed only in the western, central and south-eastern portions of the area.

A.—The Central and Western Occurrences.

The central exposures occur in the townlands to the north-west of Potchefstroom and are represented by a variable assemblage of agglomerates, tuffs and tuffy sediments which overlie the Witwatersrand beds unconformably. The western occurrences occupy more than half of the area to the west of a line drawn from Syferkuil (A–3) to Nietgedacht (B–1). They are composed essentially of lavas and pyroclastic rocks which rest on an uneven floor of Older Granite and rocks of the Lower Witwatersrand system. The lavas consist of quartz porphyries and several flows of compact to amygdaloidal "diabase". The pyroclasts include agglomerates and tuffs, and sediments which are largely composed of redeposited volcanic débris.

The Ventersdorp rocks in this sector are gently tilted or slightly folded. By virtue of their superior resistance to weathering the quartz porphyries and associated rhyolitic tuffs usually form elevated ridges. The basic lavas and tuffs on the other hand are highly susceptible to decomposition and give rise to a flat or mildly undulating landscape devoid of prominent water courses.

(*a*) *Supplies from Seeps and Wells.*

From the above considerations it follows that the quartz porphyries are hydrologically unimportant and that groundwater in the Ventersdorp system is practically confined to basic lavas, tuffs, and allied sediments. The infiltration of water in areas underlain by these rocks is facilitated by the low gradients and the high absorptive capacity of the decomposition products which cover the depressions and valleys. A large volume of the annual precipitation is therefore retained in the overburden. Part of this suspended water slowly percolates to the phreatic supply along the numerous joints and divisional planes which separate the various flows. The rest is either impounded by confining layers and impervious barriers or is gradually returned to the surface as gravity seeps. Some idea of the enormous cumulative yields from seepages can be obtained from the fact that intermittent streams, perennial pools and some alluvium flats derive most of their water from this source. These perched water supplies can generally be recovered and conserved by the sinking of wells and the excavation of infiltration trenches along the banks and slopes of the principal valleys.

(*b*) *Borehole Supplies.*

Boring for water has been mostly confined to the basic lavas. This is due to their vast areal extent, their more favourable topographic expression and the greater fertility and depth of the residual soils.

The water-bearing properties of the basic lavas are very largely controlled by their mode of extrusion. The intermittent outpouring of lava has resulted in the superimposition of several flows each of which is compact in the centre and more or less amygdaloidal towards the top and bottom. The vertical differences in the texture and composition of the successive flows have caused corresponding variations in the degree and mode of weathering and the depths to which it extends. Differential weathering is further accentuated by differences in elevation, amount of tilting, extent of jointing and permeability of the overburden. The contacts of the various lava flows are surfaces of discontinuity comparable to the bedding-planes of sedimentary rocks. Water circulating along these surfaces or along joints causes the contiguous rocks to decompose. The amygdaloidal phases of the lava are most easily affected and give rise to spongy material with a fairly high storage capacity. The more compact portions are much more resistant and usually weather to boulder-like spheroids which often render boring extremely difficult. These underground planes of weathering in which the groundwater is enclosed are irregularly distributed and difficult to locate from surface indications. This accounts for the variability of borehole results and the comparatively high percentage of failures. This, however, does not detract from the fact that excellent supplies can be struck in suitable localities. In general, it is advisable to avoid the more elevated regions and those underlain by thick deposits of calcareous tufa.

In Memoir No. 34 entitled "The Water-bearing Properties of the chief Geological Formations in the Union of South Africa", Dr. H. F. Frommurze, principal geologist on the staff of the Geological Survey, gives the following information concerning the borehole water supplies in the Ventersdorp system of the Klerksdorp District :—

"Klerksdorp is the district with the highest individual average quantity of water *per diem*, viz. :—

Total number of boreholes from which information was obtained......................	477·0
Average total depth of boreholes in feet........	95·0
Average depth at which water was struck in feet	69·0
Average depth to which water rises (rest level) in feet..................................	39·0
Average daily quantity of gallons..............	22,200·0
Percentage of failures........................	24·0
Percentage of boreholes deeper than 300 feet....	0·2
Percentage of flowing holes..................	0·6
Average annual rainfall in inches..............	20–25

Of the failures 64 per cent. were total failures, 17 per cent. struck water of no practical value, and 19 per cent. were not drilled deep enough.

The average daily yield is above the usual and the average depth below, otherwise results are fairly consistent with little that is exceptional." (See also figure 2.)

He summarises the results in the Klerksdorp District as follows :—

Depth of Water.	0–50	51–100	101–150	151–200	201–250	Total.
Total number of holes from which information was obtained..............	134	180	33	8	1	356
Up to 1,000 gals. per day	3	3	1	—	1	8
1– 10,000 ,, ,, ,,	37	62	13	6	—	118
10– 20,000 ,, ,, ,,	33	38	9	1	—	81
20– 30,000 ,, ,, ,,	23	35	3	—	—	61
30– 40,000 ,, ,, ,,	13	12	3	—	—	28
40– 50,000 ,, ,, ,,	10	11	2	—	—	23
50– 60,000 ,, ,, ,,	5	3	—	—	—	8
60– 70,000 ,, ,, ,,	3	1	—	—	—	4
70– 80,000 ,, ,, ,,	4	10	2	1	—	17
80– 90,000 ,, ,, ,,	3	3	—	—	—	6
90–100,000 ,, ,, ,,	2	—	—	—	—	2

B.—THE SOUTH-EASTERN OCCURRENCE.

The Ventersdorp system in the south-east is composed essentially of basic lavas and rests more or less conformably upon rocks of the Witwatersrand system. The lavas form the north-western segment of a broad belt which conforms to the concentric arrangement displayed by the successive ridges of Witwatersrand sediments. This belt, which is characterised by the absence of prominent surface features, reaches a considerable elevation and consitutes the watershed between the tributaries of the Loop spruit and the Vaal river. The lavas are usually close to the surface and are often exposed in broad, rounded hills. Compared with the size of the catchment areas the spruits are small and very few maintain a perennial flow.

(*a*) *Seepage Supplies.*

During the dry season the small supplies of perennial and interrupted streams are derived exclusively from seepages. The water issues directly from joints in the lavas or percolates from the satured alluvium which overlie them. In the latter case the hydraulic discharge is appreciably reduced by evaporation and transpiration. This unnecessary wastage can be obviated by the excavation of infiltration trenches which will at the same time serve to concentrate the dissipated supplies. This procedure has been followed with great success on the farm Modderfontein 52 (A–4) where the water recovered in this way from decomposed lavas is sufficient for small irrigation schemes.

(*b*) *Borehole Supplies.*

The averages obtained from sixteen available records are as follows :—

Number of successful holes....................	9
Average total depth of holes in feet............	92
Average depth at which water is struck.........	59
Average depth to which water rises............	38
Average yield in gallons per day pumping......	8,752
Percentage of absolute failures................	12
Percentage of holes not deep enough...........	7
Percentage of holes with insufficient water......	25
Total percentage of failures...................	44

The small yields and the high percentage of failures prove that the Ventersdorp system in the south-east is a very poor water-bearer.

(*c*) *Quality of the Water.*

A sample of water from the seepage springs at Modderfontein 52 was electrically tested at the Potchefstroom School of Agriculture. The results are as follows :—

Electrical Resistance..........	=1500 Ohms.
pH value....................	=7·3

This indicates that the 16 parts of dissolved matter per 100,000 parts of this water can only be composed of bicarbonates of calcium and magnesium and sulphates and chlorides of magnesium, calcium and sodium. The absence of acids and alkali carbonates renders the water fit for irrigation and stock consumption.

4. The Transvaal System.

The broad strip of country extending almost diagonally across the central portion of the area is underlain by rocks of the Transvaal system. The latter overlies the Ventersdorp system unconformably and occupies a major, unsymmetrical syncline which is characterised by a marked development of complex folding. The curved axis of this composite syncline is approximately concentric with the north-western margin of the "Vredefort" granite and practically coincides with the course of the Loop spruit and that of the Mooi river to the south of Potchefstroom. The south-eastern limb of the syncline has participated in the effects of updoming and is almost completely inverted. The compression of the north-western limb has resulted in the formation of an overthrust fault by which pre-Transvaal rocks are exposed in the western and north-western portions of the Potchefstroom townlands.

The Transvaal system has an aggregate thickness of well over 18,000 feet and consists of an apparently uninterrupted succession of rocks which are conventionally divided into the Black Reef, Dolomite and Pretoria series.

A.—The Black Reef and Dolomite Series.

The Black Reef series is the basal member of the Transvaal system and consists of conglomerates, quartzites and shales. On account of its insignificant thickness and erratic development it never forms conspicuous surface features and is mostly obscured, especially in the south-east.

The Dolomite series is the intermediate member of the system and is represented by dolomite or dolomitic limestone, chert and minor shales, which together may attain a thickness of about 5,000 feet in places. It usually forms a flat, featureless landscape, the monotony of which is only occasionally relieved by low hills and small ridges of chert. These features are more prominent and persistent in the uppermost portions of the series where chert attains its maximum development.

The entire absence of influent streams and the abundance of caves and sink-holes are some of the most salient and characteristic peculiarities of the Dolomite terrain and are due to the fact that this rock is soluble in water charged with carbon dioxide. The joints, fissures and bedding-planes to which the underground circulation in this highly compact rock is perforce restricted are therefore gradually enlarged and connected so that the entire drainage is eventually disposed of by the resultant subterranean conduits.

The igneous dykes and quartz veins which pierce the Dolomite series are of special hydrological significance and must be briefly referred to. Between the northern limits of the Potchefstroom townlands and Katdoornbosch 127 (A–3) the Dolomite is traversed by a system of remarkably straight and roughly parallel quartz veins which project as vertical ridges above the peneplain. They trend in a north-north-westerly direction and are paralleled by an obscured dyke which has been traced as far as the north-western limit of the Transvaal system on Stuk Grond 31 (B–3). These features are intersected by a diabase dyke which is traceable from the westernmost spring on Witkoppies 132 to beyond the western boundary of Oudedorp 25 (B–3). This dyke acts as an impervious barrier to the circulation of the groundwater and causes the emergence of four springs. On Rietfontein 163 (A–4) the meridional dyke of syenite and the intrusive mass of younger granite intersect the east-west drainage in the Dolomite and similarly give rise to springs on the upstream side.

(*a*) *Borehole Water Supplies.*

Although the Dolomite series is one of the most prolific water-bearers in the Union the results obtained by boring are usually very erratic and the percentage of failures is often very high. This, as has been pointed out, is due to the fact that the sub-surface water in this formation is mostly confined to solution channels and enlarged fissures and joints whose position cannot be located with certainty from surface indications. The subjoined table compiled from the available records of 19 boreholes drilled in the area under consideration clearly illustrates the variability of the yields and the erratic distribution of water in the Dolomite :—

Yield in thousands of gallons per day.	Number of holes and the depth of water in feet.							
	0–50	51–100	101–150	151–200	201–250	251–300	Over 300	Total.
No water	1	2	—	—	—	—	—	3
Up to 1	—	—	—	—	—	—	—	—
1–10	—	1	—	1	—	—	—	2
10–20	2	—	2	—	—	—	—	4
20–30	—	2	—	—	—	—	—	2
30–40	—	2	—	—	—	—	—	2
40–50	1	—	—	—	—	—	1	2
50–60	1	—	—	—	—	—	—	1
60–70	—	—	—	—	—	—	—	—
70–80	1	1	1	—	—	—	—	3
Totals	6	8	3	1	—	—	1	19

In the comparative table below, column I gives the averages for boreholes in Dolomite of the present area whilst columns II and III furnish the respective averages of the southern and northern sections of the Ventersdorp Sheet-area as given by Dr. H. F. Frommurze in the Explanation to Sheet No. 53 (N.B.—For the sake of uniformity Dr. Frommurze's analysis of unsuccessful boreholes is here presented in a different way, failures being expressed as percentages of the total number of boreholes) :—

	I	II	III
Average depth of holes in feet.........	83	102	159·0
Average depth at which water is struck	78	72	131·0
Average depth to which water rises....	45	50	93·0
Average daily yield in gallons pumping	36,125	32,300	20,000·0
Percentage of absolute failures.......	10	14	18·0
Percentage of holes with less than 1,000 gallons per day..................	0	3	5·0
Percentage of holes insufficiently deep..	5	17	18·0
Total percentage of failures...........	15	34	41·0
Percentage of holes deeper than 300 ft.	5	9	4·4

The table clearly indicates that the hydrological conditions in the Dolomite improve progressively from north to south, that is, in the direction of the principal drainage. When it is considered that the average annual rainfall and the extent of rock deformation also increase in this direction then the dependence of groundwater resources on topography, climate and structure becomes perfectly obvious.

(b) *Mine Supplies.*

The auriferous rocks of the Black Reef series are being mined by the New Machavie Gold Mining Company Ltd., on the farm Eleazar 18. According to the manager, Mr. P. H. Maasdorp, the supplies of groundwater for the New Machavie mine are constituted as follows :—

Machavie Mine............	108,000 gallons per day.
Boreholes..................	24,000 gallons per day.
TOTAL.........	132,000 gallons per day.

Details of the boreholes are not known but most of the mine water is probably contributed by Dolomite since the shafts intersecting the Black Reef series are sunk in this formation.

(c) *Water Supplies from Springs.*

With respect to the number of springs and the constancy and magnitude of their individual yields the Dolomite far surpasses all the other formations combined. Structurally these springs can be divided into Contact, Fracture and Depression springs :—

(i) *The Contact or Barrier Springs.*—Under this category belong the springs on Rietfontein 163 (A–4), Oudedorp 25, Witkoppies 132 and Buffelsvallei 87 (B–3).

The three springs on Witkoppies 132 and the " Grootfontein " spring on Oudedorp 25 issue at the intersections of the quartz veins and the east-west dyke of diabase mentioned above.

The spring on Buffelsvallei 87 occurs in Dolomite to the east of a confining ridge of quartz and to the west of an oblique fault contact of overthrust Dolomite and impervious Ongeluk lavas.

These springs are all tributaries to the Mooi river. The discharge of the individual springs has not yet been gauged.

Reference has already been made to the Dolomite springs on Rietfontein 163 (A–4). They issue in a tributary valley of the Loop spruit on the eastern or upstream side of a syenite dyke. As they are situated near the watershed the catchment area is rather limited and the flow is not particularly strong.

(ii) *Fracture Springs.*—The spring on Witstinkhoutboom 146 (A–3) is representative of this class. It occurs on the western bank of the Mooi river, near the northern boundary of the Potchefstroom townlands, and issues from Dolomite which has been fractured along an east-west fault. It has a strong, perennial yield and discharges directly into the Mooi river.

(iii) *Depression Springs.*—The springs on Rietfontein 78 (A–2), Stilfontein 39 and Hartbeestfontein 41 (B–2) occur in the valley of the Koekemoer spruit. Since more detailed knowledge concerning their causation is entirely lacking they are provisionally classified as depression springs.

The spring on Rietfontein 78 is situated in the bed of the Koekemoer valley and is altogether obscured by a thick growth of reeds. Its emergence is apparently due to the intersection by the spruit of a thick layer of chert which forms a conspicuous ridge on the western bank of the valley. According to local information the fine perennial supply of this spring was considerably stronger some fifty years ago when the lands extending as far as Hartbeestfontein 41 were all irrigated from this source.

On Stilfontein 39 and Hartbeestfontein 41 (B–2) the water issues from small fissures or bedding-planes in the Dolomite. The openings are distributed over a large area along the eastern slopes of the Koekemoer valley and the water is concentrated by means of collecting in infiltration trenches. The collecting trench on Stilfontein 39 is about 1,600 yards long and about 8 feet deep at its top end. In both localities surprisingly big volumes of water are recovered in this way.

(*d*) *Quality of the Water.*

Five samples of Dolomite water from various localities were electrically tested in the Potchefstroom School of Agriculture. The results are as follows :—

Source of Water.	Electrical Resistance.	P.H. Value.	Parts of Dissolved Matter per 100,000.	Probable Constituents.
	Ohms.			
Spring, Witstinkhoutboom 146 (A–3)...	480	7·6	40	Chiefly bicarbonates of calcium and magnesium and sulphates and chlorides of sodium, calcium and magnesium. Alkali carbonates absent.
Mooi River, north of gauging station....	540	—	33	
Spring, Buffelsvallei 87 (A–3)..........	500	—	38	
Upper Spring, Witkoppies 132 (A–3).	430	—	50	
Spring, Oudedorp 25 (A–3).............	530	—	34	

B.—THE PRETORIA SERIES.

The Pretoria series follows more or less conformably on the Dolomite. It is customarily subdivided into three stages, viz., the Timeball Hill, Daspoort and Magaliesberg or lower, middle and upper respectively. Each stage is predominantly argillaceous at the bottom and arenaceous at the top. The shales are far superior in thickness to the quartzites and are extensively invaded by sills of Bushveld diabase. In the Daspoort stage the shales are furthermore interrupted by a thick sheet of contemporaneous lavas known as the Ongeluk amygdaloidal andesite. Examples of post-Bushveld igneous rocks intrusive into the Pretoria series are afforded by the great syenite dyke to the west of Los berg and the " diorite " complex on Roodekraal 37.

The great variety of topographic forms displayed by the country underlain by the Pretoria series is intimately connected with complex tectonic deformation and the alternation of rocks of different tenacity. The Magaliesberg shales and associated igneous rocks occupy the axis of the major syncline and form a broad expanse of comparatively flat, low-lying country traversed by the Loop spruit and the southern stretch of the Mooi river. The quartzites build discontinuous and somewhat irregular chains of concentric ridges whose magnitude is inversely proportional to the angle of dip. The Ongeluk lavas, the Timeball Hill and Daspoort shales and attendant sills of diabase occupy longitudinal valleys between highly inclined quartzites or form step-like terraces between successive horizons of nearly horizonta quartzites.

(a) Water Supplies from Springs.

Numerous springs issue from rocks of the Pretoria series. Their yields are usually small and subject to seasonal fluctuations. The details in the table below refer only to the most important ones :—

Locality.	Aquifer.	Number of Springs referred to each Type.			
		Fracture.	Filtration.	Contact.	Totals.
Boschhoek 159 (A–3, 4)...	Diabase.........	1	—	—	—
	Daspoort shale..	—	2	—	3
Stompoorfontein 55 (A–3).	Daspoort quartzite	—	1	—	1
Potchefstroom Town Lands	Daspoort shale..	—	1	—	1
Varkfontein 145 (A–4)....	Diabase.........	—	—	1	1
Driefontein 35 (A–4)......	Diabase.........	—	—	3	3
Syferfontein 154 (A–4)....	Daspoort quartzite	—	1	—	1
Witpoort 125 (A–4).......	Ongeluk lavas...	—	1	—	1
Leinster 212 (B–3) (O.F.S.)	Ongeluk lavas...	—	1	—	1
	TOTALS..........	1	7	4	12

(b) Borehole Water Supplies.

On account of the topographically unsuitable conditions to which the quartzites usually give rise most of the boring for water in the Pretoria series is confined to the Ongeluk lavas and the shales and associated diabases. In general, the shales have yielded highly satisfactory borehole results, except where they have been silicified or indurated. Silicification is more wide-spread in the shales of the Timeball Hill than in those of the Daspoort stage. The adverse effect of this alteration on the water-bearing properties of the shales is clearly reflected by a comparison of the averages obtained from these two horizons. Where it is fractured and decomposed the Ongeluk lava is frequently an excellent water-bearer. Very erratic results have, however, been obtained from certain localities. This is particularly the case on Noyons (B–3), where the percentage of failures has been exceptionally high.

The following table of averages for the Pretoria series in the Gatsrand area has been compiled from figures furnished by Dr. H. F. Frommurze in Memoir No. 34 :—

	Time-ball Hill Shale.	Time-ball Hill Quartzite.	Daspoort Shale.	Daspoort Quartzite.	Ongeluk Lavas.	Intrusive Bushveld Diabase.
Total number of boreholes	74	9	34	4	55	78
Average total depth in feet	159	74	121	96	90	94
Average depth at which water is struck.........	113	57	79	77	68	66
Average depth to which water rises............	50	32	18	28	30	21
Average daily yield in gals. pumping...............	26,000	10,000	28,400	26,000	28,400	23,000
Percentage of absolute failures................	12	—	3	—	6	13
Percentage of holes with insufficient water.......	5	—	3.	—	11	5
Percentage of holes not deep enough...........	4	—	—	—	4	8
Total percentage of failures	21	30	6	—	21	26

(*c*) *Quality of the Water.*

The water of the filtration spring which issues from Daspoort quartzites on the farm Stompoorfontein 55 (A–3) may be regarded as being truly representative of the uncontaminated supplies from the normal quartzites. A sample of this water was therefore examined at the Potchefstroom School of Agriculture, the results are as follows :—

Electrical resistance........ =6,000 Ohms.
pH value.................. =5·85

These figures show that the water contains only 3–5 parts of dissolved matter per 100,000 and that it is slightly acid.

For comparison, the water from the mineralised Daspoort quartzites on Roodekraal 37 (B–3) were tested in the same way. The test reveals a concentration of 79 parts per 100,000 for the water of this locality. This figure will probably be very much higher towards the close of the dry season. Since the dissolved matter includes deleterious salts of copper the water is definitely unsuitable for irrigation purposes.

The quality of water from shales is reflected by the following table which was compiled from information kindly supplied by Mr. Mostert, Principal of the Boys' Industrial School at Potchefstroom.

The water is derived from a borehole which was drilled in 1919. It was tested in 1931 by Mr. Cutler of the Government Chemical Laboratories :—

Electrical Resistance	610·0
Total Solids	42·3
Volatile	6·0
Non-volatile	36·3
Sulphides	nil.
Chlorides	1·95
Sulphates	Faint trace.
Nitrogen as Nitrates	0·04
Free ammonia	0·0074
Albuminoid Ammonia	0·0053
Oxygen absorbed in 4 hours	0·502
Total hardness	21·0
Permanent hardness	13·0
Temporary hardness	7·0

The water from the Ongluk lavas and intrusive diabase can be expected to be of comparable quality to that derived from the Ventersdorp extrusives. (page 119).

5. The Karroo System.

Rocks of the Karroo system are sparsely represented and rarely exposed in the area and occur as comparatively thin cappings resting unconformably on rocks of the older formations. In the Potchefstroom and Klerksdorp districts small outliers composed of horizontally bedded shales and sandstones are preserved on Zandpan 43 (B–2), Wildebeestpan 40 (B–2), Eleazar 18 (A–2) and Syferfontein 21 (A–2). On the Free State side of the Vaal river more continuous occurrences are encountered to the south of Parys and to the west of Waterford 402 (B–2). In the former locality sheets of dolerite intrusive into the sediments are also exposed.

Borehole Water Supplies.

In the Potchefstroom and Klerksdorp districts very few holes have been drilled in rocks of the Karroo system. The averages of four available borehole records are as follows :—

Average total depth of holes in feet	106
Average depth at which water is struck	87
Average depth to which water rises	51
Average daily yield in gallons pumping	7,960

According to figures obtained from Memoir No. 34 the average of 56 boreholes in the Vredefort district are as follows:—

Average total depth of holes in feet.............	112
Average depth at which water is struck..........	72
Average depth to which water rises.............	45
Average daily yield in gallons pumping..........	8,460

6. Recent Deposits.

Considering the extent of the catchment areas, it will at once be obvious that large volumes of water must be stored in the deep and extensive alluvial deposits which cover the numerous graded valleys in the area. This water is most profitably tapped by the sinking of wells, the excavation of infiltration or collecting trenches or the construction of sub-surface dams. In this connection mention may be made of Mr. Fick's infiltration trench on Roodekraal 37 (B–3). This trench is a longitudinal one and is dug on the eastern side of a spruit. The depth at its top end is 12–15 feet and the water gravitates into an irrigation dam about a quarter of a mile downstream. The yield is strong and fairly constant but can be considerably increased by lining and by the excavation of transverse branch feeders. Equally satisfactory results have been obtained from collecting trenches on Stilfontein 39 (B–2).

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