The Etjo Beds of Northern Hereroland, South-west Africa.

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[Plates XLII-XLVI.]

Introduction.

While the stratigraphy of the Karroo beds of southern South-West Africa has been worked out with a considerable amount of detail, mainly by Range (13)* and Wagner (5), the succession within the Karroo System in the northern portion of the territory has until comparatively recently remained more or less obscure.

In southern South-West Africa mainly the lower two members of the Karroo System (Dwyka and Ecca Series) are represented. The Beaufort beds are not recognisable, and the Upper Karroo beds (Stormberg Series), with the exception of the basalts, form only a very minor and subordinate part of the whole succession.

North of the Khomas Highlands conditions appear to be reversed. The lower Karroo beds are apparently entirely absent, except in the immediate coastal area [Kaokoveld (7)] and it is the Upper Karroo beds, the Stormberg Series, that dominate the landscape in certain areas. In addition, while the Stormberg lavas in the southern area (Hoachanas plateau) comprise only normal basalts and andesites, in the northern region they exhibit intense differentiation, grading from basalts (melaphyres) to acid quartz-porphyries in the Kaokoveld and Erongo regions.

The relevant beds of the latter region were first briefly alluded to by Gürich in 1891 (1) and described in detail by Cloos in 1913 and 1919 (3). In 1928 they were re-examined by Frommurze and Gevers and their Karroo age suggested (12).

The geology of the Kaokoveld was first described in outline by Kuntz in 1913 (4). More detailed investigations were later carried out by Reuning, whose discovery of Karroo fossils (Mesosaurus) at the Dorosberg in 1925 for the first time definitely proved the Karroo age of these beds (7).

Identical sediments and lavas can be seen intruded by a youthful granite, forming the final differentiation product of the Stormberg eruptive cycle, at the Brandberg, thereby rendering the correlation of the very similar Erongo sediments and lavas, which are intruded by an identical granite, with the Kaoko beds very likely (12)

Stahl mainly investigated the tectonic features of the Kaokoveld, and showed that in its north-western portion the Karroo beds have been downfaulted into narrow "graben" (9 and 14).

* The numbers in parenthesis refer to the Bibliography at the end of this paper.

While the Karroo beds of the coastal area, therefore, have received a considerable amount of attention in recent years, the corresponding beds in the interior plateau of Hereroland have been less fully described, although a number of references to individual localities have been published by Hermann, Range (2), Wagner (5) and Reuning. To the latter we owe the very important discovery of the great Waterberg fault (6). (See Map, Plate XLII.)

These beds, referred to as the Waterberg Sandstone, were until comparatively recently assigned to the Nama System and correlated with portions of the Fish River beds in southern South-West Africa. The discovery by Elmenhorst, however, of reptilian tracks, described by Gürich in 1926 (8), on the farm Otjihaenamaparero, situated on the south-western slopes of the Etjo Mountain, proved their very much later age, and suggested correlation with the Stormberg Series. In 1926 Gröpel found a portion of a reptilian skull in these beds on the farm Breitenbach, north-east of the Waterberg. Stromer *v.* Reichenbach determined the fossil as the cast of part of the facial portion of the skull of a Karroo reptile, but owing to the poor degree of preservation, a closer determination was impossible.

In 1928 Range and Kräusel gave a brief description of the development of the Karroo beds throughout the entire territory, including brief references to the beds under discussion (10). In 1929 the writer briefly described these beds as developed at the Etjo Mountain and the Omatako (12).

Since then the writer had further opportunity of studying the Etjo beds in different localities, and although the investigations are not complete, particularly in the region of the Omboroko Mountains, the following notes are herewith presented as a further contribution to the knowledge of the Karroo beds of northern South-West Africa.

The main purpose of this paper is to show up the close similarity of these sediments to the Stormberg beds of the Union.

Distribution of Etjo Beds (See Map, Plate XLII).

The term Etjo beds for the sediments under discussion, proposed by Reuning (6 and 7), is to be preferred to the old name "Waterberg Beds," since it obviates confusion with the Waterberg System of the Transvaal, comprising rocks of very much greater age. In addition, Rimann has employed the same term (Waterberg beds) for portions of the Upper Nama System (Fish River beds) in the area of the Khauas Hottentot Reserve of southern South-West Africa.

Although these beds have their greatest visible extent in the great Waterberg, east of Otjivarongo, they are much better exposed, particularly the lower portions, on the south-western slopes of the Etjo plateau, the edge of which at this locality, with an elevation of 2,086 metres, is 230 metres higher than the maximum elevation of the Waterberg (Omuverumue, 1,857 metres).

The Etjo beds possess their greatest visible distribution along the southern margin of the great Waterberg fault, along which they have been brought down against different members of the Damara System (Fundamental Complex) to the north. Along this line they build up a straggling line of individual plateaux; in the south-west, near Omaruru, the Etjo Mountain (Photo 3), and then in order of sequence, to the north-east, the Omboroko Mountains, the Little and Great Waterberg (Photo 4). East of the latter, isolated outcrops, appearing from under the universal cover of Kalahari sand, have been followed by Stahl as far as the Okavango River.

In the south-west they terminate along the great fault at Omburo, 35 km. east of Omavuru. To what extent certain members of the Erongo beds, situated some 50 km. to the south-west, are to be regarded as their equivalent, is as yet uncertain.

Further south the Etjo beds take part in building up the Omburo Mountains in the region of Osombusomasse, the two Omatako pyramids and the neighbouring Okongava Mountain (Maps, Plates XLII and XLIII), as well as the Ombutosu Mountains, 35 km. to the north-west of Okahandja. The lower Etjo beds are well exposed below the north-eastern buttress of the latter moutains, representing the most southerly known outcrop of Etjo beds. Further south crustal warping has led to the greater elevation of the underlying Damara System, the Khomas ridge, built up by the latter, representing the most highly elevated tract of the whole territory.

East of the Omatako Mountains there begins the complete cover ing of loose windblown sand forming the Omaheke or Sandveld, an extension of the great Kalahari basin. Numerous boreholes sunk for water in this region (Osire-block, Waterberg and Otjituo Herero reserves) have proved the wide but irregular and scattered distribution of Etjo beds below the sand cover. The surface on which they were deposited appears to be very uneven, and consists mostly of granite and gneiss with occasional xenoliths of ancient rocks (Damara and Abbabis Systems).

The actual distribution of the Etjo beds is, therefore, considerable.

West of the Omatako Mountains the base of the Etjo beds rises fairly rapidly, with the result that in the Omburo Mountains (2,049 metres), east of Omaruru, only a sparing portion of the lower Etjo beds is still to be found among the extensive sills of dolerite that were intruded along the base of the Etjo beds between the latter and the Fundamental Complex.

Apart from subsidiary warping movements, the Etjo beds sink in an easterly and east-south-easterly direction, as indicated by the following list of elevations of the uppermost edge of the Cave Sandstone: Etjo, 2,086 metres; Omuverumue (Gr. Waterberg), 1,857 metres; Breitenbach (south of Grootfontein), 1,500 metres. Still further east also the Cave Sandstone (Etjc plateau sandstone) is said to disappear below the sand cover. Owing to its porous nature, it should be possible to obtain readily abundant supplies of water in this portion of the sandveld, possibly even artesian supplies.

Thickness of Etjo Beds.

Owing to the uneven nature of the floor and their terrestrial accumulation under predominantly arid conditions of climate, the total thickness of the Etjo beds is subject to considerable variations.

At the south-west buttress of the Etjo Mountain, the total thickness is roughly 600 metres (1,950 feet). Below the western buttress of the Omuverumue plateau (Gr. Waterberg), the total thickness appears to be considerably less, being probably in the neighbourhood of 400 metres (1,300 feet). Here, however, the position is complicated by the close neighbourhood of the great fault. Various exposures, however, indicate the latter to be situated some distance away from the foot of the mountain.

At the Great Omatako Mountain, the total thickness again does not appear appreciably to exceed 400 metres, since the Cave Sandstone forms a buttress approximately half-way up the great pyramid (Photo 2), which rises to a height of 650 metres (2,100 feet) above the surrounding plain The latter exhibits occasional outcrops of the underlying granite.

General Stratigraphy of Etjo Beds.

The Etjo beds can naturally be divided into two groups: An uppermost layer of uniform fine-grained sandstone, forming the tops of the plateau-mountains and representing the Etjo sandstone as such; and a lower group of predominantly red colour, comprising a large proportion of reddish shales and mudstones.

1. *Etjo Plateau Sandstone* (Cave Sandstone).

Since the term Etjo sandstone is commonly also applied to the abundant sandstones intercalated with shales of the lower group, the writer proposes to designate this upper aeolian sandstone building up the plateaux of the Etjo, Omboroko, Little and Great Waterberg as *Plateau Sandstone*.

It represents a fine-grained unbedded felspathic sandstone of extremely uniform texture. At numerous localities it exhibits typical aeolian false bedding. Only in its lowermost portion does it sometimes show signs of more regular bedding.

In every respect this sandstone is identical with the Cave and Bushveld Sandstones of the Union and the Forest Sandstone of Southern Rhodesia. It is further identical with the "Main Sandstone" described by Reuning from the Kaokoveld as immediately underlying the lavas of that region (7). The latter, however, is not nearly as thick as the Etjo Plateau Sandstone nor of the same morphological significance.

The Etjo Plateau Sandstone no doubt forms part of an extensive deposit of windblown sand, that in Rhaetic times apparently covered the greater part of Southern Africa from the Atlantic to the Indian Ocean (both of subsequent origin), and in areal extent by far exceeded the present distribution of Kalahari sand.

At the Great Omatako Mountain the colour of the Etjo Plateau Sandstone is cream, at the Etjo Mountain cream-yellow and pale-pink, at the Little Waterberg brick-red, and at the Great Waterberg deep-pink to pale-red.

Its thickness at the Little Waterberg is ±60 metres, at the Omuverumue ±80, at Waterberg Farm 70 to 75, and at the Great Omatako 80 to 90 metres (260 to 290 feet). The " Main Sandstone " of the Kaoko beds, according to Reuning, at the Chuab Mountain in the southern Kaokoveld is only 5 to 8 metres (16 to 26 feet) thick (7, p 104).

The latter everywhere forms the footwall to the overlying differentiated lavas, beginning with basalts (melaphyres) and ending with quartz-porphyries in the same way as in the Lebombo belt of the Transvaal and Portuguese East Africa.

Also at the Great Omatako Mountain the Plateau Sandstone formerly appears to have been overlain by basalts (see later chapter).

2. *Lower Etjo Beds* (Red Beds and Molteno Beds).

The lower Etjo beds are composed predominantly of red mudstones and shales, the latter very often sandy. Intercalated with these there occur in varying proportions, but always abundant, reddish argillaceous felspathic sandstones, brownish quartzites and reddish and white arkoses, in part conglomeratic. The latter are particularly abundant in the basal portion of the beds, where they may occur in thick massive layers, that are often highly conglomeratic.

At numerous localities this *basal arkose group*, following directly on the uneven, mostly granitic floor of the Fundamental Complex, is developed to an extent almost sufficient to warrant its separation from the red beds as a distinct group. It is invariably highly felspathic and of white colour (Photo 5). It obviously represents granite débris, in part accumulated in situ, in part transported by flowing water.

The enclosed pebbles and boulders are often well rounded, but never in their entirety.

Apparently climatic conditions at the beginning of the period of sedimentation of the Etjo beds were sufficiently humid to enable the formation of well-rounded pebbles by flowing water.

At a later period a change towards the intermittently rainy and semi-arid took place, resulting in the accumulation of reddish shales with intercalated reddish felspathic sandstones. Interspersed layers of white conglomeratic arkose indicate the frequent recurrence of more humid periods in the initial stages.

As evidenced by the tracks of saurischian and tetrapod reptiles at Otjihaenamaparero, animal life was in existence during this period, though, judging from the paucity of remains, not in great abundance.

Finally, the climate became completely arid as indicated by the accumulation of a universal cover of windblown sand some 200 feet thick.

It is apparent from this brief description that the Etjo beds of Hereroland present close similarities to the Stormberg beds of the Union. The Plateau Sandstone is practically identical with the Cave and Bushveld Sandstones.

The red sediments of the Lower Etjo beds are in general features strongly reminiscent of the Red beds, while the basal conglomeratic arkoses of light colour recall the more humid climatic conditions of the Molteno beds.

At the Etjo Mountain the Lower Etjo beds are some 550 metres (1,790 feet), at the Great Waterberg only some 300 to 350 metres (970 to 1,140 feet) thick. At the Great Omatako Mountain the thickness of this group apparently is in the neighbourhood of 350 to 400 metres (1,140 to 1,300 feet), and at the Ombutosu Mountain some 250 metres (810 feet) of sediments are still preserved below the intrusive sill of gabbro forming the top of the mountain.

The uneven nature of the floor has already been stressed.

Description of Localities.

(a) *Ombutosu Mountains.* (Map. Plate XLII.)

These hills represent an irregularly embayed table mountain, rising some 350 metres (1,140 feet) above the surrounding plain. It is capped by an extensive sill of olivine-gabbro, some 100 metres (325 feet) thick, the preserved length of outcrop being roughly 20 km.

The Lower Etjo beds are best exposed below the north-east buttress, where the following section is seen:—

Top.

Thickness.		
100	metres:	Olivine gabbro.
±20	,,	Light coloured fine-grained felspathic sandstone with some coarse arkosic sandstone.
110–120	,,	Reddish-violet baked mudstones and laminated shales with intercalations of greyish-violet clayey sandstones, showing abundant mud pellets. Narrow layers of brownish sandstone.
15–20	,,	Sill of decomposed gabbro.
±15	,,	Baked greenish-grey mudstone.
30	,,	Slope covered by scree.

A straggling line of low hills of gabbro in the Omatako plain to the north evidently represents the feeding fissure connecting the gabbro of the Ombutosu Mountains with the dolerite of the Omatako Mountains. (Map, Plate XLII.)

(b) *Omatako Mountains.*

The two Omatako Mountains represent two enormous conical "inselberge" rising some 2,100 feet above the dead-level surrounding plain (Photos 1 and 2). The *western cone* is somewhat higher than the eastern, its point having an elevation of 2,289 metres (7,440 feet), and at one time thought to be the highest point in the territory. Its base is almost circular (Map, Plate XLIII) and roughly 4½ kms. wide. Its total height above the surrounding plain is 650 metres (2,100 feet).

The basal portion of the cone is formed of Lower Etjo beds, almost entirely covered by dolerite rubble from the top of the mountain. Roughly half-way up the cone the Plateau Sandstone, some 80 to 90 metres thick, forms a well-marked ledge (Photo 2).

Above this ledge the cone is composed of coarse olivine dolerite right to the very top, which consists of a jumbled mass of enormous boulders of this rock. The preserved thickness of the dolerite is 300 to 350 metres (970 to 1,140 feet). The rock from top to bottom is a uniformly coarse olivine dolerite. The grain is considerably less coarse than that of the gabbro sheet forming the top of the Ombutosu hills and of the dyke at the southern foot of the eastern cone (see Map, Plate XLIII). The texture is typically ophitic, with abundant small grains of olivine.

Among the rubble covering the lower slopes of the cone, however, fragments of dense basalt are also to be found.

Although following directly on the Plateau (Cave) Sandstone, the rock forming the top of the cone is rather too coarse for a lava flow poured out subaerially. The rock appears to be quite uniform, showing no variation in texture from top to bottom over a thickness of roughly a thousand feet. Portion of the same rock from the eastern cone is almost coarse enough to be called a gabbro, which at the Ombutosu Mountains clearly represents an intrusive sill.

At a place on the northern slopes of the western cone a contact between the Plateau Sandstone and overlying igneous rock is exposed. The sandstone is baked to a considerable extent and followed by a layer of dense basalt one metre thick. This bottom zone is succeeded by a layer of highly vesicular basalt, 2·6 metres thick, and full of steam holes. This rock could well represent a surface flow, particularly since its upper surface is very dense, almost glassy, reddish in colour, and to some extent decomposed. Above this rock then follows uniform coarse dolerite right to the very top of the cone.

The facts, therefore, indicate that the basic igneous rock forming the top of the two Omatako cones does not represent subaerial lava flows, as would be natural to suppose, since it directly follows on Cave Sandstone, but a very thick sill of dolerite intruded between the Cave Sandstone and originally overlying basalts, now denuded away.

The eastern cone is of much more irregular shape (Photo 1 and Map, Plate XLIII), and exhibits greater geological complexity. Its elevation is lower than that of the western cone.

Along the bottom of its north-western and southern slopes there occur fine exposures of the basal arkoses and red laminated shales and mudstones of the Lower Etjo beds.

At its southern termination a broad dyke of olivine gabbro extends intermittently for a few kilometres into the adjacent plain, representing the northern termination of the dyke already referred to.

At the foot of the cone this dyke is some 150 metres (490 feet) wide. The rock is identical with that of the Ombutosu Mountain, but also comprises a fine-grained dolerite, which also occurs as " schlieren " within the coarser rock. A dense fine-grained selvage is also present. The dyke runs up the southern slope of the cone and breaks through the Cave Sandstone, which, on the eastern side of the cone, appears to have been stcped away completely (Map, Plate XLIII). On the northern slope a similar dyke extends to the bottom of the cone in more or less the same line of strike.

This dyke obviously represents the conduit for the sill of dolerite-gabbro forming the top of the cone, with which it is continuous. The schlieren and xenoliths of fine-grained dolerite within the coarse rock suggest that it also served as a feeding channel for basaltic lavas, now eroded away.

That volcanic explosive activity actually did take place in this region is further indicated by the occurrence along the western selvage of the dolerite dyke at the northern foot of the eastern cone and high up in the vicinity of the Cave Sandstone of a tuffaceous rock. Generally the latter is dark, occasionally light in colour, exhibiting abundant small shattered fragments of quartz and felspar in a matrix of fine particles and dust. This rock is very compact and cuts through the red shales and arkoses of the Lower Etjo beds in the same way as the dyke of dolerite. The position of the dyke-like exposure of tuffaceous rock is some 250 metres (810 feet) below the Cave Sandstone, the land surface of that time. The fragments of quartz and felspar must have been derived either from the underlying granite or from the beds of arkose intercalated in the Lower Etjo beds, or both.

It appears proved, therefore, that also in this region the deposition of Cave Sandstone was followed by volcanic activity and the outpouring of basaltic lavas, of which, however, now almost no trace remains, the basic rock capping the Cave Sandstone on the Omatako cones being an intrusive sill.

No fragments or boulders of the intermediate and acid lavas, that in the Erongo Area and the Kaokoveld occur above the lower basaltic lavas in great thickness, have yet been found in this region. It cannot be stated, therefore, whether the Karroo lavas in this area experienced far-reaching differentiation as in the other regions of northern South-West Africa, or only comprise normal basalts and andesites, as in the area to the south of the Khomas Highlands (Hoachanas plateau).

(c) *Etjo Mountain.*

The Etjo is one of the most striking morphological features of northern South-West Africa. It represents a long, but narrow, level plateau, its length being 15 to 16 km. and its maximum width 3 km. At the south-western buttress the edge of the plateau has an elevation of 2,086 metres (6,778 feet) (Photo 3).

One of the best exposures of Lower Etjo beds is to be found on the south-west slopes of a prominent little hill on the farm Omburo

No. 51, 22 km. west of the Etjo. The beds here are mainly composed of deep red mudstones and laminated shales, intercalated with which occur reddish argillaceous sandstones and light coloured felspathic sandstones, in part arkosic and conglomeratic. The latter are particularly abundant near the base of the hill, but seldom exceed 1 to 1·3 metres in thickness. The pebbles are in part well rounded, but a considerable number are angular. They consist mainly of quartz, pegmatite, granite and resistant members of the Damara System.

In many layers of the argillaceous rocks greenish and greenish blue clay pellets and clay-pellet conglomerates are very common. Small channels and discordancies due to contemporaneous erosion are also to be seen. Similar features are also quite common in the Red beds of the Stormberg Series.

At the Etjo itself, brownish to brownish-red quartzitic sandstones undergo a strong development for about one-third of its total height. On the farm Etjo Nord these resistant rocks form an extensive subsidiary plateau, at the western edge of which they dip at 40° to 60° towards the great fault (Map, Plate XLII). On the other side of the fault, on Omingonde, crystalline limestones of the Damara System form a number of conspicuous mountains rising to a height of 600 metres above the downfaulted Etjo beds. The minimum downthrow of the latter, therefore, must attain at least to this figure (1,950 feet).

On the farm Otjihaenamaparero quite a number of fossil tracks have been found by Elmenhorst on the surface of beds of the brownish quartzitic sandstones just mentioned. They have been described by Gürich (8). The most striking track is that of a three-toed clawed reptile, apparently saurischian, that moved on its hind legs only, without support of the tail. Gürich has named it *Saurichnium damarense*. In addition, there occur other tracks, *Saurichnium parallelum*, *anserinum* and *tetractis*, as well as the track of a small tetrapod, *tetrapodium elmenhorsti*.

For some time these tracks represented the only direct evidence of the youthful, probably Stormberg, age of these sediments. Since then, however, a fragment of a reptilian skull of Karroo type has been found on Breitenbach, east of the Waterberg.

The Etjo is capped by the Plateau (Cave) Sandstone, which here is some 70 metres thick, and gives rise to precipitous cliffs right around the edge of the plateau.

(d) *Little Waterberg.*

The Little Waterberg is a small plateau, sloping at 4° to 5° to the east, 14 km. long and 4 km. wide at the western buttress. The capping of Plateau Sandstone as usual forms precipitous cliffs and weathers brick red. On fresh surfaces the colour is pale pink.

The main interest of this mountain lies in the fine exposures of the basal arkose below the north-western buttress (Photo 5), where the following section is exposed:—

Bottom.

Thickness.	
8 metres:	Deep-red argillaceous and felspathic sandstones and sandy shales with abundant clay-pellets and occasional limestone concretions. Occasional layers of laminated shales.
4 ,,	Red mudstones with narrow intercalations of reddish argillaceous sandstones.
3½ ,,	Reddish and white coarse arkose with narrow lenticles of red shales.
3 ,,	Massive white arkose, in part conglomeratic, with narrow lenticles of reddish shales.
4 ,,	Red sandy shales and clayey sandstones.
1½ ,,	Light coloured coarse arkose.
2½ ,,	Red sandy shales and clayey sandstones.
3½ ,,	Light coloured coarse pebbly arkose with narrow lenticles of reddish shales.
½ metre:	Red sandy shales.
30–40 metres:	Very coarse massive and unbedded arkose of white colour, with abundant well rounded pebbles of quartz and crystalline limestone, and abundant angular fragments of granite and quartz; intercalated narrow lenticles of reddish sandy shales. In upper portion one massive layer of unbedded arkose 17 metres thick.
5 ,,	Reddish sandy shales and clayey sandstones.
2½ ,,	Conglomeratic white arkose.
	Reddish clayey sandstones and sandy shales with limestone concretions.
8 ,,	Coarse arkose of light colour, with an upper layer showing pronounced false bedding and angular quartz-pebbles.
150–180 ,,	Reddish sandy shales and clayey sandstones with abundant clay-pellets and limestones concretions. In lower portion these shaly rocks still contain intercalated layers of arkose, sometimes 3 to 4 metres thick; higher up there occur several well-marked beds of whitish felspathic sandstone.
60 ,,	Massive fine-grained unbedded felspathic sandstone of brick-red colour: Plateau Sandstone.

Below the sandstone cliff of the northern slopes there occur two springs, known as Okosongomingo and Onamausa. The former yields 50 to 60 cb. metres per day.

(e) *Great Waterberg.*

This is the most extensive of all the plateaux formed by the Plateau Sandstone (Photo 4). Its length is roughly 70 km. and its width approximately 18 km. The plateau has a gradual, almost imperceptible slope towards the east, where the Plateau Sandstone finally disappears under the universal cover of Kalahari sand. Around its north-western, western, southern and south-eastern edge the plateau is terminated by precipitous cliffs (Photos 4 and 6). Its highest elevation is 1,857 metres (Omuverumue).

Near its south-western termination, the level plateau is interrupted by a gap or poort, the Omuverumue (Herero = poort) here forming a subsidiary plateau of great beauty (Photo 4). This plateau is completely encircled by vertical cliffs of deep-pink Plateau Sandstone, some 80 metres thick. Owing to its jointed nature, it gives rise to innumerable vertical columns, turrets, etc. (Photo 6).

Bedding is practically absent, except in a rough way near the base. Along the path from Waterberg farm to Otjosongombo over the top of the plateau an irregular parallel bedding, dipping at 20° mostly to the east, but also in other directions, can be noticed over a distance of several kilometres. Presumably this feature represents the slopes of a number of elongate sand dunes.

The name Waterberg is derived from the occurrence of a number of prolific springs below the Plateau Sandstone cliffs, an unusual feature in this otherwise waterless territory.

The largest supplies are yielded by the closely neighbouring group of springs at Waterberg Farm (former Police Station), which in 1932 together yielded approximately 500 to 550 cb.m. per day (Fig. 1). The yield of the Otjosongombo spring in the same year was stated to be 250 to 300 cb.m. per day. These comparatively large supplies of water render horticulture possible on a considerable scale, an unusual sight in South-West Africa.

The average annual rainfall is 500 mm. (21 inches).

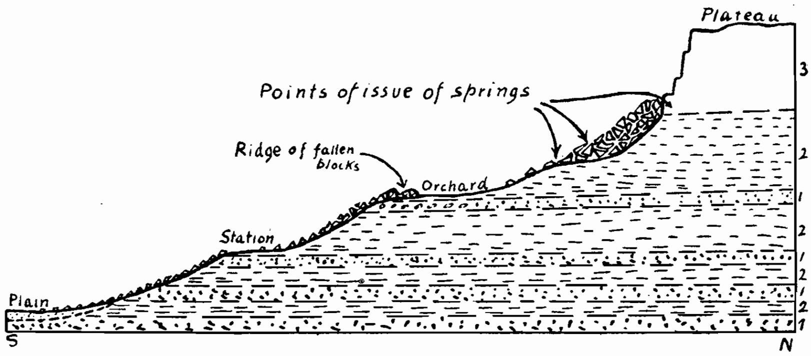

Fig. 1.—Schematic Section through Southern Slope of Great Waterberg at Former Waterberg Police Station.

1=Arkose; 2=Red Shales and Clayey Sandstones; 3=Plateau Sandstone.

The mode of occurrence of the springs is depicted in Fig. 1. The water issues from the base of the porous Plateau Sandstone near its contact with the underlying impervious shales. Generally it runs some distance through the accumulated fallen blocks of sandstone before it finally emerges. Due to the luxuriant vegetation around these springs, the resulting soils on the terrace below have become rich in humus and are very fertile. The fact, that the fallen blocks disappear on the more level portions of the terrace to give way to a dark soil and then reappear again as a distinct wall on its edge, is no doubt to be attributed to the decomposing action of the water originally stagnating on this portion of the terrace before being artifically drained.

The water is of excellent quality for agricultural purposes, being extremely soft, as the following analyses by J. P. v. d. Westhuyzen* show:—

	Great Waterberg Springs.	Okosongomingo Spring.	Onamausa Spring.
Total solids in parts per 100,000.	4·0	4·0	5·2
Free Silica	0·5	0·6	0·5
Combined Silica	0·4	0·2	0·6
$Al_2O_3+Fe_2O_3$	0·2	0·8	0·7
Ca O	trace	trace	trace
Mg O	trace	trace	trace
Na_2 O	1·1	1·0	1·6
S O_3	trace	trace	trace
Cl_2	0·7	0·9	0·7
CO_2	trace	trace	trace
Na_2SiO_3	0·8	0·4	1·2
Na Cl	1·2	1·5	1·2
Organic and Volatile Matter	1·3	0·7	1·1
Suspended Matter ...	—	—	5·1

Reaction to litmus : acid.

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* The writer is indebted to Mr. J. P. van der Westhuyzen for analysing samples of these spring waters.

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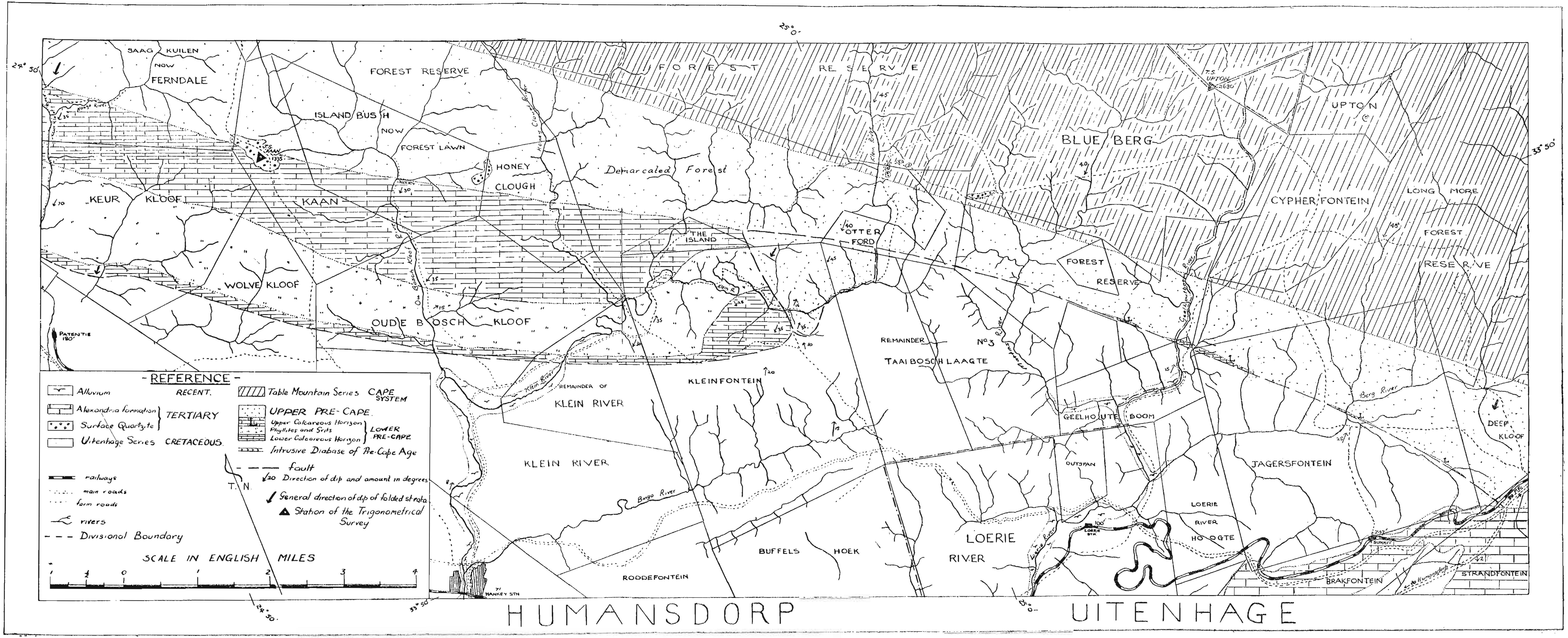
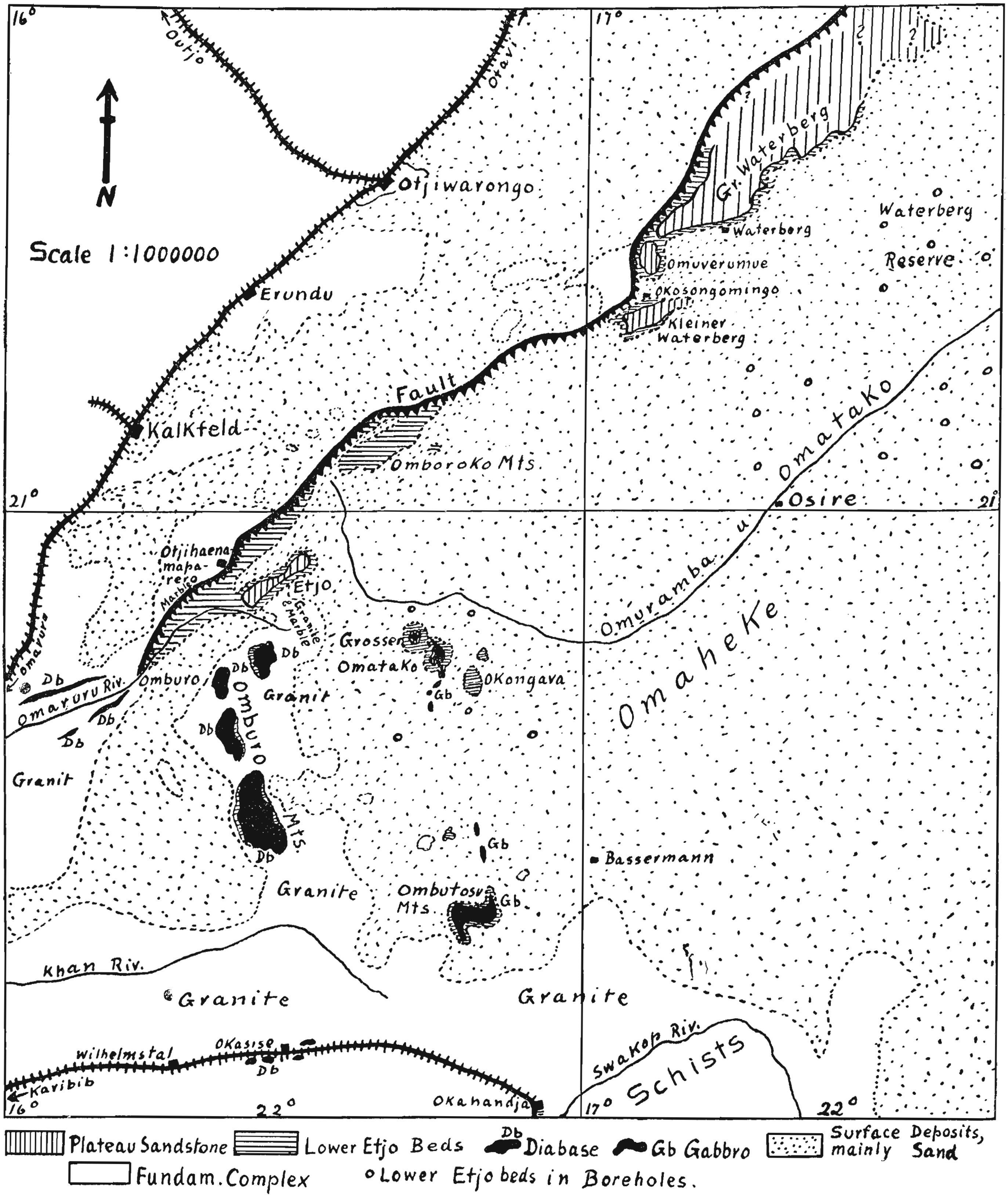
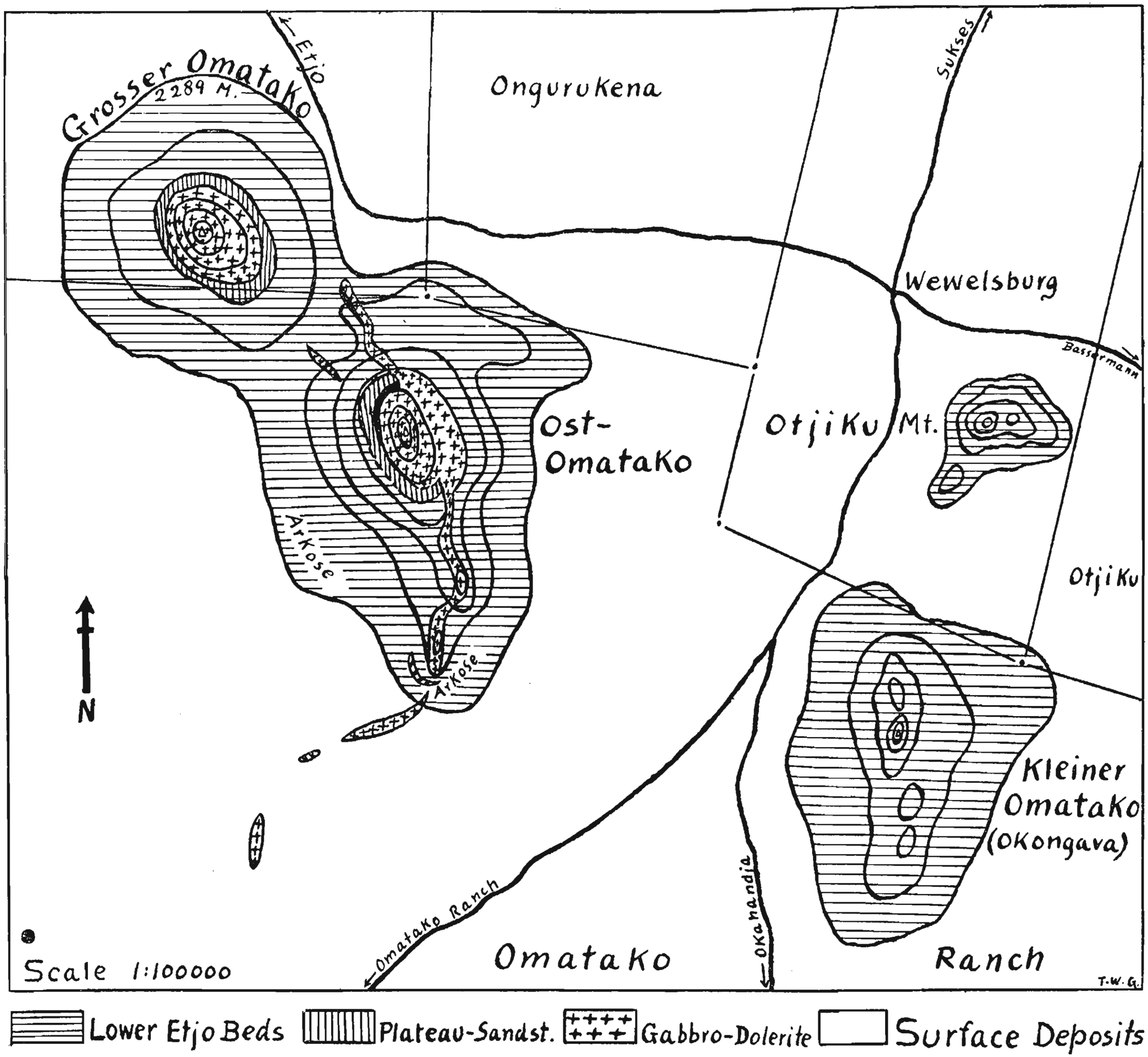


SAAG KUILEN NOW FERNDALE
FOREST RESERVE
ISLAND BUSH NOW FOREST LAWN
HONEY CLOUGH
KEUR KLOOF
KAAN
Demarcated Forest
WOLVE KLOOF
OUDE BOSCH KLOOF
THE ISLAND
OTTER FORD
FOREST RESERVE
BLUE BERG
UPTON
CYPHER FONTEIN
LONG MORE
FOREST RESERVE
REMAINDER No 3
TAAI BOSCH LAAGTE
KLEINFONTEIN
REMAINDER OF KLEIN RIVER
KLEIN RIVER
GEELHOUTE BOOM
OUTSPAN
JAGERSFONTEIN
DEEP KLOOF
LOERIE RIVER HOOGTE
LOERIE RIVER
BUFFELS HOEK
RODDEFONTEIN
BRAKFONTEIN
STRANDFONTEIN
HANKEY STN
LOERIE STN
Klein River
Bungo River
Berg River
PATENTIE
T.S. UPTON
T.S. KAAN
- REFERENCE -
Alluvium RECENT.
Alexandria formation
Surface Quartzite TERTIARY
Uitenhage Series CRETACEOUS.
Table Mountain Series CAPE SYSTEM
UPPER PRE-CAPE
Upper Calcareous Horizon
Phyllites and Grits
Lower Calcareous Horizon
LOWER PRE-CAPE
Intrusive Diabase of Pre-Cape Age
fault
Direction of dip and amount in degrees
General direction of dip of folded strata
Station of the Trigonometrical Survey
railways
main roads
farm roads
rivers
Divisional Boundary
T.N.
SCALE IN ENGLISH MILES
1 ½ 0 1 2 3 4
HUMANSDORP
UITENHAGE



Sketch Map showing Distribution of Etjo Beds in Northern Hereroland.
(Modified after Reuning.)



Sketch Map of Omatako Mountains.

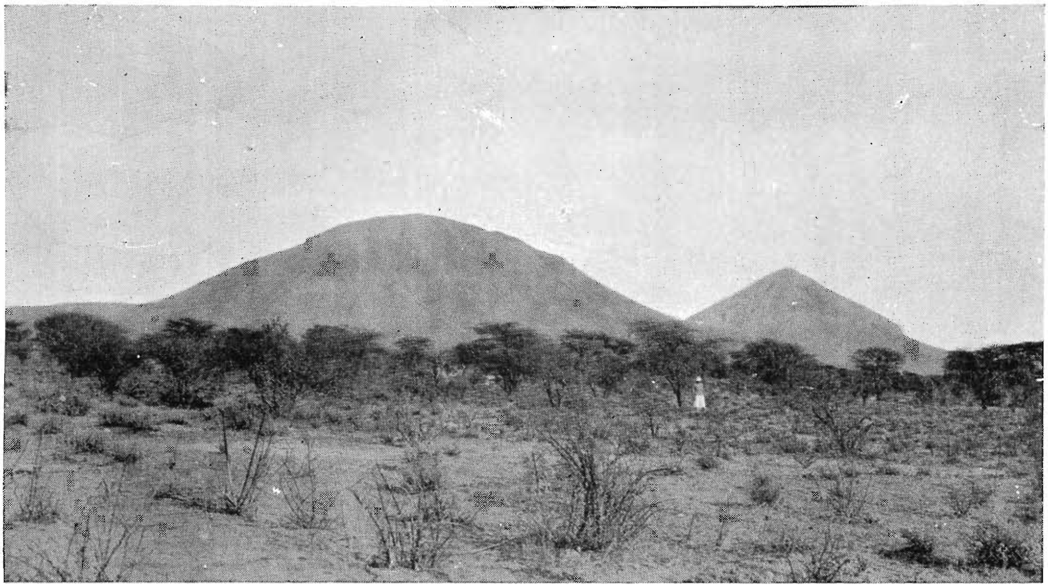


Photo: Gevers.

PHOTO 1.—The two great Omatako Mountains, the Western Cone on right. Note absence of Cave Sandstone ledge on Eastern Cone.

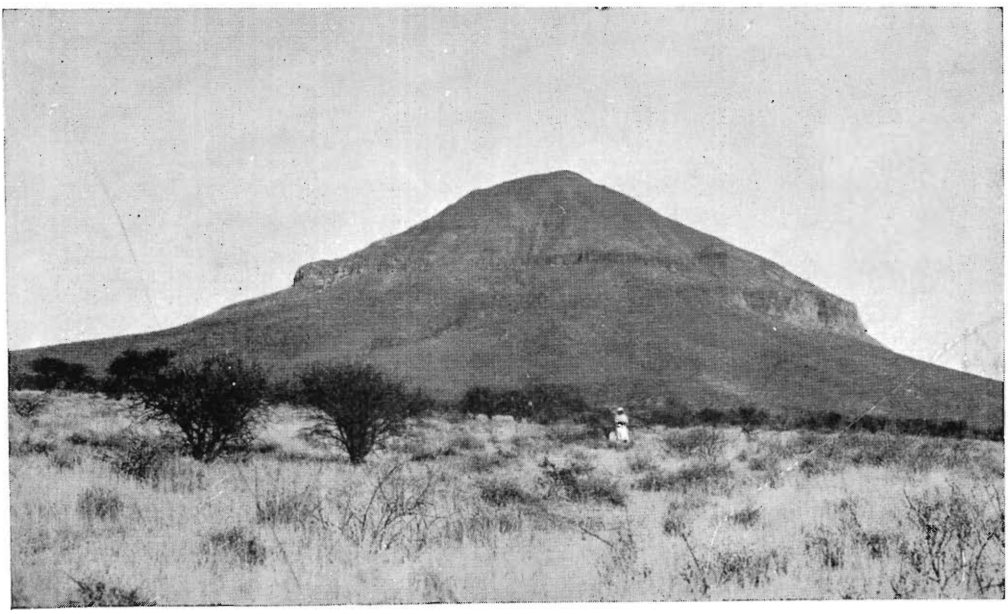


Photo: Gevers.

PHOTO 2.—The Great Omatako (Western Cone), rising 2,100 feet above plain. Ledge of Cave Sandstone half-way up, Red Beds below, Dolerite on top.

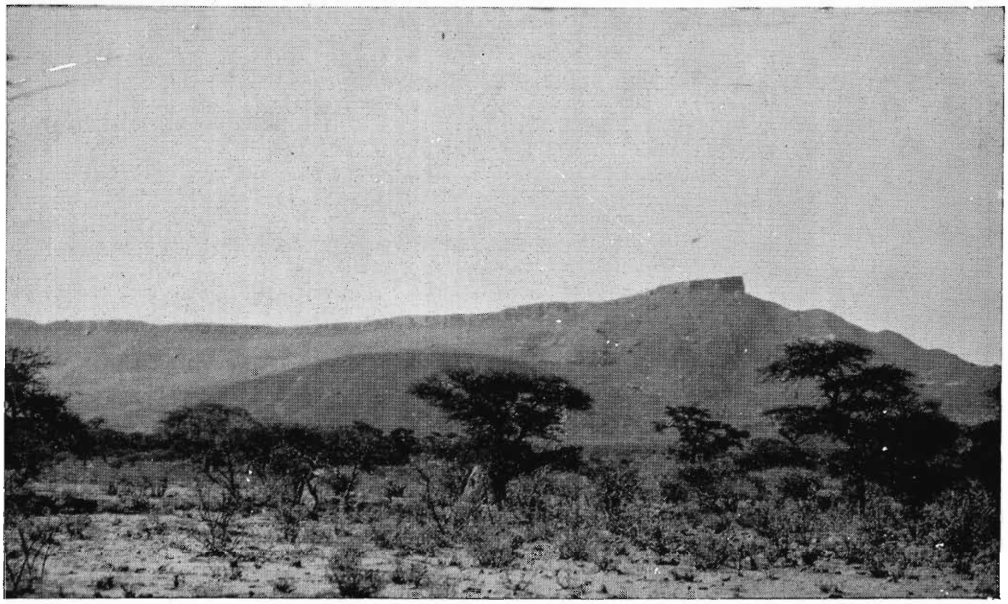


Photo: Gevers.

PHOTO 3.—The Etjo Mountain, South-western Buttress, showing Red Beds and capping of Plateau (Cave) Sandstone.

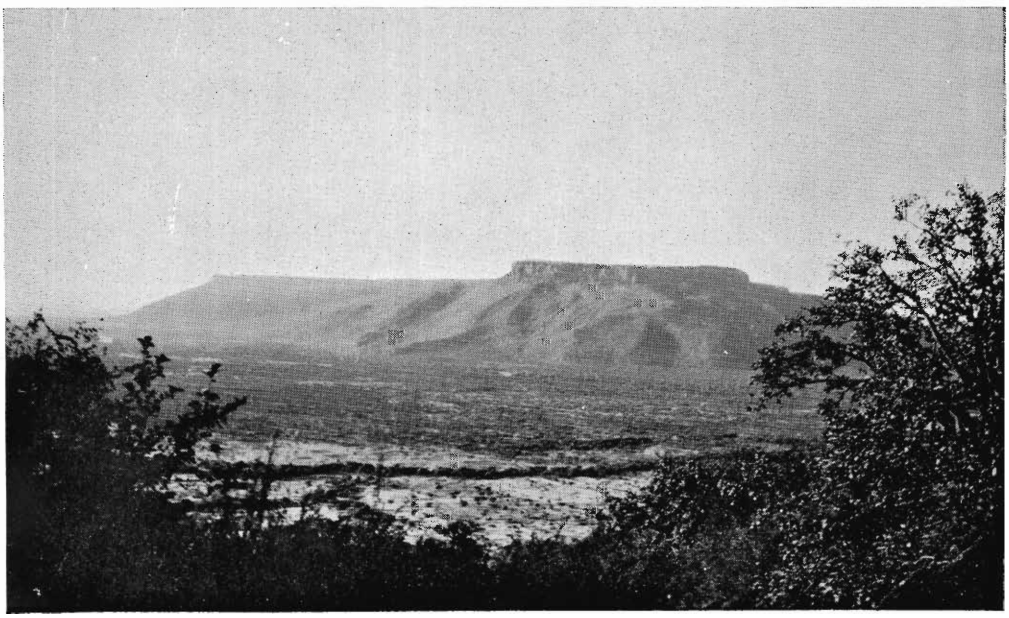


Photo: Gevers.

PHOTO 4.—The Great Waterberg—View from Little Waterberg. Omuverumue Plateau on right.