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NYASALAND PROTECTORATE

Annual Report of the Geological Survey Department for the year 1951

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CONTENTS

I. INTRODUCTION

Staff

GEOLOGIST

K. Bloomfield, B.SC. (Leeds), arrived 31st December, 1951, to fill the vacancy caused by the resignation of H. W. Ball in June.

WATER SUPPLY

W. M. Todd, Drilling Superintendent and Wells Maintenance Officer, arrived on 3rd February, 1951.

A. J. de Wet, Driller, was appointed on a monthly basis agreement on 1st August, 1951.

A. S. B. Hattingh, Driller, was appointed on a monthly basis agreement from 1st July, 1951 to 30th November, 1951.

W. L. G. Todd, Driller, was appointed on agreement on 4th August, 1951.

J. Finlayson, Water Supply Foreman, was transferred on 1st May, 1951, to the Hydrological Section of the Agricultural Department, with his Dam Building unit and its equipment.

The Department sustained a great loss on 3rd February, 1951, by the death in Blantyre Hospital of Mr. Neville Pini at the age of 50. This officer gave long and faithful service to this country, having been employed in Government Water Supply work since 1932. As Senior Driller and Wells Maintenance Officer he had an unrivalled knowledge of the water supplies and drilling conditions all over the country. He took pride in his work and always did a good job. Not the least of his services was the training of his African Staff who are now the mainstay of our enlarged drilling programme.

OFFICE STAFF

M. M. Pegg, Clerk, was appointed to act as Storekeeper and Accountant on 21st March, 1951.

Mrs. E. M. Bishop, Temporary Clerk, took over the duties of Mrs. E. Silvester on 1st February, 1951.

M. L. Namarwa, was appointed African Assistant Storekeeper on 14th November, 1950, in charge of the Water Supply stores at the Limbe Depot.

VISITORS

We were fortunate in having a visit from Dr. C. E. Tilley, F.R.S., Professor of Mineralogy and Petrology at Cambridge, who stayed from 10th August to 20th September, 1951.

Dr. Tilley's main interest lay in the corundum bearing nepheline-syenite of the Tambane Area and the Director of Geological Survey spent some three weeks with him re-examining it. He was also shown the Neno and Mlindi ring-structures, the Chilwa carbonatite, the Zomba Mountain and Mpingwe syenites, all problems in which his advice is appreciated. It is hoped to produce a joint bulletin with him when mapping of the Tambane Area has been completed.

Another welcome visitor was Mr. T. Deans of the Colonial Geological Surveys Headquarters Staff, who was with us from 30th September to 18th October, 1951.

Mr. Deans is working on the rare earth and other minerals of importance known to occur in some carbonatites and he did some preliminary sampling of the Nyasaland vents at Chilwa, Tundulu and Kangankunde Hills. The results of this work, which are awaited with much interest, will be published in due course.

We are greatly indebted to the Directorate of Colonial Geological Surveys for arranging these visits.

Dr. F. Dixey, C.M.G., visited Nyasaland for the week May 30th to June 6th. With the D.G.S. he visited the Mlindi ring where he met Mr. Ashley, E.C.A. Geologist, and later returned to Blantyre where he met all the Geologists, (excepting Mr. Habgood who was in the Northern Province) and the Drilling Superintendent.

Particular interest attaches to the Mlindi ring as its structure has been so clearly revealed by the R.A.F. aerial photographs and a striking mosaic prepared and interpreted by the Photo-Geology Section of the Directorate of Colonial Geological Surveys.

A brief visit was also made to the ring structure near Chingali, west of Zomba, also revealed for the first time by air photography.

Dr. W. Johnston, Head of the Foreign Section of the United States Geological Survey, visited this Territory in June to see the E.C.A. Geologist in the field.

EAST AFRICAN INTERTERRITORIAL GEOLOGICAL CONGRESS

Dr. Cooper, Director of Geological Survey, attended this Congress at Entebbe during the Whitsuntide week in May. The Chair was taken by Dr. Dixey and many discussions took place on subjects of great interest and importance in our geological mapping.

Owing to the great variation in degree of metamorphism of the Pre-Cambrian rocks in Africa their correlation in different territories is a very difficult problem; for this reason yearly meetings in one of the East African territories are desirable.

Programme of Work

Geological Mapping, C.D. and W. Scheme D. 878. It was hoped to complete mapping the block of country 30 miles wide between Blantyre and Zobwe on the Salisbury Road, and Messrs. Ashley, Ball and Morel were detailed to this work. Ball, however, shortly resigned leaving only two Geologists there. Terrain conditions and difficulties in obtaining transport and/or carriers greatly impeded the work with the result that the output was much lower than had been anticipated. Every effort is being made to speed it up in the coming year. Detailed accounts are given later in this Report. Mr. Morel also made a rapid reconnaissance of the Chingali Ring structure, prior to Dr. Dixey's visit. Mr. Habgood continued to work in the Livingstonia Coalfield.

Water Supply. The appointment of Mr. W. M. Todd as Drilling Superintendent has done much to improve our output of boreholes and keep the rigs working.

Two Geologists, Messrs. Garson and Holt, were engaged on geophysical work for the siting of boreholes. This work, though somewhat costly, has proved highly successful and we are building up a valuable store of experience and understanding. Detailed reports of work done are given on page 11. This section received a 35 per cent. grant from Colonial Development and Welfare funds. By request the Director of Geological Survey, made geological examinations of the Mudi Dam cut off trench and the Mungusi Dam site.

Diamond Drilling. It was planned to put down three more holes in the Livingstonia Coalfield this year and Mr. Cairns was transferred there to work with Mr. J. Ellis of the Steel Engineering Co. of Roodepoort, Transvaal, for about four months. Mr. Habgood was in charge of geological work, siting and surveying of boreholes, approach roads and sampling borehole cores.

Office Work. This burden shows no signs of diminishing, but as we have reached our full capacity, the output curve must show some flattening.

During Christmas week a Staff Conference was held at the Zomba headquarters at which much time was given to the question of costs and efficiency. In the past year there was much loss of time due to difficulties of transport, both mechanical and by human porterage. Much of the terrain covered is rough and waterless in the dry season and in consequence largely uninhabited. The difficulties of working in such country are well known, but they are greatly increased by the use of poor and unwilling labour. To replace this by a strong efficient force is our aim, but its fulfilment will not be easy.

II. THE GEOLOGY OF THE NENO DISTRICT

By Burton E. Ashley, E. C. A. Geologist

The geology of about 306 square miles was mapped in 1951. This includes all of the area covered by Preliminary Plot 38/111, and the north central portion of Sheet 42/1. Fieldwork was begun on 15th February, 1951, and ended in November, 1951.

Roughly 85 per cent. of the rocks mapped are metamorphic rocks of the Basement Complex. Probably 70 per cent. of these rocks are paragneisses. Hornblende and biotite paragneisses dominate, although there are pyroxene paragneisses in addition to the very occasional quartz-mica-schists. Although garnet is present east of the Neno Road, titanite is the common accessory in that area; garnet predominates as an accessory in the rocks near the Portuguese border.

Felspathic sandstones are interbedded with the more foliated rocks. Fresh microcline is a common accessory in the sandstones.

Interstratified with the paragneisses and sandstones are at least two beds of marble. These are composed of 90 to 95 per cent. dolomite, with accessory phlogopite, forsterite, spinel, apatite, magnetite, graphite and titanite.

Of the igneous rocks, syenite is the best represented. It is made up mainly of microperthite, with accessory biotite and pyroxene showing no lineation. Large felspars make for a porphyritic texture.

Other igneous rocks more fully described in the final Report are biotite-pyroxenites, pyroxenites, hornblendites, and hornblende gabbros.

As for the dyke rocks, trachitic felsite is the most common, with pegmatite dykes and lamprophyres also represented.

Age relationships have been determined from well exposed outcrops as follows:—

Travertine
Felsite dykes and sills
Pegmatite dykes and sills
Lamprophyre dykes and sills
Liwone syenite
Biotite-pyroxenite
Basement Metamorphic Series.

The dyke rocks are probably nearly contemporaneous with each other.

For the most part, the Basement Complex is rather gently folded; however, in the south central portion of Sheet 38/111, the Mlindi dome stands out as a spectacular example of close and symmetrical folding. Erosion has removed the inner part of the dome, and vertical, to near vertical, edges of the paragneiss form the remnant of an ovoid structure, the influence of which is reflected for five miles east–west, and seven miles north–south. The inner part of the dome is made up of intrusive syenite, and biotite-pyroxenite, the emplacement of which no doubt accentuated the local movement. Felsite, and pegmatite dykes, made prominent by erosion, cut the dome in an east–west direction.

More gently folded anticlines and synclines were mapped along the Neno escarpment, particularly in the region of the hills to the east. Along the Portuguese border, dips in the foliated paragneisses are flat to slightly west.

Faults and fractures show up well on the air photographs. A fault offsets the north end of the Mlindi dome to the east of the order of half a mile. This fault continues some six miles to the east, where it involves the hills. In the north-east part of sheet 38/111, trellis type drainage patterns result from local joints.

Graphite occurs throughout the area in the paragneisses, but probably not in commercial quantities. Various sulphdes are found in the pyroxenites, and two samples have been sent in for assay but the results showed them worthless. The most promising is an occurrence of malachite (copper carbonate) in sandstone, which is associated with a sulphde-bearing hornblende-gabbro, and a pyroxenite. This is located about eight miles south of the Mlindi dome.

X. GEOPHYSICAL WORK AND DRILLING RESULTS IN THE CENTRAL PROVINCE

by M. S. Garson, Geologist

Work was mainly confined to Lilongwe and Dowa Districts as indicated below:—

(*a*) *Lilongwe District.* This consists of a gently-undulating plateau in which shallow valleys have been cut by the largerstreams. Between these valleys a network of dambos rests within minor depressions on the surface of the plateau.

The solid rocks, consisting of steeply dipping micaceous and graphitic schists, gneisses and intrusives of the Basement Complex, are weathered to great depths, and outcrop only in a few places as isolated hills of harder gneiss and syenite.

The weathered rock is overlain by reddish clay on the low ridges, and varying thicknesses of sand, clay and gravel in the dambos. Lateritic ironstone is more evident on the slopes of streams and dambos towards the west of the District.

Geophysical survey and subsequent drilling revealed two main rock types as follows:—

(i) Wet zones occur under variuos conditions in the biotite-gneiss, and hornblende- biotite-gneiss.

Water is found mainly in the mica-rich bands of the typical lit-par-lit gneiss, due to differential weathering.

In other areas pegmatites and narrow shatter belts caused by faulting, present favourable aquifers.

Wet zones are indicated by values of 4 to 10 k.o. cms. by Constant Separation Traverses with 70 feet electrode spacing. Electrical Depth Probes on low resistivity areas give values ranging from 2 to 6 k.o. cms. for wet layers, with maximum yields around 4 k.o. cms. (*see graph Plate 5*).

(ii) Graphite-gneiss. The graphite-gneisses, normally carrying some kyanite and biotite in the Central Province, are weathered to great depths, and few outcrops are visible.

Resistivity values of over 2 k.o. cms. were accepted in graphitic areas as being suitable for drilling. However, a graph of resistivity plotted against yield indicates that values of less than 2 k.o.cms. may give quite good yields.

Insufficient evidence is yet available as to the complete range of successful resistivity values, but the present maximum yield is from values around 2.7 k.o. cms.

(*b*) *Dowa District.* Six boreholes were sunk in the Dowa District, four in the Lake-shore alluvium near Salima, one at Dowa and the other at Mponela.

(i) *Salima Area.* The greater part of the Salima coastal plain is made up of alluvial deposits consisting of sands, clays and gravels. This alluvium thins out towards the escarpment in the west, and the Senga and Rifu granite hills on the Lake-shore. Resistivity values of 0.9 to 1 k.o.cms. were sought, as these values proved most successful in the Shire and Bwanje valleys.

Fairly large yields were obtained, especially in Salima Township, where alternating layers of coarse sand and gravel were penetrated to 140 feet.

(ii) *Dowa Township.* As previous boreholes in Dowa in 1946 were unsuccessful, it was decided to make a large-scale iso-resistivity map of the Township Area, using Constant Separation Traverses at 300 feet intervals, in an attempt to trace the main water-bearing areas.

Three principal low restivity zones were found, the largest zone being of graphite-kyanite-gneiss, forming a syncline on which the township is situated. Readings were in places less that 1 k.o.cm. indicating a high percentage of graphite.

The other two low zones, probably indicating pegmatite, bear neither relation to the surface topography nor to the strike of the country rock.

A borehole sited in the southernmost zone, cutting across the Garden Stream, gave a yield of 650 gallons per hour.

(iii) *Mponela Market.* A wet zone was located by geophysical survey at Mponela, and although a rather high resistivity of 7.2 k.o. cms. was found, a useful yield of 420 gallons per hour was obtained.

As, out of four boreholes located by "hit or miss" methods in Mponela in 1937, only one was successful, the value of the present methods of geopysical survey was strikingly proved.

Mr. Habgood arrived in the Central Province at the beginning of December, in order to become familiar with the geology and geophysical values obtaining there prior to taking over the water supply work in 1952.

The two Geologists visited Mzimba District in the middle of December to complete the siting of 23 wells for cattle dip tanks, for the Veterinary Department.

Other work during the year included the siting of earth dams at N.A. Kaluluma, Msusu Mission and Sinlemba Village, in the Kasungu District. Investigation of the Dwangwa Sedimentary Series, which is probably of Karroo age, showed that there are no workable limestones in the area. Travertine deposits occurring in the Kambudzi Stream, in N.A. Chiwere's area, Dowa District, were proved to exist in workable quantity and quality.

Drilling results are given in the Table at the end of Section XII on page 14.

XI. GEOPHYSICAL WORK AND DRILLING RESULTS IN THE SOUTHERN PROVINCE

by D. N. Holt, Geologist

During the nine months April–December, 46 separate Geophysical Surveys were carried out, including 12 done for private interests. Of the sites found 30 were drilled by Government Drilling Units during 1951, five sites remaining to be drilled during 1952.

Work was carried on throughout the Southern Province and much time was spent in travelling, particularly when three drills were operating simultaneously at widely separated points.

The main centres of activity were:—

1. Chiradzulu District Village Water Supply Scheme

The area covered is situated in the foothills of the Shire Highlands and in the Palombe Plain, and is approached by the Midima Road from Limbe to Mlanje. Seven Boreholes were sited in the foothills and 19 in the plain.

These hills consist of high grade Basement Complex rocks intruded by leucocratic potash syenites, the latter forming prominent outcrops. Much C.S.T. work was necessary in these areas as good yields from the syenites can only be expected from shear zones and such are widely spaced. Resistivities for these shear zones appear lower than those obtaining under similar conditions in the Blantyre/Limbe Area, averaging 2.1 k.o. cms.

Values obtained in the Palombe Plain varied more widely, probably partly due to the variable nature of the Basement Complex which underlies the cotton soil of this area. Resistivities for water-bearing zones varied from 1.4 to 8.3 k.o. cms, although a minimum of 0.2 was obtained at Tuchila Farm in a well defined low zone where the water was saline. Where the wet zone showed values above 5 k.o. cms. the main yield was obtained from the underlying rock which appears to be well fissured locally along zones similar in nature to those found in the syenites of the foothills. The rest level of the water was in most cases within 10 ft. of the surface, even during August and September. The Geophysical curves were mostly of single layer positive type, there being no sharply defined interface between the Palombe Plain alluvium and the underlying zone of weathered rock. The interface between weathered and unweathered rock was in most cases found to be deeper than was suggested by the Geophysical Survey results. This is probably due to the narrow trough-like form of the decayed zones, whereby the maximum depth is greater than the mean depth of the area covered by depth probe.

2. Magomero, Zomba District, Resettlement Scheme

Conditions very different from those in Chiradzulu were found to the north in the Palombe Plain between the Namadzi and Ntondwe Rivers. Work was done near the Zomba–Palombe Road about 20 miles from Zomba; the country here is flat and featureless and there is no solid geology to be seen.

The alluvium is fairly uniform with a thickness averaging 20 ft. It rests everywhere directly on virtually unweathered Basement Complex granulitic syenites. These are rich in ferromagnesian minerals, and mostly have resistivities of 40–50 k.o. cms. There is little evidence of major fissuring. The water table was more than 80 ft. below the surface when the drilling was carried out in October. The 20 trial depth probes made at widely separated points all gave a hard rock interface at 20 ft., with a surface resistivity of 1.1–1.3 k.o.cms. and a value for the lower medium of less than 50 k.o.cms. Constant separation and self-potential traverses were carried over a wide area but no well defined low zones were detected. The borehole sites finally selected were found by random depth probes and are probably situated in well jointed areas in hard rock. No significant weathering was noted and the boreholes yielded water from the hard rock at depths greater than 85 ft.

3. Alimenda and Kakoma, Chikwawa District

Two boreholes were put down in the Ngabu/Nchalo Area of Chikwawa District in the hope of being able to irrigate trial plots for the pilot scheme of the Alimenda sugar project. Although it is intended eventually to irrigate by pumping from the Shire the cost of doing this initially over a distance of five miles for the trial plots was considered prohibitive. The plots for which the boreholes were required were in areas classified as follows:—Parkland, semi-parkland, bush, and salty wanje grassland. Resistivities of 0.8–2.0 k.o. cms. were found in parkland and semi-parkland and there seemed some chance of obtaining reasonably fresh water. On drilling, however, water was obtained with a salinity far too high for Agricultural purposes, and the remarks made by the Director of Geological Survey in the 1946 Report of the Geological Survey Department regarding salinity in Rift valley alluvium were found to be amply justified. Resistivities of 0.3–0.5 k.o. cms. in bush and salty wanje grassland showed the obvious unsuitability of these areas for boreholes yielding anything but brine. The desire to test the water by those concerned overrode the geophysicist's better judgment. The boreholes at Ngabu and Kakoma Maize Farm in Rift Valley Alluvium yielded water not too brackish for domestic use.

4. Chingali, Zomba District Resettlement Scheme

Resistivity values of 0.6 for Alluvium and 7.5 weathered syenite were obtained at Chingali Headquarters near the foot of the Rift Valley scarp adjacent to the Chingali River. The weathered syenite yielded 800 gallons per hour.

At Magombo, near the foot of the low level peneplain, a value of 0.8 k.o.cm. was obtained in Rift Valley Alluvium. From drilling results of the previous year this might have been expected to yield over 500 gallons per hour, but difficulty was experienced with running sand and clay, and the site was abandoned. Over a dozen depth probes were tried in areas which had failed to yield water the previous year, but resistivities were all too low to justify further drilling. At Chippeni, near sites B38 and B30 of 1950 which failed in syenite at 89 and 115 ft. respectively, a well-developed shear zone was located with values of ρ_2=3.8 and $\lambda_2 a$=60ft., but this was not drilled as it was decided that the adjacent land was unsuitable for cultivation.

*Note.—ρ_2=Specific resistance of wet zone and $\lambda_2 a$=Depth of base of wet zone.

XII. NOTES by W. M. Todd—Drilling Superintendent

Construction of Boreholes

Sixty-seven Boreholes were completed during the period 1st March to 31st December, 1951, of which six were unproductive. Two of these were in the Chikwawa District in silty clay of rift valley alluvium, from which it was found impossible to get a clear flow. The difficulties of such terrain were pointed out in 1946 when the Director of Geological Survey investigated certain areas of this District for the Tombondera Resettlement Scheme. One of the unsuccessful holes was sunk for the administration contrary to the advice formerly given. It is clear that such areas as the Mwanza Plain would be better served with a furrow.

Another area that gave trouble with similar material is the Magomero Resettlement Area. Out of four boreholes here, only one gave a large yield (1,200 gallons per hour). Two gave only a low yield and one nil.

Chiradzulu—Mlanje. Of the 24 boreholes in three Districts, three were unproductive.

Central Province. Nineteen boreholes, mainly in the Lilongwe and Dowa Districts, were all successful and yields were mostly moderately good.

Plant

On the whole the plant gave little trouble mechanically, with one exception—the No. 1 Steyn's drill.

Considerable trouble was experienced with the fuel pump of an American Diesel Engine on one of the drills, resulting in a lot of lost time. It was believed to be largely due to negligence and absenteeism on the part of the driller, whose service was later terminated. This machine also gave trouble with the breaking of a main spudding shaft bearing. It was welded twice but would not stand up to the work and much time was lost through inability to get castings made.

Maintenance

In December one Steyn's and three Edeco machines were overhauled and the Lister Engine off Edeco No. 2 was reconditioned.

Transport

Mechanically the units have performed well, but much trouble and loss of time has been caused by broken springs and cracked chassis and radiators. Commonly the springing is too stiff on British trucks but part of the trouble is probably due to excessive speed by African drivers on bad roads.

Costs

The average all-in cost of a successful borehole is about £360 including *all overheads and geophysical surveys, capital depreciation* and so on.

This is very high, and efforts are being made to reduce it. Amongst measures being taken are:—

(*a*) The insertion of 4 in. diameter G.I. pipe in lieu of 6 in. casing for small villages supplies where practicable.

(*b*) The use of lever type " bush pumps " instead of climax rotary heads in small villages.

(*c*) An attempt to reduce the time and money lost in travelling. This has been much affected by special Government jobs of " high priority ".

(*d*) Reduction in lost time due to transport breakdowns.

The onset of the rains was early and heavy and in December great trouble was experienced in getting two of the drills out of the Chiradzulu Plains. With the one exception, mentioned previously, all the drilling staff have shown their keen willingness to co-operate in this work.

The following tables give details of boreholes sunk in both the Central and Southern Provinces.

Zomba, 13th March 1952

W. G. G. Cooper
Director of Geological Survey

BOREHOLES COMPLETED IN 1951.

Central Province

Ref. No.	District and Location	Completed Depth in feet	Yield G.P.H.	Month Drilled	Rest Water Level	Salinity p.p.m.	pH Values	Remarks	Geophysical Survey Results				
									Geology	Sp. Res. fresh rock	Depth top and bottom Wet Zone	Sp. Res. of Wet Zone	Month of Survey
	Lilongwe District												
G 89	N.A. Kalumbu	115	750	Jan.	23	106	6.7		Graphite-mica gneiss	1.7	20—110	2.7	November 1950
95	Chalenga	100	120	Feb.	37	—	—		Mica-schist	8.3	60—100	3.5	December
96	Chileka Dispensary ..	120	200	March	35	—	—		Garnet-mica-gneiss	93	30— 60	5.0	,,
104	Dzenza School	125	500	March	66	—	—		Graphite-kyanite-gneiss	0.9	60—100	4.5	January 1951
103	N.A. Chitukula	95	600	April	35	—	—		Graphite-mica gneiss	0.8	30—110	2.4	,,
94	African Rec. Centre, Lilongwe	110	—	April	105	—	—	Hole deflected to be redrilled	Hblde and Qz -gneiss	200+	60—120	6.2	December
124	Nkukwe	83	360	Aug.	28	39	—	Chipili 2	Biot-gneiss	100	30— 60	3.5	April
123	Kansenga	106	700	Aug.	55	56	—	Chipili 1	Graphite-gneiss & amphibolite dyke	0.8	30— 95	3.8	,,
144	Mliu	65	300	Aug.	30	72	—	Chipili 3	Biot-gneiss	70	25— 60	5.3	August
118	Chipili	150	550	Sept.	93	—	—	Chipili 4	Biot-gneiss	180	30—110	3.7	April
117	Chiseko	88	760	Sept.	29	25	—	Chiseko 1	Biot-gneiss	190	30— 60	4.0	,,
145	Samva	82	450	Sept.	21	405	5	Chiseko 2	Biot-gneiss	45	25— 80	5.7	August
146	Maunda	95	320	Sept.	59	740	7.3	Chipili 5	Biot-gneiss	360	50— 90	5.2	,,
152	Chalendewa	104	600	Oct.	30	24	—	Chipili 6	Biot-gneiss	180	10— 50	3.7	September
151	Mwenda	110	510	Nov.	17	486	7.1	Chiseko 3	Hbl. Biot gneiss	190	15— 80	4.8	,,
149	Kasakanya Leper Colony I	93	580	Dec.	17	243	6.0		Graphite-kyanite & Hbl.-gneiss	45	30—120	2.8	,,
112	,, ,, ,, II	33	650	Dec.	10	260	6.2	Hard basic dyke in bottom 6"	Graphite-kyanite -gneiss	10	15—120	3.1	March
85	Agric. Res. Station, Chitedzi	92	550	Dec.	25	280	6.2		Graphite-mica -gneiss	1	15— 85	3.7	November
114	Mbwatalika	40	—	Dec.	—	284	6.4	Drilling in progress	Hblde-gneiss	100	36— 90	3.5	March

BOREHOLES COMPLETED IN 1951.

Central Province—(*Continued*)

Ref. No.	District and Location	Completed Depth in feet	Yield G.P.H.	Month Drilled	Rest Water Level	Salinity p.p.m.	pH Values	Remarks	Geophysical Survey Results				
									Geology	Sp. Res. fresh rock	Depth top and bottom Wet Zone	Sp. Res. of Wet Zone	Month of Survey
	Dowa District												
G 25	Mponela Market	100	420	Jan.	20	—	—		Qz-gneiss	36	25—180	7.2	May, 1950
99	Salima Township	140	2000+	May	40	44	—		Sand & gravel	60	40— 95	1.1	January, 1951
98	Salima Market	136	1200	June	31	58	—		Clay, sand & gravel	40	35— 90	1.0	January
138	Salima Airfield	140	540	July	56	91	—		Clay, sand & weathered granite	2.5	60+	2.5	May
143	Salima Native Tobacco Board	108	1000	Oct.	40	58	—		Clay, sand & gravel	25	40—120	1.1	August
137	Dowa Township	202	650	Dec.	12	—	—	Sc. graphite in pgte	Pegte & gneiss	2.4	15—180	9.2 & 7.6	May
	Kota Kota District												
G 28	Visanza Market	80	—	—	49	—	—	Drilling in progress	Hblde-gneiss & basic dyke	65	35— 80	6.0	May, 1950

BOREHOLES CONSTRUCTED IN 1951

Southern Province

Ref. No.	District and Location	Completed Depth in feet	Yield G.P.H.	Month Drilled	Rest Water Level	Salinity p.p.m.	pH Values	Remarks	Geophysical Survey Results				
									Geology	Sp. Res. fresh rock	Depth top and bottom Wet Zone	Sp. Res. of Wet Zone	Month of Survey
B 14	*Blantyre* Township near P.W.D.			March	32				Sheared syenite	195	30—100	3.7	August
L 2	Border Inn Mwanza ..	88	600	,,	6				Syenite gneiss	115	20— 40	3.6	April
B 45	Customs, Mwanza	80	675	,,	7					149	20— 64	8.0	,,
B 46	Mwanza Dispensary ..	120	540	May	15					68	7— 60	5.3	,,
L 3	Tung Exp. Station, Cholo Rd.	66	500	,,	27				Syenite gneiss	500	20— 40	2.8	,,
	Chikwawa Boma	145	Nil	Nov.	130			No G.P. Survey No water	Shire River alluvium	—	— —	—	
L 25	Alimenda Sugar Nursery ..	175	Nil	Sept.	120				Rift valley		20—300+	1.1	August
L 26	,, ,, ,, ..	150	150	,,	89	2145*	7.4		Alluvium		20—300+	2.0	,,
L 49	Ngabu	70	300	Oct.	28				,,		40—300+	0.8	October
L 52	Kakoma Maize Farm ..	120	320	Nov.	56				Rift valley alluvium		80—300+	0.9	,,
L 53	,, ,, ,, ..	80	600	,,	20						40—300+	0.7	,,
B 6	*Chiradzulu* Losa	120	250	May							15—40	1.6	
B 9	Mkalo	105	675	June	30						7—60	2.3	
B 10	Namulu ..	85	750	,,	27						20—40	2.3	
L 7	Malele ..	105	300	,,				Sheared?	Syenite gneiss	53	5—27	1.9	May
L 10	Singano ..	100	150	July	30				Syenite gneiss	110	5—35	2.4	June
L 12	Muyere ..	75	750	Nov.	6				Biot-gneiss	100	0—30	1.4	,,
L 14	Mangulama ..	70	200	July					,, ,,	50+	3—40	3.4	July
L 16	Makalakala ..	96	360	,,					Syenite ,,	40	0—40	2.1	,,
L 18	Nsokanya ..	100	675	Aug.	7			Shear zone	,, ,,	36	3—15	1.9	,,
L 19	Chiliko ..	95	900	,,	3				,, ,,	400	0—40	3.8	,,
L 22	Malonda ..	106	300	,,	13				,, ,,	27	5—40	2.7	August
L 31	Selemani ..	100	1000	Sept.	17				,, ,,	33	0—25	1.4	,,
L 33	Tetemela ..	100	1000	Oct.	13				Graphic Pegte	250	0—35	3.7	,,
L 45	Manyola ..	75	1000	,,	13				Syenite gneiss	600	20—40	8.3	September
L 54	Chitao ..	80	1000	,,	15				,, ,,	400	20—40	5.0	October
L 55	Chombe ..	100	640	Nov.	7				,, ,,	50	10—35	2.0	,,
L 57	Hasuwa ..	80	300	,,	53				,, ,,	200	20—35	8.3	,,
L 62	Kumbunya ..	81	600	Dec.				Shear zone	,, ,,	25	0—22	0.9	November
L 73	Koneliwa ..	—	600	,,	20				,, ,,	22	10—35	2.1	December

BOREHOLES CONSTRUCTED IN 1951

Southern Province—(*Continued*)

Ref. No.	District and Location	Completed Depth in feet	Yield G.P.H.	Month Drilled	Rest Level Water	Salinity p.p.m.	pH Values	Remarks	Geophysical Survey Results				
									Geology	Sp. Res. fresh rock	Depth top and bottom Wet Zone	Sp. Res. of Wet Zone	Month of Survey
	Mlanje District												
C276	Mimosa Tea Exp. Station ..	100	Nil (50)	Sept.	43			Abandoned as unable separate mud & mica	Laterite on biot-gneiss	1700 —— 300	5—70	3.0	August
B 32	Tuchila I	112	Nil	April	15	890	7.7	Mainly sod. chloride	,, ,,	230	18—50	1.6	November
B 33	Tuchila II	75	1000	,,	25	830	8.0		Pegte & biot-gneiss	140	20—55	3.6	,,
B 41	Luchenza Customs	105	Nil	,,	55	—	—	Insufficient water	Biot-gneiss	70	10—38	2.7	December
L 5	Tuchila III	80	1000	May	27	—	—		R.V. alluvium on gneiss	200	10—18	0.2	April
	Zomba District												
G 80	Luedza	110	100	Aug.	50	—	—						
L 35	Chingali Headquarters ..	100	600	Sept.	50	360	6.3	Resettlement Scheme	R.V. alluvium on syenite	75	5—40	0.6	September
L 42	Mangomba	160	Nil	,,	—	—	—		,,	—	15—300+	0.8	,,
L 58	Magomero I	133	450	Nov.	100	—	—		Gneiss	53	10—60	0.8	October
L 59	Magomero II	97	Nil	,,	—	—	—	Redrilled as below	,,	42	20—40	1.1	,,
,,	Magomero III	100	1200	Dec.	—	—	—		,,	,,	,,	,,	,,
L 60	Magomero IV	142	100	,,	94	—	—		,,	200	0—30	1.0	November
C352	Mikuyu Radio Station ..	70	2500	,,	30	—	—	Zomba-Palombe plain	Biot-gneiss	130	20—70	5.5	October
C351	Pyupyu Prision Farm I ..	101	200	Oct.	50	—	—	,,	Laterite on biot-gneiss	80	5—48	3.0	June
C 25	,, ,, ,, ..	60	320	,,	—	—	—	,,	,,	21	9—60	6.0	July

*Note:—Analysis by V. R. Greenstreet, D.I.C., Agricultural Chemist, other Salinities calculated from formula which appears to give results within 10% of correct value.

$$\text{Total Salinity} = \frac{750 \text{ p.p.m.}}{\text{Sp. Res.in K.O.Cms.}}$$

Curves showing the relation between Borehole Yields and Resistivities of Wet Zones.

M.S. Garson, Geologist.