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THE GEOLOGY OF THE ZOMBA AREA

by

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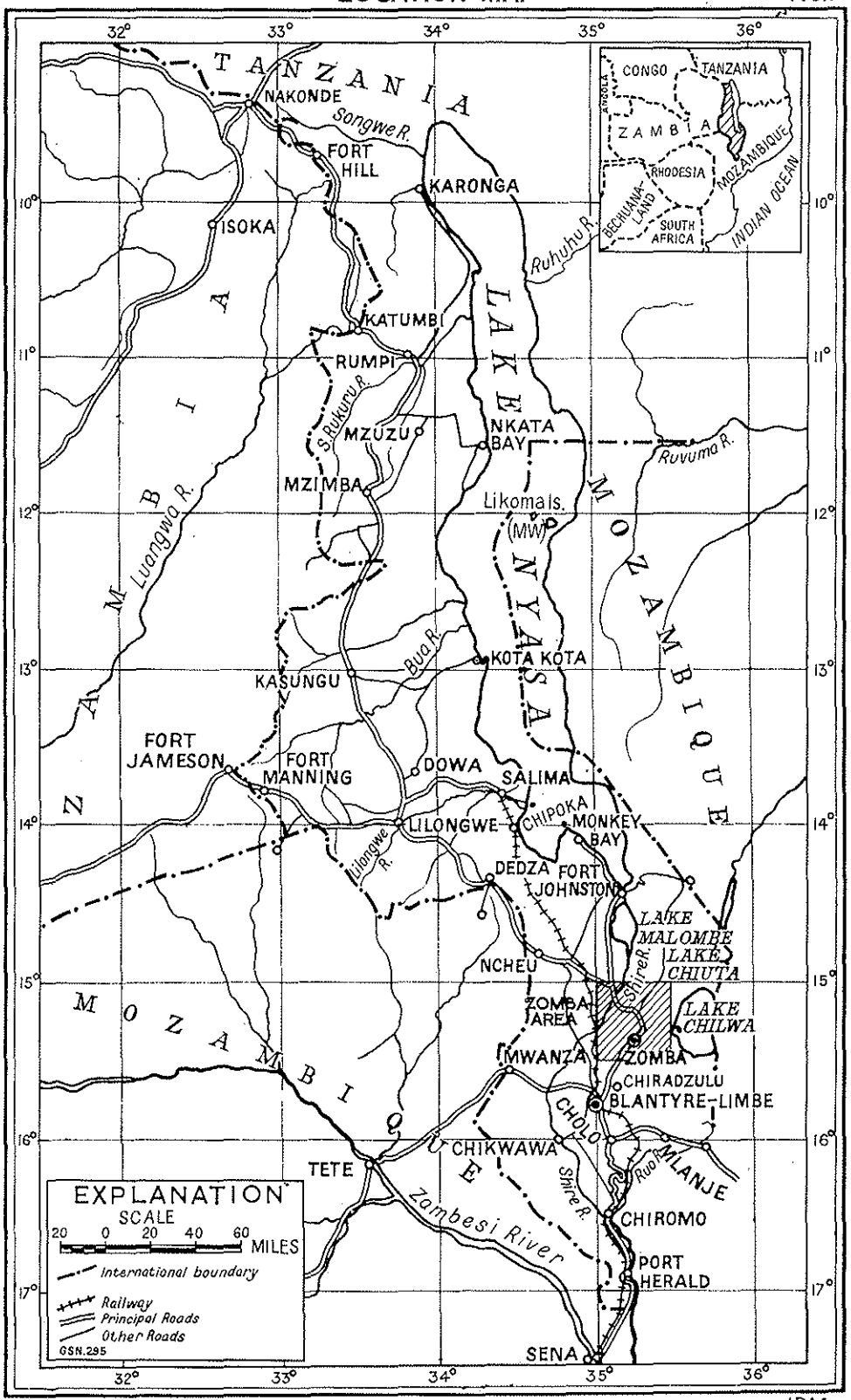
LOCATION MAP FIG.1



Geological Survey Dept. Malawi 1964 JRM.

For Lake Nyasa read Lake Malawi; Fort Hill read Chitipa; Fort Manning read Mchinji; Port Herald read Nsanje.

II. PHYSIOGRAPHY

(a) Relief

The area is one of very strong relief with variations in altitude ranging from 1,550 feet to almost 7,000 feet above sea level. It may, however, be divided into several more or less distinct physiographic units most of which are separated by escarpments or terrace-features. These units are shown on Plate I and comprise the Shire Plain, the Chiendausiku ridge, the Chingale step, the Shire Highlands, the Mlomba uplands, the Lake Chilwa Plain and the hill and mountain masses. They will be described briefly in turn.

The *Shire Plain* covers about a quarter of the total area as flat-lying featureless country on either side of the Shire River, most of which is covered with black sandy clay and supports *tsanya** vegetation. From the River there is a very gradual rise of from 25 to 40 feet per mile and the only residuals rising above the Plain are the horse-shoe-shaped Junguni Hill and the perthosite-gneiss hills Chipini, Namatunu and Kapiri-la-njuchi, outliers of the Chingale Ring Structure (*see* below). The actual edge of the Shire flood plain is marked by a low terrace-feature a few feet in height.

The *Chiendausiku ridge*, so-called because two large villages of that name on the Zomba–Balaka road are situated near its crest, is separated from the Plain by a south-west-trending terrace-feature which crosses the road just east of the Naliswe bridge. Near the northern edge of the map sheet this feature is about 50 feet in height and marks a fault-line scarp. South-westwards, however, the topographic effect is less marked and, near Nailuwa Village, the feature swings to the south-east, presumably controlled here not by faulting but by the strike of the gneisses. On the eastern side of this projecting tongue of gneisses there is a marked drop of about 20 feet to the Shire Plain and also a vegetational change from bamboo to *tsanya*: on the western side there is no very distinct feature and the line separating the Chiendausiku ridge from the colluvium of the Rivi-Rivi Valley is not marked. The north-western limit of the ridge is determined by a drop of some 20 feet just east of the Liwawadzi bridge on the Balaka road. Here again the terrace-feature, which separates it from the colluvial area of the Rivi-Rivi and Liwawadzi Streams, is partly fault-controlled. Thus the Chiendausiku ridge is a broad, deeply weathered, horst. Taken as a whole it slopes gently to the south-east at about 60 feet per mile but, in part, it is deeply dissected by the Golomwa and Naliswe Streams. The fall to the north-west is steeper and thus the ridge is broadly asymmetrical. The principal residuals are the strike-ridges of marble making up the Chenkumbi Hills.

On a regional scale the Chiendausiku ridge marks the southern termination of the fault-bounded Chiripa Plateau which lies between the Shire and Bwanje Valleys (Dixey, 1925). It may continue a short distance to the west of the Rivi-Rivi Stream in the deeply weathered rocky areas which are separated from the Stream by one or two stepped terrace-features. A more detailed description of these terrace-features which continue north-westwards into the Senzani area (Garson, 1958B, p. 15) where they are better developed will be given in a forthcoming departmental publication (Bloomfield and Garson, 1965).

The *Chingale step* is a fairly flat-lying area, between 1,900 and 2,500 feet in height, which stretches from a sharp terrace-feature at the edge of the Shire Plain to the foot of the Zomba–Malosa massif and the Rift Valley escarpment. The

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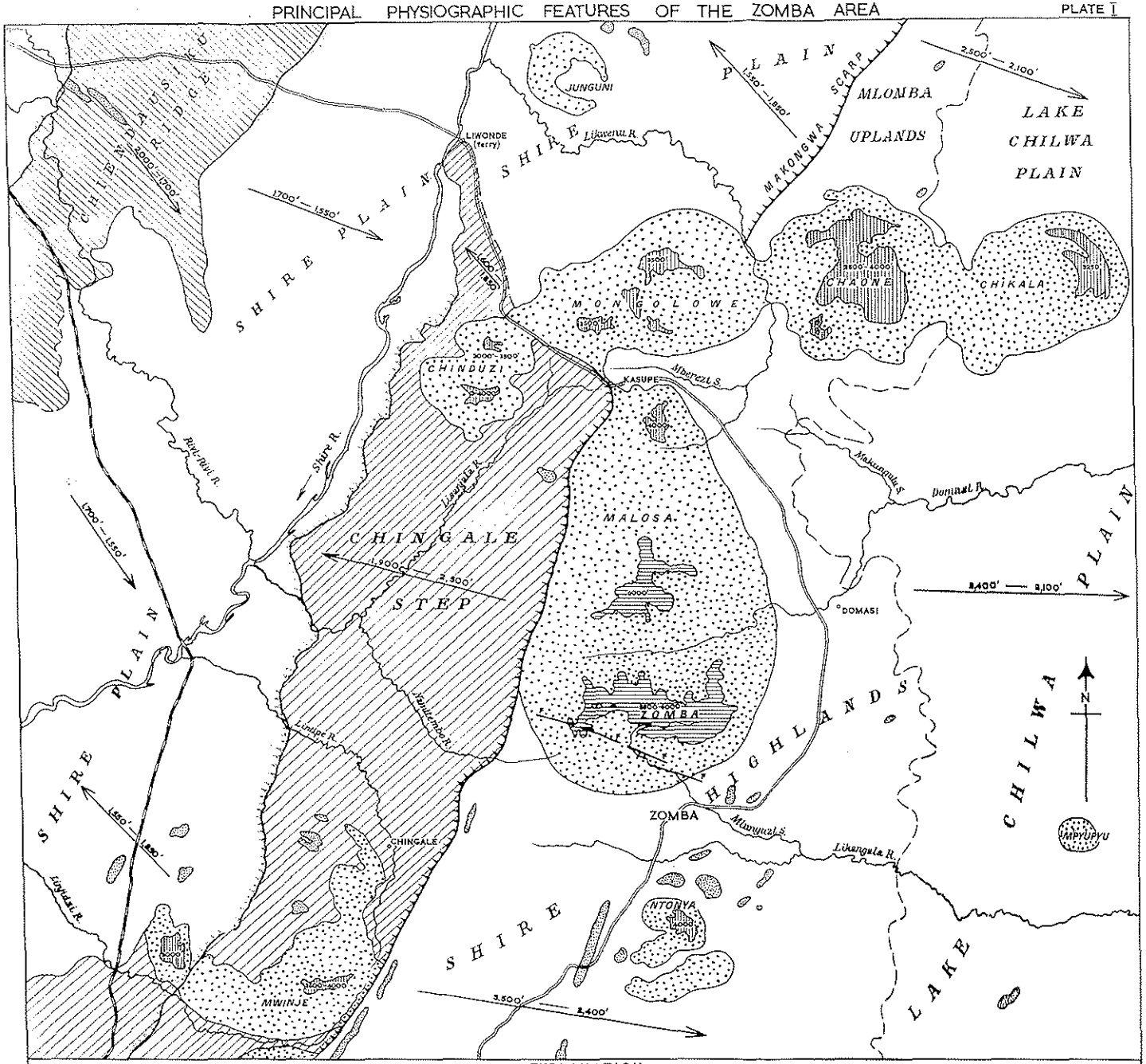
**Colophospermum mopane.*

PRINCIPAL PHYSIOGRAPHIC FEATURES OF THE ZOMBA AREA

PLATE I



EXPLANATION

- High-level residual plateaux: 3,000–4,000 feet
- " " " 5,500–6000 "
- Minor residuals
- Major "
- Escarpments
- Terrace-features
- 2,800'–2,100' Direction of maximum slope

SCALE 1:250,000

0 1 2 3 4 5 6 7 8 MILES

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Geological Survey Dept. Nyasaland 1962

JRM.

eastern part of this step is thickly covered by drift, ranging from the boulder-strewn slopes of the Mountain to sandy colluvium, and it is almost completely featureless. Westwards the country becomes rocky and much more dissected and there is a gradual increase in height from the Lisanjala Stream towards the low hills near Fort Mpimbi: taken as a whole, however, there is a gradual decrease in height of about 65 feet per mile from the foot of the mountains to the crest of the terrace-feature. East-west alkaline dykes make low continuous ridges and NNE. to NNW.–trending strike-ridges of gneiss are very apparent to the west of Mpimbi.

The very well-marked and distinct terrace-feature separating the Chingale step from the Shire Plain can be traced from just west of Chinduzi Hill in the north, past Fort Mpimbi and through the centre of the Chingale Ring Structure, to near the main railway line to Blantyre—a distance of some 30 miles. Near Mpimbi it attains its maximum height of 250 to 300 feet but there is a gradual fall southwards and, at various points within the Ring Structure, it is only about 12 feet high. Viewed from the crest of the Rift Valley escarpment near Changalumi the terrace shows as a prominent dark line resembling, from a distance, the shore of a lake particularly when the sun is low. In places, notably to the north-east of Fort Mpimbi and on the eastern bank of the Lisanjala Stream there is a well-developed sharp cliff and the terrace clearly follows rectilinear fault-lines. A north-east-trending fault is also followed in the saddle between Mirale and Chifumbe Hills. Further south the terrace seems gradually to lose its identity in the weathered perthosite-gneisses to the east of the railway line.

North of Chinduzi Hill, between the main road and the Shire River, there is a very dissected strip of country lying at about 1,750 feet above sea level and sloping gently north-westwards which appears to represent a northern extension of the Chingale step. It is bounded on the west by a low feature which may or may not be a terrace but, on the east, there is a gentle gradation into the colluvium of the Shire Plain with no break in slope.

According to Dixey (1925, p. 7) the Chingale step was once part of the old Shire Plain and has subsequently been separated from it by faults now responsible for the terrace-feature.

The *Shire Highlands* is separated from the Chingale step by a great north-east-trending escarpment between 500 and 4,000 feet in height (highest on the western side of the Zomba–Malosa massif). This feature is, perhaps, the most striking one in the present area and with its north-easterly extension, the Makongwa scarp, it stretches for 40 miles right across the centre of the map-sheet: the actual height appears to decrease gradually in both directions from Zomba Mountain. The feature is a typical fault-line scarp and marks the eastern wall of the Rift Valley in this part of southern Malawi. At the north-western foot of Malosa, clearly visible from the Liwonde–Zomba road, there is a series of triangular facets at the base of the scarp, relatively undissected and between 500 and 750 feet in height. These indicate fairly recent movement along the fault-line (cf. Cotton, 1948, p. 441). In this same area the fault-line-scarp is offset at right angles by later fractures below which lie the Chambeta Hills, syenite residuals (*see* also Bloomfield and Young, 1961, p. 74).

Near Kasupe the escarpment splits into two discontinuous steps. One, trending north-west, is responsible for a sharp rise of about 300 feet on the main Zomba road just west of the *boma* but the other, continuing the general north-easterly trend, produces only a slight rise in the road some 2 miles to the east. Within the Mongolowe Hills, to the north, the physiographic pattern caused by the Rift Valley faults is complex and is considered later.

The Shire Highlands area is of only moderate relief although broken by a number of syenitic residuals. It falls gradually eastwards at about 60 feet per mile from the edge of the Rift Valley escarpment where a ridge of high hills, parallel to the scarp and stretching from Nswaswa through Malata and Changalumi to Zomba Mountain overlooks the Shire Plain. Nswaswa Hill (4,135 feet) is the highest point on this

ridge. Most of the numerous low hills which rise slightly above the general 3,000 feet surface such as Namilongo, Naisi, Namadidi and Nsala are strike ridges of gneiss and a well-developed linear pattern is apparent on the air photographs, particularly in the country between the Blantyre road and the escarpment. Dixey (1926, p. 123) regarded the Shire Highlands as a diamond-shaped horst bounded by four branches of the Rift system and tilted towards the east.

The featureless country lying at about 2,500 feet within the re-entrant of the Mongolowe–Chaone Hills and Malosa Mountain shows solid rock only in stream sections and probably represents a deeply weathered Shire Highlands surface.

The *Mlomba uplands* lie in the north-eastern corner of the area, north of the Chaone–Chikala Hills and separated from the Shire Plain by the low Makongwa fault-line scarp. Although there is an initial rise of about 350 feet from the Plain there is a further gradual rise through strongly dissected country for a further mile or so bringing the total to 500 feet. From the crest of the scarp the ground falls away gradually to the south-east at about 60 feet per mile i.e., the same slope as the Shire Highlands which, however, is 1,000 feet higher on average. Kangolosi and Chitundu Hills, small residuals of quartzofeldspathic gneiss, stand out from the general surface. Like the Chingale step, the Mlomba uplands were regarded by Dixey (*loc. cit.*, p. 124) as split from the old valley-floor plain connecting Lakes Chilwa and Malombe (the graben surrounding the Shire Highlands horst) by relatively recent faulting.

The *Lake Chilwa Plain* develops very gradually from both the Shire Highlands and the Mlomba uplands. There is, in both areas, a gentle descent eastwards from the escarpment edge to the shores of the lake and the actual boundary between the high ground and the Plain is taken as the western limit of the colluvium i.e., about 2,400 feet O.D. in the Zomba area and 2,300 feet O.D. in the area north of the Chaone–Chikala Hills; Mlomba Market itself lies near the edge of the plain. According to Dixey (1933, p. 13) the bedrock surface dips in the same general direction as the overlying sediments but at a slightly greater angle. A detailed study by Garson (1960, p. 15) revealed five terrace-features on the apparently flat Plain indicating successive drops in lake-level (only the most prominent is shown on the 1:100,000 geological map). A series of low sand barriers, spits and bars were once either connected to the old lake-shore or formed offshore barriers.

The *Chingale Ring Structure*, rising mainly from the Chingale step, consists of a chain of hills of perthosite and perthosite-gneiss which form a ring-like feature some 8 miles in diameter and enclose a relatively featureless arena. From north to south-west, clockwise, these hills are Zobwe (2,386 feet), Lulanga (about 2,700 feet), Ndunde (about 3,550 feet), Mwinje Mountain (4,786 feet), Chifumbe (about 4,200 feet), and Mirale (3,036 feet). The ring does not close to the north-west and here the low NE.-trending strike ridges of Chipini, Namatunu and Kapiri-la-njuchi Hills (perthosite-gneiss) stand out above the plain. Most of the arena lies at the same general level as the step although it contains the small hill Chimbwata (2,250 feet).

The southern face of the Mwinje–Chifumbe massif is very steep and there is a sharp drop into the Linjidzi Valley. The summit of Mirale Hill is relatively flat and there is a high-level platform remnant at just under 3,000 feet. The eastern side of Mwinje, around Liundi Village, also has the appearance of being planed off at between 3,500 and 4,000 feet (*see* Plate I). This is about the same general level as the adjacent area of the Shire Highlands.

The *Ntonya Ring Structure*, immediately to the south of Zomba township, consists of a discontinuous ring of arcuate hills made up of gneissic granite, but instead of surrounding a flat arena as at Chingale, there is a central mass of quartz-syenite forming the Ntonya Hills (4,560 feet). Just south of Ntonya summit there is a well-developed plateau lying at about 4,000 feet.

The scenic centrepiece of the whole area is the great *Zomba-Malosa massif* (*see* frontispiece) which rises steeply from both the Shire Highlands and the Chingale step

and is bounded on all sides save the north by precipitous scarps. The total area of the massif is of the order of 65 square miles and a detailed account of its geomorphology has been given by Bloomfield and Young (1961) who recognized six major morphological regions—the plateau, Mlunguzi Valley, other regions of intermediate altitude, the Domasi Valley, the escarpments and the scarp-foot zone. The plateau areas, better developed on Zomba than on Malosa, are fine grassy uplands which make up about an eighth of the total area of the massif. Slopes are gentle to moderate and rocky residuals which stand out above the general surface comprise Chilumbi ("Main") peak (6,846 feet) and Chiradzulu peak (6,660 feet). Malosa peak (6,816 feet) has gently rounded slopes and appears to be an integral part of the plateau. On Zomba Mountain the eastern part of the plateau lies at 5,600 to 6,000 feet and the western at 6,000 to 6,300 feet; on Malosa the plateau is at 6,000 to 6,600 feet. Both watershed profiles and generalized contour maps of the plateaux (Bloomfield and Young, *loc. cit.*) show that they slope eastwards at from 1 to 2½° i.e., in the same direction as the Shire Highlands and the Lake Chilwa Plain.

A small residual plateau was noted at about 4,000 feet at the extreme northern end of Malosa Mountain i.e., at the same height as that on Ntonya.

A number of landforms were noted, including the lower Mlunguzi Valley, which appear to have been graded to a base-level which now lies at between 4,800 and 5,000 feet, approximately 1,000 feet below the level of the plateau.

The steep-sided Domasi Valley, 2,000 feet deep in places, separates Malosa and Zomba Mountains and may lie on an old fracture-zone. At its head there is a broad wind gap about 1,000 feet below the plateau surfaces to the north and south.

The southern and eastern scarps of Zomba Mountain attain a maximum height of 3,000 feet and have been formed by the differential erosion of the syenites making up the massif and the surrounding Basement Complex gneisses. At the base is a low peripheral ridge formed by a narrow alkaline granite ring dyke. The great western scarp of the massif has been described above.

North of the Zomba–Malosa massif lie, in an east–west line, the three nepheline-syenite hills Chikala, Chaone and Mongolowe all of which are roughly circular in plan. *Chikala Hill* stands at the eastern end of the line on the shores of Lake Chilwa, and rises to more than 5,000 feet. It is the most nearly circular of the three and consists of steep rounded scarps on the north, east and west sides rising to a sharp arcuate ridge which rims a plateau out of which rises a broad summit massif. The plateau lies at about 3,250 feet and both it and the containing ridge are broken by an eroded north–south fault-zone. On the west and south-west sides of the hill there is a gradual slope from the summit to the Sumulu Valley separating Chikala from Chaone and here the plateau and outer ridge are not developed.

Chaone Hill is rather lower than Chikala (4,475 feet) and consists largely of a rather dissected plateau, standing at between 3,500 and 4,000 feet, surrounded by steep slopes on all sides. There is no summit massif as on Chikala but the plateau area is much more extensive.

Mongolowe is in fact two hills, East and West Mongolowe, separated by a deep rectilinear fault-valley trending north-west. Only East Mongolowe is roughly circular in plan. Platform remnants standing at about 3,500 feet are well-developed both on the western and eastern hills; on the latter they make up a roughly circular flat-topped ridge surrounding a small summit massif (4,178 feet). To the north there is a steep drop of about 1,700 feet to the Shire Plain whilst to the south the descent is in two parts, first to the Mberezi Valley (part of the Shire Highlands) and then to the Chingale step. The landforms on the eastern side of East Mongolowe are directly controlled by the fracture pattern produced by the intersection of the main Rift Valley fault and the nepheline-syenite ring-complex. The principal effect is a bifurcation with the Likwenu Stream and one of its major tributaries flowing along parallel fractures and separated by a rectangular block of country.

Chinduzi Hill is situated a little to the south of the western end of the Chikala–Mongolowe line and is separated from East Mongolowe by a saddle through which runs the main Zomba–Liwonde road. Like Mongolowe, Chinduzi is made up of two nepheline-syenite hills separated by a rectilinear, north-west-trending, 500 feet-deep, fault-valley. Chinduzi itself forms the southern hill (4,264 feet) whilst the northern is known as Mberekezi.

Arcuate ridges are developed on both hills, more particularly on the south and south-eastern sides, and, there are also small residual plateaux at between 3,000 and 4,000 feet. South-eastwards there is a sharp descent to the Chingale step but, to the north and north-east, where the country rocks are softer pulaskites, slopes are more gradual.

Junguni Hill, the remaining nepheline-syenite ring-complex, rises 1,400 feet from the Shire Plain to the north-east of Liwonde and is surrounded on all sides by featureless black sandy clay. In plan, it is a horseshoe-shaped ridge, open to the south-east and rising to a small summit massif in the north-west. East–west fractures produce low saddles and stepped ridges. To the north-east of Junguni are two small related hills, one an arcuate ridge parallel to the main ring-feature.

Mpyupyu Hill is the only major residual not so far mentioned. It stands out of the Lake Chilwa Plain as a sharp conical feature 3,476 feet in height produced by the differential erosion of a plug of hard syenite.

A general study of the erosion surfaces in the area shows that there are distinct residual plateaux at two different levels—3,000 to 4,000 feet and about 6,000 feet, both impressed on the harder residual syenitic and granitic masses. The higher and older of these surfaces was probably formed in Cretaceous times (Bloomfield and Young, 1961, p. 78) since age determinations on one of the intrusions showed it to have been emplaced about 138 million years ago (Bloomfield, 1961A). Dixey ascribed this 6,000 feet surface, which may be correlated with a distinct shelf at the same height around Mlanje Mountain, to the late Jurassic (1938, p. 126; 1960, p. 263) but it is patently somewhat younger than this. King (1951, p. 327) would regard this surface as the result of " one of the upwarped earlier phases of the ' Gondwana ' cycle alongside the rift ". A further reduction of the base-level to about 5,000 feet in late Cretaceous or early Tertiary times is deduced on the Zomba-Malosa massif (Bloomfield and Young, *loc. cit.*).

The high-level 3,000 to 4,000 feet residual plateaux lie at about the same level as the dissected western edge of the Shire Highlands, overlooking the escarpment and probably form part of the great mid-Tertiary surface which constitutes much of the main plateau of central Africa (Dixey, 1956A, p. 26). The lower well-planed parts of the Shire Highlands and the contiguous Lake Chilwa Plain were probably formed somewhat later but also in mid-Tertiary times (Dixey, *loc. cit.*) during the " African " cycle (King, 1951, p. 327). It should be noted that in a recent paper comparing the geomorphology of eastern Africa with that of Madagascar (Dixey, 1960, p. 263) the 3,700 feet residual plateau of the Shire Highlands is thought to be of late Cretaceous age but this is unlikely on geological grounds.

The Shire Plain, originally thought by Dixey to have been formed as a valley floor feature in the early Cretaceous (1938, p. 116) is now ascribed to the end-Tertiary (Dixey, 1960, p. 263) whilst the Chiendausiku ridge and the Chingale step may perhaps be correlated with the Chileka surface (*loc. cit.*).

(b) Drainage

The Shire River, connecting Lake Malawi with the Zambesi, flows south-west through the Zomba area and maintains a steady flow all the year; the minimum recorded by the Water Development Department at Liwonde over the period 1949–60 was 4,490 cusecs and the maximum 20,675 cusecs. A second major perennial stream

is the Rivi-Rivi which rises in the Kirk Mountains and joins the Shire at Mpimbi and others draining the low-lying parts of the area include the Likwenu, the Lisanjala, the Namitembo and the Lintipe. These last all have their sources in the major mountain masses but, in addition, the Shire Plain is riddled by dry sandy stream beds subject only to the occasional flash flood.

The principal watershed in the area is the crest of the Rift Valley escarpment. From it, the streams noted above flow west into the Shire River whilst streams such as the Domasi, Likangala, Naisi and Namadzi make their way to Lake Chilwa, which has no outlet.

In many cases the drainage pattern is directly related to the structure. The trellised pattern of the upper Likangala and Mbeza Streams, very apparent when viewed from Zomba Mountain, is the result of the intersection at right angles of joints and strike ridges. Other streams with rectilinear courses which probably follow fractures are the Lisanjala, the upper Domasi and, at least in part, the Golomwa, Nkhalote and Lifani. The Likwenu Stream runs along a bifurcation of the main Rift Valley fault to the east of Mongolowe Hill and the numerous streams originating on the eastern scarp of Zomba Mountain follow close parallel N80°W joints.

A radial drainage pattern is developed on all the hills making up the Chinduzi-Chikala line, to the north of Zomba, and the Linjidzi and upper Lintipe Streams flow along arcuate courses on either side of the outer arc of the Chingale Ring Structure. Similarly, parts of the Namiwawa and Nalikukuta Streams follow the gap between the central massif of Ntonya and the discontinuous outer ring of granite making up Ulumba, Sazi and Nkholonje Hills.

The Shire River flows south-west with some well-developed meanders below the Rivi-Rivi confluence and is apparently uncontrolled by the geological structure. Likewise, the lower courses of the streams which flow across the drift-covered plain towards Lake Chilwa have a typical dendritic drainage pattern before debouching into the lake through swamps and deltas.

Thus in most cases the drainage pattern has been adjusted to the geological structure but there are some anomalies to which brief reference will be made.

For most of its course, the Lisanjala Stream is well-established and has reached a fairly mature stage. However, as it crosses the Mpimbi fault-scarp it rapidly cuts down and has obviously been rejuvenated. Below the scarp the stream flows over a flat alluvial plain. Similarly the upper Namitembo is a late mature stream which has incised a deep gorge across the outer margin of the Chingale step. This is taken to mean that both these streams were formerly established on the old Shire valley floor but have been partly rejuvenated by subsequent faulting which separated the step from the modern plain. Since the Lisanjala takes a right-angled turn after descending the fault-scarp it seems possible that it originally flowed into the Shire along the line of the lower Lintipe and that stream capture has taken place as a result of tilting of the Chingale step (*see* Plate I).

A detailed study of the drainage development of Zomba Mountain has been made recently with particular reference to the Mlunguzi and upper Domasi Streams (Bloomfield and Young, 1961, pp. 75–77). The former rises in a marsh on the plateau and first flows westwards towards a gap between Chilumbi and Chiradzulu peaks. However, shortly after leaving the marsh it begins to entrench itself below the plateau and then drops in a series of falls before turning back completely on its course to flow eastwards towards Zomba, first through a broad upland valley and then along a narrow cleft before plunging down the mountain-side. A study of the area suggests that there has been a partial reversal of drainage on the plateau caused by faulting and that the upper Mlunguzi formerly flowed eastwards as the proto-Chivundi. The Chivundi Stream is now separated from the Mlunguzi by a shallow col (see *loc. cit.*, Fig. 7).

The presence of a deep wind-gap at the head of the Domasi Valley suggests that the Domasi Stream at one time rose further to the west. Another wind-gap, north of Kasupe, prolongs the direction of the upper Mberezi Stream and both these features

seem to indicate that, at one time, the main river courses crossed the massif having their sources on land which then stood at a higher level to the west.

The course of the Likwenu Stream which first flows north-east off Malosa Mountain, then north through the Mongolowe–Chaone saddle and finally north-west across the plain to the Shire River is apparently anomalous. It is suggested that the Mberezi and upper Likwenu Streams at one time flowed eastwards to Lake Chilwa as the upper parts of the Makungulu, a tributary of the Domasi. Headward erosion by the proto-Likwenu across the saddle, which was then at a much higher level, resulted in stream-capture leaving a low broad col between it and the Makungulu.

(c) Climate

The marked climatic differences in the Zomba area are a direct reflection of the great variations in altitude although the usual monsoonal pattern of a wet season from November to April and a dry season from May to October prevails throughout.

Over the Shire Highlands and Zomba Plateau the climate is quite equable for most of the year but on the lower ground, including the Lake Chilwa Plain and the Mlomba uplands, the afternoon temperatures are often unpleasantly high, occasionally exceeding 100°F. during the months immediately preceding the onset of the rains. The only accurate figures are those for Zomba township which are given in Table I below:—

TABLE I

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean maximum temperature °F.											
80.7	80.0	79.4	78.5	75.3	71.8	71.9	75.4	80.3	85.6	84.7	81.4
Mean minimum temperature °F.											
65.8	65.8	64.8	63.0	58.4	54.6	53.5	55.5	59.8	64.9	66.5	66.1

The extreme temperatures are 95°F. and 45°F. and the average extremes, 92°F. and 47°F. Zomba Plateau is some 10°F. cooler and the Shire Plain and adjacent areas 5° to 10°F. hotter. Old temperature figures for Liwonde on the Shire River give 102°F. as the absolute maximum and 45°F. as the absolute minimum.

The general rainfall pattern is of first rains any time after mid-October and from then until the end of December violent thunderstorms of short duration, occurring at irregular intervals, the dry periods between being hot and oppressive. Steady rains are usually established in January and continue until about the end of March with frequent dry spells of a week or more occurring in early February. After March, rainfall diminishes rapidly and, on the whole, from May to September is fairly dry except for heavy scotch mists (known locally as *chiperonis*) which are common on the high ground in June and July.

Rainfall figures* are given in Table II for seven stations in the Zomba area, three on the low ground, three in the highlands and one, at Mlomba, of intermediate altitude.

The mean yearly rainfall on various parts of Zomba Mountain varies from 72.41 to 77.33 inches.

During the wet season, heavy storms are common in the vicinity of Zomba township. Of these, the most intense cloudburst in living memory took place in December 1946 when 28 inches of rain fell in 44 hours causing the loss of some 30 lives and the destruction of the township's water supply, anti-malarial works, bridges

*All rainfall and temperature figures provided by the Meteorological Department.

TABLE II

RAINFALL FIGURES (INCHES)

Station	Approx. Altitude	Period	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Liwonde	1,600 feet	30 yr. av. ..	8.24	7.27	5.53	1.56	0.34	0.10	0.09	0.14	0.07	0.55	2.35	6.73	32.97
Utale	1,640 feet	1934–44 ..	7.56	7.84	5.39	1.04	0.14	0.025	0.06	0.06	—	0.73	2.80	6.64	32.28
Chingale	2,020 feet	1952–60 ..	10.20	8.40	5.25	2.63	0.21	0.34	0.04	0.005	0.04	0.45	3.38	6.62	35.70
Mlomba ..	2,350 feet	1945–52 ..	9.05	8.41	9.39	1.70	0.61	0.20	0.19	0.07	0.11	0.39	3.03	8.73	41.88
Likwenu Mission ..	2,700 feet	1934–38 ..	15.01	14.35	8.26	3.56	0.28	0.23	0.49	0.08	—	0.34	4.68	8.41	55.69
Zomba	3,141 feet	60 yr. av. ..	11.76	10.30	9.60	3.43	0.87	0.48	0.27	0.36	0.24	1.24	4.83	10.88	54.26
Namadidi Estate ..	3,450 feet	1900–09 ..	16.02	10.40	6.96	1.92	0.31	0.32	0.15	0.13	0.43	1.51	2.98	11.12	54.04

and most of its roads (Edwards, 1948). At one time 5 inches of rain was recorded in half an hour. The cause lay in a cyclone which moved across the mainland from north of Madagascar along an unusual track with Zomba near the point of inflection.

(d) Vegetation and wildlife

The black sandy clay of the Shire Plain supports good stands of *tsanya* (*Colophospermum mopane*) usually associated with *napini* (*Terminalia sericea*) and *Combretum-Acacia* species. In places, *mtondowoko* (*Sclerocarya caffra*) and *msetanyani* (*Sterculia quinqueloba*) are conspicuous. There are palm trees along the Shire River and baobabs (*Adansonia digitata*) are locally abundant, particularly in the sandy colluvium of the Rivi-Rivi Valley and just below the terrace-feature on the east bank.

Dry *Brachystegia* bush covers much of the Chiendausiku ridge and the eastern part of the Chingale step as well as the slopes of the Rift Valley escarpments, the hills of the Chingale Ring Structure and the Chinduzi–Chikala line of hills. On the lower slopes this gives way to *Terminalia-Combretum* species. Patches of *Brachystegia-Isoberlinia* bush are also found sporadically over the Shire Highlands which is otherwise almost completely deforested, as is the Lake Chilwa Plain whose natural vegetation comprises species of *Acacia* and, in swampy ground, *Vossia* and *Phragmites* reed (*bango*).

An interesting feature is the development of thick bamboo brake (*Oxytenanthera abyssynica*) along and at the foot of the Rift Valley escarpment. This is probably due to climatic rather than geological factors.

Within the Chingale Ring Structure, the soil derived from pyroxenite is characterized by *napini, chinama* (*Combretum* sp.) and *bwazi* (*Securidaca longipenduculata*). Adjacent weathered syenite carries a sparse *mombo* (*Brachystegia* sp.) flora.

The high mountain massif of Zomba and Malosa is characterized by grassland with *Protea* scrub and patches of evergreen forest preserved in hollows. The streams flowing from the massif are lined with evergreens such as *mbawa* (*Khaya nyasica* and *Adina microcephala*) whilst the escarpments carry *Brachystegia* woodland.

Forest Reserves cover all the principal hill and mountain masses as well as a small area of *tsanya* forest near Namatunu Hill.

Maize, sun-cured tobacco, cassava and a little cotton are grown by Africans in the lower-lying areas as well as rice on the Lake Chilwa Plain, and experimentally (in 1960), near the lower Lintipe Stream. On the higher ground the principal crops are maize, groundnuts, cassava and the ubiquitous banana and paw-paw.

Flue-cured tobacco, tung and coffee are grown on the European estates of the Shire Highlands and, on Zomba Mountain, there are extensive plantations of *Pinus patula* and other conifers.

With the exception of baboons and hyenas on the slopes of the mountain, bushbuck on the plateau and an occasional leopard, civit cat, or lion there is very little game of any kind in the vicinity of Zomba township and over the greater part of the Shire Highlands. However, on the Shire Plain, larger buck are found and there is a herd of elephant in the triangle of country bounded by the Zomba–Balaka road and the Shire and Rivi-Rivi Rivers. Buffaloes are also found in this area and there are plenty of crocodiles and hippopotami in the Shire River.

Small quantities of *uraninite* and *betafite* were found in a quartz-microperthite pegmatite cutting Basement Complex gneisses on the northern slopes of Chaone Hill (Vail and Monkman, 1960, p. 121).

A little *allanite* is found in the microcline-granite which makes up the ring of the Ntonya Ring Structure, in the older microcline-microgranites and in the syenites of Zomba and Malosa Mountains.

(vi) *Conclusions*

The granitic dykes, pegmatites, and veins associated with Zomba–Malosa and Chaone plutons probably represent a late residuum in which thorium, uranium, niobium, zirconium and the rare earths have become concentrated.

Neither the Kasupe prospect nor any of the other occurrences are likely to prove of economic value at present. The main valuable elements at the former are thorium and niobium and, of these, monazite placer deposits provide more easily workable sources of thorium whilst the niobium content is too small to be of any interest. Elsewhere the quantities of the radioactive minerals are too small to be of use as ores of either uranium or niobium.

(h) Road gravel

Thin deposits of lateritic gravel, marked as Qf on the 1:100,000 geological map, are common throughout the lower areas of the Shire Highlands, the Mlomba uplands and locally on the Chingale step. The roads from Zomba to Lake Chilwa and Palombe run across broad stretches of this material but the largest deposits, already quarried by the Ministry of Works roads department, lie on either side of the main road to Kasupe, near Fakiri store and the Chilingano Stream, and on the Namwera road near its junction with the main road. No deposits were observed anywhere on the Shire plain.

Little information is available on the quality of the gravel but most of it is rather too fine-grained and has too high a clay content to be ideal for running courses. It is, however, probably suitable for the verges of tarred roads such as that from Zomba to Liwonde.

(i) Sand deposits

Only very small deposits of sand suitable for building purposes are found in the stream beds of the area although a detailed search along the Shire River might reveal a workable patch. In the valley of the Rivi-Rivi there are several bedded deposits of impure sand mixed with grey silt up to 20 feet in thickness which could probably be used for concrete and cement.

In the vicinity of Zomba township the most extensive sand deposits are those of the old dunes, bars and spits near the shores of Lake Chilwa some 16 miles to the east. Of these, that at Nchenga Village (just off the map) now used by the Ministry of Works, is 3 miles in length and should last for some years. Elsewhere there are small deposits south of Chikala Hill and just east of Mpyupyu Hill, straddling the Lake Chilwa road.

No sand of sufficient purity for glass manufacture has been found in the area.

(j) Water supplies

(i) *Rivers*

The natural water supply conditions of the region vary according to the topography. In the alluvial areas conditions are, in general, good and there are settlements along both banks of the Shire River and other perennial streams. Between these areas, on the lower valley plains, conditions are bad and the streams flow for

only short periods during the rainy season. On the higher levels, conditions are locally satisfactory.

The major perennial streams have been noted in Chapter II and Table XXXIII, below, gives the only available information on river flow, almost all from the uplands.

TABLE XXXIII

RIVER FLOW INFORMATION

River	Locality	Minimum flow (cusecs)	Maximum flow (cusecs)	No. of years recorded
Shire	Liwonde	4,490	20,675	11
Domasi	Zomba–Liwonde road	0.50	4,000	8
Likangala	Zomba–Limbe road	0.80	2,900*	8
Mlunguzi 1	Zomba	0.10	400	8
Mlunguzi 2	Zomba Plateau	2.52	346	5

Information from *Annu. Rep. Water Development Dept.*, 1961.

*Estimated flow.

It can be seen that although these streams are all perennial there are very great differences in maximum and minimum flow with both the Domasi and the Mlunguzi diminishing on occasions to a mere trickle. Although the Shire River is shown as having a minimum flow of 4,490 cusecs. over the last 11 years, in fairly recent times it has ceased to flow altogether. In 1924 it was almost completely silted up and Dixey (1925, p. 10) records pools and swamps alternating with dry ground above Liwonde with more open water towards Mpimbi. At Mpimbi itself, a dry bar caused by sediments brought down by the Lisanjala and Rivi-Rivi Streams stretched right across the river.

In 1956 a bund was built across the Shire River at Liwonde in an attempt to stop Lake Nyasa from falling too low and to allow a detailed exploration of the soils of the Lower River and of the various downstream dam sites. However, this was breached on 15th August, 1957 as a precautionary measure since the general Lake level trend continued upward and not downward as had been anticipated.

(ii) *Springs*

A number of natural springs are known in the Zomba area of which the most famous are the hot springs (104.4°F.) at Liwonde on the west bank of the Shire River. Here there are four springs lying in a 500 yard-long north-east-trending line about half-a-mile south of the ferry-point. The northernmost spring has the greatest flow and has been led into a covered bath but the others all have a steady flow and are characterized by patches of *kanjedza* palms. About 3 miles further downstream there is another hot spring about a quarter-of-a-mile back from the bank and both this and the main springs to the north are thought to occur on the continuation of the fault which marks the western limit of the Chingale step (see p. 165). Analyses of the Liwonde spring water are given in Table XXXIV and show that it is soft but that the fluorine content is too high for it to be suitable for human consumption.

Another hot spring occurs a few hundred yards south of the Mpyupyu-Lake Chilwa road (Garson, 1960, p. 50) but it is too much used and contaminated to be sampled with any accuracy.

Normal or only very slightly warm springs are found just below Kasupe on the north side of the Liwonde road (apparently on a fault-line); at mile 7 on the Zomba–Blantyre road, where the water issues from the junction between an east–west

microgranite dyke and a north–south sölvsbergite; and on Chikala plateau. These last were analysed and were found to be not unduly hard nor to contain appreciable amounts of sulphate.

TABLE XXXIV

ANALYSES OF WATER FROM LIWONDE HOT SPRINGS (PPM)

	1	2
Specific conductivity at 20°C. (millimhos)	0.39	0.37
Approximate dissolved salines	480	460
Alkalinity to methyl orange (as $CaCO_3$)	150	151
Total hardness	4	8
Chloride radicle (Cl')	59	59
Sulphate radicle (SO'')	136	135
Nitrate nitrogen	tr	nil
Nitrite nitrogen	nil	nil
Ammoniacal nitrogen	0.06	tr
Albuminoid nitrogen	0.05	tr
Oxygen absorbed from permanganate in 4 hours	0.55	0.5
Fluoride (F')	8.3	n.d.
Total iron (Fe^{++})	n.d.	nil
Aluminium (Al^{+++})	n.d.	nil
Potassium (K)	n.d.	2.7
Silica (SiO_2)	n.d.	48
pH	9.1	9.1
Main salines		
Calcium and magnesium carbonates	4	8
Sodium carbonate	155	152
Sodium sulphate	202	200
Sodium chloride	98	94
Sodium fluoride	18	5
Total	477	459

n.d.= not determined. *anal.* W. H. Kitte, Government Analyst, Salisbury.

(iii) *Wells and boreholes*

The first attempts to alleviate the chronic water shortages of the Shire and Lake Chilwa plains were made by the Geological Survey Department which carried out an extensive well-sinking programme in the 1930s. However, most of these wells, not far from the banks of seasonal streams, were also seasonal and proved expensive to maintain and, in the 1940s, the emphasis turned to boreholes. These are sited by the resistivity method of geophysical prospecting as developed by Cooper (1950) which results in an average of 94 per cent. success. A general account of the location of underground water supplies in Malawi has been given by Holt (1955) and the known working boreholes in the Zomba area are shown in Table XXXV which is divided on a geographical basis into the main physiographic units as described in Chapter II.

Within the areas of the plain the underground water supply conditions are extremely variable and the aquifers, though usually thin bands of sand and gravel, may also be perched above lenses of clay and mud. The presence of saline water is usually detectable from the geophysical results.

In the highlands the water is either contained in narrow fissures following sub-vertical fracture or pegmatite zones or occurs in basin-like depressions of weathered gneiss at the interface between solid and decomposed rock. At Kasupe, the weathered syenite contains a high proportion of clay so that there is only a high perched aquifer bearing but little water. In drilling attempts this aquifer was pierced and drained downwards into less clayey weathered syenite.

TABLE XXXV

WATER BOREHOLES SUNK IN THE ZOMBA AREA BETWEEN 1950 AND 1963 (INCL.)

Ref.	Locality	Depth (ft.)	Yield (g.p.h.)	Rest. level	Rocks penetrated	Remarks	Year drilled
A. Shire plain							
B19	Mariana	150	2,000	38	Colluvium	Chingale	1950
B20	Kuchile I	120	1,000	59	,,	resettlement	,,
B26	KuchileII	130	800	48	,,	scheme	,,
G78	Nsambo I	154	1,500	42	,,	,,	,,
B27	Nsambo II	103	800	46	,,	,,	,,
G81	Nyambalo I	142	1,200	73	,,	,,	,,
G74	Masula I	150	1,750	38	,,	,,	,,
B28	Masula II	125.5	1,500	43	,,	,,	,,
B22	Karachi I	162	700+	61	,,	,,	,,
G83	Karachi II	136	1,000	40	,,	,,	,,
B21	Kusangala I	122	1,000	26	,,	,,	,,
G82	Kusangala II	145	340	58	,,	,,	,,
B35	Railway I	187	1,200	67	,,	,,	,,
B37	Railway II	200	350	100	,,	,,	,,
B40	Railway III	120	500+	—	,,	,,	,,
B36	Railway IV	120	300	—	,,	,,	,,
K176	Utale leprosarium	100	1,000	32	Sandy clay and gravel		1956
E132	Mirale siding	150	420	90	Thick clay		1958
E131	Lundu Market	140	960	22	Clay and sand		,,
E130	Pitilosi	112	420	43	Clay over gneiss		,,
E163	Jamali	125	720	15	,,		,,
E133	Mbendekela	144	480	58	Thick clay		,,
E134	Namatulo	155	120	67	,,		,,
J4	M'manga	125	900	52	Alluvium over gneiss		1960
B. Chiendausiku ridge							
K32	Chiendausiku I	125	660	50	Basement gneiss		1954
K33	Chiendausiku II	75	300	32	Biotite-hornblende-gneiss		,,
L118	Mchenga	115	800	20	Sandy clay and gravel		1955
L122	Chikololere	90	470	9	Pegmatite		,,
J5	Kwitanda	150	400	42	Colluvium on gneiss		1960
C. Chingale step							
L35	Chingale H.Q.	100	600	50	Colluvium on gneiss		1951
L258	Chabwera	105	800	50	Gneiss		1956
L259	Kasonga	131	750	7	,,		,,
E306	Chinguni Court	107	439	70	Weathered gneiss	Liwonde	1959
D. Mlomba uplands							
K30	Mlomba Market	103	650	15	Sandy drift		1954
W1	Machinga Coop.	107	150	25	Weathered gneiss		1959
A6	Malopa						
E. Shire Highlands							
C352	Mikuyu Radio Station	70	2,500	30	Biotite-gneiss		1951
K70	Kasupe Boma	204	100	82	Hornblende-syenite	Low yield due to impermeable clay	1954

TABLE XXXV—*continued*

Ref.	Locality	Depth (ft.)	Yield (g.p.h.)	Rest level	Rocks penetrated	Remarks	Year drilled
E. Shire Highlands—cont.							
K90	Mikuyu Radio Station	90	500	25	Sandy soil on gneiss		1954
K194	Mkwere	100	800	8	Gneiss		,,
K195	Msiwila	77	900	3	,,		,,
L267	Chilingano area	110	1,000	8	Sandy clay and gravel	Mtwiche	1956
L268	Chinyangala area	100	1,000	21	,,	,,	,,
L270	Sakata Court	115	600	24	Gneiss		,,
L271	Chopi	80	600	24	,,		,,
L272	Namwali Hill (S)	85	900	10	,,		,,
L273	Mtwice Market	110	1,000	20	,,		,,
L278	Namwali Hill (N)	90	1,300	3	,,		,,
L279	Sazi Hill I	97	1,250	5	,,	Mpakate V.	,,
L280	Chilwa Approved School	116	650	14	,,		,,
L282	Sazi Hill II	106	700	10	Gneiss		1956
L250	Kasupe Boma	200	nil	—	Syenite: struck perched aquifer	Initial yield 500 gph	,,
E140	Malemia School	100	900	14	Gneiss		1958
E177	Matuta	106	880	9	,,		,,
W57	Msalabani School	99	1,080	18	Clay over gneiss		1959
J17	S.N.A. Chamba	105	270	17	Weathered gneiss		,,
W177	Songani Market	99	675	18	Sheared gneiss		1960
L280A	Chilwa Approved School	136	900	13	Gneiss	Adjacent to L280	1961
A21	Songani Asian School	140	690	9	,,		,,
A31	Malosa Agric. Station	140	900	25	Colluvial gravel		,,
A3	Mingoli Forestry Station	155	1,000	45	Weathered hornblende-gneiss		,,
F. Lake Chilwa plain							
C25	Mpyuypyu Prison Farm	60	320	—	Laterite on biotite-gneiss		1951
C351	,, ,, ,,	101	200	50	,,		,,
K19	Kachoka	179	528	50	Lake alluvium		1953
K21	Bimbi	90	400	10	Biotite-gneiss		,,
M162	Disi	91	500	25	Leucocractic granulite		,,
K46	Jali Market	100	530	—	Quartzofelds-pathic granulite		1954
E68	Likangala Court	110	750	25	Lake alluvium	N. A. Mwambo	1957
E77	Makochesi	118	550	22	Gneiss		,,
E107	Chikalosa	130	850	36	Thick drift		,,
E106	Masale	220	artesian	—	Thick clay		1958
E176	Ngwalangwa	138	720	8	Gneiss		,,
E69	Mbalu	127	270	8	Thick clay		,,
E232B	Malua	208	528	25	,,		,,
A32	Jali Market	105	1,000	48	Colluvium		1961
A109	Chirunga	82	1,000	31	,,		,,
A241	Jali Police Post	106	960	5	,,		1963