



COLONY AND PROTECTORATE OF KENYA

GEOLOGICAL SURVEY OF KENYA

GEOLOGY
OF THE
KITALE-CHERANGANI HILLS
AREA

DEGREE SHEET 26, S.W. QUARTER
(with coloured map)

by

J. M. MILLER, B.Sc., F.G.S.
Geologist

1956

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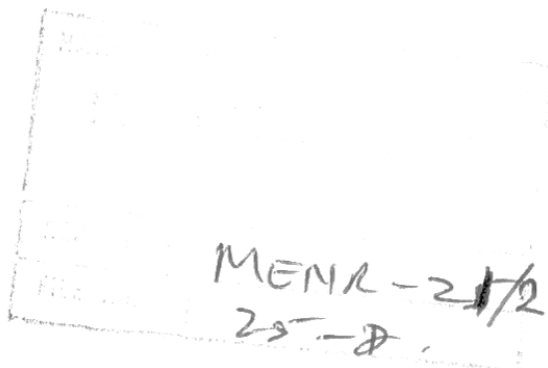
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FOREWORD

The report on the Kitale-Cherangani area extends to the east geological survey that was carried out in 1949 in the Kitale, Elgon and West Suk areas, as described in Report No. 19 which was published in 1952. The area south-west of Kitale, including the southern slopes of Mount Elgon, has also been described, in Report No. 26, published in 1954.

Apart from superficial deposits the rocks of the area consist entirely of ancient gneisses and schists. Owing to the prominence of certain bands of quartzite, Mr. Miller has been able to work out a reasonably detailed picture of the structure of the rocks, concluding that they lie mainly in a series of overfolds turned over to the west. He also demonstrates the effect of later tectonic events, an important point in the discussion of the relative ages of the Basement System of Kenya, which is believed to be of Archaean age, and the Pre-cambrian Kavirondian and Nyanzian rocks of western Kenya. The inference to be drawn from his work is that the Basement System rocks are, indeed, the oldest.

The area is remarkable in yielding evidence of a profusion of erosion bevels, which is perhaps unequalled in East Africa. On the upper levels of the Cherangani hills there is ample evidence of two planer surfaces that must have been formed in pre-Cretaceous times—the upper of the two may well be the remains of the Karroo Gondwanaland surface. At lower levels four other erosion bevels are recognised, the lowest being that of end-Tertiary age which forms the plains at the eastern foot of the Cherangani range.

A few years ago alluvial gold deposits were found in the Marun valley at the northern border of the area mapped. The reason for their presence is now traced to a granite which forms part of the high ground at the northern end of the Cherangani hills. The limit of the granite is known and the valleys into which gold is being shed have been defined, so that ample guidance is provided for future prospecting. So far, however, the amount of gold recovered has been small, and no lode deposits have been found.

In the northern central part of the area there are abundant traces of copper ores. The author believes that the copper minerals were originally precipitated with a thick series of basic lavas, which were subsequently granitized producing a series of diorite-like rocks of charnockitic affinities. Although abundant traces of the copper have been found, no extensive body of ore has yet been discovered. Prospecting by a private company, however, continues.

Signs of other minerals were discovered during the survey, notably mica, but apparently those seen hold out little hope of economic development. Attention is also drawn to the possibility of the use of water power for the generation of electricity in the Cherangani hills.

Nairobi,
5th November, 1953.

WILLIAM PULFREY,
Chief Geologist.

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MAP

Geological map of the Kitale-Cherangani hills area (degree sheet 26, south-west quarter), Scale 1:125,000	at end
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ABSTRACT

The report describes an area consisting of north-east Trans-Nzoia and the Cherangani hills, approximately 1,200 square miles in extent and bounded by the $1^{\circ} 00'$ and $1^{\circ} 30'$ North latitudes and by the $35^{\circ} 00'$ and $35^{\circ} 30'$ East longitudes.

Topographically the Cherangani hills are an ancient residual mass isolated by erosion and standing up from the mid-Tertiary peneplain. A pre-Jurassic surface bevels the summits and traces of the end-Cretaceous peneplain are discernable on its flanks, whilst to the south-west stretches the Trans-Nzoia pre-Miocene peneplain.

The whole area is occupied by rocks of the Basement System which includes granitoid gneisses, biotite-bearing and hornblende gneisses, quartzites, marbles and calc-silicate granulites, together with porphyroblastic gneisses of syenitic composition and meta-volcanic rocks including diorite-like types of charnockitic affinities. They are invaded by gabbros also of charnockitic affinities and by gneissic granite. It is probable that gold mineralization is related to the metasomatic effects of the granite.

Recent deposits are represented by alluvial flats and fans, and by soils.

The economic prospects of the area are discussed.

GEOLOGY OF THE KITALE-CHERANGANI HILLS AREA

I—INTRODUCTION AND GENERAL INFORMATION

The country mapped for this report covers quarter-degree sheet 26 S.W. (Kenya), bounded by the $1^{\circ} 00'$ and $1^{\circ} 30'$ North latitudes and by the $35^{\circ} 00'$ and $35^{\circ} 30'$ East longitudes, and is approximately 1,200 square miles in extent. It includes part of the Trans-Nzoia district, north and east of Kitale, and extends northwards into West Suk and eastwards into Marakwet district. The northern boundary lies along a line joining Kacheliba and Sigor, whilst the eastern continues south over Koh and Kameligon to behind Kaisongul (locally called "Flat Top").

The mapping was undertaken as part of the programme for the complete geological survey of the whole of Kenya, and to investigate the possibility of the occurrence of valuable mineral deposits. Prospectors at various times had brought in mineral specimens from the area, including mica, vermiculite and rutile, and traces of gold had been found in the streams draining the area.

Maps

The original topographical survey of the area compiled in 1912 at the War Office, London, was published in the 1:250,000 Africa Series as the Sekerr (Provisional) Sheet, North A36/R. This was in 1945 slightly modified topographically and towns and communications were added by the 157th (E.A. and S.R.) Base Survey Company, East African Engineers, who produced the 1:500,000 Kitale map, E.A.F. No. 1687. Preliminary plots based on aerial surveys flown by the R.A.F. between 1947 and 1950—Kenya Sheets North A-36/R-III-SW (75/III) and North A-36/R-III-NW (75/I) on the scale of 1:50,000—were issued by the Directorate of Colonial Surveys in 1951 and 1950 respectively. M. A. Unwin-Heathcote privately produced a map of Lelon on a scale of 1:25,000, which was published in a joint paper with J. B. Carson (1951).*

During the geological mapping, contours of the Kacheliba-Kipkomo area were taken from a map produced from an aerial photographic survey by Messrs. Harward, Maclachlan & Co.

As the western half of the area was covered by preliminary plots, field sheets were prepared on the scale of 1:50,000. In the eastern half, aerial photographs were used where available, gaps being filled in by plane-table survey. Form-lines on the map are based on aneroid barometer readings in the aerially photographed parts, and on Indian clinometer readings in the plane-tabled area.

Communications

The Kitale branch of the Kenya-Uganda section of the East African Railways terminates at Kitale, so that communications in the area are entirely by road. Kitale stands at the centre of a system of excellent all-weather murrum roads serving north-east Trans-Nzoia, one of which is the main road to Kacheliba and Lodwar farther north. Branching from the latter at Makutano, a road leads to the administration centre of West Suk district, Kapenguria. In addition to these main roads, the administration has built a second-class road from Kapenguria to Sigor in the Rift Valley via Cheberaria and the Marich Pass. This may also be classed as all-weather, but is only suitable for lorries and jeeps. Other motorable tracks run from Kaituma to Lelon and thence to Kapsowar, a branch turning off on the shoulder of Kaisongul and leading down to Cherangania; from Cheberaria to Kacheliba via Chessara, a branch leading north to Ptoyo; and from Sigor to Chesegeon and Tamkhal.

Access to the interior of the Cherangani hills could be obtained by a road leading from the Lelon road which followed the Marun-Moiben watershed, thence up the Kimerhua valley and along the eastern slopes of Kapsototwa to Kailelakelak. Beyond this an easy route lies to Noliwell and the plateau of Sondang.

*References are quoted on p. 33 at the end of the report.

Climate and Vegetation

The climate is one of extremes varying from that of the semi-desert of Masol to the nightly sub-arctic conditions of Kameligon. Climatically and with regard to vegetation the area falls into three distinct sections:—

1. Trans-Nzoia
2. Suk Lowlands
3. Cherangani hills

Trans-Nzoia experiences a warm climate with abundant seasonal rainfall. It lies in the Lake Victoria basin and rain falls more or less continuously from April to the end of the year in local heavy showers. Many such showers originate over the forest below Kaibubich and proceed from there in a south-westerly direction to Kitale, which accounts for the higher rainfall along this line (see Fig. 1). The natural vegetation is open grassland with scattered *Commiphora* shrubs, acacia being subordinate.

The Suk lowlands comprising Riwa, Kipkomo, and the Masol plains, being some two thousand feet lower than Trans-Nzoia are considerably drier. The rainfall although still heavy is largely lost by rapid run-off and by quick evaporation owing to the high prevailing temperatures and, apart from the banks of permanent streams, only acacia thorn scrub flourishes. Grassland predominates in the southern parts of Kipkomo and Riwa, but in Nyembases bare sand and rocks cover the plain.

On the Cherangani hills, the climate and vegetation vary according to the altitude. Temperatures are reported to fall below freezing point in the rainy season and snow and sleet are not unknown. Such severe weather conditions were not, however, experienced by the author, who remained in the high Cheranganis during April and May, 1952. The rainfall, shown as over 50 inches on Fig. 1, probably reaches double this figure in the eastern part of the range. In consequence extensive forests clothe the flanks of the mountains and marsh vegetation is common. The lower forests lying to the west of Kapsait, between 7,000 and 8,000 feet, consist chiefly of *Podocarpus* and allied species. The critical height for bamboo appears to be 8,700 ft. although a few clumps can be found in the podo forests below. *Protea* scrub grows between 7,000 and 9,000 ft. and is the dominant type of vegetation around Kaibubich. Although occasional cedar trees are to be found in the podo forest they are most numerous above 9,000 ft. It would appear that conditions are more favourable for their growth in the southern Cherangani hills, as few clumps are to be found north of Kapsait. Giant *Lobelia* are ubiquitous in the valley bottom swamps of Lelon and it appears that a combination of both altitude and marshy soil are required before this plant will grow. Another notable species is the giant heath or heather. None of this was seen below 10,000 ft. and it frequently caps the highest peaks of the range.

Population

The Suk, or "Pokot" as they call themselves, are a semi-Hamitic tribe occupying all the country north of Kapenguria. They can be divided into pastoral and agricultural groups, with transitional types. It is the aim, however, of all Suk to be pastoralists and the agricultural section of the tribe is regarded as inferior. Nonetheless, the agricultural Suk show a considerable degree of ingenuity in their methods of irrigation. All running streams are tapped by contour canals which lead to the alluvial fans to water the millet fields. This system is most highly developed in Mwino and at Sigor, where streams are led along spurs of the mountain side, whilst in the flats elevated waterways irrigate an area of some three square miles. The pastoralists are naturally to be found in the plains and on the plateaux.

The Suk grade imperceptibly into the Marakwet, an allied tribe, inhabiting the southern Cherangani hills. They have a similar mode of life to the Suk.

Trans-Nzoia and southern West Suk having formerly been a grazing ground of the Masai possess no indigenous tribes. With the establishment of European farms in Trans-Nzoia an influx of labour occurred from neighbouring locations. Thus, one can now find Nandi, Kitosh, Sebei and Marakwet living here. Before the last war Suk were also found in large numbers, but latterly they have preferred to stay in their reserve. As a result of this mixed tribal influx southern West Suk is now occupied by members of all tribes, including even Kikuyu from central Kenya, making it the most populous part of the district.

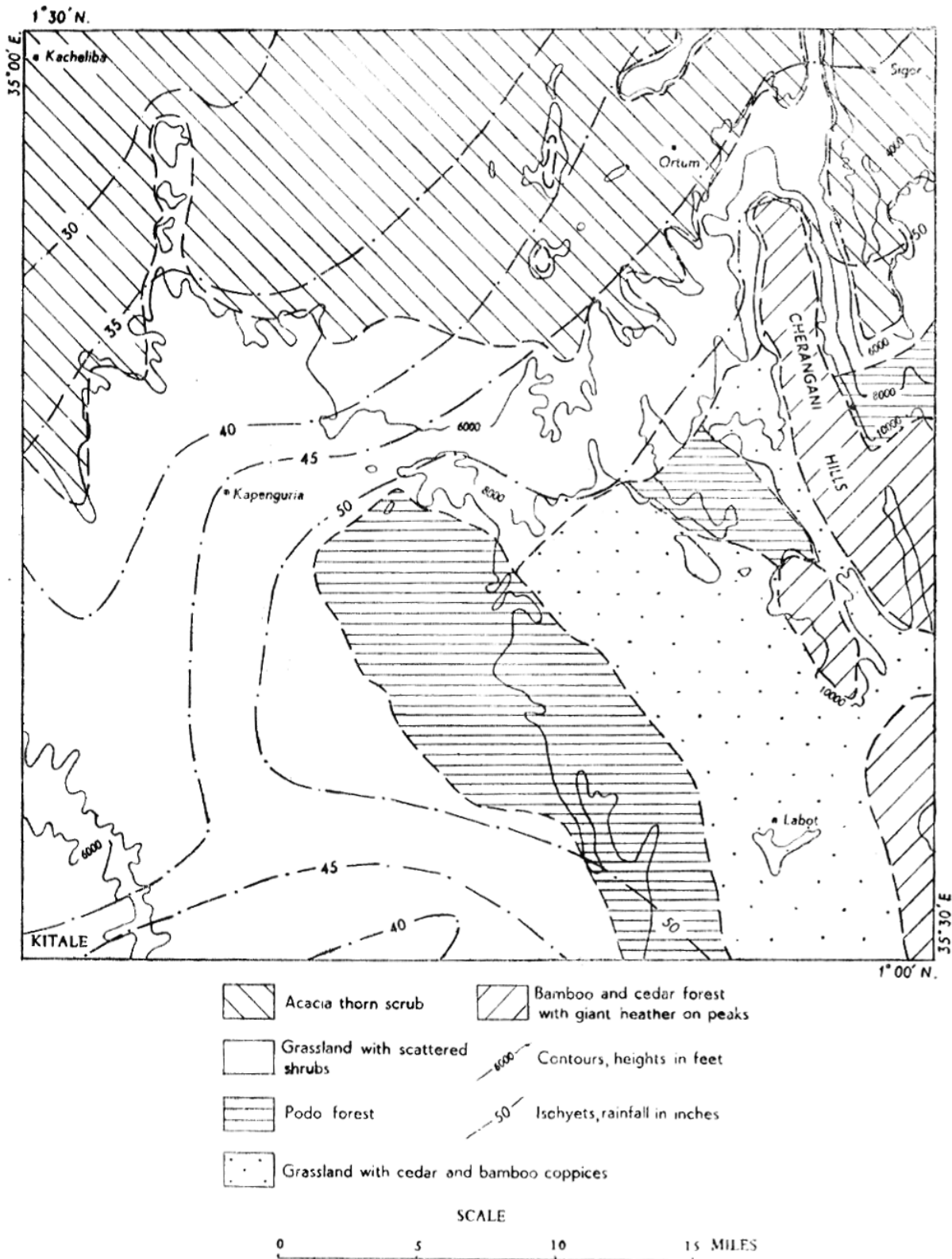


Fig. 1—Map showing rainfall and vegetation in the Kitale-Cherangani hills area.

Europeans occupy the land in Trans-Nzoia and, apart from the administration officers and missionaries at Kapenguria, reside in that part of the area only. Asians live almost entirely in Kitale, and also keep the shops at the trading centres of Keringet, Makutano, Kongelai, Kacheliba, Kapenguria, Cheberaria, Ortum, Wakor and Sigor.

Administratively the area is divided between West Suk, Elgeyo-Marakwet and Trans-Nzoia with their centres at Kapenguria, Tambach and Kitale. These cover the areas occupied

by the Suk, Marakwet and European farmlands respectively. All three districts come in the purview of the Provincial Commissioner of the Rift Valley Province, Nakuru, and, for mining matters, in that of the Warden of Mines at Kisumu.

Commercial

Kitale dominates the area, being one of the seven larger towns of Kenya. It is essentially a market town from which the agricultural and dairy produce of Trans-Nzoia is sent by rail "down-country". Local industries are few and all are connected with farming. Farms range from 500 to 10,000 acres and are operated individually or in groups. Formerly this was a great maize-producing area, many farms practising monoculture of that crop. Exhaustion of the soil in recent years has led to a change over to dairy farming, the cream produced being sent to Naivasha for cheese and butter manufacture. Other crops grown are wheat, sisal, coffee and, to a lesser extent, vegetables.

North of Kitale, sand obtained by washing the alluvium of the Koptawelil is mixed with cement and made into tiles.

The only industry carried on outside Trans-Nzoia is the cutting of cedar fence posts from the forest of Lelon. Otherwise subsistence agriculture and cattle herding comprise the entire labours of the native people.

Acknowledgments

The assistance of Captain M. A. Unwin-Heathcote and Mr. H. C. de L. Kirk in connexion with mapping and local information is gratefully acknowledged.

II—PREVIOUS GEOLOGICAL WORK

J. W. Gregory (1921, p. 215), from views obtained during his travels in 1892 and 1919, noted that the Elgeyo escarpment was probably a fault feature though he did not enter the area under discussion.

V. G. Glenday and J. Parkinson (1926) stated that before their visit no geological work had been done in the Suk hills, which seems to be correct. These men crossed the present area from Kacheliba to Ortum *via* the Lun river and then marched down the Marun out into the Rift Valley. *En route* many specimens were taken of which detailed petrographical descriptions are given in their paper. A subsidiary traverse covered the Trans-Nzoia escarpment.

In 1933 R. Murray-Hughes produced a report on the western half of Kenya based on a reconnaissance of the roads, during which he traversed the Kitale-Cherangani area and concluded that only Basement System rocks were present. His report included a map showing the more prominent faults. Subsequent work has been entirely physiographical. F. Dixey expressed views on the erosional history of the area in publications dated 1945, 1946 and 1948. Fuchs (1939) and Champion (1937) touched lightly upon this region in their Turkana studies and, more recently, R. M. Shackleton (1951) correlated two of the peneplains with those in Kavirondo.

III—PHYSIOGRAPHY

I. Topography and Drainage

The area can be divided into four natural topographical units:—

- (a) The Trans-Nzoia plains
- (b) The West Suk plains
- (c) The southern Cherangani hills
- (d) The northern Cherangani hills

These comprise roughly the four quarters of the area and can be grouped into northern and southern halves with respect to the main divide. The southern half lies in the Lake Victoria basin and has well-graded streams. The land rises from the rolling plain of Trans-Nzoia at 6,500 ft. by two well-defined steps, the Trans-Nzoia escarpment and the Kaibubich-Kaisongul escarpment, to the high plateaux of the Cherangani hills at 9,600 ft. and 10,800 ft. The gently inclined steps bevel the upturned rock formations, and it is concluded that they are remains of senile erosion surfaces. The erosion surfaces in the south are relatively well-preserved when compared with their highly dissected equivalents farther north.

The northern half of the area lies in the Lake Rudolf basin, whose rivers have cut into the high-lying plains and plateaux of the Cherangani hills. In the north-west these rivers have, apart from the Gobut range, reduced the country to a peneplain but, to the north-east, they have as yet only carved immense valleys in the softer rocks and fault-zones, leaving great ridges standing with their summits over 6,000 ft. above the intervening valley floors.

2. Peneplains

Six peneplains were recognised during the survey (Fig. 2):—

- | | |
|--|--------------|
| 1. Cherangani plateau | (10,800 ft.) |
| 2. Lelon plateau | (9,600 ft.) |
| 3. Cretaceous (?) surface | (7,600 ft.) |
| 4. Kitale plain | (6,500 ft.) |
| 5. West Suk lowlands (sub-Miocene surface) | (4,500 ft.) |
| 6. End-Tertiary surface (Masol plains) | (3,500 ft.) |

Subsidiary erosion surfaces are related to stages in the down-cutting of the Marun-Wei-Wei drainage system.

The Cherangani plateau bevels the central mountain mass at approximately 10,800 ft. Kameligon's peaks rise from this plateau which is also developed on the hills east of the Arror valley, between the Arror headstreams, and on Sondang south of the Barawa river. Tabach (10,796 ft.) is clearly an outlying remnant of this surface. North of the Barawa the plateau has been degraded some hundreds of feet and the easterly dip of the granitoid gneisses has influenced the development of a gentle slope to the east. Other degraded remnants of the surface are found on Kaptabuk (10,520 ft.) and Kaisongul (10,370 ft.).

The headstreams of the Moiben and Marun rivers are now cutting into a surface at 9,600 ft. which forms the higher parts of Lelon. This clearly represents a planation by an ancient river system which originated on the Cherangani plateau and selectively eroded the softer gneisses around the granitoid and other more resistant gneisses. It owes its preservation largely to the quartzites of Kapsait which have resisted subsequent denudation from the south-west. Kiptaburr (9,110 ft.) probably represents a degraded outlier of the Lelon surface, suggesting that this surface may originally have extended considerably beyond its present confines to the south-west of the quartzites. Kajasaror (9,265 ft.) and the Kasengow spur (9,600 ft.) are also considered to be remnants of the surface, showing that it once was developed well to the north.

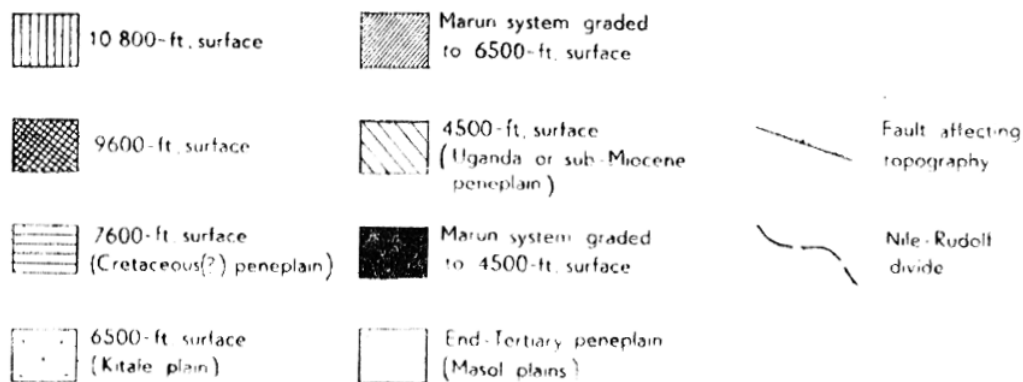
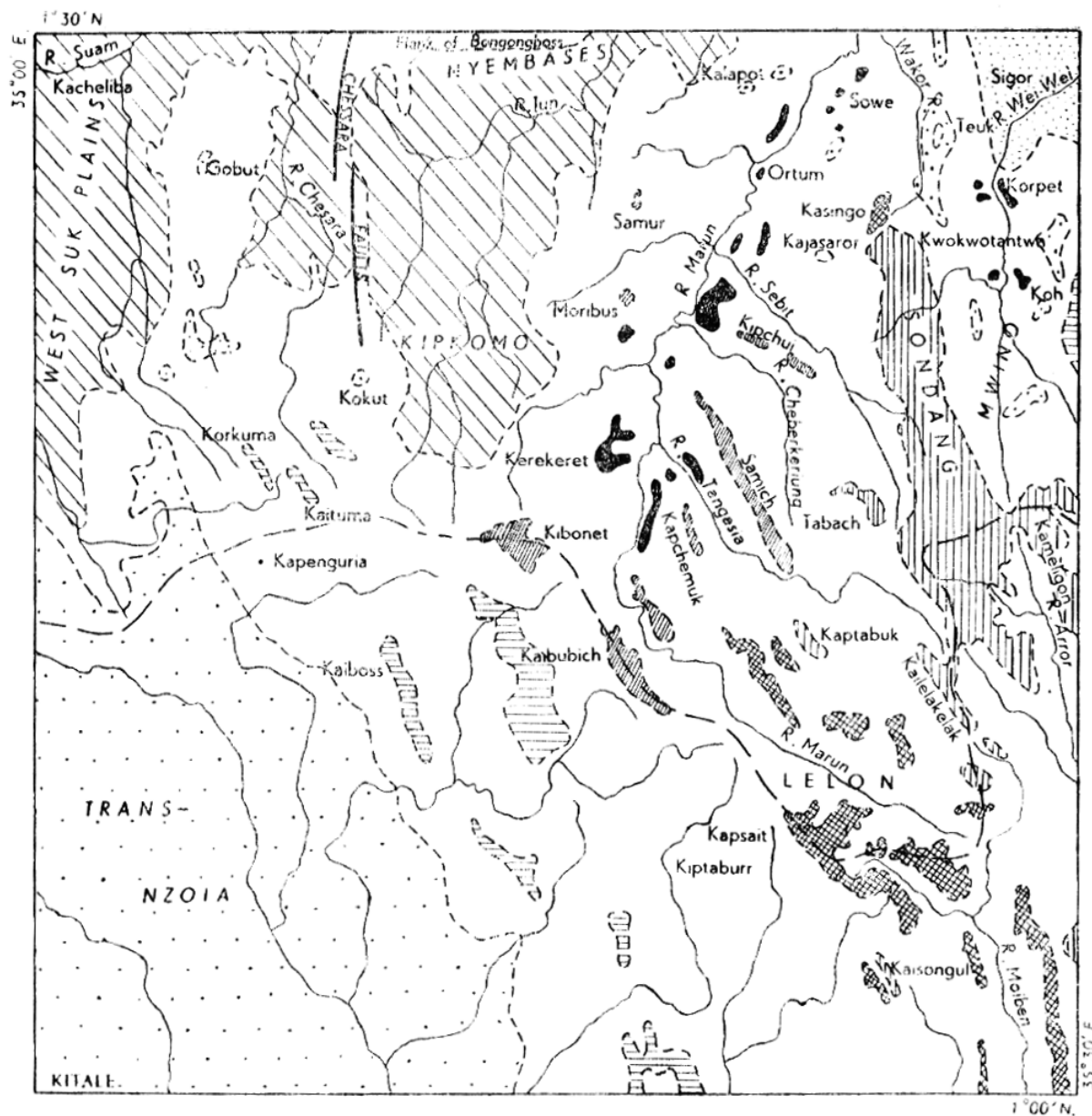
The pattern of the upper Marun tributaries suggests that they have been captured from the Moiben headstreams as far north as Kaptabuk. This is not a recent capture as the Moiben has now a steeper grade than the upper Marun.

The next recognisable planar surface, the presumed Cretaceous peneplain (Shackleton, 1951, p. 379), lies at 7,600 ft., occupying parts of the area between the Kaibubich-Kaisongul escarpment and the Trans-Nzoia escarpment* which runs south-east from Kaiboss. It is present chiefly on the crest of the latter feature and slopes upwards towards the foot of the Kaibubich-Kaisongul escarpment. The Cretaceous peneplain is also recognisable in the flat tops of the hills north-east of Kapenguria where Kaituma and Korkuma probably stood up above the general level of the peneplain.

The part of Trans-Nzoia within the area lies on the pre-Miocene "Kitale plain" surface of Dixey (1948, p. 26), at an altitude of 6,500 ft. near Keringet and gradually declining in height to 6,200 ft. at Kitale. To the north the country falls away at a fine erosion escarpment to the West Suk plains, which are encroaching on the upper peneplain in a series of strike valleys such as that seen at Keringet. Outlying remnants of the Kitale plain occur as benches on the Gobut range and on Kokut.

Examination of Fig. 2 will indicate that there were several stages in the formation of the lower Marun and Wei-Wei valleys. The rivers have been graded to successively lower levels, the former valley floors now being represented by benches on the sides of Sondang, Koh and Kalapot. The highest and most strongly developed bench occurs at 6,750 ft., this being well-displayed north of Kwokwotantwa, below Koh, and on the northern slopes of Kameligon. It is considered that this bench is part of the Kitale plain.

*It should be noted that this escarpment is not the Trans-Nzoia escarpment of Searle (1952, p. 5).



SCALE

0 5 10 15 Miles

Fig. 2—Erosion surfaces of the Cherangani hills.

A section drawn down the lower Marun valley to its confluence with the Cheberkeriung and thence along Samich to the latitude of Telok is given in Fig. 5 C. Samur, Moribus, Kapchemuk and Telok have been projected on to this profile and it is at once evident that these hills and ridges in the central Marun basin once formed a surface continuous with the Kitale Plain as represented on the section by Kabara, Kalapot and the Teuk-Kwokwotantwa bevel. This surface has a slope of 1° to the north which is the same as the slope of the West Suk plains from the foot of the escarpment* north of the Kitale plain to the Suam at Kacheliba. On projecting this surface to the south-west from the Cheberkeriung-Marun junction it is found to coincide with the hill summits between Kaibubich and Mzee.

The next lower peneplain—the West Suk lowlands—is the continuation of the main Uganda peneplain which has been classed by Shackleton (1951, p. 378) as the equivalent of the sub-Miocene surface of Kenya. In Karamoja the peneplain is at about 4,300 ft. altitude rising to 4,500 ft. and higher against the Suk mountains. It invaded the area from the north-west, the flanks of the Suk mountains being base-levelled over the plains of Riwa and Kipkomo, with only the Gobut quartzites resisting the denudation. In Kipkomo the rivers of the West Suk lowlands peneplain encroached on the Marun drainage system, the upper Iun flowing into the Suam at this period through the gap between Gobut and Bongong.

The Marun and Wei-Wei river systems cut down and graded themselves to the equivalent of the Uganda peneplain east of the Cherangani hills. The remnants of this thalweg are present at 6,500 ft. on Kerekeret and Chepkunye, descending by the southern slopes of Moribus and western Kipchui to the small hills of the lower Marun valley, at 5,000 ft. above Wakor. A discontinuous bench on Kalapot is also referable to the same surface. This old terrace lies 650 ft. above the present Marun river indicating that by this time the topography must have been similar to that of the present day. Mwino possesses a similar bench well developed on Korpet and other spurs on both sides of the valley also lying about 650 ft. above the (Wei-Wei) river. The spurs are graded to 4,250 ft. on Korpet and it seems certain that this surface is the representative of the West Suk peneplain on the eastern side of the Cherangani hills.

After the Marun was graded to the Uganda peneplain movement on the Chessara fault tilted the Kipkomo plain to the east and diverted the waters of the Iun into the Marun.

The plain standing at 3,500 ft. around Sigor is part of the Masol plains. The latter fall gradually to the north towards Lake Rudolf and are part of the end-Tertiary or main Northern Province peneplain (Dixey, 1948, p. 29).

3. Origin of the Cherangani Hills

The Cherangani hills are related by their height to the Sekerr and Chemorongi massifs lying farther north. The highest points of all three are near 11,000 ft., the axis of high ground paralleling a spur-fault from the Rift Valley whilst to the west of them lies the perfect Uganda peneplain. Thus the question may well be asked: "Are these mountains related to the Rift faulting?" Four modes of origin for the mountains are possible:—

1. By upwarping of the sides of the Rift.
2. By upfaulting of a horst block alongside the Rift.
3. By the lagging of a block as the country on both sides of it subsided.
4. By the presence of an old resistant massif lying in a fortuitous position.

If the Cherangani hills are an upwarp of a peneplain along the side of the Rift, the high plateau must be a relic of that peneplain. If upwarping took place in end-Tertiary times then, in view of the height of the Cherangani plateau, marked tilting of the peneplains should be discernible on the flanks. This is not the case; any tilting there is slight. If tilting occurred previous to the end-Tertiary bevelling and after the formation of the sub-Miocene peneplain then the end-Tertiary surface should be level and all older peneplains tilted. The section in Fig. 5A shows that the peneplains form a flight, approximately parallel to one another; similar parallelism has also been demonstrated in North Nyanza (Huddleston, 1954, p. 5). Consequently it is concluded that the Cherangani plateau has not been formed by upwarping.

*The Trans-Nzoia escarpment of Searle (1952, p. 5).

The possibility that the Cherangani hills are a horst block appears attractive at first sight as they are bounded by a northward continuation of the Elgeyo fault scarp on the east and by the Trans-Nzoia fault-line scarp to the south-west. The presence of a bench referable to the Kitale plain in the Marun and Wei-Wei valleys and similar benches in every valley on the eastern flanks of the Cherangani hills shows that the faulting within the area mapped must be pre-Kitale plain in age. Therefore the 7,600 ft. surface cannot be an up-faulted part of the Kitale plain, as the latter was not in existence at the time of the faulting. As no other faults separate the surfaces higher than the Kitale plain it is concluded that the Kitale plain, the 7,600 ft., the 9,600 ft. and the Cherangani plateau surfaces represent four cycles of erosion. The West Suk peneplain is the expression of a younger erosion cycle and is separated from the Kitale plain by erosional excarpments, while the Masol plains represent a still later cycle of end-Tertiary age. Thus in the present area there is little evidence to suggest that the Cherangani hills are either an up-faulted block or a block which has lagged as the country on both sides of it subsided. It should be noted, however, that Gibson and Mason's work (not yet published) in the Tiati-Kalossia area has shown that the Elgeyo fault, though an old feature, was markedly rejuvenated in Tertiary times, so that the hills have been emphasised on their eastern side.

The Cherangani plateau is developed chiefly upon granitoid gneisses and granite. The axis of high ground is parallel to the north-north-westerly strike of the Basement System, and it is possible that the Cherangani-Sekerr range owes its elevation to the preservation of an old peneplain upon resistant rocks. In this connexion it is perhaps significant that the Nile-Rudolf watershed passes approximately east-west across the centre of the mountain mass. East of the Rift Valley the Karissia hills and Matthews range also lie upon this east-west line. These are the only other mountains of comparable height composed of Basement System rocks in Kenya.

The presence of representatives of the sub-Miocene peneplain on the eastern side of the Cherangani hills suggests that the hills are residual on that surface. It is concluded that the Cherangani hills are an old resistant mountain mass upon and around which traces of six erosion cycles can be seen.

4. Age of the Peneplains

The Masol plains being a continuation of the plains lying around Lake Rudolf are almost certainly referable to the end-Tertiary surface of Dixey (1948, p. 29). The West Suk plains are an eastern extension of the Uganda peneplain, correlated by Shackleton (1951, p. 378) with the sub-Miocene peneplain of Kenya. Dixey (1948, p. 26) gives the Kitale plain a pre-Miocene age and considers it to be part of the 6,500 ft. peneplain of North Nyanza (1945, p. 244). Saggerson (1952, p. 5) considers that this "high" peneplain of North Nyanza lies at 6,100 ft. on the Maragoli hills and states that the sub-Miocene surface with Miocene beds upon it, lies 1,300 ft. below it. Huddleston (1954, p. 5) shows that in the Kakamega area at least four peneplains are present, following on Kent (1944, p. 112) in believing that the second of these surfaces is the sub-Miocene, which slopes upwards to 5,400 ft. at the base of the Nandi escarpment. Residuals lying on this surface are tentatively correlated with the Kitale plain, whilst still higher residuals "may represent a down-faulted portion of the 7,000 ft. surface" which bevels the crest of the Nandi escarpment. All these surfaces are parallel to one another and slope upwards to the east-north-east. For the area farther north Gibson (1954, p. 9) suggests that a step in the sub-Elgon surface from 5,700 to 5,900 ft., 15 miles south-west of Kitale, marks the eastern limit of the sub-Miocene peneplain and that the Kitale plain begins on the "top" of the step. He supports his suggestion with the fact that the easternmost deposits of middle Tertiary Bugishu beds, which in Uganda lie on the sub-Miocene peneplain, occurs near the foot of the step. Thus the Kitale plain appears to slope constantly upward at 20 ft. per mile to the north-east from 5,900 ft. north of Broderick Falls to 6,200 ft. at Kitale and thence to 6,500 ft. near Keringet. At its southern margin the 7,000 ft. surface of the Nandi escarpment lies about 1,100 ft. higher and at its north-eastern limit the 7,600 ft. surface of the Cherangani hills also lies 1,100 ft. above the Kitale plain. It is suggested that the two higher surfaces are parts of the same peneplain, which Huddleston has tentatively correlated with the supposed Cretaceous surface of the Kisii highlands in South Nyanza. The Cretaceous (?) peneplain slopes upwards parallel to the Kitale plain terminating at the foot of the Kapsait-Kaisongul escarpment.

The Kitale plain is of an age intermediate between the sub-Miocene and Cretaceous peneplains. The broad alluvial plain of the Koptawelil near Kitale lies about 200 ft. below the Kitale plain and may represent the first stages of its reduction to the sub-Miocene level in that part of the area.

This interpretation differs from Shackleton's (1951, p. 379) in that the Kitale plain is considered to be distinct from, and an older surface than, the sub-Miocene peneplain.

The Lelon and Cherangani plateaux, being residual upon the Cretaceous (?) surface, are thus probably pre-Cretaceous. It is possible that one of them may be part of the surface bevelling the Abyssinian plateau discussed by Dixey (1946, p. 369).

Glaciation

M. J. Ellerbeck (1952) has postulated that the Cherangani hills were covered by an ice-sheet during the Pleistocene and that the higher valleys of the mountain mass have been moulded by glacier ice. He also claimed the existence of drumlins, terminal moraines and hanging valleys.

Valley glaciers, according to Woolridge and Morgan (1937, p. 362) "discharge the accumulated snow of upland-snowfields". Thus to produce a valley glacier an upland-snowfield is the first essential. Snowfields in extra-glacial regions only exist on mountain masses above the height at which the ablation of the snow is exceeded by its precipitation.

The possibility of the existence of a snowfield on the Cherangani hills during the Ice Age depends upon whether they were high enough to reach the snowline at that time. Mount Elgon (14,150 ft.), which lies some 50 miles to the west, shows definite traces of glaciation. E. Nilsson (1940, p. 63) from the study of the moraines left by Pleistocene glaciers considers that the snowline lay at about 13,100 ft., or some 1,500 ft. above the highest peaks of Cherangani. The lowest Pleistocene snowline of East Africa occurred on Ruwenzori at 11,650 ft. Thus, it appears unlikely that snow could have persisted long enough to form a snowfield on the Cherangani hills in Pleistocene times. This is all the more probable when it is considered that the general level of the Cherangani plateau is about 10,800 ft. in altitude. Nilsson records terminal moraines on Ruwenzori as low as 6,500 ft., but those of Mount Elgon are not found below 11,150 ft. It should be remembered that valley glaciers are outpourings of ice from *névé* fields above the snowline and only flow providing the snowfield exists.

The "drumlins" described by Ellerbeck consist of countless earth mounds about four feet high and ten feet in diameter scattered on the gentler slopes above 9,000 ft. They have no elongation orientation and no significant distribution other than their altitude. On Sondang the mounds completely cover the hill slopes and are in contact with one another, giving each a rough polygonal outline. Aerial photographs of soil polygons from the tundra of Canada closely resemble the aerial photographs of the Sondang mounds. Such soil polygons are formed at the present day in the soil layer overlying permanently frozen sub-soil by the action of alternate freeze and thaw conditions. It is accordingly inferred that during the Pleistocene the Cheranganis above the height of 9,000 ft. were subject to similar conditions. The state of preservation of the polygons is better upon Sondang than Lelon. This is probably because at the higher and colder altitude the polygons were more perfectly developed.

The valley of the upper Aror appears to owe its U-shape not to glacier erosion but rather to the infilling of a V-shaped valley with alluvium. The history of the valley can be divided into three periods:—

1. Cutting of original valley in the 10,800-ft. peneplain. The floor of this valley is represented by a continuous bench some hundred feet above the present floor. It is especially well-developed on Kapkooh.
2. Excavation of a deep V-shaped notch in the floor of the original valley.
3. Infilling of the notch by sediments.

Swamps and alluvium infill most of the valleys of Lelon and Sondang, and some of the valleys around Kiptaburr and in Trans-Nzoia. Such a widespread alluvial filling may be due to regional tilting but deforestation and the presence of much easily erodable material

in the soil polygons has probably contributed to this aggradation. The swamps are usually contained by quartzite beds outcropping across the line of the streams. No terminal moraines were seen. The rounded topography of Lelon may be ascribed to the wet temperate climate and flat grade of the streams crossing the plateau.

Hanging valleys are generally tributary to larger rivers of considerable erosive power which have excavated their courses along the strike. In several cases in the Cherangani hills it was noted that resistant beds outcrop at the mouths of hanging valleys and it appears that the tributaries are unable to erode the harder layers fast enough to keep pace with the rapid downcutting of the larger streams. In this connexion no valleys confluent with the Arror appeared to "hang". Most examples were found at the junctions of the Moiben with its tributaries and only at the mouths of the minor streams.

The weight of evidence is thus considerably against glaciation having taken place in the high Cherangani hills during the Pleistocene. They seem rather to have experienced tundra-like conditions.

IV—SUMMARY OF GEOLOGY

The rocks of the area fall into two groups:—

1. Metamorphic rocks of the Basement System.
2. Pleistocene and Recent superficial deposits.

1. Basement System

The Basement System rocks, apart from local alluvial veneers, occupy the whole area. They consist of types similar to those described by Parkinson (1913, p. 534), Shackleton (1946, p. 5) and Schoeman (1948, p. 12). They differ from Shackleton and Schoeman's rocks in that sillimanite has not developed and migmatites are not common.

The rocks appear to have arisen by regional metamorphism of a sedimentary series of shales, sandy and calcareous shales, sandstones and limestones enabling the resultant gneisses to be classified into pelitic, psammitic and calcareous groups. A gradation is recognisable from pure psammitic rocks, the quartzites, though semi-psammitic or semi-pelitic biotite gneisses and hornblende gneisses to semi-calcareous biotite gneisses and finally to pure calcareous rocks or marbles. Migmatization, although not widespread, has resulted in the transformation of some biotite gneisses into migmatites and adjacent impure marbles to calc-silicate granulites. Kyanite and staurolite-bearing gneisses are only locally developed. Hornblende, chlorite, and actinolite schists found in the lower Marun and Wei-Wei valleys are attributed to the metamorphism of volcanic ashes. The low grade of these and associated granulites is possibly due to retrograde metamorphism related to shearing along the Marun fault. Other probably meta-volcanic rocks are represented by diorite-like types of charnockitic affinities.

Acid, basic and ultra-basic intrusive rocks have invaded the meta-sedimentary and volcanic series. They include unaltered olivine gabbros. The largest intrusive body is the foliated granite of Teuk which is one of several granites forming the core of the Cherangani-Sekerr range. Metasomatic effects attributed to this granite include granitization of semi-calcareous gneisses, formation of tourmaline schists and possibly gold mineralization.

2. Pleistocene and Recent Superficial Deposits

The superficial deposits consist of alluvial infillings of valley bottoms, an alluvial cone, and soils. Valley bottom alluvium is commonly present along streams flowing towards Lake Victoria but rare in the Lake Rudolf drainage system. The boulder fan of Ortum is of a transitional type between a landslip and an alluvial cone. The soils are all red in colour, being sandy in the drier parts of the area and containing iron concretions in Trans-Nzoia,

V.—DETAILS OF GEOLOGY

1. Basement System

For description the Basement System rocks are classified into the following groups:—

Sedimentary—

Crystalline limestones	}	Calcareous
Calc-silicate granulites		
Semi-calcareous biotite gneisses		
Hornblende-diopside gneisses	}	Semi-Pelitic
Biotite gneisses		
Biotite-garnet gneisses		
Hornblende gneisses		
Biotite-hornblende gneisses		
Garnet-hornblende gneisses	}	Psammitic
Microcline-porphyroblast gneisses		
Quartzites		
Muscovite quartzites		
Quartz-muscovite gneisses		
Quartz-felspar para-granulites	}	
Garnetiferous quartz-felspar para-granulites		

Volcanic—

Hornblende schists
Tremolite-actinolite schists
Chlorite schists
Meta-amygdaloids
Garnet-porphyroblast gneisses
Diorite-like rocks—charnockites

Migmatitic—

Semi-pelitic types

Metasomatic—

Granitoid gneisses
Tourmaline schists

Intrusive—

Foliated granite	}	Acid
Granite pegmatite		
Muscovite pegmatite		
Hypersthene-olivine gabbro	}	Basic
Meta-gabbro		
Meta-pyroxenite		
Talc-amphibole rocks		Ultra-basic

As the majority of the Basement System rocks are metamorphosed sediments it should be possible to determine from their relationship in the field the order of deposition. Isoclinal folding, however, and the fact that the planes of schistosity are not always coincident with the original bedding planes in sediments subjected to intense metamorphism complicate the establishment of the original succession. Assuming that the bedding and schistosity planes are coincident, the succession of the present area is as follows (the nature of the probable original sediments is given in parenthesis):—

7. Biotite gneisses (argillaceous sandstones).
6. Hornblende and hornblende-biotite gneisses (calcareous sandy shales).
5. Biotite gneisses (argillaceous sandstones).
4. Hornblende gneisses and amphibolites with marbles (calcareous sandy shales with limestone horizons).
3. Biotite gneisses (argillaceous sandstones).
2. Quartzites and quartz-schists (sandstones).
1. Semi-pelitic and psammitic biotite gneisses with quartzite and calc-silicate granulite lenses (argillaceous sandstones with sandstone and limestone horizons).

(1) METAMORPHOSED CALCAREOUS SEDIMENTS

The calcareous sediments have been metamorphosed into crystalline limestones, calc-silicate granulites and semi-calcareous gneisses.

The Crystalline Limestones all occur within eight miles of Twin Bridges, excellent exposures being found in a dry valley tributary to the Marun at that point. All the exposures are considered to belong to two isoclinally folded marble horizons, one outcropping west of Moribus and the other to the east. In the Marun valley one limestone bed is folded into two anticlines and a syncline, all overturned to the west, the resultant outcrops crossing and re-crossing the Marich road. These are moved to the east by faults in the Sebit valley and are found on Tamara, Kipchui and Samich. Other small lenticles of marble occur around Samur.

The limestones are white to bluish-white, alternations of these colours producing a banded effect. At Twin Bridges graphite occurs sparsely in the marble which, upon being broken, emits a smell of sulphuretted hydrogen. This is a typical "stinking" marble. Other minerals found in the marbles at various places are actinolite, diopside, scapolite and sphene. Diopside marbles occur south of Kalopot (26/111)* and at Twin Bridges (26/95) whilst on the Marich road half-a-mile north of Sebit sphene, diopside, scapolite and quartz are found in a bed of marble (26/136). Mafic lenticles are fairly common especially in the Marun valley.

The Calc-silicate Granulites are of two distinct types, those occurring as lenticles in the limestones and those not associated with limestone. The former outcrop as dark lenticles up to twenty feet in length and composed largely of hornblende, diopside, epidote, scapolite and calcite (26/136) with occasional quartz crystals. The silicates obviously represent minerals derived from original impurities in the marble. The granulites occurring separate from the limestones outcrop as a large lenticle west of Kiptaburr and are essentially melanocratic felspar-quartz-garnet-diopside-hornblende-biotite-epidote rocks. They form rounded outcrops of a greenish-black colour, spotted with red garnet. In thin sections (specimens 26/215-218) the garnets are found to have the form of irregular fractured crystals containing many chadacrysts of quartz, felspar, and apatite and, more rarely, magnetite and sphene. Between the garnets are complex, plumose growths or intensely sieved crystals of diopside. The primary hornblende is also attacked to a limited extent by this symplektite. Golden-brown sphene crystals are in general associated with the primary hornblende. Magnetite occurs as irregular grains, and apatite is present, occasionally in large crystals.

The Kiptaburr calc-silicate granulites are intimately associated with migmatites and it seems probable that the migmatizing fluids invaded the original calcareous rock, assisting in the production of garnet, diopside, and hornblende.

Semi-calcareous Gneisses are particularly well-developed around Samur there they outcrop as biotite-rich flaggy rocks (26/92). They have developed microcline porphyroblasts as a result of the action of the granitizing fluids which were also responsible for the metasomatism of the Moribus-Soko granitoid gneiss. Under the microscope biotite of a greenish-brown pleochroic variety is seen to make up 30 per cent of the rock. Diopside, pale sphene, and apatite form another 15 per cent of the constituent minerals and are the notably lime-bearing minerals of the gneiss. Quartz, oligoclase, and untwinned plagioclase are the other minerals present. It is possible that these gneisses were developed from calcareous sandy clays.

Semi-calcareous Gneisses containing hornblende, and diopside as the predominant coloured minerals are found intimately associated with hornblende gneisses, probably representing more lime-rich layers in original sandy shales. A typical example is specimen 26/194 collected on the eastern side of the Moiben valley. The outcrops consist of mesotype foliated massive gneisses of medium grain, with visible hornblende, diopside and felspar. In thin sections the texture is seen to be slightly gneissose, hornblende and pale green diopside having an irregular banded disposition with some replacement of diopside by hornblende. Yellow-green epidote is, in general, associated with the hornblende and appears to be replacing it. The felspars are microcline, orthoclase, oligoclase and untwinned plagioclase, the potash varieties being slightly predominant over the plagioclase. Quartz is also present. Sphene, magnetite and apatite occur in accessory quantities.

*Specimens numbered 26/215, etc., are housed at the Mines and Geological Department, Nairobi.

Estimated volumetric modal analyses of these rocks are listed below:—

	26/194	26/42	26/114
	%	%	%
Quartz	5	15	25
Microcline	10	3	3
Orthoclase	10	5	5
Oligoclase	5	10	8
Untwinned plagioclase	13	8	12
Hornblende	20	10	8
Diopside	30	25	25
Epidote	2	20	10
Apatite	1	1	1
Sphene	2	2	2
Magnetite	2	1	1

26/194 Eastern slope, Moiben valley.

26/42 Kacheliba road, one mile north of Nasokol.

26/114 Twin Bridges.

(2) METAMORPHOSED SEMI-PELITIC SEDIMENTS

These are gneisses which were formed by the metamorphism of sandy shales and argillaceous sandstones and are represented in the area by biotite gneisses and biotite-garnet gneisses.

Biotite Gneisses occupy two broad belts traversing the area from north to south, covering most of the area shown on the map as semi-pelitic gneisses. Where they contain calc-silicate minerals they are considered, however, as members of the semi-calcareous group. Increase in quartz places them in the psammitic group, whilst veining by felsic materials brings them into the migmatite class.

The biotite content varies in individual rocks from an evenly distributed speckling to a well-foliated crowding of the crystals, when the rock can be called biotite schist (26/11). No modal analyses were made of these gneisses, but an average specimen would approximate closely to that described by Shackleton (1946, p. 11) from the Maralal district.

Biotite-garnet Gneisses are not widespread. Although they are probably to be found in the semi-pelitic outcrop the only microscopically determined rock (26/212) of this class was found on plot 2143/3 in Trans-Nzoia, near Cherangania. It is not a typical member of the class as it has been considerably feldspathized by granitizing fluids. The hand-specimen is grey with pink microcline porphyroblasts. Estimation of thin sections show that it has the following volumetric composition:—

	26/212
	%
Quartz	30
Oligoclase	15
Orthoclase	30
Microcline	10
Garnet	5
Biotite	10

Hornblende Gneisses—Two major belts of country, one comprising Kipkomo and the upper Marun and Moiben valleys, and the other the lower Marun, Sebit and Cheberkeriung and upper Aror valleys are underlain by hornblendic gneisses. Smaller lenticles occur around Nasokol, along the Trans-Nzoia escarpment and below Koh.

In hand-specimen the gneisses have obvious foliation and are characterised by visible hornblende and feldspar, and by mesotype to leucocratic appearance. The rocks of the eastern belt are characterised by an even-grained granular appearance, some being hornblende granulites, whilst in those of the western belt coarseness of grain and some amphibolite lenticles are noticeable.

Estimated volumetric modes of these rocks, drawn from both belts, are as follows:—

	26/1	26/27	26/34	26/175	26/112
	%	%	%	%	%
Quartz	5	20	10	15	10
Orthoclase	—	—	—	15	—
Oligoclase	74	44	41	—	53
Andesine	—	—	—	23	—
Hornblende	15	30	45	40	35
Epidote	5	3	2	1	2
Apatite	—	2	2	1	—
Staurolite	—	1	—	—	—
Sphene	1	—	—	5	—

Western belt { 26/1 Gorobat hill.
 26/27 Three miles north of Cheberaria on Ptoyo road.
 26/34 Four miles north of Cheberaria on Ptoyo road.
 Eastern belt { 26/175 Kailelakelak.
 26/112 Three miles north of Ortum on Sigor road.

It will be seen that these gneisses are dominantly composed of hornblende and oligoclase or andesine feldspar with subordinate quartz. Hornblende-rich types probably represent calcareous horizons in the original sediment. Specimen 26/81 from the Jembrambe river, is a typical amphibolite with over 70 per cent hornblende together with subsidiary epidote, less than a quarter of the rock being oligoclase and quartz.

Biotite-hornblende Gneisses—These are found in a distinct horizon in Mwino adjacent to the Sondang granitic intrusion, and also as lenticles in the hornblende gneiss outcrops. Those associated with the hornblende gneisses of the Moiben valley, represented by specimen (26/168), have the following estimated volumetric mode:—

	%
Quartz	10
Oligoclase	41
Biotite	20
Hornblende	22
Epidote	3
Sphene	3
Apatite	1

This gneiss is similar to hornblende-biotite schists and gneisses described by Schoeman (1948, p. 14) from the Kitui area. On the western flanks of Mwino gneisses of similar composition (e.g. 26/162) contain andesine porphyroblasts crowded with needles and irregular crystals of epidote. Biotite partly replaces the hornblende which is now very ragged and sieved. The andesine porphyroblasts are considered to have grown at the expense of more basic feldspars in the original rock with no influx of feldspathic material.

Garnet-hornblende Gneisses—A lenticle of garnet-hornblende gneiss forms a small ridge at the north-western extremity of Kipkomo, below Bongongboss. In hand-specimen it is a well-foliated leucocratic rock with visible garnet, hornblende and quartz. A thin section of specimen 26/164 shows that the garnet and hornblende are concentrated in layers, with quartz and subordinate oligoclase in intercalated layers. Some 40 per cent of the constituent minerals is quartz, which accounts for the superior resistance to weathering of this gneiss.

Microcline-porphyroblast Gneisses—Kaptabuk and Mzee, lying between the Marun and Tangasia rivers, are largely composed of metamorphic rocks closely approximating to a syenitic composition (26/172, 177, 191, 193, 207). In outcrops they vary from unfoliated rocks crowded with rectangular bluish-grey feldspar porphyroblasts to well-foliated gneisses in which the porphyritic feldspars have a platy habit and lie in the plane of the foliation.

The porphyroblasts are carlsbad-twinned microcline-perthite containing albite-twinned oligoclase ex-solution blebs. Their average dimensions are 9 x 6 x 4 mm. The ex-solution blebs take the form of irregularly shaped and disposed patches, lenticles arranged *en échelon*, or of parallel lenticles lying across the width of the crystal. In the last case the

lenticles terminate at a definite distance from the faces of the porphyroblasts, leaving a homogenous layer around the outside of the crystal, which is represented in hand-specimens by whitish borders around the otherwise bluish-grey crystals.

The grain of the rock in which the perthites have grown is coarse. Biotite plates 1 to 3 mm. in length and similar-sized green clinopyroxenes, with 0.5 mm. oligoclase crystals, form the bulk of the minerals between the porphyroblasts. The biotite is pleochroic from greenish-brown to very pale brown and most plates are bent. Clusters of colourless granular sphene are enclosed by or edge the plates and do not occur except in association with biotite. This association may be the result of reconstitution of the mica following on the breakdown of more titaniferous biotite. The biotite is intimately intergrown with clinopyroxene, the junctions being sharp in most cases, but a little replacement has also occurred. The clinopyroxene shows pleochroism from light to medium green and the maximum extinction angle ($Z \wedge c$) measured was 46° . It is probably a ferroaugite or a hedenbergitic variety of diopside. The mineral has suffered marginal replacement by bluish-green hornblende and in some cases is poikiloblastic, enclosing magnetite and feldspar. There are also large hornblendes that may not be after pyroxene. Apatite is abundant and is present in both small euhedral and large anhedral crystals. A small amount of epidote with orthite cores is also present.

Two types of veining, namely aplite and pegmatite, occur in the porphyroblastic gneiss. The pegmatites are coarse-grained microcline-orthoclase-quartz-magnetite dykes of granitic affinities. They trend on a bearing of 10° and it would appear that they belong to the granitic pegmatites of the area.

The aplites have no clear-cut margins and are sinuous discontinuous leucocratic veins related intimately to the parent rock. They range in thickness from one inch to three feet and some have been traced over 70 yards across a valley at the southern end of the outcrop.

Thin sections (26/192) show a coarse sutured mosaic of microcline, perthite, orthoclase and oligoclase with scattered green clinopyroxene, biotite, sphene and apatite. The pyroxenes are orientated with their long axes parallel to the lengths of the veins.

The mode of origin of the porphyroblasts in the gneisses appears to have been by growth at the expense of other minerals of the rocks. At the contact of the perthites and oligoclase the perthite lobes into and encloses the latter mineral. Perthite also lobes into and replaces biotite. This is clearly seen in a slide of specimen 27/177 in which relics of a portion of a plate of biotite so invaded lie adjacent to it, but enclosed in perthite. Here, also, a cluster of granular sphene is almost surrounded by perthite, the sphene probably having once been enclosed in the biotite plate, as is its most common mode of occurrence in this slide. The perthites seen in this slide contain relics of sphene, biotite, magnetite and other minerals, which probably represent the remains of minerals replaced by the porphyroblasts in their growth.

Thus there is evidence that the perthites replaced and incorporated the minerals of the rock. In view of their size some displacement of the original minerals by the porphyroblasts is also probable.

W. T. Harry (1952, p. 148) has described a similar syenitic porphyroblastic rock in Glen Dessary, Scotland. In this case, the porphyroblasts are anti-perthite and make up some 85 per cent of the rock and are 5 to 6 cm. in length. They show random and gneissose development. Harry suggests that the porphyroblasts developed at a late stage in the history of the rock under the influence of interstitial fluids residual from migmatization at a time when stress had diminished and hydrostatic pressure was dominant, but when there was an increase in temperature. The orientation of the porphyroblastic feldspars in associated gneisses is ascribed to preferential development along S-planes in the parent gneisses where porphyroblastesis was not so pronounced. This was probably the case in the Cherangani gneiss. Harry also shows that some of the surrounding gneisses and the feldspar-porphyroblast rock have approximately the same chemical composition and deduces that the porphyroblastesis was iso-chemical. The gneisses seen in exposures around Kaptabuk grade from a melanocratic biotite gneiss in the north to a microcline-rich leucocratic type in the south, and the porphyroblasts in the north are few and have gneissose arrangement, whereas in the

south they are of random development and form over 50 per cent of the rocks. There appears to be that relationship between the porphyroblastic gneiss and the surrounding gneisses that would be expected if the porphyroblasts had been formed at the expense of the original minerals of the surrounding gneisses with little influx of feldspathic material from outside.

Around Samur biotite gneisses (26/120) with alkali feldspar, up to ten per cent green clinopyroxene, and accessory apatite and sphene, have also developed microcline porphyroblasts to a small extent. This probably represents an initial stage in the development of gneisses of the Kaptabuk type.

(3) METAMORPHOSED PSAMMITIC SEDIMENTS

The psammitic sediments comprise quartzites, muscovite quartzites, quartz-muscovite gneisses, psammitic biotite gneisses, quartz-feldspar para-granulites and garnetiferous quartz-feldspar para-granulites.

Quartzites, Muscovites-quartzites and Quartz-muscovite-gneisses have been mapped as an entity owing to their gradation into one another in both the horizontal and vertical directions. They apparently lie in two horizons low in the succession and are found at seven main localities, namely Sitama to the Suam river, Kaiboss to Terragur, Gobut to Kaisongul, Telok, Samich to Kapsototwa, Samich to Kailelakelak, Tobach to the Arror, and on Kameligon, together with several smaller lenses. The thickest bed is responsible for the continuous ridge stretching southwards from Gobut through Kwaisagat and Kibonet to Kaisongul and eventually to northern Uasin Gishu. Other beds cap the Trans-Nzoia and Samich escarpments and the peaks of Kameligon are formed of this ubiquitous rock.

Similar rocks have been described by Parkinson (1947, p. 13) in the Tsavo area, by Shackleton (1946, p. 12) around Maralal, by Schoeman (1949, p. 14) from near Sotik, and by Sanders (1954, p. 20) from north-east of Kitui. Thus they are widely distributed in the Basement System of Kenya, but nowhere so far surveyed in the country, excepting perhaps the Sotik district, are they so massive and widespread as in the present area.

The pure quartzites occur as large lenticles lying in the plane of the foliation. At the widest part of the Gobut-Kaisongul zone, they occur at three distinct horizons. In outcrop they closely resemble quartz veins, but on weathering the rocks crumble into their constituent grains, some of which are over 5 mm. in diameter. The colour of the rocks is a dirty white, and often they are translucent. In thin sections large interlocking quartz grains showing strain polarization and often with sutured margins can be seen to form the entire rock.

Fine-grained quartzites (26/199) with an average grain size of 1 mm. are found in two small lenses at Kapgeis. They have a rough orientation of the c-axes of the quartz crystals parallel to the strike. In the lower Sebit valley fine-grained banded quartzites are intimately associated with marbles, and one near Twin Bridges is stained with malachite. Pyrite in minute cubes is disseminated evenly through the rock (26/123). These quartzites on being traced southwards grade into the coarse-grained type which caps the Samich escarpment.

The quartzites outcropping half-way up the Sebit valley show minor contorted folds and thrusts in the width of the bed (26/150).

The advent of muscovite causes the rocks to be classified as muscovite quartzites. The micas always have a schistose orientation and are either evenly distributed through the rocks or concentrated in layers. The layered quartzites, well displayed around Kaisongul, closely resemble sedimentary beds, and in the field are similar in appearance to the flagstones of the upper Maji ya Chumvi beds of Triassic age in the Coast Province. Under the microscope, however, no trace of sedimentary structures can be seen, the texture being similar to that of the quartzites, with orientated muscovite flakes frequently completely enclosed in quartz crystals.

Intermingled and grading into the muscovite quartzites are quartz-muscovite gneisses (26/50) and quartz-biotite gneisses (26/62). These are mica quartzites with the addition of feldspar. All are strongly gneissose and frequently flaggy, although completely massive types outcrop in the upper Chessara valley. Some types carry biotite to the exclusion of

of muscovite. The quartz-mica gneisses may be described with reference to specimen 26/63, from three miles north of Korkuma triangulation beacon, which has the following composition:—

				%
Quartz	..	..	..	60
Microcline	..	..	..	19
Muscovite	..	..	..	20
Sphene	..	..	..	1

Fine-grained aggregates of sphene are often associated with the mica plates but also occur alone in the quartz. They may represent TiO_2 that could not be taken up by the muscovite when it was formed.

Glenday and Parkinson (1926, p. 609) record "small crystals of a colourless or very pale green kyanite" in a quartzite of saccharoidal appearance at Karetuma (Kaituma), but although the locality was visited the author was unable to find this mineral in the quartzites.

Quartz-felspar Para-granulites—A band of quartz-felspar para-granulite forms the higher slopes of the Koh-Kaok ridge above Mwino. The outcrops are dirty-white in colour and flaggy in character. At the north end of the range the flags form bare rock pavements of considerable extent. As with the quartzites the flags suggest a sedimentary origin for the rock, but the partings here are more irregular. Occasional flakes of biotite and muscovite are seen, the former increasing in the higher beds which grade into the biotite gneisses of Koh. In thin sections granular mosaics of quartz, microcline and oligoclase with clear-cut crystal boundaries, with rare muscovite and biotite, are seen.

Garnetiferous Quartz-felspar Para-granulites—These are invariably associated with the hornblende gneisses of the Kipkomo-Nyembases plain. They outcrop in the rivers as thin bands dipping with the foliation of the surrounding rocks. Banded greyish-white when fresh, the granulites weather to a golden brown. Red euhedral porphyroblastic garnets are visible, scattered along distinct bands. In each band the garnets are of uniform size, but vary in dimensions in different bands. A slide of specimen 26/80 was found to consist of quartz and microcline, the latter preponderating, forming a granular texture of equidimensional crystals with scattered flakes of muscovite. Garnets, though obvious in the hand-specimen were not cut by the section. The distribution of the garnets in bands strongly suggests a sedimentary layering of the original rock, each garnetiferous band probably representing a layer richer in iron and aluminium minerals.

(4) META-VOLCANIC ROCKS

Rocks of probable volcanic origin include hornblende schists, tremolite-actinolite schists, chlorite schists and diorite-like rocks. The schists are found in the lower Marun and lower Wei-Wei valleys and were first described by Glenday and Parkinson (1926, pp. 594–5), who also ascribed a volcanic origin to them. The *hornblende schists* (26/99, 26/101) are in the majority, being well-exposed on the road, where their glistening black slaty appearance is striking. In thin sections they are found to consist largely of acicular hornblende crystals with lenticular magnetite, set in a mosaic of quartz and oligoclase. Specimens consisting almost entirely of acicular hornblende were described by Glenday and Parkinson. A variation in these schists occurs on the western slopes of Mwino. Here the oligoclase-quartz fraction is concentrated in white irregular aggregates which mottle the otherwise black hornblende schist (26/155). It is possible that this rock may be a metamorphosed amygdaloidal lava.

Tremolite, actinolite and chlorite schists form a river cliff on the Marun three miles north of Ortum. The former (26/28) have marked fissility and resemble greenish-grey slates and, under the microscope, specimen 26/113 is seen to consist mainly of tremolite with occasional crystals of actinolite, interstitial chlorite, and scattered small crystals and aggregates of rutile. Specimen 26/128 consists largely of actinolite with scattered crystals of tremolite. "Nests" of anhedral carbonate occur, but no replacement of the amphibole is apparent. It would seem that these schists represent a more calcareous ash-band, especially as marbles outcrop within fifty yards of the river cliff.

Chlorite schists form the higher part of the cliff and are distinguished from the tremolite schists by their "fibrous" appearance. A thin section of specimen 26/141 is composed largely of chlorite, pleochroic from colourless to pale-green, with a small amount of talc. Between the chlorites are coarse granular crystals of oligoclase with relics of basic plagioclase and grains of leucoxene that have replaced ilmenite. A few small grains of golden-brown rutile are present and iron-stained carbonate replacing the chlorite occurs.

A *meta-amygdaloid* (26/219) was found in one exposure only, about half-way between Kaibubich and Kiptaburr. In hand-specimen it strongly resembles a vesicular lava, containing spheroidal white patches of a uniform 1 mm. diameter set in a dark hornblende background. A thin section shows that the spheroids consist of untwinned oligoclase, hornblende, epidote, and sphene often completely enclosed in plates of hornblende with which the spheroid hornblendes are in optical continuity. Golden-brown sphene is also enclosed in the hornblende plates. Often the margins of the feldspars are lined by an almost isotropic chlorite, and in some cases the grains are almost completely replaced by it. It is suggested that the rock was originally a basalt with vesicles infilled by calcite and zeolite. This rock differs from that found by Shackleton (1946, p. 13) near Maralal in that its "amydales" are much smaller and have suffered no subsequent deformation during metamorphism. Mineralogically, however, they are similar.

Garnet porphyroblast gneisses outcrop on Kailakelak ridge just west of the triangulation beacon. They are micaceous rocks studded with brown garnets up to 5 mm. in diameter and form a small lenticle in hornblende gneisses. Thin sections (specimen 26/174) show that the garnets are pink and crowded with chadacrysts of magnetite, quartz and epidote. Wrapped around the garnets are elongated masses of magnetite and muscovite whilst the remainder of the rock consists of enstatite, magnetite, zoisite, untwinned plagioclase and quartz. The enstatite frequently contains magnetite chadacrysts, and small euhedral crystals of apatite occur in accessory quantities. An estimated volumetric modal analysis of this rock is given below:—

	%
Quartz	10
Untwinned plagioclase ..	4
Enstatite	15
Muscovite	10
Garnet	40
Zoisite	10
Apatite	1
Magnetite	10

The garnets are porphyroblasts which have grown partly by incorporation of the surrounding minerals and partly by displacing them. Evidence of incorporation is provided by magnetite and zoisite which occur as chadacrysts in them and also in the surrounding minerals. The wrapping of muscovite and magnetite around the garnets suggests that the growth of the porphyroblasts mechanically displaced these minerals.

The gneiss contains a high proportion of iron and magnesium minerals namely garnet, magnetite and enstatite and it may represent a metamorphosed basic lava.

Diorite-like Rocks (Charnockites)

The river-beds and crags of the central part of the northern Nyembases-Kipkomo plain are composed of a greyish comparatively unfoliated massive gneiss. The general impression given by the outcrops is of a completely homogeneous rock mass of igneous appearance. Bands of black amphibolite and white siliceous granulite are associated with it. The microscope shows that the massive gneiss (27/178) is an equigranular assemblage of fresh andesine feldspar, with clusters of hypersthene and diopside in various stages of replacement by hornblende or hornblende and biotite. In some cases corona structures are well developed. Grains of magnetite are invariably associated with the mafic mineral clusters. Between the hornblende rims of the clusters and the unreplaced pyroxene there is often symplektitic intergrowth of pyroxene and hornblende. The biotite is sporadic and, like the feldspars shows no trace of alteration. The latter approximate closely to An₄₈ and are thus a basic andesine. In its texture and mineral association this rock resembles members of the charnockitic suite described by Schoeman (1951, p. 37) around Embu and Meru

and are most like the rocks he described as hypersthene diorites. The composition is very similar to that of the diorites outcropping on the southern side of Kierra ridge, diopside taking the place of augite.

Included in the diorite-like rocks are large numbers of basic patches which, having a sub-angular outline in many cases, resemble xenoliths but which are believed to be skialiths. Hornblende forms 90 per cent of such rocks, with occasional flakes of biotite intergrown with it. Andesine and magnetite altered to limonite complete the composition of the patches.

Associated with the "diorite" are bands of coarse-grained amphibolite and fine-grained pyroxene granulites. The amphibolites lie in a belt trending N.N.E.-S.S.W. near the crossing of the Chepkopek river by the Cheberaria-Ptoyo track. In hand-specimen (26/186) they consist of stout hornblende crystals up to 1 cm. in length with a little interstitial felspar. The pyroxene granulites (e.g. 26/189) are developed as irregular masses and appear in the field as fine-grained portions of the "diorite". Mineralogically they are identical with the latter containing diopside, hypersthene, hornblende, biotite and andesine felspar. The pyroxenes are partly replaced by hornblende and also by scapolite. Scapolite occurs as xenoblastic crystals in contact with and lobing into and replacing both amphiboles and pyroxenes as well as felspar. It contains many orientated inclusions which impart to it a patchy pleochroism from blue to brown.

The diorite-like rocks are shot by two types of veining, namely granite pegmatites containing small books of mica, and segregation pegmatites. The latter consist of hornblende and plagioclase crystals, the hornblendes being developed as elongated prismatic crystals some 2-3 cm. in length. Such pegmatites are considered to be the result of percolation along planes of weakness of volatiles, which have completely converted pyroxenes to hornblende, facilitating porphyroblastic growth.

Local impregnations of the basic copper carbonate, malachite, are widely distributed over the "diorite" outcrop. This mineral has often crystallized in spheroidal and other cracks developed during weathering, and is also found in some of the basic skialiths. Thin sections show that the malachite lies in cracks in the rocks and in one case (26/188) it lobes into and replaces hornblende. Associated with the malachite are a little azurite, chalcopyrite and bornite.

Traversing the "diorite" as included sinuous sheets are well-foliated biotite-microcline-plagioclase-quartz granulites (26/182) with accessory muscovite, apatite and magnetite. The felsic minerals have granular texture, with crystals 0.6 mm. in diameter. The biotites, however, are perfectly orientated in the planes of the sheets. One sheet mapped in detail appears to consist of a series of faulted sections, contorted so as to give detached arcuate outcrops, but maintaining a general direction parallel to the regional strike and the strike of the granite pegmatites.

It is suggested that the "diorites" and the biotite granulites represent a series of metamorphosed basic lava flows with interbedded clayey silts. Regional metamorphism would convert the silts into the biotite-microcline-plagioclase-quartz granulites, the biotite developing a marked orientation. The massive homogeneous lavas would have little or no foliation imposed upon them. Following regional metamorphism it is believed that granitizing fluids invaded the rocks and owing to the basic nature of the lavas, attacked them in preference to the acid granulites, converting the lavas into rocks resembling hypersthene diorites. The basic patches in the "diorite" are considered to be ungranitized relics of the metamorphosed lavas. Lindgren (1933, p. 41) states "All basic lavas contain copper, but in many cases conditions were evidently unfavourable for the concentration of copper immediately after the eruption, and the rocks retained their copper until later opportunities for ore formation were offered". It appears that in the present area the copper has not been concentrated to any extent by regional metamorphism or granitization. It is often found in the basic patches but one small discontinuous band of malachite-stained "diorite" three inches wide and six feet long occurs near the junction of the Chepkopek and Iun rivers, showing that local concentrations do exist.

Similar diorite-like rocks are found associated with the gabbros of Sowe hill. They are mesotype rocks of granular appearance, some strongly resembling the "diorites" of the Kipkomo plain. Thin sections show that the rocks are not of constant composition throughout. Specimen 26/130 collected on the southern flanks of Sowe consists mainly of diopside

hypersthene, biotite, magnetite, oligoclase and abundant accessory apatite in a typical granulitic texture. A "syenitic" type (26/127) from Kabara has diopside, biotite, magnetite, and orthoclase with plentiful accessory apatite, some of the feldspars being large (e.g. 4 mm. in length). Specimen 26/129, also from the southern flanks of Sowe, is intermediate between the two, both in composition and texture.

(5) MIGMATITES

Migmatitic gneisses are not strongly developed in the Cherangani area. The most extensive belt is that of Kiptaburr, and the rock type found there is also discontinuously developed throughout the semi-pelitic gneisses to the south-west. The dominant form of felsic veining is the lit-par-lit type, which has proceeded along the planes of the schistosity without deformation of the host-rock. In the Trans-Nzoia escarpment, south of Sitama, the granitizing fluids appear to have leached the ferromagnesian minerals from the gneisses (26/223). Hornblende crystals over an inch long with lenticular masses of granular diopside, euhedral porphyroblastic garnets and sphenes, set in a coarsely crystalline orthoclase-microcline groundmass, have been deposited by permeation and replacement in pegmatitic bands in the schistosity. Accessory minerals present are apatite and epidote. The hornblendes are pleochroic from green to greenish-brown and the maximum extinction angle measured was 14° . Some bluish-green secondary hornblende is also evident replacing the primary hornblende. The diopside shows pleochroism from pale-green to yellow-green. The sphenes are particularly euhedral presenting a nearly perfect diamond outline in thin section. The permeative origin of the bands is shown by obliteration of the foliation of the host-rock by the growth of granular diopside-feldspar masses across them. That these pegmatites could be formed by the leaching of the host-rock by alkali fluids becomes evident when it is taken into consideration that the host is a biotite-hornblende-quartz-feldspar gneiss and that a zone poor in ferromagnesian minerals surrounds them.

Migmatites with a semi-pelitic host-rock, which have suffered deformation contemporaneous with veining by felsic material, are well-exposed south of Moribus in a dry river-bed tributary to the Marun. The migmatization is probably connected with the granitization of the biotite gneisses west of the lower Marun.

(6) METASOMATISED TYPES

Granitized Gneisses—Granitoid gneisses are found on Sondang, Kalapot, Moribus, Kapchemuk, Kailelakelak, and Tabach. In the field they appear as pink medium-grained slightly foliated rocks, containing visible quartz and feldspar with a little biotite. The microscope (e.g. specimen 26/109) shows an interlocking granular mosaic of quartz, orthoclase, microcline, and oligoclase with a few small clusters of granular epidote, occasional flakes of biotite and a little magnetite. For reasons stated on page 13 this rock is considered to be a granitized semi-calcareous biotite gneiss, which accounts for the epidote in the rock.

Tourmaline Schists occur as a small lenticle in the hornblende schists of the lower Wakor river. The outcrop is massive and blocky and of dead black colour, with white quartz veinlets. A thin section of specimen 26/100 reveals that it is composed largely of needles of prismatic green-brown tourmaline averaging 4 mm. in length. Pockets and veins of quartz enclosing tourmaline needles occur sporadically through the rock.

(7) INTRUSIONS IN THE BASEMENT SYSTEM

The intrusive rocks in the Basement System are described under the following heads—acid, basic and ultra-basic. The only true acid intrusive rock of the area is the foliated granite of Teuk, but for convenience cross-cutting dykes of mica and granite pegmatite which are hydrothermal infillings of pre-existing fissures will be considered in this section. Diorite-like rocks which, however, are considered to be metamorphosed lavas have been described on earlier pages (pp. 18-20).

(a) ACID INTRUSIVE ROCKS

Granite

The ridge of hills running north from Kwokwotantwa, including the peaks of Teuk and Kongotol is, in the writer's opinion, composed of intrusive granite. It is continuous with granite outcropping in the Marich Pass, and continues north into the Sekerr massif before dying out. The intrusion has the form of a lenticle, highly inclined to the east.

In hand-specimen the granite is a leucocratic granular rock speckled with biotite and containing occasional garnet, the mica imparting an imperfect foliation. A thin section of specimen 26/134 shows quartz, microcline and orthoclase in a hypidiomorphic granular mosaic with flakes of orientated biotite.

Distributed through the intrusive body north of Teuk are xenolithic blocks of pyroxenite up to five feet in length. They are angular in shape and possess sharp contacts against the granite, which veins them in parallel-sided dykes. Similar pyroxenites outcrop among the gabbros of the lower Wakor valley and there can be little doubt but the granitic magma invaded the pyroxenites, stopping off blocks.

A thin section of one of the granite veins (26/135) in a xenolith shows a granular assemblage of quartz, orthoclase, microcline and biotite together with accessory pyroxene, garnet and epidote, and hornblende patchily replacing the pyroxene. The accessories are probably the result of partial digestion of the pyroxenite by the granitic magma.

The diorites below Kasengow are invaded by granite dykes up to ten feet in width, which doubtless are off-shoots from the main granite mass.

It is considered that the foliated granite of Teuk is the rheomorphic core of a zone of granitization extending along the length of Sondang. The non-mobilised part of this zone is represented by granitoid gneisses and more detailed mapping may reveal further intrusive granite masses among them. On being mobilised at depth the granite invaded the gabbros and pyroxenites which formerly extended north of their present outcrop.

For reasons stated in a later section of this report (pp. 29-30), it is believed that gold mineralization accompanied the intrusion of the granite. The presence of widespread granites associated with gold-bearing deposits in North Nyanza, less than one hundred miles to the south-west, points to a possible connexion between the two occurrences.

Granite Pegmatites

Granite pegmatites are relatively more abundant north-west of the Marun-Kibonet fault than in the rest of the area, and are particularly numerous in the Kipkomo-Nyembases plain. The pegmatites take the form of dykes with clear-cut margins, and trend within 20° on either side of north. They do not conform to the major folds of the area, but in a minor fold in the Jembrambe river a pegmatite appears to have been injected whilst deformation was in progress, contorting the pegmatite in conformity with the folding of the biotite gneiss. In thin sections the pegmatites are found to consist mainly of coarsely crystalline orthoclase and microcline feldspars with subsidiary amounts of quartz and muscovite.

Mica Pegmatites

Pegmatites bearing "books" of muscovite mica have a similar distribution to the granitic types. All the possibly economic veins occur in Kipkomo and the encircling hills, excepting for two reported in northern Trans-Nzoia. One pegmatite body which was pitted to a depth of ten feet at Korkuma has the shape of an irregular lens lying more or less concordant with the schistosity of the surrounding muscovite quartzites.

No relationship between the intrusive granite and the pegmatites is apparent.

(b) BASIC INTRUSIVE ROCKS

The basic intrusive rocks are unmetamorphosed hypersthene-olivine gabbros and metamorphosed olivine gabbros.

Hypersthene-olivine Gabbros and olivine-free gabbros form a sill outcropping to the west and north of Sowe, in the lower Marun and Wakor valleys. In hand-specimen the rocks are granular and melanocratic, owing their dark colour to the turbidity of the feldspars. In a thin section of one of the olivine gabbros (26/143) the microscope reveals an olivine-augite-hypersthene-labradorite rock of coarse-grained crudely ophitic texture with coronas around the olivines. Hypersthene is greatly subordinate to augite and possesses a typical green to pink pleochroism. A small flake of pleochroic green biotite is associated with one hypersthene crystal and there are occasional crystals and aggregates of a medium brown biotite. Augite and hypersthene form ferromagnesian aggregates. The feldspars, occurring as crystals up to 3 mm. in length, are turbid labradorite (An₆₈). Anhedral, cracked olivine

grains are evenly distributed through the rock and make up 50 per cent of the coloured minerals present. Corona structures are well developed, two continuous shells between the olivine and labradorite and an outer discontinuous third layer being present. The inner shell is considered by the writer to be the altered margin of the olivine whilst the outer lies in the plagioclase. The inner shell often consists of fibrous pleochroic hypersthene, but in other cases a non-pleochroic pyroxene takes its place. Finely disseminated magnetite is usually associated with this inner layer. The pyroxene shell either consists of small radiating prisms normal to the olivine or of larger stumpy crystals. Beyond the pyroxene lies a shell of dusky green amphibole of the same fibrous prismatic habit, and occasionally larger growths of blue-green or greenish-brown amphibole are associated. No symplektitic intergrowth with spinel is present but occasional grains of pleonaste were seen, associated with magnetite. The outer shell consists of fine needles of a colourless mineral which may be another amphibole. The only alteration of the gabbro beyond the turbidity of the feldspar is a slight replacement of the latter by calcite and the sporadic partial replacement of the olivine by bowlingite. Similar rocks have been described by Searle (1951, p. 21) from Riwa.

On the crest of Sowe hill close to the granite contact is an altered pyroxene-andesine (An_{40}) rock (26/97). In hand-specimen it resembles a gabbro of medium grain. Thin sections show that the pyroxenes are diopside and augite, replaced marginally and internally by hornblende. The feldspar is "fresh" but crowded with prisms and needles of epidote, and it is probably considerably more sodic than the original feldspar of the rock, before alteration. Accessory magnetite, apatite and sphene complete the mineral assemblage. A similar metamorphosed gabbro occurs in two thin sills outcropping along the Marich Road beneath the major sill. A similar stage of alteration has been reached, but here the pyroxene is a purplish-brown schillerized diallage.

Olivine Meta-gabbro—A small outcrop of olivine meta-gabbro (26/213) occurs on W. A. Davidson's farm in Trans-Nzoia. This rock is interesting in that it shows two stages of metamorphism. The original rock was a medium-grained gabbro composed essentially of olivine, diopside and labradorite. Assuming garnetiferous coronas to be the result of thermal metamorphism (Shand, 1945, p. 265) the first alteration occurred with the production of coronas around the olivines. These appear to have consisted of an inner hypersthene zone surrounded by a colourless augite zone, the whole being enclosed in a garnet corona in contact with the plagioclase. The corona formation continued until the intervening feldspars were extensively replaced and changed in composition from sodic andesine in contact with the garnet to labradorite in the centre.* This suggests that the anorthite molecule of the labradorite had been removed to provide the lime needed to form the diopside and garnet corona shells (Shand, 1945 p. 263). A second metamorphism or a later stage of the corona phase produced replacement of primary augite by hornblende and of primary and corona diopside and primary plagioclase by biotite.

(d) ULTRA-BASIC INTRUSIVE ROCKS

Meta-pyroxenites—In the Wakor river valley the main gabbro sill includes pyroxenites in a more or less altered condition. Specimen 26/144 illustrates a rock which originally consisted of interlocking crystals of lamellar-twinning diopside with a little interstitial basic plagioclase and apatite. Subsequent alteration has largely converted the pyroxene to secondary hornblende and caused the partial replacement of the ferromagnesian minerals and feldspar by epidote. It is possible that this alteration is due to magmatic water from the granite that invaded the gabbroic sill. Apart from those associated with the Sowe gabbros meta-pyroxenites form the peak of Tabach and also outcrop below Sitama in Trans-Nzoia. Both consist of coarse anhedral colourless augite crystals partly replaced by radial growths of acicular actinolite. The periphery of the Tabach intrusion has been wholly replaced by actinolite.

Xenoliths in the granite of Teuk consist of pyroxenite. Thin sections show that they consist almost entirely of pyroxene which has been largely replaced by hornblende. Sphene, calcite and epidote are present in small quantities.

Talc-amphibole Rocks—Many small lentils of soft cream-coloured talc-amphibole rock occur throughout the area generally associated with hornblende gneisses. In composition they range from asbestiform fibrous actinolite or anthophyllite with interstitial talc to talc-magnetite schists. They were probably derived by the metamorphism of ultra-basic intrusive rocks. Similar rocks have been described by Shackleton (1946, p. 20) in the Maralal area.

*The zoning also occurs in plagioclases that have no contact with either augite or garnet.

2. Pleistocene and Recent Deposits

The Recent deposits of the area include alluvial flats and cones, and soils. The alluvial flats in the valley bottoms are of two types, according to whether they are connected with the Nile or the Rudolf drainage system.

The majority of the rivers draining towards Lake Victoria have their valleys infilled with alluvium. The sides of the valleys have a moderate angle of slope and the alluvium appears to be the result of aggradation in fairly youthful valleys. The alluvium consists of quartz sand, well rounded by water action, with an admixture of clay and vegetable material.

Of the rivers flowing into Lake Rudolf only the Chessara and Wei-Wei have alluvial valley floors. These occur where the rivers emerge from the mountains on to the plains, and are clearly the result of the deposition of masses of debris at the point where the grade of the rivers is too flat to allow further transport. The rudaceous angular nature of much of this debris confirms its mode of origin. Both rivers are now cutting into their own alluvium.

At Ortum a large *alluvial cone* has been built up by the Ortum and adjacent rivers. The cone measures a mile and a half in length and a mile in width at its base and appears to be composed largely of immense angular masses of gneiss up to fifty feet in length. The granitic nature of this gneiss and a scar in the mountain side below Sondang peak at the head of the valley suggest that the cone is, in fact the remains of an old land-slide which has been redistributed by river-action. The Marun is now cutting into the feather-edge of the cone.

Soils

The ridges of Trans-Nzoia are occupied by a red non-sandy soil which contains a layer of iron concretions at a depth of about five feet below the surface. Around Kitale it is said that a well was dug on W. A. Davidson's farm to a depth of 80 feet before reaching "solid rock", but outcrops near the Trans-Nzoia escarpment show that the thickness of soil cover is considerably less at the edge of the plain. Several valleys, notably the Koptawelil, are infilled by sandy alluvium.

The Kipkomo, West Suk and Rift Valley plains are covered by a thin layer of red sandy soil similar to that described from other parts of Kenya (e.g. in Kitui, Sanders, 1954, p. 32).

The mountainous part of the area, being subjected to intense river erosion, has soils which reflect the nature of the underlying gneisses. On the quartzites a thin pink sandy soil full of quartz granules is developed, whilst the other quartz-rich gneisses are covered by soils similar to those of Trans-Nzoia but containing more sand. The gneisses rich in ferro-magnesian minerals are covered by red, non-sandy soils. Where the rivers flow over the high plateau their valley bottoms are infilled with sandy alluvium.

3. Metamorphism and Metasomatism

The belt of gneisses lying immediately to the east of the Gobut-Kaisongul quartzite ridge does not appear to have been altered by granitizing fluids to any marked degree and is therefore suitable for the determination of the metamorphic grade of the area. The dominant mineral assemblage in this belt is hornblende-oligoclase-epidote-quartz with occasional staurolite, diopside and garnet. Eskola places such an assemblage in the amphibolite facies and staurolite-kyanite sub-facies (Turner, 1948, p. 81), that is metamorphic rocks developed under conditions of moderate to high temperatures and strong directed pressure. The reported presence of kyanite in the quartzites strengthens this conclusion.

The classic metamorphic zones of Barrow and Tilley equivalent to the amphibolite facies are those of staurolite, kyanite and sillimanite. The absence of sillimanite from the Kitale-Cherangani hills area indicates that only the kyanite and staurolite zones are present there. The zones and facies determined are referable to the Becke-Grubenmann mesozone or middle depth of metamorphism.

A lower-grade mineral assemblage is found in the chlorite-, tremolite- and actinolite-bearing schists of the lower Marun valley. Chlorite-sphene-oligoclase-rutile-calcite and calcite-actinolite assemblages are found together with intercalated psammitic granulites possessing quartz-albite-microcline-biotite-muscovite-epidote assemblages. These are all referable to Eskola's greenschist facies and may indicate localised low-grade regional metamorphism. The chlorite schists show, however, a considerable degree of shearing and could

have been formed as the result of diaphthoresis or retrograde metamorphism of rocks of the amphibolite facies or even higher-grade types. The presence of a major fault of Precambrian age along this valley suggests that retrograde metamorphism might be related to shearing along a zone of weakness.

Metasomatism

The effects of granitizing emanations are shown by the country-rocks around Sondang and Kalapot in diverse ways.

The Moribus-Soko granitoid gneiss lenticle, north-west of the Marun valley, appears to owe its present constitution to the action of similar emanations. The surrounding biotite gneisses are rich in biotite and diopside with oligoclase, quartz, orthoclase, epidote, sphene and apatite. The first noticeable effect of granitization is the development of porphyroblastic microcline-perthite with oligoclase ex-solution blebs. The porphyroblasts have grown at the expense of the original orthoclase and oligoclase, and enclose biotites at their margins. At this stage hornblende began to replace diopside. Continuation of these processes produced leucocratic biotite-hornblende granitoid gneisses with accessory sphene, apatite, magnetite and epidote. The reduction in the percentage of dark minerals present may be accounted for in two ways; by the breakdown of the biotites, releasing potash and alumina for the formation of the microcline porphyroblasts, the iron set free being left as magnetite; and by the conversion of diopside to hornblende and thence to biotite which breaks down yielding further potash and alumina. It is probable that lime and magnesia have been removed from the rock. The breakdown of the biotites could not provide sufficient potash and alumina to form all the microcline present in the granitoid gneisses, and it is assumed that these radicals were introduced in granitizing fluids from the Sondang granitic gneiss. The absence of plane crystal faces and the strong foliation of the rock suggest that a magmatic stage was not reached during the formation of the granitoid gneisses.

Other lenticles of granitoid gneiss on Kapchemuk, Kailelakelak and near Tabach may have been formed in a similar manner.

Associated with the hornblende schists of the lower Marun valley are several bands of tourmaline schist. These schists have been described by Glenday and Parkinson (1926, p. 596) as "products of the intrusion of the acid magma". Hutton (Turner, 1948, p. 127) reports abundant tourmaline in greenschists, at least part of which are meta-volcanic rocks, near Otago, New Zealand. He traces the tourmaline "to the influence of hot magmatic water rising from an unexposed subjacent batholith". The Marun tourmaline schists may have had a similar origin. It is difficult to see, however, why several lenticles of schist, interbedded with hornblende schists and possessing the same dip and strike, should be formed as the result of metasomatism, leaving no trace of the rock from which they were derived. It is perhaps possible that they represent original alumina-rich bands or pockets in the succession which might be expected to yield readily to the action of pervading boron-rich solutions.

In Mwino potash-bearing granitizing fluids do not appear to have been introduced into the biotite-hornblende-andesine-quartz gneisses adjacent to the foliated granite. Andesine porphyroblasts containing epidote inclusions are however found in the gneisses nearer the granite. The rock has evidently suffered alteration as the hornblendes have been corroded and replaced by biotite. The lime set free in this replacement has probably assisted the formation of epidote in the porphyroblasts which were at the same time developed at the expense of the original feldspar. It does not appear that any material has been introduced. It is possible that the intrusion of the granite provided the necessary impetus to initiate the formation of the feldspars as they are more abundant nearer that body.

4. Structures

Folds

The disposition of the Basement System quartzites shows the complex nature of the folding in the area (Fig. 3). A series of folds with axes striking usually between N.N.W. and north can be traced in the eastern three quarters of the area, where exposures are sufficient to allow structures to be deciphered. The folds are generally overturned to the west, although east of Kapenguria small open folds occur. Two persistent fold axes run through the quartzites from Gobut to Kaisongul *via* Kibonet, that to the west being a syncline while the eastern axis is anticlinal, both being overturned to the west. At Gobut the folds are

tightly packed and isoclinal, pitching to the south. In the latitude of Korkuma the folds open out slightly and semi-pelitic gneisses appear in the axes of the folds, which are still overturned to the west. Near Kwaisagat the axes swing around to an east-west strike and become overturned to the north, which is a reversal of the direction of overturn. At the point of reversal the quartzites are thrown into a series of minor folds pitching at 40° to the south. The reversal of overturn persists to Kibonet where a break occurs at the Marun fault. South-east of this fault the overturn is again to the west and the pitch south-east, the latter being clearly shown by the lensing-out of the northerly limb of the anticline to the north-west and of the southerly limb of the syncline to the south-east. It is almost certain that the folds continue to the south-east, although they are not obvious from geological boundaries, the anticline being continuous whilst the syncline appears to die out between Kaibubich and Kapsait. The folds here find expression in three massive quartzite ridges, one overlying the semi-pelitic gneisses in the west, the central forming Kaisongul and the third overlooking the Marun-Moiben valleys to the east. The quartzites of the three ridges are all probably at the same horizon and folded into an anticline and syncline. Unfortunately, only the quartzites outcrop as the river valleys have alluvial floors, but it is possible that tongues of semi-pelitic or hornblendic gneisses occur along the axes of the folds.

The semi-pelitic and calcareous gneisses and granulites between the Trans-Nzoia and Kibonet-Kaisongul escarpments all dip generally to the north-east, but the calcareous granulites west of Kiptaburr probably lie in the core of a fold overturned to the west. In view of the close proximity of the synclinal axis west of Kapsait this fold in the granulites may be anticlinal.

The open anticline and syncline north-east of Kapenguria appear to pitch in opposite directions. It is thought that at this point the pitch is almost zero, with the occurrence of small culminations and depressions. South of the Marun fault at Kaiboss the anticline becomes overturned to the west.

The hornblendic gneisses of Kipkomo and the upper Moiben and Marun valleys are folded isoclinally into a syncline whose axial plane dips to the east. The "diorites" of Kipkomo lie on this axis, but as they are hybrid in origin their lensing out to the south probably has no structural significance.

The outcrop pattern of the quartzites and limestones of the Marun basin suggests that one limestone and possibly two quartzite beds have been folded isoclinally into two anticlines and two synclines, the axial planes dipping east and the folds pitching south. The folds broaden out between Sebit and Kailelakelak, being more tightly packed in the north and south. The structural pattern is especially well exhibited by the quartzites east of Kailelakelak where the effect on the same bed can be traced along the flanks of all four folds.

Faults

The main fracture of the area is the *Marun fault* which passes along the lower Marun valley. Its shatter-zone is well displayed in the road-cutting at the eastern end of the new concrete bridge at Twin Bridges. Between Twin Bridges and Ortum the fault cuts out a series of folded marble bands and, beyond Ortum, narrows the outcrop of the hornblende gneisses of the Marun valley. Its southerly extension leaves the Marun valley south of Moribus and proceeds along the western side of Kerekeret ridge. At this point it has down-faulted the semi-pelitic gneisses on its eastern side and moved the Kipkomo synclinal axis south-westwards to Kerekeret (see section BB' on map).

The fault bisects Kibonet where it separates the quartzites overturned to the north from those overturned to the south-west. South of Kwaisagat it finds expression in the transverse line of quartzite hills of which Kepchela is the summit, and the last traceable effect of this fracture is the cutting off of the nose of the Kaiboss fold. South-westward from Kibonet the fault downthrows to the north-west and is probably reversed.

The *Mwino fault* is probably more of a monoclinal flexure with shearing on the steep limb, rather than a true fault. The near-vertical dip of the biotite gneisses and hornblende schists in the valley bottom is in marked contrast to the more gentle dips of Koh and Kajasaror. The effect of the Mwino disturbance is to downthrow the gneisses on its eastern side.

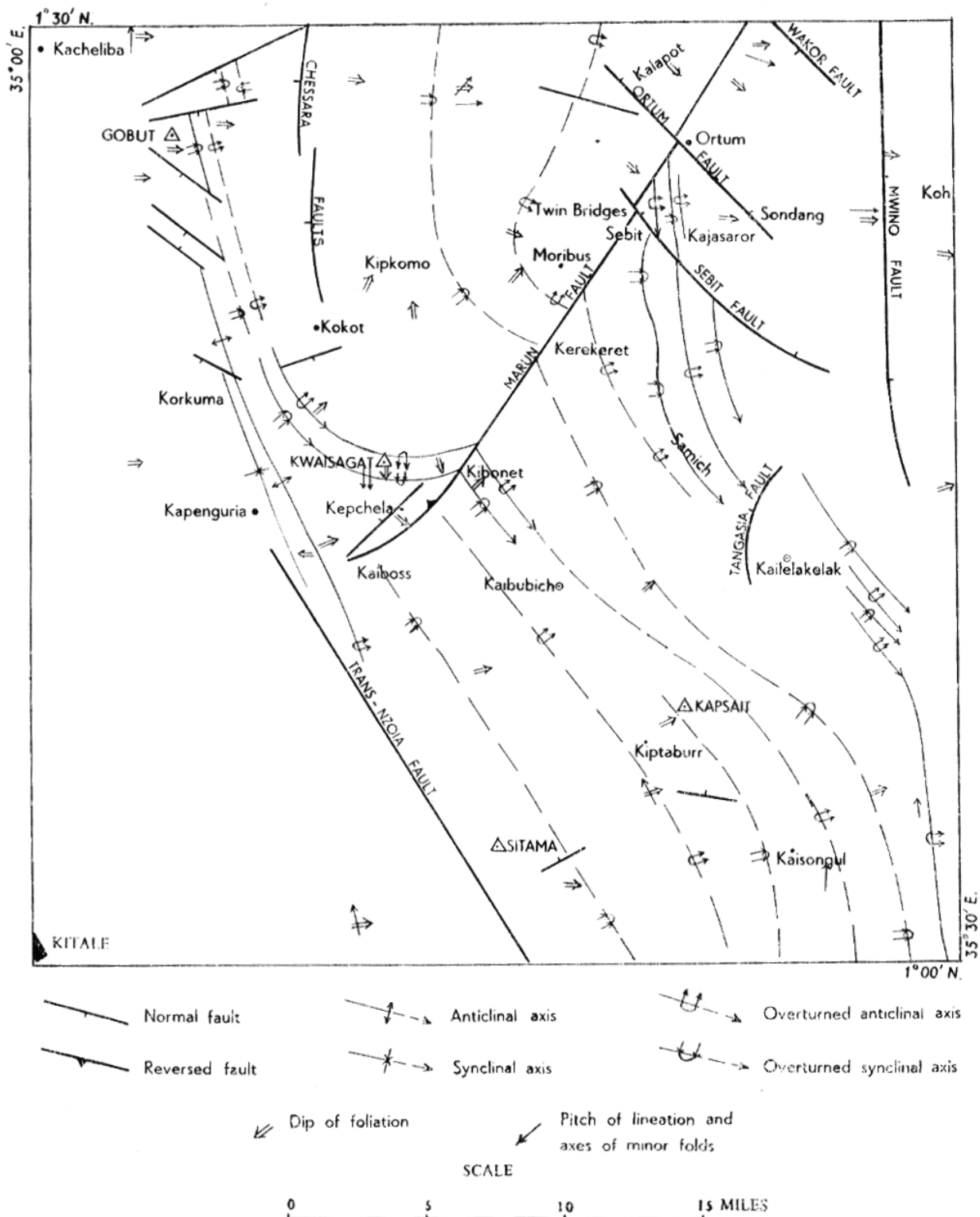


Fig. 3—Structures diagram of the Kitale-Cherangani hills area.

The cross-faults of the lower Marun valley all appear to displace the Marun fault, and are considered to be younger than that fault. The *Ortum* fault displaces the granitoid gneiss of Kalapot so that it forms the lower line of hills immediately above the west bank of the Marun between Ortum and Sebit. It finds topographical expression in the valley along which the Kacheliba-Ortum donkey-track runs. On the east bank it emerges from the alluvium to run between Sondang and Kajasaror, downthrowing the gneisses on its northern side. Beginning at the cleft of the Barawa valley in Sondang the *Sebit* fault crosses Tamara and runs down the lower Sebit valley. The main fault displaces the south-eastern margin of the Moribus-Kalapot granitoid gneiss but does not appear to continue through to its north-western boundary. A branch of this fault displaces the marble of one limb of the western

overturned anticline north of Sebit. This fault is clearly visible in a Marich Pass road-cutting half a mile north of Sebit. The main Sebit fault and the branch fault both down-throw to the east.

The Trans-Nzoia escarpment has long been considered a fault feature (Murray-Hughes, 1933, front plate), but no evidence of faulting apart from the long straight feature has previously been published. In the upper part of the Kapoet valley where it cuts through the Trans-Nzoia escarpment there is a series of quartzites and semi-pelitic gneisses dipping at 5° to the north-east, and this may reasonably be considered to be the true dip of the gneisses forming the escarpment. The lowest quartzite, on being traced from the river to Kirk's farm S.S.W. of Kaiboss, increases its angle of dip to 40° to the north-east. Talau and other small hills, overlooking the Trans-Nzoia plain formed by this lowest quartzite have similarly tilted beds. Although the escarpment is capped by quartzites at Kaiboss the feature is maintained to the south-east after the quartzites have lensed out. For these reasons it is concluded that the Trans-Nzoia escarpment is a fault-line feature.

Lineation

Two main directions of lineation are present in the area. The first is "parallel to" the generally N.N.W.-S.S.E. strike of the folds of the Basement System and is present throughout the area. The quartzites frequently exhibit a strong lineation of this type, caused by a ruckling of the mica plates on the foliation planes. The lineation of the semi-pelitic biotite gneisses is brought out by orientation of the mica plates.

In the north of the area a second lineation direction at right-angles to the first is present. This is found in the "diorites" of Kipkomo, the hornblende schists of the lower Marun valley and the hornblende schists and biotite-hornblende gneisses of Mwino. In all three cases it is related to faulting and thrusting and is probably due to movements subsequent to the development of the first lineation.

The "diorites" of Kipkomo develop in places a strong lineation due to the alignment of the ferromagnesian minerals, which is related to thrusting observed in the bed of the Lun river. The trend of the lineation is 60° , with variable plunge from horizontal to 30° to the east. The foliation planes frequently have granite pegmatites injected along them which, as they are not disturbed by the thrusting, were emplaced after movement had ceased. Where more intense movements have occurred fusiform bodies, elongated in an easterly direction with the lineation running down their length, are found. The lineation and fusiform bodies are all aligned at right-angles to the direction of movement along the thrust planes their alignment being parallel to the b-axis. No a-lineations were observed. The strike of the lineation measured in the north bank gullies tributary to the Marun varies in direction, trends of 10° and 50° being recorded with gentle north and north-easterly plunges respectively.

The hornblende schists of the lower valley show a strong lineation of the hornblende needles and magnetite aggregates down the dip of the foliation. A similar lineation occurs in the hornblende schists and biotite-hornblende gneisses of Mwino where the ferromagnesian clusters are streaked out in a similar direction. As these are both near to major dislocations the lineation is probably developed in the direction of shear movements along the fault-planes.

Structural History

The dominant structural feature of the area is the general north-north-westerly strike of the Basement System, the foliation dipping moderately to the east. The general fold pattern and the principal lineations coincide in direction with this strike. It is therefore probable that the lineation is a b-lineation and that the forces producing the folding acted from approximately E.N.E. and W.S.W. in a compressional manner. All the minor folds and the majority of the major folds are overturned to the west, suggesting that the main compressive force acted in that direction. This compression constitutes the first decipherable phase of the structural history of the area subsequent to the deposition of the Basement System.

The strike, although in general north-north-westerly in fact swings through a right-angle to slightly north of east in the neighbourhood of Kwaisagat. As, however, the isoclinal folding of the quartzites continues unbroken through the easterly swing and it is the fold axes themselves that are bent, it would appear that this east-west trend was superimposed

upon the original north-north-westerly strike of the Basement System and was probably due to a subsequent north-south compression. As the north-south compression developed the rocks failed along the line of the Marun fault. Other faults of similar trend and probably belonging to the same period are those cutting out the quartzites north of Gobut, that which faults out the northern limb of the overturned anticline south of Kokut, the Tangasia fault and the small fault east of Sitama.

The isoclinal folds in the quartzites of Kwaisagat are overturned to the north and it would appear that the main compressive forces acted towards the north.

Gibson (1954, pp. 34-38) described similar east-west trends in the Basement System of the Broderick Falls area and considers them to be due to the superimposition of the post-Kavirondian folding on the original Basement System structures.

Along the line of the Marun fault in the lower Marun valley chlorite, tremolite, and hornblende schists, whose origin is ascribed to retrograde dislocation metamorphism, are found. Similar hornblende schists adjoin the Mwino fault. It is therefore probable that these schists were developed in the same period of deformation, although the age of this deformation is difficult to determine. It may belong to a late stage of the original westerly compression. The present Marun and Mwino faults are considered to represent the effect of later movements along the original lines of weakness. All the above movements are considered to have occurred in the Pre-cambrian.

The Ortum and Sebit faults cut the Marun fault and are considered as younger than it. Related to these by similarity of trend are the Trans-Nzoia, and Wakor faults and the faults south of Gobut. It is possible that all these were developed during the operation of the north-south compressional forces.

The youngest fault of the area is the Chessara fault. In its most recent movement it has formed a fault-scarp the downthrow being to the west, and it appears to have tilted the Kipkomo portion of the West Suk peneplain to the east. Thus it is post-peneplain in age, i.e. possibly Tertiary. As the tilting of the peneplain diverted the Iun's water into the Marun, the Marun was almost certainly graded below the level of the West Suk peneplain east of the Cherangani hills. It was probably graded to the end-Tertiary peneplain and, consequently, the Chessara fault last moved between the formation of the sub-Miocene and the end-Tertiary peneplains.

VI—ECONOMIC GEOLOGY

1. Gold

At the beginning of 1951 alluvial gold was discovered by prospectors in the lower Marun valley. Panning of river and terrace gravels showed that payable values exist chiefly in the Marich Pass and to a lesser extent upstream to Wakor. Non-payable values were found as far west as Twin Bridges. Beyond that point, however, only traces appear to exist and panning frequently gives negative results.

Claims pegged in the Marun valley were largely to the north of the present area in the Marich Pass. Here A. P. S. Bon, Mrs. F. H. Calvert, C. J. and J. J. de Jager began operations in early 1951. Mrs. Calvert's claims were transferred to A. H. Erasmus in 1952 and are still in force. The other claims have since lapsed. C. J. and J. J. de Jager have also registered claims at Wakor. The total production up to March, 1953, recorded in the registers of the Mines and Geological Department is $77\frac{1}{2}$ ozs. of refined gold valued at £1,003. As is usual with alluvial gold, the silver content is low, and the fineness of the gold appears to be about 95.

Owing to the relatively short period that most of the claims were worked little equipment was installed. A sluice-box operated by Mr. A. P. S. Bon and Mrs. McNaughton was recovering half an ounce of gold from approximately three cubic yards of gravel. F. W. A. Timms, Inspector of Mines, Kisumu, took six random samples from the pegged area which all showed gold from a trace to 10 dwt. The gold consisted of coarse, flattened flakes up to a quarter of an inch in length which, in view of their size, could not have been transported far.

The presence of an intrusive granitic mass in the immediate neighbourhood of the gold deposits raises the possibility of a connexion between the two. As already stated the richest gold discoveries have been made in the Marich Pass. Feeding the Marich are the Marun, Iun and Sergoit rivers, which unify into the Marich at the western end of the Pass. Panning

of gravels in the lun valley has only proved occasional traces of gold and it is therefore probable that the Marich deposits are fed by gold coming down the Marun and Sergio only. The changes in gold values of the Marun are invariably at its junction with a major tributary. Thus the end of the known payable deposits occurs at the mouth of the Wakor which rises in the heart of the granitic outcrop, and the termination of possible economic deposits coincides with the confluence of the Sebit, whose upper valley is fed by streams from Sondang. No other tributaries of the Marun flow from the granitic outcrop.

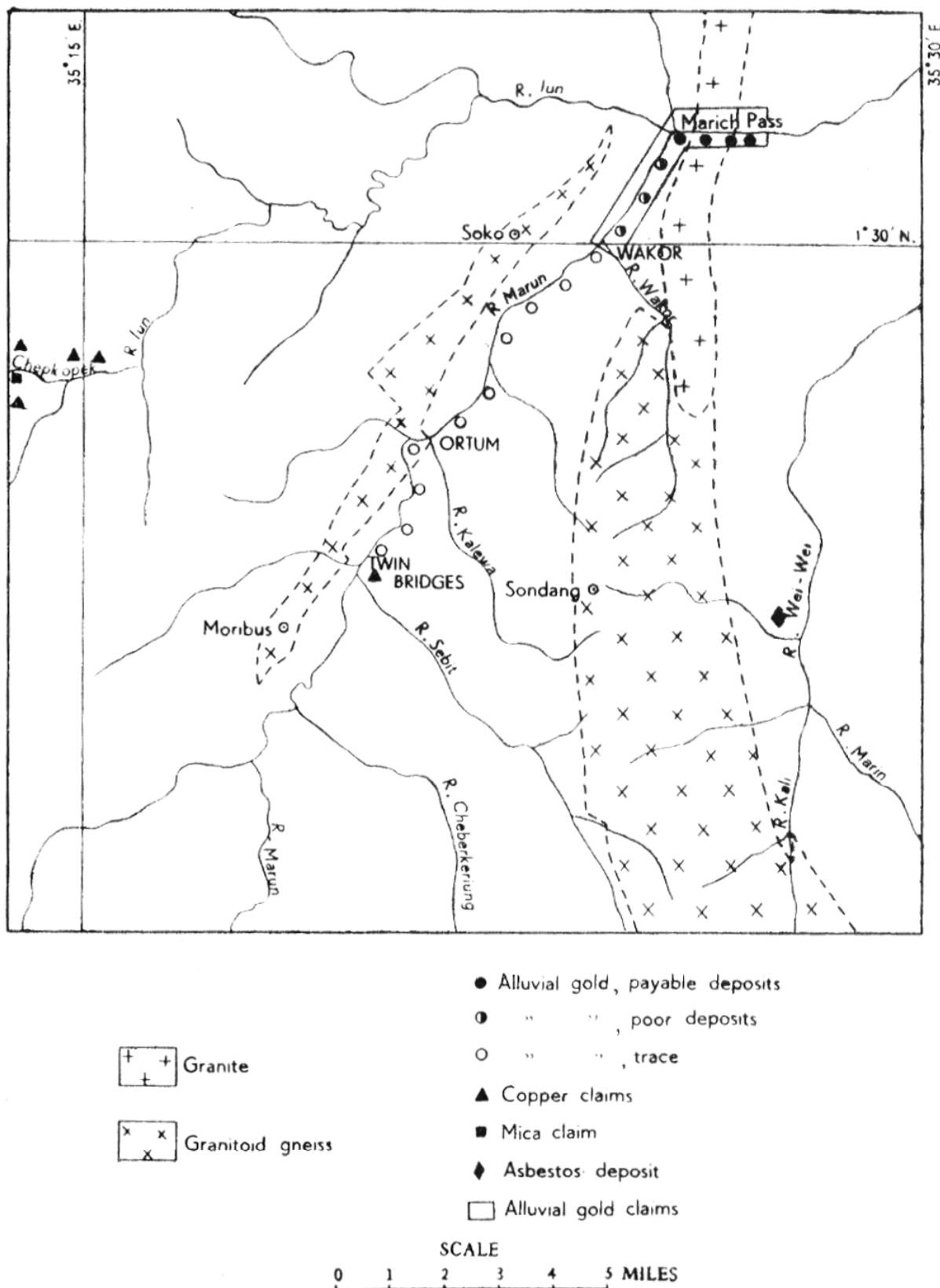


Fig. 4—Mineral deposits of the Marun-Wei-Wei basin.

It would appear that the gold may have its origin in the Sondang granitic intrusion and that future prospecting for gold-bearing quartz veins should be concentrated upon the western slopes of Sondang.

The alluvial gold deposits of Marich seem to have come down the Sergoit, Wakor, Sebit and lower Marun valleys, and extensive panning of these rivers should lead to the discovery of other gold-bearing gravels.

2. Copper

In 1951 G. W. Ulyate discovered malachite-bearing rocks near a native hut in the northern part of the area, where the Africans had been attempting to extract the green mineral as a pigment. He traced the source of the material to malachite and bornite-bearing dioritic rocks in the Kipkomo-Nyambases plain, near the junction of the Lun and Chepkopek rivers. Four mining claims at the locality were pegged and registered by D. K. Williams and Mr. Ulyate in 1952, and small excavations made. An assay of a bulk sample of the copper ore weighing approximately 1 cwt. carried out at the Mines and Geological Department showed it to contain 4.55 per cent copper, a trace of zinc, 0.2 dwt. gold and 6.7 dwt. of silver.

At this point the Frobisher Exploration Co., Ltd., who are developing Kilembe Copper Mine in Uganda, became interested and began negotiating for Exclusive Prospecting Licence No. 101 covering the area east of the Makutano-Kacheliba road and north of a line from Makutano to Sondang, as well as most of the Sekerr massif, north of the present area. The licence was granted for a period of one year with effect from 21st June, 1952 (Government Notice No. 1085 of 7th October, 1952), although the Frobisher Company abandoned its interest on 2nd September, 1952. An application of an exclusive prospecting licence over a generally similar area was made by Messrs. Williamson Diamonds, Ltd., in July, 1953 (*see* Government Notice No. 1226, dated 29th July, 1953).

In April, 1952, Dr. B. N. Temperley, D. L. Searle and the writer investigated the claims together with a further claim at Twin Bridges. The Kipkomo claims were all found to lie within the diorite-like rocks. A report (Mines and Geological Department file M1487/17a) prepared on these claims states "the malachite occurs as a local impregnation of the meta-diorite (at that time the diorite-like charnockites were considered as altered igneous intrusions), this mineral being distributed mainly in concentric and other cracks developed during spheroidal weathering and in three cases out of fifteen in the basic xenoliths (the basic patches or skialiths of the present report) mentioned above. About fifteen localities where impregnation had occurred were seen scattered about on a strip of country 3,000 yards long and 800 yards wide. At each locality about 50 lb. of impregnated rock was found. Associated with the malachite is a little azurite, chalcopryite, etc. No structures in the meta-diorite, except the basic xenoliths, were found to which the malachite occurrences could be related and they appeared to be distributed in a completely haphazard fashion. At occurrences Nos. 4 (1) and 7 to 16 the impregnated rock was *in situ* while at the other localities it was in the form of float boulders which could not have moved very far".

The origin of this deposit was tentatively ascribed to the presence of copper in the original country-rock into which acid magma soaked, the country-rock now being represented by the basic xenoliths. The report concluded "it seems unlikely that any economic concentration of malachite will be found in the diorite itself, but such might occur in any large mass of unaltered basic rock. Up to the present no such mass has been located".

Assays of channel samples taken across the outcrops of malachite-bearing rock showed an average copper content of 0.010 per cent, which is quite uneconomic. Mr. Williams and Mr. Ulyate, however, state that they sank a 10 foot deep pit on their Cheparpar claim, and recovered at least 10 tons of ore which was obviously much richer than the surface material.

At Twin Bridges malachite staining occurs in a band of quartzite exposed in an outcrop about twelve feet long and four feet wide. Near to this outcrop in a contorted aplitic dyke is an irregular vein-like streak of pyrite and chalcopryite about two feet in length. Attempts to trace extensions of the mineralized quartzite proved unsuccessful, and an assay showed its copper content to be only 0.105 per cent.

It is concluded that the copper claims so far registered in West Suk are not likely to yield deposits of economic value and only intensive prospecting over a wider area is likely to disclose more extensive deposits.

3. Mica

On Kaipakwen and Korkuma and near the Kipkomo copper claims, muscovite pegmatites containing large books of mica outcrop. The Kaipakwen occurrence consists of a lenticular sill-like body some twenty feet long and three feet thick emplaced in the quartzites. Individual books yielding sheets of green muscovite ten inches by eight inches occur, but in all cases seen the mica is spotted and cracked and not workable.

Three hundred yards south of Korkuma triangulation beacon on the crest of the ridge a discontinuous pegmatite sill cuts through the quartzites. Pits dug to a depth of five feet show that the northern lenticle lies in the plane of foliation of the country-rock. Its form is a sheet about two feet in thickness exposed on all sides by erosion. The mica is colourless muscovite, spotted and streaked by dendritic growths of iron oxide. Although several uncracked sheets measuring six inches square were picked up on the surface the excavations yielded only three "books" about two inches square.

The southern lenticle dips steeply to the east and an excavation some six feet deep and twenty feet long revealed its thickness as ten feet. In the course of digging this trench two books of the same colourless spotted mica about six inches square and seven inches long were unearthed. As the southern end of the lenticle disappeared under soil cover the pegmatite showed no decrease in width downwards, and it appears to be a fairly large vein. The nature and infrequency of the mica however reduces its value considerably.

The most promising mica deposit of the area occurs in a claim registered by D. K. Williams near his copper claims at the Chepkopek river. Although no excavations have been made, a book of mica fourteen inches by twelve and about two feet long was extracted from a pegmatite dyke outcropping near the *duka* on the Ptoyo road. Two other mica pegmatites, each containing one book six inches square visible on their outcrops, lie close to the west of the main vein. The mica so far recovered is considerably weathered but is of good quality. It belongs to the ruby muscovite type and spotting is very rare, perfectly clear pieces with no cracks measuring two inches square (size 5) occurring in badly weathered specimens. As, however, no development had been carried out on this prospect at the time of examination it is impossible to suggest whether or not the deposits are workable.

As these mica pegmatites are situated in and around the Kipkomo plain it is recommended that further prospecting for this mineral should be done in that area.

4. Asbestos

Three small lenticles of anthophyllite asbestos occur on the eastern slope of Kwokwamarun in Mwino. The asbestos is of the iron-stained woody variety with some talc, individual fibres growing across the vein. At the contact of the vein with surrounding biotite-hornblende gneisses is a narrow zone of dark green actinolite. The deposits are small, none being more than five feet long and a foot wide, and in themselves are of no economic interest. Larger deposits have been reported to exist at the entrance to the Kali valley but were not seen. Unless these are of exceptional quality and extent, transport difficulties would inevitably prove a great hinderance to successful development.

5. Road-Metal

The only rocks in the Cherangani area suitable for roadstone are the "diorites" of Kipkomo and certain quartzites around Twin Bridges. The "diorite" should prove as durable as dolerite and have about the same crushing strength. It is undoubtedly superior to the quartzites found between Sebit and Twin Bridges, but quartzites are used extensively in other parts of the world for road-metal, and, in the present area, have the advantage of lying on the only possible route through the Cherangani-Sekerr range.

6. Marble

The two marble beds which outcrop on the Marich road between the Marun river and Sebit village were chip-sampled across the strike and analysed with the following result:—

		CaO	MgO
		%	%
Western bed		35.80	16.65
Eastern bed		45.78	4.68

Anal: W. P. Horne.

British Standard Portland Cement specifications allow a maximum of 4 per cent magnesia so that a limestone to be used for cement manufacture should not contain more than 2 per cent magnesia. Consequently these marbles would not be suitable for the manufacture of cement. However, impurities such as diopside and other calc-silicates impart a pleasing colour to certain bands, which could be used as an ornamental stone.

7. Building Materials

The granite of Sondang is the only building stone noted in the Cherangani hills, but as it outcrops only in the mountainous parts of the district it is too inaccessible to permit the establishment of quarries. It is not a stone that would be favoured by African masons.

Inferior stones such as the flaggy hornblende gneisses and quartzites around Nasokol have been used as foundation courses for the mission church and shops. The durability of the hornblende-rich gneisses is questionable.

Sand is obtainable in large quantities from the Koptawelil alluvial flats where the Kitale Tile Works produces sand-cement tiles by mixing it with cement. To obtain pure sand the alluvium is washed in trenches which are filled naturally by water seepage.

8. Water-Supply

In such a region, where the majority of streams are permanent, water-supply presents few problems. The rivers of the north-western part of the area are only seasonal and the Suk dig water-holes in the dry season, but even here water is to be found throughout the year at a depth of three feet in most river-beds. To increase the available water in the Kipkomo and West Suk plains concrete weirs could be built, using the numerous pegmatite dykes for foundations.

9. Hydro-electricity

The Cherangani hills, unlike most mountain ranges in Kenya are entirely formed of Basement System gneisses. Consequently, water impounded in its valleys by dams is far less liable to be lost by seepage than in the volcanic highlands such as the Mau and the Aberdares. Although several major valleys such as those of the Mwino and the lower Marun could not be used as reservoirs because of major faults lying along their floors, most of the valleys of the central and southern Cherangani hills do not suffer from this disadvantage. The Moiben, Tangasia, and Cheberkeriung river-beds are steeply graded with narrow valleys, and dams constructed across them would only impound small lakes.

Perhaps the most suitable place for a hydro-electric barrage would be across the Marun at its junction with tributaries from Kailelakelak and Kapsait, some three miles east of Kapsait hill. All these rivers are perennial and are in an area that receives over fifty inches of rainfall annually. Pipes led from the reservoir along the hillside would allow the water to be dropped several hundreds of feet further down the Marun valley. Another suitable site is at Kapkoo in the Arror valley where the width of the valley is reduced from three hundred to fifty yards and the natural barrier would allow the impounded water to fall over a 300-ft. cliff on the southern side of the feature.

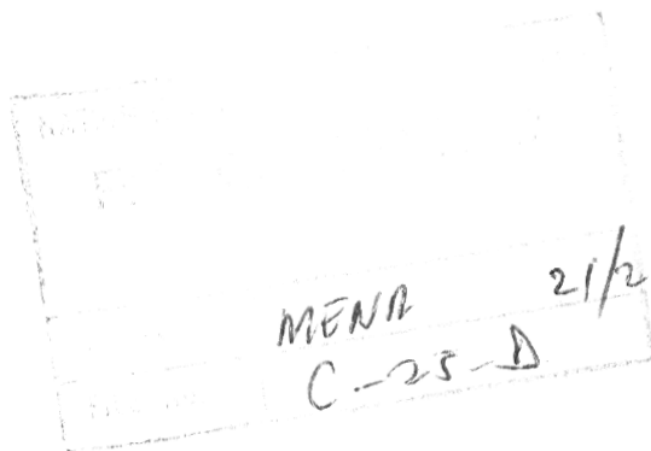
One large waterfall was observed plunging several thousand feet from Sondang into Mwino at the height of the dry season. The energy of water falling from such a height should be sufficient to operate a medium-sized generating station.

A survey by competent engineers would doubtless reveal many other excellent sites for hydro-electric power stations.

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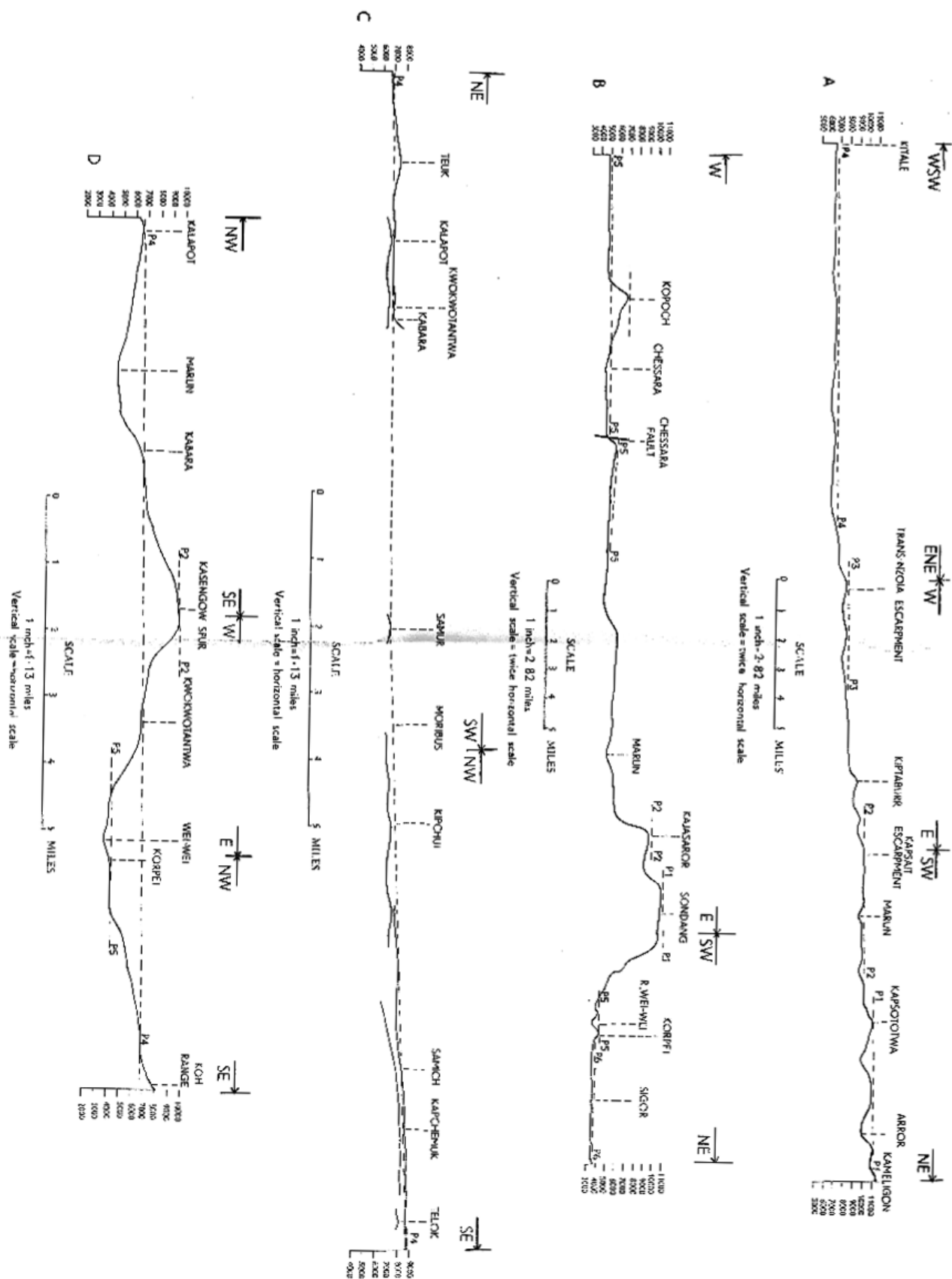


Fig. 5.—Sections to show the penneplains of the Kitale-Cherangani hills area.
 P6.—End-Tertiary penneplain (3,500-ft.).
 P5.—Sub-Miocene penneplain—West Suk lowlands (4,300-ft.).
 P4.—Kitale plain (6,500-ft.).
 P3.—Cretaceous (?) penneplain (7,600-ft.).
 P2.—Lelon plateau (9,600-ft.).
 P1.—Cherangani plateau (10,800-ft.).
 Section C shows the relationship of the Marun basin interflows to the Kwokwotintwa Bench.

DEGREE SHEET No. 26, SOUTH-WEST QUARTER

