REPORT No. 41

COLONY AND PROTECTORATE OF KENYA

GEOLOGICAL SURVEY OF KENYA

GEOLOGY
OF THE
KALOSSIA-TIATI AREA

DEGREE SHEET 26, N.E. and S.E. QUARTERS
(with two coloured geological maps)

by

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FOREWORD

The report on the Kalossia-Tiati area is the second produced by the Geological Survey of Kenya dealing with the country east and north-east of Kitale. It extends further east mapping carried out by J. M. Miller between Kitale and the eastern side of the Cherangani hills, as described in report No. 35, published in 1956. The field work, preparation of maps, petrographical examination and the compilation of the first part of the report were carried out by Mr. Gibson and Mr. Mason in co-operation, but at a later stage, owing to Emergency conditions, the work had to be divided. Mr. Gibson completed the script of the report, which was later submitted to Mr. Mason to give him an opportunity of making corrections or amendments. Mr. Gibson prepared the original drawings for text-figures 1 to 3 and 6, but the drawings for text-figures 4 and 5 were made by Mr. Mason.

Mr. Gibson left the Kenya service before the report could be edited and brought to a final stage and, owing to secondment to full-time Police duties, Mr. Mason was able to devote little time to revision and re-drafting. During the examination of the maps and consideration of the chapter on erosion surfaces it became obvious that there is more evidence of surfaces of planation in the area than had at first been obvious to the authors. The chapter has accordingly been modified and brought more into line with the evidence found by Mr. Miller in the Cherangani hills, where the existence of an unusually extended flight of peneplains can be demonstrated.

The survey of the area unfortunately produced little evidence of the presence of valuable minerals. For some time prospectors had believed that there was evidence of the occurrence of diamonds, but the survey has produced no facts to support that view.

The area lies on the western edge of the Kenya Rift Valley at a point where the graben is beginning to lose its identity. It has been possible, however, to demonstrate the continuation of one of the outer faults by the presence of hot springs and lines of silicification and brecciation. The authors believe that the western wall of the true Rift Valley passes across the south-east corner of the area, and that the Elgeyo fault and its continuations are spur faults.

Nairobi,
24th December, 1954.

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MAPS

Geological map of the Kalossia area (degree sheet 26, N.E. quarter) Scale 1:125,000	At end
Geological map of the Tiati area (degree sheet 26, S.E. quarter) Scale 1:125,000	At end

ABSTRACT

The report describes an area in western Kenya of about 2,400 square miles extent, bounded by parallels 1° 00′ N. and 2° 00′ N. and by longitudes 35° 30′ E. and 36° 00′ E. The area lies on the flank of the Great Rift Valley and its main physiographic units are, (*a*) the Elgeyo escarpment and the highlands to the west of it, (*b*) the lowland area west of the line Kailongol-Masol-Twoi-Chepkum, (*c*) the lowland area east of the same line, and (*d*) the highland masses lying within the plains. An account is given of their characteristics, climate, communications and inhabitants.

The rocks exposed in the area include (1) hornblende-biotite gneisses, biotite gneisses calcareous, semi-calcareous, and meta-intrusive rocks of the Basement System, (2) Tertiary volcanic rocks, (3) Tertiary sedimentary rocks, and (4) Pleistocene and Recent sediments and gravels.

A description of the various rock types is given and their structures and relative ages discussed.

GEOLOGY OF THE KALOSSIA-TIATI AREA

I—INTRODUCTION

The Kalossia-Tiati area as defined for this report comprises the north-east and south-east quarters of degree sheet 26 (Kenya), bounded by latitudes 1° N. and 2° N. and by longitudes 35° 30′ E. and 36° E., and is some 2,400 square miles in extent. It includes parts of West Suk, Turkana, Baringo and Elgeyo administrative districts.

The area was surveyed in quick reconnaissance style in a period of about four and a half months between April and October, 1952, as part of the programme for the primary mapping of the Colony. Particular attention was paid to the search for deposits of economic value, but the area apparently holds little promise of development in this direction. For the purposes of description the area is treated as a whole, but the geological map has been divided for printing into two sections, one of each quarter-degree area.

Nature of the Country.—The area may be divided into four main units with different physiographic characteristics as follows (Fig. 1):—

(1) The parts of Elgeyo-Marakwet and West Suk west of the foot of the Elgeyo escarpment.

(2) The plains west of the line of the Kailongol-Masol range.

(3) The plains east of the Kailongol-Masol range and, further south, east of the Kerio river.

(4) Isolated highland masses rising to elevations of over 4,000 feet from the plains and not connected with the Elgeyo escarpment.

Of these, the first is the most densely inhabited, the main concentrations of population being on the slopes of the Elgeyo escarpment and in the area between Kapsowar and Chesoi. Large tracts of this latter upland area have been deforested in the past and are now under cultivation, the fields being situated on steeply sloping valley sides. The standard of terracing is high and no serious cases of soil erosion were noted, in spite of the difficult conditions under which cultivation is carried on. In the higher regions west of the escarpment the rainfall is well distributed and adequate for crops, but on the slopes of the escarpment itself the rainfall is less reliable and the fields have to be irrigated. The Suk and Marakwet tribesmen have, in the course of time, evolved an efficient system of irrigation and water is conveyed for long distances along the side of the escarpment in contour furrows. The Embomon river provides a good example of the efficient use which is made of the available water for irrigation purposes. At Chesoi this river has an appreciable flow even during the drier seasons, but the whole of its water is lead off at various points on the slopes of the escarpment to cultivated plots so that, except during heavy rains, the Embomon river is normally dry at the point where it crosses the Tot-Chepkum road before joining the Kerio river.

Large herds of sheep, goats and cattle are maintained and are periodically driven down the escarpment to "salt licks" and to the Kerio river for water.

West of a line from Kapsowar to the edge of the escarpment about five miles south of Tot the hills are clothed with dense virgin forest, bamboo appearing at about 8,500 feet and covering large areas.

The second unit consists of a featureless arid plain covered with "wait-a-bit" thorn-bush, which is dense in parts and attains heights of from eight to ten feet. River-courses are lined with somewhat taller trees, usually of the *Acacia* variety. There are two comparatively open areas of grassland, one coincident with the area of black "cotton" soil depicted on the map north-east of Lomut, and the other lying north of the Loiya river and south of Lokirrok. The inhabitants of this plain are nomadic Suk and Turkana tribesmen, who maintain large herds of livestock and move from water-hole to water-hole during the

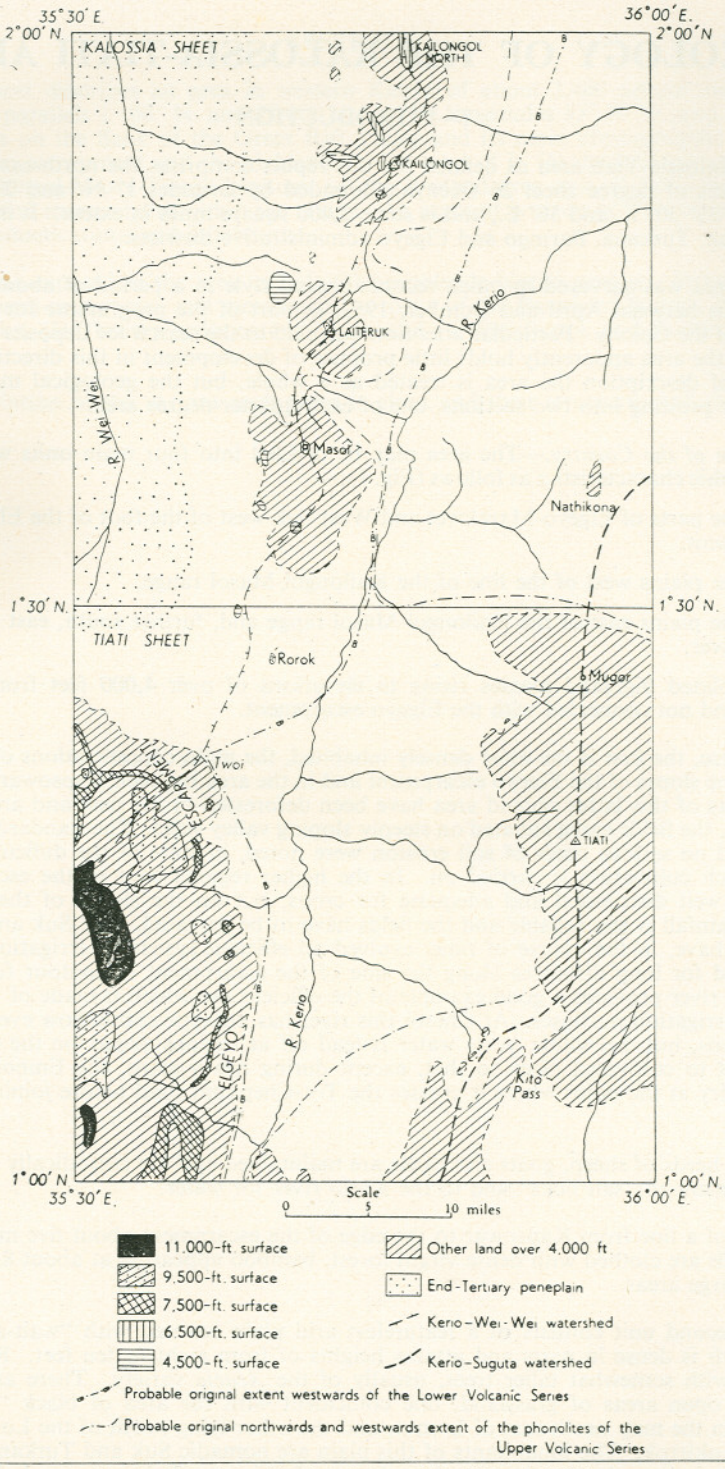


Fig. 1.—Physiographic sketch map of the Kalossia-Tiati area.

dry seasons. Their diet consists essentially of milk and blood, the latter being obtained from the cattle by blood-letting from the jugular vein, without actually killing the animals concerned. Meat is but rarely eaten and cultivation is non-existent, with the exception of a small area on the track near Lokwamur.

The third part of the area is much more dissected, and is comparatively uninhabited. Water is very scarce, there being few reliable water-holes, and the thorn-bush over large areas is impenetrable without cutting tracks. Nomadic tribesmen visit this part of the area with their herds of goats and cattle, and further north herds of camels are a common sight, being kept for milking and not for use as beasts of burden. Game of the smaller varieties is abundant, elephant and rhinoceros are to be found in the Kerio and Wei Wei valleys, and buffalo are present on the higher ground to the east.

The fourth unit comprises the hill masses of Kailongol, Laiteruk, Masol, and the Mugor-Tiati range. These hills are clothed with dense thorn-bush and are uninhabited apart from a few small settlements on Masol and Tiati, the latter, it is thought, being the homes of survivors of a former agricultural section of the Suk tribe who sought refuge from raiding Masai in the heights of Tiati many years ago.

Rock Exposures.—The rocks of the area are in the main poorly exposed. In the plains west of the Kailongol-Masol range outcrops are very rare, as there is a thick sand and gravel cover on the surface of the plains. In the volcanic areas float is often abundant, and is unreliable for mapping purposes, consisting usually of a mixture of quartz, grits, lavas, and material derived from the breakdown of rocks of the Basement System. Unweathered solid outcrops are rare. There are some fairly good outcrops on the hill areas of Kailongol, Laiteruk, Masol and Tiati, but examination is difficult owing to the density of the bush cover. Outcrops of Basement System rocks are almost continuous along the foot of the Elgeyo escarpment, but there is evidence to suggest that many of them are large slipped masses. In the highlands west of the escarpment outcrops are exceedingly rare, and in the forested areas non-existent, there being an over all humus-rich thick soil cover. River sections on the whole are disappointing as, although in places down-cutting has reached a depth of up to 40 feet, no solid outcrop has yet been exposed, such is the thickness of the alluvial cover.

Climate.—Due to the uninhabited nature of much of the country little information is available concerning the climate. Station 1, in the Table that follows, lies on the Wei-Wei river near Sigor and is the only station actually situated within the area under consideration for which any details of rainfall are available. The figures given for the other stations may, however, be taken as typical of certain localities within the Kalossia-Tiati area that have comparable relief and are similarly situated with respect to the Elgeyo escarpment. For example the figures for Stations 2 and 5, lying 25 miles west and on the south-west border of the present area respectively, may be taken as typical of the rainfall conditions in the highland area west of the Elgeyo escarpment, the high precipitation being due to the great elevation of the hills above the general level of the plains, across which the easterly winds have a comparatively uninterrupted passage.

The figures for Station 3, lying 35 miles south of the present area, may be regarded as typical of the hill masses, such as the Kailongol-Masol and Mugor-Tiati ranges, which stand in the plains. These hill masses form minor obstacles in the path of the prevalent north-easterly winds as they cross the plains and so have a somewhat higher precipitation rate. Station 4, situated at 6,000 feet on the side of the Elgeyo escarpment, some 30 miles to the south of Chepkum, may be regarded as having a rainfall typical of the Elgeyo escarpment, the main barrier lying athwart the rain-bearing winds. Station 6, lying in the plains near the south-eastern corner of the area, has a much lower rainfall comparable with that found throughout the plain areas. Rain falls on the plains mainly as isolated heavy storms of short duration, and often as many as five or six individual storms of small diameter are visible at the same time crossing the plains. Rain along the escarpment and in the hills above is, in contrast, prolonged and often falls for many hours without cessation.

RAINFALL STATISTICS, KALOSSIA-TIATI AREA

(From the summaries of the East African Meteorological Department)

Station	Altitude in feet	Total rainfall in inches, 1950	No. of rainy days 1950	Total rainfall in inches, 1951*	No. of rainy days 1951	Total rainfall in inches, 1952	No. of rainy days 1952	Annual average in inches	Years recorded
1. Chemarel (Wei-Wei) ..	4,000	n.r.	n.r.	50·30	99	—	—	—	—
2. Kapenguria (District Office)	7,000	34·00	79	55·09	152	42·24	109	47·16	21
3. Kabarnet (District Office)	6,700	4·98	90	73·05	141	45·44	108	52·35	36
4. Tambach (District Office)	6,000	35·16	105	65·01	148	39·67	113	45·36	26
5. Marakwet A.I.M. (Kapsowar) ..	7,500	39·00	105	64·37	120	50·52	106	48·61	18
6. Nginyang (Kiyang) A.I.M.	3,000	19·04	76	28·68	112	20·12	85	24·61	10

n.r. not recorded.

*The rainfall during 1951 was abnormally high, and the figures for 1950 and 1952 represent more normal conditions.

The months of November, December, January and February are comparatively dry. Rainfall commences in March, reaching a maximum in July or October depending on the locality, and continues for the remaining months of the year, June however being usually fairly dry in the plains. During the rainy months the early mornings are clear and cloud-free, but before noon, land over 8,000 feet is obscured and rain begins in the early afternoon, sweeping across the plains, and continuing into the late evening.

The temperatures in the western hills above the Elgeyo escarpment are pleasant during the day, but it is cold and damp at night. In the low-lying areas the temperatures are high from 8.00 a.m. onwards until 5.00 p.m., and the nights are warm. Champion (1937, p. 111)*, speaking of conditions in the plains, says: "They are swept by a hot persistent and sand-laden wind that renders travel and even existence an almost intolerable burden".

Communications and Settlement.—The area is poorly served by motorable tracks, many of those indicated on the map being only traversable with difficulty.

There are three main routes of access to the area. The best is from Eldoret, via Tambach, descending the Elgeyo escarpment, and thence north along the foot of the escarpment to Chepkum. Alternative entry is from Kitale, via Kapenguria, by descending the Marich Pass to Sigor and the Wei-Wei river. The road through the lower part of the Marich Pass is rough and rocky. Entry to the area by either of these routes is liable to be impossible during the rains, when the Arror river south of Chepkum and the Wei-Wei river may be impassable to vehicles. The third route lies via Nakuru north to Nginyang and was not used during the present survey. The road from Nginyang westwards over the Kito Pass is rough and hilly and impassable to heavy vehicles. On this route the Kerio river is crossed by a modern suspension bridge, built shortly after the Kolloa Affray.

Within the area the Sigor-Chepkum road is fairly well maintained, but is subject to washaways at the many drifts in wet weather. The Sigor-Lotongot road and the Lotongot-Kalossia-Amaler road to the south end of Masol are bad, with numerous deep drifts and rock escarpments. Little maintenance is possible on these roads due to the scarcity of labour.

The Turkana roads north of Lotongot and Kula are passable as far as traversed during the present survey. The Amaler-Kerio river-Kolloa road and the Kolloa-Kabarnet road are poor and rapidly becoming overgrown, and are likely to become impassable within the next year or so unless much work is done on them.

*References are quoted on page 33.

A new road is being built north from Kapsowar to Chesoi, sections of which are complete, but a bridge has yet to be built over the Arror river a short distance north of Kapsowar. North of Chesoi a foot-track continues to the area of Tot. For a large part of the way this track passes through dense forest and is wet and slippery and not usable by laden donkeys. This was the only track in the forest found during the survey, east-west ones being non-existent.

There are small African shops at Lomut, Tot, Chesagon, Lotongot, Amaler, Chesoi, and in the bush four miles north-east of the Kito Pass. Their stocks are usually insufficient for European needs. There are Tribal Police Posts at Lotongot, Amaler, Chesagon, and Tot, and good District Commissioner's rest-houses in the Elgeyo-Marakwet District at Chesoi, Chepkum, three miles south of Tot, Tot, and Cheblil.

Kalossia is an abandoned Government Station, little of which remains apart from indications of a few tracks edged with stones and now overgrown by thorn-bush.

Maps.—Maps of the area available during the survey were the 1:500,000 Kitale sheet, E.A.F. No. 1687 (4th Ed., 1945), and the G.S.G.S. map, No. 1764 North A–36/R (1914). The latter, surveyed in 1912, proved to be very inaccurate in parts. The former is a map produced by the army during the 1939–1945 war and largely based on earlier army maps, the main difference being a revision of the contouring of the Kailongol-Masol range and the addition of more locality names. The area is partly covered by aerial photographs flown during the early months of 1952.

For the survey the positions of Kailongol T.S.* and Tiati, as shown on the map E.A.F. No. 1687, were assumed to be correct, and the position of Koh was taken as that determined by Miller (1956) during his survey of the adjacent Cherangani hills. From these three basic points the map was built up, the position of the flight runs of aerial photographs being fixed as accurately as possible. Intervening areas were covered by plane-table survey and by cyclometer and compass traverses, the positions of points being fixed where possible by resection with reference to points previously determined. Surveying on the plain areas was difficult as, owing to the height and thickness of the bush, it was not possible to see more than a few yards in any direction on many occasions.

The positions of the hills in the Endo-Kipchemwa area were taken from a survey of the West Suk Forest Reserve carried out by the Forest Department.

The form-lines drawn on the geological map serve only to show the general shape of the ground and must not be regarded as surveyed levels. Many spots heights, determined during the survey by aneroid barometer and corrected for diurnal variation, are included in the map.

Locality names were taken from the Kitale map purely to aid description in the report. The majority of them are neither known nor understood by the inhabitants of the area. A few native names in current usage have been added, but these have a very restricted use, and it was frequently found that every person asked had a different name for the same feature.

The mapping of the geology was done directly on aerial photographs in the parts covered by them, and afterwards transferred to field-sheets by reduction. Elsewhere the geology was plotted on the field-sheets from information gained on the compass, cyclometer and plane-table traverses as they were carried out. The complete field-sheets were replotted at the conclusion of the survey when all the information collected and a multitude of bearings were available and could be plotted at the same time, instead of day by day, thus it is hoped averaging out many errors.

II—PREVIOUS GEOLOGICAL WORK

No large-scale geological work has been carried out in the area in the past. Several geologists have, however, made short visits to it or to the adjacent areas and have recorded comments on the features that they saw, often from a distance.

*T.S.=Trigonometrical Station.

Walcot Gibson (1893, p. 563)* visited localities south of the present area, and formed the opinion that the plateaux of Mau, Kamasia, and Laikipia were formed of lavas, tuffs and ashes which had issued from a north-south fissure, the site of which is now occupied by the Naivasha-Baringo chain of lakes.

According to Champion (1937, p. 97) Count Teleki and Admiral Von Höhnel were the first white men to set foot in Turkana, discovering Lake Rudolph in 1895. In 1902 Walker (1903) visited the Kamasia range and found it to be almost entirely composed of lava of a constant composition. He noted that the western side is a sloping plain, and that seen from Elgeyo it has the appearance of a great dissected plateau, as if it were formerly continuous with the Elgeyo plain, but had been dropped down at the line of the great Elgeyo scarp. He observed that the Nde (Kerio) valley is alluvium-filled, and that the Elgeyo scarp has at its base gneissic rocks, with an irregular capping of porphyritic phonolite. Patches of phonolite were also found below the level of the gneiss, suggesting that the lava poured out over a very uneven surface.

Gregory was another early visitor to the country south of the area mapped and noted (1921, p. 215) that the main western fault of the Rift Valley in Kenya bifurcates north of Nakuru, the plateau of Kamasia standing between the two branches, and separated from the main western plateau of Elgeyo by the deep trench of the Kerio valley.

Glenday and Parkinson (1926, p. 596) noted a low hill, which they called Kodukor (Rorok), south of Masol, composed of a fine-grained pinkish-white felspathic sandstone, and that Masol consists of hornblende and mica schists striking 10° north of east and with dips of greater than 45°, the strike being constant to the area around Kalossia. Flat-topped lava hills south-east of Masol were observed, and volcanic ash capped by lava south of Kalossia. Murray Hughes (1933) noted the occurrence of Turkana Grits in the area.

Willis (1936) made several references to the present area, and discussed the origin of the Kerio valley (op. cit., pp. 144 and 284–5) which he considered to be a canyon of erosion formed along a fault or zone of faulting. He could find no evidence of faulting associated with the Elgeyo scarp and suggested that it is an erosion precipice. He noted that the Gregory Rift Valley does not extend far to the north beyond Lake Baringo.

Champion (1937), during his tour as an Administrative Officer in Turkana, made many observations on the geology of the area. He attributed the first record of Turkana Grits to H. L. Sikes (op. cit., p. 111) and also noted that the Laiteruk-Kailongol range is composed of schists and gneisses. He described the Loriyu Plateau (now usually regarded as the plateau at the south-west end of Lake Rudolf), as "a basaltic sheet stretching from Gautoro southwards some 100 miles to Tiati, where it appears to connect with similar flat-topped lava hills in the neighbourhood of Baringo". He noted that it had a width of 15 to 25 miles and suggested that it was a stream of lava that had followed a river valley, the sides of which have now been removed by erosion, leaving the harder lavas standing up as a tableland.

Campbell Smith (1938) gave a petrographic description of volcanic rocks from Turkana which were collected by Champion, with notes on their field occurrence. Fuchs (1939, p. 223) considered that the Kerio was probably initiated in the Miocene, and its course modified by Pliocene movements. He noted that it is cutting through basalts, which may at one time have ponded back its waters. He observed (op. cit., p. 225) that the plains west of Kailongol, Laiteruk and Masol are composed of rocks of the Basement System, that there are inliers of the same rocks in the Kerio valley, and that Masol and Kailongol are composed entirely of Basement gneisses (op. cit., p. 243). He considered that the Turkana Grits of Turkana are a product of erosion of the Uganda escarpment (op. cit., p. 228).

Dixey (1948) has discussed the geology and erosion surfaces of Turkana, including the northern part of the area at present under consideration. Ellerbeck in 1952 reported traces of glacial action in the Cherangani hills, but his conclusions were refuted by Miller (1956, p. 9).

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*References are quoted on p. 33.

III—PHYSIOGRAPHY

1. Topography

The main topographic divisions of the area are as follows:—

(*a*) The Elgeyo escarpment and the highlands to the west of it, namely the eastern part of the Cherangani hills.

(*b*) The lowland area west of the Kerio-Wei-Wei divide.

(*c*) The lowland area east of the Kerio-Wei-Wei divide and the Elgeyo escarpment.

(*d*) The isolated highland masses surrounded by the plains.

The Elgeyo escarpment, flanking the Rift Valley, rises abruptly from the lowland area to a height of about 7,500 feet, the slope thereafter becoming less steep towards the west but attaining elevations of over 11,000 feet in parts. From Chepkum to Tot the trend of the escarpment is somewhat east of north. North of Tot it decreases gradually in elevation, swings to due north-south, and then, north of Chesagon, turns to a north-westerly direction as far as Sigor. The section of the escarpment north of Chesagon is more highly dissected and does not rise so abruptly from the plains as compared with the section further south. The flanks of the Cherangani hills are deeply dissected and consist of sharp ridges lying between acute V-shaped valleys.

The western lowlands are a sandy plain overlying rocks of the Basement System, and having a few isolated residual hills of Basement rocks and Turkana Grits. In the north the plain slopes gently at a rate of about 48 feet per mile from a height of 3,400 feet at the foot of the Kailongol-Masol range down to the Wei-Wei river, which lies at an altitude of less than 2,800 feet in the north-west of the area. In the central section north-east of Lomut the plain is flat with an elevation of about 3,250 feet, and is covered with black cotton soil.

The eastern lowland area is mainly covered with dissected lavas and pyroclastic rocks, with several large inliers of rocks of the Basement System. The northern portion of this plain, lying to the east of the Kailongol-Masol range and varying in elevation between 4,000 feet and 2,200 feet, is much more highly dissected than the southern section, and has abundant mesas and lava-covered Basement System residual hills.

From the plains rise the large hill masses of Kailongol (6,780 feet), Laiteruk (6,470 feet), and Masol (5,300 feet), consisting of rocks of the Basement System, and the Kite Pass (4,340 feet)-Mugor-Tiati (7,713 feet) range, consisting in the main of stratified volcanic rocks.

2. Drainage

The area as a whole forms part of the Lake Rudolf basin, the drainage pattern being related to three main rivers, namely the Wei-Wei, Kerio and Suguta rivers.

The Wei-Wei river, fed by several tributaries rising in the Cherangani hills and Suk highlands, has a permanent flow up to a point north-west of the area under review, but from that point to Lake Rudolf it is impersistant. The river lies in a broad, crocodile-infested, marshy belt and flows in many channels between low grass-covered islands. Of the right bank tributaries the Siga river is perennial up to a point two or three miles north-of the Sigor-Lomut road, the remainder being impersistant sand rivers, which frequently attain widths of nearly 100 yards, and have flat beds strewn with sand and boulders. The Lotongot river is one of the larger examples, being about 60 yards wide at Lotongot village. Six miles upstream in the Masol foothills it has shrunk to a width of a few feet. The rate of rise of water and the volume carried by these rivers is phenomenal. About half an hour after a storm on the Masol hills the Lotongot river commences to flow at Lotongot, and within a few minutes rapidly-flowing water fills the whole width of the river-bed to a depth of two feet. The flow ceases several hours later but the sand of the bed remains quick for some time in places and difficulty may be experienced with vehicles at the road-crossing.

The watershed between the Wei-Wei and the Kerio is well-defined where formed by the Kailongol-Masol range (Fig. 1) but from Rurol south-westwards it is ill-defined and low-lying as far as the Lomut area, after which it passes into the Cherangani hills in the Chemnirot area. The drainage of the low area north-east of Lomut is poorly defined and the presence of black cotton soil suggests stagnant drainage conditions. It is tentatively suggested that at the time of the Tertiary volcanic activity the course of the Kerio river may have become blocked by lava flows and ashes, resulting in the formation of a lake in the southern part of the area. The waters of this lake may have had an outlet into the Wei-Wei river over the low-lying area north-east of Lomut and, with the eventual opening of the present channel of the Kerio river, this area would revert to marsh and finally become filled in with alluvial outwash from the escarpment.

The Kerio river is perennial up to the area east of Rorok, after which it is impersistant, becoming dry in January and February. Most of its tributaries rising in the Cherangani hills are perennial, but their waters, with the exception of the Arror, Embobit, and Katupe rivers, seldom reach the Lomut-Chepkum road, being diverted and used for irrigation purposes on the slopes of the escarpment. The remainder of the tributaries of the Kerio river are impersistant sand rivers.

The Kerio-Suguta watershed follows the line Kito Pass-Tiati-Mugor. East of this line the sand rivers drain into the Suguta river which is of an impersistant nature and saline.

Aerial photographs have revealed the presence of old incised meanders and ox-bow lakes along the course of the Kerio (Fig. 2). This river, in common with others in the plains is now down-cutting and has therefore been rejuvenated. In places the rivers have banks more than 50 feet in height, and over the area as a whole, sheet and gully erosion is proceeding at a rapid rate. On rocks of the Basement System the drainage pattern is characteristically highly trellised many of the subsequent streams being controlled by the strike of the rock (Fig. 3), whereas in volcanic terrain the pattern is more linear and much less complex. In the Kalossia area erosion of the stratified volcanic rocks has resulted in the formation of typical "bad lands" topography with deep gullies and tall pinnacles.

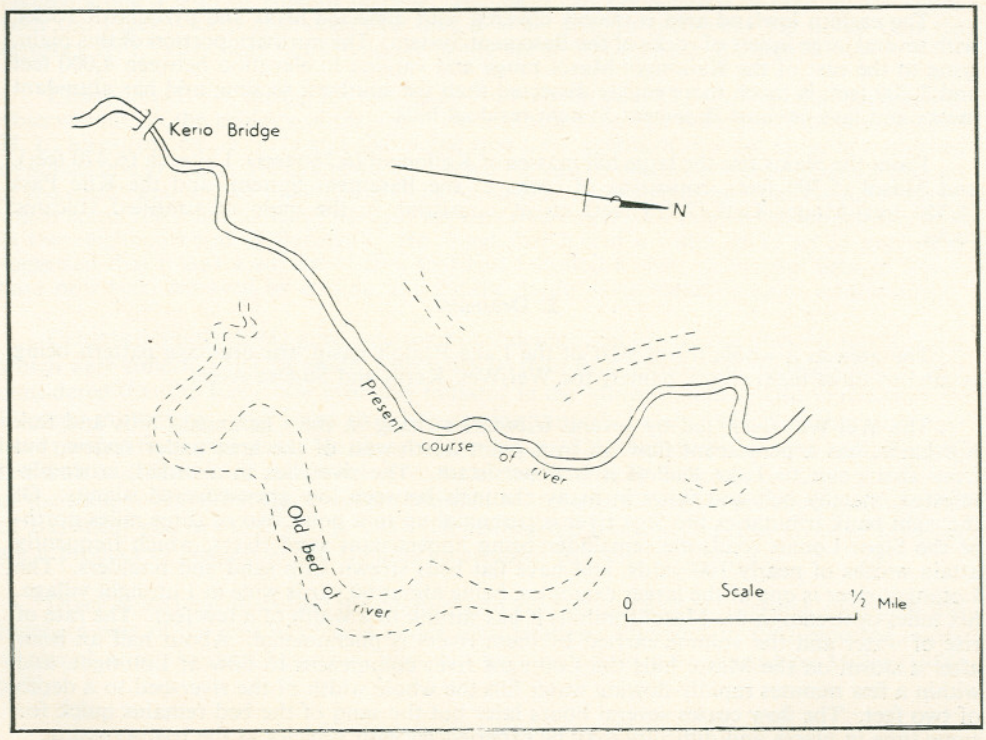


Fig. 2.—Meander belt of the Kerio river east of Tot. From aerial photograph 82D/368/I/5011, Kenya Colony.

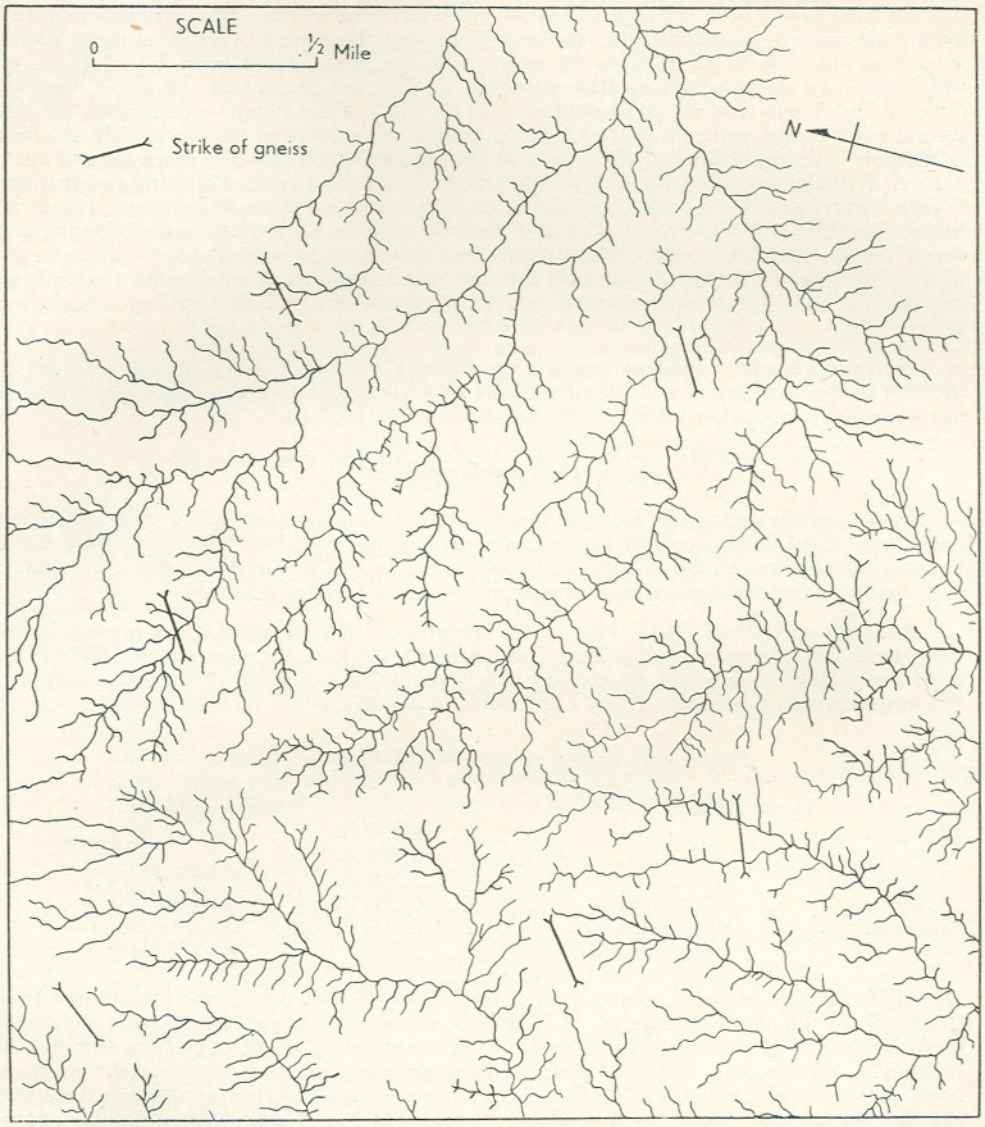


Fig. 3.—Drainage pattern on gneisses of the Basement System at Kaukia. From aerial photographs 82D/452/I/5033, Kenya Colony.

The fact that the rivers are now in the process of re-excavating their beds suggests either uplift of the area, or subsidence of the Rudolf basin further to the north. Since the downcutting is most marked in the north-east of the area the latter seems more probable, the drainage being in the process of readjusting itself to a lower grade by head-ward erosion. Dixey (1946, p. 359) attributes the depression in which Lake Rudolf lies to Miocene erosion and later gentle warping, evidence for the latter lying in the fact that the present surface of the lake lies some 500 feet below the level of the Middle Pleistocene outlet into the Nile system to the north. The rejuvenation of the rivers of the area under consideration is undoubtedly related to these changes in level of Lake Rudolf.

Willis (1936, pp. 284–6), in considering the formation of the Kerio canyon, stated that the western divide of the Kerio river coincides with the crest of the Elgeyo escarpment, that no river ever flowed through this crest, and that there was no lateral tributary of any magnitude coming from that side. In the present area there are in fact three large lateral tributaries entering the Kerio from the west, the Arror, Katupe and Embobit rivers, all of which have cut deep valleys into the escarpment, with the result that the actual western divide of the Kerio river is not coincident with the crest of the Elgeyo escarpment, but lies several miles to the west of it in the Cherangani hills. The valley of the Kerio only assumes a "canyon"-like appearance south of the present area, in which it is of a more normal open nature. Willis suggests that the canyon is a valley adjusted to a zone of faulting and that the Elgeyo escarpment is a simple precipice of erosion, there being no evidence of a fault at its foot (loc. cit., p. 144). From evidence of faulting near the Kerio river east of Chepkum it seems certain that the course of the river there is related to a fault-zone, which in all probability extends further to the south into the canyon proper. Further evidence tends to suggest that the Elgeyo escarpment is not an erosional feature but it in fact a fault-line scarp.

North of Chepkum the river appears to occupy a position between the outwash fan at the foot of the escarpment and the edge of the westerly tilted volcanics, a position which is not necessarily or demonstrably related to any zone of faulting.

3. Peneplanation

In view of the lack of an accurate topographic map of the area and of information on the correct summit levels of the various features it is not possible to do more than make tentative suggestions on the subject of erosion surfaces. Further complications arise due to faulting on a large scale at various times from the early Tertiary onwards.

According to Dixey (1948, Fig. 2) the remains of three peneplains are present in the area under consideration and judging from Miller's work in the Cherangani hills (1956, p. 5) one would assume that six erosion bevels should be traceable in the area mapped. For convenience of reference Dixey's and Miller's peneplains are tabulated below:—

PENEPLAINS IN THE AREAS NORTH-EAST OF KITALE

Dixey (1948)		Miller (1956)	
10,000 ft.		10,800 ft.	
		9,600 ft.	
7,200–7,500 ft.	end-Jurassic (?)*	7,600 ft.	Cretaceous (?)
6,200 ft.	Kitale Plain	6,500 ft.	Kitale Plain
4,500 ft.	mid-Tertiary	4,500 ft.	sub-Miocene
	end-Tertiary		end-Tertiary

During the course of the present survey it was observed that the Elgeyo escarpment rises sharply from the plains to a height of 7,500 feet, the slope then decreasing so much that a shelf-like feature is formed at this elevation. When standing on this shelf the summits of Kailongol and Laiteruk, to the north-north-east, appear to be on approximately the same level. It is possible that this 7,500-foot level represents a pre-Tertiary erosion surface and that the present-day variations in height of its residuals can be explained as due to a combination of different rates of erosion and slight posthumous movement along the fault at the base of the escarpment. This surface probably corresponds with Millers' (1956, p.5) 7,600-foot Cretaceous (?) peneplain. Benches and plateaux on the higher levels of the flanks of the Cherangani hills at about 9,500 feet and 11,000 feet altitude probably correspond with Miller's upper peneplains of pre-Cretaceous age.

If it is assumed that the "7,500-foot" bevel and the 7,600-foot surface on the Cherangani hills are equivalent, it is possible that remnants of the Kitale plain are represented by the top of Masol, by the shoulders of Kailongol, and by the hill summits of Kailongol north. The remains of the sub-Miocene surface may be represented by the tops of the hills near Rorok, by benches around Masol and at the north-west end of Laiteruk, and by the tops of

*Not observed in the present area by Dixey.

the hillocks north-west of Kailongol. The Basement System hillocks north-west of the Kito pass have approximately the same altitude, but they lie within the Rift Valley, and their summit levels may represent one of the higher bevels and not the sub-Miocene surface.

The lowest erosional surface recognized is the end-Tertiary peneplain, at about 3,200 feet, which extends northwards from approximately 1° 30′ N. to the west of the Kailongol-Masol range (Fig. 1). The northward slope of this surface is very gentle, being only 200 feet in 35 miles.

In a diagram in Dixey's 1948 paper (op. cit., Fig. 2) it is suggested that the summit of Tiati represents a remnant of the "6,200-foot" pre-Miocene peneplain. This assumption was probably based on the only geological map of the area at that time available (Huddleston, 1942), which depicts Tiati as an inlier of Basement System rocks. The present survey has shown that Tiati is composed of Tertiary volcanic rocks almost certainly of Miocene age, and therefore the summit level can bear no erosional relation to the pre-Miocene surface. It is suggested that the vent from which the basaltic lava and tuff series of Tiati was erupted lay further east, a large low cone of stratified tuffs and lava being built up. This cone was cut by later Rift faulting and has now been largely removed by erosion, but Tiati and the associated flat-topped features of Kamugos and Shero probably represent parts of the original western slopes of the cone.

IV—SUMMARY OF GEOLOGY OF THE AREA AND GEOLOGICAL SUCCESSION

With the exception of the Turkana Grits the main rock types found in the area correspond closely with those in the Nanyuki-Maralal area further east as described by Shackleton (1946). The types of rocks present, their approximate age relationships, and the principal geological events in the evolution of the area are summarized below:—

RECENT
- Superficial deposits, black cotton soil, and river alluvium.
- Down-warping of Lake Rudolf basin and rejuvenation of the river system.

PLEISTOCENE
- Deposition of Pleistocene sediments.
- Disturbance and faulting with posthumous movement on pre-existing fault-lines and silicification of fault breccias and superficial deposits.

TERTIARY
- Completion of the formation of the end-Tertiary peneplain.
- Deposition of late Tertiary sediments.
- Eruption of Phonolites—*the Upper Volcanic Series*.
- Eruption of Basalts, pyroclastic rocks and occasional trachyte—*the Lower Volcanic Series*. Erosion and formation of the *Tiati Grit Series*.
- Emplacement of minor intrusives.

LATE MESOZOIC–EARLY TERTIARY
- Deposition of *Turkana Grit Series*.
- Formation of sub-Miocene peneplain.
- Disturbance and erosion.

END-JURASSIC ?–CRETACEOUS ?
- Formation of 7,500-foot bevel.
- Disturbance and erosion.
- Formation of 9,500-foot bevel.
- Disturbances and erosion.
- Formation of 11,000-foot bevel.

PRECAMBRIAN–JURASSIC ?
- Disturbances and long continued erosion.

ARCHAEAN
- Orogenic earth movements.
- Formation of the *Basement System*.

Basement System.—The Basement System rocks of the present area are part of a monotonous succession, consisting essentially of banded hornblende-biotite gneisses, garnetiferous in parts, with occasional bands and lenses of other rock types such as crystalline limestones, hornblende-diopside rocks, amphibolites and a sillimanite-bearing gneiss. Such rocks are found widely distributed throughout Kenya and represent an original sedimentary succession which, by regional metamorphism, has been converted to a series of crystalline gneisses. Local variations in the composition of the original sediments have resulted in the formation of the bands and lenses of differing rock types.

Over the greater part of the area the strike of the Basement System rocks is somewhat east of north, with steep dips to the east. In the Kailongol-Laiteruk-Masol range there are indications of acute folding on a north-south strike.

Turkana Grit Series.—Rocks of the Turkana Grit Series are not widespread, and occur usually as small low hills in the plains. The members of the series possess very variable characteristics, the colours being pale purple, buff, or grey, and often yellow due to limonite. They vary in grade from fine-grained sandstones to coarse grits, the constituents being of variable proportions, though quartz usually plays a dominant part. A highly characteristic feature of the rocks examined is the high content of cementing materials present in the majority of cases. The constituent minerals of these rocks are derived entirely from the products of decomposition and erosion of rocks of the Basement System, no material of volcanic derivation being present. Except where affected by faulting the sediments are horizontal or have very low dips.

Minor Intrusives.—Only one poorly-exposed outcrop of a minor intrusive was located, in the north-east of the area at Chapei. Its composition corresponds closely to that of a micro-foyaite.

Tiati Grit Series.—The main occurrence of the Tiati Grit Series is to the west of Tiati in the Chemasuk area. The rocks are poorly exposed and form no distinct topographical features. They appear to occur as intercalations in the lower part of the series of basaltic tuffs and lavas. As in the case of the Turkana Grit Series there is great variation in grain size, but colours tend to be more predominantly red and purple. The constituents are mainly of volcanic origin, but small amounts of material derived from rocks of the Basement System also occur, especially where the sediments are found in close proximity to inliers of gneiss. The sediments usually dip to the west at low angles.

Lower Volcanic Series.—Rocks of the Lower Volcanic Series occupy a large part of the area, occurring in a highly weathered and decomposed condition. In the northern portion of the area they are fairly well exposed due to the deep dissection and high rate of erosion, but further to the south outcrops are few in number and poor, and mapping had therefore to be done to a large extent on the evidence of float blocks. The series is essentially basaltic in composition, being predominantly of a pyroclastic nature with intercalated minor flows of porphyritic olivine basalt, and more rarely of trachyte. The pyroclastic rocks vary from fine-grained well-bedded tuffs to coarse rocks of an agglomeratic nature. The colour of these rocks varies from buff and white, through pink and brick red, to deep purple. Fragments of fossil wood are fairly common. The general dip of the series is to the west and south-west at low angles.

Upper Volcanic Series.—The younger Volcanic Series consists of phonolites, which occur as remnants of what was probably once a large continuous flow covering the Lower Volcanic Series. The rocks are essentially fine-grained, dark grey and green in colour, with rare felspar phenocrysts, and show little variation in field or microscopic appearance. The flows dip predominantly to the west at low angles.

Tertiary Superficial Deposits.—Superficial deposits, probably of late Tertiary age, form a chain of low elongated or conical hills at the foot of the Elgeyo escarpment between Chesagon and Lomut. The rocks are highly altered and limonitized, being usually of red and brownish-yellow colours. The constituents are mainly unrecognizable, but appear to have been originally Basement System gneisses, basaltic tuffs, and sediments of the Turkana Grit type. Fragments of fossil wood were also located. The rocks are cemented mainly by chalcedonic silica and it would appear that the rocks owe their preservation to the uprising of silica-bearing solutions along a fault-line, resulting in the induration and consolidation of pre-existing surface gravels. Where mapable the strike of these sediments conforms with that of the surrounding rocks of the Basement System.

Pleistocene Sediments.—A few small outcrops of horizontally-bedded, poorly consolidated, buff-coloured sediments are to be found in the Kolloa area. They are fine-grained and contain material derived from both the Basement System and the volcanic rocks.

Recent Deposits.—These are represented by superficial sands and gravels, black cotton soil, and river alluvium. True soil only occurs in the Cherangani hills where the soil-cover, especially in the forest areas, is exceptionally deep and rich in humus.

V—DETAILS OF THE GEOLOGY

1. The Older Rocks

(1) The Basement System

Rocks of the Basement System cover the greater part of the area to the west of a line from Kailongol North to Chepkum. In addition there are inliers of similar rocks in the Kito Pass, Chemasuk, Mogorion, and Kaukia-Muruita areas. The mode of origin and subsequent alteration by regional metamorphism and granitization of the Basement System have been described in previous reports, for example, Shackleton (1946), Schoeman (1948, 1949 and 1951), Parkinson (1947), and Searle (1952). In the area under consideration the original sediments were mainly of a pelitic or semi-pelitic nature, with locally developed calcareous horizons. The regional metamorphism of these rocks has resulted in the formation of a monotonous succession of banded hornblende-biotite gneisses, with occasional bands of crystalline limestone and calc-silicate rocks. Locally there are patches of migmatite in which injection veins of quartzo-felspathic pegmatitic material invade and ramify through the gneisses. Such gneisses are in places contorted, with the veins ptygmatically folded, as may be seen on the Lotongot river south of Laiteruk, and also down-stream from Lotongot village.

Certain dark, predominantly hornblendic rocks, usually occupying areas of small extent, are thought to result from the metamorphism of rocks such as dolerite which were emplaced as sills or dykes in the original sediments of the Basement System.

For the purposes of description the rocks of the Basement System found in the area may be classified in the following groups:—

Sedimentary—	
Crystalline limestones Calc-silicate rocks Diopside-hornblende rocks	Calcareous and Semi-calcareous
Sillimanite-garnet-biotite gneiss Graphitic gneisses	Pelitic
Banded hornblende-biotite gneisses, garnetiferous in parts Biotite gneisses	Pelitic and Semi-pelitic
Quartzites Quartzo-felspathic gneisses	Psammitic
Magmatic—	
Granite	Acid
Amphibolite	Ultra-basic.

Insufficient work was carried out in the area to allow a determination of the stratigraphical sequence.

(*a*) *Metamorphosed Calcareous and Semi-calcareous Sediments*

(i) *Crystalline Limestones.*—Crystalline limestones or marbles, form two narrow bands about 100 yards wide, one in the Lebatin plains striking in a north-westerly direction, and the other in the western foothills of Laiteruk striking in a generally northerly direction. The former is a pure white coarsely crystalline limestone, whereas the latter is pale or white with scattered flakes of graphite. The country-rocks surrounding the limestone bands are banded hornblende-biotite gneisses.

A small lens of impure pink crystalline limestone associated with calc-silicate rocks occurs in the escarpment above Lomut, also enclosed in banded hornblende-biotite gneisses. Specimen 26/235.* from this locality, consists largely of calcite with crystals and aggregates of tremolitic and actinolitic amphibole, some of which are intensely sieved with granules of calcite. A few small flakes of pale brown phlogopitic mica also occur. Similar rocks occur on the southern border of the area in the escarpment above Chepkum and, further to the south between Chepkum and Tambach, there is a strong development of crystalline limestone forming a series of hills at the foot of the Elgeyo escarpment for several miles.

(ii) *Calc-silicate rocks.*—Small lenses of calc-silicate rocks with xenolith-like habit occur in the escarpment above Lomut and Chepkum in association with crystalline limestones and banded hornblende-biotite gneisses. This "xenolithic" habit was noted by Shackleton in the Nanyuki-Maralal area (1946, p. 8), and he believed that the calc-silicate patches were relics which had survived dissolution on granitization. The patches are usually dark green and white, and coarsely crystalline. In thin section specimen 26/233, from the escarpment above Lomut, was found to consist mainly of wollastonite with some pale-green diopsidic pyroxene and small amounts of tremolitic amphibole, a sodic plagioclase, a potash felspar, calcite and quartz.

Specimen 26/356, taken from the road which descends to the Arror river north of Kapsowar, is a medium-grained green crystalline rock occurring as lenses and bands too small to depict on the map, enclosed in hornblende-biotite gneiss. In thin section it is found to consist of anhedral crystals of pale-green diopside exhibiting a patchy alteration to hornblende, together with scapolite, and large crystals and aggregates of apatite.

(iii) *Hornblende-diopside rocks.*—Rocks of this type are not widespread and occur as small lenses in banded gneisses. They are characteristically dark green or black and coarsely crystalline. Specimen 26/232, from the road about two miles south-west of Rorok, is composed of about 60 per cent anhedral, slightly pleochroic, pale-green diopside, enclosing small amounts of quartz and partly replaced by green hornblende, and 30 per cent anhedral hornblende, pleochroic from yellow to strong green or bluish-green. The remainder of the rock consists of strained quartz and small amounts of felspar.

Specimen 26/271, from about one mile north-west of the Kerio river ford on the Kolloa-Amaler road, contains essentially the same constituents, but has a larger amount of well-twinned plagioclase of the composition of labradorite. Specimen 26/297, from the inlier of Basement System rocks about six miles east of Amaler, also contains small crystals of biotite, pleochroic from pale yellow to dark brown. Small amounts of microcline, iron ore and apatite are also present.

These rocks bear certain resemblances to pyroxene-amphibole rocks described by Harry (1952, p. 143) from Glen Dessarry in Inverness-shire. Harry (op. cit., p. 150) attributes the origin of these rocks to metasomatism connected with pegmatite formation and suggests that the pyroxenic end-member of the pyroxene-amphibole rock series was formed by metasomatic modification of diopside rocks of sedimentary origin. In the present area pegmatitic veins and stringers of an anastomosing nature are abundant in the gneisses and it is probable that the pyroxene-amphibole rocks described have a similar origin to those of the Glen Dessarry area.

(*b*) *Metamorphosed Pelitic Sediments*

(i) *Sillimanite-garnet-biotite gneisses.*—A small considerably weathered outcrop of gneisses of this kind occurs in the Leathetom area near the northern border of the area (specimen 26/257). The rock is a flaggy pale-coloured gneiss, thinly foliated and containing large rusty garnets. In thin section (Fig. 4 B) it is seen to consist of a mosaic of strained quartz. a little felspar, somewhat crushed and fissured euhedral garnets exhibiting alteration on the internal cracks, and abundant scattered minute sillimanite needles and aggregates in which individual crystals are frequently bent. Small amounts of biotite, pleochroic from brown to nearly colourless, are also present. This rock appears to be comparable to a sillimanite-garnet gneiss described by Shackleton (1946, p. 9) from the Nanyuki-Maralal area.

*Numbers refer to specimens and thin sections in the regional collections of the Geological Survey at Nairobi.

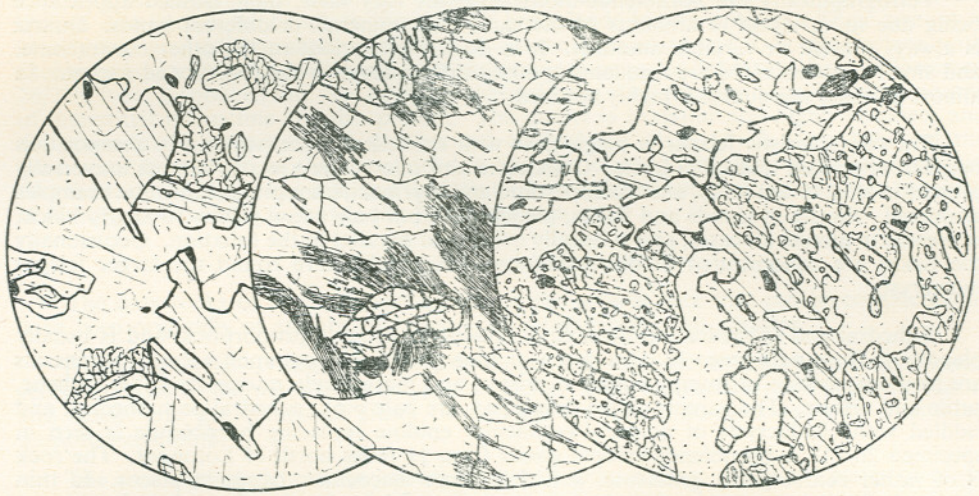


Fig. 4.—Microscope drawings of thin sections of Basement System rocks from the Kalossia-Tiati area.

A. Garnetiferous Amphibolite. Specimen 26/239, 2·1 miles south of Lomut. Ordinary light × 47. The drawing shows irregular fractured garnet and cleaved hornblende with irregular quartz and plagioclase felspar, accessory sphene and iron ore. Note the highly poikilitic nature of the garnet and, to a lesser extent, of the hornblende, both these minerals enclosing chadacrysts of quartz and felspar.

B. Sillimanite-garnet-biotite gneiss. Specimen 26/257, Leathetom area. Ordinary light × 47. Crushed and fissured garnets and abundant needles of sillimanite in felt-like aggregates are scattered throughout the rock. The remainder of the rock consists of a mosaic of strained quartz, that is granulitic in parts. A small amount of pleochroic brown biotite is present.

C. Hornblende-epidote gneiss. Specimen 26/247, 11 miles north of Lotongot. Ordinary light × 47. The replacive relationship of vermicular epidote to the subhedral hornblende is shown. Other minerals in the rock are quartz and plagioclase with small amounts of microcline and accessory iron ore and apatite.

(ii) *Graphitic gneisses.*—Two small outcrops of graphitic gneiss occur east and west of the Amaler-Lomut road about seven miles south of Amaler. The rocks are soft and poorly exposed. The gneiss (specimen 26/338) in the outcrop east of the road contains small flakes of graphite in an essentially quartzo-felspathic matrix. In thin section the gneiss is seen to consist of large amounts of strained quartz with microcline, orthoclase, and sodic plagioclase forming a granulose matrix, in which are flakes of biotite pleochroic from colourless to red-brown, and of lustrous graphite. This graphitic gneiss is essentially similar to that described by Shackleton (1946, p. 9) except that it is not found in association with crystalline limestones. Shackleton considered that the graphite represents original carbonaceous organic material imprisoned in argillaceous sediment.

(*c*) *Metamorphosed Pelitic and Semi-pelitic Sediments*

(i) *Banded hornblende-biotite* (*-garnet*) *gneiss.*—The predominant Basement System rock type of the area is banded hornblende-biotite gneiss. Gneisses of this type cover very large portions of the area with little variation in strike or appearance. The banding is usually of a regular nature, with light and dark bands of variable widths up to about three inches. The texture of the rocks varies from fine-grained almost schistose, to very coarse and pegmatitic. The gneisses are frequently cut by anastomosing pegmatitic veins and often contain lenticular pegmatitic segregations. Rarely, they are contorted.

In a belt along the Elgeyo escarpment from Chepkum to Chesagon, and extending throughout the height of the escarpment, there is a strong development of garnets in the gneisses. The garnets are of a deep pink colour and vary in size from minute grains up to crystals about half an inch in diameter. Elsewhere, on Masol and in the Kakore Pass, garnetiferous gneisses of a similar type are developed locally.

Petrographically the hornblende-biotite gneisses vary little, their banded appearance being due to variation in amounts of the same dark minerals in different bands. Quartz is always present in variable amounts. It is usually interstitial to the other constituents, and small rounded blebs are frequently poikilitically related to the felspar and garnet. In almost all cases the quartz is highly strained.

The characteristic felspar is plagioclase with subhedral form, varying in composition between oligoclase and labradorite. Orthoclase and microcline are also almost universally present in smaller amounts, and microperthite and myrmekite are present in some examples examined. Biotite in shreds and flakes, pleochroic from pale straw yellow to nearly black, is present in almost all cases, and is usually orientated parallel to the foliation. Occasionally the flakes are concentrated in discontinuous folia which curve round the larger felspar metacrysts.

Euhedral and subhedral hornblende is present in variable proportions, and is usually pleochroic from pale green to dark green or blue-green. The common accessory minerals are iron ore, apatite in stumpy euhedral prisms, and more rarely muscovite flakes, sphene, rutile and orthite. The garnets, when developed, are pale pink, euhedral or subhedral, and riddled with chadacrysts of quartz. Vermicular epidote replacing hornblende is seen in specimen 26/247, a hornblende-epidote gneiss from 11 miles north of Lotongot. The rock is of rather coarse grain, gneissose, and with more leucocratic bands in places. In thin section it is seen to consist of subhedral plagioclase felspar (with refractive index greater than that of Canada balsam), a small amount of microcline, strained subhedral quartz, green subhedral hornblende partly replaced by epidote with accessory iron ore and stumpy prisms of apatite (Fig. 4 C).

In the Kito pass, Kula, Amaler and Pelpel areas rocks of this type have been affected by faulting, causing alteration and brecciation, the foliation in some cases being completely destroyed. Slickensided surfaces are common, specimen 26/318 from the east side of the Kito Pass providing a good example. In thin section the affected rocks are found to be considerably altered and crushed—quartz is strained, fractured and sheared out into lenticles, while the felspars are similarly fractured and altered and contain rows of inclusions and quartz blebs. Rare streaks of a mylonitic nature occur, but on the whole there is little evidence of deformation intense enough to give rise to mylonitization. In specimen 26/318, the felspars are myrmekitized and biotite in ragged crystals is the only ferromagnesian mineral present. These breccias are universally heavily limonitized, the interstitial cementing material being composed partly of limonite and partly of fine-grained chalcedonic silica. The original rocks were fractured and the fragments displaced, intervening spaces being filled by crystallization from a siliceous fluid, which probably rose along the fault-planes during the process of faulting. There are also present in the fault breccias some larger veins and masses of pure, pale pink, chalcedonic silica. Specimen 26/319, also from the Kito Pass, is of this vein material and consists essentially of chalcedonic quartz and limonite with small amounts of biotite gneiss adhering to the walls of the vein. In other cases slickensided surfaces are coated with the same cherty material, as shown by specimen 26/318. The association of secondary silicification with faulting occurs in several other localities in the area and will be mentioned in the discussion of faults on a later page.

(ii) *Biotite gneisses.*—A dog-toothed ridge lying to the east of the Kailongol-Laiteruk range consists of flaggy biotite gneisses, which vary from fine-grained somewhat banded rocks to coarser gneisses of somewhat granitic texture in parts. A thin section of the finer-grained material (26/280), from about 15 miles north of Amaler, consists of small flakes of biotite, pleochroic from pale yellow to dark brown, orientated in thin wavy folia, in a groundmass containing strained quartz, often in irregular lenticular veinlets, accompanied by anhedral microcline and plagioclase. Accessory magnetite is also present. The gneiss is granulose and appears to have been sheared.

(*d*) *Metamorphosed Psammitic Sediments*

(i) *Quartzites.*—Thin quartzite bands of little extent are poorly exposed in the area between Sawerwa and Kapsowar. They are white and granulose rocks and in thin section are found to consist of a coarse sutured quartz mosaic with occasional crystals of felspar.

(ii) *Quartzo-felspathic gneisses.*—Flaggy leucocratic quartzo-felspathic gneisses have a limited distribution as bands in the normal hornblende-biotite gneisses. Their texture is usually fine-grained granulitic, consisting of quartz, orthoclase and sodic plagioclase, with accessory magnetite and small amounts of muscovite in irregular flakes and shreds. Specimen 26/238, from Kyobaken hill, was probably derived from similar rocks, though large amounts of interstitial microcline are also present. The quartz is irregular and highly strained, and the groundmass contains much fine-grained chalcedonic silica, which is probably of the same secondary origin as that mentioned in the previous section. It appears fairly certain that the rocks of Kyobaken hill, and the hills to the north and south of it, have been involved in faulting comparable to that in the Kito Pass area.

(e) *Metamorphosed Intrusive Rocks*

The only rocks of the Basement System in the present area that can be considered to have been originally of an intrusive nature are amphibolites and granites.

(i) *Amphibolites.*—These are poorly developed and exposed, usually occurring as small veins or lenses in the more normal types of gneiss. They are usually dark green or black, and dense, and are composed either of coarsely crystalline hornblende or of orientated tremolite-actinolite.

The coarse-grained varieties consist almost entirely of large subhedral plates of green hornblende with small amounts of quartz and calcic plagioclase. Accessory apatite, magnetite and ilmenite, and sphene are sometimes present. In some cases pink garnets have developed, and are usually highly poikilitic, enclosing chadacrysts of quartz and felspar. A garnetiferous amphibolite, specimen 26/239 from Kanalan, 2·1 miles south of Lomut, contains highly poikilitic pink garnet and hornblende, with strained quartz in irregular grains and plagioclase felspar. Accessory iron ore, apatite and sphene are present (Fig. 4 A). Specimen 26/267 from the Lolmorton river west of the Lomut-Lotongot road, which is a plagioclase amphibolite and fine-grained, contains subhedral prisms of pale yellow or colourless epidote. Specimen 26/357, from west of Chesoi, is coarse-grained and consist entirely of interlocking crystals of pale-grey-green actinolite hornblende.

(ii) *Granite Sheets.*—On the road from Kapsowar to the Arror river a granite sheet is exposed among banded gneisses. Only one good outcrop is visible in the road-cutting and is too small to be shown on the map. On the evidence of field relations there is little doubt that the rock is of an intrusive nature. It is a slightly foliated pink rock of granitic appearance and in thin section (specimen 26/355) is found to consist of highly strained quartz which tends to be segregated into folia, microcline, and sodic plagioclase. The felspars are not so clear as those usually found in the meta-sedimentary Basement System gneisses. Small amounts of biotite and accessory iron ore are also present. The sheet appears to be conformable to the strike of the surrounding gneisses.

2. The Younger Rocks

(1) Tertiary Sedimentary Rocks

The presence of a suite of young sedimentary rocks in Turkana has been known for some time. Champion (1937, p. 111) states that the Turkana Grits were first noted by H. L. Sikes when Director of the Public Works Department. In unpublished notes on the geology of the Turkana District Champion suggested that the so-called Turkana Grits are of more than one geological age. The possibility of variation in age has been substantiated to some extent during the course of the present survey.

If the present alluvium and float of the area were cemented and indurated the result would be Turkana Grit—the rocks of the grit series are essentially products of the consolidation of outwash derived by the erosion of nearby previously existing rocks. There are accordingly numerous facies of the grits, their nature depending solely on the relation of the locality in which they were formed to the surrounding solid rocks. Conversely, the deposits as found to-day may be of very widely differing ages, though having essentially the same characteristics. It will be realised that the dating of such deposits is difficult, though their relationship to the Tertiary volcanic rocks provides a tentative primary age division. In the area mapped two main types of grit can be expected, one formed before the extrusion

of any volcanic rocks, which will consist of material derived from rocks of the Basement System only, and the other formed during or after the volcanic activity, which could therefore contain material derived both from the Basement System and from the Tertiary rocks. Sediments may, however, have been deposited during or after the volcanic times in areas remote from volcanic rocks and consequently contain only material derived from the Basement System. The absence of Tertiary volcanic material in the sediments is not, therefore, completely diagnostic for age determination, and it cannot be averred that all sediments that do not contain fragments of lava and tuff are older than the Tertiary volcanic rocks. No fossils were found in any of the sediments examined in the present area, with the exception of small amounts of fossil wood, so no help in the problem of dating was to be had in this direction.

Bearing in mind these limitations, two main types of sediments were mapped, viz:—

(*a*) The Turkana Grit Series, containing recognizable fragments of Basement gneisses and abundant quartz, and

(*b*) The Tiati Grit Series, containing material derived from the Tertiary volcanic rocks, with or without the addition of material derived from the Basement System, and quartz.

(*a*) *Turkana Grit Series*.—Rocks of the Turkana Grit Series form a belt stretching from the Lolmorton river on the Lomut-Lotongot road south-east to the area of Rorok hill and the Chesabet river. They also occur as small outcrops on the Lotongot river five miles downstream from Lotongot, some three and a half miles and six miles east of Amaler, on the Kolloa-Amaler road in the Mogorion area, and on the same road about six miles to the north of Kolloa.

In the Lolmorton river area the sediments are about 70 feet in thickness and rest unconformably on Basement System gneisses, being horizontal or having very low dips to the east. In this locality grits and conglomerates predominate, large sub-angular pebbles of white quartz being one of the main constituents, so that the surface of the ground around is covered with pebbles of this type which have weathered out from the conglomerate. No fine-grained bands were visible, and there was no evidence of current or graded bedding.

Some five miles south-east of the Lolmorton river ford there is a knoll composed of horizontally bedded buff-coloured grits containing limonitic and kaolinitic patches, and fragments of colourless quartz up to 3 mm. in length. In thin section (specimen 26/339, Fig. 5 B) the sandstone is seen to consist of sub-angular unsorted grains of strained quartz, which occasionally show secondary growths in optical continuity, a small amount of felspar, and a few flakes of muscovite, in a cement consisting essentially of chalcedonic quartz associated with limonite. The composition by volume of this and other specimens of Turkana Grit determined on a micrometer stage are given in Table 1.

About two and a half miles west of Rorok there are two more small knolls of grit. One, with its summit at an altitude of 3,420 feet, consists of highly weathered material, much of which did not appear to be *in situ*, but on the western side an impression of horizontal bedding was obtained. The rock varies from a fine-grained sandstone to a coarse conglomerate with large pebbles of quartz, similar to that of the Lolmorton river area. The smaller feature to the south-west was found to be of similar material, and what appeared to be joints on bearings of 316° and 12° (true) were apparent. The whole area to the west, and to the east as far as the Lomut-Amaler track, is covered with quartz and grit float blocks, with patches of *in situ* material near to the track. The covering of sediments was apparently very thin as small inliers of rocks of the Basement System occur in the bottoms of some of the drifts, which are incised for depths of 15 or 20 feet.

Specimen 26/229 from the road south-west of Rorok hill is a coarse, well-consolidated, buff-coloured grit, somewhat limonitic in patches, and showing no indication of bedding. It appeared in the field, however, to be part of a horizontal bed. In thin section the rock is found to consist of poorly graded sub-angular grains of quartz and felspar, the former being predominant, and often exhibiting secondary growths, the shape of the original grains being marked by lines of inclusions. The felspar is microcline, orthoclase and small amounts of sodic plagioclase, often being turbid and sericitised due to the effects of weathering. A small flake of biotite is present and much opaque dust and limonitic staining.

TABLE I

COMPOSITION BY VOLUME OF SPECIMENS OF THE TURKANA GRIT SERIES (PER CENT)

	26/229	26/231	26/243	26/244	26/245	26/246	26/261	26/295	26/339	26/340	26/341	26/342	26/343	26/344	26/254	26/299
1. Quartz	50·48	19·81	37·02	27·81	27·12	20·21	12·13	41·83	58·91	37·39	39·71	38·81	34·05	39·64	34·29	22·35
2. Felspar	29·20	14·98	29·68	15·37	14·02	10·36	29·78	16·01	2·39	0·87	3·66	4·07	5·57	1·46	6·83	6·27
3. Chert and accessories	20·32	64·33	33·32	56·76	47·20	44·46	–	35·09	35·38	31·00	18·55	38·36	60·37	51·52	13·80	53·83
4. Calcite	–	–	–	–	11·23	24·99	58·02	7·08	–	–	8·78	18·65	–	–	4·23	17·43
5. Limonite	–	–	–	–	–	–	–	–	3·23	30·74	29·29	–	–	7·34	40·87	–
6. Cement (3+4+5)	20·32	64·33	33·32	56·76	58·43	69·45	58·02	42·17	38·61	61·74	56·62	57·01	60·37	58·86	58·90	71·26
TOTAL	100·00	99·12	100·02	99·94	99·57	100·02	99·93	100·01	99·91	100·00	99·99	99·89	99·99	99·96	100·02	99·88
Average grain size in mm.	1·47	3·60	2·50	0·60	0·70	0·20	0·20	0·70	0·70	1·10	0·70	0·70	0·50	0·30	0·30	1·05

26/229 Road south-west of Rorok hill.
26/231 Rorok hill.
26/243 Rorok hill.
26/244 Rorok hill.
26/245 Chesabet river south of Rorok hill.
26/246 Chesabet river south of Rorok hill.
26/261 1·1 miles north of Lotongot-Kangetet-Amaler road junction.
26/295 3·5 miles east of Amaler.
26/339 Hill four miles south-east of Samakitok river ford.
26/340 Chesabet river south of Rorok hill.
26/341 Chesabet river south of Rorok hill.
26/342 Chesabet river south of Rorok hill.
26/343 Chesabet river south of Rorok hill.
26/344 Chesabet river south of Rorok hill.
26/254 Lotongot river 5·9 miles downstream from Lotongot village.
26/299 Six miles east of Amaler.

Immediately to the east of the road there is a low ridge of sediments, and further to the east lies Rorok hill, an acute ridge over a mile long, trending north-south, and attaining an elevation of about 500 feet above the general level of the plain. The low ridge also strikes approximately north-south, and the dip of the beds is low to the west, so that the eastern face consists of a series of small scarp-like steps. The rocks are conglomerates and sandstones of purple and grey colours with some indication of graded bedding in places. Frequently on the exposed bedding surface of these rocks there are what appear to be large pot-holes infilled with coarse conglomeratic material, and some of the fine-grained bands contain infilled polygonal sun-cracks.

Rorok hill is covered with a jumbled mass of boulders and it is difficult to find any exposures of rock *in situ*. The predominant rock type is a coarse conglomerate with large angular white quartz pebbles and heavily limonitized interstitially. The layer of sediments appears, however, to be thin, as undoubtedly gneisses of the Basement System were discovered *in situ* on the higher slopes. The line of the hill almost certainly marks a fault, as there is abundant secondary silicification comparable to that of the Kito pass area. Many blocks show brecciation and slickensided surfaces preserved in chalcedonic quartz. This secondary silicification is not present in the outcrops west of the Lomut-Amaler track nor in the grits of the Lolmorton river area.

The chalcedonic material occurs as veins ramifying throughout the sediments and the Basement inlier exposed on the side of Rorok. Specimen 26/230 is representative of this material and was taken from a fine-grained pink- to buff-coloured vein up to two inches in width with a somewhat banded appearance. The margins of the vein include fragments of grit. In thin section it is seen that the rock consists almost entirely of chalcedonic quartz with a few larger floating quartz and felspar grains, which are almost certainly derived from the surrounding grit. Specimen 26/231 from the same locality is a coarse conglomerate containing sub-rounded and angular pebbles up to 2 cm. in diameter and concretionary feebly oolitic structures which at first sight are somewhat like fossils in appearance. In thin section this rock is seen to consist of angular grains of quartz, microcline and orthoclase, with small amounts of sericite, opaque dust and limonitic material. The cement is chalcedonic quartz, which forms radial fringes round the detrital grains and assumes zoned spherulitic structures interstitially that give rise to the oolite-like bodies.

Specimen 26/243 (Fig. 5 C) also from Rorok is a quartzose conglomerate of purple and brown colour, containing angular and sub-rounded quartz pebbles up to 2½ cm. in diameter. The quartz is usually white or pale yellow. In thin section the rock is found to consist essentially of large irregular strained aggregates of quartz, associated with fragments of felspar crystals. The cement is cryptocrystalline, being largely chalcedonic quartz. Specimen 26/244 from the same locality is finer-grained, the quartz pebbles only attaining diameters of up to 4 mm. The fresh rock is a rusty-buff in colour but the weathered surface is black. The constituents are the same as in the other specimens—quartz, microcline, orthoclase, limonite, kaolinite, sericite and chalcedony.

The Chesabet river south of Rorok reveals a good section of rocks of the Turkana Grit Series, dipping at low angles to the west and resting unconformably on banded Basement System gneisses. The beds here are silver-grey and purple sandstones and conglomerates and have the following succession:—

	Feet
Medium-grained siliceous sandstones (specimen 26/245) ..	4+
Coarse sandstone containing a coarse band made up of large quartz pebbles	6
Fine-grained siliceous grey sandstone (specimen 26/344, Fig. 5 A)	2
Coarse sandstone	5
Fine-grained grey silicified sandstone (specimen 26/246)	12
Medium-grained siliceous sandstone (specimen 26/343)	3
Fine-grained grey silicified sandstone	3
Fine-grained grey sandstone	5
Coarse grit	1
Medium-grained silicified grey sandstone, greatly pot-holed (specimen 26/342)	6
Medium-grained ferruginous sandstone with limonitic concretions (specimen 26/341)	6
Coarse purple grit (specimen 26/340)	4
(Basement System gneisses)	

The composition of the specimens mentioned are given in Table 1. Quartz, felspar and chalcedony are common to all of them, the detrital quartz grains sometimes showing secondary growth in optical continuity. Occasional flakes of muscovite were seen and some specimens have secondary calcite as a cementing medium in addition to chert. Specimen 26/344, from the Chesabet river section, is a fine-grained siliceous buff-coloured sandstone, fairly well sorted and consists of angular quartz and felspar grains cemented by chert and limonite (Fig. 5 A). From the same river section specimen 26/340 is a coarse purple grit. In thin section it is seen to consist of angular, unsorted and ungraded fragments of strained quartz with occasional fragments of microcline and orthoclase felspar. The cementing material is very fine-grained and amorphous, being calcareous and limonitic in part.

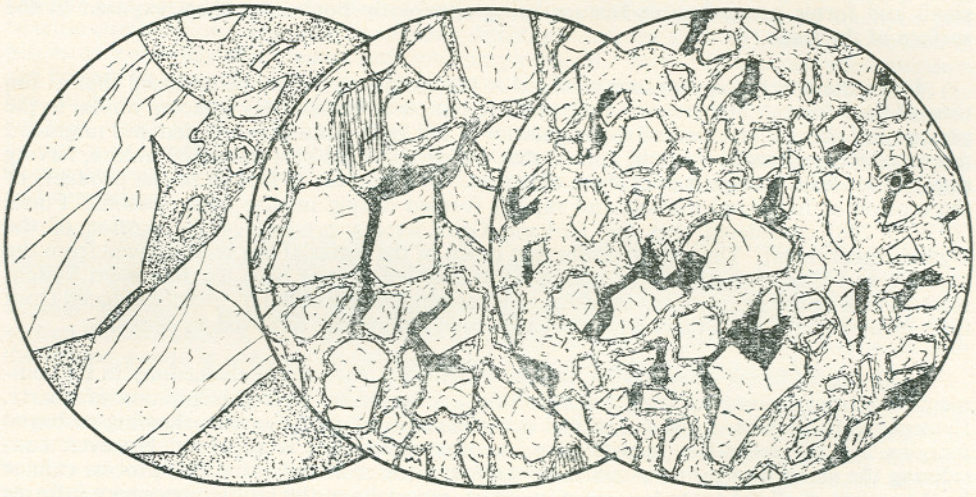


Fig. 5.—Microscope drawings of thin sections of rocks of the Turkana Grit Series.

A. Fine-grained siliceous sandstone. Specimen 26/344, Chesabet river, south of Rorok. Ordinary light × 30. The rock is fairly well sorted and consists of angular grains of quartz and felspar cemented by chert and limonite. The average grain size is 0·3 mm.

B. Medium-grained siliceous sandstone. Specimen 26/339, five miles south-east of Lolmorton ford. Ordinary light × 30. The grains of quartz and felspar are fairly well sorted and are subangular, the felspar grains being more rounded than the quartz. The cement is essentially chert with a little limonitic material. The average grain size is 0·7 mm.

C. Matrix of siliceous conglomerate. Specimen 26/243, Rorok. Ordinary light × 30. A poorly sorted rock with angular and subangular grains of quartz and felspar cemented by chert. The average grain size is 2·5 mm.

In the case of the outcrop some five miles downstream from Lotongot the rock differs greatly from other types of Turkana grits, having a brick-red lateritic appearance. The outcrop is small and highly weathered, but there are present some patches containing recognizable fragments of Basement System gneiss in a fine-grained gritty matrix, as in specimen 26/254. There is little indication of dip and strike but the material appears to be horizontally disposed. In thin section quartz, orthoclase, plagioclase and a few flakes of muscovite are apparent. The cement is stained and amorphous and appears to consist of limonite, calcite and a little chalcedony.

Specimen 26/255, from some three and a half miles east of Amaler, was taken from a small outcrop which appeared to dip to the south-west at about 35°. The rock is a pink-purple conglomerate with fragments and grains up to a quarter of an inch in diameter, set in a fine-grained cement. In thin section there is nothing to suggest the presence of material derived from volcanic rocks, in spite of the fact that the outcrop occurs in an area of lavas and tuffs. Microcline, myrmekite, orthoclase, sodic plagioclase and strained and composite quartz grains are present, with a few flakes of biotite and muscovite, and accessory garnet and iron ore. The fine-grained amorphous base contains some calcite and chalcedony.

Some six miles east of Amaler on a hillside there is a small outcrop of grit resting on Basement System gneiss and overlain by lava. The rock (specimen 26/299) is a silicified, well-consolidated, buff-coloured grit, of similar appearance to the grits of the Rorok area. In thin section the constituent minerals are revealed as quartz, felspar (altered and variably replaced by calcite), garnet, apatite and iron ore, all derived from Basement System rocks, in a base of chalcedony, limonite and calcite. The overlying lava is a phonolite of the Upper Volcanic Series.

The grits of the two outcrops on the Amaler-Kerio-Kolloa track are essentially similar lithologically to those of the Rorok area. The more northerly exposure forms a low hill, the beds being horizontal or dipping at low angles to the west. The southern outcrop is small and forms no noticeable feature being apparently horizontal sheet exposed in the surface of the track.

From the lateritic appearance of some of the sediments it may be assumed that at the time of their formation there was a marked alternation of wet and dry seasons, similar to the present day climate. In view of the angularity of the grains and the unsorted and ungraded nature of the sediments it would appear that the deposits are of a torrential nature, having suffered but little transport over short distances. They appear in fact to be the products of the erosion of high land masses, and rapidly formed during intense rainy seasons. Fuchs (1939, p. 228) considered that the Turkana Grits were a product of the erosion of the Uganda escarpment. There is no doubt that much of the material has been derived from the Uganda and Elgeyo escarpments, but an additional source has been the Basement System residual hills in the plains, some of which now remain, but are certainly greatly reduced from their former size, while others have probably been completely removed by erosion.

With regard to the cementation, it would seem that part of the chalcedony in the sediments has been derived by intra-stratal solution, followed by the reprecipitation of quartz. Evidence is to be seen in the occasional occurrence of quartz fragments showing embayed margins and the secondary growth rims on other grains. It is apparent, however, considering the amount of primary quartz remaining in the sediments, that this process cannot be the source of all the secondary silica involved, especially in the fault-zones where it forms large veins and masses, and therefore a subterranean source must be postulated, the hydrothermal siliceous solutions having arisen along fault-planes and other minor and less obvious fractures.

On evidence available in the present area it is not possible to assign a definite age to the Turkana Grit Series. They lie between the Basement System and the Tertiary phonolites and in view of the presence of fragments of fossil wood in them there is a strong probability that at least some of the sediments are of Tertiary age. Fuchs (1939, p. 228) considered that they are of Oligo-Miocene age, basing his assumption in part on fossil evidence and in part on his belief that the Uganda escarpment—the north-western continuation of the Elgeyo escarpment—was formed during the late Oligocene. He considered that the escarpment could not be of greater age than this or it would not have remained so clear-cut. Evidence accumulated in the course of the present survey tends to suggest that the Elgeyo escarpment did not originate during the Rift faulting when, however, it almost certainly suffered posthumous movement, but at a much earlier date, probably being comparable to the Nandi fault (Gibson, 1954, p. 38), which is considered in its earliest manifestations to be of Pre-cambrian age.

Shackleton (1951, p. 372) following Fuchs, accepts his dating as correct, and correlates the Turkana Grits with other sediments exposed in the escarpment near Tambach, and with the Miocene sediments of Kavirondo. In view of the absence of fossils in the sediments of the present area this can neither be proved or disproved, but considering the abundant vertebrate and invertebrate fauna occurring in the other two localities it seems unlikely that the rocks belong to the same horizon. Similarly the sediments of the Kalossia-Tiati area do not resemble the sub-volcanic (Miocene) sediments described by Shackleton (1946, p. 27) from the Laikipia plateau and Karissia hills to the east, there being no comparable shales, siltstones, marls, clays, diatomites or fossils. It is possible that these finer-grained rocks represent younger beds of the Turkana Grit Series, formed when much of the high land had been planed down by erosion, and when the quieter conditions of erosion and

deposition were more suitable for the maintenance of life and the preservation of fossil remains. These later beds may well be of Miocene age, but it is felt to be more probable that the majority of the sediments of the Turkana Grit Series examined in the present area are of late Mesozoic or early Tertiary age.

(*b*) *The Tiati Grit Series.*—Rocks of the Tiati Grit Series are not widely distributed, and are highly weathered and poorly exposed. The main outcrops are in the Chemasuk area on the Kolloa-Kerio river road, being exposed where the tributaries of the Kerio have cut down through the sand and gravel cover of the plain. Another small outcrop occurs some seven miles east of Kolloa in the foothills of the Tiati-Kito Pass range.

The sediments are mainly conglomerates, usually purple in colour, containing large angular and rounded grey pebbles of lava up to two inches in diameter of trachytic and basaltic composition. They dip in westerly directions at from 5° to 15°, and are overlain in places by extremely fine-grained grey and purple basaltic lavas. In the east the sediments can be seen to lie unconformably on gneisses of the Basement System. It is evident from the low angle of dip and the level surface of the plain that there is not a great thickness of volcanic rocks in this area, and that the sediments must therefore be at the base of the volcanics or intercalated in them near to their base. It is presumed that they were formed during periods of quiescence in the volcanic outbursts, under conditions of torrential erosion and deposition.

Few unweathered specimens could be found, and those that were sectioned were disappointing on microscopic examination. Specimen 26/321, from the river four miles north of Kolloa on the track to the Kerio river, is a purple conglomerate containing sub-angular pebbles of pale and dark grey fine-grained lavas and felspar fragments. In thin section the lava pebbles are found to be of essentially basaltic nature and are associated with the felspar grains in a fine-grained cement composed of limonite and calcite.

Specimen 26/334A, from the river five and a half miles north of Kolloa, is a coarse purple and white speckled grit. In thin section it is found to consist of large angular ungraded fragments of quartz and felspar in a cement composed mainly of calcite, but with patches of limonitic material. Specimen 26/334B from the same locality, is similar but not so coarse grained, and in thin section is seen to contain a small amount of chalcedony in the groundmass. These two specimens are unusual in not containing any obvious fragments of lava, but on their field relationship are demonstrably intra-volcanic. Specimen 26/335 from the same area, is a somewhat slabby purple and white grit, which is seen in thin section to contain fragments of lava and much fine-grained siliceous (?) material in the matrix.

The red and purple basaltic series of rocks with which the Tiati Grit Series is associated is almost certainly comparable with the Samburu Series of Shackleton (1946, pp. 29–31), which he considers is of Miocene age. It is therefore assumed that the Tiati Grit Series is also of Miocene age, and that it may be correlated in part with Shackleton's Miocene sub-volcanic sediments (op. cit., p. 27). Shackleton noted that in one place—in the Ngare Narok valley—these sediments overlie lavas. He believed that the deposits may have been laid down in lakes formed where valleys were dammed by lavas flowing into them. There is no indication in the present area that the deposits infill old valleys, and it seems more probable that they were deposited in shallow pools on the Basement System surface or on the surface of earlier lava flows during periods of inactivity and erosion between eruptions.

There is some evidence that the sediments have been affected by minor faulting. Contortion and apparent brecciation is present in places, associated with small-scale chalcedonic veining of the type noted elsewhere in obviously faulted localities.

(*c*) *Tertiary Silicified Superficial Deposits.*—A further series of sedimentary rocks of somewhat obscure relations may be included here. They form a series of ten elongated conical hills at the foot of the Elgeyo escarpment, stretching from three miles east of Lomut to about four miles north of Tot, and trending in a generally north-north-westerly direction. When seen from a distance these hills are noticeable features, having a brick-red colour. The most northerly hill lies a short distance away from the foot of the scarp. The next hill to the south (4,120 feet) consists of the same bright red material apparently banked against the scarp, the contact not showing any signs of faulting or movement. South from this hill the remainder of the occurrences diverge from the escarpment across the embayment in the scarp-line in which lies the village of Chesagon.

Outcrops are rare on these hills, the surface usually consisting of a mass of tumbled blocks and boulders. In only one case was any indication of strike obtained, and this was on the hill 4,150 feet, south of Chesagon, where the dip and strike appeared to be conformable with that of the surrounding Basement System. The material here appears to be brecciated and is veined with chalcedonic quartz. Some of it is recognizable as sheared Basement System gneiss. Specimens 26/329, 330 and 331 are from this locality. The first is a pink and white rock with sheared-out colourless quartz, milky chalcedonic veining and limonitic patches. The second is purple and white and has a more fragmental appearance, with the same chalcedonic veining. The third, of buff and purple colours, appears to be sheared and brecciated, the colourless quartz appearing as lenticles and streaks. Much brown limonitic material is present and small chalcedonic veins ramify throughout the rock. In thin section the three specimens are similar, consisting of sheared out lenticles of strained quartz, shattered and displaced felspars, and a matrix of calcite and chalcedonic silica associated with amorphous limonitic material.

Specimens 26/332 and 333 were taken from Kebeg hill, north of Chesagon. The former is a fine-grained, siliceous, purple, grey and buff-coloured rock, consisting of angular fragments which appear to have been welded together and replaced by silica to form a hard flinty mass. In thin section a few grains of quartz are recognizable, the remainder of the rock consisting of limonitic material and chalcedonic quartz, the last apparently having replaced all the original constituents. Specimen 26/333 is a deep purple in colour and appears to be of a similar nature.

Specimen 26/241 was taken from the most northerly of these hills. It is a yellow limonitic gritty rock with a few patches of quartz. An elongate, curved body with the appearance of silicified fossil wood is present, but no structures were detected in thin section to confirm its nature. The essential constituents of the rock are sheared and strained quartz grains, limonite, and chalcedonic quartz, with small amounts of sericite and calcite.

Specimen 26/240 from the next hill to the south (4,120 feet) is a fine-grained limonitic rock varying from bright yellow to brick-red in colour. It appears undoubtedly fragmental in parts, and minor chalcedonic veining is present. In thin section the groundmass is seen to consist of granulose opaque limonitic material. Some irregular patches which appear to have been originally fragments are replaced by chalcedony. A few strained quartz grains are present, also small amounts of sericite and calcite, and a small muscovite flake.

Petrographic examination is not of great help in determining the nature of these rocks. It is apparent on field examination however that brecciation and silicification, of the types noted in other faulted localities in the present area, have occurred. The linear arrangement of the hills also suggests association with a fault. Some of the material examined is undoubtedly derived from Basement System rocks, some, although now completely altered, appears to be more probably of volcanic or sedimentary origin and, in addition, fossil wood may possibly be present. It is therefore suggested that these occurrences were originally unconsolidated superficial deposits in Tertiary times, and that the rise of hydrothermal silica-bearing solutions along fault-lines provided a cementing medium, so that they are preserved at the present time and mark the positions of the faults.

Deposits of a rather similar nature have been described by Hepworth (1953) from the Bombo area, north of Kampala, in Uganda. Here there are long, narrow ridges of crush breccia and conglomerate, often of a deep red colour, cut by veins of white quartz. The red colour is attributed to haematite, probably derived by surface solution from laterites, and Hepworth believes that the quartz, which occurs as veins and infills the joints in the breccia, is of metasomatic or hydrothermal origin. He dates the movements when the red breccias were formed as post-Miocene, with a possibility of further movement later than the maturation of the end-Tertiary surface.

(2) Tertiary Volcanic Rocks

Volcanic rocks occupy a large part of the area lying east of the line Kailongol-Masol-Chepkum, and it is probable that they originally covered the whole of this part of the area and possibly extended west of the line in some places. Over much of this area the volcanic cover is thin, but in some localities it appears to be of great thickness and it would seem that the lavas and tuffs have been deposited on a rather uneven surface of Basement System rocks. Two main groups of volcanic rocks may be recognized, forming (*a*) a Lower Volcanic Series, and (*b*) an Upper Volcanic Series.

(*a*) *The Lower Volcanic Series.*—Rocks assigned to the Lower Volcanic Series occupy a large part of the country between the Kerio river and Tiati in the southern half of the area under consideration, and the greater part of the eastern third of the northern half. The rocks are in all cases highly weathered and are often poorly exposed. They are usually brick red, purple, pale grey or buff in colour, and are of fairly uniform appearance throughout the whole area. The essential rock types are porphyritic basalts and tuffs of basaltic composition, the latter predominating, especially south of Kula.

The tuffs are well-stratified (e.g. specimen 26/290, from the Kerio river south of Amaler) and often apparently graded as if they have been deposited in water (e.g. specimen 26/293A from a quarter of a mile east of the Kerio river near Amaler). In the area between Chepkum and the Kerio river torrential streams flowing from the escarpment in wet weather have cut gorges up to 50 feet deep, some of which reveal sections of bedded and graded tuffs. In places these tuffs can be seen to fill hollows in a previous surface, in well-stratified layers, leaving little doubt that in this particular locality the tuffs were deposited in water. Generally the tuffs are fine-grained soft friable rocks and are disappointing in thin section. They do however appear to be of basaltic composition. In some localities, especially between Kalossia and Kula, small amounts of fossil wood were found associated with the pyroclastics.

Rare fragments of lava recognizable as basalt, trachyte, or phonolite are present along with fragments of phenocrysts of felspar of the composition of sanidine, orthoclase or anorthoclase. Occasionally fragments of aegirine-augite phenocrysts were also recognized. In the matrix the greater part of the material is fine-grained and limonitic. Grains of iron ore are sometimes present, and chalcedony, secondary calcite, and spherulitic zeolite (cf. natrolite) were seen in some examples.

Some of the tuffs may be classed as *ignimbrites*, i.e. welded tuffs, formed by the eruption of clouds of fine dust and ash in an incandescent state, the resultant rock being fine-grained, somewhat porcellanous, and welded into a homogeneous mass. Specimen 26/350, from five miles west of Tiati, is of this type, and contains some rounded bodies with what appear to be chilled margins, bodies that may have been formed by the rolling of aggregates of incandescent material before cooling and consolidation. Fragments of such bodies are also abundant in the rocks. Specimen 26/286, from one and a quarter miles east of Amaler, is an example of another type. It resembles a rock formed from ejectamenta like Pelee's hair, subsequently infilled by zeolitic matter. It contains pools of clear analcite as the final material to crystallize.

The greater part of the pyroclastics are fine-grained pumice or lapilli tuffs, but there are occasional more agglomeratic patches. Specimen 26/294, from one mile east of the Kerio river at Amaler, is a coarse black and white rock with lava fragments up to two inches in length. The base contains fine-grained material, limonite and chalcedonic quartz. Specimen 26/296 from some two miles further east, is of a similar nature, but harder and porcellanous. Calcite occurs in the groundmass in addition to chalcedony, and altered lava fragments and felspar crystals are present.

The lavas, which are not often found *in situ*, are subordinate to the tuffs, and unweathered specimens are comparatively rare. In fresh specimens the characteristic lava is a black, fine-grained, rusty-weathering basalt, having black, shining pyroxene phenocrysts, and elongated white or glassy plagioclase phenocrysts. In thin sections pyroxene is almost always found as euhedral phenocrysts of purplish, slightly pleochroic titan-augite, exhibiting zoning and hour-glass structure, or as pale green zoned augite. Felspar is represented by phenocrysts of labradorite-bytownite, usually zoned with more sodic borders. Olivine is nearly always present in subhedral form, partly or completely altered to serpentine and iddingsite. The groundmass consists of plagioclase felspar microlites and granular crystals of pyroxene and olivine. Iron ore is often abundant and flakes of red-brown mica are sometimes present. Specimen 26/274A, from the ford across the Kerio river on the Kolloa-Amaler road, is a typical example.

In certain localities, for example on the river two to three miles south-west of Kolloa, the basalts exhibit curved surfaces resembling those of pillow lavas, but it was not evident whether, in fact, they are true pillow lavas, or whether they were undergoing spheroidal surface exfoliation or weathering.

A small area of trachyte was located some 13 miles east of Amaler, apparently lying within the series of basalts and tuffs. The rock (specimens 26/303 and 305) is purple and medium-grained with felspar phenocrysts up to 8 mm. in length. In thin section it is seen to consist of phenocrysts of sanidine in a groundmass of fluxionally orientated orthoclase prisms, limonitic patches and some interstitial quartz. Trachyte float blocks were noted in a few other localities, notably in the river four miles north of Kolloa on the Kolloa-Amaler track. Shackleton has noted the presence of a trachyte of somewhat similar appearance at the base of the Samburu Series in the Langat gorge (1946, p. 31).

The Lower Volcanic Series as a whole appears to be comparable with the Samburu Series as described by Shackleton (op. cit., pp. 29–31) in the Nanyuki–Maralal area, points of similarity being numerous. The Samburu Series consists of red and purple tuffs and lavas, underlies phonolites, and rests on Basement System gneisses. Shackleton noted regular stratification of the tuffs, indicative of deposition in water, and questionable pillow structures in the lavas. Petrographically the basalts are closely comparable. Shackleton states that the Samburu Series greatly resemble the older basaltic series of Miocene age of the Lake Rudolf region, and that the two should almost certainly be correlated. The rocks of the Lower Volcanic Series are also comparable with the Miocene basalts and tuffs described by Fuchs (1939, p. 231) from the Losidok hills, which lies on the western shores of Lake Rudolf, some 85 miles north of the present area.

(*b*) *The Upper Volcanic Series*.—Phonolitic lavas occur as isolated occurrences on rocks of the Lower Volcanic Series and the Basement System. The larger outcrops present smooth surfaces dipping at low angles to the west, and usually with well-marked edges, they are not so completely dissected and weathered as the members of the lower series. Nevertheless, from the distribution of the phonolites it would seem that they once covered a much larger area than at present, and they must therefore have undergone considerable erosion. The lavas fall into two areal divisions, one in the north-eastern part of the area (i.e. generally east and north-east of Amaler) and the second south and south-west of the Tiati area. On the evidence of the occurrence of isolated patches of phonolite in the Kakore pass, between Laiteruk and Kailongol, and in the pass south of Laiteruk it appears that tongues of phonolite once extended part way through these passes, and it is probable that the other, larger remaining phonolite outcrops in the northern half of the area were once joined into a continuous sheet, which had its origin somewhere further east.

The Mugor-Tiati-Kito Pass range, at that time probably in a somewhat different form, appears to have prevented the southern phonolite flows from reaching the northern part of the Tiati area. The tongues of phonolite stretching northwards from the southern border are the northern limit of the phonolite flows that cover the plateau of Kamasia, and from the relative absence of float blocks north of their present boundaries do not appear to have extended far beyond their present limits in the past.

The phonolites are similar over the whole area, being dense fine-grained, black or dark grey-green rusty-weathering lavas with occasional platy white felspar phenocrysts. In thin section they are seen to have a microcrystalline base containing about equal proportions of mafic and felsic minerals, the latter sometimes exhibiting a somewhat trachytic arrangement. The dark minerals tend to form mossy aggregates disseminated throughout the rock and consist of green aegirine-augite and aegirine, dark brown cossyrite, pale mauve kataphorite, rare dark blue riebeckite, and iron ore. The groundmass also contains abundant nepheline idiomorphs, micro-crystalline felspar prisms, and small amounts of interstitial analcite. The felspar phenocrysts appear to be anorthoclase. Secondary calcite is present in some specimens, and zeolite, probably natrolite, with radiating habit. Specimen 26/327 from the Kolloa-Kabarnet track on the south border of the area is typical.

The phonolites are similar to the Losiolo Phonolites north of Lorogi described by Shackleton (1946, p. 34), with which they can be correlated. They are of the Kenya type as defined by Campbell Smith (1931, pp. 229–236). Shackleton considered the Losiolo Phonolites to be of Miocene age (op. cit., p. 3), overlying the Rumuruti Phonolites, which in turn rest on the Samburu Series. In the area at present under consideration the Rumuruti Phonolites do not appear to be represented. Considering the wide areal distributed of these phonolites it would seem more probable that they were erupted from some north-south fissure, or series of cones grouped along the line of a fissure, to the east of the present area along the line of the Rift Valley, rather than from an isolated cone. This possibility was first noted by Walcot Gibson (1893, p. 563).

(3) Pleistocene Sediments

Near Kolloa, and also further south on the Kolloa-Kabarnet track, there are patches of horizontally bedded sediments up to ten feet in thickness resting on the surface of the plain. The sediments are buff-coloured, fine-grained grits, friable and poorly consolidated, and at present in the process of being rapidly removed by erosion. They do not show any signs of current or graded bedding, but may well be waterlain.

In thin section (specimen 26/325, from between the Kerio bridge and Kolloa) the rock is seen to consist of abundant fragments of streaky pumiceous lava, occasional grains of fresh glassy lava, fragments of crystalline lavas and felspar. Also present are small grains of aegirine-augite, riebeckite, sphene, quartz and biotite, i.e. the rock contains material derived both from the Basement System and from volcanic sources. No fossils were located in the sediments.

These beds resemble and may perhaps be correlated with the silts and stratified tuffs (Uaso Nyiro Beds) of Pleistocene age described by Shackleton (1946, p. 40) from west of Nanyuki.

(4) Recent Deposits

(*a*) *Gypsum*.—Small amounts of gypsum can be found on the ground and in small veins in a clayey deposit about three miles north of Amaler. The deposit appears to be superficial and formed by the evaporation of saline solutions derived either from the leaching of decomposed volcanic rocks or from ascending hot springs.

(*b*) *Sandstone Dykes*.—In the same locality a dyke-like rock is seen, standing a few inches above ground-level and crossing mounds of clay. The rock is hard, fine-grained, and buff-coloured, with some darker specks. In thin section (specimen 26/261) the rock is seen to consist of angular and sub-rounded fragments of quartz and felspar (plagioclase, orthoclase and microcline) in a calcareous cement. An analysis of the rock has been included in Table 1 for the purpose of comparison with the Turkana grits.

Specimen 26/312 from the left bank tributary of the Kerio river north of Amaler is representative of a similar, but narrower, sandstone dyke of rather coarser grain. In thin section it is seen to consist of unsorted, angular grains of strained quartz, orthoclase, microcline, and sodic plagioclase, with a little magnetite and garnet, in a semi-calcareous cement.

The constituents of the dykes are the same as those of the present-day surface sands. At sometime in the past such sands have been washed into joints and cracks in nearby rocks and have there been consolidated and indurated by the downward percolation of surface solutions, resulting in some cases in a rock more resistant to weathering than the original host, which in the course of time decomposed to clay, leaving the sandstone dyke standing above the surface.

(*c*) *Black Cotton Soil*.—The formation of these soils is usually attributed to conditions of bad drainage. As has been mentioned previously black cotton soil occupies a belt about two miles wide and fourteen miles long, north and east of Lomut. In wet weather the belt becomes a marsh and the passage of vehicles on the tracks across it is difficult or impossible. On drying out the surface is far from smooth and is crossed by deep wide polygonal cracks. A pit dug by prospectors some five miles south of Rorok revealed a depth of over twelve feet of black soil without reaching any solid formation.

(*d*) *Boulder Beds*.—The banks of the Kerio river north of Amaler are formed of boulder beds and torrential conglomerates, now in the process of being reworked by the river. The boulders and pebbles are of volcanic and Basement System origin. It is concluded from the occurrence of these deposits that at one time the rivers were far larger than they are at the present day.

(*e*) *Surface Sands and Gravels*.—The surface of the plains is covered by red and brown sands and gravels, the main constituents of which are derived from the break-down of rocks of the Basement System. Where the sands also contain material derived from volcanic rocks they tend to be of deep brown or purple colour.

(*f*) *Lateritic Ironstone* (*Murram*).—Murram was noticed locally on top of the phonolites in the southern part of the area.

3. Minor Intrusive

Microfoyaite.—A small dyke of microfoyaite was located in the extreme north of the area, in the Chapei District. It appears to be intrusive into Basement System gneiss and to be overlain by porphyritic olivine basalt. The rock (specimen 26/311) is fine-grained, silver-grey and white, with small patches of green, black and red-brown mafic minerals. In thin section the dark minerals are seen to be green aegirine-augite, often rimmed with aegirine, cossyrite, and small amounts of kataphorite. These minerals form a relatively coarse rock in association with orthoclase or anorthoclase tablets (up to 1·75 mm. in length) which exhibit trachytic texture. The felspars tend to be turbid and often enclose small needles of aegirine-augite and crystals of cossyrite. There are scattered well-shaped crystals of nepheline up to about 0·3 mm. across, now pseudomorphosed by analcite or a zeolite. A euhedral and subhedral colourless to pale brown isotropic mineral having a refractive index less than that of balsam is probably hauyne, and is also patchily replaced by zeolitic minerals. Small amounts of interstitial analcite and occasional calcite are present.

The rock corresponds closely to other minor intrusives identified as microfoyaites and hedrumites, which have been located further in Turkana by Champion at Nakapelokorok and Kosekria, and described by Campbell Smith (1938, p. 510). Comparable minor intrusive rocks in Nyasaland are known to be post-Karroo, and in Uganda are of Tertiary age.

4. Metamorphism

The Basement System was subjected to regional dynamo-thermal metamorphism after its formation. With the exception of one small area in the north, however, in the vicinity of Leathetom, minerals such as kyanite and sillimanite which are indicative of a high degree of regional metamorphism are absent. The majority of the rocks contain hornblende, biotite and garnet, and are characteristic of the meso-zone of Grubenmann, in which intermediate temperatures and high directed pressures were operative. According to the metamorphic facies concept of Eskola the rocks belong to the Epidote-Amphibolite and Amphibolite Facies (Turner, 1948).

The sillimanite-bearing gneiss of Leathetom may be indicative of a zone of higher-grade metamorphism, or alternatively the sillimanite may have been introduced at a later stage by metasomatic acitivity. The presence of almandine garnet in association with the sillimanite tends to suggest that the former is more probably the case. Sanders (1954) has commented on the status of sillimanite as an index mineral of metamorphic grade in the Basement System in Kenya and concluded that as granitization destroys sillimanite and as there is little evidence of the metasomatic introduction of sillimanite in the granitoid gneisses, some confirmation of the status of this mineral as a high grade metamorphic index is provided.

Junctions between the volcanic rocks and the rocks underlying them are invariably poorly exposed or not exposed at all and no evidence was obtained of any contact metamorphism that may have been caused by the pouring out of the Tertiary lavas.

5. Structure

(1) General

Basement System.—The foliation strike of the Basement System rocks of the area is constant at a few degrees either side of due north and south, with the exception of a few areas of local contortion, or where affected by faulting (*see* Fig. 6). In general the strike of the foliation parallels the original sedimentary bedding. Dips are usually steep to vertical and predominantly to the east so that folding is probably isoclinal, but there is some suggestion of open folding in the Kailongol-Masol range.

Lineation was not often detected, but where recognized it tended to pitch at low angles to the north-north-east, or more rarely to the north.

Turkana Grit Series.—The sediments of the Turkana Grit Series usually exhibit low dips in a westerly direction or are horizontal. In the Lolmorton river area, however, the dip appears to be to the east, as it is also locally on the low ridge to the west of Rorok, where it is a result of faulting in a predominantly westerly-dipping sequence. In the area west of Rorok a major system of jointing occurs on a bearing of 316° (true), and a less well-developed system on a bearing of 12° (true).

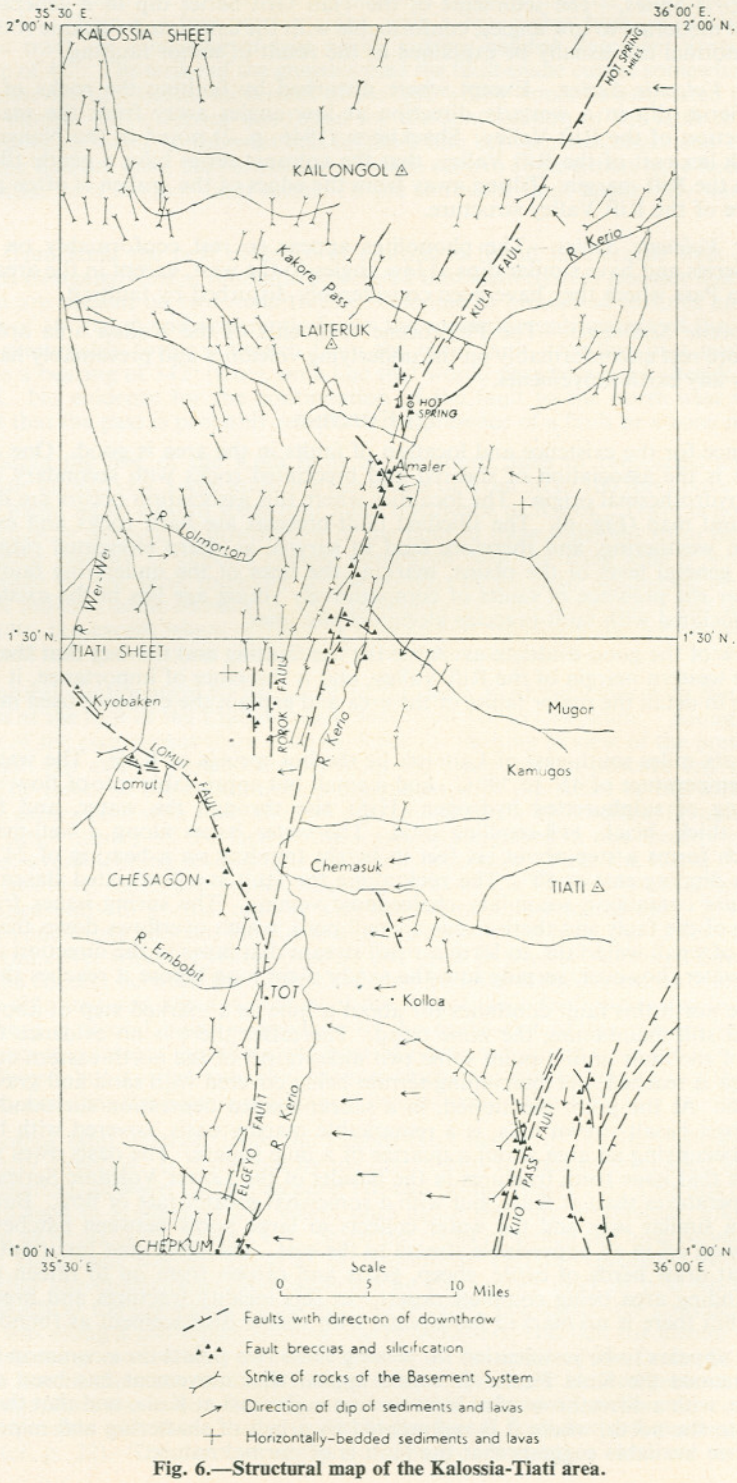


Fig. 6.—Structural map of the Kalossia-Tiati area.

Tiati Grit Series.—The sediments of the Tiati Grit Series dip in a generally westerly direction at moderate to low angles, conformable with the associated volcanic rocks. Steeper dips than normal can usually be explained as the result of minor faulting.

Lower Volcanic Series.—Except where disturbed by faulting the rocks of the Lower Volcanic Series dip in a westerly direction at low angles away from the margin of the Baringo section of the Rift Valley. Shackleton (1946, p. 2) noted in the Nanyuki-Maralal area, which lies east of the Rift Valley, that the volcanic series have a gentle tilt eastwards away from the Rift margin. Tilting away from the edges of the graben is often a characteristic feature of the Rift Valley structure.

Upper Volcanic Series.—The phonolites appear to rest conformably on the Lower Volcanic Series and have similar dips at low angles to the west, except in the area north-east of the Kito Pass where they have been considerably disturbed by faulting.

Pleistocene Sediments.—The Pleistocene sediments of the Kolloa area are horizontal and therefore rest unconformably on the underlying volcanics and presumably have not been affected by any earth movements.

(2) Faulting

Evidence for the existence and location of faults in the area is good. One of the main indications is the association of sheared and brecciated rocks with secondary chalcedonic quartz of hydrothermal origin. The localities where this association occurs are indicated on the structural map (Fig. 6). The silicified fault-breccias are hard rocks and exceptionally resistant to weathering, and therefore tend to survive as sharp elongated ridges standing above the general level of the plains, marking the lines of the underlying faults. Further evidence for the presence of faults of comparatively young age lies in the existence of hot springs associated with fault-breccias along definite lines.

In view of the good evidence available for the faulting and the fact that the area forms part of the western margin of the Rift Valley, and is therefore of importance, it is proposed to describe in detail the major faults of the area and explain the evidence used in fixing their position.

Some six miles south-east of Laiteruk lie the hot springs of Kula. The water is saline, having a temperature of 45° to 50° C., and a small but appreciable rate of flow. Bubbles of gas smelling of sulphuretted hydrogen (H_2S) rise through the water, and through the associated thick, black, evil-semlling mud. The water issues along a well-marked fault-plane which forms a step about six feet in height trending on a bearing of 24° (true), the fault-plane dipping east at 80°. The rock along the fault is a brecciated Basement System biotite gneiss containing secondary chalcedonic veining. The spring issues from the up-throw side of the fault and there forms a small pool, which overflows down the fault-plane as a series of small waterfalls, to form a small stream that flows in the direction of the Kerio river, the water, however, seeping into the sandy plain long before it reaches the Kerio.

To the north this fault continues for about a mile as a marked step of about the same height, and still maintaining the same trend. Thereafter there is no evidence for the continuation of the fault until a point some two miles north of the north-eastern corner of the present area is reached, the intervening terrain being covered with sand and gravel and lava float blocks. At the point mentioned, in a saucer-shaped depression surrounded by completely barren basalt-strewn hills, is a remarkable marshy oasis, covered with bright green grass and occupying an area about a quarter of a mile square. The oasis owes its origin to hot springs that issue from fractures in the basalts of the Lower Volcanic Series, at slightly lower temperatures than at Kula, but with a somewhat greater rate of flow. Bubbles of gas escape in a similar way and the water collects in large pools between patches of marsh, before flowing off in an appreciable stream to the east. The water and luxuriant grass are a magnet that draw herds of cattle, sheep, goats and camels from up to fifteen miles away, the surrounding area being complete desert. In this locality fractures and brecciation are apparent, but there is no marked fault-plane with visible displacement as found at Kula.

There appears to be justification for joining these two points on a common fault, which has been named the Kula Fault. It would appear that movement has been of relatively recent date, with a downthrow of at least six feet to the east at Kula, and that the movement decreased to the north, where it is represented by a belt of shattering and minor fractures. The evidence available suggests that the fault is of normal nature.

On the road some two and a half miles north of Kula marked faulting on a branch fault is visible. There is a low narrow ridge, only a few inches high, of silicified breccia crossing the track on a bearing of true north, cutting banded Basement System gneisses with a strike of 42°. The strike of the gneisses near the fault-plane curves somewhat and gives the impression of slight lateral movement of the type which would be associated with a fault of sinistral nature. No evidence was found for the continuation of the fault to the north, but it may possibly swing to the west and follow a line between Kailongol and Laiteruk on the site of the Kakore pass, the formation of which may to some extent have been governed by the presence of a fault or fault zone. To the south the fault apparently joins with the Kula fault.

South from Kula the next evidence of faulting is found in the area west of Amaler. Here low red elongated hills of limonitic brecciated Basement System gneisses with secondary silicification are present on two main trends. One line of brecciated features and outcrops has a strike of 10° (true) and apparently forms the southern continuation of the Kula fault. The other presumably forms a branch from the main fault, trending in a north-westerly direction on a bearing of 342° (true), on a line that would pass between Laiteruk and Masol if extended. No evidence for the continuation of the fault to the north-west was found, but it is felt that the pass is probably related to the presence of a fault or a zone of fractures.

Continuing the line of the Kula fault to the south, hills of brecciated and silicified gneisses occur at intervals, some attaining elevations of from 50 to 100 feet above the general level of the plain, up to a point some four miles north-east of Rorok. There is no indication of the direction or amount of downthrow of the fault in these hills, but from their increase in size and the amount of breccia present compared with the Kula area it would appear that movement on the fault increases to the south. In the area north-east of Rorok the breccia hills indicate some increase in the complexity of the fault pattern and the presence of cross-faults, but except where revealed in this manner the faults are not traceable, due to the thick sand and gravel cover, and their full extent is uncertain.

The natural continuation to the south of the Kula fault coincides with the line of the Elgeyo fault at the foot of the Elgeyo escarpment from Tot to Chepkum. Along the foot of this section of the escarpment there is no evidence for faulting in view of the presence of the large outwash fan and of slipped masses from the scarp, which obscure any possible indication. The trend of the escarpment is coincident with the strike of the rocks, and the slope of the escarpment with their angle of dip. Conditions are, therefore, favourable for the slipping of large masses off the face of the scarp, as happened in one locality in relatively recent times, overwhelming several huts and their occupants. Near the Kerio river, east of Chepkum, however, faults are visible, affecting lavas of the Lower Volcanic Series. These faults are apparently of normal nature, with small downthrow to the east. It seems likely that a fault-zone exists between the Kerio and the escarpment here, the faults being hidden by the alluvial cover which is visibly over 50 feet thick in places. Although direct evidence is lacking the contact between the Lower Volcanic Series and the Basement System gneisses is probably a faulted one, the downthrow of the Kula-Elgeyo fault increasing in a southerly direction from a pivotal point somewhere to the north-east of the present area. In the Chepkum area it is evident that there was post-Miocene movement since the Lower Volcanic Series is affected, but it is believed that the movement was posthumous along the line of an old fracture, and that the Elgeyo escarpment existed before this time in a modified form.

The Lomut fault diverges from the Elgeyo fault north of Tot and follows a roughly north-westerly direction. It is marked by the line of hills formed of brecciated and silicified Tertiary superficial deposits that lie between Tot and Lomut (*see* p. 23). This line is continued to the north-west in Kyobaken hill, where once again shearing brecciation, and secondary silicification have occurred, (*see* p. 17). Since the rocks of which the hills between Tot and Lomut are composed contain material of undoubted Tertiary (probably Miocene) age, it follows that movement must have occurred on the Lomut fault in post-Miocene times, almost certainly at the same time as on the Elgeyo fault. But again it is considered that the movement was along a previously existing line of weakness, and that the Lomut escarpment is a fault-line scarp eroded back some distance from the plane of the fault. In the escarpment above Lomut there are minor faults and contortions in the banded gneisses, apparently of greater age than the major faulting, and probably related to earlier movements which may be comparable with those that give rise to the Nandi fault in the Kakamega-Broderick Falls area (cf. p. 22). The amount of posthumous movement that occurred on the Lomut

was probably small, and may not have amounted to more than a reopening of the old fracture, thus allowing the upward passage of the hydrothermal silica-bearing solutions that cemented the superficial deposits. The height of the escarpment decreases northwards from Lomut to Sigor and it is likely that the throw of the original fault also decreased fairly rapidly in that direction.

South from Chepkum the vertical displacement probably increases. Shackleton (1951, p. 372) states that the throw near Tambach is several thousand feet, and from the evidence he gives it seems likely that it must be large. Willis (1936, p. 286) calculated the throw as being not more than 2,000 feet, working on the apparent vertical displacement of the phonolites as found on the summit of the Kamasia range near Kabarnet and in the Elgeyo escarpment. Shackleton (op. cit., p. 373) gives the height of the top of the Miocene sediments in the Elgeyo escarpment at Tambach as about 6,200 feet. The eastward extension of the Miocene beds lies below plain level at the foot of the escarpment, i.e. below an altitude of about 4,000 feet, so that there must be a minimum vertical displacement of 2,200 feet. It is fairly certain then that in this locality, some 35 miles south of the present area, vertical displacement on the fault-zone in post-Miocene times amounted to more than 2,000 feet.

The Rorok fault and the fault running through the low ridge to the west of Rorok are undoubtedly part of the same system, and the minor fault in the Chemasuk area north of Kolloa, affecting rocks of the Tiati Grit Series, is also probably related and of comparable age.

Gregory (1921, p. 215) thought that the western boundary fault of the Rift Valley bifurcated in the north, the Plateau of Kamasia standing between the two branches. From the present survey it seems more likely, however, that the Kito Pass fault and associated faults to the east form the true margin to the Rift Valley. The Kito Pass fault is clearly marked, with brecciation, shearing, and secondary silicification, whilst the faults to the east, cutting the Lower and Upper Volcanic Series, give rise to brecciation, displacement, and contortion of the flows, with resultant steep dips. Lacking an accurate topographic map the amount of vertical displacement involved is difficult to calculate, but it would seem to be of the order of at least 1,200 feet, with a strong possibility of further step-faults, downthrown to the east, occurring to the east of the present area.

The true western margin of the Rift Valley proper in the writers' opinion therefore appears to lie along the eastern edge of the Kamasia plateau, passing through the area mapped east of the Kito pass, and thence east of Tiati. Recent movement along this line is indicated by the reported presence of hot springs on it at various localities east of Tiati. A pilot who has flown over the area a considerable number of times confirms that from the air the line of the western margin of the main Rift Valley is clearly defined, lying east of the Kamasia range and Tiati, whilst Lakes Baringo and Hannington lie centrally on its floor. As noted by Willis (op. cit., p. 286) the Rift Valley as a structural feature does not extend far to the north beyond Lake Baringo. East of the north-east corner of the present area it is not obvious, there being no marked step-faulted scarps, the country appearing as a very broad, low valley, occupied by the Suguta River, and extending north to Lake Rudolf.

All the faults mapped are normal and no evidence whatsoever of any thrust faulting was located. Movement occurred on all the faults in post-Miocene times, and it is probable that they were initiated in the Pliocene and continued into the Pleistocene, especially along those lines that still show evidence of hot spring activity.

VI—ECONOMIC GEOLOGY

1. General

No mineral deposits of importance were located during the survey and it must be pointed out that in view of the inaccessibility of the area a deposit would have to be of appreciable value before it could be worked economically. The pegmatite veins seen are of simple nature, with no signs of enrichment in economic minerals. Small amounts of graphitic gneiss were noted, but the occurrence was too small to be of any economic value, and it is unlikely that any greater quantities remained undetected. It was thought possible that some of the silicified fault-breccias and silicified superficial deposits might have been mineralized, but assay showed that this was not so, traces of zinc only being found.

"Colours" of gold can be obtained on panning the bed of the Kerio river at Amaler during the dry season. No trace of gold was located in any other river in the area. Prospectors have visited the area between Lomut and Amaler in the belief that diamonds are present. At least one pit has been dug in the black cotton soil with no success. It is considered unlikely that diamonds do actually occur in the area either in a pipe or as alluvials.

The rocks of the area are on the whole unsuited for building purposes. The tuffs and lavas of the Lower Volcanic Series are too soft and weathered to be of any use, whilst the phonolites and Basement System rocks split irregularly, and excavation and dressing would be difficult.

2. Water

Except during the wet season water is scarce over the greater part of the area. The nomadic inhabitants obtain their supplies from wells in the beds of the sand-rivers, progressively deepening them as the water sinks lower during the dry season, some of the wells attaining depths of over 20 feet in loose sand. The storage capacity of the sand-rivers could be greatly increased by the construction of sub-surface weirs at intervals along their courses, but it is considered that the present prospects of development do not justify such expense. There is little or no prospect of agricultural development as the climate is not suitable, and soil is absent over the greater part of the plains. The inhabitants of the plains are not agriculturists by habit. Where cultivation is carried on, on the slopes of the escarpment and in the Cherangani hills, good use is made of the available water of which there is normally no shortage.

Should the need arise, bore-holes sited near to the line of the larger sand rivers would probably be successful.

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