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GEOLOGY
OF THE KERICHO AREA

DEGREE SHEET 42, N.W. QUARTER
(with coloured geological map)

by

F. W. BINGE, B.Sc., A.R.S.M., A.M.I.M.M.
Geologist

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FOREWORD

The publication of the geological report on the Kericho area has unfortunately been delayed for several years. The first draft was completed in 1952, but in subsequent years more information was obtained on certain subjects dealt with, so as the report was redrafted and amended new information was added from time to time. This means that all parts of the report are not of equal date validity, but as the field-work cannot be revised at present, it is preferable that the report should be made available now.

The area described extends from a little south of Kericho northwards to the equator, and at its northern edge contains the Kibigori goldfield, which geologically is a detached section of the Kakamega goldfield. Gold was discovered near Kibigori in 1948, and the two small mines that were subsequently developed in it have been a valuable addition to the gold industry of Kenya at a time when output from the major producing field was receding. From records available in the Department it appears that some £347,000-worth of gold has been produced so far and silver valued at about £1,400.

Since the survey was carried out a chance test with a geiger counter by a prospector revealed that Buru hill near Muhorono contains radio-active rock, and it soon became evident that the hill is in fact a carbonatite centre, and that pyrochlore and monazite are present. The deposit is now being investigated by a mining company.

The work carried out during the survey was financed by funds from the Colonial Development and Welfare Vote.

Nairobi,
7th December, 1957.

WILLIAM PULFREY,
Chief Geologist.

CONTENTS

PAGE

Abstract

I—Introduction 1

II—Previous Geological Work 5

III—Geomorphology 7
1. Geomorphological Units 7
2. Erosion Surfaces 7
3. Drainage 7

IV—Summary of Geology 9

V—Details of Geology 11
1. Basement System 11
2. Nyanzian System 12
3. Bukoban System (Kisii Series) 15
4. Miocene Sediments and Tuffs 19
5. Tertiary Lavas 22
6. Pleistocene and Recent 39
7. Intrusives 43
(1) Granites and Granodiorites 43
(2) Acid Minor Intrusives 44
(3) Basic Intrusives 45

VI—Tectonics 45

VII—Economic Geology 48
1. Metallic Minerals 48
(1) Iron 48
(2) Radio-active minerals and pyrochlore 48
(3) Gold 48
(i) Alluvials of the Kano Plain 48
(ii) Lodes 48
(iii) Rock Corry Gold-mine (Kibigori Gold-mine) 49
(iv) Equatorial Gold-mine 52
(v) Koru Gold Claims 56
(vi) Songhor 56
2. Non-Metallic Minerals 56
(1) Limestones 56
(2) Phosphates 57
(3) Clays 57
(4) Sands and Gravels 57
(5) Building Stones 58
(6) Ornamental Stones and Grinding Wheels 58
(7) Road-stone 58
(8) Ground-water 58
(9) Alleged Diamonds 59
3. Water-Power Resources 59
4. Areas suitable for prospecting 60

VIII—Records of underground bore-holes 60

IX—References 66

ILLUSTRATIONS

Fig. 1.—Rainfall chart of the Kericho district 3

Fig. 2.—Tectonic map of the Kericho area 46

Fig. 3.—Surface plan, Equatorial and Rock Corry Gold Mines, with some sub-surface details . . . . . at end

Fig. 4.—Geological plan, Lil section, Rock Corry Gold Mine . . . . . at end

Fig. 5.—Underground development plan, Rock Corry Gold Mine . . . . . at end

Fig. 6.—Assay plan, part of Spur section, Rock Corry Gold Mine . . . . . at end

Fig. 7.—Assay plan, part of Lil section, Rock Corry Gold Mine . . . . . at end

Fig. 8.—Transverse sections, Rock Corry Gold Mine . . . . . at end

Fig. 9.—Dip cross-section, Equatorial Gold Mine . . . . . at end

Fig. 10.—Strike cross-section, Equatorial Gold Mine . . . . . at end

MAP

Geological map of the Kericho district (degree sheet 42, N.W. quarter), Scale 1:125,000 . . . . . at end

ABSTRACT

The report describes an area in the Nyanza Province of Western Kenya bounded by the Equator and 0° 30′ latitude S. and by longitudes 35° and 35° 30′ E.

Physiographically the southern half of the area consists of volcanic plateaus with dissected margins to the north of which lies the East Kano plain. This plain represents a former extension of the Kavirondo Gulf of Lake Victoria and it is bounded on the north by the Nyando fault-scarp and on the east by the volcanic mass of Tinderet.

The rocks exposed in the area include (1) granitoid gneisses of the Basement System; (2) highly sheared and faulted lavas of the Nyanzian System (Precambrian), invaded and metasomatised in the north by Kavirondo granite and in the south by cupolas of granodiorite; and (3) the Kisii Series (Bukoban System; Upper Precambrian?), unconformably overlying the Nyanzian in the south. At the head of the Kano plain which is covered by recent clays there are (4) Lower Miocene sediments (the Koru Beds) in whose upper tuffaceous horizons are intercalated the Kericho Phonolites, the vast extrusion of which is related to the formation of the Gregory Rift Valley. These lavas are overlain by (5) the Londiani rocks, which consist mainly of pyroclastics.

In the north-east, the Tinderet suite forms an independent volcanic group, and consists also of pyroclastics followed by a differentiated suite of lavas of minor extent ranging from nephelinite, through mela-nephelinite, augitite, and melilitite to the final porphyritic analcite basanite that covers the peak.

An account is given of the various rocks, their structure and tentative correlation. Deposits of economic value are described, with particular attention to the occurrence of gold in the Nyanzian near Kibigori.

GEOLOGY OF THE KERICHO AREA

I—INTRODUCTION AND GENERAL INFORMATION

This report describes an area of some 1,200 square miles situated within the Nyanza Province of Kenya. The area is bounded by longitudes 35° and 35° 30′ East, the northern limit lying along the Equator and the southern along 0° 30′ south latitude. It corresponds with sheet No. 117 of the Directorate of Colonial Surveys. The field-work was undertaken during the last three months of 1948, throughout 1949, and for a short period in July–August, 1951. The area was of interest as rocks of the Nyanzian System, in which the gold deposits of western Kenya most frequently occur, extend into it from the adjacent Sotik area to the south. In addition new gold veins had been discovered in 1948 near Kibigori in the north-western corner in rocks of the same age, and prospecting for gold was being carried out.

Maps

The area is covered by the topographic map of Kenya published by the army, Kisumu, E.A.F. No. 1551 (1:500,000), 1944. In 1950 and 1951, after the completion of the geological work, which entailed a considerable amount of topographic mapping to fill in the very inadequate cadastral sheets then available, uncontoured preliminary plots based on aerial photography were published by the Director of Colonial Surveys. The four sheets Nos. 117/I, 117/II, 117/III and 117/IV (1:50,000) cover the entire area of the report.

The original geological map was revised and replotted on the preliminary plots, the additional time involved by this work being justified by an increased accuracy of presentation. Form-lines at 200-foot intervals, based on barometric levelling were added. No corrections for temperature variations were applied, however, and accuracy is likely to have suffered in the Tinderet and Mau Forest areas, where height control points are lacking. When aerial photographs at a scale of approximately 1:30,000 were made available in the field the geology was plotted directly onto them, the data being subsequently reduced and orientated to fit the preliminary plots.

Communications

Communications are relatively good outside the Forest Reserve areas of the Mau and Tinderet. The main railway-line from Nairobi to Kisumu traverses the area from east to west using the Kipchoriet gorge as a means of descent from the 8,000-foot divide at Mau to Lake Victoria at about 3,726 feet. Where there are farms numerous motorable tracks join the roads, linking the main towns and feeding the railway at Lumbwa and Muhoroni. In the area of the tea estates around Kericho road communications are particularly well-developed. In general the main roads follow the relatively flat lava ridges at the higher elevations and descend by valleys or spurs to the Kano plain. The Kipsigis Native Reserve is less developed and motorable tracks are scarce and often impassable during the rains.

Certain areas have no communications other than foot and cattle-tracks. These include the large uninhabited areas within the Mau and Tinderet Forest Reserves and the area enclosed by the roads joining Kapsamonget, Sondu, Ahero, and Muhoroni. In this latter area a good alignment for a road connexion exists, however, along the fault-valley at the foot of the plateau south-westwards from Muhoroni, through Kapsorok to meet the Sondu-Ahero road at Jimo.

At the time of writing (1952) work has commenced on a new road from North Lumbwa over the col north-east of Tinderet into the Sakani valley. This will connect with the existing motor-track from Songhor to Equator.

General Physiography

Compared with the greater part of Kenya the area is notable for its strikingly verdant appearance, particularly on the high lava plateau of Kericho at an elevation of between 5,000 to 8,000 feet. In the southern part of the area the ground rises eastwards towards the 10,000-foot summit of the Mau ridge, passing from the open grasslands of the Kipsigis Reserve, gashed by deep gorges and valleys on the west, through a belt of tea plantations lying against the Forest boundary, into the dense forest of the Mau.

In the north-east, separated from the Kericho plateau by the deep valley of the Kipchoriet, Tinderet rises to over 8,100 feet from the plain on the west. Viewed from the plain, Tinderet has the typical appearance of a volcano, but this is less apparent from the south since the peak is joined by a shoulder, at little less than its maximum elevation, to even higher ground to the north-east in the region of Equator. The higher parts of the peak are thickly forested and constitute a forest reserve that abounds mainly with wild pig.

The central and western part of the area consists of a wide plain over which the Nyando River and its tributaries meander at an elevation little above that of Lake Victoria. This plain is bounded on the north by a precipitous scarp running parallel with the Equator, while to the south thick and deeply eroded lava flows wedge out towards the lake.

Outcrops

In general, owing to the rejuvenated nature of the drainage and the relatively high rainfall, outcrops are most numerous in the valleys. The plateau highlands and the forested areas carry a thick soil cover. In such localities exposures of the Tertiary lavas are extremely rare and in the forest the vegetation makes progress slow and geologically unfruitful. As a result the forests did not receive the attention devoted to the areas around Sondu, Muhoroni, Songhor and Kibigori. The Miriu valley, south of Sondu, was traversed in detail as the faulting in the Nyanzian and Bukoban rocks of that part of the area is complicated. The determination of the structure there is not, even now, entirely satisfactory, particularly in the extreme south-west corner of the area.

Owing to the age, shattering and high degree of hydrothermal alteration of the older rocks, identification in the field was by no means certain and despite microscope examination, some types of highly epidotized basalt and altered rhyolite cannot with certainty be ascribed to their correct system, whether Nyanzian or Bukoban. Some difficulty was also encountered in the Nyanzian rocks of the Kibigori area where the structure is complicated and requires mapping on a larger scale. Further east along the base of the scarp in the area between Chemilil T.S.* and Down T.S. differentiation between highly mylonitized granitic rocks, some of which are post-Nyanzian intrusions and others of Basement System age, remains uncertain.

On the higher slopes of Tinderet exposures are most numerous in the streams. Excellent exposures are available at lower elevation along the railway-line, which provides an east-west section of the volcanic succession that was mapped in detail by Maufe† as long ago as 1906.

The roads in the central valley area provide good exposures of rock from place to place from which a fair idea of the succession of lavas, tuffs and ashes can be obtained. Exposures along the hill-slopes between the roads are however poor, with the result that it is not possible to correlate with certainty the exposures seen on separate road traverses, particularly as the lavas and ashes lack marker horizons.

Vegetation

The grasslands of the Kericho district were originally covered by thick forest similar to that now preserved on the Mau. The grassy glades so typical at higher elevations on the western Mau are, in the opinion of M. C. Argyle of the Forest Department, the result of fire and clearing, and he considers that given protection they would be re-colonized by the forest. The glades occur notably on a fine compact white ash in the N.E. corner of the area, and it was in reply to a query whether this formation had any influence on the forest growth that the above opinion was received. Mr. Argyle also stated that irregular patches of bamboo occur in the west Mau Forest at about 8,200 feet, and on the S.W. Mau rather more thickly but at somewhat greater elevations of between 8,500 to 8,800 feet. These patches stand out clearly on the air-photos and have been included in the map as they are of value in identifying one's position where normal resection methods cannot be used owing to the thick forest growth.

Along the western edge of the West and S.W. Mau between roughly 7,000 and 7,800 feet there is a savannah zone of *Acacia*, well typified at Londiani, Kedowa and Lumbwa, but which is not encountered further south. Topographically it corresponds with the outcrop of later lavas, ashes and tuffs and is absent on the older phonolites in the Kericho area. A marked decrease in vegetation is also noted on leaving the phonolite and entering upon the Nyanzian formations on the Chemoisiet-Ngoina road in the south of the area. Hobley remarks that in 1918 the boundary marking the ancient forest clearings of the Sirikwa could still be seen, and remnants of the original forest survive today where they have been spared in some of the valleys around Kericho. Secondary growth has, however, sprung up between Jamji and Kitumbi as well as to the north of the Ngoina road.

*T.S. = triangulation station.

†References are given on p. 66.

The high rainfall forest of the Mau and Tinderet consists mainly of *Polyscias kikuyuensis*, *Macaranga kilimandscharica*, *Olea hochstetteri*, *Casearia battisocombei*, and *Fagara* sp. (satinwood).

On the Kano plains, tree growth is scanty and shade-trees are uncommon, probably due to the relatively heavy population inhabiting the area and the constant demand for wood-fuel.

Rainfall

The area competes with the Nyembeni hills north-east of Mount Kenya for the distinction of having the greatest annual rainfall in Kenya. Fig. 1, based on records from some thirty gauges listed by the East African Meteorological Department, indicates that the rainfall generally increases with elevation, leaving a narrow central area of lower precipitation (40 to 50 inches a year) following the valley of the Kipchoriet River from Lumbwa towards the Lake. Notably high falls of rain are recorded in the Mboga Vale area on the flank of Tinderet.

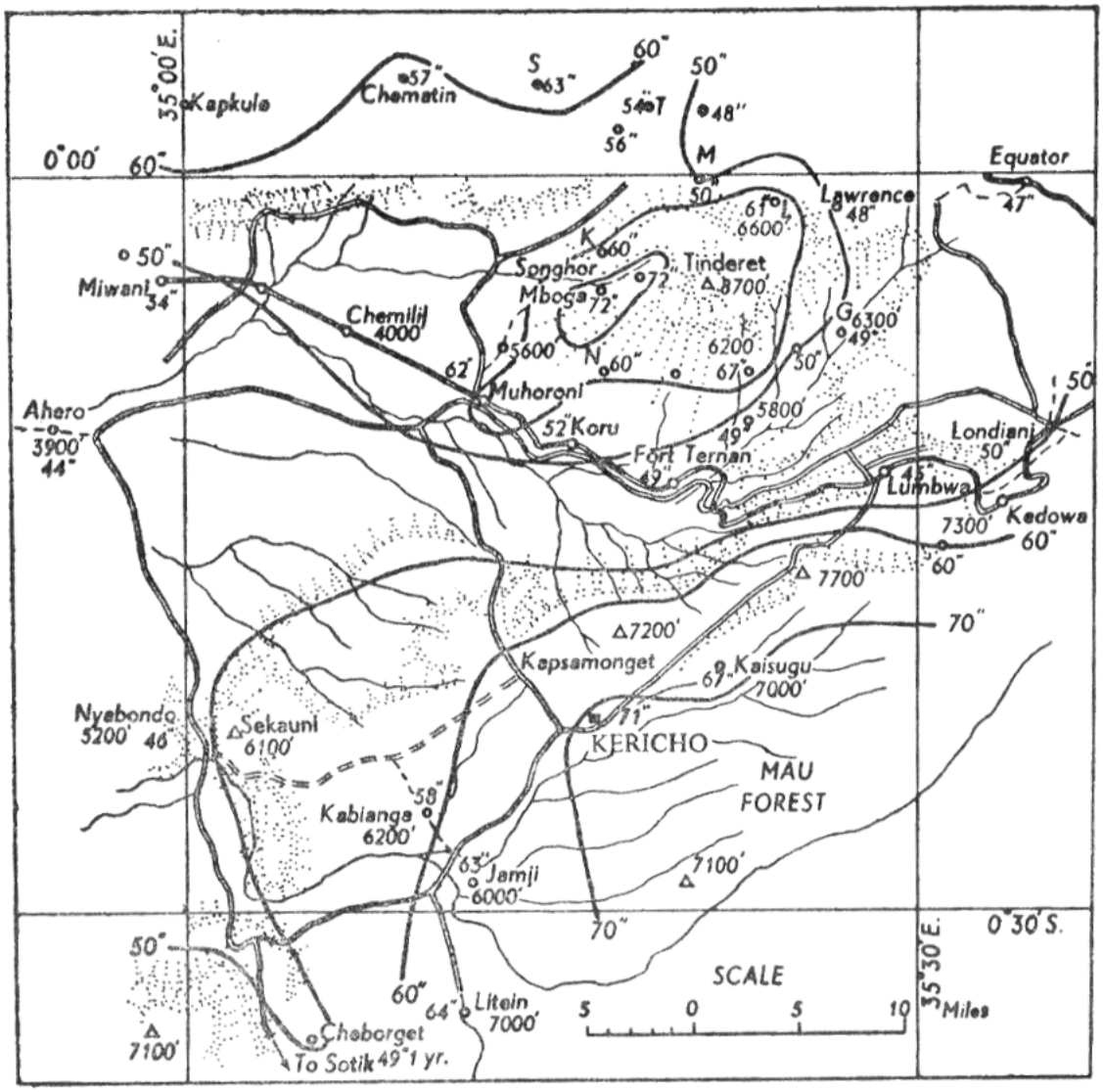


Fig. 1.—Rainfall chart of the Kericho District.*

The prevailing winds are north-easterly to easterly. While camped near Muhoroni in August it was particularly noticeable that the rainstorms rising to the east in the direction of Londiani swept either to the south-west along the Kericho highlands or broke away towards Tinderet, with the result that the Kipchoriet valley was relatively rainless.

* In the text the spelling Sekauani is used.

The driest month of the year is January when less than an average of two inches of rain is recorded. During the rest of the year the average exceeds five inches monthly, rising steadily to two peaks of intensity of about 12 inches in April-May and again in August, with a marked decrease in June.

Population

(*a*) Native Inhabitants. The most important tribe within the area is the Kipsigis, whose Belgut Reserve occupies some eight hundred square miles south of the railway-line, roughly from Lumbwa to Muhoroni. Their customs have been investigated and described in interesting detail by Peristiany (1939), who describes them as manly, reticent and naturally distrustful of strangers. Though originally a pastoral tribe of Nilo-hamitic stock, the Kipsigis are becoming increasingly agricultural and produce good crops of maize on their fertile locations. The greater part of the manual labour is undertaken by the women, as the idea that there is dignity or other benefit attached to work is unacceptable to the men. For this reason porters cannot be recruited from amongst them, which adds to the difficulty of surveying the more inaccessible parts of the Mau.

The Luo densely occupy the Kano plain and the area west of the Sondu valley. This tribe is Nilotic and unlike its neighbours, lives in family communities consisting of a group of huts generally strongly protected by an encircling thorn hedge.

A small area of the Nandi Reserve lies in the north-west corner of the area, north of the Kibigori-Songhor road. The tribe is closely related to the Kipsigis both in customs and language, being derived from the same stock.

The forest reserves are at present uninhabited. Their former extensions at the lower elevations near Kericho were largely cleared in by-gone days by the Sirikwa, the original inhabitants of the area, of whom no trace now remains apart from the pits marking the location of their dwellings. These pits are more fully described later (p. 43).

(*b*) European Farming. The lands alienated for farming by settlers are confined generally on the west by the Lumbwa-Sotik road, and are bounded on the east by the western and south-western Mau Forest Reserves. The Kericho area is coming increasingly under development for the production of tea by large companies utilizing the most modern methods, controlled by scientific and technical research. The north-eastern quarter of the area, with Lumbwa as a centre, is entirely occupied by farms, apart from the Tinderet Forest Reserve. This agricultural area extends westwards through Muhoroni and Songhor to Kibigori, mainly on the north of the railway-line. Cattle farming is generally practised at the higher elevations though maize is grown in the more open valleys. On the flanks of Tinderet there are coffee plantations and on the Kano plain, where the rainfall is less, sisal and sugar-cane are grown on large estates.

Schools and Missions, etc.

Government-aided elementary schools have been established in the Native Reserves. They are of indirect interest to the geologist as they provide landmarks, and are generally accessible by motorable tracks. There is a large Teachers Training School for Africans at Kabianga, south of Kericho, and in addition there are private missions of various denominations. One in Kericho is noted for the quality of its craft-weaving. Others are situated in the high valleys of Tinderet north of Fort Ternan. A Government Agricultural Station is sited at Lumbwa and a large Veterinary Quarantine Reserve at Kibigori.

Commercial

The products of the sisal and tea estates are processed in factories, the latter industry providing employment for more persons than the combination of all others. The standard of housing and welfare for African labour on the tea estates is particularly high.

An up-to-date workshop and small aerodrome is at present in operation at Fort Ternan.

Other commercial activities not already mentioned are related to the production of minerals in small quantities, mostly to meet local requirements. Limestone, however, is extracted in the Koru-Muhoroni area from deposits of Miocene age and calcined for a wider market. Gold is mined and milled on a small scale at Kibigori. Road-stone is dug by the Public Works Department from place to place but no large quarries of stone of notable quality are exploited.

The District Headquarters are at Kericho, which is a rapidly expanding small town with banking, hotel and the best shopping facilities in the area. A European primary school was opened there a few years ago.

Trading centres of secondary importance are Lumbwa, Muhoroni and Songhor. Local trading is carried out within the reserves at weekly markets, the chief of which are at Sondu, Maragwa, Kericho, Ladhri, Kiligis and Kibigori.

Acknowledgements

The kind hospitality and ready information received from so many residents in the area is most gratefully acknowledged.

II—PREVIOUS GEOLOGICAL WORK

The earliest map of the area in the Department is part of a topographical sketch of a much wider area published by G. A. Fischer (1895) as a result of a journey in 1885 and 1886. He crossed the Kano plain west of the boundary of the Kericho area, and sketched in the Nyando escarpment, under the name "Nandi Gebirge", as far east as Tinderet, where he showed the scarp as bending to the south and crossing the flank of Tinderet, to continue southwards onto the Kericho plateau. Other escarpments were shown that presumably correspond with the plateau edges between Sekauani and Kapsamonget.

In 1899 G. H. Gorges passed through the south-west corner of the area on his way from Naivasha to Lake Victoria, traversing the Miriu valley (Gorges, 1900). Four years later Prior (1903) gave petrographical descriptions of various rocks collected in the area by Sir Harry Johnston. He mentioned earthy limestone in alluvials of the Nyando valley (*op. cit.*, p. 231), nephelinites with melilite and perovskite in the hills on the north (*op. cit.*, pp. 234 and 250), and phonolites with abundant sphene and no soda amphiboles from other parts of the area.

The first account of detailed geological work was given by H. B. Maufe (Muff, 1908) who traversed the area in 1906 along the line of the Uganda railway. He pointed out (*op. cit.*, p. 22) that mica gneisses appear from below the volcanic rocks near Muhoroni and can be seen for about six miles thereafter, noted (*ibid.*, p. 30) that nephelinites occur along the railway on both sides of Lumbwa and Fort Ternan stations, and described the section exposed along the railway between Fort Ternan and Muhoroni (*ibid.*, p. 47). He pointed out that agglomerate and tuffs predominate among the volcanic rocks and that the lavas, being nephelinites and "melilite basalts", differ from those found on the east side of the Great Rift Valley. He showed that the volcanic rocks dip at a gentler angle than the slope of the country and that, therefore, older and older beds are met as one descends to lower levels. As a further consequence the same horizon sometimes extends for long distances in the railway cuttings.

In 1909 G. R. Chesnaye discovered the fossiliferous Miocene deposits at Koru and Muhoroni (Le Gros Clark and Leakey, 1951, p. 1), and in 1912 Goldschlag gave detailed descriptions of some of the volcanic rocks of the area. He described pantellerite, nepheline tephrite and phonolitic tuff from Lumbwa, and nephelinite from Fort Ternan.

In 1918 and 1921 several papers on the cave earths in the Kericho district were published by C. W. Hobley, A. Knight-Bruce and E. P. Cathcart.

Three years later Gregory (1921, pp. 121, 127–8), after traversing the route followed by Maufe, gave his account of the geology seen along and from the railway. He considered that the phonolite forming the Lumbwa plateau was the oldest volcanic rock in the area, comparing it with the Kapitian phonolite of central Kenya. He briefly mentioned the caves in the volcanic area, stating that they are excavated in a sheet of decomposed phonolite. The younger volcanics he divided into two, the melilite nephelinites of Tinderet of probably upper Pliocene age, and the phonolitic trachytes around Londiani, probably of lower Pliocene age. He compared Tinderet with Mt. Elgon, and noted that it is of later date than the faults bounding the Kavirondo Gulf rift valley. At the same time, however, he correlated the lavas of Tinderet with the nephelinites of Gwasi.

E. J. Wayland visited the area in 1927 (Wayland 1928, pp. 7 and 40) and examined the Miocene limestones at Koru. He described the finding of gastropods and animal bones and teeth in the beds.

In 1930 Wayland made a general reconnaissance of South Nyanza, and passed through Sondu and visited Kericho. He noted artifacts in gravels at Sondu. He observed the granites and lava caps between Sondu and the Kano plain, and lavas of the Kisii Series on the Kericho road (Wayland, 1931, pp. 8–9).

A. T. Hopwood visited the fossil localities at Koru in 1931 and published reports of his findings two years later. In 1932 L. S. B. Leakey and D. G. McInnes discovered the Miocene beds of Songhor (Le Gros Clark and L. S. B. Leakey, 1951, p. 1). Miss H. Bancroft published in 1933 an account of the fossil wood found in the tuffs associated with the Miocene beds at Koru. She identified two group-species, *Dadoxylon* sp. and *Helictoxylon* sp.

P. E. Kent investigated the Miocene beds at Songhor and Koru in 1935, though his results were not published until 1942 and 1944. In 1942 he published an account of the physiography and Pleistocene events in the Kavirondo Gulf area. On a sketch map he showed the southern boundary of the rift valley as an almost east-west fault, extending as far east as the longitude of Fort Ternan, and pointed out (Kent, 1942, p. 22) that south of Koru and Muhoroni the edge of the Kericho phonolites stands up as much as 1,500 feet above the valley floor. He considered the age of the faulting as probably middle Pleistocene. In a detailed paper (Kent, 1944 B, pp. 105–110) he described the various Miocene beds exposed and their succession near Legetet, Mnara and Songhor, and dykes cutting the volcanic rocks. He showed that at Koru thick nephelinites overlie a tuff series with intercalations of fossiliferous limestones and red clays near the middle and with red clays at the base resting on conglomerate containing gneiss pebbles. The fauna of the beds was listed. Kent correlated the Songhor–Koru successions generally with those at Rusinga (*op. cit.*, p. 112) and suggested that the Miocene beds along the Kavirondo Gulf rift valley may have been deposited in a large Miocene lake (*op. cit.*, p. 113 and fig. 1, p. 86). In his second paper Kent (1944 A, p. 18–19) concluded that the Tertiary lavas of the area are Miocene (post-lower Miocene) but that the phonolitic trachytes of the east, described by Gregory, might be post-Miocene.

F. Dixey in 1946 used Kent's results in a discussion of the relationship of the main peneplain of central Africa to lower Miocene sediments. He suggested (Dixey, 1946 A, p. 245) that the Kavirondo valley was a product largely of erosion in early Tertiary times, and that the mid-Tertiary peneplain was eroded across the Miocene sediments deposited in it. Dixey used the same ideas in a paper that followed soon afterwards (Dixey, 1946 B, pp. 341 and 353).

Shackleton worked in the area mapped in 1945 and 1947 and subsequently published a paper in which the structure of the Kavirondo Gulf rift valley and the extent and slope of the sub-Miocene peneplain are discussed (Shackleton, 1951). He presented a generalized map showing the distribution of the Miocene beds in the Songhor–Koru area and redescribed the Koru beds and the volcanic rocks associated with them. The thickness of the Koru beds at Legetet was put at 200 to 300 feet and it was indicated, on microscope evidence, that the sediments are probably non-volcanic and do not contain minerals derived from other known Tertiary rocks. At Songhor, however, it was found that the beds associated with the Koru limestone are tuffaceous and contain minerals of the Tertiary volcanic suite. The presence of the limestone on the up-faulted side of the escarpment north of Songhor was demonstrated, the throw of the fault being estimated at about 1,000 feet.

Shackleton made a quick traverse across the north side of Tinderet and found that the basic lavas of the lower slopes are overlain by phonolites. He also indicated that the phonolites of the Lumbwa plateau mainly overlie the southern part of the Tinderet volcanic pile, though some phonolites are intercalated in the Tinderet lavas. Discussing Tinderet (*op. cit.*, p. 376) Shackleton pointed out that it is not a volcanic cone as suggested by Gregory's figure (1921, p. 126), though it is probably near a centre of eruption or the remains of a volcano.

As a result of his work Shackleton concluded that there was no pre-Miocene valley on the site of Kavirondo valley and that it developed as a result of rift faulting.

Finally in 1951 and 1952 memoirs were published on some of the Miocene vertebrate fossils of Koru (Le Gros Clark and Leakey, 1951; Le Gros Clark and Thomas, 1952).

Unpublished reports resulting from visits by W. Pulfrey in 1944 and A. Huddleston in 1948, the former in connexion with the limestone at Legetet and the latter on a reconnaissance between Kibigori to Muhoroni, are available in the records of the Kenya Geological Survey.

The adjacent areas to the west, south-west and south have been geologically surveyed, and are described respectively in reports on the Kisumu area (Saggerson, 1952), the Kisii area (Huddleston, 1951), and the Sotik area (Schoeman, 1949). References are made in the text to the views of these observers in connexion with the geology under discussion. The areas to the north and east still remain unsurveyed.

III—GEOMORPHOLOGY

1. Geomorphological Units

The general physiography of the area has been briefly described in the Introduction. In this chapter the geological relationship of the major land-forms are discussed. The area can be divided into five general geomorphological units:—

(1) The eastern end of the Kano plain, consisting of relatively recent lacustrine and fluvial sediments resting upon granitoid gneisses of the Basement System.

(2) The east-west fault-scarp of the Nandi highlands along the northern edge of the area, where there is a faulted complex of Nyanzian and Basement System rocks invaded by granite and overlain to the east by lavas and pyroclastics derived from Tinderet.

(3) A range of hills in the south-west corner of the area, where there are the northern termination of the Bukoban System, small inliers of Nyanzian rocks, and intrusions of leucogranites and granodiorites. The hills controlled the direction of outflow of the Miocene phonolites to the west.

(4) The Kericho plateau which is covered by phonolites and occupies much of the south-eastern part of the area. Higher ground in the Lumbwa township area and along the eastern boundary is occupied by more nepheline-rich volcanic extrusions and pyroclastics derived from activity in the Londiani region.

(5) The volcanic mass of Tinderet, the greater part of which is covered by basanite, associated with earlier flows of various basic types of nephelinite in the north-eastern quarter.

2. Erosion Surfaces

Apart from the sub-Miocene surface in the Nyando valley there are no extensive exposed erosion bevels. The sub-Miocene surface extends southwards under the Kericho phonolites, the base of which is seen at 4,900 feet in three exposures in the Mumek gorge and at the same elevation in the Sondu area.

Another small but well-defined area of planation, into which the Chemoisiet river has incised its bed, exists in the south-west corner of the area. The phonolite again rests on this surface, which can be recognized also in the more eroded Chelemei area, south of Sondu. The surface now stands at about 5,700 feet, with monadocks of more resistant rock rising as small rounded hills to 5,900 feet, representing a slope of about 50 feet per mile to the north-west for the sub-Miocene surface (cf. Shackleton, 1951, pl. XXIV).

The interposition of a ridge along the line Marumbasi–Kapsamonget must be assumed to account for the remarkable extension of the Kericho phonolites towards Sotik in a south-westerly direction rather than westerly to the lake on the sub-Miocene surface, which would otherwise appear to present the steeper and more direct gradient. The phonolites flowed to the west only after the drainage basin to the south-west had been filled, when the latter flows could overtop the ridge and pour westwards onto the lakeward continuation of the sub-Miocene surface. Irregularity of the sub-Miocene surface is indicated by the different levels at which the phonolite rests on the Basement System rocks, for example south of Muhoroni the level varies from 4,400 feet to 4,700 feet, becoming more regular to the east at about 4,750 feet. West of the Sondu flexure* the phonolites dip more steeply indicating a westerly tilt of the surface at the flexure, the base of the series falling rapidly to 4,200 at Boror on the Kisumu–Muhoroni road. Eslewhere the base of the phonolite is obscured by alluvium.

3. Drainage

(1) General

The drainage of the area is controlled by the level of Lake Victoria to the west. This base-level now stands at 3,726 feet and was probably at some 4,200 feet at its maximum height in Pleistocene times. Two main rivers, the Nyando in the plain at the head of the Kavirondo Gulf, and the Miriu (Sondu) in the south-east integrate the drainage system to the Lake.

The Nyando is a young river on the old lake plain, fed from the Nandi highlands on the north by several youthful streams, most of which are perennial. At the base of the scarp these streams cut deeply through poorly sorted lenticular beds of coarse gravels, sands and sandy clays. To the east the Nyando divides into two main systems, the Ainomotua north

*See Fig. 2, p. 46.

of Tinderet, flowing along the Nyando fault-zone, and the Kipchoriet to the south, which erodes the junction of the earlier Tinderet suite of volcanics and the later phonolites of the Kericho plateau. In its upper reaches the Kipchoriet flows over the Londiani volcanics and a group of tributaries from the north-east has eroded the junction between the Tinderet and Londiani volcanics. Tinderet therefore has an almost complete circumferential drainage fed by the radial system off the peak itself. To the west of the present area the Nyando flows into a swamp before debouching into the lake. At the swamp it is joined by the Awach which rises in a rectangular pattern of gorges on the Kericho phonolite plateau in the neighbourhood of Sosiot. The severe erosion caused by these tributaries is stimulated by the post-phonolite warping along the Sondu flexure and the heavy rainfall on the plateau.

The southern and south-eastern portion of the area is drained by the Miriu. On previous maps this river is referred to as the Sondu and Yurith, but as neither of these names appear to be known in the locality they are not used here. The Miriu is a youthful river which has rejuvenated the sub-mature drainage on the phonolite plateau. In the Sotik area it has eroded southwards along the phonolite-Bukoban contact and captured the drainage from the Mau, which originally, being consequent in character, flowed in a south-westerly direction to the Mogorro.

The change of drainage pattern, as represented in the Mau forest in the south-eastern part of the area, is a notable feature. The immature parallel system of narrow V-shaped valleys with rounded interfluves found there probably developed as a result of the infilling of valleys by volcanic rocks of more recent date than the phonolites. Nephelinites and porphyritic pyroxene-rich phonolites were found above 7,000 feet in the Tatwakapsigesa area, north-east of Kericho, and similar types of later age than the Kericho phonolites may well extend over a large area of the upper forest region to the south-east. It was not found possible to enter the Mau to check this suggestion. At lower elevations a more integrated type of drainage is notably developed on the older phonolites. The streams here have also been rejuvenated and have eroded deep gorges in their middle reaches. The Chemoisiet, to the west of the main Kericho-Sotik road, demonstrates this well.

(2) Capture of the Sotik Rivers by the Miriu

The extension of the phonolites over the Kericho and Sotik area from north-east to south-west suggests the direction in which they were free to flow. As indicated above (p. 7) it is believed that the flow of lava to the west in the direction of Sondu was hindered until the later stages of eruption by a ridge on the sub-Miocene surface, and it is clear that the lavas were contained south from Sekauani by the entire length of the Kisii highlands. The resultant lava surface had a general slope to the south-west, and rivers began to flow down it. Originally the Chemoisiet must have flowed southwards to Sotik but a reversal of drainage occurred. Post-Bukoban and pre-Miocene faulting allowed the erosion of a gap through the Bukoban monadnock south of Sondu and this was exploited in Tertiary times by the Miriu river which had been strongly rejuvenated by the faulting on the southern side of the Kavirondo rift valley. The Chemoisiet and other streams in the Sotik area were captured. The southward extension of the Miriu was by means of the Thoimbili, along the Bukoban-phonolite contact, and resulted in the capture of the Kipsonoi, Sisi, Itare and Kiptiget streams, whose headwaters leave the present area in the south-east corner. Formerly the main river draining the Sondu area occupied the valley on the west of the Kekonge ridge, crossing eastwards from Maragwa at 5,400 feet towards the Kekonge gap. The valley now contains a beheaded misfit stream flowing from a wide swampy area part of which appears on the map just west of Maragwa. The stream flowing past Sondu at this time was not connected with the Miriu river but flowed south from Sondu.

Small falls are seen at Sondu and upstream in the deeply eroded valley through the Nyanzian at Kapruben, Rigonget and Tegabi.

(3) Drainage of the Kano Plain and Tinderet

The retreat of the shore-line of Lake Victoria in the Pleistocene period from Muhoroni to Kisumu, a distance of about twenty-eight miles, implying a lowering of water-level of some five hundred feet in the process, does not explain the peculiar incised meanders of the Nyando river in its lower reaches. The average gradient at the meanders is four inches per hundred feet (seventeen and a half feet per mile). The meanders are small and tight, and the incision into the sediments is steep-sided without slip-offs on the inner edge of the meanders. Oxbows are occasionally to be seen south of Kibigori.

These conditions indicate a relatively recent and rapid process of rejuvenation. The gradient in the meander zone shows that the plain has been tilted to the west. A greater degree of compaction of the off-shore Pleistocene lake sediments, which may be assumed to be thicker and finer than their contemporaries nearer shore, may also be partly responsible for the maintenance of the sharp incision of the river-bed.

The gradient of the Nyando increases sharply at Muhoroni in its southern main tributary, the Kipchoriet. There are small falls formed by resistant outcrops of granitic orthogneiss (specimen 42/272*), the foliation of which strikes across the river, where the main Kisumu road crosses the stream.

The Kipchoriet continues its course upstream between banks of sediments derived from the volcanic series. Basement System rocks are exposed in places in the bed as far as the longitude of Koru, after which it passes onto the phonolites. The grade again increases south of Fort Ternan where the river is confined within a deep narrow gorge. The river has eroded a gorge 250 feet deep into the phonolite near Tunnel Station and the depth of the river-bed below the interfluves increases to at least 700 feet at Lumbwa, where river terrace gravels occur. As the crests of the interfluves are gently rounded, particularly on the Kericho phonolites, the imposition of a second cycle of intense erosion on an earlier, more mature, cycle appears to be indicated.

From the south the Kipchoriet is fed by numerous small highly active perennial streams flowing off the Kericho plateau, and a highly dissected scarp rising over 1,000 feet has resulted. This scarp stretches in so marked a line from Lumbwa to the south of Muhoroni that in the past it has been mistaken for the continuation of the southern Kavirondo rift fault. There is, however, no evidence of faulting and the feature must be attributed to the erosional effects of the Kipchoriet working along the junction of the Tinderet suite of lavas and the phonolites.

At Fort Ternan a subsidiary system of unintegrated drainage cuts back to the north-east, exposing a wide area of agglomerates and ashes overlaid by nephelinites, fine white tuffs and finally phonolite. The source of these streams is in the high ground over 8,000 feet, rising to 9,496 feet at the volcanic vent of Timboroa, which lies just outside the north-east corner of the area. This peak is also the source of the northern main tributary of the Nyando, the Mtetei, which flows eastwards to enter the present area north-east of Songhor, where it is known as the Ainomotua.

On the west side of Tinderet the general radial drainage pattern is broken by an exceptional deep tangential valley, the reason for which remains obscure, in the upper reaches of the Mbogo. As the bed and both flanks of this valley consist of basanites there is no question of the river having selectively eroded a weak bed of pyroclastic material. The linearity of the valley suggests faulting but, though the trend coincides with the N.E.–S.W. direction of the Sondu fault and the faults in the Mtetei valley, no evidence of displacement or faulting were seen in the Mbogo valley itself or on its alignment to the south where the road skirts the Soba ridge.

IV—SUMMARY OF GEOLOGY

The earliest rocks in the area are of Precambrian age and are represented by the Basement System, the Nyanzian System and the Bukoban System. The Bukoban System rests unconformably on the Nyanzian. The Kavirondian System is not present. During the considerable lapse of time between the close of deposition of the Bukoban System and the Tertiary era folding and faulting took place and there were intrusions of dolerite into the Bukoban and Nyanzian rocks.

The earliest of the Tertiary rocks are represented by fossiliferous lower Miocene limestones and tuffs. They are succeeded by pyroclastics on Tinderet, a volcano of central type which raised an ash-cone at this period. The immense volume of phonolites comprising the Kericho plateau was extruded from the Mau region after the first Tinderet eruptions. Subsequently there was a renewal of volcanic activity at Tinderet and in the Londiani region, during which nephelinites and mela-nephelinites were poured out. The final eruptive phase at Tinderet, after a lengthy period of quiescence, resulted in the extrusion of basanites. The Londiani volcanicity continued intermittently throughout the period.

Major rift-faulting occurred on the southern side of the Kavirondo Gulf in the late Pliocene or early Pleistocene according to Shackleton (1951, p. 386) but died out in the present area, being replaced by downwarping along ancient tectonic trends in the Nyanzian.

*Numbers prefixed by 42/ refer to specimens in the regional collection of the Geological Survey.

Basement System

A small area at the head of the Kano plain consists of granitoid gneisses cut by pegmatites and generally unmineralized quartz veins. In the north-west a part of the Kavirondo granite batholith enters the area, and is intrusive into both the Nyanzian and the Basement System. In the zone of the east-west Nyando fault mylonites have been formed and it is difficult to distinguish the Basement System rocks from the Kavirondo granite in such cases.

Nyanzian System

Rocks of this system occur in two small areas in the south-west and north-west and are notably sheared. The southern outcrops are the continuation of the system mapped in the adjacent Sotik district (Schoeman, 1949) where there are acid and intermediate lavas, amongst which phyllites and banded ironstones occur. These latter types are commonly seen in the Ngoina area, whereas exposures at Kibigori are characterized by rhyolites invaded by microgranites associated with the nearby Kavirondo granite and by metadolerites.

The structural trend of the Nyanzian rocks in the south is roughly N.E.–S.W., and has exercised a marked control upon Tertiary tectonics and the location of volcanic centres of eruption. In the Kibigori area the strike is roughly east-west with a medium angle of dip to the north. Small auriferous deposits occur in a shear-zone generally associated with quartz. The shear has the same attitude as the Nyanzian lavas with a slightly steeper dip

Granites

Apart from the Kavirondo granite mentioned above, small intrusions of granodiorite (Gd) and a coarse-grained leucogranite (Gl) occur in the southern Nyanzian exposures. The former is probably faulted at Sondu against the Nyanzian and extends beneath the Kericho phonolites to the east, where small exposures occur in the Mumek gorge. The leucogranite occurs as a small cupola at Koywalelach and may be of somewhat later age.

Kisii Series (*Bukoban System*)

Basalts, quartzites, felsites and dacites of this series are represented over a small area in the south-west. They form a continuation of beds mapped in the Kisii District and mark the present northern limit of the Bukoban basin. The series is highly faulted, dolerites being emplaced along the faults in some cases. The faults and certain zones of intense epidotization generally comply with the common north-east to south-west tectonic trend previously mentioned.

Tertiary Sediments and Volcanics

The greater part of the area is covered by Tertiary volcanics. Sediments at the base of the group are poorly represented in isolated exposures and consist of Miocene limestones and bedded tuffs resting on gneisses of the sub-Miocene peneplain. The volcanics are divided into the Kericho plateau phonolites, derived from the region of the Mau and connected with the Great Rift Valley faulting; the Tinderet suite of pyroclastic rocks and nephelinites, which have a strong petrographic similarity to Tertiary volcanic rocks of Gwasi and Mt. Elgon; and the Londiani–Lumbwa suite, which consists mainly of pyroclastic rocks with intercalated flows of phonolitic nephelinite, nephelinite and phonolite.

Pleistocene and Recent

A fall in the level of Lake Victoria in later Pleistocene times has exposed an area of Pleistocene sediments on the Kano plain, bordered on the north by detritus derived from the rift scarp. The streams have been rejuvenated by the Pleistocene falls in base-level which also resulted in extensive river capture in the south-east part of the area, and in Sotik by the Miriu.

Correlation with Other Areas

The correlation of the rocks of the Basement, Nyanzian and Bukoban Systems with those of neighbouring areas is straightforward and need not be considered here. The intrusive granites in the south-west of the area are post-Nyanzian and pre-Bukoban. In the north the granite is part of the major plutonic phase of the Upper Precambrian? (Pulfrey, 1946, p. 8), associated with which are the numerous acid and basic intrusions so characteristic of the Nyanzian area at Kibigori. In the Sondu area some doleritic and quartz intrusions of post-Bukoban and pre-Miocene age are recognized. The correlation of the rocks of Tertiary age is described in detail in Section 5 of Chapter V.

V—DETAILS OF GEOLOGY

1. Basement System

The Basement System outcrops in two areas occupying some fifty square miles in all at the head of the Kano plain. The northern of the two areas includes the isolated ridge standing conspicuously from the plain west of Songhor and continues northwards past the Equator. The second area extends between a line joining Koru and Muhoroni and the dissected phonolite scarp aligned roughly along the 0° 15′ parallel. The intervening ground between the two areas is covered by volcanic tuffs and lavas together with the soils derived from them beneath which, at no great depth lie Basement System rocks. This statement is supported by evidence from bore-hole No. C1292, situated on a farm four and a half miles north-west of Muhoroni where drilling was carried out to a depth of 244 feet, the Basement System being struck at approximately 4,270 feet above sea-level. Another bore-hole, No. C888, located some five miles further west near Chemilil station, failed however to reach the Basement System though drilled down to a datum height of 3,780 feet. These facts and the altitude of the Basement System south-east of Muhoroni show that the surface of the gneisses slopes down westwards and that west of Muhoroni it is hidden below an increasing cover of sediments. The economic significance of this with respect to the possible future search for or exploitation of alluvials derived from the Nyanzian in the Nyando valley is discussed on page 48.

The most notable characteristic of the Basement System rocks in the area is their granitic appearance and the frequent occurrence of coarse-grained pegmatitic veins aligned with the foliation, which trends generally between north and north-east, the dips varying from 40° to 80° to the east. The rocks are banded in parts and generally grey or pink in colour. Owing to the leucocratic character of most the gneissose structure is not particularly marked in hand-specimens. From the evidence of thin sections, however, it is clear that the region has been subjected to a high degree of dynamic and regional metamorphism, the former being super-imposed on the latter. An example of the later dynamic metamorphism is seen in a thin section of specimen 42/272 (Kipchoriet bridge, Muhoroni) in which there is granulation among the larger grains and flame-like recrystallization of quartz round and between crystals of sodic plagioclase. Greenish highly pleochroic shreds of biotite are caught up in this structure and wrapped round the more resistant felspars, which generally have assumed a rounded appearance and often show mortar structure at their boundaries. In the region of Songhor and Koru a still more advanced stage is observed in certain zones, aligned generally east-west, where the Basement System rocks and the granites have been mylonitized and the cataclastic effect is in parts so intense that the origin of a rock cannot be determined apart from its position with respect to neighbouring, less sheared rocks (e.g. specimens 42/335, from near Koitatui, four miles south-west of Koru).

In most respects the gneisses are remarkably similar to those described by Schoeman from the Sotik area (1949, p. 11). The non-granitized types and the quartzite of that area are, however, not represented here. Another difference is the fairly widespread occurrence of narrow pegmatitic veins which are not seen further south. Common to both areas is the intrusion of post-Nyanzian granites into the Basement System and the difficulty of distinguishing them, where they are gneissose, from the granitoid gneisses derived by the granitization of the Basement System.

West of Songhor the extension of the Kavirondo granite batholith mapped by Pulfrey (1946) and Saggerson (1952) is strongly represented along the crest of the Kibigori scarp. At the base of the scarp and in the vicinity of the Kapchure river, where the granite is highly sheared and faulted together with Basement System rocks, the exact contact becomes a matter of opinion. Certain of the rock types from this zone which are considered to be ortho-gneisses are, however, similar to types seen south-west of Muhoroni. Almost identical coarse-grained pegmatites also occur in both areas (cf. 42/358 from the Volo Sisal Estate, about 2 m. N.N.W. of Chemelil and 42/332, from the R. Meswa west of Muhoroni), which suggests that certain of the more homogeneous or coarse-grained types seen in the Muhoroni area may well be gneissic or sheared granites. Examples of these suspected ortho-gneisses are found on Ndoyomara hill (42/323), south-west of the junction of the Kericho road with the main Kisumu-Lumbwa road. North of this hill, beside the main road at Kiligis, tombstone weathering in sediments of the Basement System is to be seen. Upstream by the bridge a more melanocratic granitic type is exposed (42/272), and other exposures along the foothills, two miles to the east of Koiabi hill (42/335) and also two miles south of this hill (42/393), consist of finely granular sheared rocks that could possibly be post-Nyanzian granites rather than members of the Basement System. This view is supported to some extent by

the frequency of quartz and pegmatitic veins in this area and by the fact that in some of them, just north of Koiabi hill, gold has been found. At Sondu also there are well-marked shear zones in the granodiorites and in places the rocks are indistinguishable from Basement System types (specimens 42/246 and 42/261).

The ability to distinguish between ortho- and para-gneisses in the Basement System is considered to be a matter of economic importance since pegmatites and quartz veins associated with the former are more likely to be mineralized and worth prospecting. Though the occurrence of orthogneiss may be inferred in the present area no definite criteria could be established from the specimens examined whereby they could be distinguished from para-gneisses. The area has therefore been mapped for the present as granitoid gneiss.

Petrology

The essential mineral constituents of the gneisses are felspar, quartz, and mica in the form of biotite and muscovite. The felspar occurs mainly as microcline and as sodic varieties of plagioclase ranging from albite to oligoclase in composition. The accessory minerals commonly consist of epidote, sericite, and chlorite, and occasionally garnet.

The microcline twinning is discontinuous in the potash felspar and appears to have resulted through the application of stress. The quartz almost invariably shows a high degree of strain polarization. This is common also in the pegmatites and intrusives (e.g. specimen 42/273 from near the Kipchoriet bridge on the Muhoroni-Kisumu road) but a granulose microcline aplite (42/331, from the R. Meswa, near Muhoroni) is a notable exception.

The biotite is a dull green variety, highly pleochroic from pale green to mostly black, such as is commonly associated with dynamic metamorphism. It is not particularly abundant except in a biotite gneiss (42/334) collected at the Meswa road-crossing north of Muhoroni. The flakes of biotite are often deformed and wrapped around the minerals that have survived cataclasis.

Epidote is seen in most sections as scattered crystals and aggregates. In the biotite gneiss mentioned above it is associated with the biotite and is often seen as microlites speckling the felspars, with preferred orientation along the cleavage. According to Harker (1950, p. 352) this is characteristic of retrograde metamorphism.

A very characteristic effect, also noted by Schoeman in the rocks of the Sotik area, is the inclusion of irregular but generally rounded drop-like myrmekitic quartz within the plagioclase.

2. Nyanzian System

This system, together with the Kavirondian System, makes up a large part of the Precambrian rocks of western Kenya. The Kavirondian System does not occur in the present area, but the Nyanzian is found exposed over a small area near Sondu in the south-west and in two areas near Kibigori in the north-west. This formation and the Basement System, when they are in the vicinity of granitic intrusions, are the only rocks of the area in which auriferous deposits are likely to be found emplaced.

Sondu Area

In the Sondu area the Nyanzian exposures occur mainly south of the Chemoisiet river and west of the main Kericho-Sotik road. They are a continuation of the more extensive area of such rocks mapped by Schoeman (1949) along the Kipsonoi river, and are identical in type. Schoeman noted that they resemble the upper "slaty and andesitic group" of the Nyanzian mapped by Shackleton (1946, p. 15) in the Migori area. It is possible that Schoeman was mistaken in the inclusion of certain of his "andesite group" with the Nyanzian. The rocks that the writer considers doubtful are found outcropping on the slopes below the Bukoban quartzites in the Ngoina and Kipsonoi area. They are relatively unsheared in comparison with the rest of the Nyanzian, have pilotaxitic texture and are often porphyritic and sometimes vesicular. Bukoban basalts underlying the Bukoban quartzite are well-developed north of Ikonge and enter the Sotik area in the north-west corner. The porphyritic andesites of Schoeman are therefore considered by the writer to be part of the lower Bukoban and highly epidotized rocks along the Chemoisiet in the present area near Mabasi have been mapped as such. This explains the lack of agreement between the present map and the map of the Sotik area.

The Nyanzian in the Sondu area is tightly folded and consists mainly of shales and highly sheared rhyolites, amongst which small lenticles of banded ironstones occur. The latter, being the most resistant members, are generally found outcropping on hill-tops and ridges. In the Sotik area the shear planes dip steeply on either side of the prevalent north-east to south-west strike, which is difficult to determine owing to the high degree of shearing. On passing into the present area the strike of the shearing tends in places to vary slightly on the limbs of the folds, in such a manner as to indicate plunge to the north-east, the axis of the fold between Musori and Kiptenten conforming with the general trend noted to the south. A banded ironstone occurs in both limbs of the fold in this area. The rhyolites are particularly sheared along the north bank of the Chemoisiet to the north-east of Musori where the river follows the junction with the phonolite. Further down-stream the river has eroded a 400-foot gorge through the Nyanzian and more massive rhyolites (42/184) outcrop at Kapruben falls, to the north of which is emplaced the Koywalelach granite, where metamorphosed sedimentary types occur near the contact.

At the contact below the Ninet falls there is a chiastolite-garnet mudstone (42/173) which gives place to a sheared rhyolite (42/172) further out near the confluence of the tributary. The garnets in the metamorphosed mudstones are colourless and sparse. The rhyolite is a light grey rock with signs of slickensides on the joint-planes that retains in the hand-specimen traces of original flow structure. In thin section the rock is found to be mainly composed of a fine-grained recrystallized aggregate of quartz and felspar with orientated sericite flakes and scattered irregular clots of pyrite. The Kapruben rhyolite (42/184) is micro-porphyritic, but has been sufficiently crushed to break most of the original quartz phenocrysts and to separate them in the devitrified quartzose matrix. Secondary chlorite, sericite, pyrite and some epidote have developed. These rocks are similar to rhyolites described by Huddleston from the Kisii area (1951, p. 12).

In the Kipsewon stream east of the granite contact the Nyanzian is represented by a sandstone hornfels (42/316), but to the west where the Chepkongo erodes the contact the Nyanzian rocks are mostly highly altered, cleaved and decomposed, so that their exact nature remains doubtful. They appear to be meta-basalts (specimens 42/302, 42/303, 42/293 and 42/294) and are invaded by stringers of granite in certain sections of the stream-bed. Above these rocks there are fresher and more massive basalts (42/200 and 42/201), which are presumed to be lower Bukoban in age. To the south-west where the stream cuts the contact, some of the lavas are highly epidotized (42/197) while others are largely converted to actinolite (42/198). At the confluence with the Chemoisiet river there is a sheared epidiorite (42/185). On the northern slope of the Chemoisiet valley in the side valley below Kamwegi spur a highly uralitized rock (42/187), in which no indication of the original texture survives, occurs below the Bukoban quartzite horizon, while still further west at the southern termination of the spur Nyanzian phyllites were seen underlying the quartzite. Between this locality and the R. Chemosiet there are lavas that are presumed to be of Bukoban age. The junction between the Nyanzian and Lower Bukoban basalts south of Koywalelach has not, however, been satisfactorily established and requires further study.

Only three other small outcrops of Nyanzian rocks were recognized near Sondu. The most northern apparently forms a roof-pendant on the granodiorite, and is exposed around the toe of the phonolite-capped ridge north of Maraboi. It consists of epidotized lavas, the epidote occurring as metacrysts or marginally to amygdaloidal quartz (42/249). The rock is crowded with minute spherulites, which can be particularly well seen in the epidote, which has not replaced them. This lava cannot be definitely identified as a Nyanzian rhyolite and might equally well be an altered Bukoban dacite lava, though if it occurs in a roof-pendant as suggested it must be Nyanzian.

A faulted wedge of Nyanzian rhyolite (42/231) lying between Bukoban dacites, is crossed by the motor-track three-quarters of a mile south of Sondu Police Post, and similar rocks, which are presumed to be Nyanzian, occur between the Kisii road and the Miriu river below a vesicular Bukoban andesite. No mineralized veins were found in any of these Nyanzian rocks.

Nyanzian System in the Kibigori Area

At Kibigori the Nyanzian System is represented by a complex of highly altered and sheared acid and basic lavas and tuffs, which are cut by dolerites of at least two, and possibly three ages, together with numerous acid veins and sills of rhyolitic and microgranitic composition of various ages (*see* figs. 3–10, at end). The whole Kibigori area is much faulted due to its location at the intersection of the east-west Nyando fault and the Nandi fault.

The granite outcrop just north of the main contact with the Nyanzian rocks forms a conspicuous linear scarp extending along and nearly parallel with the Equator, but irregular small exposures of granite are also seen amongst the lavas suggesting that the latter are either part of a large roof-pendant or fault-blocks caught up in the Nandi-Nyando faulting.

Since the Nyanzian rocks here strike generally from east by north to west by south with a low dip to the north, and as the intrusives adopt roughly the same attitude, the more numerous exposures are to be found on the scarp face, while relatively wide expanses of the more resistant epidiorite are found on the crest. Bands of epidiorite also occur between the cross-faults that pass north-westwards out of the area. Another exposure of epidiorite occurs in granite to the east of the fracture marked as the "Nandi fault" by Shackleton (1951, pl. XXVII). On the air-photograph this epidiorite shows up clearly as a dark zone ending against the N.W.-S.E. fault.

Detailed Geology of Equatorial Claims

The best evidence of the geology of the Nyanzian rocks at Kibigori is derived from the bore-holes and detailed work conducted by P. C. Benedict within the Equatorial claims, south-west of Kibongwa, over a period of nearly nine months ending in May 1951. The economic aspects of this work are described in Chapter VII. After a close macroscopic study Benedict classified the lavas obtained from the bore-holes into four acid and three basic types, which are invaded by a series of dykes, most of which have a flatter dip than the shear in which the quartz vein is emplaced (*see* fig. 9). The main mineralized shear dips at 25° to the north. Benedict considered that the Nyanzian rocks are part of the inverted limb of a recumbent fold with the axial plane dipping to the north, the schistosity in the fold being more or less horizontal but undulating. The undulation, he thought, was due to later warping and not to dilation by the numerous intrusions. In cross-sections that he submitted shear-zones are shown as thrust faults on theoretical grounds.

Benedict's final classification of the Nyanzian rocks on the property was as follows:—

(3) *Rhyolite*. Near the top of the volcanic sequence as revealed by drilling.

(2) *Basalt flows with intercalated tuffs*. The basalt is bleached and zoisitized with the result that metamorphosed tuffs were logged as basalts where the bedding was obscured.

(1) *Fragmental Volcanic rocks*. Apparently basaltic with numerous pebbles and occasional boulders that require care to distinguish them from the dykes in the cores.

Petrography of the Nyanzian rocks of the Equatorial Claims

A number of thin sections of the various types of rock cut by the bore-holes were prepared from samples of the cores, taken mainly at the contacts logged by Benedict and now stored at Nairobi. A rapid examination of these slides with the microscope indicates that the rocks have generally been subjected to hydrothermal alteration and are accordingly not readily classified into the types macroscopically determined by Benedict. The following notes will indicate their general character.

Specimens 42/523 and 524 from the "rhyolite" in Bore-hole 5 at 21 and 34·5 feet respectively are dellenites and contain porphyritic resorbed oligoclase in microcrystalline groundmasses. In 42/523 there are also a few actinolitic pseudomorphs of original ferromagnesian mineral and a few small remains of quartz phenocrysts. The matrix consists of a closely felted trachytic matte of felspar prisms and actinolite crystals with a glass-clear base that presumably consists of quartz and felspar. Flow structure is evident in specimen 42/524, but the rock is much less trachytic than specimen 42/523. The matrix is much more granular and quartz is more obvious. Chlorite and epidote occur in scattered patches.

The "basalts" are meta-basalts and are represented by slides 475C, 480A, 530 and 610. Specimen 42/475C (from bore-hole No. 1 at 89 feet) contains a few small dusky pseudomorphs of felspar phenocrysts in a matrix composed of a plexus of actinolite needles and recrystallized felspar. It is much cut by quartz and quartz-chlorite stringers, and patches of granular quartz are frequent. In 42/530 (from bore-hole No. 5 at 117 feet) the contact between the basalt and a rhyolite (quartz porphyry) dyke is shown. The dyke transects a veinlet of quartz cutting the meta-basalt, and a crude foliation that has developed in the lava.

Benedict also separated an "intermediate volcanic type" which is represented by specimen 42/504 from bore-hole No. 4 at 95·7 feet. In thin section it is seen that the rock is similar to the dellenites mentioned above. It is cut by porphyry. It also resembles an inclusion in the volcanic fragmental rock 42/475 from bore-hole No. 1 at 75 feet. This rock is a sheared and recrystallized porphyritic rhyolite.

Specimen 42/617A, also from a fragmental bed has been described in conversation by Pulfrey as resembling an "adinole" and it may well be that some of the rocks consisting of quartz and albite with variable amounts of actinolite, chlorite and epidote which are fairly common in this Nyanzian suite are in fact altered argillaceous sediments. Specimen 42/603 from bore-hole No. 10 at 298 feet is a sheared crystal tuff in which abundant flakes of anamorphic biotite have developed. Actinolite is also present as scattered stellate aggregates.

3. Bukoban System (Kisii Series)

A small tract in the extreme south-western corner of the area consists of rocks of the Bukoban System, and is an extension of the Kisii hills in which comparable rocks have been mapped by Shackleton (1946), Schoeman (1949), Huddleston (1951) and Saggerson (1952). The order of succession and the character of the rocks in the present area are identical with those described from the adjoining areas where the sequence is:—

(4) Quartz andesites and dacites.

(3) Porphyritic and non-porphyritic felsites.

(2) Quartzite.

(1) Porphyritic and non-porphyritic basalts.

Dykes of dolerite and quartz veins cut the series, their disposition being controlled by tension fractures, most of which strike generally in the north-east to south-west direction.

The geology of the system is complicated by block faulting and zonal epidotization. In parts the latter is so complete that epidosites have formed and the original nature of the rocks is indeterminate. The determination of structure therefore depends in many cases on the mapping of the quartzite, which unfortunately tends to be discontinuous and more poorly developed in this area as one proceeds northwards.

(1) The Porphyritic and Non-Porphyritic Basalts

The two types of basalt are not differentiated on the map. A porphyritic variety (e.g. specimen 42/236) occurs a mile south-east of Maragwa between the Sotik road and the river. Exposures along the road to the south are highly sheared while to the west, on the col between Kingusu and Riomego hills, epidosites (42/205) of doubtful origin occur. Along the southern border, below the quartzite, blue-grey vesicular basalt of finer grain outcrops, and specimens 42/218 and 42/215 of this rock correspond with specimen 41/275 collected by Huddleston higher up the Sirembe valley to the south-west. It is therefore evident that the normal sequence with quartzite underlain by basalts is well-developed in this locality although Schoeman (1949) shows Nyanzian below the quartzite to the north-east of Ikonge on his map of the Sotik area. The quartzite horizon on the spur north of Ikonge does not enter the present area as would be supposed from Schoeman's map, but, being horizontal, swings round and up the eastern flank of the Sirembe valley. Since it was not found, however, by Huddleston further up the valley between the lower basalts and the upper felsites it must thin out rapidly in that direction or be cut out by faulting.

The basalts are considered to continue up the Chemoisiet river for more than two miles. At Mabasi, the Nyanzian can be recognized with certainty on the southern side of the Chemoisiet valley but the rocks on the lower slopes are highly epidotized basalts (42/179 to 42/183), and whether they are Nyanzian or Bukoban is difficult to determine. Further east, in the Kamaget area, less epidotized examples are found (42/200 and 42/202). These are fresh-looking albitized basalts, lacking the intense shearing of the Nyanzian, and similar to basalts described in the Kisii area as Bukoban. It is therefore assumed that the Bukoban underlies the quartzite over the greater part of the small plain drained by the Chepkongo east of the Marumbasi ridge, though exposures were not found there. The overlying quartzite marking the top of the basalts can be followed on the evidence of float along the foot of the ridge to the north at about the 5,800-foot contour. The basalts outcrop in the gorge and deep valley north of Sekauani (42/235). The quartzite in the Kibgnetswe valley south of

Marumbasi and in the Miriu dip to the west at approximately 20°. As a result of this the lower basalts are only found at the head of the deeply eroded valleys of the Maiba and Kibgnetswe (42/252) on the flank of the main ridge, which consists of the porphyritic felsite down to the level of the Miriu river. To the west of the river basalts are again found. This river is therefore exploiting a fault, though its actual trace was not clearly seen in the field.

The basalts of the valley are notably amygdaloidal, vesicles being filled with plumose quartz. Along the line from Chelemei to Marumbasi a particularly coarse-grained ophitic type occurs (42/254, 42/253 and 42/252). It is identical with a rock (41/272) found by Huddleston in the Kioge area which he considered to be a post-Bukoban dolerite dyke. The occurrence in the present area lies on the same line as Huddleston's dyke but it was not observed that the basalt invades the upper felsites. It is therefore considered as a coarse-textured flow of the lower Bukoban basalts.

North of Sekauani in the Kipmulgelwo gorge the basalts underlie the porphyritic felsites and are overlapped by Tertiary phonolite. Here also the basalts are highly altered and epidotized but the original ophitic texture can still be recognized (specimen 42/300).

(2) Quartzites

The disposition of this group has been partly mentioned in the preceding section. Additional small outcrops disconnected by faulting, occur in the extreme south-western corner of the area and correlate with the quartzites mapped further west by Saggerson (1952). Almost horizontal beds north of Kingusu hill could not be traced to the east round the spur up the Sirembe valley. The quartzite is again seen well-developed on the east flank of Riomego hill and is cut off to the south by a fault into which a "bull" quartz vein has been emplaced. To the east of Maragwa the quartzite horizon dips to the south-east and east towards the river and the same bed is found across the Miriu on Kamwegi spur.

The quartzites are seldom more than one hundred feet thick when best developed in this area and thin out to the north, where the horizon is traceable only by float and a thin layer of chalcedonic sediment containing grains of rounded quartz.

Three textural varieties of quartzite are recognizable petrographically. In the first the grains are closely compacted and cemented by microcrystalline quartz or chalcedonic silica which is sometimes stained by iron oxide near joint planes, as in specimen 42/291 from the Kibeneti valley, near Kamaget. The thin section of this specimen also contains a rock fragment composed of sutured quartz grains, indicating that the quartzite was partly derived from the Basement System quartzites of the Sotik area. The purity of the quartzite is partly attributable to derivation from this source.

In the second variety, the sediment has been recrystallized to form a finely sutured mosaic of even grain, the quartz crystals showing faint undulose extinction (42/192, from the east slope of Kibogat hill). In the third variety the grains are found "floating" in a cryptocrystalline cherty matrix. The grains are irregularly spaced and widely separated as in specimen 42/297, from south of Sekauani, or they occur in bands (42/209, from the south spur of Kamwegi). Such rocks were evidently formed by the sedimentation of wind-blown grains in a lake in which silica was being chemically precipitated, and are allied to the concretionary and banded cherts described by Huddleston (1951, p. 30) as of local occurrence in parts of the Kisii area.

It is evident that the waters of the basin in which sedimentation occurred was in parts highly siliceous due to the accumulation of colloidal silica over a long period. A condition of intense chemical denudation on the surrounding land with resultant destruction of the felspars would liberate ample silica for this purpose which would be transported in a colloidal state by the streams. Deposition of the colloids may have resulted in some cases by dehydration in coastal lagoons, but in the case of the banded cherts ionic neutralization of repeated accumulations of ferric oxide and silica sols would produce deposition in that order and seems the more likely explanation of their formation.

As the general petrographical character of the quartzites has been fully described by Huddleston and others the details need no repetition here. There are however certain peculiarities of these sediments which bear upon the geological conditions existing at the time of formation that have not been stressed previously and these are considered in the following section in some detail.

Conditions of formation of the Kisii Series quartzites and relationship to the Bukoban System of Tanganyika and Uganda

Now that the entire area covered by the Bukoban in Kenya has been mapped the succession may be compared with that of deposits of the same age in Uganda and Tanganyika. The type area is in the Uha district of Tanganyika (Teale, 1933, p. 18). Quartzites of Bukoban age also occur some hundred miles south of the Kisii area in the east Musoma area of Tanganyika, where, together with sandstones, greywackes and shales they form the Ikorongo Series and have been described by Stockley (e.g. 1936, pp. 20–23). The basal conglomerates and coarse grits are better developed in that area than in Kenya. At Ikorongo the quartzites are 250 feet thick and are followed by 1,560 feet of shales and sandstones. The quartzite extends over hundreds of square miles and continues to the south.

Another area of Bukoban rocks known as the Buanji Series, 1,800 feet thick, occurs in the south-western highlands of Tanganyika, where the basal beds consist of ferruginous grits, sandstones and quartzites with some shale bands. These beds are overlain by some 600 feet of more shaly sediments, followed by 70 feet of dolomite capped by andesitic lavas.

The Bukoban sandstones west of Lake Victoria, near Bukoba, from which the present name of the System is obtained, were described by Combe (1925, pp. 14–20). Here the sandstones are several thousand feet thick and are dominantly fine- to medium-grained, compact, white unfossiliferous sediments with interbedded quartzitic types and fine-grained compact shale-like argillaceous sandstones. Like the Kisii quartzites they rest on basalts. These sediments have been traced one hundred and fifty miles to the south-west over a width of twenty miles.

In Kenya the Bukoban quartzites, as in southern Tanganyika, are capped by andesites and acid lavas. They are now found around a faulted basin some fifty miles long from north to south and roughly twenty miles wide. The quartzites average some 250 feet in thickness with a maximum of 400 feet, though in parts they are discontinuous and they thin out to the north. The Bukoban shore-line in Kenya therefore appears to have been situated about 0° 25′ S.

The most notable features of the Kisii quartzites are their lack of variation in grade and composition both laterally and throughout their thickness, the absence, except very locally even at the base, of the boulder or pebbly facies, and the entire absence of argillaceous beds. Bedding has been seldom observed except towards the southern part of the basin. The grain size is remarkably constant throughout and varies from 0·5 mm. to 0·25 mm., the matrix being generally siliceous and sometimes ferruginous. The grains are well-rounded though they are below the size normally considered capable of being rounded in water. Ripple-marks, having a wave-length of one and a half inches and an amplitude of half an inch, were consistently observed throughout the beds in the Kisii area though this effect is uncommon further north. Schoeman noted that the ripples in the Sotik area are of a symmetrical or oscillation type. The sediments are almost entirely free from felspar except in the neighbourhood of the intrusive granites and contain also a notably low content of metamorphic and ferromagnesian minerals and often of mica. These features require explanation since the sediments must have been derived from nearby gneisses and quartzites of the Basement System and from granitoid rocks in it. In addition the heavy mineral content shows little lateral variation and is most rich in iron oxides.

The character of the quartzites cannot be accounted for by a simple explanation such as that advanced by Stockley in respect of the East Musoma area, where he considered that the Bukoban sediments were deposited by many streams loaded with fine sand entering on all sides into extensive lakes. The Kisii quartzites must have been derived mainly from the quartzitic horizons of the Basement System. Outcrops of such rocks occur in the east Sotik area (Schoeman, 1949, p. 33) and it is probable that in Bukoban times in the tops of anticlinal folds they outcropped over extensive areas and possibly extended along the strike north of their present outcrops. A notable lack of felspar in sediments is normally considered to indicate a condition of base-levelling with intense decomposition (Pettijohn, 1949, p. 441). The lack of contamination by the products of decomposition is thought likely in the present case to be due to their removal by wind action assisted by some water-sorting. Wind action would also allow the comminution and sorting of the quartz grains—a similar degree of size reduction by stream action would imply a greater distance of transportation than seems available. Iron oxide skins on the quartz grains such as are characteristic of desert conditions, would naturally tend to be removed during the sorting and would partly account for the preponderance of iron in the heavy mineral content of the sediments. The rare and local boulder beds indicate that a few streams existed, but it appears most likely that the bulk of the material was introduced into the basin by wind action, aided by

sheet-flows of rain-water resulting from storms on a rocky desert surface. The preservation of oscillation ripples shows the lack of bottom currents or tides to distribute, grade and sort the sand, but heated surface currents generated by offshore winds may have existed and have aided the separation and removal of any slow settling argillaceous material entering the lake. Surface currents of this type would flow upon a relatively cold hypolimnion and there would be no overturn under tropical fresh-water lake conditions to cause contamination of the more rapidly settled sands. The relatively great thickness of sediments, of types characteristically deposited adjacent to land, indicates that the basin must have been sinking at the same rate as the sands were being deposited.

(3) The Porphyritic Felsites

In the Kisii area Huddleston (1951, p. 31) separated porphyritic and the non-porphyritic felsites in the group above the quartzites, but in the present area non-porphyritic varieties are not found.

The porphyritic felsites form the resistant ridge of hills from Sekauani south to Kamwegi, maintaining a consistent level of 6,000 feet, with several rounded peaks at intervals along the ridge rising slightly above this common elevation. Along the eastern flank the base of the porphyritic felsites is found outcropping above the 5,800-foot contour. Though the ridge is cut by a series of faults striking generally in a N.E.-S.W. direction no major displacement was observed on the east side, but tilting of the blocks and downthrow on the west is apparent.

South of Sondu the Miriu has cut a north-south linear gorge through the felsites along the faulted axis of a syncline. To the west the felsites occupy the southern part of the relatively level uplands at 5,600 feet, and underlie the dacites to the north, below which they again outcrop around Kisage hill. They are down-faulted against the Nyanzian along the line of the main road between Mabere and Kabondo. Specimen 42/243 from this highly sheared contact is a devitrified felsite with perlitic cracks and relic flow structure. Ghost phenocrysts of felspar with mottled alteration as is characteristic of the porphyritic felsites are still recognizable, though the rock is much altered.

The porphyritic felsites are readily recognized in the field as their altered green felspar phenocrysts with rounded terminations stand out conspicuously from the reddish or purple matrices of the weathered rocks. When fresh they are dark grey with glassy phenocrysts. The twenty specimens collected from various localities show little variation petrographically. Specimen 42/295 is typical of the fresher rocks and 42/278 of the weathered, while 42/188 and 42/269 from Kamwegi and 42/233A (a perlitic recrystallized rhyolite) at the mill in the Miriu valley one mile south-east of Sondu show the mottled alteration of the felspars. The felsite at the mill is downfaulted against a wedge of Nyanzian which is seen on the road to the east.

Impregnation of the felsites by cherty silica and quartz is commonly observed along zones and shear fractures, usually orientated N.E.-S.W. The silicification is not connected with the Tertiary earth movements.

(4) Quartz Andesites and Dacites

The dacites overlie the felsites on the highest ground south of Sondu and outcrop as low as 5,300 feet in the bed of the Gariba valley (42/237). Amygdaloidal types that are sometimes porphyritic (42/241) occur as an upper flow that is well-developed along the Kekonge-Brangi ridge to the west. Porphyritic texture is not common, however, the rocks being usually medium- to fine-grained, and grey. Amygdales sometimes reach one inch in diameter and are filled by quartz with zonal growth lines (42/229). The plagioclase ranges in composition from andesine to oligoclase, crystallizing with Carlsbad twins and more rarely with lamellar twins (42/228), or as stumpy prisms and skeletal crystals (42/242). The groundmasses are microcrystalline to glassy and, when crystalline, consist of orthoclase and quartz, the latter being present in appreciable amount as pools or in micrographic intergrowth with the felspar. Sphene and black iron oxides are present in minor amounts. Chlorite is the most common secondary mineral and is accompanied by epidote and calcite.

At Sekauani, where the amygdaloidal type also outcrops, there is a zone of epidosite running N.N.E.-S.S.W. near the peak. In a slide of this rock (42/226) only the faintest relics of the dacite texture remains. On the ridge to the south the dacites are not readily recognized owing to their alteration, but they can be traced down to 5,100 feet along the Sondu motor-track.

The upper Bukoban rhyolites and tuffs found on the highest ground in the Kisii hills further south-west are not represented in this area.

4. Miocene Sediments and Tuffs

The rocks of Miocene age in the area mapped that have been most studied in the past occur in the vicinity of Koru and Songhor. Outcrops are also exposed, however, in an almost unbroken belt from Muhoroni northwards to the Songhor inselberg, bordering the Kano plain along the base of the Tinderet volcanics. Outcrops are well seen in the Kipturu and Meswa streams and at the base of Chemoros hill, north of which there is an erosional gap of some two miles at the Mbogo valley. On the interfluves the Miocene is generally concealed by soils resulting from the decomposition of the later Tinderet lavas.

In the Koru area the basal beds, consisting of tuffs, limestones and marls resting on the Basement System and overlain by nephelinitic agglomerates, were designated the "Koru Beds" by Shackleton (1951, p. 364). Apart from the basal section described by Shackleton one mile west-north-west of Koru the lowest members of the Koru beds are rarely observed, being generally concealed by soil. The base can however be delimited in the valley to the north-west of Mnara* with fair accuracy. Here the ash beds are micaceous and similar to those seen at Meswa river, one and a quarter miles north of Muhoroni.

In the Chamtwara stream, south of Legetate, the basal beds of the Miocene are obscured by recent alluvials and the fossiliferous beds discovered by Chesnaye (Gregory, 1921, p. 129), which occur just north of the bridge where the railway crosses the stream near Muhoroni station, are considered to be reconstituted gravels derived from the Miocene beds which outcrop at the head of the valley.

Higher in the succession in this area the biotitic tuffs give place to agglomeratic sediments outcropping along the south edge of the Legetet plateau and around Mnara, which contain fragments and blocks of gneiss and below which lie the reddish marls and micaceous clays described in detail by Shackleton (1951, p. 364).

Kent records idiomorphic melanite garnets and altered nepheline-bearing lava blocks in his basal agglomeratic beds at Rusinga. The basal beds in the Koru area are however notably free from volcanic material, but garnetiferous horizons were seen in tuffs and agglomerates associated with the red argillaceous and limestone beds of Songhor and also at a higher horizon of tuffs which outcrops not far below the massive Tinderet agglomerates in the Fort Ternan area.

The limestones associated with the red beds outcrop for the most part in the upper valley of the Chamtwara, where six remnant patches occur between 4,670 and 5,050 feet. Two further limestone exposures, one of which follows the 5,000-foot form-line and the other lying at just above 4,800 feet, are found south-east of Legetet. The dips in these beds are generally less than 10° and quite irregular in direction. The main limestone outcrops lie at the foot of Legetet on the northern side, where they are worked for lime. A bore-hole here having a collar elevation of about 4,690 feet passed through seventy-one feet of limestone followed by twenty-one feet of fragmentary limestone and gneiss with black sands before reaching the Basement System rocks at 4,590 feet. The limestone is capped by a thin remnant of agglomerate and tuff corresponding with similar beds underlying the 300 feet flow of nephelinite that makes up the Legetet plateau. Cutting the limestone with a N.E.-S.W. strike, i.e. radial to Tinderet, is an alnöite dyke described by Pulfrey (1953), who also mapped normal step-faulting in a neighbouring outcrop of the limestone, and red marl beds and basal gravels in the valley north of the limestone. Further downstream the writer observed bedded dirty-yellow gritty silts and, across the valley to the north at slightly lower elevation than the Legetet outcrops, there is another remnant of the limestone overlain by a mela-nephelinite flow, which continues westwards to form the Legetate spur. This lava is overlain by a basanite (42/346), which forms a remarkably fine columnar capping to Legetate itself (42/324). Much of the limestone had been already removed by erosion prior to the extrusion of the mela-nephelinite, as is indicated by the fact that a tongue of the lava separates the two limestone remnants on the south side of the valley. The lava continues eastwards and lies on the junction of the volcanic agglomerate and the Koru Beds. Shackleton (1951, p. 364-5) has described exposures in the area between Muhoroni and Songhor. His information is supplemented by the results obtained during the work of the writer around Chemoros.

In the Meswa and Kipturu streams at 4,300 feet, near the road-crossings one and a half miles north of Muhoroni, the Koru Beds consist of gritty deposits containing small books of biotite and blocks of a pinkish felspathic rock and biotite gneiss derived from the Basement

*Mnara, the Kiswahili for a steeple, describes this isolated hill aptly. It can probably be identified with "Manava" (Gregory, 1921, p. 122) and is also called Chauget by Shackleton (1951, plate XXVII).

System. Some of the blocks of gneiss are large slabs lying conformably with the bedding. These beds represent the base of the series and judging from the evidence of dips they are gently crumpled, with a general inclination to the north-west.

Gritty tuffs in the Kipturu, north-west of Legetate are often highly calcitized. A local farmer reported other calcareous tuffs about four miles north-east of Muhoroni and west of the spur that descends to Legetate, and a specimen of a green richly garnetiferous tuff from that locality was supplied. This horizon probably occurs between 4,600 and 4,700 feet and may be compared with a similar horizon mentioned by Shackleton as occurring in the Koru Beds at Songhor both below and above the grey limestone which there lies at about 4,450 feet (1951, p. 365). Garnetiferous tuffs in the Fort Ternan area occur at 5,200 feet on the lower slopes of the hill just east of the airfield. No limestones, however, occur at this elevation though the tuffs are sometimes calcitized (42/679).

North of the Meswa outcrops the Koru Beds are exposed at about 4,250 feet in the valley south of the Kwoisos lava remnant. Shackleton (1951, p. 365) reported that "nephelinite agglomerate and tuffs are underlain by a limestone with large gastropods and gastropod eggs, and downstream for about three-quarters of a mile there are discontinuous small exposures of yellowish and reddish fine-grained beds with gastropods and gastropod eggs." At 4,300 feet the writer observed a massive greenish-grey agglomerate overlain by Tinderet lava. The agglomerate continues up the stream-bed to the 4,400-foot level, where it contains much calcitized fossil wood, rhombs of brown calcite and blocks of lava (42/353). Biotite and gneiss fragments are absent from the agglomerate and it is considered to represent a thick horizon above the Koru Beds, since it again outcrops at 4,570 feet in the small valley immediately to the north of Chemoros. The intervening area is obscured by soil cover. At the exposure the beds are grit-free, non-stratified felspathic (?) tuffs, coloured fawn, buff or cream and overlain by a steel-grey basic lava on the north of the valley at the 4,660-foot level. South of the valley exposures are again found at the foot of the Chemoros spur at 4,680 feet where there are massive micaceous agglomerates containing much fossilized wood, and beds of the same composition continue up the spur giving place to a hard grey-green mica-free variety of agglomerate followed, just below the crest, by a thin bed of unconsolidated ash immediately underlying the blue-grey lava capping of the hill at 4,800 feet. The unconsolidated ash is similar to ashes noted below the lavas on Kapurtay hill, north of Songhor. It appears that there is a thickness of some 600 feet of agglomerates and tuffs overlying the Koru Beds and below the lavas in this area.

The east-west valley lying north of Kwoisos was not examined in its upper reaches. A specimen collected at about 4,400 feet by Mr. Martin, the owner of the farm, from white exposures that can be seen on the air photographs, consists of a light-coloured gritty fossiliferous tuff. This rock is similar in appearance to the tuffs at the Meswa exposures.

North of the part of the area just described no exposures of Miocene rocks were found over a distance of some two miles, though probably Miocene beds originally wrapped round the southern side of the Songhor inselberg, but have since been removed by erosion by the Mbogo stream. North-east of the inselberg Miocene rocks occur as remnants in the gullies near the road, as described in detail by Kent (1944, p. 107), and their extensions up the Ainomotua stream and along the Kapsabet road north of the Equator at higher elevations are described by Shackleton (1951, p. 366).

Additional information was obtained by the writer on exposures not previously described in the Kapurtay area to the north, east and south of that peak.

On a traverse commencing at the old broken bridge at the Ainapgnetuny north of Songhor and up the track to Kapurtay the succession is fairly well exposed and consists of:—

	feet
(Top of traverse 5,361 ft. O.D.)	
Olivine mela-nephelinite (42/348)	30
Phonolitic lavas (42/349)	380
Tuffs	140
(No exposure 4,810 to 4,710 ft. at the spur)	
Agglomerate containing gastropods at 4,710 ft. at the spur	—
Light khaki clays interbedded with agglomerate	100
Calcified agglomerate	50
Coarse grey stratified tuffs	90
(Lower end of traverse, 4,470 ft. O.D.)	

On the traverse basanites are not seen below the phonolites, but on the northern slope of the Kapurtay ridge there is a belt of basanite (42/356) lying at about 4,850 feet, the continuation of which to the east and south-east around the ridge is inferred from the air photographs. Where the hill slope meets the plain on the western edge, at about 4,800 feet, limestone is reported to have been worked by the local residents. The wide flat valley to the west is covered by a tenacious black soil on which corn and sisal is cultivated. There are no exposures here except in the small tributary of the Ainapgnetuny which flows from the north-east. In the bed of this stream compact nephelinitic agglomerates (42/355) were seen at about 4,550 feet, giving place to a softer, less coarse tuffaceous horizon at 4,640 feet at the base of the hill ridge north of Kapurtay. This horizon probably corresponds with that seen above 4,800 feet on Kapurtay and strengthens the impression given by the air-photograph that there is an east-west fault running between Kapurtay and the ridge to the north through the saddle, though no evidence of a fault can be seen on the ground owing to soil cover.

The tuffs are cut by another east-west fracture zone, evidence of which is to be found in exposures further to the north and, judging from the air-photograph, this fault continues along the ridge face to the east. The ridge itself rises sharply to over 5,800 feet and consists of coarse volcanic agglomerate. The base of these beds lies at 4,800 feet at the western end of the spur and outcrops were traced to 5,100 feet at a point some three miles up the spur to the east. No reliable measurements of dip could be obtained at the exposures but from distant observation they appear to dip at a low angle slightly to the west of north, that is, away from Tinderet. The agglomerate contains huge blocks of Tinderet lavas and is related in type to the coarse pyroclastics seen in the railway section from Lumbwa to Tunnel Station. These rocks must represent a violent explosive phase of Tinderet that preceded the outflow of lavas.

On the north bank of the valley east-south-east of Kapurtay the lower Koru Beds are again exposed. The sequence has been detailed by Shackleton (1951, p. 365). The inclusion of large slabs of Basement System rocks in the basal beds, which dip south at 13°, was confirmed during the present survey. The blocks and the biotite crystals that accompany them strongly suggest correlation with the Meswa and Mnara exposures. The gneiss that the beds overlie outcrops on Peverett's farm across a small stream east of the Koru Beds exposures. The exposures lie at 4,700 feet, some 300 feet above the Songhor gullies, but at about the same elevation as the basal beds at Koru. The continuous Miocene outcrops traceable down the valley to the Songhor gullies consist of nephelinitic tuffs which dip to the north and north-west, representing a sequence higher in the Miocene than the basal beds previously mentioned.

Two further isolated exposures which appear to be connected with the Koru beds require mention. Both rest on the Basement System and are well-bedded and contain an abundance of fossil wood, though no gastropods were found. The first occurs in the small gully east of Koitaburot hill, three and a half miles due south of Muhoroni. The beds, lying at 4,600 feet, are sandy and tuffaceous with the dip of 6° variably south-east, north-east or north-west. Unfortunately they are not found in contact with the phonolite of Koitaburot which must have flowed across them from the direction of Koiabi. Unusual concretions (42/342) in the form of laminated discs from two to three inches in diameter and about one inch in thickness are found in the beds. The laminations consist of fine wavy banding parallel with the plane of the disc, and probably represent the original bedding of the host rock. No nuclei were found in the concretions.

Despite a careful search no further remnants of the Koru beds were found south of the Kipchoriet river nor are such beds preserved at the phonolite and Basement System junction in the plateau scarp. It must therefore be presumed that over much of the southern part of the Kavirondo trough in the neighbourhood of Muhoroni there was no deposition, or that there was a period of erosion prior to the extrusion of the phonolites, when all but the small outlier near Koitaburot was removed.

The second occurrence is a bed of tuff (42/264), highly calcitized and containing fossil wood, that occurs in a small exposure at Kibogat, nine miles north of Sondu. It is overlain by a thin remnant capping of phonolite, and underlying agglomeratic tuffs dip almost due north at 15°. The beds are probably related to the tuffaceous horizon beneath the phonolite described by Shackleton (1951, p. 369) at the Kendu fault*.

*Shackleton refers to the Nyabondo plateau, north-west of Sondu, as the Sondu outlier and the scarp along ts northern face as the Sondu escarpment. The latter name could however be better applied to the N.E.-S.W. faulting that runs through Sondu itself and along the zone of the monoclinal flexture also described by Shackleton. In this report the term Kendu fault as employed by Saggerson (1952, p. 72) is used.

Correlation with other Areas

The Miocene of western Kenya has been described by Oswald (1914), Kent (1944 B) and Shackleton (1951). Oswald divided the Miocene into upper, middle and lower series of the Karungu area. The nature of the sediments of the Lower Series indicates torrential conditions with rapid deposition by rivers and currents in a lagoon or gulf. The Middle Series has thin beds of travertine and is described as being redder, more varied, and fossiliferous. Sands and gravels are more common towards the base and transitional conditions are indicated by greenish-grey clays, sometimes speckled with biotite. These beds were deposited under more mature river conditions and under calm lagoon conditions where it is presumed ferruginous springs were common. The Upper Series is characterized by argillaceous sandstones containing large plates of biotite and it is presumed was laid down by rivers under the conditions approaching those of base-levelling. Fossils are rare but calcified tree trunks occur below the capping of nepheline basalts. Thin bands of travertine limestones alternate with clay and sand, the last representing wet season deposition. As the upper fine-grained sediments are as thick as the middle and lower combined a comparatively long period seems necessary for their deposition and since the lowest beds had been proved by fossil evidence to be Lower Miocene, Oswald concluded that the Upper Series might well range into the Pliocene.

The similarity in certain respects of Oswald's Upper and Middle beds with Miocene sediments in the present area is a notable feature but their range is here confined to the Lower Miocene, the limestones amongst the red beds being dated by fossils from Koru and Songhor.

Kent (1944 B) compared the Koru deposits with the Miocene he had studied in detail on Rusinga Island and considered that both occupy early stages of the same generally volcanic episode and have closely similar faunas. In each area there are thin basal tuffs closely associated with overlying normal clays (the Argillaceous Series on Rusinga), which are followed by tuffaceous sediments. Kent noted that the tuffs at Koru are thicker than the clays beneath them and, as Shackleton also pointed out, that the beds at Songhor are more tuffaceous than their equivalents near Koru. Above these tuffs lie the red beds, including limestone, which is prominent at Koru and Songhor but subordinate at Rusinga.

In general the rocks of the Lower Miocene are interpreted as the result of a phase of intermittent explosive volcanic eruption during which the fossiliferous lacustrine beds forming the lowest part of the sequence were deposited, followed by an upward passage through tuffs to agglomerates. Before the extrusion of the lavas that form the higher part of the sequence the explosive activity of Tinderet became intense resulting in the thick beds of extremely coarse volcanic agglomerate and breccia seen in the railway section in the Kipchoriet valley between Lumbwa and Tunnel Station, and north of the Ainomotua valley.

The Miocene beds are cut by dyke intrusions and faulted. In the present area dykes are uncommon but are often radial in relation to the highest point of Tinderet.

The closer correlation of the Miocene sediments and pyroclastics will probably depend on the recognition and further study of the garnetiferous horizons of which there are evidently more than one. Shackleton (1951, p. 356) arrived at a somewhat similar conclusion when working in Rusinga and recommended correlation on the basis of the explosive eruption of melanite nephelinite yielding nephelinite agglomerate crowded with melanite crystals from which, he claimed, the melanite in other tuffs has been derived.

5. The Tertiary Lavas

(1) Distribution and Geology

Johannsen's (1938) nomenclature has been used for the lavas except that "phonolitic nephelinite" is preferred to his "nephelinite phonolite" (*op. cit.*, p. 256). The phonolitic nephelinites are transitional types between phonolite and nephelinite, having a composition in which the nepheline-orthoclase ratio exceeds 2:1 approximately, and there is a notable increase of pyroxene, generally aegirine-augite, as compared with the phonolites. The nephelinites are felspar-free and with increase of pyroxene pass into the mela-nephelinitic group. The term "mela-nephelinite" prefixed by an indicative mineral name that may be olivine or melilite, is used in preference to "nepheline basalt", which has been employed to describe basic nephelinite by most previous writers. Slightly more basic than the mela-nephelinites are the "augitites", described by Miss Neilson (Gregory, 1921, p. 403).

In the present area a remarkable gradational suite of lavas is to be found ranging from trachytes, through phonolitic trachytes, phonolites, phonolitic nephelinites, nephelinites, and mela-nephelinites to melilitites. The suite becomes progressively more silica-poor, successive members containing increasingly larger proportions of undersaturated minerals. Some of the more basic members are, however, saturated, e.g. the augitites. Other types present are limburgites, tephrites and basanites.

The field relationship of the various lavas is complicated by their derivation from at least three volcanic sources. The nephelinites, mela-nephelinites, tephrites and basanites are characteristic extrusives from Tinderet, to the south of which is the immense plateau of Losuguta-type lava derived from the Mau area. Flows of nephelinite, phonolitic nephelinite and late Kenya-type phonolites, intercalated with pyroclastics, have originated from vents and volcanoes in the region of Londiani. They banked up on the east side of Tinderet and erosion has produced the topographic effect that Tinderet is a spur projecting westward from the Londiani plateau. This effect was noted by Shackleton (1951, p. 368) who erroneously assumed that the Londiani phonolites would be found to overlie Tinderet and that the Londiani and Kericho phonolites are of the same type and age. It seems certain that the Londiani phonolites are of later age and it is now known that the crest of Tinderet is composed of felsparphyric basanites.

The Tinderet and Lumbwa Suites

The pyroclastic activity of Tinderet apparently began in the Miocene since volcanic tuffs, becoming progressively more agglomeratic, rest upon the Koru beds and limestones, the date of which has been proved by the evidence of fossils. Towards the close of its explosive phase Tinderet had built itself into a dominating volcanic ash-cone and, at some time during that period, the Kericho phonolites were quietly extruded from a source in the Mau region. The evidence of phonolite intercalated with the Tinderet tuffs is to be seen in the railway section between Tunnel Station and Fort Ternan, and the junction is exposed for ten miles along the southern slopes of the Baraget valley of Fort Ternan where the phonolite is found overlying the tuffs. This junction must dip steeply to the south as there is no exposure of the Tinderet tuffs to be seen at the base of the Kipchoriet gorge one mile west of Tunnel Station though the river has excavated through six hundred feet of phonolite at this point. To the east of Tunnel Station the contact follows the Kipchoriet gorge, the northern slopes of which are tuffs and the southern phonolites.

Following the extrusion of the phonolites a more intense phase of eruption occurred at Tinderet, with the production of coarse nephelinitic agglomerates. These are well exposed along the railway cuttings from Lumbwa to Tunnel Stations and are not found interbedded with phonolitic Kericho lavas north of the railway though one small remnant of tuff and agglomerate was seen overlying the phonolite on the small but conspicuous knoll one and a half miles south of Fort Ternan Station.

Subsequently outpourings of phonolitic nephelinites derived from the Londiani centre flowed westwards over the Lumbwa area. These beds can now be traced overlying the coarse Tinderet agglomerate along the ridge followed by the main road from Lumbwa to Tunnel Station, and south of the Kipchoriet river they overlie the Kericho phonolites on the plateau at Kipserger and on all the higher ground to the east between the Lumbwa valley and the Tugenon river. North of Lumbwa the outcrops of phonolitic nephelinite are confined to the hills east of the Namuting and Lelu valleys and are nowhere found further west amongst the volcanic rocks derived from Tinderet. Above the phonolitic nephelinite lies an ash horizon overlain by nephelinite, the flows of which are exposed over an extensive area. The nephelinite appears likely to be contemporaneous in the lava suites derived from both Tinderet and Londiani, though this cannot be stated with absolute certainty as the outcrop was not traced continuously from Tinderet to Lumbwa across the intervening Namuting and Malaget valleys. The nephelinites are well-exposed along the lower ridges of Tinderet in the Fort Ternan area and are found also as outliers in the Baraget valley where they overlie the phonolites. Nephelinite is also seen overlying the phonolitic nephelinite at Road Peak near the road along the Lumbwa-Tunnel ridge. An isolated exposure of nephelinite is also found capping Tatwakapsigesa T.S., east of the Kericho-Lumbwa road, and resting on agglomerates dipping radially outwards, which suggests that this peak was a subsidiary vent at the period of extrusion of the nephelinites.

On Tinderet itself the nephelinites are succeeded on the southern flanks by basanites that probably continue up to the peak, though tuffaceous beds, credibly reported to be quarried as building stone by the Mission, occur in the Mugut valley at about 6,600 feet where they probably represent an inlier of the lower tuffs. On the western flank of the

mountain the basanites overlap any nephelinites that may have existed there, and rest on the lower Miocene tuffaceous and agglomeratic beds. The basanites flowed extensively to the west across the head of the Kano plains. Outlying remnants are seen at Kipsomo, west of Muhoroni, and on the road to Chemilil Station. Two small outliers still survive in the Ainomotua valley between the Songhor and Chemilil ridges, and are probably an extension of the late flow capping and encircling Kapurtay hill further up the valley. One of the outliers was a source of artifacts and stone tools and chippings are to be found there. The small outcrop at the base of the granite scarp one mile west of Down T.S. and that two and a quarter miles east of Down T.S. are not so easily explained, as their position makes it improbable that they can be part of a flow from Tinderet. They may more probably represent small fissure eruptions associated with the Nyando fault. A number of conspicuous isolated conical hills in the Muhoroni region, such as Legetate, Mnara, Kabenjuck, Koitatui, Koiabi and Kapchui, are topographically suggestive of volcanic plugs. In all cases these hills are composed either of basanite or olivine-melilite mela-nephelinite. Vertical columnar jointing is particularly well developed on Legetate and Kabenjuck. The relationship of the cones to the adjacent formations could not, however, be definitely established as intrusive as the lower parts of the hills are concealed by talus.

The summit of Tinderet consists of two peaks, the southernmost, on which the triangulation beacon is located, being slightly the higher. An ascent was made up the prominent north-western spur. Though exposures are rare on this route the continuation of olivine basanite up to 7,600 feet was established by float blocks. Above this elevation there are occasional outcrops of felsparphyric basanites (42/465 from about 7,800 feet) in which the olivine is completely altered. At 8,160 feet felsparphyric basanite (42/466, 42/647) is again exposed, extending to 8,300 feet, and also capping the northern of the two peaks and outcropping on the col between them. No evidence of a crater was seen. The quiet outwelling of the tephrites and basanites as a final phase of activity of Tinderet has concealed any crater that may have existed in the pyroclastic rocks and the flows extended over the older nephelinites, agglomerates and tuffs. On another traverse east-north-east of the peak, onto the watershed between the Lelu stream and the Sakani, it was found that the base of the porphyritic basanites lies on porphyritic nephelinites at about 7,000 feet, and the basanite was traced southwards up to the glades in the forest at 7,730 feet on the spur. The glades stand out conspicuously on the air-photos of Tinderet. The Londiani phonolites did not extend over the higher parts of Tinderet, as Shackleton surmised might be the case, though small remnants (42/470) are seen in the valley above the Sakani falls at 6,500 feet, near the equator. This indicates that the erosion of the Sakani valley in the basanites and tephrites occurred prior to the extrusion of this member of the Londiani phonolites.

The sequence above the nephelinites of the Londiani volcanics can be examined up the hill-road north of Lumbwa, where a succession of lavas and pyroclastic rocks occurs. An upper bed of phonolitic nephelinite (42/430) was found at the road junction by Road Hill T.S. Above this lies a bed of tuff followed by over two hundred feet of nephelinite (42/431), which constitutes the spur followed by the road to B.O.T., trigonometrical station, and above which lies a thin capping of porphyritic phonolite (42/432). These phonolites extend north of the road and occupy the high ground east of the Malaget stream, which rises further north in an area of fine white welded tuff (42/435). Outliers of the phonolite form a conspicuous ridge across the valley west of Segetet, to the north of which, in the high ground around Sacharan and Masiria, further outcrops of phonolite are suspected to occur since they occupy the ridge four miles north-west of Segetet and are found both at the end of the spur by the forest boundary two miles north-west of Segetet and above the Equator-Songhor road on Kiporice. The north-east corner of the area was not closely traversed and other outcrops of phonolite may survive in that part on some of the higher ridges north of the Songhor-Equator road, though they are not evident on the air-photographs.

The Londiani plateau, judging from a casual survey in passing over the main roads to the north-west and east of the town, consists mainly of tuffs. The phonolites on Segetet when viewed from the road west of Londiani appear to have flowed to the south-east from a source to the north-west of Limutet. Inspection of the latest contoured map of this area (preliminary plot 188/1) shows a dome-shaped hill rising to 8,450 feet situated just east of the longitude 35° 30′, which is the eastern limit of the present area, and some two miles north-west of Limutet. This may prove to be the source of the Segetet phonolites.

The continuation of the nephelinites up the Malaget valley below the phonolites is inferred from exposures seen across the stream at the base of the scarp north-west of Segetet. The scarp itself below the forest boundary beacon consists of grey and fawn tuffs and

agglomerates, capped on the plateau edge by a thin bed of phonolite. The flat top of the spur consists of white tuffs similar to those seen in the Malaget Timber Concession further north where, in the valley at 7,600 feet, a thick sequence of bedded deposits occurs (specimens 42/436 to 42/438).

The Kericho Phonolites

Exposures of the Kericho phonolites cover approximately three hundred square miles in the Kericho district and are the extension of some seven hundred square miles of similar lavas mapped in the Sotik District. If an average thickness over this area of only one-tenth of a mile is assumed, though a maximum depth exceeding one thousand feet has been observed in both areas, it can be estimated that the volume of the lavas exceeds one hundred cubic miles. This estimate is low as no allowance has been made for an additional thousand square miles represented by the Mau Forest Reserve beneath which the phonolite flows will almost certainly extend up to the edge of the Great Rift Valley.

A volcanic extrusion of this size must be related to a geological event of the first magnitude. It is concluded therefore that the phonolites are closely related to early faulting of the Rift Valley and that they preceded the downfaulting of the rift, since the lavas would otherwise have flowed into the depression so caused and not away from it. The date of the faulting can be approximately fixed in view of the intercalation of the phonolites with the Lower Miocene tuffs in the Fort Ternan area (Maufe, 1908, p. 48 and Shackleton, 1951, p. 368).

The phonolites were mainly extruded in a west and south-westerly direction, evidence being obtained from the direction of flow-vesicles and phenocrysts. The distance the lava could flow to the north and west was controlled by Tinderet, as it then existed, by the Kapsomonget ridge, and by the barrier range of the Kisii hills to the south-west. In the north the phonolites therefore flowed tangentially around the south flank of the cone of Tinderet and finally debouched in a north-westerly direction across the Kano plains. This accounts for the considerable thickness and regularity of the flows along the present Kipchoriet scarp, all of which dip to the west at about $3\frac{1}{2}^{\circ}$, circumferentially to Tinderet. The absence of any remnants of phonolite flows on the floor of the valley amongst the Miocene beds or under the Tinderet volcanics, where they would otherwise have been well preserved, is also explained. Further south the phonolites, having overflowed the Kapsomonget ridge, flooded the sub-Miocene peneplain and passed around the north end of the ridge of Bukoban lavas at Sekauani to form the Nyabando plateau to the west and the Lalibuch flows on the Awach plain to the north-west.

The Kericho plateau is notable for the strong erosional scarp formed by the Kipchoriet along its north side and the well-developed topographic features marking the line of the monoclinal flexure that runs north-east from Sondu. The lavas are remarkable for the number and thickness of their beds, their freedom from interbedded pyroclastic material, and also for their low angle of dip, which indicates a very fluid condition of flow and lack of subsequent tilting. Subsidiary vents and fissures along and at the junction of lines of tectonic weakness, as first proposed by Gregory, may also have added quiet extrusions of lava to the main flows originating in the Mau. There is evidence to suggest that Kapchepterro hill and Tatwakapsigesa represented vents of this type. The latter was certainly an eruptive centre in post-Kericho phonolite times since pyroclastics and radial dykes occur on it. The agglomerates are seen overlying the phonolite at Kaisugu and on the northern and western sides of the peak itself.

The Londiani Agglomerates and Tuffs

The extent and number of the pyroclastic beds in the Lumbwa area is indicated in the table of the volcanic succession from Mau to Koru (p. 27). They are referred to as the Londiani Agglomerates and Tuffs since they were clearly derived from volcanic sources in that area and separate relatively thin beds of phonolitic nephelinites, nephelinites and trachytic phonolites. The more coarse-grained beds are by no means so coarsely agglomeratic as the thick nephelinitic agglomerates which are considered to have initiated the revival of vulcanicity at Tinderet.

Welded Tuffs

Characteristic of the upper pyroclasts are welded tuffs, which have an excellently developed flow structure, indicating that the component fragments retained their heat on settling and must have been deposited rapidly at no great distance from the volcanic source.

The term "ignimbrite" has been applied to such rocks in New Zealand by Marshall (Cotton, 1944, p. 199) but according to Barksdale (1951, p. 441) they were first described by Iddings in 1909 as "welded tuffs". Fenner (1948, p. 883) attributed the structure of such rocks to the softening and collapse of their pumice fragments by heat derived from the superincumbent mass, so that they become pressed down and aligned to form a rock which megascopically resembles a felsitic rhyolite or even a structureless obsidian. According to Barksdale, no glassy welded tuffs of age earlier than Upper Cretaceous have been found. The occurrences in the north Lumbwa area are probably late Tertiary and may be even Pleistocene in age, since the ash cones on the Londiani plateau from which they presumably derived are excellently preserved.

The welded tuffs are overlain by the upper trachytic phonolite in the north Lumbwa area and are found on the Equator road north-east of Tinderet (e.g. specimen 42/435), where they probably occur extensively above 8,000 feet. In the Malaget valley they outcrop at 6,800 feet, lying below the phonolite which composes Segetet hill. These beds, which have been worked for building stone, continue down the valley and are again seen at the head of the tributary one and a half miles south-east of Segetet, where specimen 42/448 was collected at 7,400 feet. An exposure of the same rock type was found on the small though prominent hillock called Kerma, situated in the valley south of the railway some two miles east of Lumbwa town. The elevation here is 6,900 feet and the tuffs occur both above and below a thin bed of phonolite (42/426) which forms a bench on the hillside. Further east, equivalent beds form the Kedowa tuffs, which are much worked for building stone.

Since the welded tuffs are similar in type and composition throughout the area they are regarded as contemporaneous, and the various elevations at which they are found indicates the irregularity of the topography at the time of their formation. This irregularity may be attributed to the banking up and erosion of the Londiani volcanics to the north-east and east of Tinderet.

The Mela-nephelinites

The mela-nephelinites and their basic variations, which are of particular petrographic interest, have been excluded from the previous general account, mainly on account of the difficulty of determining their exact position in the sequence.

On the Legetate ridge the mela-nephelinites (42/325) overlie the Koru Beds and underlie basanites (42/346). Mela-nephelinites also form the Legetet plateau and the base of Koiabi further south, where they are again found beneath basanites. On the hill one and a third miles south of Koru Station a small outlier of mela-nephelinite (42/374) rests on eroded tuffs whereas between the road and railway near the Cheberir stream-crossing two small outliers of analcime basanite (42/458) were found.

Nearer the Fort Ternan area the peak of Kapchui consists of olivine-melilite mela-nephelinite above nephelinite and the hills north of the railway, such as Eseget, north of the Fort Ternan air-strip, and that across the Sawaset valley to the east, are nephelinites capped by more augite-rich lavas. The ridge east of the air-strip across the Mugut consists of mela-nephelinite (42/457) resting on nephelinitic agglomerate, and at Fort Ternan station Maufe (1908, p. 49) reported olivine nephelinite and melilite nephelinite lava flows among the tuffs. This last relationship was not confirmed. On the road at 5,280 feet, some one and a quarter miles east of the station, a nepheline melilitite (42/395) occurs, apparently resting upon the tuffs. Owing to its position, 300 feet above the similar lava noted by Maufe at the station, it is difficult to consider the two as the same flow unless the latter is a remnant lying against the flank of an earlier valley of the Namuting. No further exposures of this type of lava are seen until the Lumbwa area is reached where three small exposures were found. Two of these once again rest upon nephelinite, viz. three-quarters of a mile east-north-east and the second (42/439, melilite-melanite nephelinite) two and three-quarter miles north-north-east of Road Peak T.S. Finally a small outlier rests on the coarse agglomerate at the highest point of the spur one and an eighth miles west of Lumbwa station (42/445, porphyritic melilite nephelinite).

These types probably represent local basic varieties of the nephelinite flows. Gregory (1921, p. 209) has drawn attention to the possibility that they correspond to similar rocks of northern Tanganyika and Elgon.

East-West Volcanic Succession from Mau to Koru

The present survey has not shown any necessity to revise the succession from Mau Summit to Koru described in detail by Maufe in 1908. Maufe's work, has however been supplemented by the determination of elevations of the outcrops and the calculation therefrom of the approximate thickness of the various beds. For more easy reference the sequence is set out in tabular form and for greater completeness has been started at the crest of the watershed near Mau Summit Station although this lies twelve miles to the east of the area mapped.

In general the beds have a westerly dip slightly less than the general westerly slope of the country so that older beds are encountered at lower elevations. The sequence covers a vertical interval of 3,580 feet between 8,200 feet at Mau Summit and 4,620 feet at Koru, and the thickness of beds given is slightly exaggerated since no allowance has been made for the gentle dip. In this succession there is roughly 1,060 feet of lavas, 1,950 feet of tuffs and 570 feet of agglomerates. It should be borne in mind that the 275 feet of Kericho phonolite included in the lavas has a discordant relationship and is of considerably greater thickness to the south.

TABLE I.—GEOLOGICAL SUCCESSION ALONG RAILWAY FROM MAU SUMMIT TO KORU

(*Based on Maufe*, 1908, *pp.* 47-49)

Description	Mileage on Railway	Approx. elevation in feet above O.D. of junctions	Approx. thickness in feet	Remarks
		8,200		
Decomposed Tuff			50	First cutting W. of Mau Summit Summit.
	491	8,150		
Basic Phonolite			100	In rock cutting.
	492	8,050		
Porphyritic Trachyte			350	Trachyte with quartz in groundmass in several cuttings; similar to Limuru trachytes.
	496	7,700		
Soft green tuff with fragments of lava and pumice (*Kedowa Tuffs*)			700	W. of Londiani Station. At mile 507/10, near the base, a trachyte mass invades tuff.
	508/6	7,000		
Phonolite			50	Amygdaloidal above and compact below.
	509/3	6,950		Base of Phonolite.
Tuff			50	
		6,900(?)		Level assumed.
Green Trachytic Lava			10(?)	In deep cutting before viaduct.
	510	6,890(?)		
Tuff			170	
	511	6,720		
Phonolitic Nephelinite(?)			45	Decomposed lava outcrops, probably phonolite nephelinite suite.
	512	6,675		
Tuff (?)			175	Small hillock Limburgite (?) with columnar jointing.
	512/14	6,500		

TABLE I.—GEOLOGICAL SUCCESSION ALONG RAILWAY FROM MAU SUMMIT TO KORU — (*Contd.*)

Description	Mileage on Railway	Approx. elevation in feet above O.D. of junctions	Approx. thickness in feet	Remarks
Mela-nephelinite (?)			50	Dark green nephelinite with perovskite.
	513/11	6,450		Assumed base of lava.
Tuff	514/4	6,410	50	Outcrops.
	514/6	6,400		Upper limit of agglomerate.
Agglomerate			40	
	514/14	6,360		Base of agglomerate.
Nephelinite	515½		30(?)	Outcrops.
		6,330		Lumbwa Station.
				A decomposed lava overlain by raised river terrace gravels 40 feet above river.
Coarse agglomerate	516	6,330		Agglomerate outcrops overlain by nephelinite.
	516/10 and 517/10			Same nephelinite between agglomerate.
Coarse agglomerate		240		Upper agglomerate with blocks of nephelinitic lavas up to 20 feet long.
Coarse agglomerate	519			Decomposed nephelinite outcrop overlying agglomerate for short distance.
	523/10	6,090		Base of agglomerate.
Tuff			365	Dull greenish-grey; with irregular intrusive dark blue phonolite beyond tunnel.
	528	about 5,725		Irregular junction; with slight induration at a junction at 5,850 feet.
Kericho Phonolite			275	Compact, black, with hexagonal jointing in centre but base brecciated and vesicular, disturbing the underlying tuffs which tongue into the phonolite.
	529/13	5,450		Base of phonolite.
Tuff and coarse agglomerate.			170	Similar to 517/10-523/10 type.
Tuff				
Melilite mela-nephelinite	532/15	5,280	20(?)	Thickness assumed.
			160	Calcitized and contains mineralized fossil wood.
Tuff and agglomerate		5,100		
Olivine mela-nephelinite			60(?)	Maufe's nepheline basalt with no felspar.
	534/8	5,040		
Agglomerate			200	Cutting at mile 537—four dykes from 1 ft. to 12½ ft., striking N.N.E.-S.S.W.
				Contains blocks of biotite gneiss.

TABLE I.—GEOLOGICAL SUCCESSION ALONG RAILWAY FROM MAU SUMMIT TO KORU — (*Contd.*)

Description	Mileage on Railway	Approx. elevation in feet above O.D. of junctions	Approx. thickness in feet	Remarks
	537/10	4,840		
Banded Tuffs			20	Dip 12° to N. 13° E.
	537/13	4,820		
Nephelinite			20	
		4,800		
Tuff and agglomerate			50	Cut by dyke striking W.N.W.-E.S.E.
	538	4,750		
Interbedded lava with tuff and agglomerate.			70	
	538/13	4,680		
Tuff			60	
Gneiss, Basement System	541/14	4,620		
				To the N.W. and N. are the Lower Miocene Koru Beds of Legetet.

(2) PETROGRAPHY OF THE TERTIARY LAVAS

Specimens collected along the railway by previous observers, who mainly followed this route across the area, have been described by Prior (1903), Maufe (1908), Goldschlag (1912), Gregory (1921), Odman (1930), Campbell Smith (1931), and Kent (1942). Attention was drawn to the greater proportion of nepheline-bearing rocks in this area compared with the Great Rift Valley and to the rock-series represented by the various lavas ranging from phonolitic trachytes of Londiani to rocks rich in nepheline, and at the basic end including melilite nephelinites and melilitites. Prior's contention that the rocks contain a greater proportion of lime, magnesia and titanic acid than the normal extrusives of Kenya is confirmed.

Analcite Basanites and Tephrites

These rocks were designated basalts and olivine basalts in the field until the small but essential occurrence of analcite and zeolite in the base was recognized by microscope examination. They are similar petrographically to rocks described by Shackleton (1945) from the Nyeri area, which lies at the same latitude but east of the main Rift Valley. Shackleton described olivine basalts (Kijabe type), basalts with olivine and augite phenocrysts and picritic basalts, though he claimed that the rocks contain, in every case, an alkali residuum of either zeolite, analcite or orthoclase. This description would equally well apply to the lavas of the upper part of the Tinderet suite.

Two varieties of basaltic lavas can be recognized on Tinderet. The peak itself is capped by a felsparphyric variety, similar in the hand-specimen to the Kijabe basalt, with abundant tabular phenocrysts of plagioclase (labradorite) up to 5 mm. x 1 mm. in size. Porphyritic olivine, augite and magnetite is generally present, as in specimen 42/466, the first being sometimes represented only by pseudomorphs (42/465). The scattered black pyroxenes and green olivines stand out in fresh specimens from a dense base. When weathered the rocks are soft, light fawn in colour and spotted with orange-brown iddingsite pseudomorphs of olivine. The phenocrysts of felspar, though altered, are easily recognizable. The rocks are sufficiently magnetic to make the compass unreliable in their vicinity. They weather to considerable depth in some areas, which in places results in landslides on steep slopes, as at Soba.

The augite is pale and often more titaniferous marginally, simply twinned, and sometimes crystallized in aggregates (42/464/2). In specimen 42/466 the augite finished crystallizing late and sometimes encloses plagioclase and magnetite. The groundmass is finely crystalline with small interstitial patches of analcite and zeolite. Analcite also occurs in small vesicles. Unless an undiscovered core of basanite occurs on Tinderet the felsparphyric types must be assumed to be the latest extrusion.

The more common variety of basanite on Tinderet contains plagioclase in the groundmass only while the olivine and augite are porphyritic. The augites are generally zoned with browner borders and the olivines show signs of resorption and partial alteration to serpentine. The groundmass consists of finely crystalline plagioclase, pyroxene and magnetite with a little interstitial analcite. In a few cases second generation olivines occur also in the groundmass (42/357, Mbogo vale) and perovskite is sometimes also present (42/324, Legetate summit). The plagioclase crystals are generally unorientated but in some cases (42/399, from the end of the track north of Fort Ternan) have a trachytic arrangement. Biotite is an unusual accessory but occurs for example in specimen 42/394, from the outcrop south-east of Koiabi.

Two specimens of a particularly olivine-rich variety were found in the Mbogo vale (42/460 and 42/461). These appear to correspond with the picrite described by Shackleton (1945, p. 17). The composition of the Tinderet rocks is approximately twenty-three per cent olivine, fifty-one per cent augite, sixteen per cent magnetite, five per cent plagioclase (labradorite) and five per cent other minerals including biotite, analcite and zeolites. The rocks are fairly coarsely crystalline and contain olivine phenocrysts as much as 2 cm. across that are seen in slides to be fresh or with alteration to iddingsite, varying from border zones to complete replacement.

Tephrites are uncommon and only three specimens were collected (42/361, from the road south-east of Base T.S.; 42/362, from the same road about half a mile further east, and 42/389 from the knoll at the road bend west of Fort Ternan air-strip). The relatively high proportion of analcite in the base of the first and last specimens became evident on treatment with phosphoric acid and methylene blue. Augite and magnetite are present both as phenocrysts and in the groundmass. The plagioclase (oligoclase) occurs only in the matrix together with biotite, apatite and kataphorite in specimen 42/362, and with perovskite in specimen 42/389. Felspar was not recognized in the groundmass of the latter, and the rock should perhaps be considered as an analcimite rather than a tephrite.

Augitites

Augitites have previously been described by Neilson (Gregory, 1921, p. 403), Prior (1903, p. 249), Maufe (1908, p. 30) and Campbell Smith (1931, p. 251), the last of whom gives analyses and norms. Similar rocks have been found on Elgon and classed as melanephelinites by Searle (1952, p. 61). Specimens were collected during the present survey north of Legetate at the Meswa stream (42/326), at the north-east base of Koiabi hill (42/344), and along the railway three and a quarter miles west of Fort Ternan (42/387 and 42/388).

The Tinderet type contains augite as phenocrysts and in the groundmass, while perovskite and apatite are common accessory minerals. Magnetite is ubiquitous. The texture of the groundmass is microcrystalline with some rare interstitial glassy patches. In specimen 42/402, from the main road north-east of Tunnel Station, analcite appears to be present in the base.

Mela-nephelinites and Melilitites

These are melanocratic nephelinites having pyroxene or melilite in excess of nepheline. The nepheline usually occurs as phenocrysts and is generally also found in the groundmass, which is microcrystalline and in some cases has a trachytic texture.

The augite is often zoned and usually pale green, or greyish mauve when titaniferous. It occurs in two generations. The phenocrysts are sometimes grouped so that the rocks have a glomeroporphyritic texture. Granular perovskite and subhedral magnetite are common constituents while apatite is an accessory in most specimens and is sometimes enclosed in the melilite. Secondary zeolite after nepheline is also observed in most slides.

Examples containing porphyritic nepheline are represented by specimens 42/324/1 (Legetate), 42/325 (track north-east of Legetate), 42/341 (Koitabusot), 42/383 (east-north-east of Kapurtay) and 42/457 (Fort Ternan) whereas specimen 42/374 (1½ miles south of Koru) and 42/391 (2,000 ft. south of Kapchui) show nepheline in less abundance and size. Zoned augites with cores of green pyroxene occur sporadically in specimens 42/374, 42/383 and 42/391. The last also exhibits aegirine reaction rims on the augite and good examples of a type of apatite that is common in many of the nephelinitic rocks of this area and Mt. Elgon. Fine black inclusions line the borders of the apatite crystals and a median crack often seems parallel to the c axis, causing a resemblance to melilite.

Increased basicity is indicated in some types by the occurrence of olivine and melilite. These rocks generally occur on the summits of small outstanding cone-shaped hills, and it is possible that they are intrusive. Representative examples are specimen 42/328 from Kabenjuck and 42/406 from Kapchui. In the former the pyroxene and olivine is porphyritic, whereas the melilite and nepheline occur in the matrix which mainly consists of microlites of pyroxene. Specimen 42/406 shows the same suite of minerals with an increase in the amount of nepheline and melilite and this tendency is continued in 42/395, a nepheline melilitite from the main road east-south-east of Fort Ternan, in which most of the phenocrysts are melilite. This rock differs from the melilitite described by Prior (1903, p. 249) in having less pyroxene. The nepheline is highly altered to zeolite and remains mainly as ghost crystals. The melilite however is a late mineral and fresh and appears to have grown at the expense of the groundmass which is seen forming inclusions in it. The edges of some crystals have an irregular stepped outline as a result of such growth. The melilite phenocrysts are tabular up to 2·5 mm. in size and have an unusual birefringence similar to that noted by Odman (1930, p. 481) in the melilites of Mt. Elgon. The central parts of the crystals have pale grey polarization colours, often changing to yellow towards the edges. The refractive index in ordinary light was found to be $N_E = 1{\cdot}6275$ and the birefringence is often patchy and irregular in a single crystal varying from 0·004 to 0·016. This compares with measurements by Odman of $N_E = 1{\cdot}626$ and birefringence of 0·016 for melilites from Mt. Elgon lavas. These figures indicate that the melilites in question, which are uniaxial negative, are probably a sodium-rich variety. No analyses are yet available to confirm this but the above characteristics agree closely with those described by Goldsmith (1948, p. 437) for an artificially prepared mineral corresponding to 70 gehlenite + 30 $NaCaAlSi_2O_7$.

The unusual birefringence of the melilites is best seen in specimen 42/445, which is a melilite nephelinite containing aegirine-augite. It is more soda-rich than usual and does not contain olivine. This rock occurs on the spur top 1,400 yards west of Lumbwa station. A nephelinite containing resorbed melilite in lesser amount together with many fresh phenocrysts of nepheline, a few phenocrysts of pyroxene and a dark brown melanite garnet set in a fine-grained dark green groundmass is represented by specimen 42/439 from the base of the southern end of Quarry T.S. ridge. The groundmass is microcrystalline and contains crystallites of pyroxene and small idiomorphs of nepheline. Anhedral grains of perovskite are also present and the rock is amygdaloidal, the amygdales being irregular and filled with zeolites including natrolite.

Nephelinites

In the hand-specimen the nephelinites vary little from a dark greenish grey colour, though in thin section they appear dark green, through yellow or brownish green to grey-green or blue-green. In some, coarse-grained phenocrysts are easily recognizable macroscopically while, in others, medium-grained phenocrysts are less readily apparent. In specimens 42/350 (a block from the agglomerates north-west of Kapurtay), 42/390 (north of the Siriret river) and 42/431 (from near B.O.T. trigonometrical station) the texture is much more fine-grained and the rocks appear dense.

In fifteen thin sections of nephelinites cut from specimens collected in the Ainomotua and Kipchoriet valleys the nepheline occurs as phenocrysts, either as microphenocrysts or as glomeroporphyritic groups. The nepheline crystals are sometimes seriate but more generally they are of two distinct generations. Prisms of aegirine-augite, often twinned and zoned, also occur in most of the rocks as phenocrysts, sometimes rimmed with aegirine. Augite is a relatively uncommon constituent. The most common accessory minerals are perovskite, magnetite, sphene and apatite. A dark brown melanite is also occasionally present. The groundmass is microcrystalline to glassy, coloured dark green or bluish-green in thin section by the pyroxenes and freely sprinkled with magnetite in most cases. Secondary alteration of the nepheline to zeolite is not uncommon particularly at the edges of the crystals, and zeolite together with calcite also occupies amygdales and cracks.

Specimen 42/369 from the valley east of Kapurtay contains phenocrysts up to 3 mm. and is characteristic of the porphyritic varieties but the thin section made from it is free from perovskite which is, however, seen as polysynthetic twins in, for example, specimen 42/397 collected 4,000 ft. south-east of Kapchui T.S., west of Fort Ternan. The specimens from the Lumbwa area associated with the Londiani volcanics are microporphyritic and have a distinctly bluer base than those derived from Tinderet. Sphene is more common in these Lumbwa rocks than perovskite (42/404 from the hill west of Road Peak, 42/413 from the North Lumbwa road west of Quarry T.S. and 42/416 from near Kapkegora). Melanite and perovskite occur in specimen 42/414 (from east of Spur T.S.), in which also the pyroxene and iron ore content is less than normal. Specimen 42/390 from north of the Siriret river north-east of Koru is augite-rich and contains nepheline in abundance only in the groundmass, together with a little perovskite and apatite. Two specimens (42/350 and 42/355) represent lapilli from the nephelinitic agglomerate in the north Songhor area and are composed mainly of nepheline and aegirine-augite with very few accessory minerals.

Phonolitic Nephelinites

The phonolitic nephelinites of this area were first described by Prior (1903, p. 239) who referred to them as "more ordinary type of phonolite with abundant sphene and no soda amphiboles". The adjective "ordinary" however should not be presumed to imply that lavas of this type are of common occurrence in Kenya since they have previously been described only from Mount Elgon by Odman (1930, p. 495) and Searle (1952, p. 64). Phonolitic nephelinites also occur in the Homa-Ruri area of South Nyanza (Pulfrey, 1943, p. 4). In the present area similar rocks are found in which nepheline and sphene are prominent and show better crystalline development, and there is a marked deficiency of magnetite in the aegirine-augite-rich varieties.

In comparison with the phonolites, the phonolitic nephelinites of Lumbwa are characterized by an increase of porphyritic nepheline and the presence of phenocrysts of aegirine-augite and sphene. The felspar content is progressively reduced as nephelinitic composition is approached, and is most typically found only in the groundmass together with interstitial nepheline. In the more phonolitic members of this group felspar approaches equality in amount with nepheline and occurs as porphyritic anorthoclase (42/423, from half a mile west of Lumbwa; 42/424, Lumbwa and 42/429, Road Hill T.S.). The coarsely porphyritic soda-pyroxene-rich phonolites with trachytic texture that occur near Tatwakapsigesa are considered to represent the more acid end of this type (42/675, Kaisuga, and 42/676 a little over ¾ mile east-south-east of Takwakapsigesa beacon).

Of the accessory minerals, sphene is notably well-developed as phenocrysts up to one and a half millimetres in length (42/401, from main road north-east of Tunnel Station; 42/403, main road south of Fort Ternan Station trigonometrical point; 42/412, North Lumbwa road south-west of Quarry T.S.; 42/449, near the forest edge on the North Lumbwa road). Apatite and magnetite are common constituents, the latter in small amount except in the more basic types that have a pale green augite proxying aegirine-augite.

The transitional character of these lavas between phonolite and nephelinite is shown not only by the decrease in felspar but also by the fact that some contain aegirine-augite and augite, whereas others contain augite only (42/409B, from 2 miles west of Lumbwa; 42/428, from 3 miles south-east of Lumbwa; and 42/456, from 2 miles north-east of Boys T.S.). The sphene content is not effected to any marked extent by the variation in the type of pyroxene. The texture of the more basic types tends to be glomeroporphyritic.

The groundmass generally consists of a microcrystalline aggregate of pyroxene and felspar with little or no interstitial matter in the more basic types and the texture is often trachytic at the acid end of the group. Occasional sodic amphiboles, such as cossyrite and kataphorite, can be recognized but biotite is absent throughout. Alteration of the nepheline to zeolite is fairly common. The variety of phonolitic nephelinite containing barkevikitic hornblende from Elgon mentioned by Odman and Searle is rare in the Lumbwa region. Only one specimen (42/409B) of this type was collected, from an outcrop above the railway line two and three-quarter miles west of Lumbwa station.

Phonolites and Trachytoid Phonolites

Two main types of phonolites may be distinguished in this area. First there are the older extensive flows which build up the Kericho plateau. These are related to the Losuguta type described by Campbell Smith (1931, p. 236). Overlying them in parts and particularly

in the north-east of the area are phonolites of Kenya-type (Campbell Smith, 1931, p. 236) derived from vents in the Londiani area, of which the trachytoid phonolites are a textural variation. The latter can usually be distinguished in hand-specimen from the phonolites by their colour and feel—they are generally grey or greyish buff and rough to the touch. According to Pulfrey (1946, p. 19) in Maragoli some Kenya-type phonolites contain megascopic felspar phenocrysts, but they are usually much smaller than those found in the Kapiti-type phonolites. The phenocrysts also appear to be more prismatic than platy though this may not always be so.

The Losuguta-type lavas are typically porphyritic, usually vesicular, and some have biotite as phenocrysts. The phenocrysts are, however, generally less well developed in the Losuguta than in the Kapiti-type in which they are normally so prominent that there is little doubt of the lava type.

In general the phonolites in this area appear to be more coarsely crystallized than similar lavas on Mount Elgon.

Kericho Phonolite (*Losuguta type*)

The petrography of these lavas, which continue into the Sotik area, has been described in some detail by Schoeman (1949, pp. 27-29). It is therefore only necessary here to draw attention to the main characteristics.

Although the plateau lavas are generally porphyritic, with typical glassy phenocrysts of orthoclase and greasy-looking greenish nephelines, they cannot be equated with the more coarsely porphyritic Kapitian type, though there are certain similarities in composition and mode of occurrence.

Schoeman reported the occurrence of olivine, which is a characteristic mineral of the Kapitian type in these lavas in the Sotik area. This mineral was not observed in the Kericho area in the eighteen thin sections examined. These sections are, however, mainly of the dense less porphyritic lavas encountered in the field, the identification of which required confirmation under the microscope.

Specimens were taken from various horizons from 4,700 feet near the base of the flows in the Mumek gorge (42/289); at 5,400 feet further east in the same valley (42/276); and at 5,400 feet on the spur to the east of Sekauani (42/299). Other specimens in this last area, representing the upper flows at 5,700 feet, are 42/274, 42/275 and 42/285. All these specimens with the exception of 42/276 which is deficient in ferromagnesian minerals, are remarkably uniform in composition with a notable content of various soda amphiboles, mainly cossyrite and kataphorite, occurring as microcrystalline anhedral or subhedral patches in the groundmass. Small phenocrysts of pale green pyroxene and pleochroic biotite together with some magnetite are common to all, though scarce in amount.

The flows in the Chemoisiet and Itare river areas are often finer-grained or even glassy, when perlitic cracking is observed (42/305 and 42/306 from the River Itare south-east of Kipkaren and 42/310 from the Rigonget falls, west of Jamji).

To the north in the Kipchoriet valley the uniformity of composition continues as is shown by specimen 42/392 from the base of the hill south of Kapchui, Fort Ternan. Specimen 42/396 represents the phonolite intercalated among the tuffs of the Tinderet suite on the railway scarp west of Fort Ternan at mile 532/15 and corresponds with Gregory's specimen 579, probably from the top of the flow at the same place. This was one of the rocks described by Miss Neilson (Gregory, 1921, p. 393) amongst the phonolites of Kapitian type, but which was subsequently excluded from that group by Campbell Smith (1931, p. 236) and classed with the Losuguta type. Campbell Smith admits that the distinction between the Losuguta and Kapitian types is by no means a sharp one, but regards the former as intermediate in character between the phonolites of Kapiti and Kenya type. Gregory's specimen appears to be a more fine-grained equivalent of specimen 42/396, which is sufficiently crystalline to enable pyroxene and sodic amphibole to be recognized. The slide also shows a characteristic patchy appearance of the groundmass that is common to many of these rocks, and is not diagnostic of any particular horizon. Finally the constant vesicularity of the phonolites deserves mention. The vesicles which are invariably filled by growths of zeolite and calcite, are generally small but always show a marked linear distortion as a result of flow (specimen 42/318, from Koroma, in which the vesicles are drawn out into thin discs, is an extreme case).

Upper Phonolites (Kenya type—Intermediate Variety)

The phonolites above 6,800 ft. in the Lumbwa area, and overlying the Kericho plateau flows at Kapsamonget, are distinguished by their texture and the greater proportion and better development of soda amphiboles. They have fewer phenocrysts of orthoclase and nepheline than the Kericho phonolites and contain no biotite.

The Lumbwa phonolites may be divided into four textural groups. In the first, the amphibole is scattered uniformly throughout the base as shreds and grains or as microscopic patches ophitically intergrown with the orthoclase, felspathoid and soda pyroxene, which is variably either aegirine or aegirine-augite (42/364, Kiporice; 42/418, on road north-west of Tatwakapsigesa; 42/426A, Kerma hill; and 42/432 on road north of B.O.T. triangulation station). In the second group the melanocratic minerals have a tendency to form small aggregates (42/443, from the track south of Segetet). The aggregates become coarser in some cases (42/411, from the Malaget valley, north of Road Hill T.S.) or leucocratic patches in the groundmass contrast with parts rich in aggregates, as in specimen 42/433, from the main Londiani road about half a mile east of the boundary of the mapped area. This texture corresponds with that described by Prior (1903, p. 238) as "intermediate", and grades into his third group or "Kamasia type" in which the aggregates are even more coarse (42/440, 42/442 A and B, from the ridge west of Segetet). In the last specimen a slight variation is found as the dark mineral clumps are drawn out by flow.

All these variations are found in the phonolite flows outcropping between 6,800 and 7,600 ft. to the north of Lumbwa, apart from specimen 42/364 which represents the small isolated exposure on the summit of Kiporice at 8,700 ft. on the Timboroa-Songhor road.

A leucocratic variation is also seen in the small outcrops in the Sakani valley north of Tinderet. In these rocks the amphibole content is much reduced and flow structures are developed (42/463 and 42/470).

According to Campbell Smith (1931, p. 230), Miss Neilson, in arranging Gregory's phonolites, included Prior's "intermediate" and "Kamasia" types within the Kenya type. The occurrence of these various types in the same flow series as demonstrated in the north Lumbwa outcrops confirms this classification. The writer agrees with Campbell Smith that the retention of the type names would be useful for descriptive purposes, but that they should all be considered as variations of the Kenya-type lava.

Trachytoid Phonolites

Previous writers have used the term "phonolitic trachyte" for rocks approaching the saturated end of the phonolite series in which nepheline is not recognizable but which contain soda pyroxenes or amphiboles (e.g. Prior, 1903, p. 241). The less basic lavas in the area mapped, however, contain phenocrysts of nepheline, and can be more suitably referred to as trachytoid phonolites. As they are rich in soda amphiboles and carry no biotite they are related to the Kenya-type phonolites. Specimen 42/286, from the hill just west of Kapsamonget, has a trachytic texture only in part. In specimen 42/322 from Kabukyek, further west, the rock is equally porphyritic but has a more pronounced trachytic texture. The rocks are coarsely porphyritic with tabular phenocrysts of orthoclase up to 1 cm., euhedral nephelines up to 2 mm. with resorbed margins, and smaller aegirines. The amphibole, mainly a dark brown sodic variety, occurs only in the matrix. The pyroxene is aegirine-augite and there is cossyrite and some blue arfvedsonite on interstitial subhedral growths between the felspar and nepheline in the matrix.

A variation of this type is seen in the uppermost flows east of Segetet at 7,800 feet (specimen 42/447) in which nepheline was not recognized, but euhedral analcite appears in the base.

Other Trachytic Phonolites and Trachytes

Apart from the Kenya-type phonolites just described there is a small area of very coarsely porphyritic phonolite just east of Tatwakapsigesa. This rock is represented by specimen 42/676, bombs of which occur in the massive underlying agglomerate at Kaisugu (42/675). The phonolite is related to the phonolitic nephelinites in that soda pyroxenes and sphene are well developed. The anorthoclase reaches a size of 2 cm. and the phenocrysts of nepheline up to 1 cm., in a dense base which proves under the microscope to consist of felspar in trachytic arrangement with some glass. The pyroxene is a zoned aegirine-augite. Magnetite occurs in two generations but is relatively scarcely speckled in the base in which there is a little apatite. No biotite occurs in this rock.

Felspathoidal Trachyte

A small outcrop of very fine-grained phonolitic trachyte (specimen 42/459) occurs near the Police Post, Koru. In thin section the rock is observed to consist mainly of flow-orientated subhedral prisms of orthoclase, pale prismatic pyroxenes, spotted with magnetite. There are a few orthoclase and apatite microphenocrysts. No euhedral nepheline is present but weakly birefringent material in the groundmass is almost certainly a felspathoid.

A similar fine-grained trachytic rock occurs at 5,000 ft. on Kapurtay hill, Songhor, between the basanite capping and the lower tuffs. The rock consists largely of felspar and contains less pyroxene than the Koru rock with more magnetite speckled throughout as loose aggregates, probably representing the remains of original pyroxene crystals. The orthoclase is better developed and there is also present a little brown interstitial amphibole in the groundmass.

Analyses of Tertiary Lavas of the Kericho area

The results of the analyses of various lava types encountered in the area are shown in Table II together with the calculated norms. The deficiency of silica in the nepheline melilitite analysis (No. 1) which results in the appearance of calcium orthosilicate and leucite in the norm is notable. On the other hand the Lumbwa nepheline tephrite (analysis B) has an unusual excess of silica and aluminium. The phonolitic nephelinite (No. 5) also has certain uncommon features as there is a comparative deficiency in iron and calcium together with an increase of soda which results in the appearance of acmite in the norm with a lack of the usual magnetite. When the percentages of the various oxides are plotted as a variation diagram against silica content it is apparent that the lavas have a serial relationship. The curves for the oxides of calcium, magnesium, titanium and Fe_2O_3 vary sympathetically with each other and are antipathetic to those of aluminium, sodium, potassium and FeO, which tend to rise in the more acid lava types.

TABLE II.—ANALYSES OF TERTIARY LAVAS, KERICHO DISTRICT

	1	2	3	A	4	5	6	7	B	8	9
SiO_2	36·64	41·42	41·50	43·47	46·50	50·82	52·48	53·54	54·71	53·78	54·76
Al_2O_3	11·68	14·33	14·67	12·60	14·94	15·71	18·48	20·13	20·29	18·17	19·97
Fe_2O_3	8·11	7·16	7·88	9·85	5·93	4·02	4·60	2·93	5·44	3·11	2·21
FeO	4·63	3·46	3·73	3·53	5·44	2·71	3·26	2·32	4·60	3·96	3·00
MgO	5·61	4·53	3·48	4·11	7·14	1·12	0·91	1·05	2·03	1·01	0·80
CaO	18·32	13·22	8·30	11·96	10·86	4·40	2·40	2·12	2·10	2·08	1·26
Na_2O	2·10	4·56	5·92	3·25	3·51	8·09	4·83	5·98	6·42	7·21	8·32
K_2O	2·11	2·24	3·39	1·74	1·10	4·64	6·09	5·76	1·58	5·46	5·72
H_2O+	4·94	4·20	4·56	4·14	1·40	4·24	3·62	2·58	2·00	1·82	2·28
H_2O-	2·10	1·24	3·36		1·16	0·64	2·12	2·22		2·14	0·36
CO_2	0·22	0·42	0·14	—	0·32	0·26	0·30	Nil	—	0·24	0·12
TiO_2	2·55	2·45	2·00	2·52	1·43	0·95	0·40	0·50	Trace	0·40	0·60
P_2O_5	0·21	0·05	0·15	1·04	0·09	0·27	0·13	0·09	—	0·12	0·13
SO_3	0·01	0·03	0·10	—	—	Nil	—	Nil	—	—	—
Cl	0·01	0·02	0·12	—	—	0·01	—	0·23	—	0·32	0·03
F	0·10	0·14	0·13	—	0·06	0·05	0·11	0·07	—	0·03	0·14
MnO	0·21	0·21	0·56	1·74	0·15	0·17	0·20	0·31	—	0·38	0·21
BaO	—	0·23	—	—	—	0·13	—	—	—	—	—
Less O Equivalent ..	0·04	0·06	0·08	—	0·03	0·02	0·05	0·09	—	0·08	0·07
	99·51	99·85	99·91	99·95	100·00	98·21	99·88	99·74	99·17	100·15	99·84

1. Nepheline melilitite (42/395) from Fort Ternan. W. P. Horne and J. Furst, Analysts.
2. Mela-nephelinite (42/391) from Kapchui, Fort Ternan. W. P. Horne and J. Furst, Analysts.
3. Nephelinite (Londiani type) (42/431) from B.O.T., T.S., Lumbwa. W. P. Horne and J. Furst, Analysts.

A. Nephelinite from Fort Ternan. (Goldschlag, 1912, p. 596.)

4. Porphyritic basanite (42/346) from N.E. Legetate, Tinderet. W. P. Horne and J. Furst, Analysts.
5. Phonolitic nephelinite (42/408) from Road Peak, Lumbwa. W. P. Horne and J. Furst, Analysts.
6. Trachytic phonolite (42/286) from Kapsamonget, Kericho. W. P. Horne and J. Furst, Analysts.
7. Porphyritic phonolite (42/432) from Londiani Road, north of B.O.T., T.S., W. P. Horne and J. Furst, Analysts.

B. Nepheline tephrite (Lumbwa), No. 9 of Table 85, Johannsen, 1938, Vol. IV, p. 234.

8. Phonolite (42/364) from Kiporice Hill, Equator road, W. P. Horne and J. Furst, Analysts.
9. Phonolite (42/289). Kericho Phonolites, basal flow from Mumek. W. P. Horne and J. Furst, Analysts.

Norms

	1	2	3	A	4	5	6	7	B	8	9
Q	—	—	—	—	—	—	—	—	2·10	—	—
C	—	—	—	—	—	—	0·82	—	4·18	—	—
or	—	12·79	20·02	10·01	6·67	27·24	35·58	33·92	9·45	32·25	33·92
ab	—	2·62	9·43	21·48	22·53	15·72	33·54	31·44	53·97	33·01	29·34
an	16·40	11·95	3·61	15·01	21·68	—	8·90	10·56	10·56	1·67	0·28
lc	9·59	—	—	—	—	—	—	—	—	—	—
ne	9·66	19·60	21·87	3·12	3·69	21·30	3·69	10·22	—	14·48	22·15
hl	—	—	—	—	—	—	—	0·36	—	0·47	—
ac	—	—	—	—	—	11·55	—	—	—	—	—
ns	—	—	—	—	—	0·12	—	—	—	—	—
di	29·38	24·41	18·79	22·25	23·92	13·10	—	—	—	5·39	4·50
wo	—	8·24	1·86	3·94	—	1·16	—	—	—	—	—
hy	—	—	—	—	—	—	—	—	9·06	—	—
ol	0·28	—	—	—	6·69	—	3·04	3·04	—	3·02	1·92
cs	10·66	—	—	—	—	—	—	—	—	—	—
mt	8·35	4·87	7·89	9·74	8·58	—	6·73	4·18	7·89	4·41	3·25
hm	2·40	3·84	2·40	3·04	—	—	—	—	—	—	—
il	4·71	4·56	3·80	4·71	2·74	1·82	0·76	0·91	—	0·76	1·22
ap	—	—	—	2·35	—	0·67	0·34	—	—	0·34	—
fr	—	—	—	—	—	—	0·23	—	—	—	—
cc	0·50	0·90	3·20	—	0·70	0·60	0·70	—	—	0·60	0·20
H_2O	7·04	5·44	7·82	4·14	2·56	4·88	5·74	4·80	2·00	3·96	2·64

TABLE III.—PROVISIONAL CORRELATION OF THE TERTIARY AND PLEISTOCENE IN THE KERICHO AREA

		ELGON	W. NYANZA	PRESENT AREA		E. RIFT VALLEY
		Davies (1934)	Shackleton (1946 and 1951)	Tinderet Suite	Londiani-Lumbwa Suite	Shackleton (1945)
PLEISTOCENE	Lower		Homa basalts	Decomposed Basic lava flows on Kano plains	Quartz trachytes of Londiani	Limuru, Ngong and Emuruagiring quartz trachytes U. Laikipian basalts
PLIOCENE	Upper	Phonolites		Basanites and tephrites	Phonolites (trachytoid) of North Lumbwa	Kenyte lava and agglomerates L. Laikipian basalt
	Lower	Basalts Mela-nephelinites Nephelinites (sediments)			Londiani Agglomerates and tuffs (Kedowa Tuffs)	Nyeri, Kinangop, Fort Hall, Suguroi and Nairobi Tuffs
MIOCENE	Upper	(uplift)			Londiani Phonolites Nephelinites (Lumbwa)	Thomson's Falls, Losiolo, Rumuruti — Phonolites
		Bugishu Beds			Tuffs Phonolites and Tuffs	
			Gwasi Volcanics	Mela-nephelinites	Mela-nephelinites Tuffs	
				Nephelinite	Nephelinites Tuffs	Simbara Series
				Phonolitic trachyte (Koru)	Phonolitic Nephelinites	
				Coarse volcanic agglomerates		Samburu Series
				Tuffs and Kericho Phonolite		Kapiti Phonolite
			(Lunene lavas)			
			Kiangata Agglomerates	Coarse volcanic agglomerates		
			Hiwegi Series			
			Rusinga Agglomerate			
				Melanite tuffs and agglomerates		
	Lower		Kiahera Series	Koru Beds		
PRE-CAMBRIAN			BASEMENT SYSTEM GNEISSES	BASEMENT SYSTEM GNEISSES		

..... Represents unconformity

(3) Correlation of the Tertiary and Pleistocene Volcanic Rocks of the Kericho Area

The correlation of the lowest Tertiary volcanic rocks is on the fossil evidence of the lower Miocene Koru Beds, which are followed by the tuffaceous beds in which the Kericho Phonolite is intercalated. The junction between the Koru beds and the tuffaceous sequence is an unconformity, which is assumed to mark the end of the lower Miocene. The correlation of higher horizons is less definite since fossil evidence is lacking. One is forced therefore to compare the volcanic types and sequence with that found elsewhere in Kenya. The Kedowa tuffs followed by the quartz trachytes of Londiani provide an extensive and characteristic succession which can be matched on the east of the Gregory Rift Valley, where they have been regarded as extending over the Pliocene and lower Pleistocene (Shackleton, 1945, table opp. p. 6). Assuming this correlation to be correct the Londiani succession therefore extends through the upper Miocene and Pliocene.

In Table III composite correlation columns for areas to the west and east are included for comparison. The sequences on both sides of the Great Rift Valley correspond relatively closely though the successions at the large central volcances, Tinderet and Kenya, contrast, the one being nephelinitic and the other phonolitic. The Kapitian phonolites that rest on the Basement System east of the Rift Valley are similar to the Kericho Phonolites, although the latter are of Losaguta-type, and still more so to their extensions in the Sotik area. Gregory (1921, p. 121) agreed that the eastern and western basal flows are closely similar and that there is little distinction between the Kapitian and Losuguta-types. Campbell Smith (1931, p. 241) also noted the similarity of the groundmass of these two types of lava and regarded (*ibid.*, p. 236) the Losuguta-type as probably intermediate between the Kapiti type and kenytes. The order of succession in the phonolite types from Losuguta, through the Intermediate, to the Kenya type is found on both sides of the Rift (cf. Gregory, 1921, p. 133). In the east the phonolites are followed by tuffs and locally by trachytes or by analcite basalts (or basanites) and then by quartz trachytes. This order, except for the first trachytes, is in agreement with the observed Londiani succession. The correlation of the Tinderet suite and the Londiani plateau flows has been made on the assumption that the nephelinites and mela-nephelinites, which are common to both, are contemporaneous. The Londiani phonolites which overlie the nephelinites are considered as equivalent in age to the Thomson's Falls, Rumuruti and Losiolo phonolites which have been dated as Upper Miocene. In consequence the nephelinites of Tinderet would be middle Miocene. This view agrees with that of Kent (1944 A, pp. 18-19) who arrived at the same conclusion from other considerations. The Tinderet basanites petrographically resemble the Laikipian basalts closely (Shackleton, 1945, pp. 13 and 17) and are provisionally correlated with them since their degree of erosion and weathering makes it doubtful that they can be as late as Pleistocene.

The correlation west of the Rift Valley between the similar suites of Tinderet, Gwasi and Elgon is less satisfactory but as these are all central volcanoes a closer relationship cannot perhaps be expected. The date of the Elgon suite has been considered by Davies (1934, p. 71) as Pliocene on the evidence of the Bugishu Beds. The Tinderet basanites correlate well with the Elgon basalts under the present scheme and the upper phonolites of Elgon correspond in type and age with the north Lumbwa phonolites.

Evidence with respect to the age ranges of the lavas of the Gwasi area is not definite. In Gregory's opinion (1921, p. 122) the nephelinites of Gwasi are "clearly Pliocene or Upper Miocene", and Shackleton (1951, p. 350) placed the Lunene nephelinitic lavas of Rusinga which correspond with the Gwasi flows, in the Miocene, equating them with the Tinderet lavas. More recently the area has been mapped by McCall (1958, p. 26) who agrees that the Gwasi volcanicity began in the lower Miocene, but is unable to give an upper age limit other than that the later volcanicity was Tertiary.

Finally, one point that may cause confusion to future workers requires mention. Shackleton (1951, p. 350) tables the phonolites as younger than the Tinderet suite. This is correct only in respect to the Londiani and North Lumbwa (Kenya type) phonolites. The Kericho flows are older than the nephelinites.

6. Pleistocene and Recent

(1) General

The Kano plain is a surface formed by the deposition of silts and muds laid down under lacustrine conditions prior to the retreat of Lake Victoria in the early Pleistocene. The maximum level attained by the lake is represented by finely banded fossiliferous

argillaceous sediments at 4,300 feet on the banks of the Mbogo stream at the western end of Songhor hill. These beds correspond in level with a small area of well-bedded clays, in which no fossils were seen, covering a small area to the south of Muhoroni above the bridge on the Kipchoriet river. Here the river flows through high banks of clays for some miles and Pleistocene (?) sediments in the south bank some hundred feet above the present river level are intensely eroded. It is not clear whether the lake in which they were deposited was originally part of the main lake that once extended eastwards from the Kavirondo Gulf, or whether it was a small independent sheet of water that adjoined.

The original level of the lake corresponds with that established by other observers to the west and is a few hundred feet higher than the shore-line noted in the Kisumu and South Nyanza areas. This slight difference is accounted for by the westward tilting of the plain, evidence for which was noted in the present stream characteristics.

The alluvium in the southern part of the plains overlies flows of Kericho phonolite which finger out in wedges towards Kisumu and on the eastern border superficially extensive thin flows of more recent basic lavas derived from Tinderet rest on the sediments, but for the most part these flows are now so decomposed that they yield a soil indistinguishable from the sediments. Their position can however be roughly mapped from surviving fragments of float and by a study of the air-photographs. The log of bore-hole No. C.1214, west of Songhor, shows beds of bouldery lavas within the sediments, which probably indicates the intercalation of lava flows. The sediments have been proved by drilling to rest upon rocks of the Basement System along the eastern margin, but the occurrence of green schists in the south bank of the Kipchoriet near Kiligis may indicate that rocks of Nyanzian age underlie the plains sediments between this point and the outcrops of the same age mapped at Kibigori. Unfortunately the bore-hole near Chemilil Station was discontinued before the base of the sediments was reached.

In the valleys bordering the plains a few small patches of gravel, presumably Pleistocene in age, are found as raised terraces in the vicinity of Lumbwa Township and at Sondu. In the latter locality, Wayland (1931, p. 9) reported the occurrence of artifacts. In these rejuvenated narrow valleys the deposition of recent alluvials is negligible in quantity, though minor accumulations of quartzose sand occur where the streams erode the granite or gneiss and the beds are not contaminated by material derived from the lavas. The position of such deposits is described in Chapter VII (p. 57).

(2) Weathering, Soils and Erosion

Superficially the Kano plain consist of "black-cotton soils" grading into brown soils. These soils do not support a natural tree growth. No calcareous horizon was noted in the area mapped similar to that nearer the lake at Ahero. Its absence is probably due to the closeness of the water-table to the surface at Ahero, whereas it lies at increasing depth beneath the surface to the east in the present area.

The soils along the base of the Nyando scarp near Kibigori consist mainly of talus, grading in the stream banks into poorly sorted material varying in size from boulders downwards. The soil is of poor quality and supports a thorny type of vegetation. Further west, however, near the River Robo the soil improves and sugar plantations are cultivated.

The soil derived from the Basement System gneisses or from the granites is poor in quality, light coloured and gritty. There is little depth of sub-soil and rock exposures are numerous in such areas, where sisal is the only crop that can be grown.

A particularly deep soil-cover is characteristic of the interfluves of Kericho phonolites. The drillers' log of the African Tea Holdings bore-hole No. C1149 records 175 feet of soil and clay before the lava was struck and below this there was another fifty feet of "clay" followed by 158 feet of "loose" lava. The so-called "clay" beds presumably represent weathered phonolite.

The normal colour of the phonolitic soils is dark chocolate red, a sign of fertility and good drainage. As these soils are also slightly acid in character in the Kericho area they are suitable for the cultivation of tea. The texture is granular near the surface and the absorption good. Under pressure the soil becomes plastic and slippery. The Belgut Reserve is remarkably free from the effects of soil erosion so characteristic of many pastoral areas in Kenya. This is mainly due to the good grass cover and the rapid absorption of rainfall, which minimizes surface run-off and the formation of gullies. Where gullying has begun on cattle trails under heavy and continuous use, effective measures of control have been introduced.

Certain soils in the Londiani-Timboroa area have been described by Gracie (1930) and are mentioned here since they correspond in nature and condition with soils in the north-east part of the present area. The samples tested by Gracie appear to have been derived from the upper phonolites, and from the trachytes and white ashes of Londiani. These soils are a lighter colour and drier than those of the Kericho plateau. Strong winds were noted in this area during December and unless precautions are taken serious losses of top soil will result. It was observed that erosion of this character was being permitted to occur east of the Malagwe valley.

Analyses selected from Gracie (1930, pp. 69-75) are given in table IV and indicate the general chemical characteristics of some of the soils in the north and north-east of the Lumbwa region.

TABLE IV

No.	Exchangeable Calcium	Lime Requirement	pH	Specific Acidity	Total Nitrogen	Description
	%	%			%	
686	0·146	0·37	4·20	631	0·244	Very pale red soil with crystals of sanidine. Very acid.
507	0·276	—	4·92	120	0·314	White soil. Londiani flat lands.
433	0·451	0·24	5·16	69	0·389	Top of ridge, dark red soil.
434	0·231	0·41	4·49	324	0·351	Side of ridge, dark red soil.
37	0·258	0·39	4·75	178	0·323	Ridge top, dark red.

No. 686. Above Londiani on the Londiani-Lumbwa road. Field on which very poor wheat was growing.

No. 507. Londiani District (exact location not mentioned). Flat poorly-drained land.

Nos. 433 and 434. From the ridge near Timboroa.

No. 37. Virgin soil near the western Molo road.

The basanites and basic nephelinites of the Tinderet Suite are relatively resistant to weathering in the foothills and on the plain, with the result that remnant plateaus and isolated conical hills are common in the Muhoroni region. On Tinderet itself and along the Mtetei valley road, the basanites are often found in a highly weathered condition, which may result from the greater rainfall in those parts.

Soil erosion is most severe in the area on agricultural land at the 4,200-foot level. It is particularly evident in the Ainomotua and Mbogo valleys near Songhor and on the Muhoroni Sisal Estate south of the Kipchoriet. It is notable that such severe erosion is not to be found elsewhere at the same level between these points. The common factor in both cases is the occurrence of light, unconsolidated soils of sedimentary origin while, in the intervening area, any similar sediments that may exist are protected by a mantle of lava or soil derived from the breakdown of lava, or the exposures consist of the often consolidated lapilli agglomerates that initiated the Tinderet volcanicity. The level mentioned also coincides with the highest points at which recent lacustrine sediments, possibly Pleistocene in age, were found.

On Tinderet the effects of erosion are most marked on the southern slopes at elevations between 6,800 to 7,400 feet. Landslides due to headwater stream erosion have here produced acute-crested interfluves. A large landslip on the Soba ridge has resulted in what is locally considered to be a parasitic crater on Tinderet. There is, however, no geological evidence to support this and examination of the air photos shows the slip lines below the so-called crater. A somewhat similar arcuate landslide has occurred in the ashes near the Malaget road on the north-east edge of the area, though in this case stream drainage has developed from the site of the slip.

(3) CAVES

There are a number of caves in the Kericho District. They have been previously referred to as the "Lumbwa caves" but as they are not near Lumbwa and as the use of that name for the Kipsigis or their country is a misnomer the phrase should be avoided.

The caves were visited in 1918 and described by Hobley (1918). They were noted in the following localities: Bagua, 7½ miles north-north-west of Kericho on the Kipgues Stream (35° 15′ E.; 0° 15′ S.); Gitoi, on the Jamji river just west of the main road bridge; Kipchebos on the Kiptiget; Kiptoit and Kibroise on the Chemunguet, a small stream east of the old cart road which it is believed used to run south from Kitumbi. The Gitoi and Kiptoit caves have now collapsed. A few others, not listed above, were reported by Africans and one of them was visited by the present writer on the Maramara near its confluence with the Jamji at 0° 30′ S.

The entrance to the caves in almost every case lies at the foot of a waterfall and they have been hewn artificially in what appears to be a grey powdery ash or light volcanic tuff often enriched in calcium phosphate. The phosphate content however varies considerably. The average of twenty samples listed by Hobley was 0·83 per cent and the highest 5·35 per cent. Only two other samples showed a content greater than 1 per cent. An analysis of one sample is as follows (*op. cit.*, p. 485):—

	%
SiO_2	47·76
Al_2O_3	22·03
Fe_2O_3	4·98
MgO	1·08
CaO	2·97
Na_2O	4·87
K_2O	2·88
H_2O	13·95
P_2O_5	0·13
MnO_2	0·32
CO_2	trace
TOTAL	100·97

Anal.: V. H. Kirkham and W. Colet Birch.

The material excavated is used as cattle feed. It is locally called *ngenda* or *chumvi* (salt) though it has no salty flavour. It is consumed with avidity by cattle and the poorer quality material is considered by the Africans as fit only for goats. Though there is no doubt that the cave-earth is of benefit to the animals, a number of writers have speculated on its physiological value. Emphasis has been placed both on the phosphate content and on the desire of herbivora for a supply of sodium additional to that provided by their normal diet. The matter remains undecided, however, and it appears possible that some trace elements may be of importance.

Hobley's assumption that a large quantity of this material is available in the Kericho District is considered to be exaggerated. It is extremely doubtful whether a consistent ash horizon can be inferred over the entire area of about one hundred and sixty square miles enclosed by a line through the widely scattered positions of the caves. The Kipgues caves, at an elevation of about 5,000 feet, are the only ones noted to the north of Kericho and they are not less than fifteen miles from the others, which occur relatively closely grouped in the southern part of the area around Jamji at elevations nearer 6,000 feet. In general, ash horizons are better developed in the north and north-east parts of the area amongst the upper lavas. In the lower Kericho Phonolites they are not seen and no caves or ash beds are found in the excellent exposures of over 1,000 feet from the 5,900-foot level downwards as revealed by the gorges west of Sosiot.

Bore-holes north of Kericho indicate ancient weathered land surfaces between the phonolite flows and some intermediate ashy beds. In general, waterfalls occur at the more compact and resistant centres of each lava flow which, being jointed, allows percolation of stream-water and enrichment of salts at the undersurface.

From personal observations at the Maramara caves I consider the excavations there have been made in a highly decomposed part of the phonolite flow and the bed cannot be correlated with that on the Kipgues.

(4) Sirikwa Pits

A number of small, irregularly spaced, circular depressions were observed in the phonolitic soils of the Belgut Reserve. They generally occur in groups on the higher ground or on valley slopes. The depressions are bounded in most cases by an annular raised lip of soil having a small gap on the downslope side, and in some cases this gap or entrance is also flanked radially for a few yards on either side by raised banks of earth. Good examples can be seen on the western slope of the Changware stream just south of the District Commissioner's camp at Kiptere.

Natural explanations of the depressions such as that they are collapsed caves or tunnels in the lava, caved blow-holes or ash-cones are all open to objections. Natural openings of this kind are seen nowhere in the solid rock of the well-exposed lavas in the gorges, and the deep weathering would hardly permit the preservation of such structures for any length of time. The pits are therefore considered to be artificial excavations of relatively recent date. This view is supported by the fact that the local Africans, who have no explanation for the simplest geographical features, readily and consistently give a common explanation for these pits. They are, they say, the sites of the huts of the Sirikwa, who originally inhabited the area and were driven out or exterminated by the Kipsigis.

This explanation accounts for the entrances noted on the downslope sides which would prevent the inflow of rain-wash. Even though they are now without covers, rain does not collect in the hollows, rain-wash being diverted by the raised lips. No archaeological excavations have been undertaken on these sites as far as is known.

7. Intrusives

(1) Granites and Granodiorites

(*a*) *Nandi Granite*

The small area of leucogranite which enters the north-west corner of the area is an extension of the Maragoli granite mapped over a wide area of Nyanza Province by Pulfrey (1946), Saggerson (1952) and Huddleston (1954). The exact age of this intrusion has not yet been determined but, on comparison with intrusives in the Kakamega area, is probably early Precambrian (Holmes and Cahen, 1955, pp. 30 and 31).

Adamellitic types such as have been frequently found further west were not recognized in the present area. In the hand-specimen (42/377, from the escarpment north of the Rock Corry mine mill, a little north of the area mapped) the rock in this area is a medium-grained leucocratic rock speckled with mica, chlorite and a little epidote. The mica is not abundant. In thin section it is seen that the texture is granitoid, with fairly fresh microcline, associated with and enclosing crystals of albite which are generally sericitized. The sutured quartz shows strain polarization and has penetrated along cracks developed by pressure in the felspars. The mica is a pale green variety, strongly pleochroic to dull green and often partly altered to chlorite. Magnetite, sphene and granular epidote are accessory.

The difficulty of distinguishing the granite from the granitoid gneiss of the Basement System, where both have been sheared along the Nyando faults, has been mentioned in the section dealing with the Basement System (p. 11). There is therefore some uncertainty with regard to the location of the granite-Basement System contact. It is certainly farther east than indicated by Shackleton (1951, Pl. XXVII and p. 348) and the granite and Nyanzian rocks are not sharply separated from the Basement System by the Nandi fault. From a reconnaissance of this area Huddleston (1948) formed the opinion that the granite extends as far east as the Chemilil ridge and the present writer agrees with this view, though it may be found on more detailed examination that the contact hereabouts is irregular and has been complicated by the Tertiary wedge and block faulting.

The auriferous veins and impregnations in the Nyanzian shear-zones of Kibigori are probably related to this granite, the steep main contact of which lies at no great distance to the north and west, and the high proportion of microgranitic intrusive dykes cut by the diamond drill-holes at the gold mines must certainly be connected with the granite derived from this source.

(*b*) *Sondu Granodiorite*

The Sondu granodiorite outcrops near the Kendu fault and the Sondu flexure in the south-western part of the area. For the most part it is highly sheared and resembles the Basement System granitoid gneisses, but non-foliated exposures can be seen in the Miriu River below the Sondu bridge and also in the Jimo area a few miles to the north. In these

exposures the rock is medium-grained with greenish or pinkish felspars up to 2 mm., and with a variable proportion of mafic minerals. Since the granodiorite invades rocks of presumable Nyanzian age along the Miriu and underlies a Nyanzian roof pendant at Kabortho it is considered to be equivalent in age to the G_2 granites of Kisii (Huddleston, 1951, p. 36).

In thin sections of specimens from Sondu (e.g. 42/238) the plagioclase felspars are often zoned with rims of albite and are frequently sericitized. Quartz occurs irregularly distributed and as occasional droplets in the felspars. Little primary mafic mineral remains. Secondary minerals include strongly pleochroic blue-green chlorite that largely replaces biotite. A little epidote is also present. Magnetite and pyrite occur as scarce accessories.

In the Jimo exposures (42/265), the mafic mineral content is greater, due to well crystallized hornblende associated with biotite, seriticized oligoclase, microcline, quartz, sphene, leucoxenized ilmenite, apatite, and chlorite partly replacing some of the biotite. The mineral assemblage is similar to that noted by Saggerson (1952, p. 61) in the extension of the outcrop to the west, which he calls the Miriu granodiorite.

The granodiorite extends beneath the phonolites to the east where it was found in small exposures in the Mumek gorge. The rock here (42/287) is related to the more leucocratic Sondu type. The plagioclase in it occurs as subhedral crystals and is much kaolinized. Microcline is again present in large grains, the quartz shows strain polarization and the biotite also is deformed and bent, being altered in part to chlorite. Some secondary epidote and sphene were also noted.

(c) *Koywalelach Leucogranite*

A small ridge of tor-forming granite, that has invaded and metamorphosed Nyanzian rocks, is exposed at Koywalelach, north of the Chemoisiet River. It is similar in most respects to the G_3 granite of Wanjare described by Huddleston (1951, p. 38). There are no signs of metallic mineralization associated with this intrusion. The granite, which is generally coarser-grained than the Sondu intrusion, is deficient in mafic minerals but shows signs of contamination by assimilation near the contact. The weathered rock is yellowish, with a mottling of pale green due to chlorite. In a thin section of specimen 42/174 the quartz is strained and the plagioclase twin lamella are sometimes bent. Muscovite occurs as shreds and shear-aggregates along fractures. The rock is pyritized, but the pyrite is largely replaced by iron oxide. In specimen 42/196 large crystals of biotite are present but some are partly or wholly replaced by epidote and chlorite. A small amount of hornblende is also present. The plagioclase is usually heavily sericitized. In some cases (e.g. 42/301) quartz is more abundantly developed and microcline microperthite is present. Specimen 42/208 collected from the Ninet Falls is highly epidotized, as are the old lavas in this part of the area.

Shallow residual deposits of medium- to coarse-grained sand, resulting from the decomposition and removal of felspar, are preserved in parts on the less severe slopes on this granite.

(2) Acid Minor Intrusives

No acid intrusives were noted in association with the Sondu granodiorite or the Koywalelach leucogranite.

In describing the granitoid orthogneisses of the Muhoroni and Songhor areas the common occurrence of narrow intrusive pegmatites was mentioned. Most of these consist of coarse-grained microcline in sutured intergrowth with quartz (42/358), showing in some cases mortar texture and strain as a result of post-intrusion shearing. The felspar is often pinkish and bold streaks of dark greenish biotite are common in the outcrops. There is no evidence of metallic mineralization of economic value in these rocks, though low gold values have apparently been found in a quartz vein in the Koru area. There are numerous microgranite intrusives in the Nyanzian of Kibigori. Some of these are micro-porphyritic but the majority are so fine-grained as to resemble closely the Nyanzian rhyolites. As the dip is generally low towards the north and the area is both faulted and strongly eroded, the recognition and mapping of these intrusives is no simple matter and requires large scale mapping. On the present map therefore minor intrusions into the Nyanzian, except for the epidiorites, are not shown. The evidence supplied by the bore-holes in the Kibigori area indicates the extent of the problem more fully (*see* Chapter VIII).

West of the mines near the Robo river a wide dyke of quartz monzonite (42/371) is separated from the granite by a wedge of Nyanzian. The age relationship of this rock to the granite is not determinate here as it passes out of the area to the west without contact with the granite. In the Maragoli area quartz monzonite is found veining the granite (Pulfrey, 1946, p. 21).

(3) Basic Intrusives

Basic intrusives are of infrequent occurrence in the area mapped and for the most part are members of the dolerite family. They invade both the Nyanzian and Bukoban, but have not been classified into older (D_2) and younger (D_3) types according to practice in adjoining areas. The D_2 dolerites are pre-Bukoban while the D_3 dolerites cut the Bukoban but do not invade the Tertiary lavas.

The dolerites are mainly distinguished by their degree of alteration. In the vicinity of the Nandi granite the older sills and dykes have been metamorphosed to epidiorites and on the higher ground occupy a relatively large part of the Nyanzian outcrop. This is due less to their thickness than to the attitude of the low-dipping sills and the manner of erosion. At the foot of the scarp the outcrops are less obvious since they dip into it northwards.

In the bore-hole cores from the Equatorial gold-mine at Kibigori three varieties of "dolerite" were logged by P. C. Benedict of Safari Exploration Ltd. on the basis of grain size, viz. "fine-", "medium-" and "erratic-grained" types. The "fine-grained" variety, which is considered to be the youngest, occurs more rarely than the others, as narrow dykes. They are better developed in the Rock Corry mine to the east where they are found unsheared and cutting the auriferous vein. Specimen 42/617 from bore-hole No. 7 at 173·6 ft. (Equatorial gold-mine) shows the contact of a dyke of this type cutting rhyolite. It is highly altered and consists largely of hornblende, chlorite, epidote and the remains of altered felspars. The composition and degree of metamorphism of the "medium-grained" and "erratic-grained" epidiorites is the same. A pale variety of hornblende, granular sodic plagioclase, and a little quartz are present in specimen 42/580 (a medium-grained type: bore-hole No. 10 at 9·3 ft.). Specimen 42/639 (bore-hole No. 11 at 58·3 ft.) is considerably coarser, and preserves relics of its original doleritic texture. Specimen 42/616 (an example of the so-called "erratic-grained" type) is still coarser and contains large crystals of hornblende associated with oligoclase derived from a more calcic felspar, skeletal ilmenite, granular epidote and quartz. The original ophitic texture is recognizable in parts.

The dolerites cutting the Bukoban rocks south of Sondu are similar to those described by Huddleston (1951, p. 43) and Schoeman (1949, p. 32). Doleritic rocks cutting the Jimo granodiorite are exposed in the bed of the Asawo south of the bridge. One of these proved to be a porphyritic meta-dolerite (42/263).

Basic Tertiary dykes occur to a minor extent amongst the lavas. They were not observed among the plateau lavas, except in the vicinity of suspected volcanic vents such as Tatwa-kapsigesa. They are more common, though still rare, cutting the Tinderet suite, in which the few that were observed in the railway exposures have a general radial arrangement with respect to Tinderet. These dykes are melanocratic and closely related to the nephelinites. Pulfrey (1953) recognized an alnöite cutting the Miocene Legetet limestone at Legetet and Muff (1908, p. 49) reported dykes containing blocks of biotite gneiss cutting the agglomerates west of Fort Ternan.

VI—TECTONICS

Pre-Tertiary.—The general trend of the Basement System rocks is roughly from north to south but there are local variations in the Muhoroni area. Between Koru and Muhoroni the foliation strikes in a more north-easterly direction parallel to the Sondu flexure and to the west, in the river exposures near Kiligis, the foliation swings into a north-westerly trend on the projected line of the Nandi fault. In the Songhor area the foliation is north-south, at right-angles to the main Kavirondo Gulf rift-faulting, but zones of highly cataclastic rocks and mylonites are found here with an east-west orientation and are probably the result of the Tertiary rifting.

In the Nyanzian rocks there is isoclinal folding on a general north-east–south-west trend in the southern exposures and this trend is believed to have influenced the location of volcanic vents during the Tertiary era. The post-Nyanzian granodiorite in the Sondu area is in parts highly sheared and gneissose. The foliation is east-west in the Maraboi area swinging to north-east–south-west. This shearing is not seen in the Kericho phonolites though it is parallel to the Tertiary-Kendu fault and the Sondu flexure. In the Kibigori area the Nyanzian is highly faulted along the Nandi scarp by Tertiary movements.

The Bukoban rocks in the Sondhu area are disturbed by pre-Tertiary faulting which does not affect the Kericho Phonolites. These faults generally follow a north-south trend with minor compensating east-west faults. Dolerites are emplaced in some of the north-south faults indicating that these were probably open tensional fractures, a view which is supported by evidence of block faulting in the Sondu valley. The Bukoban rocks in this area also have zones of epidotization along the fault-trends mentioned.

Tertiary.—The evolution of the Kavirondo Rift Valley has been described by Shackleton (1951, p. 383) who, having summarized the previous views of Gregory, Bullard, Kent and Dixey, submits conclusions that agree with those of Gregory, i.e. that the Kavirondo depression is tectonic and tensional. According to Shackleton (*op. cit.*, p. 386) the main deformation occurred in the late Pliocene or earliest Pleistocene "as a result of which the surfaces (i.e. the three main erosion surfaces recognized in western Kenya) were faulted and uplifted. The uplift was greatest near the margin of the Gregory Rift Valley, which was meanwhile depressed. The floor of the Kavirondo Valley remained more or less level".

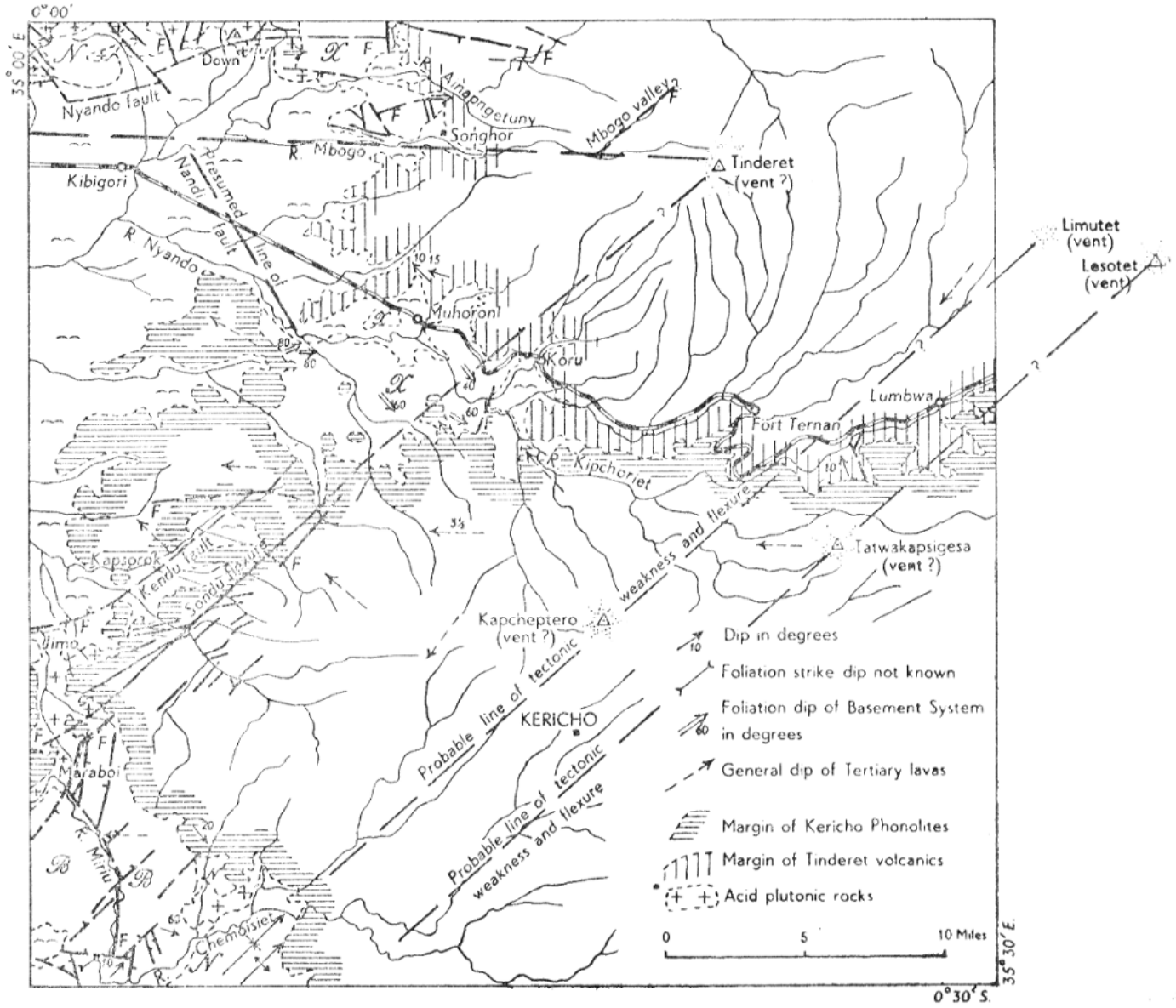


Fig. 2.—Tectonic map of the Kericho area

It appears that the Tertiary structures are more closely related to those of Precambrian age than Shackleton is prepared to admit (1951, p. 386). The southern or Kendu rift-fault and Sondu flexure for example are apparently modelled on the earlier structures in the Sondu granodiorite. Again, the Sondu flexure is parallel to the tectonic trend of the Nyanzian further south. This same trend has influenced the erosion of the phonolites around Kericho and has apparently controlled the alignment of centres of volcanic eruption, e.g. Limutet and Kapcheptero on the line of the lower Chemoisiet; Lesotet, in the Londiani area, and Tatwakapsigesa lie on a parallel line to the east; and Tinderet lies on the extension of the line of the Sondu flexure, to which the Mbogo valley and the faulting in the Ainapgnetungy are also parallel. This trend along N. 55° E. is too strongly marked to be coincidental and undoubtedly indicates the trend of crustal weaknesses in this area.

The Kendu fault along the northern scarp of the Nyabondo plateau enters the present area near Jimo where it now makes no topographical feature. It is here either cut off by the Sondu flexure or swings into a line parallel with it along the line of the Kapsorok valley, to the west of which there lie cuestas of phonolite showing irregularities in their direction of dip. Similarly, east of the flexure, the phonolites appear to be disturbed by minor cross-faulting or possibly by ruckling.

The Nyando fault along the base of the northern scarp is shown by Shackleton (1951, Plate XXVII) to pass through the north of Chemill and thence eastwards up the Kamaasae north of the equator. This appears to be a simplification of the facts, since there is evidence of a number of roughly parallel shear-zones to be seen in the area east of Down T.S. In the Nyangoro, one and a quarter miles below the bridge, an intensely cataclastic zone is seen striking slightly to the south of east and across the south-western foot of the Chemill ridge up the Ainomotua valley. Evidence of faulting in this valley is found at the falls three-quarters of a mile west of the two bridges, where slickensides on joint faces dipping south at 65° indicate heave to the south-east. Farther east Kent reported an altered nephelinite dyke with east-west strikes intrusive into the Miocene beds of the Songhor gullies. Still farther east, and north of Kapurtay T.S., two faults with the trend of those already mentioned were noted. The southern of these has down-thrown the Miocene to the south and has itself been intersected by the north-east–south-west faulting up the Ainapgnetung valley in the vicinity of the gneiss inlier. The Nyando fault is therefore considered to be a complex system.

Shackleton (1951, p. 379) places the high-level peneplain north of the Nyando faults at an elevation of more than 7,000 feet whereas the Songhor and Chemill ridges rise to about 5,500 feet. Assuming that the relatively flat crests of these ridges represent the same erosion surface the downthrow of the Nyando fault system is more than 1,500 feet.

Owing to alluvial deposits along the Mbogo no evidence could be found of faulting along the southern base of the Songhor inselberg. The striking east-west line of erosion along the Mbogo on Tinderet, coupled with the tilting generally at about 15° to the north-west of the Miocene sediments in the Meswa valley further south, is however suggestive of some dislocation along the line of the Mbogo.

The Miocene sediments, though in parts dislocated by minor faults and having gentle variations of dip, nowhere contain evidence of thrusting and compression. To account for the difference of level of the Miocene beds in the various exposures at Koru and Songhor, Shackleton (1951, p. 366) assumed that the whole area was tilted about 1° slightly south of west. It is doubtful whether this could alone account for the differences observed. The occurrence of the basal beds in the Ainapgnetung valley east of Kapurtay at a higher elevation than the beds in the Songhor gullies is due to displacement by the Nyando faulting, and it is to be noted that the general dip in the Miocene in the Meswa valley is to the north-west. The base of the Koru beds certainly lies at higher elevations in the more easterly exposures, for example, at Legetet and Koitaburot they rest on gneiss at 4,500 feet compared with an elevation of 4,250 feet for the exposures north and north-west of Muhoroni. If the line of the Sondu flexure is extended to the north-west, however, it is found to separate these exposures and the difference in elevation and steeper dip of the beds in the Meswa valley can be explained.

The Nandi fault, striking south-east and then south from Elgon, enters the present area north of Kibigori, and the complicated Nyanzian geology on the scarp there is due mainly to the junction of the Nyando and Nandi displacements. It is not certain at present which fault mapped in the present area represents the Nandi fault, since the area immediately to the north still remains to be mapped. The alignment of the fault on Huddleston's (1954) map of the Kakamega area suggests that the first fault entering the present area east of Y3 trigonometrical station is the Nandi fault, i.e. it is further west that the positi on indicated by Shackleton (1951, Plate XXVII). A subsidiary fault certainly occurs in the pl ace shown by Shackleton, but there are evidently a number of faults crossing the scarp and detailed mapping will be required for their exact location. The manner in which the Nyando scarp juts out north of Kibigori from the regular scarp-line to the east, also suggests that the major fault follows the Lumaiywa valley, which defines the eastern side of the projection. It is postulated that further south the Nandi fault will cut and throw the Nyando rift-fault.

VII—ECONOMIC GEOLOGY

Streams encountered on traverses during the course of the survey were in most cases panned for evidence of economic minerals, and the concentrates were examined in the field. It is believed that no extensive outcrop containing metallic minerals is likely to have escaped notice in the area. Prospectors seeking gold in the Nyanzian rocks should however bear in mind that loaming values in the vicinity of even high-grade lodes may produce remarkably low values in the pan owing to the strong degree of erosion along the Nyando escarpment.

1. Metallic Minerals

(1) Iron

No extensive pyritic ore-bodies or lateritic ironstones suitable for iron smelting are known in the area. Buru hill (Long. 35° 10′ E., Lat. 0° 11′ S.) has on its summit small areas of lateritic ironstone which are worked for building blocks, but the amount available is insufficient for an iron industry.

Concentrates panned from streams draining the lavas are invariably rich in black sands, consisting mainly of magnetite and ilmenite in about equal proportions. Economic beds of such sands are unlikely, however, owing to the restricted widths of the valleys and the steep gradients of the streams. Deposition of heavy minerals is most likely to occur along the border of the Kano plain.

(2) Radio-active Minerals and Pyrochlore

The hill at Buru was found by R. B. Taylor in 1954 to be radio-active. Shackleton (1951, p. 348) had examined the outcrops previously and noted that the rock resembles the banded ironstones of the Nyanzian system, though he thought it more probable that it represents a gossanous capping above a pyritic sulphide body. Taylor's discovery and an analysis of the rock suggest that it is more likely to be a volcanic vent, probably containing carbonatites, like the carbonatite centres at Ruri and Rangwa, farther west. The analysis of a grab sample gave the following result:—

	Per cent
CaO	13·57
P_2O_5	1·45
Rare earths	2·90
ThO_2	0·10
Cb_2O_5	0·50

Anal.: W. P. Horne and Mrs. R. A. Inamdar.

No uranium was detected by a fluorescence test on the material (ground to −100 mesh) Concentrates obtained from the rock contain pyrochlore crystals and monazite.

An exclusive prospecting licence dated 1st December, 1955, was granted to G. G. Smallwood over an area of 9½ square miles on the south-west side of Muhoroni and containing Buru hill. The licence was renewed for a further year on 1st December, 1956. In June 1956, Mr. Smallwood made an agreement with New Consolidated Goldfields Ltd., who subsequently took over the prospecting of the hill.

(3) Gold

(i) *Alluvials of the Kano Plain.*—As a result of the denudation of the veins in the Nyanzian north of Kibigori there is a possibility that gold-bearing alluvials exist in the sediments of the Kano plain. The prospects of locating and working such deposits are, however, poor due to the rapid increase in the depth of sediments southwards from the fault-scarp. The detritus at the foot of the scarp requires detailed prospecting above the 4,200-foot contour, below which alluvial mining by cheap sluicing methods would be impracticable owing to lack of gradient for concentration and disposal of tailings.

A report that gold had been panned by Africans from the Asawo at Jimo north of Sondu was investigated. The geological situation is not an unlikely one, but no gold was found in the shallow excavations tested.

(ii) *Lodes.*—Workable veins of auriferous quartz have been found only in rocks of Nyanzian age along the outcrop of an extensive shear-zone at the base of the Kibigori scarp. Prospecting some years ago resulted in the development of two small mines operating under the titles of Rock Corry Gold Mine (formerly known as the Kibigori Gold Mine) and Equatorial Gold Mine. These properties are located at the western end of the shear-zone, the extension of which to the east is being prospected.

The history of this small gold-field perhaps dates back to 1912 when, it is said, gold was discovered in rubble used for dam construction at Miwani. Attention was not focused on the area, however, until thirty-six years later when gold was discovered in quartz from the present mine area, though the occurrence of rocks of Nyanzian age there, similar to those of the Nyanza Province gold-fields, had been pointed out in 1945 by a departmental geologist, Shackleton. I. W. Anderson was the first to prospect the area and located the outcrop of the vein in the Spur section (*see* Fig. 3, at end) in June 1948, whereupon in partnership with C. F. Ferguson, the Kibigori Gold Mining Syndicate was established. Mr. E. N. Mantheakis pegged the adjacent area to the west, on which a rich outcrop was subsequently located. Prospecting has been undertaken along the possible strike extension to the west between the Bongwa valley and the Robo river, but without success. This area is much disturbed by Tertiary faulting and contains an intrusion of quartz monzonite and barren quartz veins of presumably post-mineralization date. Occasional values have been found in small quartz veins in Nyanzian country-rock on the summit and face of the main scarp a little north of the present area in Nandi country. For the most part these occurrences are uneconomic, though one was worked for a short period by Hansen Elijah. Some of these veins contain scheelite as well as gold.

(iii) *Rock Corry Gold Mine* (*Kibigori Gold Mine*).—Huddleston (1948, 1949, 1950) prepared departmental reports, from which details have been extracted, on this property during the early stages of its development. The active development of ore ceased in October 1955, with the diminution of the shear and advent of low values in the "Lil" section. The reluctance of the owner to risk further capital on underground exploration appears natural since the bore-hole investigation in the "Spur" section had been negative. There appears, however to be no reason to suppose that the shear or gold values do not persist to greater depths'.

The production of gold over the operating period up to the last quarter of 1955 is shown in the following statement:—

TAVLE V—ROCK CORRY GOLD MINE OUTPUT

Year	Tonnage mined and milled	Gold recovered from tables	Sands cyanided	Gold recovered from sands	Total Gold recovered
		(*ozs.*)	(*tons*)	(*ozs.*)	(*ozs.*)
1949	1,911	1,385·9	—	—	1,385·9
1950	3,467	1,284·3	3,710	820·3	2,104·6
1951	2,594	903·86	1,875	387·22	1,291·08
1952	1,627	1,957·57	505	187·93	2,145·50
1953	2,069	3,490·85	172	72·00	3,562·85
1954	2,555	2,266·16	425	221·07	2,487·23
1955*	2,767	1,961·22	1,817	223·49	2,184·71
TOTALS ..	16,990	13,249·86	8,504	1,912·01	15,161·87

*Record up to September.

The property was prospected along a strike of some 16,000 feet, but it was found that payable values were restricted to intervals within 3,000 feet of strike near the western end of the shear. In general the strike of the narrow shear-zone is parallel to the strike of the Nyanzian rhyolites, basalts and tuffs. The dip of the shear is, however, some degrees flatter than the dip of the lavas and the geology is complicated by numerous acid dykes, dipping generally at low angles, together with dolerites. The shear is further discussed on a later page (p. 52) in connexion with the Equatorial Mine.

Location and Workings.—The mine is located 3·2 miles north-north-west of Kibigori station, and consists of 145 claims within a rectangular area 6,300 feet east to west by 4,800 feet north to south, out of which, on the southern boundary, are excised the claims held by the Equatorial Gold Mine. Development workings are almost entirely restricted to two mining locations known as "Patricia" and "Tove" situated at the south-eastern corner of the block.

Operations along the strike from west to east occur in the following sections, i.e., Boundary, Lil, Spur, Boma and Rosterman (Fig. 3). Production up to 1952 was mainly derived from the original operations on the Spur section supplemented by small tonnages of high-grade ore from the Boma section. With the exhaustion of payable values in these sections the faulted extension was traced to the west where the Lil workings (Figs. 4, 5 and 8a) were developed by means of an adit and inclined shaft down the dip for 330 feet. The main shear dies out in this shaft against porphyritic andesite at 305 feet. Small tonnages were mined below the east drive at the 305-ft. level by a winze extending 50 feet down the dip, from which sub-drive 355 was driven eastwards for 125 feet. Below the sub-drive there were stopes to the 370-ft. level, when the shoot of values died out to the east.

The underground plans of stopes and values (Figs. 6 and 7) prepared by Frobisher Ltd. are the most reliable available, being based on cut samples assayed by the Mines and Geological Department, Nairobi. The normal development of the mine was controlled by panned samples on which no great reliance can be placed.

Lil Section.—No definite pattern of gold deposition appears from the assay plan. There is, however, a suggestion of gently pitching shoots which are not apparently related to the geology. On the 225 level west values were particularly poor along 250 feet of drive, where epidiorite forms the hanging wall, but good ore was encountered thereafter. The controlling factor here, as in the levels above, may be a tongue of intrusive porphyritic andesite which cuts the shear in the levels above and has contorted the normal strike direction by dilation in its immediate vicinity. On the 75 level west the drive passed through this intrusive but it is uncertain whether the continuation of the main shear was encountered thereafter. Some exploration from surface has been undertaken by means of a trench and shaft on the westerly extension of the shear near the common boundary with the Equatorial Mine. The main shear, dipping north at 30°, appears to have been located in the trench excavated in silvery white phyllites but the shaft, 100 feet to the north, did not disclose vein or values apart from a barren quartz body dipping at a low angle to the north-east at about 90 feet depth. The prospects of locating an ore-body between the boundary and the "Lil" section is not considered to be promising.

East of the boundary there is an area of coarse detritus and to the immediate west an intrusive sill of medium-grained andesite which, judging from the exposure in the upper part of the shaft, dips to the north-east at some 20°.

Spur Section.—There are no reliable assay or stope plans of the whole of this section of the mine, which was developed from two inclined shafts, one on the dip of the shear and the other on a steeper vein branching off into the hanging wall. The steeper vein represents the infilling of a tension fracture and suggests the possibility of under-thrusting along the main shear. The number one shaft, which is in the southern part of the section, flattens out below the second level, along which, both to east and west, the values and widths rapidly decrease. The number two shaft, in the northern part of the section lies at the intersection of the hanging wall and the shear and was sunk to an inclined depth of about 220 feet. The geological section of the ore-body in this shaft (Fig. 8 (*b*)) indicates the characteristic lenticular nature of the quartz-sulphide vein in the shear zone. The vein attains a maximum width of 11 feet, the central 4-foot portion consisting of sulphides, mainly pyrite with some pyrrhotite, the rest of the vein being clear glassy quartz. At an inclined depth of 200 feet the vein flattens and rolls into the roof of the shaft. There are three levels from this shaft, the ore having been stoped out to surface above the No. 1 East level, which terminated in unpayable values over a six-inch width. At 90 feet from the shaft in No. 3 Drive West the vein decreased to a width of two feet and the sulphides and values had vanished. The vein branches here, however, and sulphides form the hanging-wall branch, while the lower is composed of quartz. At 150 feet depth there are also drives to east and west. In the former, at 47 feet from the shaft, the vein flattens and is only partly exposed in the roof. Huddleston noted that the values here are connected with the sulphide content of the vein and that the quartz alone carries low and erratic values. This, however, cannot be applied as a general rule to all sections of the mine. The west part of the Boma section is particularly rich in sulphides but, apart from the enrichment at the top of the sulphide zone, the gold values are not payable.

Boma Section.—There is possibly a number of mineralized veins complicated by cross-faulting in this section, which has been explored by scattered workings of small extent, both above and below the mine road. Contours derived from the bore-hole logs indicate a flattening of the dip of the main shear to 20°, but east of the Boma fault there is a change

of strike to a more north-easterly direction and the dips are about 40°. The "road pit" (Fig. 3), sunk to only 27 feet, merits further exploration in depth. It contains a strong sulphide zone dipping to the south-east at 32°, contrary to the usual disposition of veins here, and the foot-wall carries disseminated values in sulphides.

The main Boma workings, which are unsurveyed, consist of an inclined shaft at 48° about 80 feet long. The vein is reported to have a maximum width of 8 feet before thinning out and flattening at 70 feet depth. The gold values were particularly good at 35 feet where the shear branched, with a 6-inch stringer in the roof. The strike was explored by drives in oxidized ore to the east and west from the 35-foot level. The drive to the east was abandoned after 120 feet but that to the west ran out of values within 20 feet from the shaft, where it was faulted and displaced to the north.

The West Boma workings, which are opencast, produced small tonnages of the highest-grade ore mined from the property. A double, strongly pyritic shear can be seen in epidiorite in these workings. The dip is 20° north-north-west and the general tenor of gold is about 1 dwt. The area in the valley west of these workings yielded nothing of value by surface exploration and the bore-holes down dip were equally discouraging.

Rosterman Section.—East of the Boma section the extension of the shear has not been prospected with great thoroughness and trenches are scarce. Low values were reported to occur in trenches on the small knoll near the eastern boundary of the claims. Since I. W. Andersen has recently located the shear, containing gold, some 1,000 feet further to the east of the boundary, it would appear that more attention might be paid to this section.

Petrography of the Ore.—Huddleston (1950) examined a number of thin and polished sections of the ore and reported that it consists of a fine-grained sutured mosaic of clear quartz in which some of the large grains exhibit undulose extinction. Calcite aggregates, invariably associated with fine shreds of chloritic material, are fairly common, and the pyrite generally occurs with them. No constant relationship in the association between gold and pyrite was observed. In one slide an outgrowth of gold occurs on pyrite while in another the gold was seen enclosed in pyrite. The gold grains measured in the slides varied from 0·16 mm. x 0·02 mm. to 0·055 mm. x 0·008 mm. This suggests that finer grinding than was practised would have been advantageous. Pyrrhotite and chalcocite were also observed in the ore.

Milling.—The mill, with a maximum capacity of 30 tons per day, is situated on the main road four miles east of the mine, where adequate water is available from the Chemase. The gold recovery process is normal, the reduction of the ore being by primary jaw crusher followed by a Marcy ball-mill. The resulting sands (minus 25 mesh) are led to three corduroy tables, the concentrate from which is amalgamated direct, resulting in a recovery of about 70 per cent of the gold in the ore. The balance of the recovery is now attained by flotation and cyanidation of the clarified light fraction, amounting to 70 per cent of the tonnage milled, fine sands and slimes assaying 5 dwts. gold per ton being previously retained in a dam for retreatment. Laboratory experiments in the Department indicated that a concentration of these "tails" could be attained by flotation, and further gold extracted by cyanidation after regrinding to minus 300 mesh. Low gold recovery figures result if the pulp is poorly aerated or insufficiently ground. The security arrangements to prevent thefts of gold are particularly good at this mill since all gold recovery processes are handled in caged-off areas.

Diamond Drilling at the Rock Corry Mine.—A programme of exploration by means of vertical diamond drill-holes to test the extension of the shear-zone at shallow depth below the workings in the Spur and Boma sections was completed in 1954. Unfortunately the cores from the nine holes drilled failed to indicate additional ore reserves, though mineralized shears of narrow widths and poor values were encountered that were insufficient to encourage further exploration. The best result was an assay of 5·6 dwts. over a true width of 12 inches in the Boma section. Details of the footage drilled and assay results are shown in Table VI. The core recovery averaged over 90 per cent in alternations of Nyanzian tuffs and lavas, injected by numerous low-dipping dykes and steeper dolerites. A high rate of wear of the diamond crowns was reported to occur when drilling the epidiorite. No particular difficulties from jointing, caving or loss of water were encountered.

The location is not favourable for exploration by drilling to greater depths on the shear owing to the rapid rise north of the mine of the scarp face, whose angle of slope (20° to 30°) is roughly the same as the dip of the shear, though in the opposite direction.

TABLE VI

Bore-hole No.	Collar altitude	Vertical Depth drilled	Sampled Depth Quartz and/or shear		Dip	Assay
	(*ft.*)	(*ft.*)				*Dwts./ton*
No. 1	4,663·5	370·4	156	157·5	25°	3·4
			288·9	291·4	60°	0·2
			295·6	297·75	37°	Tr
			313·5	316·1	?	Tr
"Cuthbert" ..	4,644·3	350·7	195·9	197·3	20°	Tr
			197·4	197·8	20°	0·9
			197·8	200·75	20°	0·2
No. 2C	4,645	345·7	295·9	296·8		Tr
No. SD	4,566	151·7	123·5	124·5		0·2
No. 3	4,585	304·7	255·5	260·25	35°	Tr
			260·25	262·5	35°	0·2
			262·5	264·75	35°	0·5
			264·75	266·0	35°	Tr
			284·3	287·0		Tr
No. 3D	4,560	244·5	114·5	115·3		0·4
			140·7	141·9		0·3
No. 4	4,643	356·9	253·0	268·4*		1·6
			259·5	263·0	15°	1·0
			263·0	265·5	20°	0·2
			265·5	268·0		Tr
B.W.H. 1.. ..	4,590·7	142·25	94·1	95·1	30°	1·4
			95·9	98·3	55°	1·2
			101·3	103·6	65°	5·6
A.H. 1	4,564·5	160·0	125·6	126·8	20°	0·9
			126·8	129·8	30°	1·2

*Core fragments only. Otherwise results shown are from split cores.

(iv) *Equatorial Gold Mine.*—Mining claims were registered by E. N. Mantheakis in 1948. Subsequently an exclusive prospecting licence was also granted over an area of approximately eight square miles covering the adjacent ground to the north and extending from the Chiptindin stream on the west to the Lumaiywa stream on the east. During the two-year tenure of this licence only casual prospecting of the area was undertaken. Low gold values in quartz stringers were found on Kibongwa and followed to shallow depths, but no economic prospects were disclosed. The area appears to warrant further examination.

In 1951, under an agreement with the Safari Exploration Co. of South Africa, the claims were thoroughly examined and tested. This work was under the control of P. C. Benedict, from whose detailed reports submitted to the Mines and Geological Department much of the following information has been obtained. Owing to lack of agreement on financial matters, the option to work the property was not taken up. The property was transferred in 1951 to Chemilil Sisal Estates Ltd. and production was delayed until 1953 when a small mill was erected at the sisal factory, some ten miles distant from the mine.* Production figures from the start of operations are shown in the following table:—

Year	Tonnage mined and milled	Gold
		(*fine ozs.*)
1953	850	647·76
1954	2,951	1,144·59
1955	2,031	2,236·45
1956	4,853	4,130·38

*Since the closing of the Rock Corry Mine, its mill has been rented by Chemilil Sisal Estates Ltd. for treating ore from the Equatorial Mine.

Assays indicate that the bullion has a silver content of about 1·86 per cent. The value of the production up to the end of 1956 is estimated at £102,315 (gold £101,846, silver £469).

Exploratory Work by Safari Exploration Co.—During 1951 the Safari Exploration Co. sank a total of twenty-four bore-holes with a total footage of 4,032 feet. In addition to surface geological and topographic mapping (*see* Fig. 3) assisted by trenching and loaming, 562 feet of underground work was undertaken. The total expenditure incurred was just over £25,000, which Benedict reported was roughly distributed as follows:—

	Per cent
Diamond drilling and work connected therewith ..	50
Underground exploration	32
Preliminary and later inspections, legal costs, salaries, etc.	10
Surface prospecting, surveys, trenching, etc.	6
Surface construction, huts, roads, etc.	2

The diamond drilling cost some £2·74 per foot drilled and the underground exploration £10·92 per foot.

As a result of the examination it is considered that the following ore reserves were indicated (sample widths being increased by one foot and not allowed to fall below 3½ ft. vertical for the purposes of calculation):—

	Vertical width (Feet)	Tons	Grade per ton (Dwts.)
"Low-Grade" Blocks	3·7	1,357	22
"High-Grade" Blocks	3·9	3,659	72
Total Probable Ore	3·8	5,016	59
Possible Ore suggested by drilling ..	3·5	13,500	29
Total Probable and Possible Ore ..		18,516	37

The ore-body was explored underground over a strike length of 450 feet, and it has a possible extension down dip of not less than 100 feet, with an average width of three and a half feet. The gold content of the ore is remarkably uniform for such high-grade material. Apart from occasional localities that yielded spectacular specimens there is little really coarse gold present nor is there much very fine-grained gold. Out of the 214 sections sampled only seven had a foot-dwt. value above twice the average value for the block from which they were taken, and only nineteen samples had a value slightly below half the average value for their block. The variation from twice-value or half-value was slight.

Characteristics of the Main Shear and Gold Values.—Contours on the mineralized shear derived from the underground and bore-hole evidence from the Equatorial Mine and on the Rock Corry Mine have been plotted on the combined mine plan (Fig. 3). It is evident that both properties are working veins in the same shear, and assays indicate that the known secondary shears in the foot- and hanging-walls do not contain economic deposits of gold. This has been confirmed by surface exploration. In the search for additional ore reserves, however, the possibility of other shears *en echelon* should not be overlooked. The continuity of the shear between the Equatorial and the Lil workings as shown on the plan is somewhat conjectural due to the difficulty, noted by Benedict, of recognizing the shear in the weathered rock of the trenches when gold values or quartz are absent, since the dip and strike of the schistosity in the Nyanzian rocks conforms closely to that of the main shear. There is possibly some dislocation of the shear in the vicinity of the common boundary of the properties due to the intrusion of porphyritic andesite. The disturbance resulting from this intrusion is well seen in the western part of the Lil workings. The normal fault between the Lil and the Spur workings throws down the shear about 150 feet to the east. This effect is characteristic of dip-faults in both properties. The outcrop of the gently dipping, gently rolling shear is roughly parallel to the granite-Nyanzian contact two miles to the north. The scarp rising from the contact suggests that the granite plunges steeply southwards and it is likely that the shear meets the contact at approximately 90°. The main shear is therefore

assumed to result from forces exerted on the country-rock by the intrusion and crystallization of the batholith. Subsequent intrusions of sill-like bodies, conformable in most cases to the general bedding and schistosity of the Nyanzian, would also be expected in such case and these in fact were revealed in great numbers in the bore-holes.

It is notable that in the case of the Equatorial Mine the economic values in gold so far proved by boring occur in the shear only above a tuffaceous horizon (Figs. 9 and 10). There is also a suggestion that there is enrichment where the shear passes through a basaltic horizon but there is no noticeable variation in the vicinity of rhyolites. The last are often found to behave more competently than neighbouring rocks and the shear follows them preferentially. The shear has been proved to continue below the tuffaceous horizon and still contains gold values though they would be uneconomic to mine.

The main shear is well developed, easily recognized and correlatable without doubt in the cores. In its explored part its content diminishes with depth. As there is no evidence in the bore-holes of the plutonic rock from which the mineralizing hydro-thermal solutions must have originated, nor any marked change in metamorphism of the wall-rocks to indicate its proximity, the possibility exists that there are other gold concentrations along the shear at greater depth. As the workable lenses so far discovered on the two properties are relatively small in extent there is, however, some doubt whether deeper and more costly exploration would be profitable. Details of the location and values encountered in the main shear by the bore-holes are summarized in Table VII. It must be pointed out that the value of 6·2 dwts. over 8·2 feet recorded in bore-hole No. 18 may be misleading as there are high values in the foot-wall which, if combined with the next sample above, give a figure of 14·29 dwts. from 252·6 to 255·3 feet. This indicates possible ore in the vicinity of this hole over normal mining widths.

TABLE VII—BORE-HOLE VALUES OF VEINS IN THE MAIN SHEAR AT THE EQUATORIAL MINE

(Compiled from a report by P. C. Benedict)

Bore-hole	Depth of hole in feet	Elevation* at Collar	Attitude	Approx. Depth of Lode in feet	Width of Lode in feet	Gold Value in dwts.
1	89	4,524	Vertical	79	0·4 H.W. 1·65 Qtz. 1·0 F.W.	5·0 180·6 1·15
2	119	4,544	Vertical	106	0·8 H.W. 2·42 Qtz.	6·35 24·81
3	147	4,567	Vertical	134	1·28 H.W. 1·42 Qtz. 1·70 F.W.	2·80 20·85 1·20
4	173	4,585	Vertical	161	0·67 H.W. 1·08 Qtz. 1·38 F.W.	6·40 5·93 4·25
5	192	4,605	Vertical	179	2·60 H.W. 2·75 Qtz. 1·65 F.W.	2·07 16·05 0·63
6	91	4,536	Vertical	60	3·5 Shear	0·12
7	305	4,547	68½°	221	0·55 Qtz. 4·20 F.W.	19·35 0·15
8	259	4,561	67°	241	0·9 Qtz. 1·2 Shear	1·45 1·43

*Datum height roughly established from Kibigori Station.

TABLE VII—BORE-HOLE VALUES OF VEINS IN THE MAIN SHEAR AT THE EQUATORIAL MINE—(*Contd.*)

Bore-hole	Depth of hole in feet	Elevation* at Collar	Attitude	Approx. Depth of Lode in feet	Width of Lode in feet	Gold Value in dwts.
9	285	4,541	Vertical	191	0·75 Shear	2·15
10	336	4,580	Vertical	290	1·3 Shear	Nil
11	175	4,519	Vertical	164	1·5 H.W. 1·9 Qtz. 0·75 F.W.	1·00 2·20 6·80
12	192	4,514	Vertical	176	Not Sampled (of poor appearance)	
13	207	4,580	Vertical	194	1·2 H.W. 0·95 Qtz. 0·60 F.W.	0·13 301·00 1·60
14	166	4,601	Vertical	134	5·7 Shear	1·29
15	219	4,524	Vertical	213	1·65 Qtz.	4·45
16	209	4,647	Vertical	204	0·77 H.W. 1·95 Qtz. 1·50 F.W.	4·90 97·50 4·70
17	47	4,531	Vertical	Abandoned		
18	268	4,633	Vertical	247	8·2 Shear or Qtz.	6·2
19	316	4,682	Vertical	300	1·5	28·7
20	282	4,677	Vertical	258	3·3	0·7
21	257	4,572	Vertical	245	2·5	1·0
22	316	4,626	Vertical	294	3·0	0·15
23	345	4,700	Vertical	321	0·7	1·18
24	36	4,670	Vertical	Abandoned		

*Datum height roughly established from Kibigori Station.

In bore-hole No. 16 rhyolite flows containing auriferous sulphides were cut. From 29 to 31·6 feet in depth a pyritic rhyolite assayed 0·25 dwts. gold and a similar body was again reported from 33·4 to 43·6 feet, though its upper part while rich in pyrite (2%) and pyrrhotite (4%) was barren of gold from 33·4 to 38·6 feet. The base of the same flow, however, contains some 10 per cent of sulphides and assayed 7·2 dwts. of gold over 5 feet*. This rhyolite was not recognized or assayed in the neighbouring holes to the north and requires further attention. The values found in the bore-hole may possibly be derived from a zone of secondary enrichment at the base of a shallow oxidized zone.

Mining.—Rock conditions are good except in oxidized ground so that little support is required at depth. The quartz and country-rock, especially the rhyolite, are hard drilling but break well on blasting. As the mine is well above water-table level there is no pumping problem. Drill-water is derived by pipe-line from a spring on the scarp.

*Prospecting at a later date failed to confirm these values in gold.

Prior to 1953 ore was mined from an opencast working on outcrop, but was later obtained from underground by means of an adit intersecting the 4,450-foot level at a point just east of Shaft B.

Metallurgy.—There are no milling difficulties. Pyrite in the ore averages about 0·25 per cent with some chalcopyrite and sphalerite (?). The slightly pyritic shear may require rather finer grinding than the quartz lode to recover the gold. The mill feed, estimated from past production figures, is in the region of 22 dwts. per ton, the mill recovery being only a little over 60 per cent.

(v) *The Koru Gold Claims.*—Two precious metals lode locations, each of ten claims, were registered in 1950 by M. E. Margaritis in the Koru area on the south bank of the Kipchoriet River and roughly between the confluences of the Merwamo and Baraget tributaries (Long. 35° 14½′ E.; Lat. 0° 12′ S.). The claims were relinquished in 1952 after a small amount of trenching and three opencasts representing a total excavation of 800 cubic yards had been undertaken.

Low gold values appear to have been obtained in discontinuous quartz veins and pegmatites in the granitoid gneiss, which outcrops along the river to the north of Koiabi. The occurrence of gold-bearing veins in Basement System rocks is unusual and the reported discovery should be treated with reserve, as "salting" from other sources is not impossible. Similar types of country-rock veined with pegmatites occur in the valley directly south of Koitatui but samples from quartz veins in this area, as well as from pegmatites two miles south of Koiabi hill, when panned were found to be barren.

(vi) *Songhor.*—Three miles north-east of Songhor Police Post at Long. 35° 15½′ E.; Lat. 0° 0½′ S. there is an outcrop of granitic gneiss with which thin veins of glassy quartz are associated. These veins carry low values in gold that are uneconomic to work. No systematic prospecting has been undertaken, but the lack of width of the veins and their discontinuity on surface suggests that they are not worth much attention.

The occurrence is, however, of interest as it resembles the environment of the Koru prospect and suggests that the pegmatites and veins seen in the granitoid gneiss are derived from a plutonic source and not the result of segregation during the metamorphism of Basement System sediments.

2. Non-Metallics

(1) Limestones

Two sources of lime are available in the area mapped:—

(i) The Lower Miocene sedimentary limestones.

(ii) The calcareous basal tuffs of the Miocene.

Analyses of the limestones indicate that they are of good quality and compare favourably with other limestone deposits in Kenya. The average of eight analyses of the Legetet limestones is as follows—CaO 53·1 per cent, MgO 0·6 per cent, P_2O_5 1·3 per cent. The iron oxide varies from 1·5 to about 3 per cent, while the magnesia varies from 0·3 to 1·73 per cent in different samples. The reserves available are not large by world standards and no exposed deposits additional to those already known are likely to be discovered. The amount of material present is, however, amply sufficient to support an expanding lime-burning industry in this part of the country.

For some years limestone was obtained by R. H. Walker, from the deposit north-west of the summit of Legetet and burned in kilns near by. In 1951 the Homa Lime Co., Kisumu, acquired rights to win limestone from the Legetet deposits and expanded operations by the erection of kilns near Koru station. The kilns on Legetet farm were removed, and the new kilns were fed by limestone quarried from the deposit north of the summit of Legetet. Production figures (*see* Table VIII) indicate an output of over 200 tons per month in 1954, the total estimated value of the material produced in that year being £12,408. Since then output has been expanded considerably and by 1957 was approaching 1,000 tons of limestone per month, the estimated annual value being £34,540.

The calcareous tuffs are likely to be more variable in their lime content than the limestones but in selected areas, such as the Kipturu valley, they approach tuffaceous limestone in quality, with as much as 48 per cent $CaCO_3$ (specimen 42/340 A).

TABLE VIII—LIME PRODUCTION—KORU

Year	Producer	Limestone quarried	Slaked Lime produced
		(*tons*)	(*tons*)
1945	R. H. Walker	1,700	1,037
1946	R. H. Walker	2,000	1,226
1947	R. H. Walker	1,800	1,100
1948	R. H. Walker	3,500	2,069
1949	R. H. Walker	3,000	1,900
1950	R. H. Walker	2,000	1,430
1951	Homa Lime Co.	3,600	2,257
	R. H. Walker	2,500	1,720
1952	Homa Lime Co.	4,800	2,597
1953	Homa Lime Co.	5,250	3,068
1954	Homa Lime Co.	5,156	2,661
1955	Homa Lime Co.	8,857	3,543
1956	Homa Lime Co.	9,652	3,886
1957	Homa Lime Co.	11,324	5,842*

*Includes 1,417 tons agricultural lime, which represents residue from sifting and separating.

The extent of the calcareous tuffs has not been determined but there are likely to be considerable reserves of such material near the junction with the Basement System. This source of lime was first briefly mentioned by Scott (1932, p. 7) who quoted the result of one analysis as 77·8 per cent $CaCO_3$ with 2·5 per cent P_2O_5.

Similar tuffs having a lower lime content also occur around Fort Ternan but would hardly be suitable for burning, though they may well provide a source of dressed blocks for building purposes.

The treatment of acid soils by unburnt limestone was suggested by Gracie (1930, p. 116) who pointed out that this might have economic advantages under certain circumstances. In this connexion the use of the local calcareous tuffs should not be overlooked whenever such material is available and easily extracted. The small phosphorus content of the tuffs adds somewhat to their agricultural value.

(2) PHOSPHATES

Scott (1932) drew attention to the phosphorus content of the calcareous tuffs, remarking that by present methods of extraction they would be uneconomic, though they may have future possibilities. The average content of commercial phosphate deposits is however in the region of 30 per cent P_2O_5 so that great technical advances would have to be made, or there would have to be a great scarcity of phosphates from other sources, before these deposits became workable. It is possible that a more diligent search and assay of bore-hole and surface samples might lead to the discovery of high-grade material around Tinderet.

Apatite in unusual concentrations was found in alluvials some years ago by a prospector at Songhor. In view of the quantity of such alluvial material available it is unlikely that the phosphate could be worked.

(3) CLAYS

No clays of particular economic value were noted. Clean, well-graded and uniform deposits may be expected to occur around the shores of the lower Pleistocene Lake Victoria at about the 4,200-foot level, and attention is directed to the eroded area south of Muhoroni and in the valley near Boror, on the Kisumu road. The deposits in the Mbogo valley at the west end of the Songhor inselberge contain some beds of volcanic dust (42/352).

(4) SANDS AND GRAVELS

The largest quantity of cleanest sand occurs in the Cherote stream north-east of Chemill (at Long. 35° 11′ E.; Lat. 0° 0′ 30″ S.), and minor beds are exploited in the Asawo valley north of Sondu at Long. 35° 0′ 30″ E.; Lat. 0° 21″ S. Gravels occur in lenticular beds and are worked on the same stream at Jimo. There are lateritized gravels around the Police Post at Sondu. Residual coarse sands are found on the Koywalelach ridge (Long. 35° 06′ 45″ E.; Lat. 0° 27′ 30″ S.). This is the only available source of supply on the Kericho plateau and has been exploited for dam construction work, but the reserves are relatively limited.

(5) Building Stones

The only stone suitable for dressing into building blocks in the area mapped is volcanic tuff. In the highest horizon seen, at 8,200 feet, some four miles east-south-east of Tatwakapsigesa (Long. 35° 29′ E.; Lat. 0° 17′ 40″ S.), the stone is of good quality and low porosity but suffers from the defect that it is difficult to split in a vertical plane. There is no vehicle track to this site.

The Kedowa Tuffs in the area east of the area mapped yield the stone most used for building in the district. Only stone of poor quality was, however, observed at lower elevations in the valley near Lumbwa. Good quality material of excellent colour is obtainable from the welded tuffs outcrops at Long. 35° 29′ E.; Lat. 0° 8′ 30″ S. and workable beds occur along the east bank of the Malaget stream as far as the south base of Segetet, where there is a small quarry. A possible source of stone for the Kericho town area exists in the valley south of Spur T.S. below the Lumbwa road at 6,500 ft. (Long. 35° 25′ 50″ E.; Lat. 0° 14′ 10″ S.).

Near Fort Ternan stone is quarried from the tuffaceous bed at Tunnel Station for use in building on several farms. Much of the tuff is impregnated with calcite and suitable for working, though the quality is not generally so good as that of the Kedowa Tuffs.

Near Muhoroni certain horizons of the Koru Beds contain workable stone. Quarries were seen at the Meswa stream road-crossing and about a mile south of Legetet T.S. To serve areas on the plain some use might be made of the vitric tuff outcropping south of the road three-quarters of a mile west of Ladhri store. (0° 9′ S., 37° 04′ E.).

(6) Ornamental Stones and Grinding Wheels

The granites examined are generally too jointed to provide large blocks of rock suitable for ornamental purposes. Grinding stones for use in the local water-mills are, however, prepared by the Africans from the Koywalelach rock, although the Basement System quartzites from the Sotik area are a source of more suitable material.

(7) Road-stone

The fresh phonolites and the trachytes provide good material for road-stone. The fracture of the former, however, tends to be splintery and the overburden of weathered rock is generally considerable. No large quarries have been developed, the stone being exploited at the nearest available outcrop. Under these circumstances the pits are shallow and the rock won is generally of poor quality.

(8) Ground-water

The location of bore-holes in the area with their depth, yield levels and output are given in Table IX, compiled from information supplied by the Hydraulic Branch of the Ministry of Works. Unfortunately the elevations of the bore-hole collars are not available and the drillers' logs cannot be taken as an altogether reliable guide in so far as the geological formations passed through are concerned. As a result until the sludges have been logged by a geologist and the elevations provided they are not of much assistance in the determination of the solid geology.

In general, poor results have so far been attained in the search for water in the Tinderet volcanics (bore-hole 5) and on the deeply weathered surface of the Kericho Phonolites (bore-holes 9, 10 and 11). The depth of decomposition of the surface of the Kericho Phonolites is indicated by the 250 ft. of "clays" recorded in bore-hole 10 and the 125 ft. in bore-hole 11. In the former it is preserved by a thin covering of nephelinite and agglomerate from the Tatwakapsigesa vent. The Kericho town bore-hole (C 1407) passed through 800 feet of phonolites which varied only in their degree of hardness, due probably to the lesser density of the tops and bottoms of the various flows encountered.

The bore-holes in the Londiani volcanics (Nos. 6, 7 and 8) have yielded better results due to the alternation of relatively impervious lava beds with porous tuffaceous horizons, which may be expected to outcrop to the east.

A good yield was also obtained by the shallow hole (No. 4) drilled through the limestone which rests on the Basement System at Legetet. Similarly, good yields result from the holes in the lake beds of the Kano Plains where they meet the basement, as in No. 3, or find water-tables perched on the Tinderet lavas interbedded with sediments (bore-hole 2). The most westerly hole (No. 1) was abandoned at 272 feet before striking water or the Basement System. There are at present no geophysical records to indicate the likely depth of the Basement System below the sediments in this area, but the rapid increase of depth of sediments away from the scarp, as indicated by bore-holes in the Miwani area to the west, in conjunction with the hole near Chemilil Station, suggest the likelihood of depths in excess of 500 feet in the middle of the basin.

TABLE—IX BORE-HOLE RECORDS

	M.O.W. Bore-hole No.	Name	Location (approx.)		Depth (ft.)	Water at Depth (ft.)	Formation	Yield (Gals./ Hour)
			Long. (E)	Lat. (S)				
1	C 888	Chemilil Station	35° 06′	0° 5′	272 (Abandoned)	Nil	Lake sediments	Nil
2	C 1214	Mbogo R.	35° 09½′	0° 3½′	180	126 and 180 on lava	Lake beds and lava beds	600
3	C 1292	Kwoissos	35° 10½′	0° 6′	336	320 on Basement	Lake sediments	600
4	C 759	W. Legetet	35° 14′	0° 9′	112	71	Miocene limestone Basement at 100 ft.	2,500
5	C 1378	Kiptiris River	35° 22½′	0° 9½′	600	Nil	Tinderet Nephelinites and Tuffs	Nil
6	C 1305	Robotham's	35° 29′	0° 8½′	340	320 on lava	Londiani volcanics	2,500
7	C 369	Tugenon River	35° 26½′(?)	0° 15¾′(?)	297	36 and 284 (artesian)	Londiani volcanics	700
8	C 1134	E. Tatwa-kapsigesa	35° 25½′	0° 17′	350	108 and 250	Londiani volcanics	1,000
9	C 758	E. Kaisugu	35° 24′	0° 18½′	180 (increased to 418)	98 and 180 (now dried up)	Junction of nephelinite on Kericho Phonolites	240 184
10	C 1509	E. Kaisugu	35° 23½′	0° 18¾′	555 (Abandoned)	Nil	Junction of nephelinites on Kericho Phonolites (mainly clay and decomposed rock; 250 ft. to 304 ft. lava)	Nil
11	C 1407	Kericho Town	35° 17½′	0° 22′	800	Nil	Kericho Phonolites Top 125 ft. in clay	60

(9) ALLEGED DIAMONDS

On several occasions prospectors have discovered what they thought were diamonds in the Songhor area. When examined in the Department it was found that the stones were either clear glassy zircons or yellowish to brownish octahedra of perovskite.

3. Water-Power Resources

Resources of water-power are plentiful in the south-east part of the area and the rivers, though they have relatively little volume, flow throughout the year and numerous small falls exist. The tea companies in the Kericho area have developed a number of small hydro-electric power-stations on the Kitho, Kimugu, Timbilil and Saosa streams. The greatest flow occurs in the Chemoisiet and Kipchoriet rivers. A diversion of the former river at Sondu, north through the wind-gap, would provide about 400 feet of head by a relatively simple engineering scheme, as well as water for agricultural purposes on the plain near Jimo. The Kipchoriet river between Lumbwa and Muhoroni has, however, no natural power sites.

North of Tinderet a water-power reservation exists on the Sakani river where it crosses the equator. Here, there is an excellent head but relatively little water. No suitable sites were seen south of the equator on the streams flowing from the north through the Nyando fault scarp.

4. Areas Suitable for Prospecting

The part of the area with the best prospects of mineralization is that occupied by the Nyanzian System adjacent to the granite in its north-west corner. Experience has shown that the important consideration for the prospector is the recognition and sampling of shear-zones rather than quartz veins, unless they are gossanous or mineralized. Particular attention should be paid to veins emplaced in shear-zones. To a lesser extent search might be extended to the east in the area between Chemilil ridge and the granite scarp west of the Nyangoro river. In the Muhoroni area the prospects are less favourable, but gold may occur in veins and pegmatites between the Kipchoriet river and the phonolite scarp. Similar conditions exist in the Asawo valley north of Sondu. Conditions favourable to mineralization appear to exist along the line of the Chemoisiet river from Mabasi to the Koywalelach granite intrusion and at the Nyanzian contact there.

VIII—RECORDS OF UNDERGROUND BORE-HOLES

1. Rock Corry Gold Mine

Two typical examples along the strike are recorded to indicate the variable nature of the rocks drilled. No. 1 is from the Spur section and No. 4 from the Boma section of the mine.

BORE-HOLE NO. 1

Grid location 5361 N., 7143 E. Collar datum height 4,663·5 ft. Vertical hole, depth 370′ 5″. Logged by F. W. Binge.

Depth in feet	*Lithology*
0 — 11	Soil, no core.
11 — 13·5	Coarse-grained epidiorite.
13·5 — 16	Meta-rhyolite and quartz stringer.
16 — 42	Coarse-grained epidiorite with foliation dip 62°; with quartz veinlet at 33 ft. dipping 70°.
42 — 45·75	Meta-rhyolite. FW 25°.*
45·75— 72·5	Coarse-grained epidiorite with pyrites in quartz augen at 46 ft. FW 53°.
72·5 — 79·3	Glassy rhyolite with phenocrysts at 76·5 ft. FW 20°.
79·3 — 80·1	Tuffs (basaltic?). FW 55°.
80·1 — 83·5	Medium-grained basalt.
83·5 —106·1	Glassy rhyolite to 85 feet then with phenocrysts to 94 feet and 4-inch barren milky quartz vein at 98 ft.
106·1 —121·9	Epidiorite. Flow banding at 113·4 to 113·9 ft.
121·9 —134·2	Glassy rhyolite with veinlets of unmineralized quartz. FW 25°.
134·2 —149·3	Fine-grained basalt with streaks of mafic minerals. Unmineralized quartz veinlet at 138·7 ft. FW 37°.
149·3 — 156	Silicified tuff with porphyroclasts.
156 — 157	Sheared basalt with veinlets of pyritic quartz. *Assayed* 3·4 *dwts. gold* from 156 to 157·5 ft.
157 — 158·1	Basalt. FW 55°.
158·1 — 166·1	Tuff (basaltic?).
166·1 — 177	Streaky, purple, blue and green tuff with augen. FW 40°.
177 — 179·7	Basalt.
179·7 — 183·1	Meta-rhyolite. FW 15°.
183·1 — 195	Tuff (basaltic?) with rhyolite intrusive at 183·8 ft.
195 — 202·4	Rhyolite. Rolling footwall contact about 25°.
202·4 — 225	Fine-grained basalt.

*FW 25° indicates that the measured dip of 25° is at the base or foot-wall of the rhyolite.

BORE-HOLE NO. 1—ROCK CORRY GOLD-MINE—(*Contd.*)

Depth in feet	*Lithology*
225 — 237·8	Meta-basalt.
237·8 — 251·3	Tuff (basaltic) with quartz stringer at 244 ft. and tendency to become streaky at base. Dip 10°.
251·3 — 258·7	Porphyritic rhyolite with quartz and pyrite in vertical joints and veinlet at 264·2 feet. FW 50°.
258·7 — 283	Meta-rhyolite.
283 — 287	Basalt.
287 — 289	Meta-rhyolite.
289 — 291	Banded rhyolite and basalt. FW 60°.
291 — 291·6	Mineralized quartz veinlet cuts in and out of core. *Assayed* 0·2 *dwts. gold* from 288·9 to 291·4 feet. FW 40°.
291·6 — 291·8	Dolerite.
291·8 — 294	Rhyolite.
294 — 296·5	Dolerite.
296·5 — 297·25	Sheared and mineralized zone (main shear). Dip 37°. *Assayed trace gold* from 295·6 to 297·75 feet.
297·25— 298	Meta-rhyolite.
298 — 300·75	Basalt, slightly sheared with quartz veinlet at 299 feet.
300·75— 301	Shear zone, unmineralized.
301 — 304·7	Basalt with oval phenocrysts at 302·7 feet and unmineralized quartz bleb at 303·4 feet.
304·7 — 308·7	Jointed and streaky tuff.
308·7 — 313·5	Basalt with inclusions.
313·5 — 315·7	Sheared unmineralized quartz. *Assayed trace gold* from 313·5 to 316·1 feet.
315·7 — 320·7	Basalt with quartz and sulphide at 318 feet. *Assayed trace gold* from 318·1 to 320·1 feet.
320·7 — 330	Banded green and purple rhyolite with phenocrysts in basal 3·5 feet. Dip 20°.
330 — 330·7	Dolerite (fresh).
330·7 — 333·4	Streaky tuff.
333·4 — 335·5	Glassy rhyolite (brownish). Base step faulted, dip 20°.
335·5 — 338·5	Meta-rhyolite (brown grey). FW 40°.
338·5 — 341	Sheared streaky tuff.
341 — 342·5	Basalt.
342·5 — 346·6	Fine-grained dolerite. Broken core from 344·9 to 346 feet which may represent a fault-zone. FW 40°.
346·6 — 349	Meta-rhyolite. FW 34°.
349 — 349·9	Tuff (?) or altered sediment with small pebbles. FW 45°.
349·9 — 352·9	Epidotized rhyolite with sulphide in cracks. FW 20°. *Assayed trace gold* from 351·6 to 352·9 feet.
352·9 — 354·2	Basalt.
354·2 — 358·1	Fine-grained rhyolite with veinlets of quartz.
358·1 — 359·4	Basic dyke, silicified, green. FW about 60°.
359·4 — 362·3	Epidotized rhyolite. Possible fault at 362 feet with dolerite intrusion.
362·3 — 370·4	Glassy rhyolite, pyritic.

Bottom of bore-hole No. 1, *Rock Corry Gold-mine.*

BORE-HOLE NO. 4, ROCK CORRY GOLD-MINE

Grid location 5663 N., 7660 E. Collar datum height 4,643 feet. Vertical hole, depth 356·9 feet. Logged by F. W. Binge.

Depth in feet	*Lithology*
0 — 16·9	Basic dyke. Broken core.
16·9 — 19·7	Meta-rhyolite.

BORE-HOLE NO. 4, ROCK CORRY GOLD-MINE—(*Contd.*)

Depth in feet	*Lithology*
19·7 — 31	Porphyritic microgranite with quartz insets.
31 — 31·9	Unmineralized tongue of glassy quartz; flat base with amphibolite veinlet at 31·4 feet. Dip steep.
31·9 — 36·8	Porphyritic rhyolite with chilled base. FW 20°.
36·8 — 40·2	Microgranite intrusive with chilled margins. FW 35°.
40·2 — 40·9	Porphyritic rhyolite. FW 20°.
40·9 — 47·5	Microgranite as at 40 feet depth. FW 35°.
47·5 — 62·2	Meta-rhyolite with augen. FW 20°.
62·2 — 72·4	Basalt. FW about 25°.
72·4 — 79	Rhyolite with flow banding and augen. Sheared barren quartz at 77·5 to 79 feet. FW 20°.
79 — 87·2	Sheared dolerite (older).
87·2 — 94·7	Medium-grained epidiorite. FW 35°.
94·7 — 97	Foliated dolerite (older). FW 45°.
97 — 97·7	Quartz veinlet, step faulted. FW 0°.
97·7 — 100·6	Dolerite (older).
100·6 — 103·5	Tuff (?). FW 45°.
103·5 — 105·9	Sheared basalt.
105·9 — 110·9	Epidiorite, medium-grained with foliated base. FW 30°.
110·9 — 112·7	Tuff (?). FW 60°.
112·7 — 118	Meta-rhyolite.
118 — 118·9	Barren milky quartz.
118·9 — 142	Meta-rhyolite becoming coarser-grained in depth with darker base.
142 — 166·5	Epidotized porphyritic microgranite.
166·5 — 170·9	Rhyolite with pyrite in joints.
170·9 — 178·9	Tuff with quartz veinlet at 177·7. Dip 20°.
178·9 — 183	Rhyolite intrusive into tuff. FW 15°.
183 — 204·6	Tuff. FW 30°.
204·6 — 212	Meta-rhyolite with glassy grey basal section. FW 55°.
212 — 229	Tuff.
229 — 233·7	Microgranite. FW 20°.
233·7 — 253·1	Tuff, banded at base and with quartz veinlets.
253·1 — 258	Meta-rhyolite, sheared and injected with barren quartz. HW 0°.*
258 — 259·5	Sheared epidiorite.
259·5 — 268	Sheared rhyolite with quartz. Dip 15°. *Assayed* 1 *dwt. gold* from 259·5 to 263 feet. *Assayed* 0·2 *dwts. gold* from 263 to 265·5 feet. *Assayed trace gold* from 265·5 to 268 feet.
268 — 269·9	Meta-rhyolite with glassy top section. HW 20°.
269·9 — 270·8	Sheared dolerite (older). HW 15°. FW 30°.
270·8 — 271·3	Meta-rhyolite.
271·3 — 280·7	Banded and foliated tuff, silicified at 279·8 feet and with pyrite in joints.
280·7 — 284·2	Rhyolitic or silicified band of tuff (?).
284·2 — 285·3	Sheared tuff with secondary quartz. Sulphides associated with melanocratic bands.
285·3 — 287	Banded tuff, grey and brown.
287 — 317·8	Fine-grained meta-rhyolite with chilled upper margin, becoming coarser-grained in depth and with quartz blebs and veinlets in joints at 312 feet. FW 45°.
317·8 — 328·4	Sheared and banded tuffs with quartz augen. Shearing more notable at 319 feet and quartz pebble at 323·5 feet with broken core below 326 feet. Foliation dip 15°.
328·4 — 330·1	Meta-rhyolite. HW 15°. FW 10°.
330·1 — 336·9	Banded tuffs.
336·9 — 346·5	Meta-rhyolite intrusive, with chilled margin. Glassy from 342·5 to 343·3 feet. FW 45°.
346·5 — 356·7	Tuffs with included quartz grains (non-pyroclastic sediments ?).

Bottom of Bore-hole No. 4, Rock Corry Gold-mine.

*HW means a hanging-wall measurement of the dip.

2. Equatorial Gold-mine

Bore-holes Nos. 5 and 10, which are illustrated in the section in Figure 9, have been selected for description as characteristic of this property.

Bore-hole No. 5

Grid location 5243 N., 5324 E. Collar datum height 4,605. Vertical hole, depth 192 feet. Logged by P. C. Benedict. Benedict's wording has been slighlty modified in several cases.

Depth in feet	*Lithology*
0 — 14	Probably rhyolite flow; with felspar phenocrysts.
14 — 20	Rhyolite without felspar phenocrysts.
20 — 21·3	Probably rhyolite flow; with felspar phenocrysts.
21·3 — 34·5	Rhyolite without phenocrysts. Relatively coarse-grained. Possibly hydrothermal alteration. Flow banding dip 60°.
34·5 — 40·1	As above, but possibly finer-grained lower flow.
40·1 — 44·0	Fine-grained rhyolite dyke. HW 20°.
44·0 — 44·7	Either fine-grained basic dyke or recrystallized.
44·7 — 61·8	Microgranite type C. FW about 25°.
61·8 — 76·2	Acid volcanic (acid appearance conceivably due to alteration). Predominantly with flow structure. 62·3–62·9 probable tuff beds and lenticles; 66·6–66·8 probably tuff beds dipping 20°; 71·4–72, half-inch green bands dipping 25°.
76·2 — 84·4	Microgranite Type C. Irregular walls affected by faulting.
84·4 — 86·7	Volcanic. Basaltic but possibly recrystallized by dykes.
86·7 — 87·8	Fine-grained rhyolite dyke (could be microgranite, type B).
87·8 — 89·6	Volcanic, basaltic ?—dark green.
89·6 — 97·8	Coarse-grained rhyolite dyke. Type specimen FW 45°.
97·8 — 110·5	Basalt. Sparse scattered felspar insets.
110·5 — 112·2	Coarse-grained rhyolite dyke.
112·2 — 113	Fine-grained rhyolite dyke presumably intrusive into coarse-grained rhyolite.
113 — 114·2	Coarse-grained rhyolite dyke. Lower contact 40°.
114·2 — 115	Fine-grained rhyolite dyke, intrudes coarser rhyolite.
115 — 117·4	Coarse-grained rhyolite dyke. FW 5°.
117·4 — 127	Basalt.
127 — 127·8	Fine-grained rhyolite dyke. FW 15°.
127·8 — 134·9	Microgranite, type AC. Type specimen.
134·9 — 135·6	Fine-grained rhyolite dyke. Altered. HW 20°. FW 0°.
135·6 — 151·8	Basalt.
151·8 — 152·1	Fine-grained rhyolite dyke. Dips at low angle.
152·1 — 164·2	Basalt.
164·2 — 168·3	Fine-grained rhyolite dyke. Centre indistinguishable from micro-granite type B. FW 5°. Two quartz stringers dipping at 70°.
168·3 — 176	Basalt. Similar to 134·9 to 164·2 but browner due to development of fine-grained biotite for 3 feet in shear at top.
176 — 178·6	Presumably volcanic. White, light greenish white, brown and green. Hanging-wall highly sheared. Shearing averages 15° dip, with distortion around some of the quartz. 176·0 — 176·4 10% pyrite. 176·4 — 176·7 Blue quartz with *visible gold*. HW 65°. FW 30°. 176·7 — 177 5% pyrite. 177 — 177·6 80% blue quartz. HW irregular. FW 20°. 177·6 — 178·6 ½% pyrite becoming less towards vein. *Assayed* 2·07 *dwts. gold* from 176 to 178·6 feet.
178·6 — 181·2	*Quartz Vein.* Predominantly bluish grey to almost white along fractures. No banding. Less than ½% pyrite; trace chalcopyrite, sphalerite, and pyrrhotite. *Visible gold* at nineteen places. HW dips 25° and FW irregularly at 40°. *Assayed* 16·05 *dwts. gold* over 2·75 feet from 178·6 to 181·35 feet.

BORE-HOLE NO. 5, EQUATORIAL GOLD-MINE—(*Contd.*)

Depth in feet	*Lithology*
181·2 — 183	Altered foot-wall, bleached to greyish white. Only slight shearing. 2% pyrite and some quartz. Possibly some fine-grained rhyolite dyke as below. *Assayed* 2·25 *dwts. gold* from 181·35 to 183 feet.
183 — 185	Fine-grained rhyolite dyke. Altered for first foot. Near hanging-wall same as microgranite type B.
185 — 189·9	Basalt.
189·9 — 190·2	Veinlet, white quartz (unlike main Equatorial vein). Dip 5°. *Assayed* 0·13 *dwts. gold* over 0·3 feet.
190·2 — 192	Basalt. 30% poor looking quartz from 191·5 to 191·75 feet.

Bottom of bore-hole No. 5, Equatorial Gold-mine.

BORE-HOLE NO. 10, EQUATORIAL GOLD-MINE

Grid location 5570 N., 5289 E. Collar datum height 4,580 feet. Vertical to 336·5 feet Logged by P. C. Benedict (wording modified in places).

Depth in feet	*Lithology*
0 — 12	Medium-grained dolerite. Type specimen.
12 — 21·5	Fine-grained dolerite.
21·5 — 25	Fault or shear-zone in fine-grained dolerite dip 75°.
25 — 32·3	Fine-grained dolerite. Two feet chilled margin at lower contact, which dips at 40°.
32·3 — 45	Basalt.
45 — 60	Basalt. Probably another flow, lighter coloured and more acid looking. 45–60 feet quartz amygdales to half an inch diameter. 45–55 feet minute tufts of biotite.
60 — 63·7	Microgranite type B. FW 20°.
63·7 — 73·4	Basalt.
73·4 — 84·4	Microgranite type B–C (?). More abundant phenocrysts than type BC and bigger phenocrysts than type B. FW dips 45°.
84·4 — 94·8	Basalt; some amygdales.
94·8 — 99·6	Fine-grained rhyolite porphyry dyke, mostly fresh. HW dips 60°. FW, indications of steep angle.
99·6 — 100·9	Volcanic, light-coloured, faintly sheared with 20° dip.
100·9 — 114	Microgranite type C with rather abundant quartz phenocrysts, some bluish. FW 60°.
114 — 133·5	Basalt. Fresh and clean.
133·5 — 134·6	Fine-grained dolerite. HW 20°. FW 25°.
134·6 — 136·2	Basalt, brownish and possibly baked.
136·2 — 137	Fine-grained dolerite. HW 45°. FW 60°.
137 — 146	Basalt, blackish.
146 — 152	Basalt. Probably a different flow. Lighter coloured, coarser and pro gressively so in depth.
152 — 158·5	Microgranite, type A. Fairly fresh.
158·5 — 161·7	Microgranite, type B. At upper contact throws dykelets into type A and is definitely younger than type A. Hanging-wall steep and irregular.
161·7 — 163·2	Basalt.
163·2 — 166·6	Fine-grained dyke of intermediate composition.
166·6 — 176·3	Basalt.
176·3 — 183·8	Basalt. Conceivably different flow.
183·8 — 192·3	Coarse-grained rhyolite dyke. HW 40°. FW broken, but shows dykelet.
192·3 — 201·2	Basalt.
201·2 — 212·2	Microgranite, type B–C. HW 20°.
212·2 — 226·2	Basalt with light green alteration streaks.
226·2 — 227·8	Fine-grained dolerite. HW 20°. FW 40°. Chilled at top and gets pro-gressively coarser downwards.
227·8 — 234·8	Erratic-grained dolerite.
234·8 — 235·5	Basalt which seems to have gradational contact both above and below.

BORE-HOLE NO. 10, EQUATORIAL GOLD-MINE—(*Contd.*)

Depth in feet	*Lithology*
235·5 — 241·6	Erratic-grained dolerite.
241·6 — 258	Microgranite type B. Altered in patches.
258 — 275±	Basalt.
275± — 290·1	Basaltic tuff. Drag-folded light coloured coarser beds in fine-grained groundmass. Bedding from flat to 15° up; other limb from 15° to 40° down.
290·1 — 291·4	*Equatorial Shear-zone.* Well-sheared with dip about 23°. No sulphides. About 25% zoisite bands and blebs, which are common on the Equatorial property and have no connexion with the vein mineralization. *Assayed nil gold* from 290·1 to 291·4 feet.
291·4 — 300	Drag-folded tuffs. *Sludge assayed nil to* 0·2 *dwts. gold* from 299 to 336 feet.
300 — 320·1	Basaltic (?) fragmental rock with many porphyritic pebbles and much felspar irregularly scattered throughout the groundmass.
320·1 — 322·9	Coarse-grained rhyolite dyke. HW 60°. FW 30°.
322·9 — 325·5	Basaltic fragmental rock.
325·5 — 328·5	Coarse-grained rhyolite dyke. HW 45°.
328·5 — 336·5	Microgranite type B. HW has steep dip. *Assayed nil gold* from 327·2 to 328·8 and from 330·1 to 332·0 feet. 327·2–328·0 feet. Quartz. ½% pyrite, no shearing. 328·3–328·5 feet. Quartz and ½% pyrite, no shear, average dip about 70° but very irregular. 329 feet. Veinlet of quartz. Dip 35°. 330–330·5 feet. Quartz and ½% pyrite, dip averages 65–70°. 331·5–331·9 feet. Quartz on one side of core only. Dip vertical and no shear.

Bottom of bore-hole No. 10, *Equatorial Gold-mine.*

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G.P.K. 2431—1m—9/58