The South Turkana Expedition: Scientific Papers III. A Geological Reconnaissance of South Turkana
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Source: *The Geographical Journal*, Vol. 136, No. 1 (Mar., 1970), pp. 61-73
Published by: The Royal Geographical Society (with the Institute of British Geographers)
Stable URL: http://www.jstor.org/stable/1795682
Accessed: 10/07/2014 08:18

THE SOUTH TURKANA EXPEDITION

SCIENTIFIC PAPERS III.

A GEOLOGICAL RECONNAISSANCE OF SOUTH TURKANA

SULTAN RHEMTULLA

SOUTH TURKANA as referred to in this paper is the area currently being investigated by the Royal Geographical Society South Turkana Expedition. The area (Fig. 1) covers some 9500 km^2 immediately to the south of Lake Rudolf in Northern Kenya. It embraces the southern and south-western shores of Lake Rudolf together with those parts of the northward flowing Kerio and Suguta rivers and the intervening high ground of the Loriu Plateau which are north of 1°30′N. A more detailed description of the region with precise boundaries is given by Gwynne (1969).

During the first field season (July–August 1968) the author undertook a geological reconnaissance of the area in order to prepare a geological map and report for subsequent use by the South Turkana Expedition. This paper embodies the findings of that report.

The earliest geological work in the area was carried out in 1888 in the course of an expedition to Lake Rudolf under the leadership of Count Paul Teleki. Various aspects of the geology were described by Höhnel (1891), Rosiwal (1891), Toula (1891) and Suess (1891). An active volcano at the southern end of Lake Rudolf was named after Teleki. Angelis d'Ossat and Millosevich (1900) described the material collected by Sacchi before his untimely death during Bottego's expedition to the Lake Rudolf area in 1895–7. In a report on the northern parts of the then East African Protectorate, Parkinson (1920) made only passing reference to the present area. Gregory (1921) devoted a chapter to the northern section of the rift valley in Kenya, though he himself had not visited the region described here. The Cambridge Expedition of 1930–1 (Fuchs, 1934) was concerned primarily with the parts of the area bordering Lake Rudolf. Two years later, Arambourg (1934a; 1934b; 1935; 1943) carried out reconnaissance traverses south of Lake Rudolf, though the main object of the expedition was a study of the fossiliferous deposits of the Omo region at the northern end of the lake. Murray-Hughes (1933) summarized the geology of the western half of Kenya. He named flat-lying sediments which rest on the Basement Complex west of Lake Rudolf the Turkana Grits, tentatively referring them to the Jurassic. The greater part of the South Turkana area was shown as being covered by undifferentiated volcanics. Murray-Hughes evidently relied entirely on the work of Champion, an administrative officer, for data on the Turkana region. Champion (1935a; 1935b; 1937a; 1937b) subsequently published several accounts of the volcanic geology and physiography of the country south and west of Lake Rudolf; the volcanic rocks he collected were described by Smith (1938). Fuchs (1939) led an earlier Royal Geographical Society expedition to the region around Lake Rudolf in 1934. Inadequate knowledge of the surrounding areas, in particular the ground to the south, hampered the full interpretation of geological events in the Lake Rudolf basin. Dodson (1963) described the geology of that part of the South Turkana area

➔ The author is a member of the East African Geological Research Unit, Nairobi, and was geologist to the South Turkana expedition.

south of Lake Rudolf and east of the meridian 36°30′E. Other reports of the Geological Survey of Kenya (Dixey, 1948; Mason and Gibson, 1957; Baker, 1963; Joubert, 1966; Dodson, report in the press) deal with the geology of some of the surrounding country. In recent years, detailed palaeontological work has been carried out in the Kanapoi district (Patterson, 1966).

The geology of the southern part of the South Turkana area is being investigated in detail by S. D. Weaver (Bedford College, University of London) and the author as part of a wider project being carried out by the East African Geological Research Unit. Mr. Weaver has very kindly made available some preliminary results for incorporation in this account.

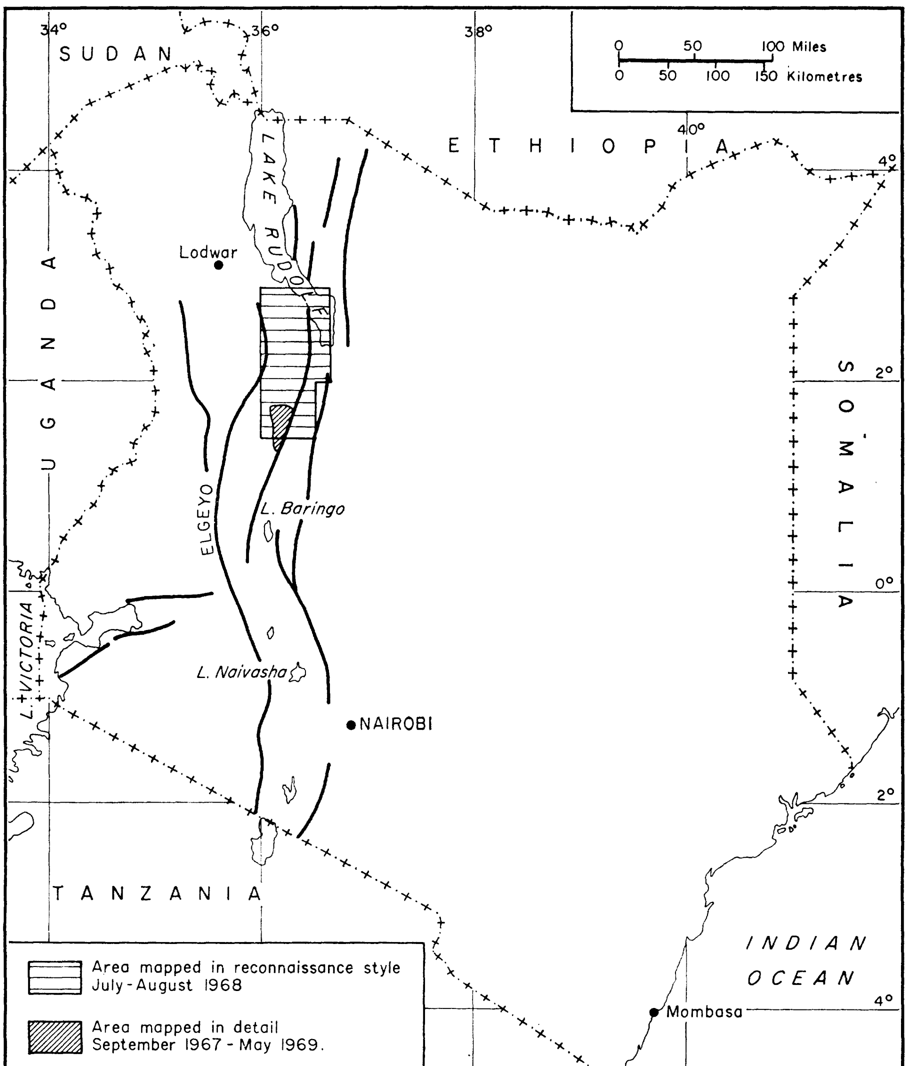

Fig. 1. Map showing position of the area and the main rift faults in Kenya

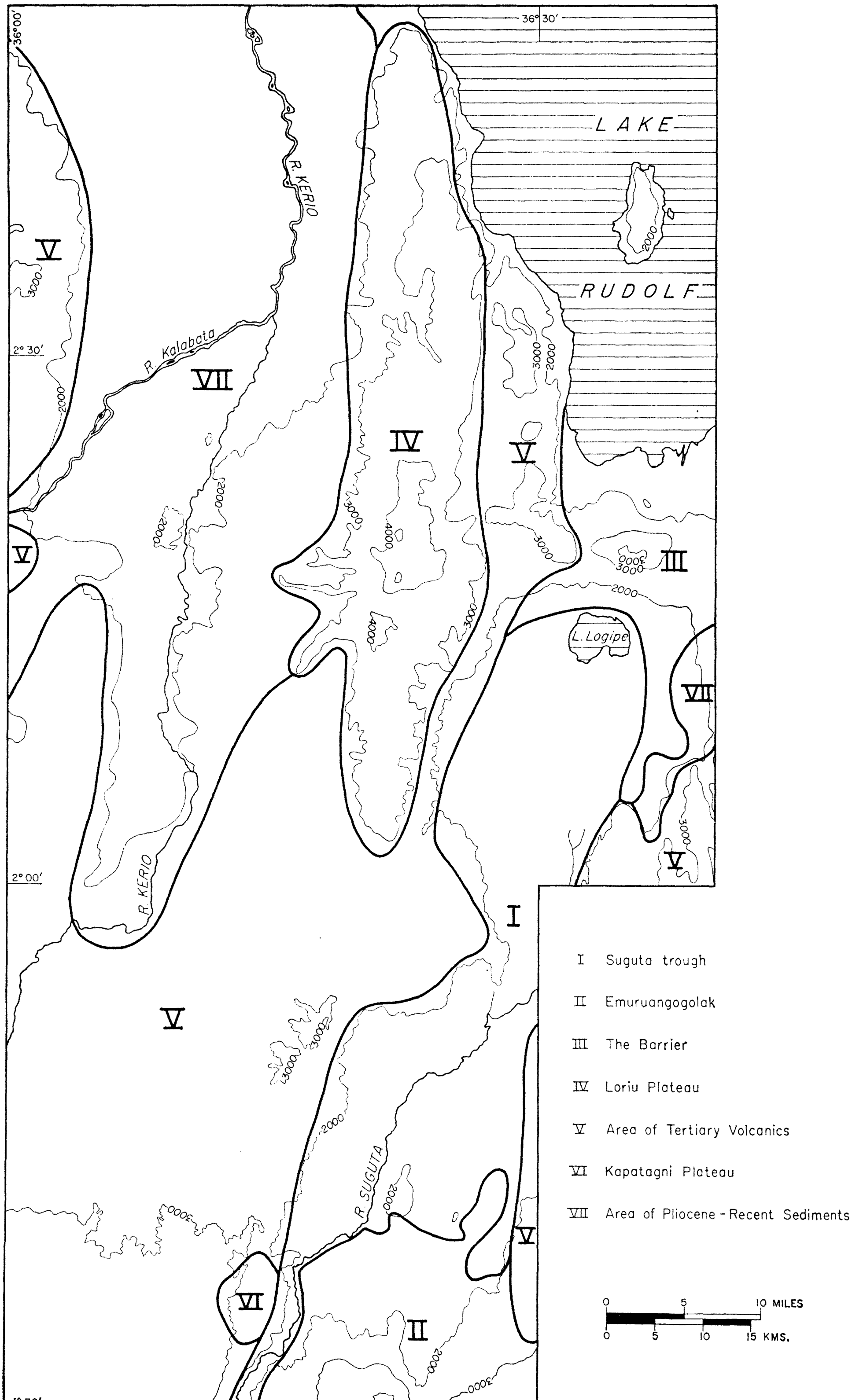

Fig. 2. Physiographic divisions in the South Turkana area

PHYSIOGRAPHY

The area can be divided into seven broad physiographic zones (Fig. 2). Tectonic activity, volcanicity, erosion and sedimentation have all contributed to produce a wide variety of landforms.

1. *The Suguta Trough*

In the south-eastern part of the area the Suguta River occupies a tectonic trough floored by Quaternary sediments and occasional lava flows. The trough is bounded to the east and west by downwarped and faulted Tertiary volcanics and is cut off from Lake Rudolf in the north by the Quaternary volcanic rocks of a complex central volcano known as 'the Barrier'. Another Quaternary volcano, Emuruangogolak, flanks the south-eastern part of the trough and for some distance the Suguta River cuts through the marginal flows from this centre.

Towards the northern end the Suguta River fans out into a number of distributaries; the trough at this point is about 15 km in width and bears vast unbroken stretches of Recent sediments. Barchans, built by prevailing westerly winds, are locally well developed. Details of the river and the pattern of lakes in the north Suguta are given in Gwynne (1969, p. 235). Accurate heights for the floor of the Suguta trough near Lake Logipe were obtained by members of the present expedition (Caukwell and Lovegrove, unpublished data). They confirm earlier claims (e.g. Dodson, 1963, p. 6) that the trough represents a former southern extension of Lake Rudolf. Evidence of higher lake levels is preserved in a number of fossil beaches around the Barrier and other high ground further south. From the position of these beaches and extent of Quaternary sedimentation, it would seem that the lake extended south to about 1°37′N during Pleistocene times.

2. *Emuruangogolak*

A complex Quaternary caldera volcano, Emuruangogolak, covers a large area in the south-east. It rises to more than 760 m above the Suguta valley floor and consists of at least three main centres as well as numerous smaller lava and pyroclastic cones. The main caldera is just south of 1°30′N. The older surfaces of Emuruangogolak are largely obscured by recent lavas and ashes which are little dissected and devoid of vegetation.

3. *The Barrier*

Cutting off Lake Logipe from Lake Rudolf is a Quaternary caldera volcano known as the Barrier. Teleki's and Andrew's volcanoes are two recent centres; the former was active at the end of the last century, and both display fresh flows. Active hot springs and geysers are present in the area.

4. *The Loriu Plateau*

The Loriu Plateau runs north–south for about 64 km and lavas cover the greater part of it. A group of low hills on the Plateau form part of a Tertiary volcanic centre from which the lavas dip away on all sides (Plate Va). On the west is a gentle bouldery slope which leads up to the plateau but the eastern margin is a fault scarp more than 366 m high (Plate Vb).

5. *The area of Tertiary volcanics*

This region differs from the more recent volcanic areas described in being highly dissected and faulted. The area of Tertiary volcanics west, south and east of Loriu consists of lavas and tuffs derived from a number of central volcanoes. Rugged and deeply eroded central zones of plugs and dykes (Plate VIIb) are separated by more regular and levelled flank flows. These flank flows are locally dissected and faulted (Plate VIII). A similar occurrence of Tertiary volcanics occupies the small area west and north-east of Emuruangogolak. These rocks are downwarped into the Suguta trough, as are the Tertiary formations west of the Suguta.

6. *Kapatagni Plateau*

A small plateau covering about 64 km^2 lies within the area of the Tertiary volcanics. The surface is no more than 90 m above the general level of the surrounding country, but it forms a distinctive flat feature. The plateau is entirely in an area otherwise characterized by central type volcanism.

7. *The area covered by Pliocene to Recent sediments*

This zone is bounded by Tertiary volcanics in the west and the Loriu Plateau in the east. The horizontal sediments are only mildly dissected so the area is one of low topographic relief. In some places the beds are capped by thin lava flows, but elsewhere small inliers of older lavas rise as low hills above the surrounding sediments.

Drainage: South Turkana is a semi-desert area with rainfall of only about 25 cm per annum. The Kerio and the Suguta are the main streams in the area and all the tributaries are sand rivers that carry water only immediately after heavy rainfall. However, most of the major tributaries (e.g. Kalabata, Kasamanang and Nasaken) contain water at depth and these supplies are of considerable importance in this arid region. The most important single factor governing the drainage pattern in South Turkana is the over-all slope of the rift floor which falls steadily from some 1830 m at Nakuru to about 366 m at Lake Rudolf. The courses of the two main rivers are closely controlled by the northward slope.

The Kerio is a semi-permanent river which dries out only during the season of least rainfall (generally August–November). It receives most of its surface recharge from tributaries flowing down the Elgeyo Escarpment far to the south-west. The Suguta has its main source at Kapedo hot springs but it has at least two tributary sources: a small semi-permanent one at the Lorusio hot springs some 13 km north of Kapedo and another one, hitherto unrecorded, 3 km south of the Kamuge-Suguta confluence. The latter, like the Kapedo springs, provides hot (about 45°C) saline water with a high fluorine content. Just before reaching Lake Logipe the river breaks into many distributaries and finally disappears. West of the Suguta the main tributaries tend to flow due eastwards (e.g. the Lomelo, Kamuge, and Kalabata streambeds) as a result of local faulting and/or downwarping towards the centre of the rift. A few tributaries tend to flow parallel to the fault trend (e.g. the Kalomongro and Kanomocho streambeds, 16 km north of Lomelo).

Volcanic events are responsible for local modification of the drainage; radial or approximately radial drainage patterns developed, for instance, at the main volcanic centres. The Barrier provides the most impressive example of the influence of volcanic activity on pre-existing drainage for it now effectively cuts off the Suguta trough from a former extension into Lake Rudolf.

GEOLOGY

Neogene volcanics and sediments cover most of the area, but metamorphic rocks of the underlying Precambrian basement are exposed at Lokhone and along the Loriu Plateau. Little or no record is preserved of events between late Precambrian times and the onset of volcanicity, warping, faulting and sedimentation during the

Miocene. Biotite- and hornblende-bearing gneisses are the most common metamorphic rocks. The volcanics are chiefly basalts, hawaiites, mugearites, trachytes and trachytic and basaltic pyroclastics.

Doleritic dykes locally invade the pre-volcanic sediments, and nephelinites and microfoyaites are emplaced in some of the early basalts. The sediments range from lacustrine grits and silts to windblown sands. The formations are arranged below in approximate stratigraphical order, and the ages of the main tectonic events are also indicated in the table:

Quaternary	(10) Volcanics of Emuruangogolak and 'the Barrier'
	(9) Pliocene to Recent Sediments
Pliocene	— Warping and minor faulting —
	(8) Basalts of Lomi and Kanapoi
	— Faulting —
	(7) Trachytes of Kapatagni
	(6) Basalts of Lopirapira
	— Faulting —
	(5) Volcanics of Kafkandal, Nasaken and Kanatim; Tirr Tirr Series
	— Faulting —
	(4) Basalts of Napeitom, Kagumnyikal and Loriu
	— Faulting and long period of erosion —
Miocene	(3) Early basalts
	(2) Pre-volcanic sediments
	— Major unconformity —
	(1) Precambrian basement rocks

1. *Precambrian basement*

In the west the basement rocks are exposed at Lokhone Hill north of the Kalabata river. The inlier is surrounded by Tertiary to Recent lavas and sediments. The rock types are biotite-gneisses, biotite-hornblende gneisses and hornblende-pyroxene gneisses. (Specimens ST/101, 102, 103).[1] The foliation dips steeply west-north-westwards at angles of about 50°. Views from the top of the hill, just beyond the western edge of the present area, show the structures there to be tight isoclinal folds.

Biotite-gneisses are exposed on Loriu as inliers among the volcanics, and similar rocks form the greater part of the 366 m high Mugor scarp. They are also well exposed under the volcanics along the western shores of Lake Rudolf. The relationships of the volcanics to the Precambrian basement rocks on Loriu indicate that the plateau is an upfaulted and tilted basement block.

2. *Pre-volcanic sediments*

The best exposures occur between the basement rocks and the earliest volcanics on the western and southern margins of the Lokhone inlier. Other pre-volcanic sediments are exposed along the western edge of the area between the latitudes 2°9′N and 2°17′N and they visibly underlie the basalts at the Kaipet Hills (Plate VIa). These sediments form an extension eastwards of the Turkana Grits mapped by Joubert (1966) in the Loperot area.

The sediments are typically well bedded quartzo-feldspathic grits (ST/46), but distinct horizons of purple-red silts (ST/40) and buff silts (ST/42) occur locally. The grits and some of the silts are highly calcareous and weathered surfaces often show the solution effects which are commonly associated with limestone outcrops.

[1] The specimens referred to in this paper are housed in the Geology Department, University College, Nairobi.

The grits show evidence of deposition under deltaic conditions and flood washings with current bedding and fluting are often visible. A number of doleritic dykes (ST/45) are emplaced in these sediments. The dykes tend to erode more readily than the country rock to form linear trenches.

3. *Early basalts*

Dodson (1963, p. 28) described the early basalts exposed in the north-eastern part of the area. He distinguished two basalt groups of Miocene age; the lower one a dominantly aphyric basalt with some pyroxene-phyric upper members, and an upper group of porphyritic basalts, containing phenocrysts of olivine, plagioclase and pyroxenes in varying proportions. It is possible that the upper group of porphyritic basalts is equivalent to the Pliocene basalts distinguished by the author around Napeitom and Kagumnyikal in the western part of the area. In the west the early basalts are exposed in the highly dissected and faulted hills around Kachau and Chiblet, and in the ground between Kaipet and Kangetet.

Kachau and Chiblet are basalt hills north of the Kalabata river. Their eastern edge is faulted and Pliocene to Recent sediments are banked against it. The basalts of Kaipet and Kangetet occupy a similar position south of the Kalabata and they are the earliest lavas overlying the basement rocks. In the Kachau hills an unconformity within the basalt group is marked by an intermittent fossiliferous sedimentary formation. These sediments were examined in the east–west trending valleys 3 km south of the trigonometrical beacon near Kachau. The basalts include numerous flows from different sources. Some cones are preserved but occasionally the source of the lava can only be inferred from structural studies. Not all areas have similar numbers or types of flows, but in general the earliest flows consist of aphyric olivine basalts or basanites. These are overlain by four to five flows of porphyritic basalts and basanites having olivines and augites as the main phenocrysts. In some areas (e.g. Kachau and Chiblet) the uppermost lavas of this group are trachybasalts. Smith (1938, p. 533) described nephelinites from the Chiblet area. These are probably associated with dykes and plugs of microfoyaites and nephelinites shown on the map. These early basalts are probably Miocene in age and they are tentatively correlated with the Samburu Basalts described from the rift shoulders east and south-east of the present area (Shackleton, 1946; Baker, 1963).

4. *Basalts of Napeitom, Kagumnyikal and Loriu*

The basalts of the Napeitom area overlie those exposed at Kagumnyikal Hill, the two formations being separated at some localities by an erosional unconformity and at others by an angular discordance. For the purpose of this account, however, these lavas are treated as a single unit and they are described here with the basalts of the Loriu Plateau with which they are probably broadly contemporaneous. Correlation with successions established south of the present area suggests a Pliocene age for the Napeitom lavas. (East African Geological Research Unit, unpublished data.) Most of the basaltic rocks examined contain olivine and interstitial analcime and are best described as basanites.

The Napeitom section (Plate VIb) exposes some aphyric, vesicular purple-grey and ash-grey basalts but the dominant type is a fresh mafic basanite with phenocrysts of olivine and pyroxene. The lavas were evidently derived from a number of local centres (Plate VIIa). One denuded cone is visible from the road about 16 km north of Napeitom and others were recognized across the basalt outcrop (see Fig. 3).

The Kagumnyikal lavas are chiefly olivine basalts and basanites. One prominent type which can be traced over a large area is a coarsely porphyritic basanite with

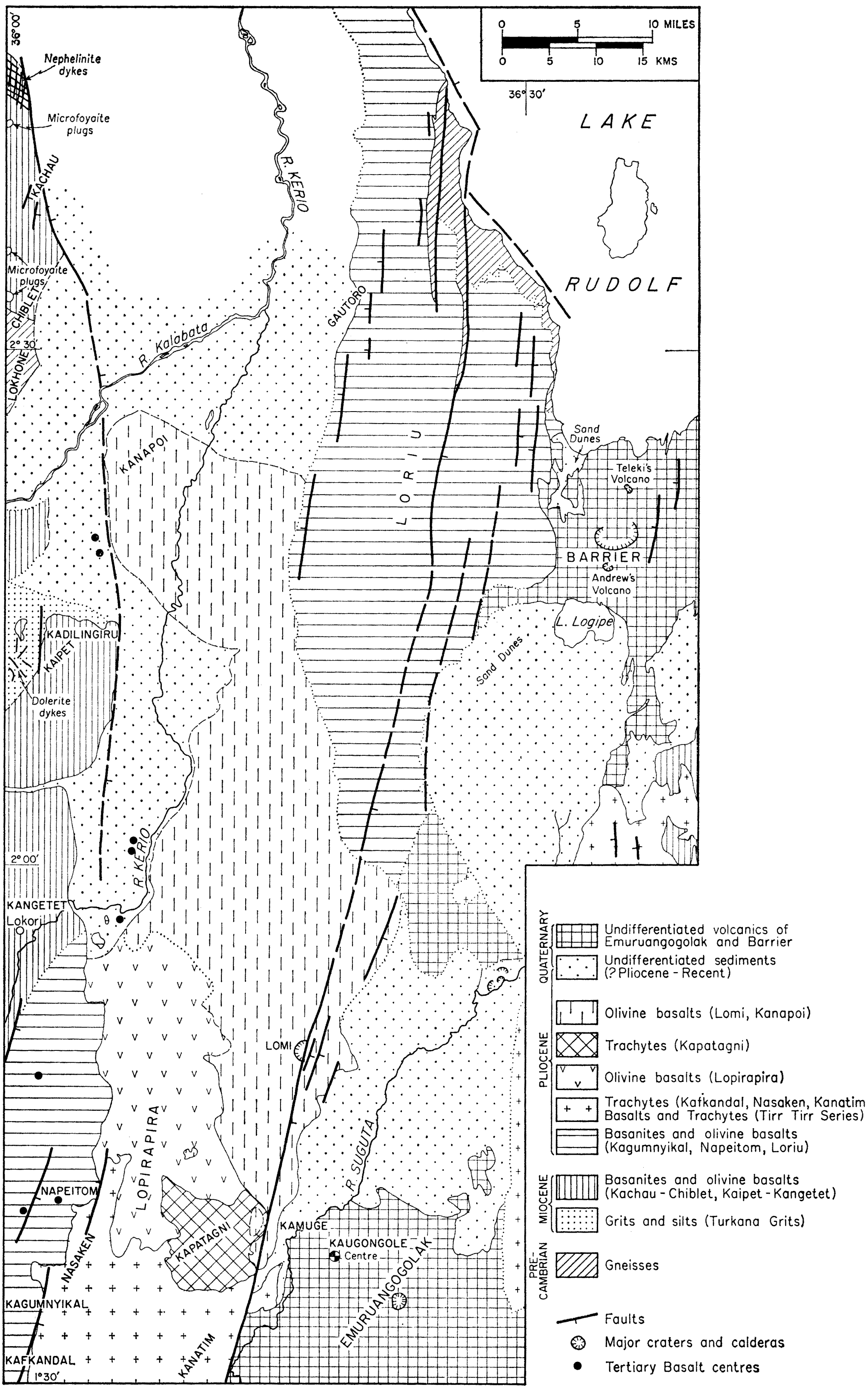

Fig. 3. Geological sketch-map of the South Turkana area

feldspar phenocrysts about an inch across. The other flows comprise dark aphyric basalts and basanites together with some porphyritic varieties having either olivine or olivine and feldspar phenocrysts.

Olivine basalts with phenocrysts of olivine and pyroxene cover the surface of the Loriu Plateau between the Kerio river and Lake Rudolf. The flows seem to have been derived from a local centre (Plate Va), and from the degree of dissection it is suggested that the lavas are not older than the basalts exposed in the neighbourhood of Napeitom. Until more evidence is forthcoming, the volcanics on the Plateau are considered, therefore, to be broadly equivalent in age to the Napeitom and Kagumnyikal lavas. Older flows of purplish aphyric basalts and sparsely porphyritic basalts are exposed in the deep valleys on the western side of the plateau and it is not unlikely that some of these lavas are of Miocene age; they are not, however, distinguished from other Loriu volcanics on the map. It is of some interest to note that it was in one of the valleys on the western side of the plateau that Champion collected a specimen of olivine nephelinite (Smith, 1938, p. 534).

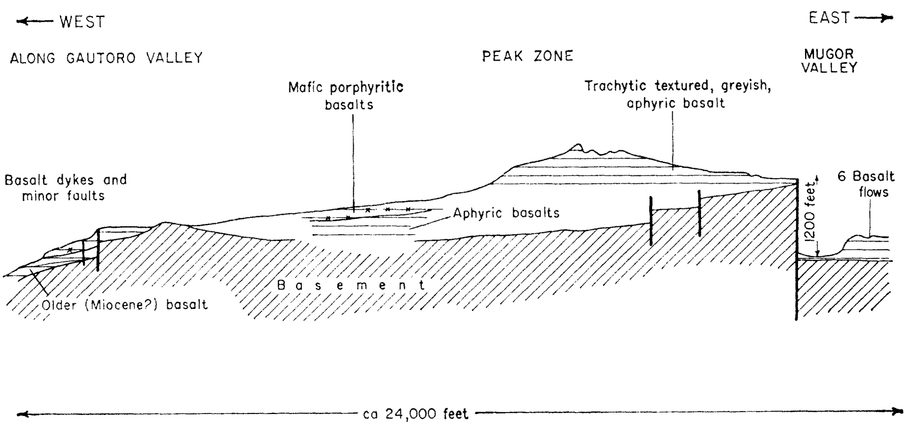

Fig. 4. A sketch section across the Loriu Plateau (24,000 ft = 7340 m; 1200 ft = 367 m)

The older basalts are banked against Precambrian rocks for they underlie the lavas of the plateau surface in the deep valleys on the western side of Loriu but they are not present higher up on the plateau where the younger lavas are in direct contact with the Precambrian rocks. This strongly suggests that faulting of the Loriu block began before the eruption of any basalts. The lower members of the basalt sequence of the Mugor scarp are correlated tentatively with the older lavas observed in the deep valleys on the western side of the plateau (Fig. 4).

5. *Volcanics of Kafkandal, Nasaken, Kanatim; Tirr Tirr Series*

Kafkandal, Nasaken and Kanatim are three separate complex composite volcanoes of similar form and lithology; they were active over about the same period of time. The main rock types are trachytes and tuffs but mugearites and rare basalts appear on the flanks of the volcanoes. The activity evidently commenced at Kafkandal, in the centre of which at least three feeder plugs are revealed in a rugged area of deep erosion. The lavas and tuffs within the central zone dip steeply in all directions, but away from the centre individual beds and flows thin rapidly and dips become more gentle. Nasaken volcano has an added complexity in that it has numerous small centres along its eastern flank. These small centres are distinguished by their rugged appearance, deep dissection, and haphazard dip directions. The Kanatim central zone contains a single elongated plug. All three volcanoes are cut by numerous north–south trending faults with downthrows to the east; these were active before the eruption of the basalts of the Lopirapira area which are banked against the trachyte scarps.

Most of the trachytes are pale greenish, fissile lavas with sanidine phenocrysts but aphyric types also occur. Sanidine is often accompanied by some anorthoclase and albite. The pyroxene is typically pale green aegirine or aegirine-augite and katophorite, arfvedsonite and aenigmatite are commonly present. Towards the centre of the complex, the Nasaken trachytes are quartz-bearing, but towards the fringes these trachytes grade into purplish brown mugearites. Welded tuffs and other pyroclastics occupy at least 40 per cent of the total volume of the complex.

The Tirr Tirr series (Dodson, 1963; Baker, 1963), on the eastern side of the rift includes trachytes, tuffs and basalts which were probably erupted at about the same time as the Kafkandal, Nasaken and Kanatim volcanics. The Tirr Tirr flows are faulted and downwarped towards the Suguta valley.

6. *Basalts of the Lopirapira area*

This group consists of a series of basalt flows banked against the eastern faulted edge of the Nasaken volcanics. Lopirapira is the name of a small, well-defined, symmetrical agglomerate cone, but the main source for most of the basalts probably lies in the area around Nathelot (this is a local name given to a large prominent dyke), where numerous dykes are revealed in a deeply eroded area. There are at least two types and age of dykes. The earlier north to north-easterly trending basaltic dykes display large feldspar phenocrysts, whereas the later dykes are characterized by north-east and east-north-east trends and are composed of aphyric basalts. The dykes are emplaced in earlier members of the Lopirapira basalts. Whereas no feeding relationships were found, lavas similar to the dyke rocks are present as flows. The other basalt types present are pyroxene-phyric lavas with only a few feldspar phenocrysts. The entire Lopirapira succession dips at 5° or 10° towards the east or east-south-east and this is attributed to regional tilting before the eruptions of overlying trachytes of the Kapatagni group.

7. *Kapatagni trachytes*

Kapatagni is a distinctive plateau composed of lower porphyritic and upper aphyric trachytes together attaining a thickness of some 60 m. On the western side of the plateau the trachytes are separated by a thick formation of bedded grits and reworked lapilli tuffs. Elsewhere the upper and lower trachytes are frequently separated by welded tuffs which are about 26m thick along the north-eastern edge of the plateau but in most sections they are generally less than 3 m thick. In the absence of any structural evidence indicating a central source for the trachytes, it is considered likely that the isolated plateau-forming group originated by fissure eruptions. The eastern extent of the plateau is marked by a major north–south fault which represents the southern continuation of the Mugor fault.

The younger volcanic rocks of Lomi are banked against this fault scarp.

8. *Volcanics of Lomi and Kanapoi*

South of Loriu a major volcanic group is centred on a caldera at Lomi. On the map no distinction is made between these volcanics and the lavas described as Kanapoi Basalts (Patterson, 1966) and for the purpose of this report all the basalts between the Kachau-Chiblet-Kangetet area and Lomi are grouped together. Grit beds were encountered within the volcanic succession, however, and there is little doubt that these sediments could be used to subdivide the basaltic group during more detailed mapping. The Kanapoi lavas gave an isotopic date of 2·9 million years (Patterson, 1966). From the stage of dissection and their stratigraphic position, a similar age is suggested for the Lomi volcanics. Lomi is a composite basaltic volcano. Only flank flows from the centre were examined; they consist of dark grey and purple-grey aphyric basalts and porphyritic basalts containing fresh olivine phenocrysts. The eastern edge of the caldera is downwarped and faulted into the Suguta trough along a north–south axis which lies on the join between the Kapatagni fault in the south and the Mugor fault in the north. It seems that movements in this major tectonic zone continued with diminishing intensity throughout the period of build-up of Lomi volcano.

9. *Pliocene to Recent Sediments*

No detailed systematic study of the sediments was possible in the short time spent in the field but it is clear that the main occurrence of intravolcanic sediments in Turkana formed as wash deposits in shallow lakes within tectonically formed troughs. The sediments between Loriu and the Miocene basalts occupy an early trough whilst the Suguta trough is a much younger feature in which sedimentation started in mid-Pleistocene times and continued to the present day. Smaller developments of intravolcanic sediments are common throughout most formations. These mostly originated in small local lakes formed in erosional hollows (e.g. patches of sediments beside the road 2·5 km south of Napeitom), or caused by temporary damming of watercourses by lava flows (e.g. a small area of sediments 800 m north of Lomelo).

10. *Volcanics of Emuruangogolak and the 'Barrier'*

Occupying the area east of the Suguta river and extending just beyond latitude 2°N, are the volcanics of a complex caldera volcano known as Emuruangogolak. Outside the main caldera, which contains well preserved vents and dykes, Emuruangogolak has at least two recently active centres as well as numerous parasitic ash cones. The only specimens collected were dark vesicular olivine basalts and feldsparphyric olivine basalts forming the flanks of the volcano. Lapilli tuffs are abundant and it is possible that trachytes occur in the older parts of the complex.

The Barrier is a very similar caldera complex north of Lake Logipe. It is ably described by Dodson (1963) and the volcano was not traversed during the present work.

STRUCTURE

South Turkana lies entirely within the Eastern (Gregory) Rift Valley. At this latitude, however, the rift is not a well-defined graben, but a broad zone about 160 km across characterized by divergent faults and marginal monoclinical downwarps. The central trough seen in the area further south can be traced into the Suguta valley which is bounded to the east by the Samburu monocline (Baker, 1965) and to the west by the Mugor fault and its extension southwards (Fig. 5). The earliest recognizable faults affecting the volcanics cut the Miocene basalts. The basalts at Kachau and Chiblet are truncated on the east by a fault zone which is marked by fluorite and calcite veins and the same zone can be traced southwards through the trachytes of the Nasaken group. Movements commenced after the eruption of the early basalts and continued with diminishing throws until after extrusion of the Nasaken volcanics.

Various episodes of faulting and warping have been recognized in the southern half of the area where a more complete sequence of Pliocene events has been worked out during detailed mapping. The various volcanic groups are downfaulted along their eastern margins and the structures became progressively younger towards the Suguta trough which is bounded on the west by faulting and downwarping of early Pleistocene age; similar late Pliocene to early Pleistocene flexures define the eastern margin of the trough.

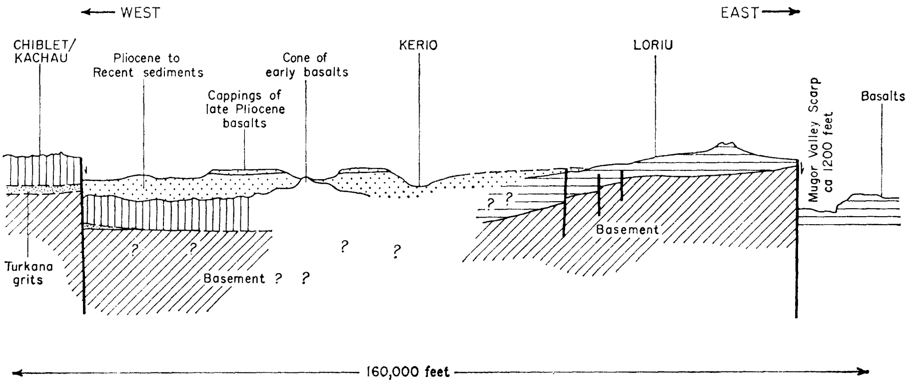

Fig. 5. A generalized sketch section across the northern part of the area (160,000 ft = 49,000 m; 1200 ft = 367 m)

More accurate height control will be required to determine the precise form of the upfaulted Loriu block. Since there is no definite evidence of any major faults in the western section of Loriu, the plateau is not necessarily to be regarded as a horst. A number of minor faults were noted, but it is unlikely that their cumulative effect would approach in magnitude the throw of the Mugor fault in the east. The physiography does suggest some uplift in the west and it seems that the plateau is an upfaulted tilted block. The faulting which started before the eruption of the earliest Loriu volcanics must have continued throughout the Pliocene, for the Pliocene basalts on Loriu show a westward tilt.

In the Quaternary volcanics, the flank flows of Emuruangogolak show a pattern of tight minor faulting, some of the faults being simply shattered dilation fractures.

Acknowledgements

I would like to thank Professor B. C. King for helpful advice in the field and Dr. L. A. J. Williams for constant helpful advice and encouragement in preparing this paper. I would also like to thank the Royal Geographical Society and the East African Geological Research Unit for the opportunity of carrying out field-work with the RGS South Turkana Expedition. The work in Nairobi was made possible by financial assistance from UNESCO (Contract UNESCO/SC/1582/29–20 168) to whom I am most grateful.

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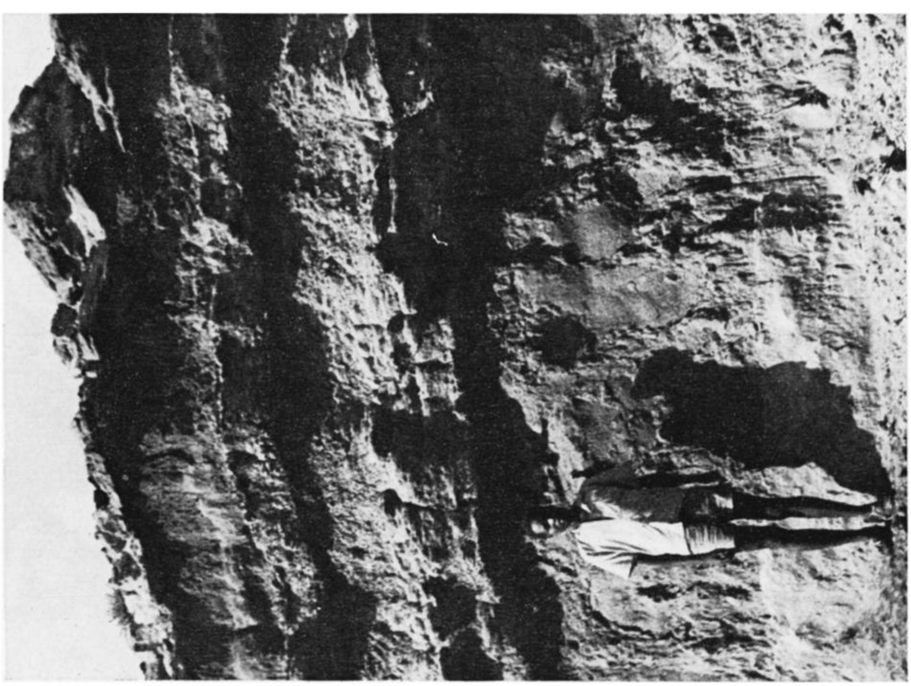
See between pages 112/113 for Plates V–VIII

PLATE V

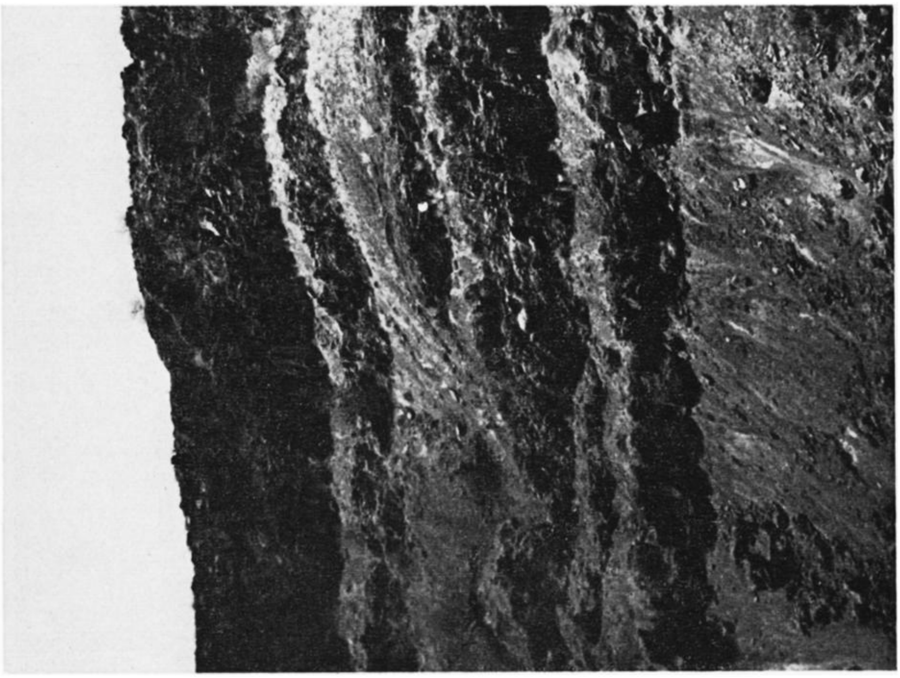
a. The hills on the Loriu Plateau represent a dissected volcanic centre

b. Mugor Valley; the Mugor fault scarp on the left. The light coloured rocks are steeply dipping Precambrian gneisses, capped by the gneisses of the Loriu Plateau

PLATE VI



a. Pre-volcanic sediments north-west of Kaipet Hills



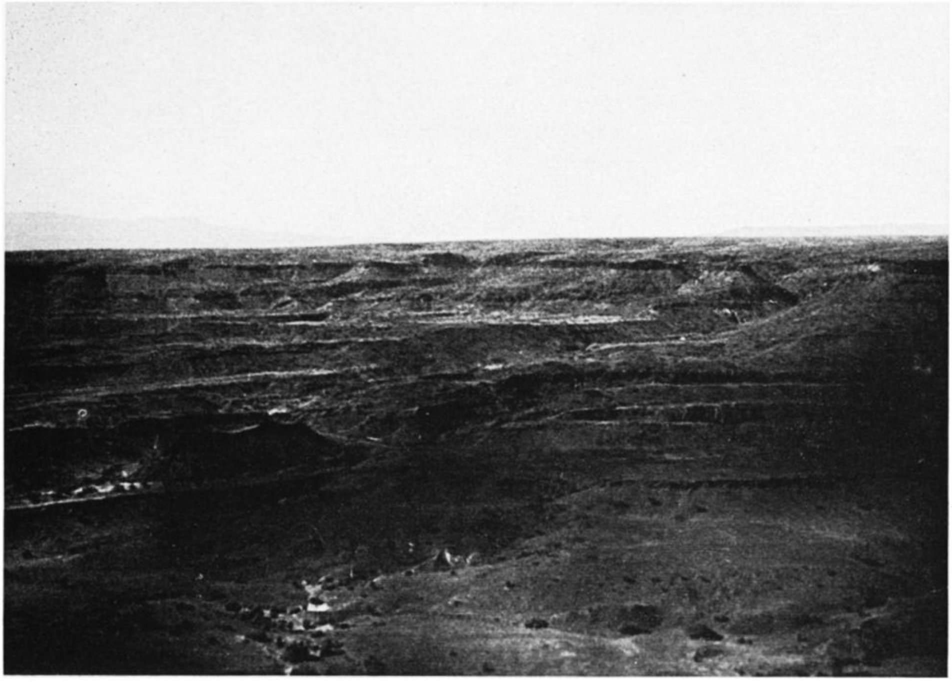
b. Six flows of Napeitom basalts separated by red paleo-soils. The exposures are in a river section 366 m east of Napeitom

PLATE VII

a. A basalt cone within Napeitom basalts; 4·8 km east of Lokori

b. Plugs and dykes marking a central zone of a typical trachyte-tuff volcano, 9·7 km south of Kanatim

PLATE VIII



a. Dissected flank flows of trachytes and tuffs from Nasaken

b. Eroded central zone of Lomelo volcano showing dykes, plugs and the haphazard structures within the pyroclastics