

GEOLOGY OF THE MOLO AREA

DEGREE SHEET 42, N.E. QUARTER

(With coloured geological map)

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MAP

Geological map of the Molo area (Degree sheet 42, N.E.)	at end
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ABSTRACT

The report describes an area of approximately 1,200 square miles in the Rift Valley region west of Nakuru, bounded by the equator and latitude $0^{\circ}30'S$ and longitudes $35^{\circ}30'E$ and $36^{\circ}00'E$. The greater part of the area to the west and south consists of forested highlands and farmland on the western shoulder of the rift, while the north-eastern quadrant includes the Rongai Plain on the floor of the Rift Valley. This area includes much of the highest ground to the west of the rift and can be considered as the centre of the volcanic activity for the region.

The rocks encountered are limited to the Tertiary and Quaternary volcanic suite of central Kenya and are largely pyroclastic in origin. A wide range of lava types have been recognized and described, ranging from melilite and perovskite melanephelinites and basanites, through varieties of basalt, phonolite and trachyte to the quartz trachytes of the Londiani region. Many of the pyroclastic rocks are attributed to an ash-flow origin, and this concept is briefly described.

The structure of the area is largely obscured by late-stage pyroclastic activity and little has been added to present knowledge of Rift Valley tectonics.

GEOLOGY OF THE MOLO AREA

I—INTRODUCTION

During the period February 1962 to July 1962 a geological reconnaissance was carried out in an area to the west of Nakuru, including the western scarp of the Rift Valley, Mount Londiani and the northern Mau. The survey covered some 1,200 square miles bounded by the equator and latitude $0^{\circ}30'S$ and longitudes $35^{\circ}30'E$ and $36^{\circ}00'E$.

The area falls within the Rift Valley Province, with the greater part administered by the District Commissioner, Nakuru. A smaller part in the north-east, belonging to the Baringo District, is administered from Eldama Ravine, and areas in the north-west and south-west are administered from Kericho.

Land Utilization.—The Molo area can be divided into two major parts, the larger, some 56 per cent of the whole, being ranch, plantation and farmland, while the smaller, some 42 per cent, is covered by natural and planted forests. The remaining 2 per cent in the north falls within the Lembus land unit and is grazed by the cattle and goats of the Tugen and Njemps tribesmen.

The extreme north-east of the area, consisting of that part at lowest altitude (below 5,500 ft.) and with lowest rainfall (averaging less than 35 inches per annum) is extensively used for sisal plantations. A factory for extracting the fibre is sited on the Molo River one mile south of Mogotio, and another just outside the area to the north-east.

The Rongai Plain, which extends from Kampi ya Moto in the north (5,500 ft.) to south of the Nakuru—Mau Summit Road (6,500 ft.), and is flanked to the west by the rising land at the foot of the Rift Valley scarp, is utilized mainly for the production of maize, beef and dairy cattle. At a slightly higher altitude (6,500-7,500 ft.) the rolling hills and plains in the Njoro area carry maize and cattle, also wheat, market garden produce and peas.

A belt of highly productive small mixed farms extends along the well-watered lower slopes of the north-east Mau (between 7,500 and 8,500 ft.) from Njoro through Elburgon and Turi to Molo. Mixed farming is also carried out on the plain north of Londiani (7,500-8,000 ft.). On the high ground south of Turi, in the region of Mau Summit and particularly within the large arable enclave in the Mau Forest which occupies the south-west quadrant of the area, cultivation is carried out to altitudes of 9,000 ft. Wheat and pyrethrum, cattle and sheep are the major products.

Small specialist projects have been developed in connexion with, or as part of the local agricultural industry. Peas are canned at Njoro and meat products at Turi, and a butchery at Londiani, transporting by rail, provides regular meat supplies as far away as Nakuru and Kisumu. A large poultry farm at Londiani supplies eggs to the Nakuru and Nairobi markets and crops of strawberries from Njoro and Molo and peaches from Londiani and Kedowa are flown to Europe at certain seasons of the year. Dairy produce is processed by a Kenya Co-operative Creameries factory on the railway at Molo.

Experimental plots and research stations dealing with a variety of crops are maintained by the Agriculture Department. Improved varieties of pyrethrum are developed two miles north-west of Molo, and the problems of the maintenance of high-altitude grasslands are investigated six miles south-west of Molo. Research into strains of wheat resistant to rust diseases is carried out at the Plant Breeding Station, Njoro, and ex-

perimental plots are maintained on the Rongai Plain. Egerton Agricultural College is situated three miles south of Njoro, a forest training school one mile north-east of Londiani and a Mission trade school one mile north of that place.

Communications.—Well-developed road and rail systems serve the area. The main line railway heading north-west from Nairobi divides at a junction west of Nakuru and both branches enter the east of the area. The northern branch, the Uganda line, traverses the plain, supporting a branch line to Solai in the north-east, from Rongai. The main line then passes between Mt. Londiani and Kilombe, looping north of the equator to return to Maji Mazuri. From Makutano the railway climbs rapidly, spiralling twice to attain an altitude of 8,800 ft. before recrossing the equator one-and-a-half miles west of Equator Station. The southern track, the Kisumu line, climbs steadily from Njoro, reaching the top of the Mau slope before Molo. It reaches its maximum altitude in the col between Mount Londiani and the western Mau, a locality consequently known, somewhat misleadingly, as Mau Summit. The railway's tortuous descent south of Londiani indicates the steepness of the terrain near Kedowa and in the valley of the Nyando River. The railway route, heading west at a height of 6,500 ft. crosses the western margin at longitude 35°30'E, some two miles east of Lumbwa.

The main Nairobi-Uganda road, with a tarmacadam surface, traverses the Rongai Plain and ascends the rift scarp north of Molo, and a recently completed tarmacadam road runs from Mau Summit to Kericho on a new alignment by-passing Londiani and Lumbwa. Other stretches of road with tarred surfaces link Molo with the main Nakuru road to the north, and Njoro with Nakuru. A system of secondary roads of earth or tarmacadam radiate from Londiani, Molo and other centres, and minor roads are often maintained to a high standard by private estates, farms, sawmills and the Forest Department. These form a comprehensive network serving the entire area except for some of the steepest hill slopes and densely forested parts. Maintenance notwithstanding, periods of heavy rain, to which the region is subject, are liable to render impassable all but the major roads.

Forests.—The higher slopes are extensively forested with a natural association of cedar, podocarpus, olive and bamboo, and sawmills have been established to exploit timber. The sawmill situated four miles south-west of Njoro specializes in the production of cedar slats, exported for use in the manufacture of pencils, and cedar oil extracted from the sawdust and shavings.

II—PHYSIOGRAPHY

The area can be subdivided into six main areas (Fig. 1) as follows:

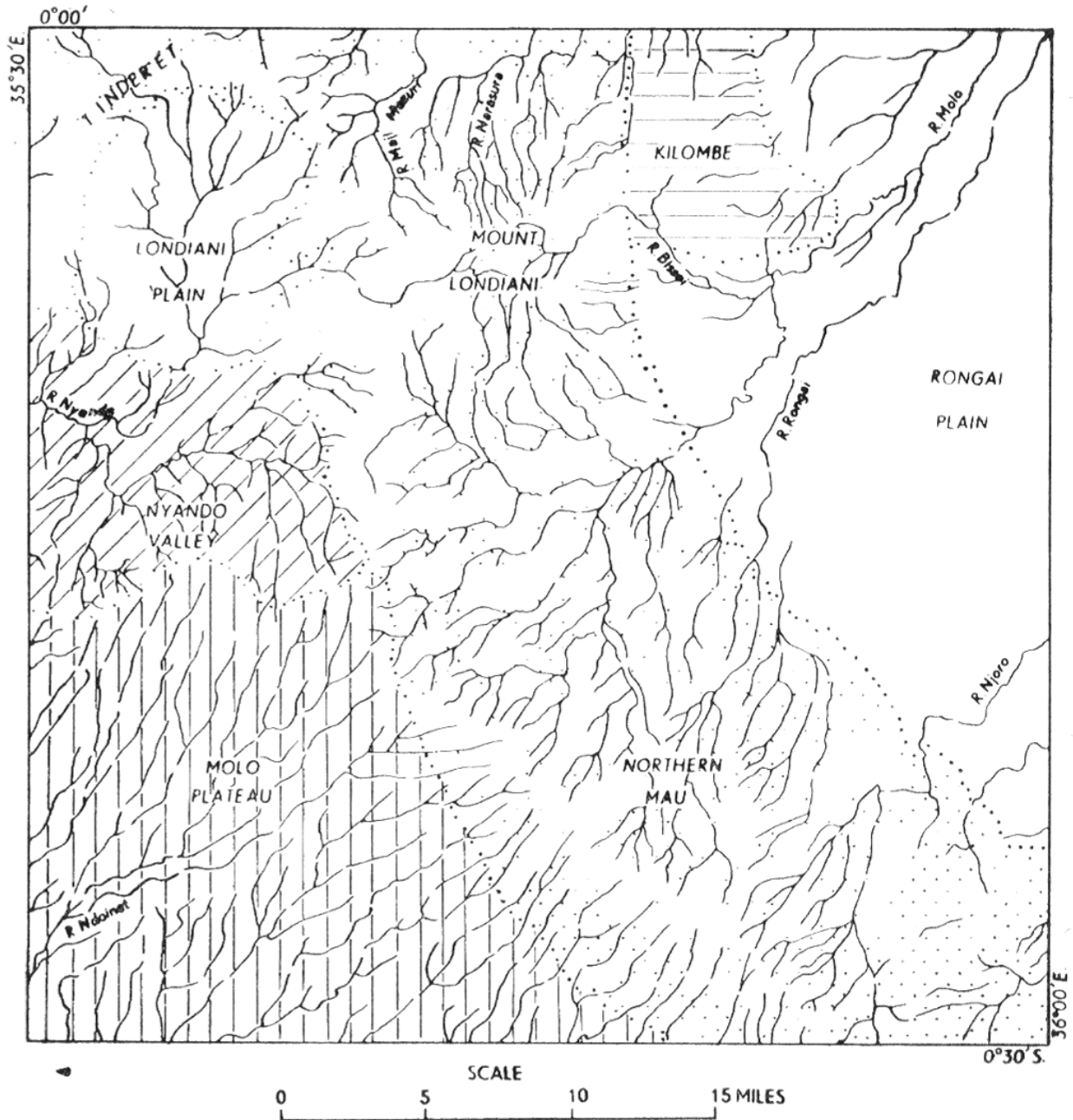


Fig. 1—Physiography of the Molo area

1. The Rongai Plain, sloping gently north-east from 7,000 ft. in the south and 6,500 ft. in the west and occupying some 250 square miles of the Rift Valley floor in the north-east.
2. Kilombe Hill, a young, well-preserved volcano with a crater partly infilled with lake sediments. It rises from the Rongai Plain north-east of Mount Londiani. The hill covers a base area of some 40 square miles at 6,000 ft. rising to about 7,000 ft. at the rim, with local peaks exceeding 7,500 ft.
3. The major topographical axis running north-south through the centre of the area, formed by the forested mountain masses of the Mau to the south and Mount Londiani to the north, with high ground extending to the north-west on to the eastern flank of Tinderet.

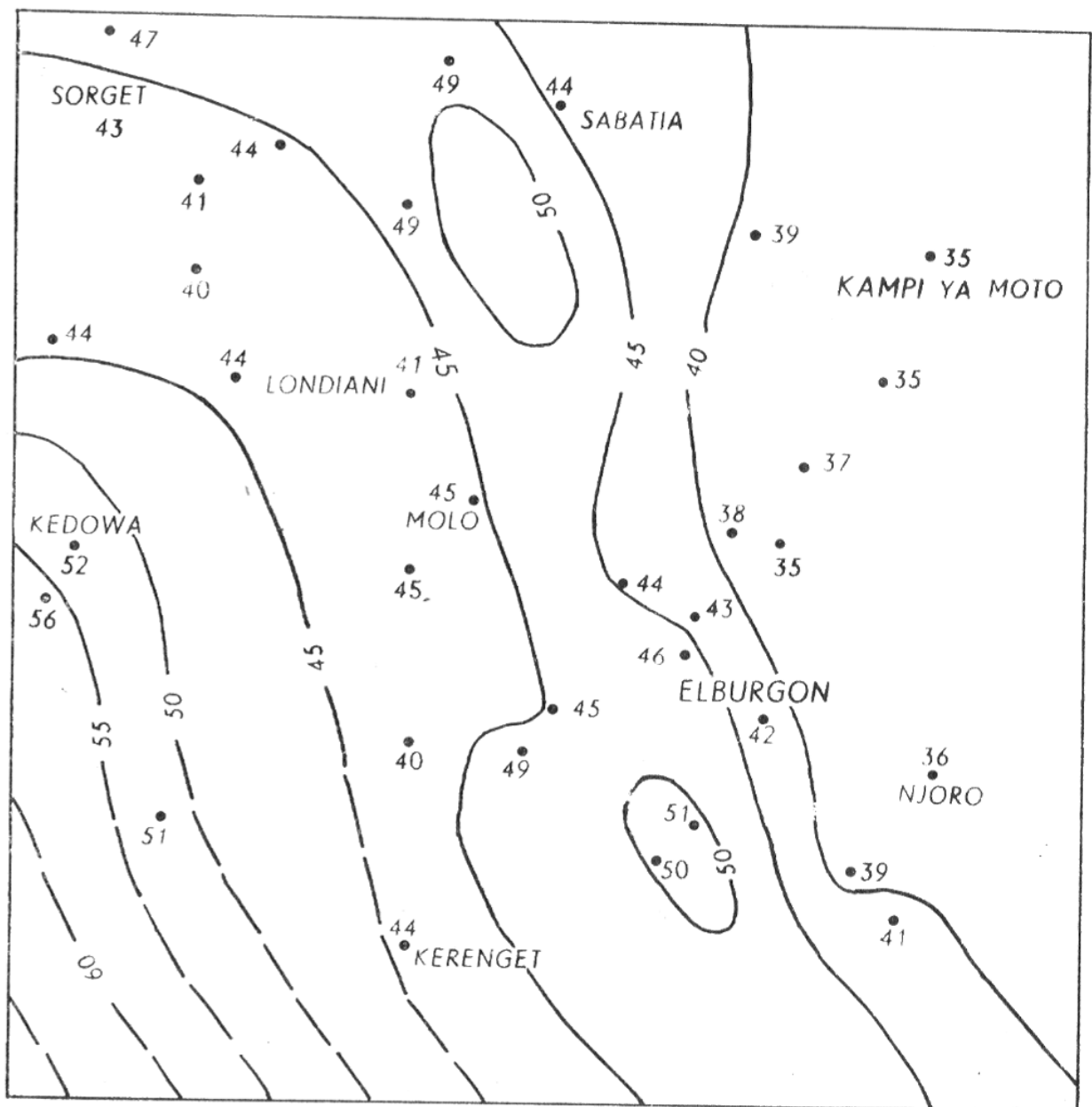
4. The Londiani Plain, which consists of a depression lying between 7,500 ft. and 8,000 ft. flanked to the north and west by spurs of Tinderet, and to the east by Mount Londiani.
5. The Molo Plateau (250 square miles) which occupies most of the south-western quarter of the area and carries an almost complete margin of forest. Rising from 7,600 ft. in the extreme south-west the gradient is uniform and only slightly steeper than the slope of the underlying rocks. The highest parts rise above 9,000 ft. to the north and east.
6. The highly dissected country about Kedowa and to the west which forms part of the Nyando River valley.

Rainfall.—Average rainfall figures extracted from the published records of the Meteorological Department of the East African Community and shown diagrammatically in Fig. 2 indicate a variation from about 35 inches in the east and north-east to above 60 inches in the south-west, with marked increase in precipitation with increase in altitude. The latter factor is well demonstrated by the records of a north-east to south-west line of stations on the slopes of the Mau, east of Elburgon, where an increase in altitude of over 2,200 ft. in nine miles is reflected in an increase in average annual rainfall from 35 inches to 51 inches.

Rainfall is markedly seasonal with precipitation peaks in April-May and July-August and the driest spell in December and January. Rain for the majority of the area is carried on the prevailing north-easterly winds, but the high rainfall experienced in the extreme south-west is largely non-seasonal, and is carried by afternoon thunderstorms from the west and south.

Drainage.—The river courses of the region (Fig. 1) display a crudely radial pattern and contribute to four major lakes in East Africa's vast area of inland drainage. The drainage systems of the northern and eastern slopes of the mountains collect in the Njoro, Rongai, Molo, Bissoi, Narasura and Maji Mazuri rivers, and contribute a major part of the supply to the permanent rivers flowing in the floor of the Rift Valley. The Njoro River, flowing east, drains into the saline Lake Nakuru. The Molo and Rongai rivers, originating on the northern slopes of the Mau, traverse the Rongai Plain. The Bissoi River, draining the north-eastern slope of Mount Londiani, is a major tributary of the Molo River, joining it on the plains south-east of Kilombe, and the Narasura and Maji Mazuri rivers, draining the north and north-west of the mountain, flow north into the floor of the Rift Valley, until they combine in the Perkerra River to flow into Lake Baringo.

The rivers draining southern Tinderet, western Mount Londiani and the north-western Mau contribute to the Nyando River which flows westwards from Kedowa down the Lumbwa Valley and enters the Kavirondo Gulf of Lake Victoria south of Kisumu. The system of nearly parallel consequent streams flowing south-west on the Molo Plateau emerge from the forest to combine with the rivers of the Kericho region, and drain into the Kavirondo Gulf via the Sondu River. Those streams flowing south-west over the southern boundary between $35^{\circ}40'E$ and $35^{\circ}50'E$ contribute to the Mara River which drains into Lake Victoria south of the Kenya-Tanzania border. Those few streams draining south-east from the peak of the Mau, crossing the southern boundary east of longitude $35^{\circ}50'E$, form the headwaters of the Narok and Uaso Ngiro rivers, draining via the latter southwards into Lake Natron.



Average annual rainfall in inches — Isohyets at 5 inch intervals

Fig. 2—Average annual rainfall in the Molo area

III—PREVIOUS GEOLOGICAL WORK

The atlas published by the Survey of Kenya (1959, p. 34*) suggests the earliest travelers to enter the area were Capt. Frederick Lugard (later Lord Lugard), heading for Kabarnet from Lake Nakuru, who passed near Kampi ya Moto in 1889, and F. J. Jackson who in the same year pioneered a route between Nakuru and Sotik which passed near Njoro. In 1891 Joseph Martin found a direct route on to the Mau at about this latitude and in 1891-2 Capt. J. R. L. MacDonald made a preliminary survey of the route for a railway to Uganda. Sir George Whitehouse was responsible for a more comprehensive route-survey for the Uganda Railway in 1898.

The first explorer to show a specifically geological interest in the Rift Valley of Kenya was J. W. Gregory (1894, p. 306) whose expedition of 1892-3 reached the eastern margin of the area when travelling from Lake Nakuru to Lake Baringo. He observed the relatively gentle slope of the rift wall on the western side opposite Nakuru, attributing this to the structure of the valley thereabouts, which he visualized as derived from a faulted syncline, with walls formed by dip slopes interrupted by numerous cliffs originating from a series of parallel faults.

E. E. Walker (1903, p. 6) a Government geologist, carried out a number of country-wide traverses in 1902 and 1903 to assess the economic mineral potential of Kenya. In the course of his travels he climbed Kilombe. He referred to the volcano as Eldalat, describing it as a good example of a volcanic cone, dissected by a stream which has cut a ravine in the eastern flank.

G. T. Prior published a report (1903, pp. 239 and 250) on the petrology of various rock specimens collected by Gregory and officers of the Uganda Survey. From among the latter Prior described a phonolitic-nephelinite with aegirine-augite and sphene from the lower Kedowa River, and melilite and perovskite-bearing nephelinites from the lower Kedowa and Nyando rivers.

In 1905-6 H. B. Maufe of the British Geological Survey traversed the country along the length of the newly constructed railway from Mombasa to Kisumu and in his report (Maufe, 1908, pp. 45-48) described those parts east and west of Mau Summit as the "western flank of the rift" and the "Nandi Slope" respectively. He noted the great thicknesses of red derived volcanic soils on the east-facing slopes and commented on the presence of a massive flow of streaky rhyolite south-west of Molo "which contains so many inclusions it resembles an agglomerate." This is shown on the map accompanying this report as a eutaxitic welded tuff of tuff-flow origin. To the west of Mau Summit the railway descends rapidly over a succession of rocks which dip less steeply to the west. Maufe distinguished two lava types between Mau Summit and Londiani, referring to the first as a basic phonolite and younger varieties as quartz-bearing trachytes. Between Kedowa and Lumbwa, Maufe collected a suite of rocks including trachyte, phonolite, limburgite, nephelinite, agglomerates and tuff.

Gregory revisited Kenya in 1919, and was again impressed by the gentle slope of the western Rift Valley wall at this latitude. He suggested as a contributory cause the readily weathered soft volcanic tuffs composing the slope (Gregory, 1920, p. 22). In his later volume on East African geology Gregory (1921, pp. 120-129) made several observations on the Molo-Londiani district. He related the pyroclastic rocks banked against the western scarp wall to an origin at the Menengai Caldera and commented on the probable faulted origin of the steep hill slope between the Molo and Bissoi rivers. Gregory also noted a succession of lavas with intercalated tuffs as he ascended the Nyando River valley from the west to Mau Summit. The basal member is a phonolite; intermediate flows are of nephelinite and phonolitic nephelinite and the uppermost

* References are quoted on p. 38.

flows have the composition of phonolitic trachyte. He suggested that the phonolitic trachytes are mid-Pliocene in age, and were succeeded in the late Pliocene by the upper Tinderet volcanic rocks. He visualized the easterly extension of the Kavirondo Rift faulting succeeding most of the volcanic activity, but preceding the extrusion of the upper Tinderet and Lumbwa rocks.

Bailey Willis (1936, pp. 64, 265, 270) in his study of East African Rift Valley structures also stressed the unusual nature of the rift wall in this region, and insisted that no true escarpment exists, but that structurally the rift wall is a monoclinical flexure, its form being partly masked by subsequent volcanic activity.

E. C. Bullard in 1933-34 carried out a series of gravity measurements to elucidate the structure at depth beneath Rift Valleys and provide evidence of their mode of formation (Bullard, 1936, pp. 509-518).

In 1952-3 G. J. H. McCall, then a geologist of the Hydrological Section of the Ministry of Works, mapped the Nakuru area as part of a detailed investigation into groundwater conditions in the northern part of the farming area within the Rift Valley. The report (McCall, 1957B) includes the Rongai, Njoro and Kampi ya Moto parts of the present area. One of McCall's main geological interests is the Menengai Caldera, situated north of Nakuru, with which he dealt in a paper presented to the International Geological Congress in 1956 (McCall, 1957A). In both publications McCall's observations, like the Menengai ash, extend far to the west. The same geologist also wrote a brief account of Kilombe Caldera (McCall, 1964).

Archaeological interest has persisted in the area for several decades and reached its height with the investigation of the caves at the junction of the Njoro and Little Shuru Rivers, three miles south-west of Njoro, by Dr. and Mrs. L. S. B. Leakey in 1938. References to this work are abundant in archaeological literature (e.g. Leakey, 1950). More recently several similar caves have been investigated in the upper reaches of the Ndoinet River in the centre of the Molo Plateau.

After joining the Mines and Geological Department McCall extended his mapping of the Nakuru area to include the quarter-degree sheets immediately to the east and north-east of the present area (McCall, 1967). J. Walsh mapped the Eldama Ravine area to the north in 1959-60 (Walsh, 1969) and to the south L. A. J. Williams (report in preparation) mapped the southern Mau in 1962. The Kericho area to the west was mapped by F. W. Binge in 1949 and the report published in 1962.

IV—SUMMARY OF GEOLOGY

The entire area is covered by volcanic rocks, ranging in age from Tertiary to Recent, and lacustrine and fluvial sediments derived directly from them. The bulk of the rocks form an interleaved succession of pyroclastics, apparently derived from several different sources, which cover an extraordinary range of variation in colour, texture, fragment size and degree of welding. Lava flows are less common but as they normally possess greater resistance to erosion they outcrop more persistently where they occur. Broad tracts of thickly forested country and a copious soil cover derived from the weathering of a mantle of recent ash combine to obscure outcrops of bedrock. Some difficulty was thus experienced in relating different parts of the succession isolated by these natural barriers.

In two small areas the exposure is exceptionally good; in the west in the region of Kedowa and the Nyando Valley and in the centre, where the main road climbs the Mau scarp west of Rongai. In both cases rugged terrain combined with a complex stratigraphical sequence of small units of contrasting rock types renders mapping on a reconnaissance scale difficult and generalizations have been inevitable.

Apart from a few boulders of syenite on the flanks of Kilombe Volcano all rocks are extrusive lava flows, ash-flows or ash-fall pyroclastics and sediments derived from them.

Phonolites.—The lowest member of the succession of the Molo Plateau is a distinctive biotite phonolite which outcrops extensively in the south-west and in the scarp south-east of Kedowa. It is correlated with the Kericho phonolite which outcrops farther west. Younger phonolites occur as small widely dispersed flows at different heights in the succession and phonolitic plugs were recognized at Mount Blackett and in the Nyando Valley.

Basalts.—Olivine basalts are locally intercalated in the older phonolites, and also occur near Maji Mazuri and west of Londiani. Alkali basalts occur locally on the Molo Plateau.

Trachytes and quartz trachytes.—Trachytic lavas, locally carrying small amounts of free quartz, form the lower slopes of Mount Londiani and extend from west of Londiani township to the northern boundary of the map between Maji Mazuri and Kilombe.

Tuffs, agglomerates and sediments.—Much of the Mau and Mount Londiani are composed of variable pyroclastic rocks among which many can be recognized as derived by an ash-flow rather than an ash-fall mechanism. Many of these rocks are welded and contain glassy discoidal compressed pumice fragments and numerous erratic particles of lava. Outcrops extend from Maji Mazuri and Tinderet to Kedowa, Molo and the southern boundary of the area. Overlying the ash-flow tuffs and forming much of Tinderet and the Mau are yellow bleached agglomerates, lapilli tuffs and intercalated sediments. Renewal of pyroclastic deposition occurred in the Pleistocene, and such rocks cover the Rongai Plain and much of the Mau, Londiani and Tinderet.

Little can be added to general knowledge of the age and mechanics of Rift Valley formation from evidence in the area since much of the late stage extrusion and pyroclastic activity post-dates the faulting, obliterating the structure with lava flows and a blanket of ash.

The area proved to contain no rocks older than Tertiary, and apart from horizons of building stone and pozzuolanic material little of economic value was found.

V—DETAILS OF GEOLOGY

The rocks of the area range in age from Miocene to Recent. The phonolites of the Molo Plateau are correlated with the Kericho phonolites further west, which overlie directly the basal Tinderet agglomerates and tuffs associated with the Koru sediments of proven Miocene age (Binge, 1962).

Petrologically the rocks of the area range from Tertiary lavas of extreme basic composition to quartz trachytes. The outcrops of undersaturated rocks are concentrated in the west, particularly about the Nyando Valley, and are apparently associated with a source at Tinderet. The basanites, and melilite and perovskite melanephelinite members are comparable with those found in the Mtetei Valley and about Nabkoi and Lessos on the north-western flank of Tinderet (Jennings, 1964).

Trachytes were extruded from Mount Londiani and Kilombe, but it is only the extensive flows to the west from the former source which contain free quartz, particularly the outcrops about Londiani.

The succession of lava types on the western shoulder of the rift in this area appears to be:—

Pleistocene	Basalts and basanites	West of Mt. Londiani
Pliocene	{ Trachytes and quartz trachytes Basalt Phonolites Basic nephelinites Phonolitic nephelinites	Mt. Londiani and Kilombe Maji Mazuri Nyando Valley, Sorget, etc. Nyando Valley Molo Plateau; scarp S.E. of Kedowa; Nyando Valley.
Miocene	Phonolites	Molo Plateau; scarp S.E. of Kedowa.

1. Tertiary

(1) KERICHO PHONOLITES

The phonolite lava flows outcropping extensively in the extreme south-west are apparently the oldest rocks of the area, and are correlated with the Kericho phonolites to the west (Binge, 1962, p. 25). They constitute the basal member of the sequence forming the Molo Plateau, and their upper surface slopes in a generally south-westerly direction at some 60 feet per mile. Since this is only slightly shallower than the gradient of the river beds the outcrops appear as elongated strips fingering up the valleys. The height of the upper surface of these flows rises from 8,000 ft. in the south-west to above 8,600 ft. three miles north-west of Keringet Office, and nearly that height four miles west-south-west of Simba Swamp. A thickness of 500-600 feet of phonolite is exposed in the scarp two miles south of Kedowa.

The phonolite is a fissile porphyritic lava with a fine grained groundmass. Typically it forms rounded billows in valley floors, and rapids and platforms in stream beds. A thick weathered zone caps the unaltered rock and cattle tracks and erosion gullies in this horizon produce extensive quarry-like scars in the hillsides, displaying pale grey to off-white clayey rock-rubble and grit, and lag deposit of sub-spherical boulders from six inches to two feet in diameter. These represent the ultimate cores of large exfoliated blocks derived by the shedding of numerous layers in the course of spheroidal weathering. In some exposures every stage in derivation is demonstrated, from large flat surfaces of altered rock, patterned with concentric fractures about an unaltered core to isolated spherical boulders of unaltered phonolite balanced on plinths of rotten rock. Exposures of uniformly well-weathered phonolite can be recognized by occasional feldspar and biotite crystals, and small cubic holes after nepheline, preserved in an off-white clayey matrix.

Specimens of phonolite were collected from the river bed one-and-a-half miles south of Keringet Office (42/988)*; the Songon River, nine miles south of Ndoinet and the river bed three-and-a-half miles north-east of there (42/951, 42/928) and the lower part of the scarp two miles south of Kedowa (42/851). In each case the rock, with flinty or hackly fracture, has a fine-grained groundmass with feldspar, nepheline and biotite phenocrysts. Subhedral, simply twinned feldspar plates attain lengths of between 3 and 10mm.; euhedral and subhedral nepheline crystals form clusters with diameters between 3 and 6mm.; biotite flakes are 1-3mm. in length.

In thin section the biotite is pleochroic from deep foxey-red to pale straw-yellow. Rounded resorbed microphenocrysts of aegirine-augite, sometimes with a deeper green fringe of aegirine also occur, while 2mm. grains of black iron ore are rare. The groundmass is invariably a very fine-grained feldspathic lattice with the soda-amphiboles cossyrite and kataphorite.

* Numbers 42/988, etc., refer to specimens in the regional collection of the Mines and Geological Department, Nairobi.

(2) BASALTS INTERCALATED IN KERICHO PHONOLITES

Basalts outcrop in the stream bed four and six miles south-south-east of Ndoinet. The rock of the northerly exposure (42/952) is a fine-grained black lava with 2mm. diameter vesicles and occasional microphenocrysts. Small crystals of multiple-twinned basic labradorite (An_{58}) are accompanied by subhedral augite and olivine phenocrysts attaining lengths of 1mm., in an indeterminable chloritic base peppered with black iron ore. Vugs are largely chlorite-filled.

The fine grained, hackly, black basalt from two miles farther south (42/953) contains plagioclase and olivine microphenocrysts (the latter largely altered to serpentine) in a groundmass of plagioclase laths and grains of pyroxene and black iron ore.

A compact basic lava (specimen 42/983) exposed by faulting in the river four miles south-east of Five Mile Post is of limited outcrop, and consists of a shelf on which the river course is only lightly etched. The fault-line defines the edge of the shelf, and the notch eroded at the waterfall is negligible. Olivine phenocrysts 3mm. in length are partly altered to chlorite and serpentine minerals, and are contained in a fine-grained base of pyroxene grains, larger euhedral black iron ore crystals and small pools of zeolitic mosaic in a base of interstitial felspar.

(3) PHONOLITIC NEPHELINITES

These lavas outcrop extensively in the Nyando River valley at altitudes below 7,200 ft. and on the west of the Molo Plateau between 7,300 ft. and 8,500 ft. It is suggested that the height discrepancy results from north-east to south-west faulting along the foot of the scarp east of the Kericho road. It is apparent from outcrops mapped and petrological descriptions that the lavas of the Nyando Valley extend to the west into the Kericho area, where they were mapped as phonolitic nephelinites overlying a great thickness of biotite-bearing phonolite (Binge 1962, p. 32).

Cooling-fractures in the phonolitic nephelinite flows are widely spaced, so the boulders derived by spheroidal weathering are large and rounded. Within the outcrop of these lavas cliff or crag features are rare; more usually steep slopes are paved with giant cobbles, and rounded hills carry a float of oblately spheroidal boulders, often several feet in diameter. Auto-breccias are locally present near the base of the flows.

Lavas of this group show wide variation, mainly in type and proportion of phenocrysts, and examples with a selection of well-formed crystals make an interesting petrological study. A typical member appears in hand specimen as a greenish grey rock with a fine-grained groundmass carrying numerous large clusters of euhedral nepheline crystals, individually reaching 3mm. across, occasional felspar prisms and micro-laths of pyroxene. Phenocryst content is extraordinarily variable. Sometimes the nephelines are close-packed to the exclusion of other varieties; in others large conspicuous felspars approach nepheline in amount, while pyroxene prisms are best developed in varieties almost devoid of leucocratic phenocrysts.

Numerous specimens of these lavas were collected, including examples from the Nyando River valley on the western boundary, half a mile south of the road-rail crossing (42/828); from the hills one-and-a-half miles and three miles south-west of Mount Blackett, and the valley three miles south-south-west (42/832; 42/845; 42/865); high on the scarp two miles south of Kedowa (42/850); and on the Molo Plateau three miles south of Kerisoi Forest Station (42/935).

Felspar appears to be absent from some lavas (42/935) and occurs only in the groundmass of others (42/832). In some (42/865 and 42/845) felspar phenocrysts occur in an indeterminable, near-isotropic base, while in others well developed felspar occurs both as phenocrysts and in the groundmass (42/828). Felspar phenocrysts, often slightly

rounded, are usually simply twinned, occasionally vaguely cross-hatched, and in one example showed incipient multiple twinning. Biaxial negative figures with moderate or small optic-axial angles suggest anorthoclase.

The pyroxene is usually highly zoned aegirine-augite in euhedral or subhedral prisms 2-3mm. long, with outer fringes of aegirine. Rarely the pyroxene is augite, zoned with neutral cores, and outer margins weakly pleochroic in pale shades of brown and greenish brown (42/832). Sometimes aegirine-augite carries a pinkish augitic border (42/850). Aegirine-augite, boldly pleochroic in shades of green, is often partly resorbed and the zoning, parallel to the terminal pyramid faces, produces a bold chevron pattern across the entire crystal.

Occasional sphene euhedra, often exceeding 0.5mm. in length, occur in all rocks, often associated with small well-formed or skeletal black iron ore grains, which also occur separately.

(4) NEPHELINITES AND MELANEPHELINITES OF NYANDO VALLEY

Lava flows of unusual composition and limited distribution occur near or at the top of the phonolitic nephelinite sequence in the Nyando Valley, on the flanks of a prominent hill one mile north-east of the road-rail crossing on the western boundary.

The rock capping the western spur of the hill (42/822) is a black glassy lava dotted with waxy microphenocrysts, and cut by a reticulate pattern of reddish fractures. Microscopic examination showed the isotropic glassy base to be locally devitrified, and to contain abundant well-preserved prisms of melilite up to 0.5mm. in length and small nepheline euhedra forming clusters up to 1mm. in diameter. Perovskite euhedra with diameters of 0.25mm. are present and occasionally attain a diameter of 1mm. Rare small aegirine-augite prisms occur, preserved within crystals of melilite.

Specimens of lava from west (42/823), north-west and north-east (42/825) of the hill are all characterized by partly glassy, partly altered turbid indeterminate bases. Nepheline phenocrysts are abundant singly or in clusters, and the groundmass is locally crammed with small nepheline euhedra. Melilite is poorly preserved but lath-like pseudomorphs attain a length of 1mm. in specimen 42/825. Aegirine-augite grains, peppered with included nepheline, exceed 0.5mm. in length and include also small perovskite euhedra, which are also common in the groundmass of 42/823. Large perovskite crystals are rare, usually occurring singly, or occasionally associated with large skeletal crystals of black iron ore, 4mm. in diameter, and prisms of apatite.

The rocks capping hills one mile north-east and one mile south-east of the road-rail crossing on the western boundary are more basic lavas. The flows are limited in extent and their outcrops are significantly aligned along a possible north-south fault zone.

The heavy hackly black rock from the Nyando Valley south of the road (specimen 42/820) carries abundant 2mm. olivine phenocrysts. Occurring singly or in clusters, they are traversed by tracts of opaque olive-green serpentine minerals developed along bold fractures. Single, zoned, buff-coloured augite euhedra attain lengths of 1.5mm., and augite also occurs in groups of smaller elongate prisms forming roughly radial clusters, associated with black iron ore. Investigation of the fine-grained groundmass reveals a predominance of granular pyroxene, subordinate black iron ore, occasional interstitial pools of analcime and rare subhedral grains of nepheline, but no recognizable feldspar. The rock is thus classified as an extremely basic melanephelinite. A xenolithic patch of coarse-grained quartz-feldspar rock shows a distinct reaction rim with the rock matrix.

The abundant olivine and zoned augite phenocrysts in a fine-grained blue-black lava from the hilltop north of the Lumbwa road, specimen 42/824, display similar size and habit. The rock base is more leucocratic than the previous example; pools of zeolite, largely analcime, are larger and more common and the included grains of pyroxene

and black iron ore are smaller. Search revealed no indubitable nepheline, but a few micro-laths, apparently of plagioclase feldspar. The rock is closely related to the previous basic melanephelinite, but shows in the presence of plagioclase and lack of nepheline an affinity with analcime basanites.

Exposures in the streambed and as rocky knolls in the valley floor one-and-a-quarter miles north of Kedowa were interpreted as a dyke (the more northerly exposure) and small intrusive bodies in the country rock of tuff and ash. The age of the bleached tuffs and agglomerates into which these are intruded cannot be clearly demonstrated, but these minor intrusions are probably younger than the lava flows just described.

The dyke, a fine-grained black rock in which only nepheline phenocrysts could be recognized in hand specimen 42/807, was found to carry highly altered lath-like patches in the groundmass which could equally represent altered feldspar or altered melilite. The nepheline phenocrysts, often euhedral but occasionally largely resorbed, occur with perforated laths of aegirine-augite, in a base largely of analcime, with aegirine-augite, black iron ore and granules of perovskite, the latter indicating a suitable environment for original melilite.

The rock of the knolls (42/810) is composed of more normal phonolitic nephelinite with phenocrysts of nepheline, anorthoclase, sphene and zoned augite, all showing resorption or reaction to varying degrees, in a background of occasional flakes of cosyrite, laths of feldspar and aegirine-augite with a finely crystalline, probably feldspathic base.

(5) TUFFS OF THE MAU AND MOUNT LONDIANI

The bulk of the Tertiary tuffs in the Molo area are demonstrably of ash-flow origin, as contrasted to tuffs of ash-fall (airborne) origin. Ash-flow tuffs are rocks which result from the consolidation of high-temperature mixtures of pyroclastic material and gas, ejected explosively from a crater or from a fissure, which have travelled rapidly down the crater slopes or along the ground. Ash-fall tuffs result from the compaction of pyroclastic material which has fallen to the ground from airborne clouds.

Ash-flow tuffs move in much the same way as molten lavas, following existing valleys and flowing round obstacles. They are typically tens of feet thick, unsorted and unbedded, showing varying degrees of compaction and welding by their own heat, and often showing columnar jointing developed by shrinking on cooling. Ash-fall tuffs, in contrast, mantle the ground irrespective of topography, and frequently show marked stratification due to sorting of the components into size units.

A characteristic of ash-flow tuffs is their eutaxitic texture, resulting from the flattening of component fragments with their long axes lying parallel in a horizontal plane, which appear as streaks and lenses in the solidified rock. With increase in the degree of compaction pumice fragments show stages from almost equidimensional vesicular lapilli to completely flattened streaky glass. Eutaxitic welded tuffs commonly form satisfactory building stones, and throughout the area their outcrops are marked by lines of quarries.

Crystal inclusions, particularly prismatic and platy fragments of sanidine and sanidine-anorthoclase, are common in all the tuffs of the Mo'o area, but only when the crystal inclusions occur abundantly are the rocks referred to as crystal tuffs.

Devitrification and microcrystallization within glass fragments occurs both in compressed pumice lapilli and in the groundmass. In the pumice lapilli sheafs of microlites are sometimes disposed in crude spherular aggregates, but more commonly are arranged parallel or sub-parallel to the boundaries of the lensoid compressed pumice fragments.

(a) *Tuffs of the south-west*

The oldest tuffs exposed in the Molo area are found in valley sides at two locations in the south-west, the first four miles north-west of Ndoinet and the other three miles north of Ndoinet. In each place they directly underlie the phonolitic nephelinite already described.

The exposure north-west of Ndoinet shows 30 to 40 feet of brilliantly coloured mottled clays derived from the weathering of tuffs and agglomerates, with occasional fragments of relatively unaltered pyroclastic material. At the second locality north of Ndoinet the tuff appears to be much less deeply weathered, but exposures there are few and small.

(b) *Pink fine-grained eutaxitic tuffs*

The relationship between these tuffs (Tvf₂ on map) and the pale grey eutaxitic crystal tuffs (Tvf₃) is not clear. At a quarry exposure four miles south-east of Kedowa Tvf₂ overlies Tvf₂, whereas a mile to the north-west the situation is reversed. Three miles south of Mount Blackett Tvf₂ directly overlies phonolitic nephelinite, and is separated from the higher Tvf₃ by 200 feet of agglomerate identical to Tvf₄, described later. It appears likely that Tvf₂ and Tvf₃ (and possibly also Tvf₄) are in fact different zones of the same ash-flow unit. Comparison of the altitudes of the different units in different parts of the area proves of no value in determining stratigraphic relationships as it is clear that the tuffs were extruded over an already irregular topography which was greatly modified by faulting subsequent to tuff deposition.

A typical specimen of pink, fine-grained eutaxitic tuff, 42/932 from the Molo Plateau four miles south-east of Kerisoi, is a lightly welded, sparsely feldspathic tuff with an orange pink base and thin eutaxitic fragments of mottled purple and white colour. Three miles farther south-east from Kerisoi (42/931) the dull pink base is crammed with grey tassellated lenses up to 5cm. by 2cm. with occasional elongated central cavities. In this section the devitrification of compressed fragments has not wholly obscured relic pumice structure, and the original pore spaces are now seen as thin dark streaks across the aggregates of microlites, parallel to the elongation of the fragments.

In specimen 42/806 from the same tuff north of Kedowa a few fragments of feldspar are present in the slide, and many of the grey pumice fragments display limited compression with hollow cores partly filled with yellow alteration products.

(c) *Pale grey eutaxitic crystal tuffs*

Specimens of these rocks were collected from one mile south of Limutet (specimen 42/874), two miles south-west of Londiani (42/861), four miles south of Mount Blackett (42/737), the forest road two-and-a-half miles south-east of Kedowa (42/839) and the quarry one mile east of Kedowa (42/878). The rocks are generally pale grey to off-white in colour with elongated eutaxitic fragments commonly between 2cm. and 3cm. in length. Such inclusions are not conspicuous, being very similar in texture and colour to the matrix, as are most of the rare included lava fragments. The eutaxitic lenses can be seen to bifurcate and display tassellated ends, and occasionally to wrap around included crystal and lava fragments. Broken surfaces vary in texture from porcellanous to hackly. In specimens 42/737 and 42/839 external moulds of twigs and leaves are common.

In thin section occasional included lava pellets, 2mm. across, of trachyte or phonolite and blocks of streaky glass are seen to accompany abundant partly resorbed sanidine crystals, often simply twinned. Compressed pumice lenses attain lengths of 10mm. The thinner lenses are entirely of brownish glass, preserving faint traces of the original pumice pores as dark streaks parallel to the elongation, and under crossed nicols partial devitrification is seen, with microlites arranged in crudely spherular patterns. Thicker lenses display a broad margin of devitrified glass and have hollow

centres. Such hollow centres are often infilled with vapour-phase minerals growing radially inwards from the cavity walls. Minerals recognized in such cavities are aegirine and feldspar.

The less well compacted varieties, such as 42/878, show a lesser degree of compaction of included fragments set in a powdery base with only a few feldspar relics. These varieties make good building stones and small quarries follow several miles of the outcrop in the Kedowa area.

(6) TERTIARY PYROCLASTIC ROCKS OF THE UPPER MAU

Rocks overlying the biotite phonolites and crystal tuffs of the western Molo Plateau forming the high ground of the Kerisoi-Five Mile Post ridge and the forested highlands of the Upper Mau, are almost exclusively pyroclastic in origin. Predominating in the lower part of the sequence highly compressed, welded eutaxitic ash-flow tuffs are commonly exposed on the Molo Plateau and south of Keringet, while scant exposures on the higher ground and in the eastern Mau Forest suggest that uncompressed tuffs and agglomerates form the majority of the upper part of the sequence. Poor exposure over much of the area in the south is caused by a thick mantle of soil derived from a sporadic cover of recent ashes.

The rock succession is composed of highly varied units, with lateral and vertical variation too rapid to obtain a precise stratigraphical sequence from the disproportionately poor exposure available. Rocks overlying, underlying and probably intercalated with the eutaxitic welded tuffs to the west of the eastern Mau Forest are commonly bleached fragmental rocks of agglomerate-grade with equidimensional hollow pumice fragments and smaller angular chips of lava and black glass dispersed or concentrated in an ash-grade matrix. A few exposures display well-defined bedding and can be referred to an ash-fall origin, but the majority are of unbedded inhomogeneous material probably representing uncompressed, poorly welded, ash-flow tuff.

Descending the slope into the Rift Valley, within the eastern Mau Forest towards the south of the area, the highest exposure located is of well-bedded ashes, material of relatively recent origin from a source in the Rift Valley, possibly Menengai. Elsewhere the highest exposure is of coarse-grained bleached agglomerate, comparable to that immediately underlying the ashes to the west. Underlying this, high in the scarp, is a substantial band of pale eutaxitic welded-tuff, similar, but not identical to those to the west of the forest already described. The persistent exposure of this tuff in the upper part of the scarp, followed by a considerable steep descent without rock exposure, suggests that the scarp slope is a significant fault zone, with the inference that the welded tuff forming the bold feature at the top was emplaced before final faulting occurred. Eutaxitic welded tuffs also outcrop at the foot of the slope, but evidence for correlation with the members high in the scarp is tenuous.

The porous black ash which occurs widely at the foot of the scarp in the south outcrops over a wide area in the country about Elburgon, where it is seen persistently in streambeds to heights up to 8,800 ft. in otherwise poorly exposed country. The topography of the countryside about Elburgon is of a gently billowing forested slope rising some 2,000 feet in 10 miles, from the margin of the Rongai Plain to the Upper Mau. This slope replaces the more precise scarp which bounds the Rift Valley farther north, and on its eastern margin at this latitude.

In the lower part of the valley of the Molo River, where it descends the Rift Valley wall in the centre of the area, both eutaxitic welded tuff and porous black ash are well displayed. Here the black ash floors the river bed, and the eutaxitic member forms bold features in the valley walls. Both apparently dip in a generally north-easterly direction at some 10° .

(a) *Grey and bleached agglomerates, tuffs and sediments*

Bleached yellow, buff and pale grey agglomerates, Tvf₄ on the map, appear to compose the majority of the Mau succession. Usually soft and readily eroded, they do not normally form conspicuous exposures. In the upper part of the succession ash-fall rocks are more common, distinguished by narrow banding of contrasting types, but ash-flow types also occur. Extensive pyroclastic deposition, and removal, reworking and redeposition by water, occurred contemporaneously. Outcrops of lake deposits were recognized, and exposures of pebble beds and cross-bedded tuffs provide evidence of sedimentary origin.

The agglomerates consist of a fine-grained ashy base with included rock fragments and generally uncompressed pumice, varying in size and proportion, close-packed or dispersed. They occur first in the succession beneath the lowest ash-flow tuff and persistently recur. Their origin is doubtful, but certainly many sources were involved. The majority were probably derived from the Mau and Mount Londiani, but those in the north-west were from Tinderet, and those immediately underlying the latest ashes came from the Rift Valley.

In the Kedowa district bleached agglomerates occur (i)—underlying and intercalated with pale crystal ash-flow tuffs (Tvf₃); (ii)—south of the Nyando Valley, apparently overlying both basalts and phonolites, and (iii)—in the Kedowa River valley where pale agglomerates probably form a valley-fill deposit, partly sedimentary.

(a) The south-facing scarp of the Kedowa Plateau (capped by phonolitic trachyte) two-and-a-half miles north-west of Kedowa is composed of variable, friable, bleached, off-white agglomerates and tuffs, with yellow and rusty included fragments. Ill-defined banding locally suggests an ash-fall origin. Rocks exposed in the Kedowa-Londiani road one-and-a-half miles north-east of Kedowa contain pumice bombs over 30cm. in diameter in a powder-grey base, packed with striated pumice fragments varying from 1cm. to 15cm. in length. Railway cuttings to the east display further rocks of this group, of contrasting appearance, including a 20-foot columnar-jointed band, with compact yellow base and 4cm. widely-spaced yellow and grey pumice fragments. Beneath these are exposures of grey lapilli tuff with 1cm. to 2cm. yellow and white dispersed fragments traversed by broad undulating bands of yellow tuff.

(b) A series of minor cliff features are visible on either side of the Kericho road between two and four miles south-west of Kedowa. These are composed of coarse agglomerate, locally quarried as a poor-quality building stone. West of the road the outcrop dips gently 2° to 3° north-east.

In the quarry three miles west-south-west of Kedowa the rock is composed of a pale grey base with 2-15cm. pumice bombs, locally slightly compressed. In the quarry two-and-a-half miles west of Kedowa the agglomerate (42/818) carries widely spaced 6-10cm. uncompressed black pumice bombs accompanied by smaller fragments, in a powdery grey base with angular obsidian chips, lava fragments and felspar crystals. Farther west the rock is bleached, and the texture preserved in shades of cream, yellow and off-white.

(c) The possible valley-fill deposit is exposed in roadstone quarries near the Kericho road, both north-east and south-west of Kedowa. It is variable, but one mile north-east of Kedowa appears as a lapilli tuff with an off-white fine-grained base carrying 1-3cm. striated yellow pumice fragments. To the east of the road this overlies agglomerate with a grey base and included 8cm. charcoal-black bombs and 2-5cm. striated yellow pumice fragments.

On the Molo Plateau a hard band within the pale tuffs and agglomerates is locally quarried for building stone. Its outcrop caps ridges and often forms a minor cliff feature. Samples were taken from three miles north-east (42/929) and six-and-a-half miles east-north-east of Ndoinet Forest Camp, (42/947), and six miles west-south-west of Five Mile Post. In each case the base is yellow or buff-grey, and slightly compressed grey and charcoal-black pumice fragments are commonly about 20cm. long. Felspar crystals and angular glassy chips occur in the base. The presence of a pebble band through one exposure suggests a sedimentary horizon.

At many exposures of bleached tuffs banding and definite sedimentary structures are absent. Definite sediments were recognized in several isolated localities however, with pebble-beds, laminated clays, well-defined bedding, grading within bands, cross-bedding and occasional slump structures.

A large quarry on the Kerisoi-Five Mile Post road, five-and-a-half miles east of Kerisoi Forest Station, exposes sediments overlying coarse bleached agglomerates. Dips are irregular, from horizontal to 30° south and east. The uppermost unit is a 30-foot band of powdery buff ash with abundant whole and broken concentrically layered, spherical nodules of 1cm. diameter. The underlying chalky, cream-coloured ash carries rare nodules and hollow, yellow, weathered pumice flecks. This in turn overlies a 4-foot pebble bed (42/867; 42/868).

Similar fine-grained, buff, nodular tuffs are exposed in a road-stone quarry five-and-a-half miles south-west of Five Mile Post. There the exposed succession includes brown and ochreous clay horizons and coloured tuff bands, the well defined bedding being locally contorted due to slumping (42/959). Only traces of bedding remain in a swirled and slumped, gritty, nodular sediment from six miles south-west of Five Mile Post (42/942).

Ripple marks in fine ash, and undulating and graded bedding in fine tuffs, are well preserved in specimen 42/968 from the river valley five miles west-north-west of Keringet, while alternation of grain size in narrow bands is displayed in a finely laminated white clay and grit sediment from the river bed two-and-a-half miles south of Molo (42/753). Sections through sedimentary horizons are common in the deeply incised river valleys south, south-east and east of Molo.

It is unlikely that any strict stratigraphical significance can be attached to these exposures of sediment. Rather they indicate that the prolonged period of sporadic ash-fall pyroclastic activity was also a period of considerable rainfall, and numerous small lakes were formed on the undulating terrain of unconsolidated fragmental debris, material readily amenable to transport and redeposition by small streams. Bodily movement of large quantities of waterlogged detritus as mud-flows down gentle gradients is also envisaged.

North of the Londiani Plain, in the region of Sorget and Makutano, and towards Maji Mazuri and the northern boundary, pale coarse tuffs and agglomerates with associated sediments outcrop on the south-eastern flank of Tinderet and the ridge joining it to Mount Londiani. To the west they overlie fine grey and off-white crystal eutaxitic tuffs, and farther east the coarser darker eutaxitic tuffs of the Molo and Maji Mazuri area. Although probably derived from Tinderet and Mount Londiani, these rocks cannot be distinguished from the similar association of bleached agglomerates and pale bedded sediments on the Mau and Molo Plateau, with which they are correlated.

Well-bedded sequences, mainly of undoubted waterlain origin from Maji Mazuri and farther east, and a major development of lacustrine sediments from a lake which extended from Londiani to Sorget and Makutano, have been delineated. These are considered to post-date the tuffs and agglomerates, and to be largely composed of

reworked detritus from them. Some justification is felt for the correlation of sediments occurring along the northern boundary east of Maji Mazuri, along the railway south of Maji Mazuri, and on the plain north of Londiani, where in each case they are immediately overlain by trachyte lava, with fine-grained banded tuffs of aeolian or lacustrine origin in the road cuttings two miles north-east of Molo, and indubitable sediments in the steep river gully four miles north-east of Molo, both exposures again overlain by lava. The correlation may be further extended to include sedimentary horizons high in the sequence on the Molo Plateau, including those exposed six miles east of Kerisoi Forest Station, and four miles south-south-west of Five Mile Post, both outcropping at about 8,900 ft. These sediments were deposited in different lakes and ponds, at different altitudes, but apparently at much the same time.

(b) Black ashes of Elburgon

These rocks occur widely on the gentle slope of the Rift Valley wall in the southern half of the area, where they are banked against a terraced scarp, overlying the grey eutaxitic welded tuffs and yellow tuffs and agglomerates of which the Mau is composed. Their homogeneity, lack of bedding and columnar jointing suggest an ash-flow origin, the flows probably emanating from the scarp faults. Previously (McCall, 1957A, p. 61) they had been ascribed to an ash-fall origin from a source at Menengai.

Due to their soft, readily weathered nature and overburden of thick soil and more recent ashes, they are generally seen only in stream beds, in which the stream is often incised in a small gorge. They are easily worked and are often cut into blocks for use as poor-grade building stone.

Specimens were examined from a quarry near the road bridge on the Molo River three miles south-west of Rongai (42/761), from beneath a lava flow in a tributary to the Molo River six miles south-west of Rongai (42/801), from the Rongai River bed at Elburgon Forest Station (42/984), four miles north-east of Elburgon (42/991), from the quarry at Nessuit Forest Station (42/1004), from the Njoro River two miles south-east of Nessuit (42/1009) and six miles south of Nessuit (42/1012).

Due to their porous texture and the nature of their exposure in river beds these rocks usually appear in the field as sooty-black waterlogged material. The ash is occasionally sculptured by river action, but more often occurs as billowing platforms with rare columnar jointing producing a polygonal pattern on the surface, with a cell diameter of about 25cm., well displayed in the Molo River four miles south-west of Rongai, and the Njoro River near Nessuit. Small waterfalls are common in the rivers, and locally the strata apparently dip north-east at about 10°.

On drying out these rocks display a dark grey or purple friable, gritty base, usually flecked with small rock pellets and abundant glassy felspar crystals often attaining a length of 4mm. Conspicuous but rare included pumice fragments have rounded irregular shapes, commonly 1cm. in diameter, with a large-scale vesicular structure. Welding in the matrix is just sufficient to cause the pumice fragments to be bisected as the rock breaks. In unwelded ashes breaks occur round rather than through included pumice fragments.

In thin section partial devitrification of larger pumice fragments can be recognized, and some show limited compression. The groundmass is composed almost entirely of well defined, uncompressed glassy shards, and many pore spaces carry minute crystals of vapour phase minerals, aegirine-augite and felspar. Uncompressed ovoid pumice patches occasionally include felspar phenocrysts, which like those of the base are whole or fragmented sanidine crystals, and fine-grained pellets of trachytic lava are common.

(c) *Eutaxitic welded tuffs*

Under this heading are grouped a series of welded pyroclastics of varying aspect of colour, texture, pumice content, degree of compaction and devitrification. In no single exposure is a large enough cross-section seen to enable complete correlation to be made with other exposures, since the rocks appear to vary progressively both laterally and vertically. Three main types were recognized—(i) Coarse-grained eutaxitic welded tuffs; (ii) Fine-grained grey tuffs; (iii) Medium-grained blue and purple tuffs.

(i) *Coarse-grained eutaxitic welded tuffs*

Rocks of this group were found in the valley of the Molo River four miles north-north-east of Molo, at several localities in the Molo-Turi area at varying altitudes to about 8,600 ft., in a quarry one-and-a-half miles south-west of Molo at 8,400 ft., four miles west of Rongai at 6,700 ft. and at varying altitudes in the scarp above the last mentioned exposure. The ash-flow clearly had its source or sources in the Molo area, and flowed generally eastwards. In the Molo River valley it directly overlies the black ashes of Elburgon. Almost identical types are exposed on the west flank of Mount Londiani and in the Makutano-Maji Mazuri region in the north-west of the area, and around Nessuit in the south-east.

The Molo River tuff, specimen 43/802, carries devitrified pumice fragments up to 30mm. long varied in streaks of pale and dark grey along their lengths, often with elongated central cavities. Exotic green, grey and yellow lava inclusions, partly rounded, reach diameters of 15mm. The ashy matrix, pale or khaki-grey in colour, is crammed with red, yellow and white grit particles. In thin section the compressed pumice shows axiolitic devitrification, with microlites up to 2mm. in length, and interstitial cavities have fringes of micro-crystals of aegirine and cossyrite. Crystal inclusions include euhedral sanidine and skeletal grains of opaque iron ore. The matrix is mainly glassy, with shards and contorted devitrified lenticles.

Rocks from the northern exposure, specimens 42/908 from the roadside half-a-mile south-west of Maji Mazuri and 42/899 from a small quarry six miles west of that place, are pale green-grey in colour with darker elongate bifurcating lenses up to 40mm. long and included lava fragments up to 15mm. across. The glassy matrix carries laths of simply twinned feldspar.

Both the Maji Mazuri and the Mount Londiani tuffs, which are overlain directly by Londiani trachytes, have a thin, interbedded layer of waterlain ashes and tuffs.

(ii) *Fine-grained grey tuffs*

This variety, a relatively thin unit near the base of the welded tuff succession, outcrops widely due to its resistance to erosion. It was mapped in a series of exposures around the Molo Plateau and the Mau Forest.

A typical specimen, 42/946 from four miles south-west of Five Mile Post, has a fine-grained grey base packed with grit-sized particles of included phonolitic and trachytic lava, occasional irregular chips of black glass, and pumice fragments. The lava inclusions have an exterior alteration colouring of yellow, brown or grey. Rare chips of black glass are roughly equidimensional up to 3mm. in diameter, and are frequently set obliquely to the general compressional fabric of the rock.

In well-compressed specimens, such as 42/974 collected five miles south-west of Keri-nget, collapsed pumice forms glassy streaks up to 15mm. long, but only 1mm. thick. Occasional included feldspar crystals are seen, and finely striated hollows in the ground-mass appear to be impressions of plant stems.

Specimen 42/976 from the road-river crossing two miles south of Kiptunga shows in thin section a completely glassy base packed with pellets of rock up to 2mm. in diameter, mainly of phonolite and trachyte, though one such pellet shows a multiple-twinned crystal of labradorite. Abundant angular chips of glass occur, and compressed devitrified pumice lenses are accompanied by small feldspar fragments and occasional minute prisms believed to be aegirine.

(iii) *Medium-grained blue and purple tuffs*

Attractive blue and purple building stones are exposed at several localities among the rounded hills north-west of Molo. Specimen 42/698, from four miles north-west of Molo, is of a purple grey colour, with a medium grained matrix with rounded pellets of lava sometimes exceeding 10mm. in diameter, compressed pumice lenses up to 30mm. long, occasional feldspar crystals, and a scatter of yellow, white and red inclusions. In thin section the matrix is seen to consist of closely packed devitrified shards and an abundant scatter of small prisms of green aegirine. Compressed pumice lenses display tassellated ends, and devitrification has led to the development of sheaves of microlites lying perpendicular to the margins of the lenses. Such lenses sometimes have hollow cores with vapour-phase crystals of aegirine and feldspar.

(7) SEDIMENTS OF LONDANI AND MAJI MAZURI

The rivers incised on the Londani Plain expose bedded sediments, which include bands several feet thick of compact chalky tuffs and claystones, some carrying nodules up to 10mm. in diameter, white laminated claystones, friable khaki and ochreous soils, and well-bedded sandstones, grits and gravel deposits, white, buff, yellow and orange in colour.

A compact nodular chalky clay forms the diminutive hill on the plain four miles north of Londani, and bedded sandstone, grit and gravel-beds form a series of rapids in the river five miles north of Londani. Current-bedding is visible in the sandstones at the road-river crossing two miles north of Londani. In the bed of the river draining an embayment in the lava boundary four miles north-east of Londani the forest track crosses an exposure of some 40 feet of bedded sandstones, including bands sufficiently compact to form a 16-foot waterfall in the river.

Natural exposures in the sediments of the Londani Plain are poor, but the road leading from Makutano Sawmill to the forest station follows the line of a disused fuel siding, dating back to the time railway engines burned wood fuel. The rail-cuttings display well-exposed sections of bedded sandstones and clays, nodular tuffs and poorly sorted agglomerates, some with highly contorted bedding resulting from slumping (42/883).

In several localities rivers flowing off the lava-covered slopes of Mount Londani plunge as waterfalls on to underlying sediments. In such an exposure, west of Kilombe and five miles east-north-east of Sabatia, the river falls some 60 feet. The river, already well incised in a lava flow, cuts through some 30 feet of lava, 10 feet of ropery contaminated lava (the sole of the flow), 10 feet of terra cotta soil (the baked upper tuffs) and 10 feet of poorly sorted yellow tuffaceous sediments, after which the river bed, still descending rapidly, is lost beneath rubble of fallen lava blocks.

Rocks from the valley three-and-a-half miles east of Sabatia where a north-flowing river etches a fault line, consist of bedded sandstones with occasional harder water-lain tuff horizons. Lensing bands of sandstone, grit and gravel are well displayed. Another inlier of sediments three miles east-north-east of Maji Mazuri consists of a variety of well-bedded grits, sandstones, pebbles and laminated clays, some contorted by slumping.

Buff, yellow and orange bedded sandstones, clays and pebble-beds outcrop in the rail-cuttings and sawmill tracks at Maji Mazuri. In the track passing beneath the railway half-a-mile south of Maji Mazuri, erratic one-and-a-half and two-foot boulders are included in the finely bedded sequence. Resulting from explosions which preceded the lava flows, the blocks dropped on to the unconsolidated sediments and sank into them, distorting the bedding to a depth of three feet.

The junction between phonolitic-trachyte lava flows and underlying sediments is seen again in the rail cuttings between Makutano and Maji Mazuri where the rail alignment follows the lava boundary. At the bend two miles south-west of Maji Mazuri 15 feet of poorly sorted sediments with occasional erratic boulders is overlain by five feet of well-bedded sandstone and capped by trachyte lava.

On the western boundary three-and-a-half miles south-west of Sorget a deeply incised river flows down a gently terraced bed cut in finely laminated white clays at 7,800 ft. No rock exposures were seen in the steep valley walls. Similar aeolian or lacustrine, finely banded deposits were encountered in a glade on the ridge at a height of 8,000 ft. three miles south-west of Sorget.

No fossil remains were found in any of the sediments mapped.

(8) ALKALI BASALTS OF MOLO PLATEAU

A flow of blue grey non-porphyrific alkaline lava overlies a tuffaceous horizon on the interfluvium between the Ndoinet and Songon rivers three miles east of Ndoinet. Downstream of the road bridge over the Ndoinet River one-and-a-half miles farther east, the granular lava has a vesicular texture and a silvery sheen. A porphyritic alkaline lava was collected from the dam spillway five miles north-west of Keringet.

In hand specimen the lava from the first-mentioned locality, 42/948, feldspar phenocrysts up to 4mm. long occur. In thin section small anhedral olivine phenocrysts are associated with grains of black iron ore, which also occurs as isolated euhedral and skeletal crystals. Occasional prisms of augite attain sizes of up to 1.5mm. and large feldspar phenocrysts with carlsbad and fine cross-hatch twinning prove to be anorthoclase with a rather high optic-axial angle. The groundmass carries abundant small laths of sodic plagioclase, and the interstitial material includes pyroxene, soda-amphiboles, calcite and probably analcime.

Anorthoclase phenocrysts in a pale, granular, silvery grey lava from the second locality (42/950) occur in clusters. They display resorbed subhedral shapes, fine-grained cross-hatch twinning and a rather high optic-axial angle. No olivine was seen in this example, but black iron ore and prismatic augite phenocrysts are present in a base of closely packed sodic-plagioclase laths, granular pyroxene, iron ore and sodic amphiboles.

(9) BASALTS OF MAJI MAZURI

A small lobe of basalt lava was located in the forest one mile south of Maji Mazuri. The lava overlies waterlain tuffs and ashes displayed in tracks and railway cuttings, and is directly overlain by trachyte to the east and south.

This black lava, with ovoid vesicles 20mm. in diameter, contains pyroxene crystals 3mm. in length and less common glassy green olivine. In thin section 42/907 the ferromagnesian are accompanied by labradorite phenocrysts in 2.5mm. laths, set in a groundmass of plagioclase, pyroxene and black iron ore.

(10) TINDERET PHONOLITES

Not all of the phonolites shown as Tinderet phonolite (Tvp₂) in the accompanying map can be shown to have been extruded from Tinderet Volcano, and to fall within the original group as defined by Binge (1962). Other exposures at Mount Blackett,

south-east of Tinderet, and in the south-east and north-east corners of the map are included here for convenience, since they are very similar to the true Tinderet phonolites, and possibly of the same age.

A typical specimen of this rock from the slopes of Tinderet five miles north-west of Makutano (42/897) is a blue-black, fine-grained lava with anorthoclase and rare nepheline phenocrysts. In thin section the fine-grained groundmass is seen to consist of a felted mat of anorthoclase feldspars with interstitial cossyrite, kataphorite and amorphous nepheline.

The steep-sided flat-topped Mount Blackett, south of the Mau Summit-Londiani road, rises several hundreds of feet above the surrounding countryside. It is composed entirely of uniform, fine-grained phonolite, and despite the fineness of grain of the rock it is considered to be a phonolite plug. A specimen of the rock, 42/726, shows sparse euhedral phenocrysts of nepheline and anorthoclase set in a greenish black groundmass seen in thin section to be crammed with minute crystals of nepheline and carrying trains of flow-aligned feldspar laths, with patches of cossyrite and kataphorite.

The only occurrence of phonolite in the south-east corner of the map area is a bluff of lava among the welded tuffs of the Mau Escarpment four miles south-south-west of Nessuit. The extent of the visible outcrop is limited by heavy forest cover. The rock, specimen 42/1014, contains euhedral anorthoclase phenocrysts 8mm. in length with carlsbad twinning visible to the naked eye. The groundmass, rich in grains of nepheline, contains dispersed crystals of cossyrite and kataphorite and poikilitic plates of barkevikite. A basic clot cut by the thin section contains a core of olivine altering marginally to iddingsite and with a rim of barkevikite.

A number of small hills rising above the plain in the north-east of the area are horsts of older rock uplifted by grid-faulting and partly buried by late pyroclastics. The outcrop three miles south-east of Mogotio (42/995A) is of a granular silver grey porphyritic rock with rare aegirine-augite set in a fine-grained matrix of trachytic texture of anorthoclase, cossyrite, kataphorite and iron ore.

(11) NYANDO VALLEY PHONOLITES

Exposures of blue black phonolite seen in the Nyando River bed one-and-a-half miles north-west of Kedowa immediately overlie a finely bedded sequence of tuffs, clays and soils, with a baked upper member 8cm. thick and terra-cotta in colour. The phonolite base dips west and lies below 6,700 ft. at the road-river bridge two-and-a-half miles north-west of Kedowa. The blue black phonolite is overlain by trachyte, and in the railway cuttings one mile west of Kedowa there is a thin intermediate layer of white tuff and agglomerate. To the west of the river phonolite reaches a maximum altitude of 7,100 ft.

Farther west, both north and south of the Nyando River, the phonolite overlies phonolitic nephelinites, a relationship again demonstrated at the boundary of a small inlier of phonolitic nephelinite in the stream bed two miles west-south-west of Kedowa. Exposures defining the phonolite boundary in the railway cuttings three miles north-west of Kedowa alternate between phonolite and phonolitic nephelinite, and on the hilltop 1,000 feet higher the phonolite is overlain by trachyte.

South of the Kisumu road, phonolite overlies phonolitic nephelinites and bleached tuffs, and is itself overlain to the north of the road by trachyte which produces a crenelated scarp-line with exposures indicating a general southerly dip. Evidence from the roadstone pit north of the road, one mile east of the boundary, suggests that the phonolite outcrop consists of at least two flows, divided by a coarse agglomerate or boulder-bed horizon.

The phonolite of the Nyando Valley one mile west of Kedowa (42/879) is a dark blue black lava, with hackly fracture and abundant phenocrysts. Felspars display a typically plate-like form 10mm. long, and nepheline crystals 4mm. in diameter occur singly or in clusters. No ferromagnesian crystals can be seen in hand specimen. Phonolite from the top of the hill four miles south-east of Londiani (42/815) displays a smoother fracture but contains similar phenocrysts. Microphenocrysts cut in thin section are biotite and twinned euhedral augite. The phonolites of the scarp north of the Kisumu road carry abundant hexagonal biotite flakes 4mm. in diameter in addition to phenocrysts of nepheline and felspar.

(12) TRACHYTES AND QUARTZ TRACHYTES OF LONDIANI AND KILOMBE

Mount Londiani (9,872 ft.) stands on the western shoulder of the Rift Valley just south of the equator. The lower slopes of the mountain, to the west, are composed of flows of trachyte lava which extend as far west as Londiani and Maji Mazuri, and are bounded by a prominent scarp feature which can be traced almost continuously between these two towns. The lava reappears two miles west of Londiani capping the phonolite and agglomerate hills north and south of the Kisumu road as far as the western boundary.

To the south of Mount Londiani the trachyte outcrops do not extend beyond the line of the Molo River, which etches the lava boundary and has cut a deep gorge in the softer pyroclastic rocks beneath. Lava outcrops are sporadically exposed between the road cutting west of the Jolly Farmer Hotel north-east of Molo (7,900 ft.) and the valley floor (6,500 ft.) in billowing slopes derived from the original dip of the flows into the valley, together with limited later fault movement.

The steep scarp slope running north-south from Kilombe Hill to the Nakuru-Makutano main road is interpreted as a lava-faced scarp. No bold fault-steps are seen: the original major fault line must run to the east of the foot of the present slope, passing beneath the col between Mount Londiani and Kilombe and is now covered by the mantle of later pyroclastic rocks on the Rift Valley floor.

Kilombe Hill consists of a well-preserved vent, with crater, composed mainly of lavas indistinguishable from those of Mount Londiani. It is situated astride the main Rift faulting in this area (McCall, 1964). To the north some flows of Londiani and Kilombe trachyte entered the Eldama Ravine area, where they were mapped under the Lake Hannington phonolite group (Walsh, 1969).

Typically these rocks appear on freshly broken surfaces as granular blue grey lavas, with glassy felspar phenocrysts showing rectangular sections. Weathered surfaces usually display a typical satin-like, silver-grey trachytic sheen, but occasionally weathering produces a finely mottled appearance with minute flecks of dark brown, khaki and green, giving a general "heather-mixture" effect and an aggregate colour of pale brown or brown-grey.

The vast majority contain potassic felspar (sanidine-anorthoclase) as occasional macrophenocrysts and abundant microphenocrysts, accompanying sodic ferromagnesian minerals (cossyrite, kataphorite and sometimes aegirine, aegirine-augite or barkevikite), often black iron ore, and rarely biotite, in a variable amount of fine-grained intergrown interstitial base, predominantly feldspathic, in which neither quartz nor nepheline can be recognized.

In some rocks the fine-grained base appears to be composed of a quartz-felspar intergrowth, and in others quartz occurs in optical continuity infilling minute, widely spaced irregular interstices. In others ophitic plates in the groundmass are accompanied by small clear pools of quartz. In one of the specimens collected olivine was recognized, indicating a tendency to undersaturation among occasional rocks of this group.

(a) *Trachytes*

The only specimen of trachyte showing undersaturation in silica collected within the area is a rock carrying rare olivine phenocrysts, from the forest boundary five miles west of Rongai. In hand specimen (42/766) the rock has a mottled green grey base and carries abundant felspar phenocrysts. The felspar macrophenocrysts occur singly or as clusters of prisms and commonly attain dimensions of 2.5 x 1mm. They consist of simply twinned euhedral sanidine-anorthoclase in a flow-aligned base of smaller laths. Aegirine-augite prisms, 0.2mm. in diameter, often associated with grains of black iron ore, show diagnostic cross sections, and weak pleochroism in shades of pale green. They are surrounded by a sheath of alteration to yellow-green highly birefringent amphibole, and isolated laths of the latter mineral occur in the feldspathic base accompanied by a copious scatter of flakes of cossyrite and kataphorite. Olivine crystals appear in the slide as a single cluster of small fresh euhedra individually attaining diameters of 0.3mm. with rare cracks and narrow blackened margins.

The lava from the main road four miles north of Mau Summit (42/759) has weathered to a fine-grained, granular, pink rock. The sanidine-anorthoclase phenocrysts, partly resorbed, are accompanied by several types of sodic amphibole in the base. Kataphorite, markedly pleochroic from bottle- or blue-green to khaki- or olive-green to purple- or greenish brown, occurs as dispersed interstitial flakes or poikilitic plates, as does cossyrite, pleochroic from pale buff or straw-yellow to chestnut or russet-brown to deep chocolate brown, often nearly opaque. Most common are poorly developed prisms of bright fawn poorly-pleochroic barkevikite. The groundmass is a fine-grained mosaic of felspar.

The lava in the railway cutting on the northern boundary, one-and-a-half miles north of Maji Mazuri (42/916) appears as a sparsely porphyritic streaky grey rock, and that in the forest two miles south-west of Sabatia (42/918) is glistening dark grey granular and porphyritic. Both have resorbed microphenocrysts of sanidine-anorthoclase which display progressive extinction across the crystals. Cossyrite, kataphorite and barkevikite are present in both.

The rock from the lip of a waterfall four-and-a-half miles east of Sabatia (42/919) is more abundantly porphyritic, with common 8mm. sanidine-anorthoclase crystals accompanied by ragged microphenocrysts of aegirine-augite and grains of black iron ore in a base of fine-grained felspar and dispersed interstitial fragments of optically continuous cossyrite and kataphorite.

The silvery green grey lava from the hill north of the waterfall on the rim of Kilombe Crater (42/797) is indistinguishable from many of the Mount Londiani lavas, with large euhedral sanidine-anorthoclase macrophenocrysts, and abundant smaller partly resorbed flow-aligned sanidine-anorthoclase laths in a base characterized by sodic amphiboles. Other fine-grained rocks from the western rim of Kilombe, such as 42/795, include types with only sodic amphiboles and felspar prisms in a fine-grained, leucocratic, mosaic base, and a streaky purple and fawn lava (42/794) of interest because its streamed-out vesicles carry marginal fringes of felspar laths and acicular prisms of a yellow green, highly birefringent ferromagnesian mineral, probably aegirine-augite, possibly the result of crystallization from the vapour phase.

(b) *Quartz trachytes (Pantelleritic trachytes)*

The lava outcropping on the lower slope of Mount Londiani three miles north-east of Mau Summit (42/719) is sparsely porphyritic, granular, mottled and khaki coloured. The thin section shows a texture of flow-aligned microphenocrysts of sanidine-anorthoclase, accompanied by sodic amphiboles. Kataphorite forms larger crystals than in most rocks, occasionally attaining a length of 0.4mm. The rock also contains rare anhedral quartz crystals.

Lavas displayed in cuttings along the new Kericho road between Mau Summit and the Londiani turn-off all contain small amounts of quartz in the matrix. They are otherwise indistinguishable from more normal members of the group. From a bluff above the railway one mile north-west of Mau Summit the rock (42/714) is a medium green grey porphyritic lava with small iron-stained feldspars. The weathered rock has a pale powder-green mottled appearance with 5mm. patches stained chocolate brown. Sanidine-anorthoclase phenocrysts occur in a trachytic texture of imprecisely twinned laths of feldspar, and coesite and kataphorite are accompanied by poorly preserved flakes of brown biotite. Quartz occurs as optically continuous interstitial infillings in the groundmass. In some sections the sodic-amphiboles are amplified by barkevikite, and poorly preserved subhedra of aegirine occasionally occur.

The most extreme member of this group, specimen 42/804, forms a slight bluff north of the river, one-and-a-half miles north-west of Kedowa, where it appears as a fine-grained, glistening, grey porphyritic trachyte with occasional vugs filled with waxy zeolites. The euhedral macrophenocrysts of sanidine 2mm. long and flow-aligned second-generation sanidine laths 0.5mm. long are accompanied by coesite and small prisms of aegirine in a fine-grained, locally zeolitic groundmass. Crystals of quartz, occasionally with poikilitic relation to small prisms of aegirine, form rare pools in the groundmass, and display occasional crystal faces against euhedral zeolite, filling irregular vugs. The vugs, of elongate shape, have scalloped margins and attain lengths of 12mm. Euhedral acicular aegirine prisms, and less common feldspar laths, protrude from the groundmass of the rock into the vugs, which have a complete narrow lining of zeolite, probably analcime, aligned perpendicular to the vug walls. The bulk of the cavity is filled by spherular aggregates of clear zeolite, possibly natrolite, with central small mosaic patches of quartz.

Further evidence of local oversaturation with silica is provided by the composition of the syenite boulders which strew the flanks of Kilombe. In hand specimen this holocrystalline rock (42/793) is apparently composed of two main constituents, prismatic white feldspar crystals with clear glassy cores attaining lengths of 8mm. and less common ferromagnesian clusters 5-8mm. in diameter. In thin section the dominant feldspar appears as slightly altered perthitic orthoclase with smaller amounts of clear well-twinned plagioclase within the oligoclase range. The predominant dark mineral is highly pleochroic green hornblende, and subhedral quartz crystals are present attaining diameters of 1mm.

2. Pleistocene

(1) MAFIC BASALTS, BASANITES AND LIMBURGITES OF LONDIANI

Olivine basalt lava flows occur sporadically over the western third of the area. Their varied composition and limited outcrop at varying altitudes suggests they are of local origin, not remnants of extensive lava sheets, and that their extrusion occurred late in the succession.

Owing to their resistance to erosion these basalts are usually found capping hill features. Basalts lie upon surfaces composed of most of the preceding members of the succession, including eutaxitic welded tuffs, bleached lapilli-tuffs and sediments of Tinderet and the Mau, Londiani quartz-trachyte and phonolite lavas from Tinderet.

Four conical or steeply rounded hills north and north-west of Londiani, rising some 800 feet from the plain mark the sites of basalt vents. No craters are preserved, but Limutet (8,416 ft.) retains the suggestion of an arcuate form, and both Limutet and Lesotet (8,352 ft.) show successions of basalt lava flows alternating with lava boulders and basaltic ash dipping steeply and randomly on their upper slopes. In general the most basic flows are found near the vents, and the more extensive flows on the plains include the feldspar-rich members.

Outcrops of olivine basalt on the western boundary three miles south-west of Kedowa are overlain by agglomerates dipping 2° - 3° north-east. This may represent the dip of the underlying basalt surface, and suggests the position of a source for these lava flows beyond the western boundary of the map area.

Generally these rocks are heavy, blue black medium or fine-grained lavas in which both bottle-green olivine and black augite phenocrysts are conspicuous, and readily distinguished with the naked eye. The rock fracture may be smooth, or more often hackly, and chlorite- and carbonate-filled vugs and occasional plagioclase crystals are displayed.

The steep hill three-and-a-half miles west of Maji Mazuri provides poor exposures of pale tuffs towards the base, while glades on the upper slopes are paved with large lava boulders. An increase in profile-gradient towards the peak suggests a lava capping, but exposure is lost on the forested summit. In hand-specimen 42/910 the lava is of medium grain, with abundant feldspar and occasional olivine crystals. In thin section euhedral phenocrysts of zoned augite and deeply cracked olivine are accompanied by irregular multiple-twinned plagioclase laths of basic labradorite composition (An_{71}). Phenocrysts attain a length of 2mm. and are contained in a medium-grained groundmass of plagioclase laths, and granules of pyroxene and black iron ore.

The rock (42/876) forming the summit of Limutet, six miles north-west of Londiani, is a heavy purple-coloured fine grained basalt with abundant 2-3mm. ferromagnesian phenocrysts in a finely vesicular base. The thin section shows abundant close-packed augite euhedra, occurring singly or in clusters, with neutral cores and pale green outer zones. Subordinate subhedral olivine phenocrysts with bold fractures and boundaries accentuated by a bright foxy-red margin of alteration products occur with microphenocrysts of pyroxene, plagioclase and russet-brown pseudomorphs after olivine. The groundmass, mainly of pyroxene, plagioclase and black iron ore, contains some interstitial low-birefringent material possibly analcime. This rock is one of several which show an affinity with basanites.

The Limutet basalts overlie off-white eutaxitic welded crystal-tuffs and bleached lapilli-tuffs of Tinderet, exposed in a gully and quarries immediately to the south. Farther south towards the Londiani-Kisumu road basalt flows apparently overlie Londiani phonolitic trachyte. Basalt flows forming low hills north and south of the Kisumu road three-and-a-half miles west-north-west of Londiani (42/864) carry large resorbed phenocrysts of olivine with russet alteration rims, neutral coloured augite with hour-glass zoning, and small vugs infilled with calcite. Microphenocrysts are exclusively ferromagnesian, multiple-twinned laths of basic labradorite occurring with a faint flow-alignment only in the groundmass.

Many other limited outcrops of basalt occur around Londiani; at the Lessotet vent three miles to the north (42/880); at a similar vent three miles to the north-north-east (42/900); and above the waterfall one-and-a-half miles to the south-west. Basalts at the last three localities all include plagioclase phenocrysts within the bytownite composition range (An_{70} - An_{76}), and in the last two examples zeolitic-vugs and zeolites in the groundmass again suggest a basanitic affinity. Carlsbad and multiple twinning in zoned plagioclase phenocrysts from Lessotet lava indicate cores more sodic than the outer rims. The composition is from An_{66} (labradorite) to An_{72} (bytownite).

Olivine and augite form two generations of phenocrysts in basalt specimens 42/852 and 42/853 collected from the lava flows near the Kericho road south-west of Kedowa. Calcite, zeolite and chlorite filled vugs occur in a groundmass of plagioclase, pyroxene, black iron ore and possible interstitial analcime.

On the Molo Plateau four miles west-north-west of Keringet no basalt feature is exposed, but a gently domed cultivated ridge of chocolate-coloured soil carries a copious float of basalt boulders. The rock (42/957) consists of felspar-rich olivine basalt with felspar and olivine phenocrysts in a base of plagioclase laths, clusters of iron ore grains, poikilitic pyroxene, interstitial carbonate and amber-coloured mesostasis, with carbonate-filled vugs.

The sparsely vesicular porphyritic black lava from four miles south of the Lumbwa road on the western boundary (42/829) was found to contain only olivine phenocrysts. Common vugs, 1mm. in diameter, are infilled with zeolites, crystallizing with spherular habit, and small patches of interstitial analcime are rare. Neither nepheline nor plagioclase is present in the base which consists of granular pyroxene and subordinate black iron ore in an amber-coloured isotropic mesostasis. The rock is thus classified as limburgite.

(2) MAU ASHES WITH BASAL TUFF

Much of the southern third of the map area is covered by a thick mantle of soil derived from a covering of ash. These ashes, the product of air-borne showers of pyroclastic material, extend far to the south of the present area, and reach their maximum known thickness of about 800 feet some 20 miles south of the southern border of the map (Williams, Report No. 96). A Pleistocene age for these ashes seems justified on the basis of their deep weathering and erosion.

At the base of the ashes locally are exposed lapilli-tuffs containing powdery yellowish pumice fragments set in a brownish grey ash base. The pumice fragments are somewhat flattened and poorly aligned. Rare fragments of phonolitic lava are also seen.

Most of the area in which Mau ashes occur is characterized by heavy rainfall, and the ashes have undergone complete alteration to clays and clayey soils. Rare exposures of relatively unaltered rock show earthy, poorly consolidated ashes of reddish or yellowish brown colour, with fine colour-banding and cross-bedding on all scales. Angular fragments of obsidian up to 50mm. across are extremely common, and occasionally rounded calcareous concretions are seen.

(3) TUFFS AND ASHES OF MOGOTIO

North of Kampi ya Moto and east of Kilombe the greater part of the countryside is covered by a highly varied bedded sequence of coarse-grained yellow and khaki tuffs. Exposure is good, being nearly continuous in the beds of the Molo River and those rivers to the north.

A specimen, typical of much of the sequence, collected from a quarry one-and-a-half miles south-east of Mogotio, has a compact, fine-grained, buff base with occasional rounded pellets of included lava, numerous small felspar crystals and angular chips of black glass. The wider-spaced larger fragments consist of randomly disposed uncom-pressed black and silver-grey pumice lapilli up to 20mm. in length.

The succession at the river crossing north of Kilelwa Hill shows about ten feet of unsorted khaki tuff, with glass and pumice fragments, overlying ten feet of more compact but coarser tuff, with abundant close-packed pumice lapilli, some fresh and black and others hollow and yellow in colour. Occasional flattened bombs two to three feet in diameter are included, and this band forms the lip of a small waterfall beneath which a succession of bedded clays and soils represents the weathered product of layered ashes.

Good exposure of this variable sequence is displayed near the watermill in the Molo River three miles south-west of Mogotio. The cliffs in the valley wall are of common khaki-yellow tuff with a scatter of black glassy chips and felspar crystals, and with pale grey glistening pumice lapilli 20mm. to 30mm. in length. Pavements of rock form-

ing the stream bed just above the waterfall are of harder mid-grey tuff, with thin eutaxitic compressed fragments 10mm. to 20mm. in length and less common small uncompressed pumice lapilli. Beneath the waterfall the rocks are coarser-grained uncompressed khaki yellow tuffs.

Impressive bomb-beds on various scales are displayed. A rock from the streambed two-and-a-half miles west-north-west of Mogotio consists of porphyritic pumice bombs of remarkably uniform size, about 50mm. diameter with fresh glassy black cores weathering to lemon-yellow exteriors, closely packed in a dull yellow base with abundant flecks of black glass.

(4) ASHES OF TINDERET

Pleistocene ashes, attributed to a source at Tinderet, mantle the ridge which carries the road and railway between Makutano and the north-west corner of the area. Natural exposures in this region are virtually non-existent, but numerous cuttings for road and railway provide plentiful information. Even so the nature of the base of the unit, and the height at which it overlies the earlier Tinderet agglomerates and lapilli-tuffs, is unknown, and the mapped boundary must be accepted as provisional.

Isolated exposures near the Sorget-Timboroa road in the extreme north-west display completely rotted bleached uncompressed tuffs with abundant 20mm. to 30mm. pumice fragments. Also exposed are many well-bedded deposits with sandstones, laminated clays, and chalky textures. Occasional flakes of biotite were seen.

In recent cuttings for the new road in the north-west an overburden of 40 ft. to 50 ft. of red soil covers variegated clays which preserve a relic tuff structure in brilliant colours of orange, yellow, red and chocolate-brown. In the upper spiral loop of the railway, carved in bedded ashes and tuffs three-and-a-half miles from the western boundary, unconformable cross-cutting by different units in a sequence of fine-, medium- and coarse-grained tuffs is well displayed. The colour range is usually from cream to buff or khaki, with occasional yellow, green or rusty members.

Some two miles farther east dips in an alternating series of ashes of sand and clay grade vary from horizontal to 30° east-south-east. Fine- and coarse-grained yellow weathered bedded ashes with steep and undulating dips exposed in a rail cutting four miles north-west of Makutano (specimen 42/898) contain occasional much harder and larger angular fragments which prove to be of vesicular porphyritic olivine basalt. This deposit may be related in age to the basalt lava cones of south-west Sorget.

In a deep roadstone quarry half a mile south of Makutano a 50 foot sequence is exposed in which well-bedded clays and ashes are confined to the lowest few feet and the remainder composed of coarse-grained tuff with only rudimentary banding. The hilltop one mile south-south-east of Makutano outcrops flaggy bedded ashes which dip south-west at some 12°. In hand specimen 42/904 the rock, of sandstone grade, is compact, well cemented and khaki-coloured, with the bedding locally accentuated by layers of nodules up to 4mm. in diameter. These are composed of an outer rim of light brown, extremely fine-grained material, often including a core of rock matrix, but in others completely obliterating the core with homogeneous fine-grained cement. In thin section little can be recognized in the fine-grained base of clay minerals, but numerous small pyroxene crystals and occasional rock fragments with large olivine phenocrysts suggest it is of basaltic composition.

The outcrop of bedded ashes on the western flank of Mount Londiani is exposed in an erosion scour near a farm track two-and-a-half miles west of the peak. The beds are finely laminated ashes of sand and clay grade, with rare 20mm. layers of fine tuff. They exhibit a general shallow dip to the north-east.

(5) KILELWA HILL PHONOLITES

The zeolite-rich lava flows of Kilelwa Hill, four miles west of Mogotio, are unlike any phonolites seen elsewhere in the area, in texture or in composition. The low hill rises above the plain composed of Mogotio tuffs, and probably marks the source of these lavas. The river bed, deeply incised in tuffs and agglomerates, separates the two outcrops of lava.

In hand specimen 42/923 the lava is a hackly grey black sparsely porphyritic rock with a waxy texture. In thin section occasional fresh simply twinned euhedral sanidine-anorthoclase phenocrysts up to 5mm. in length are accompanied by rare subhedral partly resorbed microphenocrysts of aegirine-augite and analcime pseudomorphs after nepheline. Dispersed flakes of cossyrite, prisms and granules of aegirine-augite, and grains of black iron ore accompany minute randomly oriented feldspar laths in a low-birefringent, locally isotropic base, which is largely composed of analcime.

The rock of the northern outcrop contains rare rounded phenocrysts of sanidine-anorthoclase, deeply coloured elongate prisms of aegirine-augite and microphenocrysts of nepheline. The groundmass has a boldly striated texture with elongate lenses composed mainly of analcime, subordinate unaltered nepheline, crude spherular aggregates of zeolite, and rare central calcite cores. The darker surrounding patches contain black iron ore, cossyrite, kataphorite and aegirine or aegirine-augite, and a scatter of randomly disposed microlaths of feldspar is common to both light and dark streaks.

(6) TRACHYTES OF THE NORTH-EAST

Trachyte lavas exposed by faulting near the eastern boundary north-east and south-east of Kampi ya Moto are considered to be younger than the phonolites and trachytes of the extreme north-east.

An example taken from a highly pumiceous lava from the minor scarp two miles north-east of Kampi ya Moto, 42/1000, contains small patches of compact blue and blue green base surrounded by a highly vesicular swirled texture, with pore spaces stained rusty brown. Included fragments attain lengths of 20mm. and rare feldspar phenocrysts reach 3mm. x 3mm. In thin section very fine-grained patches can be distinguished from glassy material which is typically devitrified into spherular aggregates of feldspar laths and flakes of sodic amphibole. Occasionally ferromagnesian and feldspar prisms protrude into the vesicles beyond the margins of the glass. The highly pumiceous and contaminated lava flow exposed at the top of the fault scarp on the eastern boundary south-east of Kampi ya Moto is tentatively correlated with the rock just described.

(7) EUTAXITIC WELDED TUFFS OF THE NORTH-EAST

Hill features standing above the level of the plain in the north-east include those one mile south of McCalls Sidings and the fault scarp south-east of Kampi ya Moto. These features are nearly buried by Menengai pumice. The fault scarp is capped by a lava flow 30 feet thick, highly streaky and vesicular in texture and contaminated by much included debris.

The pyroclastic material forming most of the scarp is extremely ill-sorted and coarse-grained and is characterized by uncompressed pumice bombs of porphyritic black glass up to a foot in diameter and compact angular fragments of glass and lava blocks. Often coarse and medium grained fragments are closely packed and little interstitial material is seen; sometimes black glass as bombs and fragments constitutes over half the bulk of the rock. Elsewhere layers of eutaxitic welded tuff are encountered, again carrying a high proportion of black glass both as angular blocks and compressed pumice lenses.

East of Kampi ya Moto copious float of giant pumice bombs associated with this formation litters the countryside. Agglomerates and eutaxitic tuffs in this locality display a wide colour range, with deep grey and brown predominating, but always displaying the characteristic abundance of black glass.

3. Quaternary

(1) BLACK ASHES OF RONGAI PLAIN AND NJORO

These distinctive black ashes with glassy bombs are widespread in the Menengai area, and are attributed to a source at that volcano. Their outcrop extends from the plain east of Njoro, beneath the later silver-grey pumice beds, and is seen again in the beds of the Molo, Rongai and Bissoi Rivers. The black ash overlies conformably the yellow-bedded Mogotio tuffs, the boundary lying approximately along the line of the Kampi ya Moto-Eldama Ravine road. At the southern extremity of its outcrop the black ash of the Rongai Plain overlies the older black ash of the Elburgon area, with which it shares many characteristics. The boundary between the two is ill-defined.

The black ash of the Rongai Plain has a fine-grained porous base. Its friable texture and susceptibility to erosion prevents it forming marked features: its most common exposures are in the floors of river beds where it invariably has a sooty waterlogged appearance. The base colour, most commonly black, varies locally to dark purple and purple grey with rusty partings. A variety of included close-packed, light coloured, grit-sized pellets of lava are accompanied by angular chips of black glass and plate-like felspar crystals, which occasionally attain a length of 5mm. A high proportion of the included fragments are of uncompressed pumice, usually black in colour and coarsely vesicular, but occasionally with striated texture and a grey or streaky grey and green colour. Some angular fragments of trachytic lava carry 3mm. felspar phenocrysts. The base shows little compaction and on breaking fractures avoid the included fragments, giving broken faces a pebbled appearance and concealing the pumiceous nature of the inclusions.

Highly variable in proportion, but quite common generally, are large glassy bombs. These occur in all sizes from two inches to two feet in diameter, and although occasionally equidimensional are usually considerably flattened. They present highly irregular amoeboid shapes with rough ropy surfaces. The bombs are composed of porphyritic black glass with 5mm. felspar prisms. The vesicles, often several centimetres long, vary widely in size, shape and distribution within the bombs. A streaky structure is frequently displayed, with contorted lenses of fresh dense black glass suspended within a coarsely vesicular swirled matrix. Alteration results in tracts of green and green grey colour throughout the pumice.

Often the red soil for two or three feet overlying black ash on the Rongai Plain carries a concentration of these bombs, which occur in such numbers locally that they are collected and used in building dry stone walls. No bedding was recognized in any of these deposits, but occasionally small-scale columnar jointing was observed in more homogeneous exposures, as in the Molo River one mile south-west of Rongai. Sculpturing of these soft ashes by river action is common, and streams often run in the bottoms of narrow gorges.

Removal of soil to reinforce the railway embankment has resulted in extensive exposures adjacent to the railway two miles east-south-east of Rongai. A farther mile down the line from Rongai a pit exposes three feet of red soil overlying close-packed, fine-grained khaki coloured tuff carrying striated grey pumice fragments and felspar crystals 5mm. long. Underlying this is waterlogged black ash with large bombs of porphyritic glass.

A similar sequence is displayed in a pit near the main road four miles south-east of Rongai. Some four feet of red soil overlie four feet of yellow and ochreous fine-grained tuffs, and dusty purple black friable ash with abundant bombs over one foot in diameter. Similar black ash was encountered beneath four feet of red soil and an equal thickness of pale unconsolidated, uncompressed, horizontally banded silver-grey Menengai pumice two miles north-north-west of Njoro. The ash there is of dark brown colour with small angular lava fragments and large bombs in a friable base containing felspar crystals and pumice lapilli.

(2) PYROCLASTICS AND SEDIMENTS OF RONGAI PLAIN AND MAU SLOPE

Recent deposits on the plain near Njoro are represented only by well-bedded, glistening, grey unconsolidated pumice. Elsewhere however, particularly to the north and north-west, the Pleistocene to Recent succession is expanded with the inclusion of yellow sediments and white bleached tuffs at the base, and lateral variation is observed from relatively fresh medium-grained glistening pumice on the plain in the east, to impressive accumulations of much finer-grained clays and ochreous sandy soils produced by weathering of finer ash on the scarp slopes to the west.

Sediments are poorly displayed in sections at bends in the Molo River from two miles north to two miles south-west of Rongai. In river sections the sediments consist of medium- and fine-grained, yellow and buff, banded tuffaceous deposits showing coarse and fine-grained bedding and unconformable cross-cutting of earlier by later beds, as in specimen 42/762 from one-and-a-half miles south-west of Rongai. These sediments grade upward into layered clays, iron-rich soils and ochreous sandstones.

Sediments from a similar part of the succession are also exposed in the road on the north bank of the Molo River four miles south-west of Rongai, where, with bleached tuffs, they overlie trachyte lava and underlie ochreous bedded soils and ashes. The sediments at this locality form a varied, well-bedded sequence dipping some 10° east-north-east. The succession, of which some 10 feet are displayed in banks at the roadside, has a basal member two feet thick of alternating thin units of laminated clay and sandstone. This is overlain by some four feet of coarse sandstone, a pebble and pumice bed lensing from two to eight inches in thickness, and a capping of three feet of pale homogeneous fine-grained tuff.

The bleached tuff at this locality, well exposed in the track to the farmhouse a quarter mile farther north, bears a close superficial resemblance to those exposed in the forest high on the western Mau. The exposures suggest that the later bedded clay and ochreous soil sequence overlies the bleached tuff unconformably, the tuff forming low mounds and the bedded ashes smothering mounds and hollows alike. The bleached tuff with a fine cream-coloured base contains rare ovoid lapilli 6mm. long of glistening grey or black pumice, fine-grained grey angular lava fragments 10mm. long, some with felspar phenocrysts, isolated felspar crystals and chips of black glass 3mm. long. Inspection shows the base to contain abundant small striated pumice relics rotted to a lemon-yellow dust, the same form of alteration affecting the margins of the larger pumice lapilli.

The lateral equivalent of the bedded soils and pumice of the plain is the weathered product of the finer-grained material from the same pumice showers which was transported farther afield, and is now exposed along the foot of the scarp and at various localities on the scarp slope. In the outcrops on the slopes the bedding parallels the underlying ground surface and at the foot of the scarp slope several hundred feet of deposits accumulated locally. These have proved particularly susceptible to weathering, and very rarely are relics of pumice seen in the higher beds. The ash-fall deposits are now represented by bedded clays and soils, some retaining sandstone textures, and rarely, more consolidated members display "ghost" fragments of pumice. Complete gra-

dations from beds of fresh glistening grey pumice through yellow rotted pumice beds to soils and clays can be demonstrated in roadside exposures two to three miles south-west of Njoro, and in a river gully three miles west-north-west of Kampi ya Moto.

These beds have also proved particularly prone to severe erosion. Scouring has frequently removed up to 100 feet of bedded soils and clays, locally producing vast amphitheatres with nearly flat floors and vertical walls. Differential erosion of beds of slightly differing compaction has produced steeply terraced walls and pillars, and weirdly sculptured forms. Elsewhere severe badland topography and deep ravines have developed. These distinctive land forms occur at intervals around the foot of the scarp from the flanks of Kilombe to Egerton College, three miles south of Njoro.

Spectacular examples of erosion are also seen in the river gully three miles west-north-west of Kampi ya Moto, beneath and to the east of the railway five to six miles north-west of Rongai, and on the interfluvies four miles south-west of Rongai.

(3) MENENGAI PUMICE

Much of that part of the Rongai Plain nearest Menengai, from north of Njoro to south of Kampi ya Moto, carries a mantle of uncompressed pumice. Owing to its completely unconsolidated and uncemented nature it forms no features and natural exposures are virtually non-existent. Tracing the outcrop of the formation is not difficult however, as due to limited soil overburden road and rail tracks expose pumice in shallow cuttings and drainage gullies. Elsewhere empty silage pits proved a valuable source of information.

The pumice is glistening pale green grey or silver grey in colour and occurs in roughly equidimensional lapilli. In ovoid fragments a distinct striation and elongation of vesicles parallel to the long axis occurs. The lapilli vary in size from one to ten millimetres in diameter, with the coarser fragments occurring in beds on the plain towards the eastern margin. The deposits are horizontally banded in units of six inches to two feet, and within units fragments are remarkably uniform in size. This reflects the mode of deposition from pumice showers within which a high degree of sorting occurred. The deposits are remarkably homogeneous also, usually containing pumice lapilli only, but sometimes including a small proportion of minute chips of black glass. Successions of more weathered beds show layers of fresh pumice alternating with layers of yellow or chocolate coloured soils, rich in pumice lapilli.

Exposures of bedded pumice in roadside banks, shallow rail cuttings and gullies are extensive on the east of the plain, particularly in the disused rail alignment from six miles south of Kampi ya Moto to the eastern boundary, and in the Kampi ya Moto-Nakuru road from three miles south-west of Kampi ya Moto.

Good exposures of bedded unconsolidated pumice are shown in the low scarp four miles north-east of Njoro, attributed to erosion of deposits burying a hidden fault scarp. The layers show a persistent easterly dip of some 10° . Towards the top of the succession a more compact, fine-grained greenish tuff horizon with rare pumice lapilli occurs. The thin section (42/1010) shows pellets of included lava, occasional feldspar crystals, and vesicles of pumice infilled with laths of vapour-phase minerals, recognized as feldspar and aegirine-augite.

(4) SEDIMENTS OF RIFT VALLEY FLOOR AND KILOMBE

Capping a low hill eight miles south of Njoro are bedded deposits including sedimentary horizons, which are well exposed in the motor track skirting the summit. The feature is interpreted as a tilted horst developed as a result of grid-faulting. The deposits consist mainly of khaki yellow bedded tuffs with rotted yellow pumice fragments, averaging 5mm. across but which occasionally reach 30mm. and rare chips of black

glass. The outcrops weather into flaggy pavements of pock-marked slabs with a persistent dip of 8° to 10° to the east. Poor and scattered exposures on the sloping plain to the east and north-east point to similar rock types in that locality.

The sediments which formed in the old crater-lake of the Kilombe vent attained a thickness of over 400 feet. Only at the lip of the waterfall, where the drainage streams of the crater funnel into a deep gorge, are medium-grained tuffs seen, the succession above providing limited exposures mainly of finely laminated clays, with occasional well cemented bands. Gently terraced banks suggest a cyclic repetition during deposition, with some two to three feet of finely laminated grey and white clays overlain by up to six inches of fine-grained tuff with a compact and firmly cemented one inch capping. The clays are preferentially eroded and occur in diminutive cliff features while the harder bands provide cobbled pavements, perfectly horizontal and often over ten feet wide.

Exposures at the foot of the waterfall are also of sediments, being finely banded pale brown grits and clays, displaying infilled mud-cracks and cross-bedding.

(5) SEDIMENTS OF MAU SUMMIT

A large area of poor exposure in the region of Mau Summit is caused by a mantle of fine-grained pyroclastic debris now weathered to a sequence of bedded clays.

Before the Molo River cut back from the east and the Kedowa River from the west the level area was probably more extensive, and served as a depository not only for direct ash-fall material but also for debris washed down from the higher ground to north and south. Pools formed locally, and much of the material is consequently waterlain. Exposures are poor but bedded clays and soils with iron-clay horizons can be seen near the the road-river crossing three-and-a-half miles north-north-west of Molo and in the road quarry and exposures down towards the river, one-and-a-half miles north of Molo. In a dam in the forest two-and-a-half miles north-north-east of Molo bedded deposits of sandstone grade are exposed in the spillway. Exposures of apparently waterlain material are displayed in a road cutting two miles north of Mau Summit, where 50 feet of gently undulating bedded ashes and tuffs are displayed.

VI—STRUCTURE

The western wall of the Rift Valley divides the Molo area into two unequal units; the larger, the highlands of the rift shoulder to the west, and plains of the rift floor to the east.

Unfortunately little direct evidence can be obtained regarding the style and age of faulting as the greater part of the pyroclastic deposits post-dates the major periods of rift formation, and considerable pyroclastic activity continued until relatively recent times. Even on the eastern margin, at which longitude Recent grid-faulting is well-displayed to the north of the Equator, a deep mantle of unconsolidated bedded pumice from Menengai obscures most of the evidence of tectonic activity.

As the Molo area includes the western wall of the Kenya Rift Valley at the latitude corresponding to the transverse Kavirondo Rift Valley one might anticipate information on the mode of rift formation from the site of their junction. The evidence suggests however, that the complex tectonic pattern at depth has produced an area of crustal weakness particularly amenable to exploitation during periods of volcanic activity, and no evidence of a junction between the north-south and east-west rift structures is seen. The area includes the major fissure volcanoes of Mount Londiani and the Mau (the latter extending out of the area to the south), the central type volcanoes of Kilombe and Tinderet (the latter centred just west of the north-west corner of the map), plugs marking ancient volcanic vents at Mount Blackett and also in the Nyando Valley, the late-stage basalt vents of Lessotet, Limutet and others on the plain north of Londiani,

and the Menengai Caldera at the eastern margin, apart from others which may not have been recognized or may be buried beneath later deposits. The accumulated deposits from these sources result in this area being the highest on the western shoulder of the rift, and quite possibly carrying the greatest depth of volcanic material on the valley floor.

Some 15 to 20 miles north of the Equator, which defines the northern boundary of the Molo area, the fault zone responsible for the major downthrow, and hence considered to define the western margin of the Rift, extends north-south between longitudes $35^{\circ}36'$ and $35^{\circ}40'$ east.

The steep eastern aspect of Mount Londiani, although a lava-faced fault scarp rather than a fault-line, indicates the position of a major fault buried beneath rift floor deposits to the immediate east. This feature also dies abruptly to the south where, before the latitude of the main road, post-faulting pyroclastic and lava deposits are banked against the slope. To the west of Njoro and Elburgon the easy gradient of the western wall of the Rift is interpreted as a gently terraced slope, with the total downthrow shared between several faults, and carrying a thick mantle of later pyroclastic deposits. This region demonstrates an offset to the east in the position of the western Rift wall, with minor fault features assuming a north-north-westerly trend. At the southern boundary the two most distinct fault scarp slopes pass out of the area between longitudes $35^{\circ}54'$ and $35^{\circ}57'$ east.

In attempting to date the rift faulting in this area one is hampered by lack of direct evidence. However, geologists working in better exposed country to north and south have reached conclusions which, although showing a range of different interpretations, provide a fair consensus of opinion in favour of the initiation of rift formation in Miocene times, probably sited along a topographical low (Pulfrey, 1960, p. 12; McCall *et al*, 1967, p. 196).

Similarly there is general agreement that tectonic activity was renewed in Middle or Upper Pleistocene times with development of a pattern of grid-faults and the production of many minor horsts and graben on the rift floor. Faulting has recurred on a small scale, mainly as renewed movement along pre-existing lines of weakness, sporadically to the present day. Thus the major north-south fault, whose receded lava-faced scarp forms the eastern aspect of Mount Londiani, should probably be referred to the original rift faulting of Miocene age.

The complex of small faults downthrowing either east or west on the scarp slope near the main road in the centre of the area, together with the pronounced graben features which carry the Njoro River, and the Njoro-Mau Narok roads in the south-east, should be referred to the later stage of grid-faulting, in Middle or Upper Pleistocene times. Also to be tentatively included in this group are the faults upthrowing the lava horsts of the Rift Valley floor in the extreme north-east.

In this context it is significant that of the 1,400 feet drop in the base of the lava flow, between the road cutting at the Jolly Farmer Hotel north-east of Molo township and the exposures near the Molo River bridge at the foot of the scarp slope, only some 500 feet is apparently the result of the accumulated downthrow of all faults, the remainder representing the original substantial dip of the lava flow.

The faults on the Rongai Plain, those etched by the Molo, Njoro and Rongai rivers, and that forming the scarp on the eastern boundary north-east of Njoro, are probably of even later movement. Faults of the latter two age groups are largely implied from evidence on aerial photographs. In the graben in the south-east the features are most pronounced, particularly the west-facing walls, but exposure is sporadic in the streambeds and almost non-existent in the scarps and on the surrounding hill tops.

VII—ECONOMIC GEOLOGY

1. Building Materials

Building Stone

The main geological resource of the area is building stone, which is quarried from the Mogotio tuffs, the Elburgon black ash, and various local well-cemented horizons in bleached tuffs and agglomerates, but mainly from eutaxitic welded tuffs. A single stone quarry is operated on the outcrop of the quartz-trachyte three-and-a-half miles west-south-west of Londiani.

The Kedowa stone is of high quality, and is much favoured owing to the proximity of its outcrop to the railway, and the lack of superior stone nearer to Kericho and Kisumu. Tea plantations at Kericho often utilize Kedowa tuff. It is of interest that some farmers in the Elburgon district allow poor quality stone (Elburgon black ash) to be quarried on their land for use by people living lower down on the Rongai Plain and less fortunately situated with regard to supplies of building stone, while themselves transporting superior stone from quarries in eutaxitic welded tuff outcrops nearer Molo.

Pozzuolana

Interest has been shown, particularly by the Homa Lime Co., in the natural cementing properties of various weathered ashes and tuffs west of the Rift. Samples of five different rock types from three different localities in the Kedowa-Keriso area were collected, and preliminary testing indicated that all possessed pozzuolanic qualities. Again, with transport the limiting factor, there is no great potential for this material until major constructional development is undertaken locally.

2. Water

Borehole Data

A great many boreholes have been drilled for water in the cultivated part of the area, particularly for farms near Elburgon, in the vicinity of Mau Summit, and on the poorly watered Rongai Plain. Search for water has met with varying success, failures being particularly common in the region of Kampi ya Moto, where the water-table lies at a considerable depth (McCall, 1957B, p. 39).

A summary of borehole information extracted from the records of the Water Development Department, Nairobi, follows.

Borehole Records

No.	Locality	Depth (feet)	Water struck (feet)	Rest level (feet)	Yield (gallons per hour)
C61 ..	Mau Summit	352	219, 238, 325	285	300
C62 ..	S.E. of Rongai	466	—	—	Dry
C63 ..	S.W. of Rongai	350	343	176	250
C67 ..	Mau Summit	300	?	?	60
C68 ..	Mau Summit	375	365	?	60
C69 ..	Mau Summit	402	390	302	500
C108 ..	Turi	130	75	65	500
C131 ..	Turi	150	120-148	43	1,500
C132 ..	Turi	150	138-140	52	200
C147 ..	W. of Rongai	318	160, 233	69	155
C148 ..	W. of Rongai	254	?	88	90
C196 ..	E. of Rongai	400	380	205	1,000
C202 ..	S. of Njoro	450	435	124	2,000
C205 ..	S. of Njoro	460	380	340	150
C208 ..	W. of Njoro	655	—	—	Dry
C211 ..	Njoro	444	305	295	400
C214 ..	N.E. of Njoro	400	210	180	650
C220 ..	S. of Njoro	500	470	110	1,800
C223 ..	S. of Njoro	613	350, 500, 570	175	1,440
C241 ..	Molo township	400	140, 270	70	240
C258 ..	W. of Njoro	348	300-348	182	2,300
C272 ..	Keringet	235	215	42	500
C273 ..	Keringet	416	370	280	2,040
C277 ..	N. of Keringet	428	380	300	2,080
C288 ..	N.E. of Elburgon	600	350	269	70
C293 ..	E. of Rongai	415	390	375	900
C322 ..	S. of Kilombe	600	—	—	Dry
C327 ..	S. of Njoro	449	130, 350, 375 -449	116	2,400
C329 ..	Molo township	318	270-290	24	2,200
C330 ..	W. of Molo	300	240	51	620
C332 ..	Keringet	504	470	230	500
C333 ..	Keringet	272	170, 235	80	700
C334 ..	Keringet	406	390	200	2,550
C344 ..	N. of Keringet	453	435	270	2,100
C349 ..	W. of Five Mile Post	425	390	90	670
C351 ..	Five Mile Post	600	?	120	203
C375 ..	N.E. of Elburgon	200	130	?	2,700
C376 ..	Elburgon	300	230-265	120	2,500
C379 ..	N. of Elburgon	245	220	Artesian	2,280
C422 ..	Molo township	260	150-260	130	2,900
C423 ..	N.E. of Elburgon	700	640-680	210	1,700
C476 ..	N.E. of Molo	330	211-235	140	720
C485 ..	Njoro	394	275	210	3,000
C501 ..	S. of Kilombe	350	265	221	650
C502 ..	N.E. of Molo	500	253, 290, 450 -500	177	1,040
C503 ..	N.E. of Molo	520	—	—	20
C516 ..	E. of Molo	630	410, 550, 615	338	900
C541 ..	S. of Kilombe	400	280, 300, 317 332, 365	223	620
C557 ..	S.W. of McCalls Sidings	560	—	—	Dry
C576 ..	Esageri	400	—	—	Dry

Borehole Records—(Contd.)

No.	Locality	Depth (feet)	Water struck (feet)	Rest level (feet)	Yield (gallons per hour)
C591 ..	S. of McCalls Sidings ..	270	—	—	Dry
C615 ..	S. of McCalls Sidings ..	820	—	—	Dry
C624 ..	E. of Elburgon ..	300	200	200	1,342
C641 ..	S.W. of Kampi ya Moto ..	406	345, 397	337	1,100
C642 ..	N. of McCalls Sidings ..	550	—	—	Dry
C648 ..	E. of Eburgon ..	750	—	—	Dry
C655 ..	E. of Eburgon ..	490	425-490	249	1,200
C665 ..	N. of Elburgon ..	670	455	450	25
C666 ..	E. of Rongai ..	518	480-500	430	1,300
C680 ..	Kampi ya Moto ..	602	—	—	Dry
C711 ..	Esageri ..	464	195, 380, 455	155	1,200
C741 ..	S.E. of Teret ..	438	170-410	140	300
C745 ..	S. of Njoro ..	600	445	316	412
C793 ..	N. of Elburgon ..	972	824	550	1,000
C799 ..	S. of Rongai ..	551	92-195	82	1,300
C802 ..	S.E. of Rongai ..	360	264	212	2,000
C803 ..	S.E. of Rongai ..	599	527	510	1,300
C827 ..	S.E. of Rongai ..	250	130-204	109	1,300
C916 ..	S. of Njoro ..	700	423, 512-700	387	800
C958 ..	Mau Summit Station ..	550	550	66	1,200
C984 ..	N. of Elburgon ..	351	188, 295	130	1,800
C985 ..	S.E. of Rongai ..	495	481	475	600
C991 ..	S. of Kilombe ..	397	120, 280	135	900
C1021 ..	Elburgon ..	390	198	69	3,150
C1033 ..	Elburgon ..	600	201	113	2,720
C1036 ..	S. of Kampi ya Moto ..	610	—	—	Dry
C1040 ..	N.E. of Rongai ..	442	400-425	392	1,800
C1089 ..	N.W. of Njoro ..	800	—	—	Dry
C1125 ..	Njoro ..	410	355-390	263	2,820
C1142 ..	Molo ..	453	?	?	2,500
C1296 ..	S. of Kilombe ..	310	90, 255, 280	62	2,100
C1307 ..	Mau Summit ..	420	95, 160, 320	75	412
C1308 ..	N. of Molo ..	400	100, 250, 360	23	900
C1314 ..	E. of Rongai ..	500	395-445, 470-485	360	2,200
C1325 ..	N.E. of Elburgon ..	630	360, 615, 630	295	950
C1329 ..	Mau Summit ..	450	140, 250, 350	80	450
C1334 ..	Rongai ..	410	120, 390	70	2,100
C1362 ..	N.E. of Njoro ..	655	640	575	1,000
C1364 ..	N.E. of Mau Summit ..	570	520, 570	520	1,760
C1386 ..	N. of Molo ..	500	150, 225, 450	110	400
C1460 ..	S. of Rongai ..	218	52, 166	20	2,400
C1461 ..	S. of Rongai ..	196	120, 180	38	2,000
C1462 ..	Rongai township ..	200	41, 180	38	2,400
C1463 ..	Rongai township ..	365	68, 150, 330	45	2,100
C1474 ..	N. of Molo ..	400	350	130	1,100
C1491 ..	Njoro ..	532	352, 496	280	2,300
C1504 ..	Turi ..	535	483	300	80
C1585 ..	S. of Njoro ..	510	305	285	300
C1638 ..	Mau Summit ..	505	470	435	1,030
C1641 ..	N. of Elburgon ..	600	445	250	1,350
C1647 ..	S.W. of Rongai ..	717	167, 421, 680	120	1,000

Borehole Records—(Contd.)

No.	Locality	Depth (feet)	Water struck (feet)	Rest level (feet)	Yield (gallons per hour)
C1750 ..	N. of Rongai	361	275, 335-350	241	3,000
C1809 ..	W. of McCalls Sidings ..	608	—	—	Dry
C1867 ..	N.E. of Molo	633	570-590	518	1,000
C1869 ..	S. of Rongai	410	320-410	210	750
C1873 ..	N.E. of Molo	737	680	502	300
C1888 ..	N.W. of Londiani	374	330	160	3,500
C2099 ..	E. of Molo	565	260	274	420
C2152 ..	S.E. of Kilombe	660	—	—	Dry
C2157 ..	Mau Summit	770	642	572	2,200
C2181 ..	Mau Summit	750	730	250	1,200
C2226 ..	Mau Summit	760	645	600	240
C2276 ..	S. of Njoro	450	228, 355, 434	108	2,000
C2281 ..	E. of Molo	435	300-400	250	960
C2286 ..	N.E. of Molo	650	620	390	2,000
C2323 ..	Mau Summit	375	270, 330	180	1,500
C2346 ..	Rongai township	202	70, 140, 180	46	1,000
C2366 ..	Mau Summit	416	350-380	300	3,000
C2428 ..	Mau Summit	676	150, 420, 620	132	1,200
C2448 ..	E. of Teret	949	630, 800, 920	515	1,600
C2505 ..	Molo township	600	100, 400-450	80	500
C2532 ..	N. of Menengai Halt ..	930	600, 785	598	1,400
C2553 ..	Molo township	550	220, 420	220	1,500
C2563 ..	S. of Rongai	284	160	67	3,000
C2564 ..	N. of Elburgon	718	346, 520, 630	352	3,000
C2579 ..	Keringet	542	160, 420, 485	50	3,000
C2640 ..	N. of Keringet	752	200, 644, 730	534	1,300
C2641 ..	S. of Kerisoi	615	450, 505, 610	318	1,300?
C2665 ..	Kedowa	632	—	—	Dry
C2678 ..	Kedowa	450	385, 425	140	550
C2680 ..	Molo	280	260	160	300
C2692 ..	W. of Londiani	410	208-390	153	2,000
C2693 ..	N.W. of Londiani	450	360	200	1,200
C2700 ..	N. of Kerisoi	560	260-520	159	520
C2726 ..	Kedowa	404	120, 312, 404	80	220
C2795 ..	S. of Njoro	230	180	25	500
C2808 ..	N. of Londiani	277	270	257	600
C2809 ..	N. of Londiani	240	40	?	360
C2810 ..	N. of Londiani	140	50	?	260
C2831 ..	N. of Londiani	520	500	52	650
C2832 ..	Mau Summit	176	160	90	240
C2853 ..	S.W. of Rongai	582	540	330	650
C2879 ..	N.W. of Molo	100	—	—	Dry
C2880 ..	N.W. of Molo	240	—	—	Dry
C2882 ..	Molo township	750	270-750	320	2,200
C2894 ..	S. of Njoro	592	64, 293, 553	33	1,000
C2938 ..	N.W. of Londiani	178	178	90	250
C2973 ..	Molo township	739	720	162	700
C2985 ..	N.W. of Londiani	476	220-445	256	2,000
C2995 ..	Five Mile Post	400	?	?	100
C3005 ..	Elburgon township ..	407	?	?	4,000
C3072 ..	Mount Blackett	608	60, 340 480-580	24	3,600
C3076 ..	Kedowa	600	240, 477, 578	83	3,000
C3150 ..	N.W. of Molo	465	440	126	2,500

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