7. *The* Miocene Beds *of the* Victoria Nyanza *and the* Geology *of the* Country *between the* Lake *and the* Kisii Highlands.

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[Plates XX–XXX.]

Contents.

I. Introduction.

In the winter of 1911 I undertook a journey to the Victoria Nyanza on behalf of the British Museum, in order to investigate some beds of Miocene age, discovered in 1909 by Mr. G. R. Chesnaye while prospecting near Karungu on the eastern coast of the lake. He discovered fragments of bones and of Chelonian carapaces in low cliffs capped with basalt, situated a few miles to the south-east of Karungu. Mr. C. W. Hobley, C.M.G., H.M. Provincial Commissioner, who has made important researches in the natural history and anthropology of British East Africa, immediately realized the significance and importance of the discovery, and induced the late Mr. D. B. Pigott, a Government official, to undertake a search for further specimens. As the result of his efforts, he forwarded to Mr. Hobley a portion of the left ramus of the mandible, some teeth, and the patella and calcaneum of a *Dinotherium*, together with fragmentary remains indicating the presence of a small Rhinoceros *(Aceratherium)*, *Trionyx*, *Testudo*, and some Crocodilian remains.

Mr. Hobley presented these fossils to the British Museum, and Dr. C. W. Andrews, F.R.S., described and figured the remains of the *Dinotherium*, which he named *D. hobleyi*, in the Proceedings of the Zoological Society for 1911 (pp. 943–45 & pl. xlviii), regarding the species as very similar to *D. cuvieri* Kaup, of the Lower and Middle Miocene of France, especially characteristic of the Burdigalian horizon.

Unfortunately, nothing was known of the circumstances of the discovery, for Mr. Pigott was shortly afterwards killed by crocodiles, when his raft was upset by a hippopotamus that he had wounded. Accordingly, I offered to utilize my leave by going out to Africa, in order to make a thorough investigation of the locality and to collect specimens for the British Museum.[1]

The time at my disposal for the actual work was short, owing to the lengthy voyage: only two months remained for me to carry out the examination of the entire district, and to search for further outcrops of the beds, to describe, measure, and correlate the strata in the different exposures, to collect and extract fossils and to determine horizons, to make plans to scale of the chief outcrops and a map of the neighbourhood, as well as to take a series of illustrative photographs of the beds.

Contrary to expectation, there was no definite bone-bed: isolated bones only occurred at wide intervals, and nearly always in a fragmentary or shattered condition; hence it was practically useless to employ native labour.[2]

I am greatly indebted to Dr. C. W. Andrews and to Mr. R. B. Newton for their reports accompanying this paper on the Vertebrata and on the Mollusca respectively.

II. Description of the Miocene Series of the Victoria Nyanza.

Broadly speaking, the entire series of these lacustrine sediments may be classified into the following three groups, according to their dominant character; but there is no unconformity or discontinuity

[1] At the instance of Dr. A. Smith Woodward, F.R.S., the expenses of the journey were defrayed by subscription, chiefly by the generosity of Mr. Charles Storey, F.G.S., and also by the late Rev. R. Ashington Bullen, Sir Henry Howorth, F.R.S., Dr. G. B. Longstaff, Dr. A. Smith Woodward, Mr. W. Heward Bell, Mr. H. R. Knipe, the late Mr. W. H. Sutcliffe, and Mr. W. E. Balston; and I also received special facilities for railway-transport in British East Africa by kind permission of the Secretary of State for the Colonies.

[2] The district is malarious, and lies in the heart of an area devastated by sleeping-sickness. All reconnoitring has to be undertaken on foot, for no horse can live in this country of the tsetse-fly; the season happened to be phenomenally hot, even for this Equatorial district, the shade-temperature averaging 95° Fahr. and sometimes reaching 110° Fahr. Sir Percy Girouard, then Governor of British East Africa, kindly placed the little Government schooner at my disposal, thus enabling me to save time in reaching Karungu from the railhead at Kisumu. I have also great pleasure in acknowledging with gratitude the ready assistance and hospitality of Mr. C. W. Hobley, C.M.G., H.M. Provincial Commissioner at Nairobi, Mr. John Ainsworth, C.M.G., H.M. Provincial Commissioner at Kisumu, Mr. D. C. Crampton, H.M. District Commissioner at Kisii, and Dr. B. W. Cherrett at Kisii; and in tendering my thanks to Mr. Waller, H.M. Director of Government Transport, who rendered me much assistance on my arrival at Mombasa.

of sedimentation to be observed anywhere in the series, although changes in character are frequent:—

(1) An upper series (average thickness=70 feet) of grey and brown clays and shales, containing very few fossils. Beds of sandstone are of rare occurrence.
(2) A middle series (average thickness=30 feet) of variable red and grey clays, with white sandstones in the lower half.
(3) A lower series (average thickness=55 feet) of buff-coloured sandstones and torrential gravels (containing the *Dinotherium* Zone), passing down (at Nira) into clays and marlstones.

Travertinous beds occur at intervals throughout the whole series.[1] The exposures are in gullies and cliffs at Nira, Kachuku, and Kikongo, to the east of Karungu (see Pl. XXVI, and § III on the Distribution of the Miocene Series, p. 135).

(1) The upper series (Beds 1 to 12) forms a natural division, consisting mainly of pale-grey, sometimes brownish-grey clays, which frequently alternate with thin seams of shale (often with dendritic manganese oxide). Chiefly in the upper part (for instance, Nos. 3, 5, & 8, but also No. 11 at South Nira) beds of grey, fine-grained, argillaceous sandstones occur, usually current-bedded—generally about 3 feet thick and exceptionally (No. 3 at East Kachuku) 10 feet thick (see Pl. XX). They are composed of quartz-grains, large plates of biotite, and augite-crystals.

Fossils are extremely rare in this upper series, and usually occur only in the sandstones; for instance, a few land-shells in No. 8 (*Tropidophora nyasana* E. A. Smith, *Limicolaria*, *Cerastus*), an *Ampullaria* and a crocodile's tooth in No. 5, and an indeterminable river-crab and some Crocodilian scutes in the clay of No. 12 at Nira. At the very top of the series, immediately below the capping of nepheline-basalt, the grey clay of No. 1 contains portions of calcified tree-trunks ranging up to 1 foot in diameter and 1½ foot in length, of Dicotyledons. They have been examined under the microscope by Miss N. Bancroft, who finds that the specimens represent types belonging to the Malvaceæ (similar to the African *Bombax insigne*), to the Geraniales (*Humiria*), to the Papilionales, and to the Caprifoliaceæ (similar to some species of *Lonicera* and *Viburnum*). Since one of these stems, in the same state of mineralization, occurred embedded in the lower brecciated portion of the basalt-flow at Kachuku, it seems probable that they had been fossilized by the agency of calcareous springs at the time of the deposition of the grey clays, and before the eruption of the basaltic lava-flows.

Thin beds of travertine alternating with grey clay are characteristic of the horizon of Nos. 9 & 10 in the eastern area, but do not occur at Nira in the extreme west.

Immediately below the sandstone of No. 8 at Kikongo, in the extreme east of the area, a breccia (1 foot thick) occurs of coarse

[1] The detailed measurements and descriptions are given in the comparative table of the outcrops exposed in the various gullies, Appendix I.

grey sandstone with angular and but slightly rolled fragments (measuring up to an inch and a half in diameter) of pink and grey gneiss, green andesite, and quartz, all derived from the country farther east, which seems to point to fairly-close proximity of the land. Here, too, at Kikongo, at the base of No. 12, another bed of sandstone occurs, which is not found farther east.

(2) The middle series (Beds 13 to 25) is much more varied in character, and fossils are more frequent. In general, the tendency of the clays to become red is very marked; thin beds of travertine occur at intervals, and sandstones and gravels prevail towards the base.

Transitional conditions are indicated by No. 13, which consists of about 5 feet of greenish-grey clay (sometimes speckled with flakes of biotite), with intercalary layers of pink concretions. Some fragmentary Chelonian remains (ribs and scutes of *Trionyx*) and a large Artiodactyl astragalus were the only fossils obtained at this horizon.

The most persistent bed in the whole of the Miocene Series is No. 14, which constitutes a marked physical feature, giving rise to a nearly level terrace, fairly wide at Nira and forming the upper edge of a small cliff. Typically this bed consists of a dull-red hard marlstone, passing occasionally either into impure travertine or more rarely into a soft clay. In places it is mottled red and grey; usually it is only 6 inches thick, but it may swell out to 18 inches, and is traversed by vertical joints filled with calcite and limonite. The upper surface of the terrace presents the appearance of an irregular pavement of bricks. At the extreme east (Kikongo) it has lost its redness, and has become dark grey. It is characterized by numerous casts of *Ampullaria ovata* and *Lanistes carinatus*, also opercula of the former, together with fragmentary Chelonian and Crocodilian remains. A similar bed yielding similar fossils occurs with less constancy in the upper part of No. 15, which consists of rapid alternations of red clay and thin layers of pinkish-white calcareous concretions, somewhat resembling lösspüppchen. Probably they were formed by gentle currents disturbing the deposits from calcareous springs in a muddy lagoon. The redness of the clay is inconstant, and frequently passes into a grey or greenish-grey. No. 15 thins out eastwards.

Nos. 13, 14, & 15 form essentially a natural group (10 to 12 feet thick) separated from a somewhat similar group (Nos. 18, 19, & 20, 8 to 12 feet in all), in which red clay predominates (with numerous inconstant seams, 1 to 2 inches thick, of argillaceous travertine), by a very constant horizon (1 to 2 feet thick) of Nos. 16 & 17. In No. 16 (see Pl. XXI), a grey argillaceous sandstone, I found a very few but interesting jaw-bones of a small new type of Hyracoid (*Miohyrax oswaldi*), with *Ampullaria ovata*, scutes of *Trionyx* and crocodile. No. 16 overlies a sandy clay (No. 17), the last-named bed enclosing an occasional seam of sandstone with similar Crocodilian and Chelonian remains, all in a very fragmentary condition. Fossil bones are a little more frequent in the lower part (Nos. 18

to 20) of the series, and coprolites (probably Crocodilian) are characteristic of these beds. No. 20 at Nira displays an interesting instance of a contemporaneous water-channel in the underlying clay, now filled up by a buff-coloured sandstone.

Nos. 21 to 23 form another natural group, consisting of pale-grey or even white sandstones, current-bedded, and sometimes exceedingly hard. Towards the east they become argillaceous, and even pass laterally into grey clays (at Kikongo), mottled sometimes with red. Where the sandstone becomes gravelly, the constituents are usually of grey sandstone (apparently derived from older beds in the Miocene Series), together with quartz, ironstone, green andesite, and pink gneiss. In the lower sandstone (No. 23) of Nira I noticed a number of stylolithic concretions, lying adjacent one to the other, each consisting of spiral coats, and probably due to some special conditions of contraction during consolidation. As soon as the beds become more arenaceous fossils occur more frequently, and in the hard sandstone (No. 22) of Kachuku I found the tibia of a Proboscidean somewhat resembling that of *Dinotherium*, associated with *Ampullaria* and a *Podocnemis*. Chelonian and Crocodilian remains occur in all the sandstones of this series, and I was able to restore a nearly complete carapace of *Cycloderma victoriæ* (from about a hundred pieces) occurring in the white sandstone of No. 21.

Nos. 24 & 25 form a natural group, composed of a fine orange gravel (No. 24) overlying a greenish-grey clay with seams of cellular travertine. The gravelly sand is only a few inches thick (3 to 9 inches), but constitutes a very definite horizon. It is of special interest for containing teeth, not only of Crocodile and *Dinotherium*, but also of *Protopterus* (which has not, I believe, been found hitherto in a fossil condition) and of rodents similar to *Phiomys*. The underlying greenish-grey clay of No. 24 contained opercula of *Ampullaria* and fairly numerous shells of *Cleopatra exarata*. The grey clay of No. 25 (sometimes reddish towards the west) contains remains of *Trionyx*, coprolites, and part of a tusk, probably of *Dinotherium*.

(3) The lower series (Nos. 26 to 37) includes beds of a more torrential character than the preceding.

Nos. 26 to 29 form a variable series (7 to 8 feet thick) of sandstones and gravels, becoming coarser and more calcareous towards the base; the constituents comprise not only grey sandstone, quartz, pink gneiss, and green andesite, but also jasper. At Kachuku No. 28 forms a coarse, nodular, calcareous conglomerate, and most of the pebbles have a calcareous coating; it often contains large lumps (measuring up to 2 feet in diameter) of yellow marlstone, evidently derived from a lower bed, enveloped in several concentric coatings of carbonate of lime. Fossils are very sparing and fragmentary in these gravels, and mainly consist of Chelonian and Crocodilian remains with coprolites and a fragment of *Dinotherium*-tusk. The beds of gravel are lenticular and inconstant, and in the gully of South Nira Nos. 28 & 29 are altogether absent.

This group of gravels rests upon a remarkably persistent conglomerate (No. 30) of calcareous nodules (but not extending far to the east of Kachuku), passing in places into a nodular sandstone of such hardness that, where it has been undercut by the action of temporary waterfalls in the gullies, it only breaks off in large slabs measuring 12 by 4 feet or thereabouts (Pl. XXII, fig. 1). In some cases I found a nodule, with its many concentric coats, containing a fossil, such as a *Trionyx* scute, for a nucleus; but often no definite nucleus could be traced. The nodules have not been sorted according to size, but lie haphazard in a white calcareous cement, from small pebbles up to boulders 2 feet in diameter. They are always, however, ellipsoidal like river-pebbles and, when they are fractured, the fracture-planes prove to be frequently coated with dendritic manganese.

Below this conglomerate occurs a very variable group (No. 31) of grey or brown clay with *Ampullaria ovata* Olivier and *Cleopatra bulimoides* Olivier, brown seams of marlstone, and calcareous conglomerate at the western end (at Nira) of the outcrop; but towards the east, at Kachuku, this group (only exposed in a narrow gully) consists of 6 feet of grey clay overlying 14 feet of hard buff-coloured sandstones, current-bedded and having streaks of pebbles, very similar to the Triassic pebble-beds at Nottingham. They enclose two zones of gravel composed of overlapping lenticular beds (the pebbles consisting simply of quartz and ironstone), and it was only in these hard gravels that bones occurred, often much shattered and fragmentary, and at wide and uncertain intervals.

The upper gravel zone immediately underlies a discontinuous layer of yellow marlstone (Pl. XXII, fig. 2), and is particularly characterized by remains of *Dinotherium* and Anthracotheres (*Brachyodus*, *Merycopotamus*, *Merycops africanus*, etc.), Rhinoceros, a Carnivore (*Pseudælurus africanus*), part of the carapace of a giant Tortoise (*Testudo*), *Trionyx*, Crocodile, and a land-shell (*Cerastus mœllendorffi*).

In the lower gravel zone only much shattered Chelonian remains were present. Grey travertine, 2 feet thick, is visible at the base of this zone.

Nos. 32 to 36 form a variable group of brown clays, alternating with orange-brown marlstone (32 & 34) containing *Ampullaria* and *Cleopatra*, and often exhibiting small cavities lined with calcite-crystals. At West Kachuku this group passes into brown clay with layers of travertine, overlying a buff-coloured sandstone enclosing streaks of gravel and lenticles of travertine. This in turn overlies an orange-brown marlstone containing so much angular quartz that it becomes a quartz-ironstone breccia, facing the Kuja Plain in a low cliff at West Kachuku.

Finally, the lowest bed (No. 37) is a mottled dark-crimson and yellow clay (6 to 12 feet) overlying (at Nira) a dark-green amphibolite [1] belonging to the basement-floor of schists and gneisses, upon which these Miocene beds were deposited. (See § IV, p. 138.)

Summary of Physical Conditions.

The quartz-ironstone breccia was probably derived from the weathered products of the old land-surface, which must have accumulated to a great thickness before the transgression of the lake formed the lagoon in which the Miocene Series was deposited. Therewas doubtless a more or less steady subsidence throughout the period of deposition, rapid at first and gradually diminishing in intensity. To these earth-movements may be ascribed the formation of the quartz-veins which traversed not only the basement of amphibolites, but even penetrated for a short distance into the lowest clays (at Nira), accompanied by ferruginous thermal waters reddening the basal clays. Calcareous springs were also active, especially in the lower section of the deposits, but travertine was formed intermittently up to the top of the whole series. The torrential character of the sediments brought down by a large river (probably the precursor of the present Kuja) is prevalent in the lower series, as shown by the frequent alternation of current-bedded sandstones with beds of gravel at Kachuku; but farther west, at Nira, the older part of the same period is represented by a prevalence of clays and marlstones, while on the east the whole series is missing. The upper part of the lower series is marked by the formation of beds of calcareous nodules, showing the existence of fairly strong currents, capable of rolling along and keeping in constant movement large and heavy nodules up to 2 feet in diameter in the lime-laden waters of the lagoon or shallow gulf. This was followed by a well-marked torrential period of calcareous gravels, the constituents of which were derived, not from the south, but from the east.

The middle series marks a transitional period when the new river-system was becoming mature, wherefore torrential deposits are exceptional and temporary, forming only thin beds of fine gravel. White or pale-grey current-bedded sandstones are characteristic of the commencement of this series, but there is a continually increasing tendency to deposit finer and yet finer sediments until red clays predominate, interrupted by travertinous layers and more rarely by thin seams of sandstone. The remarkable persistence of the travertinous marlstone of No. 14, which is readily recognizable from Nira to Kikongo (where, however, it has lost its redness and has become quite grey), seems to indicate the presence at this

[1] The rock is a fine-grained felt of green acicular hornblende, abundant microlites of an acid labradorite, quite fresh and doubtless secondary, and fine aggregates of small quartz-granules. A few unaltered grains of ilmenite still occur, although it has mostly been changed to leucoxene, and there is a little zoisite and diffused calcite. The original rock was, not improbably, a dolerite.

time of a calm lagoon, communicating with the main body of the lake to a sufficient extent to allow the molluscs *Ampullaria* and *Lanistes* to live in its waters and to be preserved in this bed. The remark may be made, in passing, that no bivalves were preserved in any of the deposits—a circumstance difficult to explain, in view of the abundance of *Unio*, *Ætheria*, *Sphærium*, etc., on the shores of the present lake, unless the sediments were laid down at such a distance from land that the only shells capable of being deposited were those of gastropods which floated until they became waterlogged and eventually sank. At the present day, gastropod shells are seen floating on the lake several miles away from the shore.

The red coloration of the clays is the most marked feature of the middle series, especially in the western area, and perhaps indicates the activity of ferruginous springs in this district.

Finally, the upper series indicates the time when the rivers had nearly reached their base-levels, and were no longer able to bring down heavy loads: the sediments consist essentially of grey or brown clays alternating with shales, and interrupted quite exceptionally by grey sandstones, or more frequently by thin seams of travertine. These sandstones with large plates of biotite and augite-crystals probably were the product of unusually wet seasons, when the rivers were swollen beyond their ordinary dimensions. In the uppermost beds the petrified stems represent some unwonted circumstances, in which waterlogged tree-trunks were calcified by the agency of calcareous springs.

The upper series (averaging 70 feet) is nearly equal in thickness to the middle and lower series taken together. This circumstance, in conjunction with the argillaceous nature of the sediments, indicates that a very long period of time elapsed during their deposition; therefore, although the lowest beds are of Lower Miocene age, it is not impossible that the uppermost beds may extend even into the Pliocene.

III. Distribution of the Miocene Series.

These Miocene deposits have been almost completely overwhelmed by flows of nepheline-basalt, which do not, however, seem to have appreciably baked the underlying clays for more than a few inches; but the junction was everywhere obscured by thick downwash and overgrowth half way up the cliffs of East Kachuku and Kikongo. The insignificant amount of baking was probably due to the fact that the lava-streams had reached their southernmost limit, and had therefore already cooled down considerably.

The Miocene deposits are present along the southern margin of the lava-plateau, from Nira on the lake to Kikongo, 4½ miles away to the east (Pl. XXVI, fig. 1), but unfortunately they are still for the greater part concealed beneath a thick covering of superficial deposit termed regur or black cotton-soil; and it is only in the gullies of Nira, Kachuku, and Kikongo that a relatively small portion has been uncovered. The occurrence of stone-implements of a Neolithic character (chiefly made of devitrified obsidian, but also of quartzite and quartz-porphyry, all with a thick brown patina), which I found lying on the wide terraces of Beds 23 & 26, both at Nira and at Kachuku, seems to indicate that a considerable space of time has elapsed since the first formation of these gullies. Every year will see a larger area exposed by the torrents of the rainy season, and a periodical search by a geologist or by a Government official on his round of the province through Karungu would certainly result in important finds.

Everywhere I found the dip of these beds constant: namely, 8° north by west. As a result of this northerly dip, they soon disappear completely beneath the basalt-plateau, which extends for 30 miles northwards; and even the deep meridional valleys at Kitama and Kikongo failed to reveal any trace of them. These broad valleys seem to have been excavated in the deposits prior to the eruptions of the basalt, which flowed down into the valleys from the higher ground, completely covering and sealing up the lateral slopes. Another reason for believing that a great part of these deposits must have been destroyed by denudation before the outflow of the lava-streams, is founded on the circumstance that the continuity of the beds between Nira and Kachuku has been interrupted by a basalt-flow extending from Nira Hill down to the actual level of the plain, filling up an old valley which had been eroded in the soft clays and sandstones.

Even on the south, no traces of the beds could be discovered. In this direction the uplifted strata, which also thin out southwards, would have occurred at a continuously higher level, and were therefore more liable to be destroyed by denudation when the lake stood much higher than at present, or by the erosion of the Kuja and its tributaries.

South of the wide Kuja Valley I could find no indication of them in the hills of granitic gneiss, which extend to the Anglo-German frontier—despite the fact that this area is probably a depressed block of land, judging from the obviously drowned valleys lying between the long narrow promontories of Mohuru; but the initial formation of these valleys may have preceded the deposition of the Miocene sediments.

The shallowness of the Bay of Karungu, in sharp contrast with the steep gradients of the lake-bottom along the coast to the north and south, indicates that the Miocene deposits had once a considerable westward extension over the site of the bay, and have been destroyed by the action of the waves, which break on this shore in heavy rollers.

There are, indeed, indications that the series thins out southwards, and probably it never extended very far in that direction. The exposures, both at East Kachuku and at Kikongo, lie considerably (namely, 6 furlongs and 10 furlongs respectively) to the south of the line of strike of the outcrops at Nira and Kachuku, and in both the two first-named localities the lower beds have thinned out considerably: for instance, Beds 30 to 36 are completely absent and only a trace of the crimson clay of No. 37 is visible at East Kachuku. Moreover, the lower beds of the middle series are already thinner, and the unproductive upper series of grey clays and shales is alone well developed in these two southernmost occurrences.

The only chance, therefore, of finding further outcrops was to search along the line of strike. After leaving Kikongo, I noted that the basalt no longer rested on the Miocene deposits, but directly upon an ancient and much-altered augite-andesite, which extends over a wide area, now completely deserted and given back to wild animals, owing to sleeping-sickness. Finally, I found what appeared to be an isolated remnant of the upper beds near Minyere on the Kuja River, 15 miles in a straight line from the lake-shore, tilted up at exactly the same inclination: namely, 8° north by west, at 3906 feet, very nearly the same altitude as Kachuku (3960 feet).

Here, in a gap on the wooded banks of the river, where lions and antelopes come down to drink, I found the following downward succession, similar to No. 3 of Nira or No. 4 of Kikongo:—

	Thickness in feet	inches.
(1) Hard brown shale	0	6 to 9
(2) Brown clay	1	0
(3) Brown shale	0	6
(4) Brown clay, becoming sandy in the lower part, and overlying the old augite-andesite, which extends in rocky masses of angular boulders more than halfway across the river	8	0

In another exposure, 100 yards farther down the river, grey clays were visible, forming a low cliff in a broad tributary valley, about 50 yards away from the Ogo Ford of the Kuja; they probably belong to a lower horizon, and are similar to No. 9 of Nira and Kachuku:—

	Thickness in inches.
(1) Hard grey clay, shaly in the lower 3 inches	9
(2) Grey shale	3
(3) Grey clay	3
(4) Limonitic clay	9
(5) Grey clay, base not seen	12

The broad valleys in this region, tributary to the Kuja, all show a grey clayey soil, perhaps due to washed-out remnants of these deposits.

Although not a trace of fossils was visible, it was clear that the character of these beds is altogether different from the homogeneous river-alluvium of the opposite bank. They are precisely similar to the upper beds of the Miocene Series as seen at Nira, East Kachuku, and Kikongo; they occur on the same line of strike and at the same altitude, and show the same dip. Hence, it seems only reasonable to consider that this occurrence represents the easternmost remnant of the beds, and that they have been completely denuded away from any part of the intervening andesitic area which they may once have covered. Probably this extensive denudation was not so much subaërial, as due to the lake having stood for a long period at a level of nearly 4100 feet above the sea: that is, about 328 feet above the present level, as indicated by the evidence which I adduce later (p. 146).

IV. Basement-Floor of the Miocene Series.

The amphibolite at Nira is traversed by a vein of quartz a foot thick (running in a west-north-west to east-south-east direction), which passes up into the overlying crimson clay, and extends also laterally. It is evidently owing to associated ferruginous solutions that both the amphibolite and the originally yellow clay are traversed by a network of veins with dark crimson staining. In the gully of South Nira the amphibolite passes upwards into about 20 feet of rotten rock (a grey, sandy, brown-veined clay), covered by a foot of brown ferruginous sandstone, probably representing the ancient ironstone soil or murram which cloaked the older rocks prior to the transgression of the lake in Miocene times. This basement-floor of amphibolite is not level, but rises in small irregular bosses and ridges, with a north-westerly strike, covered by the crimson basement-clay (No. 37); on the south-eastern and eastern side of the South Nira Gully it rises in a rounded knoll, which is directly overlain and flooded by the nepheline-basalt from Nira Hill.

This basement is not actually visible at Kachuku, but the cliff of quartz-ironstone breccia at West Kachuku is probably the old soil of the amphibolite, somewhat remanié by the transgressive waters of the lake, and it is overlapped by the crimson clay (No. 37). It forms a low bare ridge with north-westerly strike, stretching towards Nira, and it is free from the envelope of black cotton-soil extending on each side. Farther east the crimson clay, cropping out about 150 yards from the base of the cliff of East Kachuku, overlies a similar quartz-ironstone breccia, full of particles of angular quartz (up to 2 inches in longest diameter) and of partly rounded ironstone. Lower down the slope a pale greenish-grey phyllite [1] crops out from under this ironstone breccia, having a foliation directed 30° south-south-west and a north-north-west to south-south-east strike. It forms the western and southern selvage to the rounded hill of Rabur, and borders the alluvial plain of the Kuja. Rabur rises rather abruptly out of the gentle slope of the schistose area, and consists of a dark-green fine-grained zoisite-hornblende rock.[2] It is probably an altered dolerite, and weathers into rounded blocks, contrasting with the splintery chloritic calc-

[1] It consists essentially of calcite and chlorite, with abundant leucoxene in drawn-out lenticles and a little quartz.

[2] The rock is chiefly composed of green hornblende in sheaves of bladed crystals, together with zoisite and some quartz in very fine aggregates. Ilmenite is rather abundant, often altered marginally to leucoxene; pyrite and epidote are accessory.

schist at its base. It is noteworthy that the amphibolite of Nira occurs exactly on the prolonged line of strike of the schist. This chloritic schist perhaps represents the strongly-sheared selvage of a zone of amphibolites lying north of the broad zone of gneiss that occurs on the south of the Kuja Plain (see p. 140).

At Kikongo, the junction of the Miocene beds with its basement-floor is greatly obscured by downwash and murram; but, on the eastern side (in the Kitama Valley), a boss about 100 yards in diameter of the underlying igneous basement crops up. The rock is a highly-altered and decomposed hornblende-porphyrite with massive jointing, and probably represents an ancient intrusive mass; the microscope reveals no evidence of any pressure-metamorphism. In this case, and in several others, it was impossible to obtain fresh and unaltered rock-specimens, owing to the great depth to which alteration has taken place.

South of Kikongo the lower slopes immediately below the deposits consist only of quartz-ironstone breccia, and the underlying rock was not revealed until I reached a point 2 miles away to the south, where a very much weathered and chloritized amphibolite rises out of its thick mantle of ironstone-breccia. It is not unlike a much-altered and coarser variety of the amphibolite of Nira. The rock is but slightly schistose (dipping 67° south-westwards), and shows the north-westerly and south-easterly strike which is characteristic of the metamorphic area east of the Victoria Nyanza. It has weathered deeply to a rich orange-brown soil with some quartz, exactly in the manner of the other amphibolites.

The next hill on the east, separated by a broad shallow valley, only shows the usual quartz-ironstone breccia, but it is traversed by a reef (striking north-east and south-west) of brownish quartz, 10 feet thick, veined with white quartz. The neighbouring hills on the east and south-east are similar in appearance and composition.

South of Nira and Kachuku the wide alluvial plain of the Kuja Valley extends for 5 miles, unbroken in relief excepting for nests of termites, 10 to 15 feet high. Towards the lake-shore the brown sandy soil occurs in gentle ridges, probably marking old storm-ridges. Very often the soil is black between the ridges, with occasional angular pieces of basalt derived from the regur which occurs near the shore between Nira and Karungu. The Miocene deposits probably extended originally for a considerable distance southwards over the site of this alluvial plain. The Kuja flows now along the southern border of the plain; in the dry season its banks rise about 20 feet above the river-level, and consist of homogeneous brown alluvium without any shells. In one place (below the last ford), a layer of black alluvium (derived from regur from the north) is intercalated midway in the brown river-mud; but there is no sign of shaly lamination.

Almost immediately south of the river is a wide zone of grey gneiss of granitic appearance. The outlying hills, such as Nakanero (altitude, 4040 feet) and Angaohi (4006 feet), rise out of river-alluvium to a height of about 300 feet above it, and were obviously once islands when the lake stood at a higher level. Still farther south the bays of Gurekeri and Mohuru are just as obviously drowned valleys, and this characteristic becomes increasingly pronounced in the gulfs farther southwards as far as Mwanza. But the lake at the present day is falling in level, and therefore these drowned valleys are no longer so deeply submerged as they once were.

This gneiss[1] weathers into large bare blocks, usually rounded, but sometimes angular, often longer than broad, and vividly recalling the granite-tors of Devon and Cornwall. Both in this and in the other instances of granitic gneiss which I observed in the Nyanza province, the gneiss is so much fresher than the schists, that it is probable that they are of later date, as in Rhodesia, and that they have undergone only a slight amount of pressure. Most of the occurrences present the appearance of having originally been intrusive granites.

V. The Basalt-Plateau of Gwasi.

The Miocene beds are capped by the terminal lava-flows belonging to the basaltic system of Gwasi (6384 feet), the central peak of which rises 17 miles north of the southern tongues of the lava-streams that have buried up the sediments. On sailing round this massif of Gwasi, from the Kavirondo Gulf to Karungu, I was struck by the resemblance of the scenery to that of the basalt-plateau of Skye and the Western Highlands, the lofty cliffs consisting of flow upon flow of columnar black basalt like Ben More in Mull; while the flat-topped outliers, now detached by extensive denudation, are the exact counterparts of Macleod's Tables in Skye. The outlying islands of Mfwanganu on the north-west and of the symmetrical pyramid of Nagodaluru on the south-west once (as shown by the soundings) stood in connexion with the main mass. The neighbouring systems of Gembe (6208 feet) on the north, of Ruri (5583 feet) with its many cones on the north-east, and even of Homa (5742 feet) still farther north-east, consist of the same nepheline-basalt or nephelinite, and form a geological unity.

Although the basalt, at a superficial glance, appears to be of very

[1] The felspar and quartz prevail over the ferromagnesian constituents; the orthoclase allotriomorphs (up to 5 mm. in length) are often turbid centrally with decomposition-products, and enclose an occasional granule of kyanite and zircon—the cleared margin often shows undulose extinction, with *patches of fresh microcline developing at its expense.* Plagioclase (*oligoclase-andesine*, Ab_5An_3) *is quite subordinate.* Quartz occurs in granulitic mosaics, with rough parallelism bordering the orthoclase-crystals, and here sometimes shows a myrmekitic intergrowth. Green hornblende is present in larger crystals (up to 4 mm. in length) than the biotite with which it is associated, but is not so frequent, and shows the usual pleochroism (α, pale straw; β, sap-green; γ, blue-green). Biotite occurs in greenish flakes, enclosing apatite and small zircons with pleochroic halves. Sphene is accessory in pale-brown, rather large crystals, sometimes bordering the rare grains of magnetite; and a few granules of pyrite are present.

uniform texture and composition, it is, on the contrary, extremely variable, exactly like other nepheline-lavas. The most typical variety is a specimen[1] which I collected south of Homa Bay, on the Rungwena Plateau, belonging to the Ruri system. It presents many points of similarity to the nepheline-basalt of Fogo in the Cape Verde Islands.

The regularity of the slope from the central mass, right down to the last lava-streams at Nira and Kikongo is very distinct, when viewed from the lake or from the Kuja Plain. In several cases, it is clear that many of the now isolated hills that rise above the Bay of Karungu have been carved out of the plateau by denudation, whether they are flat-topped hills such as Omangi (4532 feet) or conical peaks such as Tigra (5031 feet) and Okai (4857 feet), which still show a lava-flow in section capping their actual summits. The lava[2] on Nira Hill, for instance, was clearly once in continuity, not with Nundowat on the east, but with flat-topped Omangi on the north-north-east, but it is now separated by a wide and deep valley. On the other hand, it is also evident that there were several subsidiary points of eruption, even so far south as the peak of Nundowat (4479 feet), almost at the southern limit of the plateau, overlooking the Miocene deposits. It is a boss of huge

[1] The black compact rock, with irregular fracture, contains numerous crystals of pale-green augite (diopside) measuring up to 11 mm. in longest diameter, with frequent twinning, both simple, lamellar, and herring-bone, often zoned, and sometimes bordered by augite of a darker green; occasionally enclosing magnetite-grains, a nepheline-crystal, or some brown glass full of microlites. A few rather small crystals of olivine have been serpentinized and stained yellow by iron oxide, and in several cases are surrounded by a wreath of green augite and magnetite-granules. Nepheline is present in large fresh idiomorphs, enclosing augite-needles and magnetite, as well as in small quadratic crystals. Magnetite is abundant in large hexagonal crystals, down to quite small dimensions. Apatite is fairly frequent, enclosing numerous minute, purple-black, longitudinal rods. The ground-mass consists of a close felt of augite- and magnetite-granules, with occasional clear streaks of allotriomorphic nepheline, into which larger needles of green augite project.

[2] This rock is very similar to the Rungwena basalt, and contains similar augites but no porphyritic nepheline; and, since no olivine is present, it would be properly termed a nephelinite rather than a nepheline-basalt. On the other hand, it contains some pale-brown, nearly resorbed hornblende-crystals, sometimes surrounded by a wreath of augites with occasional small flakes of biotite. In the clear streaks of allotriomorphic nepheline in the ground-mass occur some instances where allotriomorphic sanidine seems also to be present; but the twinning is much less sharp than usual.

C. Uhlig collected some specimens of the lava 1600 yards inland from Karungu, and here, according to the description by M. Goldschlag ('Beiträge zur *Kenntnis der Geologie & Petrographie Ostafrikas I.' Centralblatt f. Min.* 1912, pp. 567 & 593), it proved to be nephelinite, since no olivine was present; it contained allotriomorphic nepheline, like my specimens collected a little farther south. Uhlig's three specimens were taken all close one to the other, but showed considerable variety: in one case nepheline occurs mostly in the ground-mass, and is only occasionally idiomorphic; the proportion of nepheline-crystals increases in the second specimen; and, in the third specimen, the nepheline is almost exclusively in the form of idiomorphs, while the ground-mass contains some glass in this specimen alone.

angular boulders of scoriaceous nepheline-basalt[1] (see Pl. XXI), 30 yards in length from south-west to north-east and 20 yards wide, rising rather abruptly to a height of 30 or 40 feet from the general surface of the lava-plateau.

The lava on the surface of this plateau is highly scoriaceous, with steam-cavities measuring up to 4 inches in length, and it descends very steeply, but apparently with its original slope, into the valleys of Kachuku on the south and of Ubware on the north. In both these cases I found the lava-stream to be highly brecciated with large fragments of its own substance, indicating its superficial character; and, near the head of the Kachuku Valley, I noticed that the lava-stream had not merely caught up and rolled along cooled fragments of its own substance, but contained one of the calcified tree-stems from the uppermost clays of the Miocene beds over which the lava had flowed.

The nepheline-basalt seems to be particularly susceptible to atmospheric denudation, and, owing to its homogeneous nature, it weathers readily into conical hills. The outlier of Homa still preserves the plateau-like character, although the detached northern peak is conical. The dissection of Ruri is much farther advanced, and it consists entirely of a group of cones, while the outliers on the extreme eastern margin of the basaltic area consist of separate symmetrical cones: for instance, Chamanga, Uchimbo, and Asego, rising with remarkable abruptness (slopes of 32°) from the level alluvial plain.

The products of denudation of the nepheline-basalt consist of black cotton-soil or regur, a black alkaline clay (very sticky and plastic when wet, but friable and cracking readily when dry). Everywhere in this area the regur swathes the lower slopes of the basalt hills in a thick mantle, and fills up the valleys. As Mr. H. B. Maufe has remarked,[2] the most suitable conditions for its formation are to be found on

> 'level or gently rolling ground where the rocky substratum is impervious and the under-drainage consequently bad.'

Now, the clays of the Miocene beds form a completely impervious substratum, and here I found the greatest thickness of regur: namely, up to 20 feet. Everywhere it contained land-shells (*Tropidophora* sp.) still showing colour-bands, with occasional angular fragments of basalt; and in the lower half the little grey, rough,

[1] This rock is also very similar to the Rungwena basalt, but contains no porphyritic nepheline; the augite shows the same characteristics, and serpentinized olivines are also present, with a very few flakes of biotite, in a somewhat similar ground-mass of looser texture. The nepheline of the ground-mass has, however, become more individualized, although not showing crystal-outlines; allotriomorphic nepheline enclosing small augites and magnetites forms the major part of the matrix; the remainder consists of a yellowish base, probably serpentinized glass. A single hexagonal crystal of leucite is visible in the slide.

[2] 'Report relating to the Geology of the East Africa Protectorate' Colonial Reports, Miscellaneous, No. 45, 1908, p. 55.

calcareous concretions or kunkar are frequent, while in the wide valley of Wawengi (between Karungu and Omangi) bones of antelope, zebra, warthog, etc., sometimes occur: probably the animals were mired in the extremely sticky black clay during the rainy season.

The presence of this regur with land-shells over the zone of Miocene beds along the foot of the lava-streams, and the absence of any freshwater shells, would seem to indicate that this area has not been submerged by the lake since the uptilted Miocene deposits were concealed by lava. In the gully of West Kachuku, however, the lower half of the regur showed a roughly-stratified layer of boulders of basalt with fragments of the Miocene sandstones, and these were probably brought down by a temporary torrent during an exceptionally heavy rainfall.

Inland the impervious substratum necessary for the formation of the regur is provided by a yellow loam; for instance, in the Kitama Valley, 4 feet of regur overlay 6 feet of yellow-brown loam (derived from the disintegration of the basalt), containing small lumps of kunkar and land-shells, together with occasional angular fragments of basalt (about 2 inches in diameter), and weathering in vertical walls, the whole presenting great similarity in appearance to the lœss of China. Similar relations between the regur and the lœss occur also in the wide valleys draining into Karungu Bay.

It was exclusively in the basaltic region that I observed this black earth, both in the Karungu district and again over the Rungwena Plateau (south of Homa Bay) nearly as far as Langueh. In the banks of the Agulu Muk River, which cuts through this plateau, I noticed the following succession:—

	Thickness in feet.
(1) Regur	4
(2) Compact, calcareous, brownish-grey loam (lœss), with fragments of basalt	3
(3) Soft grey clay, with fragments of basalt	4
(4) Coarse yellow gravel, with partly rounded blocks (measuring as much as 18 inches in longest diameter) of quartz-porphyry, quartzite, andesites, and banded jasper, dipping 5° north-eastwards, that is, towards the river	3
(5) Quartz-porphyry *in situ*, much decomposed.	

As one descends to the lake from the Rungwena Plateau, the following section is seen in the right bank of the Rungwena River:—

	Thickness in feet.
(1) Regur	3
(2) Hard grey volcanic tuff, dipping 8° north-north-westwards, that is, towards the river	1
(3) Brown clay, with sparse pebbles of quartzite, granite, basalt, jasper, and ironstone	4

Nearer still to Homa Bay, Seminya and the hill west of it consist of a grey volcanic tuff, dipping 2° northwards, veined with hæmatite. Probably Ruri was the centre of the explosive action which gave rise to these tuffs.

VI. Geology of the Country between the Victoria Nyanza and the Kisii Highlands.

The gneisses and amphibolites forming the foundation upon which the Miocene beds repose, together with the nepheline-basalts which cap them, have already been described, and a reference has been made to the old augite-andesite that occurs east of Kikongo. This augite-andesite,[1] together with its agglomerate, has a considerable distribution, extending for 11 miles from near Kikongo eastwards to Gongogongo, and from Nonnia south-eastwards for at any rate 9 miles and probably much farther. The hills and ridges of this andesite have the same north-westerly and south-easterly strike as the rest of the gneissic area, yet there is no evidence of cataclastic structure in the rock, although it has been much altered (the augite, in particular, being uralitized), and it is everywhere traversed by thin veins of quartz.

The steep-sided hills of the andesite often display rugged crags and precipices, especially above the Gogo Falls on the Kuja River, in the Kodondo Cliffs, and in the striking hill of Nyakuru (4673 feet) with its twin peaks. This area has evidently undergone a great amount of denudation, whence we may infer that the rock now exposed was probably rather deep-seated originally.

An interesting circumstance is the occurrence at Metamala of the andesitic agglomerate weathering into picturesque rugged crags of bare rock, crowded with rounded masses (2 feet or more in diameter) of grey quartz-augite diorite,[2] and also of microgranite, gneiss,

[1] The rock is least altered at Kodondo (5 miles east of Kikongo). Here it is compact and greenish grey, displaying splintery fracture, crowded with tabular idiomorphs (measuring up to 4 mm.), dusty and saussuritized, of plagioclase (andesine, Ab_3An_2), and abundant idiomorphs (up to 3 mm.) of pale-green augite (diopside), much uralitized, the uralite in turn altering to chlorite and epidote. The augite is sometimes twinned, and contains apatite; when adjacent to a quartz-vein it is margined by a secondary brownish-green hornblende. Biotite is represented by a few pseudomorphs of chlorite with magnetite and a little epidote; originally it was partly resorbed. Magnetite occurs in large grains enclosing apatite, as well as small plagioclases and augites. Apatite and pyrite are accessory. The ground-mass is micropœcilitic, the texture being coarser round the bigger augites. Thin irregular veins of quartz traverse the rock.

At Nyakuru (3 miles south-east of Kodondo) the rock is nearly identical; but the augite has here been entirely uralitized, and the uralite has also been partly altered to chlorite; some original biotite, however, still remains unaltered, with a resorption-border of magnetite and actinolite.

At the Ogo Ford on the Kuja River (6 miles east-north-east of Kodondo) the rock is also very similar, but has undergone alteration to a greater degree, the uralitized augite having been replaced by chlorite, or by epidote and calcite, or even entirely by calcite. Yet the plagioclase is fresher than in the previous two specimens.

[2] In this rock plagioclase (oligoclase-andesine, Ab_5An_3) predominates in tabular crystals (measuring up to 1 cm. in longest diameter), with a strong tendency to idiomorphism: it is occasionally intergrown with orthoclase—zoning is seldom visible, and is confined to the margin, which is often composed of fresher felspar; it is sometimes partly intergrown with quartz peripherally, and contains chlorite along cracks, but is not so decomposed as

jasper, and andesite in a dark-green fine-grained matrix, so as to present the appearance of a puddingstone. The contained rocks do not, however, weather unequally, as might be expected, but in perfect uniformity with the matrix—as if the rock had been cut through sharply and cleanly with a knife, irrespective of its varied contents. Microscopic examination suggests that the diorite is merely the deep-seated form of the augite-andesite, the augite in both cases being uralitized; and the uniformity of weathering is further accounted for by the intimate manner in which both the matrix and the contained rock-fragments are penetrated by a network of thin veins of quartz.

Crags of this agglomerate occur on both sides of the Ogo Valley and up the Dodo Valley to Dodo and Taygoreh, as well as south of Metamala. On the periphery of the agglomerates, for instance, at Moroya, more than 5 miles south-west of Metamala, a dark-green banded tuff occurs (see footnote), very hard and compact, also silicified, but without the big rounded fragments; and this banded tuff also builds up the hills of Godateli and Yangena west of Metamala. The summit of Godateli is traversed by a thick vein of white quartz striking north-north-east and south-south-west, which has so resisted weathering as to cause the formation of this rounded hill above the rolling plain of tuff. The low hill between the Metamala and Moroya plains (covered by quartz-ironstone breccia) similarly owes its formation to the presence of quartz-veins and their resistance to weathering. Although time did not allow me to determine the limits of the agglomerate and tuff on the south-east, it is clear that they cover an area exceeding 5 miles in diameter, and mark the centre of eruption of the augite-andesites, which probably extend as far south-eastwards beyond the agglomerate as they do westwards and north-westwards.

The agglomerate and tuff weather to a mixture of ironstone and quartz, and honeycombed patches of murram are frequent here, as on other ferruginous soils.

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the orthoclase, which is subordinate in amount and turbid. Green hornblende is abundant in imperfect crystals (up to 3 mm.) with a uralitic aspect, the uralite changing to chlorite, calcite, and epidote. Some biotite (associated with the hornblende) was originally present, enclosing apatite, but is now altered to epidote and calcite. Sphene and magnetite are accessory. Quartz is abundant in interstitial granules, sometimes with strings of fluid inclusions. Fine veins traverse the slide, filled with quartz and epidote, or else recemented by secondary minerals—a fractured quartz-grain by secondary quartz, felspar by felspar, and hornblende by hornblende.

In the tuff of Moroya, on the southern periphery of this outcrop of agglomerate, the fragments consist essentially of the constituents of the diorite, but with diopside only partly uralitized, the uralite changing into chlorite (exactly as in the andesite of Kodondo). Hence the hornblende of the diorite is probably all derived from augite, and the original rock would have been a quartz-augite-diorite.

The tuff, both at Metamala and at Moroya, is a crystal-tuff composed of the constituents of the diorite, and numerous fragments of microlitic felts of quartz with oligoclase-microlites; both rocks are traversed by fine veins of quartz (sometimes with epidote), and are evidently very siliceous.

Along a zone about 50 feet above the present level of the Kuja Valley (that is, at an altitude of about 4000 feet), occur quantities of well-rounded pebbles of quartzite (measuring up to 6 inches in length), which have evidently been brought down by the Kuja from the parent-rock of the quartzite of the Kisii Highlands at a time when the river flowed at a higher level than at the present day. This zone of quartzite-pebbles is well marked along both sides of the Olasi Valley, especially on its south side, between Nangina and Nyaroya, and also along the low ridge above the Ogo Ford north of Yangena.

Although further evidence is necessary, it seems to me probable that this zone of pebbles at the 4000-foot level marks an old beach-line of the Victoria Nyanza. It is extremely noticeable, both in this district and in the area south of the basaltic cliffs of Nira, Kachuku, and Kikongo, that all the hills and contours below this altitude are gentle and rounded (for instance, Rabur), with particularly broad valleys; while abruptly above this level I noticed pointed hills (for instance, Mirema), terminating in rough and rugged crags. Exactly the same striking contrast is noticeable in looking across the Kavirondo Gulf from Kendu, vividly recalling the contrast in Norway between the lower rounded glaciated slopes and the non-glaciated crags and peaks above them. This level is roughly about 300 feet above the present level of the lake, which must (at this altitude of 4000 feet) have just reached to the foot of the basaltic cliffs, and must have chiefly contributed to the destruction of the Miocene deposits at their base. On the western shore of the Victoria Nyanza, gravel-deposits and caves occur at a height exceeding 300 feet above the lake in the cliffs of the coast of Buddu, north of the Kagera River.[1]

In proceeding eastwards from Metamala I found that the coarse agglomerate persists up to the gneiss of Gongogongo, without passing into tuff as it does on the west and south. The acacia forest on the steep slopes of this range of hills precluded any exact observations of the mutual relations of these rocks, but the gneiss forms a gigantic obelisk of colossal, bare, rounded blocks, thus constituting a natural landmark for many miles round. The rock is a pink granitic biotite-gneiss,[2] weathering pale brown, and probably was originally an intrusive granite. On the north-east side

[1] Sir William Garstin, 'Report on the Upper Nile' Cairo, 1904, pp. 32–39.

[2] This rock contains numerous allotriomorphs (measuring up to 9 mm. in longest diameter) of orthoclase (microperthite), of tabular habit with Carlsbad twins, and traversed by a finely dusty perthitic network; sometimes displaying a brecciated margin of plagioclase. Plagioclase (oligoclase-andesine, Ab_2An_1) is subordinate, occurring in smaller crystals (measuring up to 7 mm. in longest diameter), often interstitial between the larger orthoclase-crystals; occasionally turbid centrally with flakelets of white mica, but clear marginally. Biotite (up to 2 mm.) is only sparingly present, sometimes with bent lamellæ; it encloses zircons with pleochroic halos, as well as magnetite and apatite. Magnetite is accessory, enclosing apatite. Quartz occurs in large interstitial grains, containing strings of very small fluid inclusions, and sometimes displays brecciated margins; it encloses biotite, and occasionally plagioclase.

of the Gongogongo Range a broad zone of amphibolite[1] extends for 5 miles through the district of Sakwa down to the Kuja River. Exposures are extremely rare, for the rock is greatly altered, and weathers to a considerable thickness of red-brown clay. Wide valleys opening out to the north-west alternate with steep grassy ridges.

North of the Kuja extends for many miles the wide plateau of Kamagambo, composed of a granitic hornblende-gneiss.[2] Its essentially level surface, and the fact that the Kuja has carved deep meanders into it, coupled with the presence of old river-gravels containing big quartzite-pebbles derived from the Kisii Highlands, serve to indicate that this plateau is essentially an old peneplain in which the Kuja has cut down its meanders to 300 feet below its surface, owing to the rejuvenation of its course, to which further reference will be made later on. The formation of the peneplain must have taken place at the time when the lake stood at the 4000-foot level, but slightly below the level of this gneiss plateau.

I left the district of Sakwa, and entered that of Kamagambo by a wooden bridge which has been constructed by native labour, replacing a ford immediately above some picturesque waterfalls at 4347 feet. Rapids are characteristic for several miles downwards from this part of the river's course. The gneiss weathers readily and deeply into pale yellow-brown or orange sands, or else into greenish-white clays; and the contrast is striking, between the gentle slope of the gneiss on the right bank and the steeper inclination of the more resistant amphibolite on the left.

Before one reaches the top of the grassy gneiss plateau a black peaty soil is noticeable in several places; but, on the actual summit

[1] The rock near the junction with the biotite-gneiss is a green, extremely close-grained zoisite-amphibolite, consisting of a very fine aggregate of granular zoisite, clinozoisite, and abundant bladed green hornblende in a quartzose matrix, with a few granules of magnetite. Some indistinct pseudomorphs after primary hornblende consist of secondary hornblende and zoisite, with magnetite-granules and some chlorite enclosing calcite. Clearer areas, consisting of aggregates of quartz, zoisite, and flakelets of white mica, may possibly represent original felspars. Chlorite enclosing calcite in lamellæ is probably after biotite. Calcite is diffused through the slide, and a little epidote is present. The original rock may have been a not very basic, rather finely crystalline basalt.

[2] A gneissose banding is suggested by successive wavy zones of quartz alternating with felspar, and by the hornblendes lying with their long axes parallel to these zones. Orthoclase predominates in allotriomorphic crystals (measuring up to 5 mm. in longest diameter), turbid with dusty decomposition-products and flakelets of white mica; it is altered in patches to clear albite, especially marginally, where it is sometimes brecciated. Green hornblende (measuring up to 2 mm. in longest diameter) is both primary and secondary; the primary is pale green, somewhat bent, containing apatite and magnetite, and alters along the cleavages into a yellow serpentinous mineral with some epidote. The secondary hornblende occurs only in association with quartz: it is fresh and unaltered, and sometimes twinned (α, pale straw; β, sap-green; γ, blue-green). Quartz is abundant as a fine granulitic mosaic, showing undulose extinction. Leucoxene is present in rather big dusky grains, with their long axes parallel to the planes of schistosity. Magnetite is accessory in crushed and drawn-out grains.

(4614 feet), a yellow-brown sand prevails, with frequent stretches of old river-gravel containing large quartzite pebbles, and patches of murram often occur in which these pebbles are sometimes embedded.

The plateau stretches far to the northward, but is dominated on the east by the lofty quartzite-escarpment, trending north-north-west and south-south-east, of the Kisii Highlands. This cliff rises 1500 feet above the level of the old peneplain, and stretches far away to the south-south-east; while on the north-north-west it ends in the bastion of Itumbe, still 6000 feet above the sea. The upper edge is precipitous, but the lower slopes show here an inclination of only 35°. The low rounded foothills at the base of the white quartzite-cliff are composed of a dark-green, very fine-grained dolerite,[1] forming a sill which has insinuated itself between the gneissic basement and the cover of quartzitic sandstones, changing the latter near the contact into snow-white quartzite—a conspicuous zone of colour in the face of the escarpment. The underlying dolerite weathers deeply to a thick red clay, which is very fertile, and hence determines the situation of the numerous settlements of the Kisii people. It forms the belt of lower ground, not only at the base of this Vinyo escarpment, but also within the deep gorge of the Kuja River, which has cut its way through the quartzite-plateau. The dolerite-sill comes also to view along the floor of the upper course of the Kuja within the area of the Kisii Highlands.

Skirting the western base of the escarpment, I crossed the Kuja again by a ford at the altitude of 4441 feet: that is, only 94 feet above the level of the river at the Sakwa bridge, $6\frac{1}{2}$ miles lower down, thus revealing a very gentle gradient for this part of its course. The rock is here an extremely-rotten sericitic chlorite-schist,[2] with foliation directed 60° south-south-westwards, and it was difficult to obtain even a moderately-fresh specimen.

[1] The rock consists of a fine felt of laths of plagioclase (oligoclase-andesine, Ab_5An_3), together with granular, very pale-brown augite. In a more deep-seated specimen from the Vinyo Gorge the augite is subophitic, and has become replaced by chlorite. Ilmenite has become completely altered to leucoxene, and there is some interstitial chlorite, probably representing an altered glassy base. Fine aggregates of small quartz-granules, with interstitial vermicular chlorite, occur in irregular nests (especially along zones), and have probably been derived from the absorption of the overlying quartzite. The rock near the junction becomes full of amygdales of quartz ($\frac{3}{4}$ inch or less in diameter), either chalcedonic containing spherulitic chlorite centrally, or else an aggregate of quartz-grains with a lining of chlorite. Other amygdales may consist of a nucleus of pyrite surrounded by epidote, and this in turn by chalcedony. Pyrite also occurs in irregular masses bordered by hæmatite. Much-altered specimens of the junction-rock become essentially a quartz-epidote rock with chlorite.

[2] The schistosity of the greenish-grey rock with silky foliation-planes is due to very fine flakes of sericitic mica and chlorite. The numerous 'eyes,' occurring down to small dimensions, are composed of very fine aggregates of spherulitic chalcedony and chlorite, and are wrapped round by chlorite and sericite. In some cases such aggregates show prismatic outlines, as if pseudomorphous after felspar-crystals with their long axes nearly normal to the foliation-planes.

A specimen of rock taken a little farther on, within the Kuja Gorge (Pl. XXIII, fig. 1), just before one comes to the dolerite itself, helps to explain the original character of these decomposed schists. An outcrop of a very compact pale-grey rock, with a strike of north by west, occurs at a distance of a mile (measured transversely to the strike) from the schist at the ford. It is a spherulitic quartz-porphyry,[1] which has undergone some crushing and alteration, becoming a so-called sericite-porphyroid. Perhaps the schists of the Kuja Ford are to be regarded as the marginal and more extensively-crushed modification of the original quartz-porphyry, with the usual increase of sericite, or as the crushed tuffs of the quartz-porphyry. The actual contact of the dolerite-sill with the ancient quartz-porphyry could not be observed, owing to the thickness of red soil.

In order to make an examination of the quartzite south of the Kuja Gorge at Vinyo, I ascended the rounded slopes of the dolerite extending up to the precipices of the well-bedded quartzite, which is 500 to 600 feet thick. Although I searched diligently for fossils, it was a fruitless task; but the exposures of bare rock were so numerous along the edge of the escarpment, and the section from the base of the cliff up to the summit was so readily accessible, that I could hardly have failed in my search if any fossils had been present. The rock is, on the whole, very uniform, consisting of well-bedded quartzitic sandstone, weathering in large slabs, with streaks of hæmatite along the bedding-planes and joints. Half way up the cliff I collected a piece of a slab showing sun-cracks; ripple-marks were abundantly present at all levels, and occasionally impressions of raindrops and worm-tracks were visible. Current-bedding is prevalent, and sometimes there is a zone of a fine conglomerate containing quartz-pebbles (up to $\frac{3}{8}$ inch in longest diameter). The dip varies here from 5° to 10° west-south-westwards, and the prevalent direction of the ripple-marks was west-south-westwards and east-north-eastwards, indicating a gentle current from the south-south-east; but I also observed the

[1] The rock is pale grey, compact, but slightly schistose, somewhat waxy in lustre, and contains a few scattered, small, grey quartz-grains. Under the microscope the quartz-phenocrysts present all the usual characteristics of a typical quartz-porphyry: as, for example, the corroded and lobed appearance and the inclusions of ground-mass (now altered to fine aggregates of white mica); the quartz encloses an occasional flakelet of biotite, and shows strain-shadows; a hexagonal cross-section is present. Tourmaline occurs in a few thin, pale indigo-blue strings, showing some parallelism and in one case bordering a quartz-crystal. Under crossed nicols the ground-mass (but slightly dusky in comparison with the quartz-crystals) is resolved into a mosaic of mutually interfering spherulites, considerably cracked, and showing tiny flakelets of sericitic mica along the innumerable cracks; even the felspathic portion seems to have altered into quartz and sericite. While most of the spherulites are greatly shattered and cracked, a few are comparatively intact, with white mica sweeping round them. Sericitic aggregates also occur in strings between spherulites, and probably represent some of an originally glassy base. The radial selvage enveloping a corroded quartz extinguishes simultaneously with it, and in optical continuity.

directions west and east, north-west and south-east, and north-north-east and south-south-west. Crossing the plateau (here reduced by erosion to a width of only 6 furlongs) from the escarpment eastwards until I overlooked the upper course of the Kuja, I descended near Kenin, returning to the Kuja Gorge. The angle of the slope immediately below the nearly-vertical cliff is as high as 65°. Near the junction with the dolerite the buff-coloured quartzitic sandstone, veined and blotched purple with hæmatite, becomes changed to a snow-white quartzite, and the dolerite is here highly amygdaloidal with amygdales of quartz (as already described), and decomposes into a thick mantle of fertile red soil. The cone of Kinsunsi on the right bank of the Kuja, near the western exit of the gorge, is an apophysis of the sill or laccolite, and is surrounded by an aureole of white quartz.

It seems natural to assume that these quartzites belong to the same series as the quartzites of the Nandi Hills on the north side of the Kavirondo Gulf; but they are far more uniform in character than the Nandi Quartzites described by Mr. G. F. Scott-Elliot & Prof. J. W. Gregory[1] as belonging to the Karagwe Series, which is so much more extensively developed on the western side of the Victoria Nyanza, where it reaches a thickness of over 1200 feet. The quartzite belongs to the uppermost division of the Series, which has been traced to the southern end of Tanganyika and is probably of the same age as the Waterberg Series of the Transvaal: that is, presumably Devonian.

The quartzitic sandstones of the Kisii Highlands have not been subjected to the pressure which has tilted up the Karagwe Beds to a high angle, and crushed them until they are highly contorted. If it were not for the intrusion of the underlying dolerite, these Kisii sandstones would doubtless have still preserved their original horizontality.

Crossing the Kuja as I proceeded on my march to Kisii Boma, I found the ford in the centre of the gorge to lie at an altitude of 4894 feet. Comparing this with the altitude of the ford outside and below the gorge (that is, 4441 feet), we find a fall of 453 feet in $2\frac{1}{2}$ miles, or a gradient of 1 in 29, accounting for the numerous rapids of the Kuja in its rocky bed through the gorge. This gradient stands in marked contrast with the lower and succeeding stretch to the Sakwa bridge (only 94 feet in $6\frac{1}{2}$ miles).

In addition to the evidence of the rejuvenation of the river, as shown by the very frequent rapids and waterfalls, the angles of slope of its valley yield further support to this conclusion. From the 65° of the quartzite immediately below the precipices of the edge of the plateau the angle rapidly changes to a long slope of 10° over the easily-decomposed dolerite, and, on approaching the river, it suddenly alters to a short slope of 30° (cut also in the same dolerite) down to the present bed of the river.

If one keeps a northerly direction over the nearly-level summit

[1] 'The Geology of Mount Ruwenzori' Q. J. G. S. vol. li (1895) pp. 677, 678.

of the quartzite-plateau (over 6000 feet high) the view to the westward over Kitembe shows its flat-topped outliers above the gneissic peneplain at their foot, and the west-south-western slope of their surface is a dip-slope. Turning thence north-westwards, I left the Kuja basin and descended to the Yawi River (a tributary of the Riana), over white quartzite down to the amygdaloidal dolerite, here exposed over a wide surface; and the symmetrical cone of Saria marks another apophysis, with an aureole of white quartzite, similar to the occurrence of the Kinsunsi cone. From Saria a steep descent to the Nyanchoba led to the basement-floor of pink granitic biotite-gneiss[1] below the dolerite: it decomposes to a red-brown soil.

Crossing a bastion of the doleritic plateau of Merinde, I descended again to the biotite-gneiss, traversing a wide valley (tributary to the Riana). On its northern slope, just at the western foot of Nyachwa, the gneiss is directly overlain by the dolerite, which shows massive jointing and no signs of flow or columnar structure. This doleritic spur of Nyachwa forms the left side of the valley of the Riana, with its gold-bearing sands. Kisii Boma, the present centre of administration, lies on the lower northern slopes of Nyachwa, at the height of 5705 feet. On the summit, I noticed firmly embedded in the dolerite a lump of white quartzite (12 × 6 inches): this had doubtless been floated off by the intrusive dolerite from its overlying cover of quartzite, which has been long ago denuded away. Probably the dolerite never reached the surface when molten, but insinuated itself as a sill beneath the ancient sandstones, which must have extended far to the west and north beyond their present limits.

During the two days which I had to spend at Kisii Boma before returning to the lake-shores, I marched across to the Manga Escarpment, which stretches in commanding cliffs far to the north-north-east (Pl. XXIII, fig. 2). The lower ground at its base comprises the thickly-populated district of Kitutu in the basin

[1] The rock encloses numerous allotriomorphic crystals (measuring up to 7 mm. in longest diameter) of microcline-microperthite with perthitic network and Carlsbad twinning, quite fresh and slightly dusty, and often outlined with hæmatitic dust; occasional inclusions of biotite, plagioclase, and quartz-granules, and sometimes thin veins and blebs of green hornblende. Plagioclase (andesine, Ab_3An_2) is also present in smaller crystals (up to 4 mm.), with a tendency to idiomorphism; often it is turbid centrally with flakelets of white mica, zoisite, epidote, and calcite, and occasional patches and thin veins of secondary hornblende, but showing cleared margins of secondary felspar in optical continuity—sometimes enclosing quartz-granules. Biotite (up to 2 mm.) is fairly abundant, often greenish, enclosing apatite and zircon, and associated with magnetite; it is altering to chlorite, epidote, and lenticular aggregates of carbonates—in one case a sagenite-web is evident. A few prisms of brown hornblende are present, on which biotite is moulded. Magnetite and sphene are also accessory, and a small grain of kyanite was observed. Quartz is rather abundant and interstitial, mostly in large grains containing strings of minute fluid inclusions; it is occasionally brecciated marginally, but shows only a slight degree of undulose extinction; sometimes it encloses isolated flakelets of white mica.

of the Megusi River, and is composed of the same sill of dolerite as that which occurs at the base of the Vinyo Escarpment. As one approaches the cliffs, about 700 feet high, of the Manga Escarpment, it is soon evident that they consist of the same current-bedded quartzitic sandstone as at Vinyo, much stained and blotched with crimson hæmatite, and frequently displaying ripple-marks and impressions of raindrops, as also an occasional streak of quartz-pebbles. A close search for fossils was equally fruitless. Here, however, the dip is 12° south-south-eastwards, while at Vinyo it was 10° west-south-westwards: from my lofty standpoint (6388 feet) it certainly seemed to me that the intervening strata had been raised into a low dome by the intrusive dolerite. For this reason, the intrusion may, perhaps, be regarded rather as a laccolite of low curvature than as a sill. The hæmatitic staining seems to have proceeded from below, rising up the vertical joints and extending along the bedding-planes: it was, not improbably, due to pneumatolytic action accompanying the intrusion of the dolerite. Wherever the iron-oxide is most evident the weathering is greatest, and even swallow-holes (6 feet in diameter) occur near the edge of the precipitous escarpment.

The view to the south and east shows that the Kisii Highlands form an extensive plateau of quartzitic sandstone, greatly dissected by the Kuja and its tributaries flowing southwards, as well as by the Northern Awach (the Awach Mateni) flowing northwards. The plateau culminates in the distant heights of Chamonyeru (7068 feet) in the east.

The edge of the escarpment is itself a watershed between the basins of the Kuja and the Megusi (a tributary of the Southern Awach or Awach Madoung). The eastern streams which drain the escarpment and flow to the Kuja are very chalybeate, deriving the iron from the hæmatite of the quartzite.

After leaving Kisii Boma on my march west-north-westwards to Homa Bay, I left the dolerite behind at Nyachwa, and entered again on the peneplain of biotite-gneiss which extends across the deep Riana Valley, rising northwards in the rounded bluff of Meriba and stretching up to the Kona Plateau and watershed, whence the rivers run directly northwards to the Kavirondo Gulf. This part of the old plateau, 12½ miles from Kisii, is composed of a crushed, pale brownish-grey porphyry,[1] showing similarity with the Vinyo quartz-porphyry. It weathers readily to a yellow-

[1] The rock consists of a dusky mosaic of quartz-grains, with interstitial sericite, as in the Vinyo rock; and, although the spherulitic structure is not so well marked, some instances can still be made out containing a nucleus of sericite flakelets, but there has been considerable recrystallization: all the felspathic constituent of the spherulites and ground-mass seems to have been altered into quartz and sericitic mica. No phenocrysts are present, but there are numerous small mossy aggregates of limonite. The rock has been much fractured and veined by a mosaic of clear interlocking quartz-granules; and, where the crack has fractured one of the dusky quartz-grains, the clear quartz of the vein is in optical continuity with it.

brown sandy soil, and the wide valley of the Nyakuru which traverses this rock only shows gentle rounded slopes of 8°.

The summit of the plateau at the 13th mile from Kisii consists of a pink granitic biotite-gneiss[1]; but the porphyroid soon reappears, weathering to a depth of over 6 feet of yellow sand. Apparently overlying it occurs a small outcrop of a greenish-grey chloritic calc-schist.[2]

On descending from the Kona Plateau, one notes that the rock at the 14th mile from Kisii (before coming to Sori Kodongo), becomes highly schistose and mylonitic, consisting practically of very fine mosaics of quartz with sericitic mica and much limonite, readily decomposing to a reddish-brown sandy soil. It is, perhaps, the greatly-crushed marginal modification of the porphyroid, forming a parallel to the sericitic schists of the Kuja Gorge below Vinyo. As I proceeded, I found the underlying rock to be extremely ferruginous, weathering so deeply that no fresh rock could be reached. Much murram has formed in patches, as it always does where there is much iron in the soil. Numerous veins of quartz, a foot thick, run in a north-westerly and south-easterly direction: that is, in the same direction as the strike of the gneisses and schists, and in evident relation to the earth-movements that have affected this district. The low rounded ridges in this area belong to the amphibolite-group, but the rocks are altered and decomposed to an excessive degree.

Shortly before one gets to Langueh, the rock is seen to be a greenish-grey fine-grained epidote-schist,[3] probably a much-altered amphibolite, and half a mile farther on the very dark-green

[1] The rock contains numerous allotriomorphs (measuring up to 7 mm. in longest diameter) of orthoclase (microperthite) with microperthitic interpenetration; it is turbid with dusty decomposition-products, flakelets of white mica, etc., and hæmatitic dust. Plagioclase (oligoclase-andesine, Ab_2An_1), also somewhat decomposed, is subordinate. Quartz is abundant in separate grains (up to 3 mm.), as well as in granophyric intergrowths with the felspars; it is much cracked, and sometimes brecciated marginally; it contains some biotite and also calcite. Biotite (up to 2 mm.) is somewhat sparse; it encloses magnetite, and has been entirely altered to chlorite (partly spherulitic and exhibiting the usual blotchy pleochroism), with epidote, calcite, and some hæmatite. Sphene bordered with hæmatite is accessory, and calcite occurs along cracks.

[2] The rock is mainly composed of aragonite and spherulitic chalcedony in alternating zones, with some chlorite and much sericitic mica in interstitial aggregates. Numerous small curved markings are present, circular, ellipsoidal, or kidney-shaped, and in some cases somewhat compressed and drawn out, all approximately of the same size; they are evidently anterior to the formation of the chalcedony or the white mica, which traverses them independently. They are finely granular on the concave side, bluish black by transmitted and white by reflected light. They somewhat recall the tests of *Cypris*, but Prof. Bonney, who has kindly examined the slide, considers them to be merely extraneous matter thrust outwards during the formation of the spherulitic chalcedony.

[3] This rock consists of schistose aggregates of epidote and quartz-granules, pistacite and zoisite, and some yellow-green serpentinous mineral showing aggregate polarization. Much limonite is present in strings and patches. The rock has been considerably fractured and veined with quartz.

compact rock may be termed a zoisite-hornstone[1]: it is probably an amphibolite that has been altered by the intrusion of a neighbouring diabasic rock, also greatly altered and deeply weathered, but possibly a teschenite[2] originally. The last-named rock crops out of the weathered débris at less than a mile from the outcrop of the altered rock, and occupies the Rungwe Valley at Langueh, a little Indian trading-station, 18 miles from Kisii Boma.

From the Kona Plateau there had been a slow but steady descent, although the view to the eastward was blocked by low hills and ridges, probably of amphibolites; but beyond Langueh (4651 feet) these hills flattened out, and on the north and north-west lay a nearly treeless and extensive volcanic plateau, traversed only by shallow valleys extending north-eastwards towards the Kavirondo Gulf. Between Langueh and the Ogweyo River, the low south-westerly and north-easterly ridges are composed of a dark-green tuff[3] derived from a rather acid andesitic lava; I did not, however, find this lava *in situ*.

The summit of this lower plateau is composed of the nepheline-basalt already described (p. 141), which probably flowed out from Ruri or Gembe as a centre, and the remainder of the country as far as Homa Bay is occupied by this basalt and its tuffs (see p. 143).

[1] The rock has a pitchy lustre and splintery fracture, and presents a somewhat brecciated appearance. Larger clearer patches, usually with prismatic and rectangular outlines, are composed of a mosaic of quartz-granules, flakelets of white mica and interstitial chlorite, and may be pseudomorphous after felspar. Other aggregates consisting of zoisite and quartz show outlines recalling hornblende. Zoisite is abundant, and is honeycombed with quartz, presenting a micropœcilitic appearance; the largest of the zoisite-crystals are prismatic, in a radiating sheaf. Small specks of kaolin are frequent, and nests of epidote and calcite occur scattered in the rock, which is traversed by thin veins of quartz and epidote.

[2] The rock contains abundant crystals (measuring up to 4 mm. in longest diameter) of plagioclase (acid labradorite, Ab_1An_1), mostly of prismatic habit, very turbid and decomposed, largely replaced by flakelets of white mica, and traversed by numerous cracks filled with chlorite and occasionally epidote; there is an instance of a granophyric intergrowth of turbid felspar and quartz. Colourless augite (malacolite) occupies the bulk of the slide, having crystallized later than the felspar, in aggregates of allotriomorphic crystals (measuring up to 3 mm. in longest diameter) with a tendency to form long prisms; it contains small diallagic rods; it is sometimes twinned and intergrown in a pegmatitic manner, so that a fresh crystal may be intergrown with a uralitized crystal. Zeolitic pseudomorphs, possibly after elæolite, are pale brown and minutely fibrous, polarizing like moiré silk in low greys and extinguishing parallel to the fibres; they enclose small patches of augite in a pegmatitic intergrowth, especially centrally. Some clear secondary green hornblende is present, developing at the expense of the augite, and is associated with some quartz. Apatite and magnetite are accessory.

[3] The rock is compact and very fine-grained: numerous fragments of crystals are present, but all of very small dimensions:—Abundant plagioclase (oligoclase-andesine, Ab_3An_2); a little orthoclase; many angular fragments of very pale-green diopside, quite fresh and free from inclusions, sometimes exhibiting lamellar twinning; numerous microlitic felts of oligoclase, colourless augite-granules and interstitial glass; and lapilli of brown dusty glass with zeolites filling the steam-cavities. Chlorite is abundant interstitially, and a subordinate amount of zeolite and calcite is present.

At the base of the valley of the Agulu Muk, the river-gravels overlie a rotten rock resembling a quartz-porphyry; and at the south-eastern corner of Homa Bay the hills of Najanja (rising to 4451 feet, and trending from north-west to south-east) form an important physical feature. They are built up of a purple quartz-porphyrite,[1] probably part of the same mass. In places the porphyrite is traversed by quartz-veins, and forms rounded hills and ridges; it weathers to a red-brown soil.

Crossing this spur of quartz-porphyrite, I found that its eastern slopes were bordered by a low selvage, 300 yards wide, of banded gypsum, layers of pure gypsum (usually $\frac{1}{4}$ inch, but sometimes as much as an inch thick) occurring in frequent alternation with yellow-brown argillaceous layers of similar thickness. The outcrop has a general north-westerly and south-easterly strike, dips 10° south-south-westwards, and shows a bare fretted surface. Many loose blocks are lying on the surface, tilted in all directions. It is probably of the same age as the presumably Pliocene beds, which I found north of Homa Mountain (see below); but this area must have been separated and shut off from the Nyanza, to form a lagoon without an exit.

My course lay north-eastwards across the alluvial plain, about 4 miles wide, of the Southern Awach or Aloychi River, from which isolated cones of basalt, as, for instance, Uchimbo and Chamanga (or Chanvanga) rise abruptly with slopes of 30° to 40°. A thick envelope of regur covers the northern part of the plain. On passing Chamanga, one notes that the ground rises slightly at the village of Kumgendia to form a low rounded ridge, about 2 miles wide. The rock does not crop out at the surface, but the purplish-brown sandy soil is probably derived from a rock similar to the quartz-porphyrite of Najanja.

The northern slope is steeper, and the path to Kendu passes between a low hill of basalt on the west and the basaltic cone of Orian (Rabur) on the east. Pebbles of quartz, jasper, and hæmatitic quartzite (like that of the Kisii Highlands) lie scattered on this slope, and perhaps indicate the old lake-beach at about 4000 feet, to which I have already referred (p. 146).

Another alluvial plain (also covered with black earth) extends for about 4 miles to the Northern Awach; while on the west it is bordered by an outspur from Homa, ending in a low scarped bluff:

[1] The rock has a splintery fracture, and contains somewhat melted-down phenocrysts (up to 4 mm.) of plagioclase (oligoclase-andesine, Ab_5An_3) which enclose occasional particles of green augite and little patches of a pale-green serpentinous aggregate; some pericline-twinning occurs. The quartz-phenocrysts (up to 7 mm.) are corroded and lobed in the typical manner, but also show a few hexagonal sections; they moreover enclose circular patches of the serpentinous aggregate: a very narrow, radiate, quartzose selvage borders the quartz-crystals, but is absent round the felspars. Minute crystals of pale-green augite occur very sparingly. The ground-mass is dusty, quartzose, sometimes microspherulitic, containing abundant microlites and needles of oligoclase and occasionally small aggregates of quartz-granules. The pale-green serpentinous aggregate also occurs disseminated in the ground-mass, and probably represents original glassy matter. Hæmatite-dust imparts to the rock its reddish colour.

this consists of a flow of phonolite,[1] overlying a cellular, yellowish earthy, calcareous tuff, much veined with calcite, and containing fragments of nepheline-crystals, a little biotite, some magnetite-granules, and a little zeolite. It is somewhat reddened and baked near the plane of contact.

Between the Northern Awach and the Kavirondo Gulf at Kendu is a hill of brown clay, its low slopes measuring no more than 5°. As we reach the summit, a crater-lake, Lake Simbi (Pl. XXIV), is suddenly disclosed to view, slightly elliptical in outline, the long axis running west-north-west and east-south-east and measuring about three-quarters of a mile, while the width of the lake is a little more than half of this. The river rises to between 70 and 100 feet above the surface of the lake, which stands somewhat below the level of the plain of the Awach on the south, but slightly above that of the Nyanza on the north.

The solid rock only appears in two places on the south-western shore, and consists of the micaceous sandstone which I subsequently found well developed along the coast west of the Awach. Elsewhere, the rim of the lake is composed of a brown clay dipping everywhere away from the centre of the lake at an angle of 30° to 40°. In places the clay contains blocks of gneiss (which occurs *in situ* only a couple of miles away to the east) and pebbles of quartz, but in no case were there any fragments of lava. On the edge of the eastern rim I found a block of travertinous limestone, measuring $3 \times 1\frac{1}{2}$ feet, containing a fragment of bone, and clearly belonging to the same series as the Pliocene beds west of the Awach (see below, p. 158). This block was indurated, and presented the appearance of having been subjected to heat. The outward dip of the clay of the lake-margin conveyed the impression that Lake Simbi marks the site of an explosion-crater similar to those of the Eifel. Probably it was formed within the memory of man, for the natives told me of a legend that its site was once occupied by a hill crowned by a homestead belonging to a very wicked chief, and that it was destroyed and disappeared in a single night. The water of the lake is yellow-green, due to the presence of confervæ, and jelly-like lumps of an emerald-green *Nostoc* occur along the margin. It is strongly alkaline and also bitter, with the fishy taste of carbonate of soda.[2]

[1] The rock is pale grey, compact, and fine-grained, exhibiting irregular fracture and a honeycombed surface, with some indications of lines of flow; occasional white felspars (up to 4 mm.) are visible. Under the microscope the felspar (sanidine) occurs in a few large phenocrysts with occasional Carlsbad twinning, but it has been much altered to a soda-zeolite. The ground-mass consists of a very fine-grained felt of abundant small nepheline-crystals, sanidine-microlites and granules, and needles of very pale-green augite in mossy aggregates and patches stained brown by iron-oxide, in a glassy base.

[2] Prof F. Stanley Kipping, F.R.S., has kindly examined my sample of the water, and informs me that, while sodium carbonate is the main component, iron salts, together with sulphates and silica, are present in appreciable quantities; smaller quantities of calcium and magnesium salts and phosphates are also present.

A thin crystalline crust is deposited round the shore, and has essentially the same composition as the water. It is gathered by the natives in baskets for mixing with their food, and for treating their tobacco. I noticed a similar efflorescence of soda on the borders of the Kimera swamp, north of Homa Mountain. The water is gradually rising, as shown by some half-immersed, dead candelabra euphorbias, already standing 10 feet away from the shore.

West of the mouth of the Awach River, the ground rises to form a terrace running east-south-eastwards and west-north-westwards, about a mile wide, between the Nyanza and the Kimera swamp; and it faces the Nyanza in a cliff about 30 feet high, flattening out again on the west. The lake has now retreated for about a quarter of a mile from the base of the cliff, which is cloaked at its foot by talus. The downward succession of the beds (dipping 5° north-north-eastwards), as revealed in the cliff, consists of:—

	Thickness in feet.
(1) Grey or pale-buff argillaceous sandstone, with small flakes of biotite and larger plates of greenish talc, also markings of dendritic manganese; current-bedded and coarser-grained than the lower beds. It contains pebbles of quartz up to three-eighths of an inch long. Calcite occurs along the bedding-planes.	5
(2) Brown, shaly, sandy clay	3
(3) Hard argillaceous sandstone, in thin beds alternating with shales	3
(4) Brown shaly clay, often wedging out	3
(5) (Base not seen.) Argillaceous current-bedded sandstone. Coarse beds, alternating with finer	10

A large surface of bare rock is exposed on the summit of the broad stony terrace, and the beds, instead of showing a plane surface, appear in gentle undulations, giving rise to a number of shallow basins. No ripple-marks are visible anywhere, and not a trace of any fossils. On the terrace the dip changes in the southern part to 5° south-westwards, whence we may infer that the terrace itself is a low anticline.

Farther west, only Beds 2 and 3 are visible in the cliff, which flattens out and finally becomes quite grass-grown. After some interval, another group of strata appear, evidently at a slightly higher horizon than the above-described series, but the actual junction was not visible. The cliff shows:—

	Thickness in feet	*inches.*
Recent soil	1	0
Gravelly grey clay	2	0
White calcareous travertine	0	6
Greenish-grey clay	1	0
(Base not seen.) White calcareous travertine in undulating beds, with tusks of elephant, bones of zebra, antelope, etc.	3	0

Still farther west, near a very big sycamore fig-tree, which forms a landmark, this travertine is more fully exposed over a wider area. Here the succession consists of:—

	Thickness in feet	inches.
(1) Greenish-grey sandstone, with bones of baboon.	2 to 6	0
(2) Grey gravelly clay, with streaks of sand and gravel	3	0
(3) White calcareous travertine, with bones of *Elephas* aff. *meridionalis*, *Hippopotamus*, *Phacochœrus*, and antelope [1]	6 ins. to 1	6
(4) (Base not seen.) Greenish-grey clay	4	0

The beds have been thrown into a broad syncline; for, in the western part of the exposure, they dip 20° south-south-eastwards, and in the eastern part (about 150 yards distant) they dip 50° north-north-westwards. These directions differ altogether from those observed in the sandstone cliff 5 miles away to the east, but it is probable that they are due to a local subsidence, perhaps caused by the leaching-out of underlying soda-beds, for there is still a strong efflorescence of soda on the surface of the beds of clay, and the crust is continually collected by the natives, as at Lake Simbi.

These beds are probably of late-Pliocene age, and they may be compared with the beds found north of Lake Rudolf, in the lower course of the Omo River, by E. Brumpt [2] in 1903, containing, among other bones, *Hipparion* (near to the Pliocene *H. lybicum*), *Hippopotamus*, *Rhinoceros*, *Phacochœrus*, *Buffelus*, *Camelopardalis*, antelopes, and *Elephas* cf. *meridionalis*. A tooth of *Dinotherium* was also recorded from these beds; but, either it is a Pliocene species, or it may have been derived from some earlier beds similar to the Karungu Miocene Series. The uppermost stratum consisted here of gypsum, and I have already suggested that the gypsum beds of the south-eastern angle of Homa Bay probably belong to the Pliocene Series north of Homa Mountain.

A rounded spur of hornblende-biotite-gneiss rises out of the low-lying country east of Lake Simbi, and this granitic gneiss,[3] which shows a more marked cataclastic structure than any

[1] These fossils will shortly be described by Dr. C. W. Andrews in a future paper.

[2] E. Haug, 'Traité de Géologie' vol. ii, pt. 3 (1911) p. 1727.

[3] The rock contains abundant allotriomorphs (up to 8 mm.) of plagioclase (oligoclase-andesine, Ab_5An_3), in which the fine twinning is often repeatedly bent; only traces of zoning are present, and decomposition-products (white mica, calcite, epidote, and zoisite) occur centrally. Orthoclase is less in quantity and in smaller grains (up to 4 mm.), usually turbid centrally. Green hornblende (up to 3 mm.) is fairly abundant (α, pale straw; β, olive-green; γ, blue-green), sometimes twinned, occasionally bent; it is especially associated with quartz and some may have recrystallized; occasionally with epidote and calcite centrally. Biotite is rather sparing, and has altered either to chlorite or to a mixture of chlorite, epidote, and zoisite; it has been much crinkled and contorted, encloses apatite, and is associated with magnetite and sphene. Magnetite occurs in a few crushed grains, and several pinkish-brown crystals of sphene are present. Quartz is abundant, very much crushed and rolled out into lenticular masses; the grains show denticulate margins and undulose extinction, with strings of inclusions.

of the other gneisses of which I collected specimens, and is probably older in date, stretches far away to the east-north-east through the districts of Nyakongo and Nyakàch. South of this gneissic area lie the slates of Wire Hill (a conspicuous flat-topped hill rising to 5276 feet), but I was unable to examine them. Their distribution is approximately indicated in a sketch-map (which Mr. C. W. Hobley kindly allowed me to examine) made by Mr. J. S. Coates, Government Geologist, in 1909. He designates these slates the Wire Hill Beds, and they appear to be associated in places with chalcopyrite in quartz and graphite, according to information kindly given to me by Mr. G. R. Chesnaye. Probably they belong to the same series as the schists at the base of the Vinyo Escarpment, but their relations to the gneiss are as yet unknown.

Appendix I.

Abridged Statement of the Downward Succession of the Miocene Beds at Nira, with Indications of the Points of Difference from the Outcrops at South Nira, West Kachuku, Kachuku, East Kachuku, and Kikongo.

Upper Series (Nos. 1–12).

Beds.		*Thickness in feet.*
No. 1.	Grey clays with calcified tree-stems, overlying a greenish-grey conglomerate, passing down gradually into argillaceous sandstone	8
No. 2.	Pale greenish-grey clay, with seams of brown shales	8
No. 3.	Brown clay, with thin seams of shale; northwards the clay becomes grey. At East Kachuku and Kikongo Nos. 2 & 3 consist of grey current-bedded sandstones, containing biotite and augite	9
No. 4.	Pale-grey clay. At East Kachuku it becomes an argillaceous sandstone	8
No. 5.	Hard grey clay, passing (at South Nira) into sandstone containing biotite and augite. At Kachuku it contains *Ampullaria ovata* and crocodiles' teeth	2½
No. 6.	Soft grey clay	2½
No. 7.	Pale-brown clay with septarian nodules; eastwards it becomes shaly	3
No. 8.	Grey calcareous sandstone, with thin seams of grey clay. At Kikongo it is current-bedded, containing augite and enclosing a few land-shells (*Tropidophora nyasana*, *Limicolaria*, and *Cerastus*)	6
No. 9.	Thinly-bedded grey clays and brown shales. At Kachuku and Kikongo the clay alternates with thin seams of travertine, and at Kikongo the lower part contains seams of grey sandstone	7
No. 10.	Brown clay. At Kachuku and Kikongo it consists of grey clay, with thin seams of travertine	5
No. 11.	Grey clay. At South Nira the upper foot is a massive grey sandstone	5
No. 12.	Brownish-grey clay yielding a river-crab (*Telphusa*) and scutes of crocodile. At South Nira and Kachuku are numerous seams of shale. At Kikongo the lower half consists of grey sandstone	4½

MIDDLE SERIES (Nos. 13–25).

		Thickness in feet.
No. 13.	Yellow-grey clay containing large plates of biotite; it yields *Trionyx*, *Testudo*, and Artiodactyls. Eastwards it becomes greenish-grey, with a discontinuous seam of white or pink calcareous concretions	5½
No. 14.	Dull-red marlstone, travertinous in places. It becomes greenish grey at Kikongo. It contains many casts of *Ampullaria ovata* (with opercula) and of *Lanistes carinatus*, as also *Trionyx* and other Chelonian remains. This bed forms a very definite and constant horizon	0½–1½
No. 15.	Red or grey clay, with a marlstone like No. 14 in the upper half, containing similar fossils, Artiodactylian *(Prodromotherium)* and Crocodilian remains. Thin layers of calcareous concretions in the lower half	5½
No. 16.	Grey sandstone, with a thin median seam of grey or red clay. At Kachuku it contains mandibles of small Hyracoids *(Miohyrax)*, *Trionyx*, crocodile, *Ampullaria ovata*, and *Cleopatra exarata*	1
No. 17.	Grey or red clay, passing down into grey sandstone which contains (at Kachuku) crocodile, *Trionyx*, and *Ampullaria ovata*	1
No. 18.	Red and grey mottled clay, sometimes with thin seams of sandstone or (at Kachuku, where it thickens to 3½ feet) of travertine	1
No. 19.	Grey sandstone with *Ampullaria ovata*, passing down into red clay which (at Kachuku) contains inconstant seams of mudstone. The lowest bed at Kachuku contains Chelonian and Crocodilian remains, together with *Cleopatra exarata*	2–3
No. 20.	Grey current-bedded sandstone passing down into red clay with seams of travertine, containing Chelonian, Crocodilian, Rhinoceros, and Proboscidean remains	4–5
No. 21.	White, current-bedded, calcareous sandstone, becoming argillaceous below, and containing *Cycloderma victoriæ*, *Ampullaria ovata*, *Lanistes carinatus*, *Burtoa nilotica*	2
No. 22.	Pale-grey current-bedded sandstone, becoming gravelly below. At Kikongo Nos. 21 & 22 are represented by grey clay. At Kachuku the latter bed contains a large Proboscidean tibia (perhaps of *Dinotherium*), Chelonian remains *(Podocnemis)*, and *Ampullaria ovata*	2
No. 23.	Grey sandstone passing into conglomerate. At Kachuku it is markedly calcareous	0½
No. 24.	Orange-coloured sand yielding teeth of *Protopterus*, crocodile, *Dinotherium*, small rodents (aff. *Phiomys*), etc., overlying a greenish-grey clay with *Ampullaria ovata* and *Cleopatra exarata*. At Kachuku this clay also contains *Achatina*. A thin travertine or travertinous sandstone yielding Chelonian remains forms the base	1½
No. 25.	Grey argillaceous gravel, overlying a red and grey mottled clay with Chelonian remains	2

LOWER SERIES (Nos. 26–37).

No. 26.	Buff-coloured, nodular, current-bedded sandstone, with remains of *Trionyx* and crocodile	0½–1
No. 27.	Grey, argillaceous sandstone, sometimes passing laterally into a coarse gravel composed of pink gneiss, green andesite, quartz, jasper, and grey sandstone (from an older bed); it contains fragmentary remains of *Trionyx* and crocodile, with coprolites	3

		Thickness in feet.
No. 28.	Hard, buff-coloured, nodular sandstone. At Kachuku it becomes a coarse calcareous conglomerate	$0\frac{1}{2}$
No. 29.	Yellow argillaceous gravel, with intercalations of greenish-grey clay or of yellow sandstone. It is a calcareous gravel at Kachuku, containing Chelonian remains and a fragment of a tusk	3
No. 30.	Conglomerate of rounded calcareous nodules (up to 2 feet in diameter) in a calcareous cement, each nodule showing concentric coats. It passes sometimes into a hard buff-coloured sandstone, and forms a very constant horizon ...	2
No. 31.	(*a*) Upper part (beds i & ii), 4 feet. Grey clay, with seams of sandstone and gravel, containing teeth of *Dinotherium* and bones of Anthracotheres (*Brachyodus* etc.).	
	(*b*) Middle part (beds iii–vii), 3 feet. Grey or brown clay, with seams of reddish-brown marlstone containing *Ampullaria ovata*. At Kachuku it becomes a current-bedded sandstone with a discontinuous seam of brown marlstone, containing a Proboscidean scapula and the mandible of a Carnivore (*Pseudælurus africanus*) (at West Kachuku).	
	(*c*) Lower part (beds viii–xv), 13 to 18 feet. Brown clay, with inconstant seams of calcareous conglomerate in the upper part. In the lower part it consists of grey clay which yields *Cleopatra bulimoides* and *Ampullaria ovata*, alternating with thin seams of current-bedded sandstone. Eastwards this division becomes more arenaceous, until at Kachuku it consists of two zones of lenticular beds of gravel, separated by 4 feet of buff-coloured current-bedded sandstone. The Upper Gravel Zone is the chief depository of bones of *Dinotherium hobleyi* (mandible, femur, humerus, tusk), bones of Anthracotheres, allied to *Hyopotamus* (large humerus and tibia of *Brachyodus*, mandible of *Merycops*, *Merycopotamus*, etc.), Rhinoceros, a Carnivore (*Pseudælurus africanus*) and a Creodont, giant tortoise (*Testudo*), *Trionyx*, crocodile, and *Cerastus* cf. *mœllendorffi*. In the Lower Gravel Zone only shattered Chelonian remains occur, and seams of travertine become dominant. The base of this division is not visible at Kachuku, although present at West Kachuku .	20–25
No. 32.	Dark-brown ferruginous marlstone yielding *Cleopatra bulimoides*, *Ampullaria ovata*, and *Lanistes carinatus*. Passes eastwards into a quartz-ironstone breccia, 3 feet thick	$0\frac{1}{2}$–3
No. 33.	Brown clay. At West Kachuku it is represented by a pale-buff-coloured sandstone, with lenticles of travertinous gravel	$3\frac{1}{2}$
No. 34.	Orange-coloured marlstone, with *Ampullaria ovata*. At West Kachuku it is represented by 6 feet of greenish-grey clay with numerous seams of travertine	$1\frac{1}{2}$
No. 35.	Brown clay	2
No. 36.	Brown sandstone. Nos. 33 to 36 are absent at South Nira and Nos. 35 & 36 are represented at West Kachuku by 5 feet of orange-brown marlstone with seams of travertine.	$0\frac{2}{3}$
No. 37.	Mottled crimson and pale-yellow clay, traversed by a vein of quartz. It is represented at West Kachuku, and even so far east as the cliff of East Kachuku. At East Kachuku Nos. 30 to 36 have thinned out, and at Kikongo Nos. 30 to 37 are completely missing	11

EXPLANATION OF PLATES XX–XXVI.

Plate XX.

Upper end of gully at Nira, looking north-east by east, showing the Upper Series. (See p. 130.)

Plate XXI.

Kachuku, upper end of gully, looking north-eastwards, showing part of the Upper and the Middle Series; the basaltic peak of Nundowat is seen in the distance. (See p. 131.)

Plate XXII.

Fig. 1. Gully of West Kachuku, looking north-north-westwards, showing the ledge of calcareous conglomerate (Bed 30); the basaltic hill of Nira is seen in the distance. (See p. 133.)

2. Lower part of Kachuku Gully, looking north-eastwards, showing the Upper Gravel Zone of Bed 31, containing *Dinotherium*, Anthracotheres, giant tortoise, etc.; the basaltic peak of Nundowat is seen in the distance. (See p. 133.)

Plate XXIII.

Fig. 1. Gorge of the Kuja, looking east-north-eastwards, showing the exit of the river from the Vinyo Escarpment. (See p. 149.)

2. Edge of the Manga Escarpment (quartzite), with the dolerite-sill at its base forming the fertile district of Kitutu. (See p. 151.)

Plate XXIV.

Crater-lake of Simbi, looking south-eastwards. (See p. 156.)

Plate XXV.

Geological map of the district between the Victoria Nyanza and the Kisii Highlands, on the scale of $4\frac{1}{2}$ miles to the inch, or 1 : 285,120.

Plate XXVI.

Fig. 1. Geological map of the neighbourhood of Karungu, showing the outcrop of the Miocene deposits at Nira, Kachuku, and Kikongo, on the scale of 2 miles to the inch, or 1 : 126,720.

2. Plan of the outcrop of the Miocene deposits at Nira, on the scale of 75 yards to the inch, or 1 : 2700.

3. Plan of the outcrop of the Miocene deposits at Kachuku, on the scale of 75 yards to the inch, or 1 : 2700.

F. O., Photo.

Bemrose, Collo. Derby

UPPER END OF GULLY AT NIRA, LOOKING NORTH-EAST BY EAST, SHOWING THE UPPER SERIES.

KACHUKU, UPPER END OF GULLY, LOOKING NORTH-EASTWARDS, SHOWING PART OF UPPER AND MIDDLE SERIES; THE BASALT PEAK OF NUNDOWAT IS SEEN IN THE DISTANCE.

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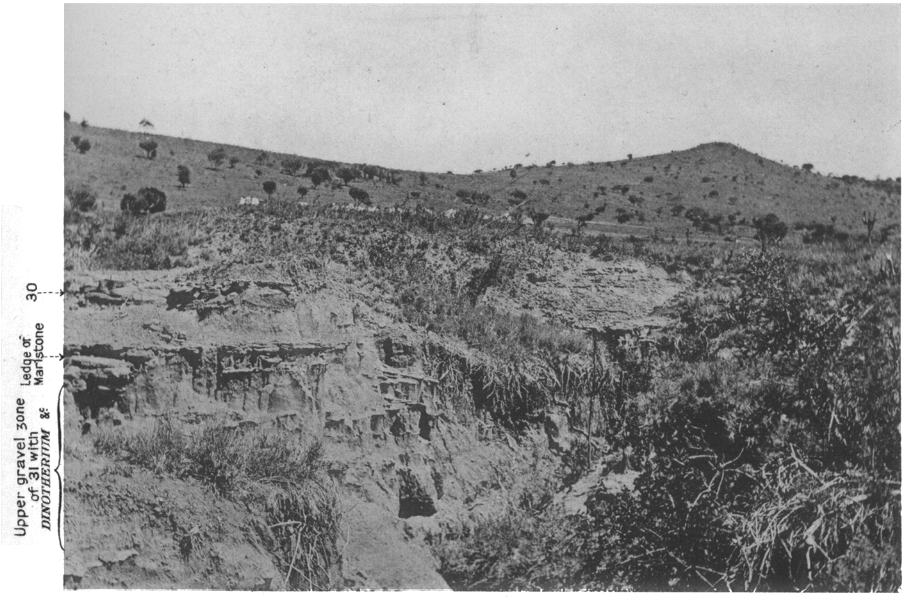
Fig. 1. Gully of West Kachuku, looking north-north-westwards.

F. O., Photo.

Fig. 2. Lower part of Kachuku Gully, looking north-eastwards.



F. O., Photo.

Bemrose, Collo. Derby.

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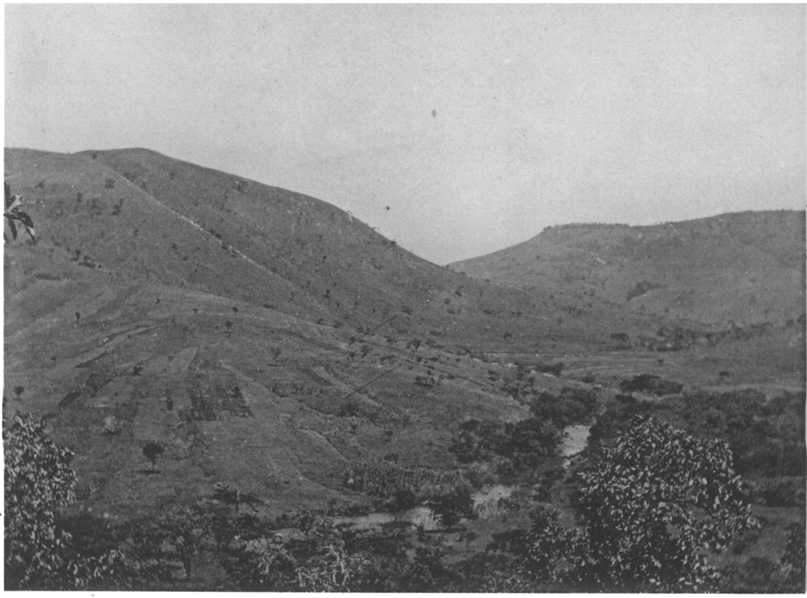
FIG. 1. GORGE OF THE KUJA, LOOKING EAST-NORTH-EASTWARDS.

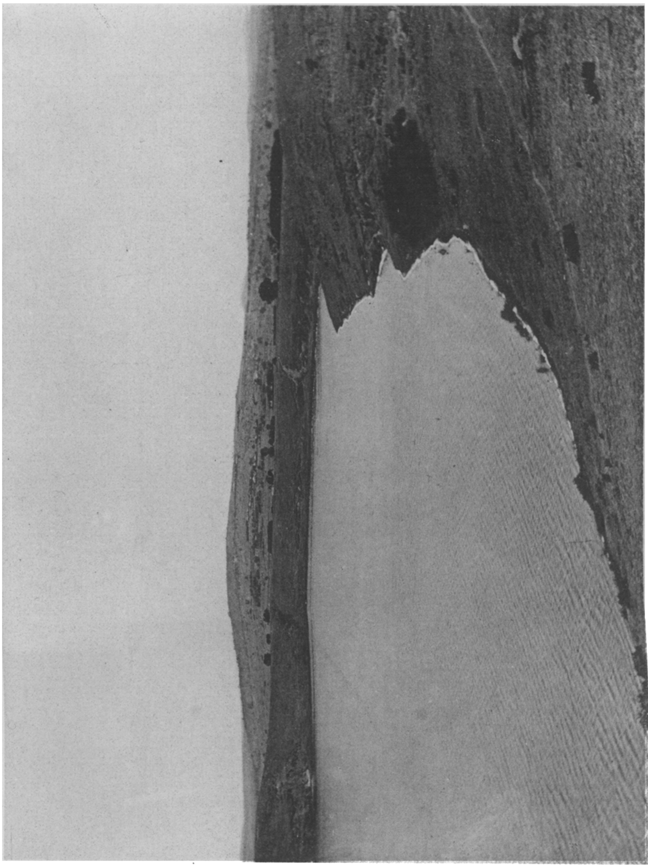


F. O., Photo.

FIG. 2. EDGE OF THE MANGA ESCARPMENT (QUARTZITE).

F.O., Photo.

Bemrose, Collo., Derby



F. O., Photo.

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CRATER-LAKE OF SIMBI, LOOKING SOUTH-EASTWARDS.

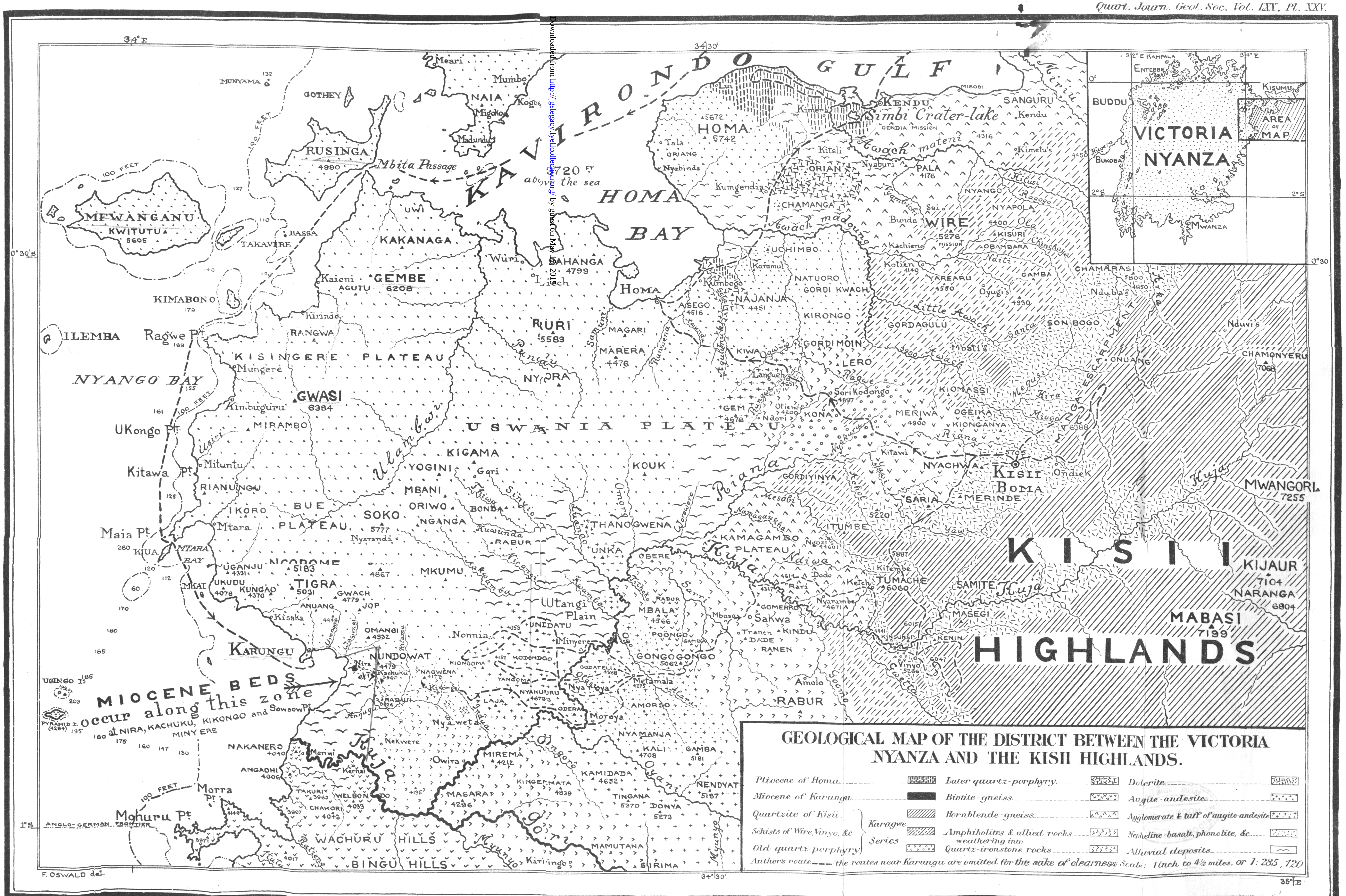
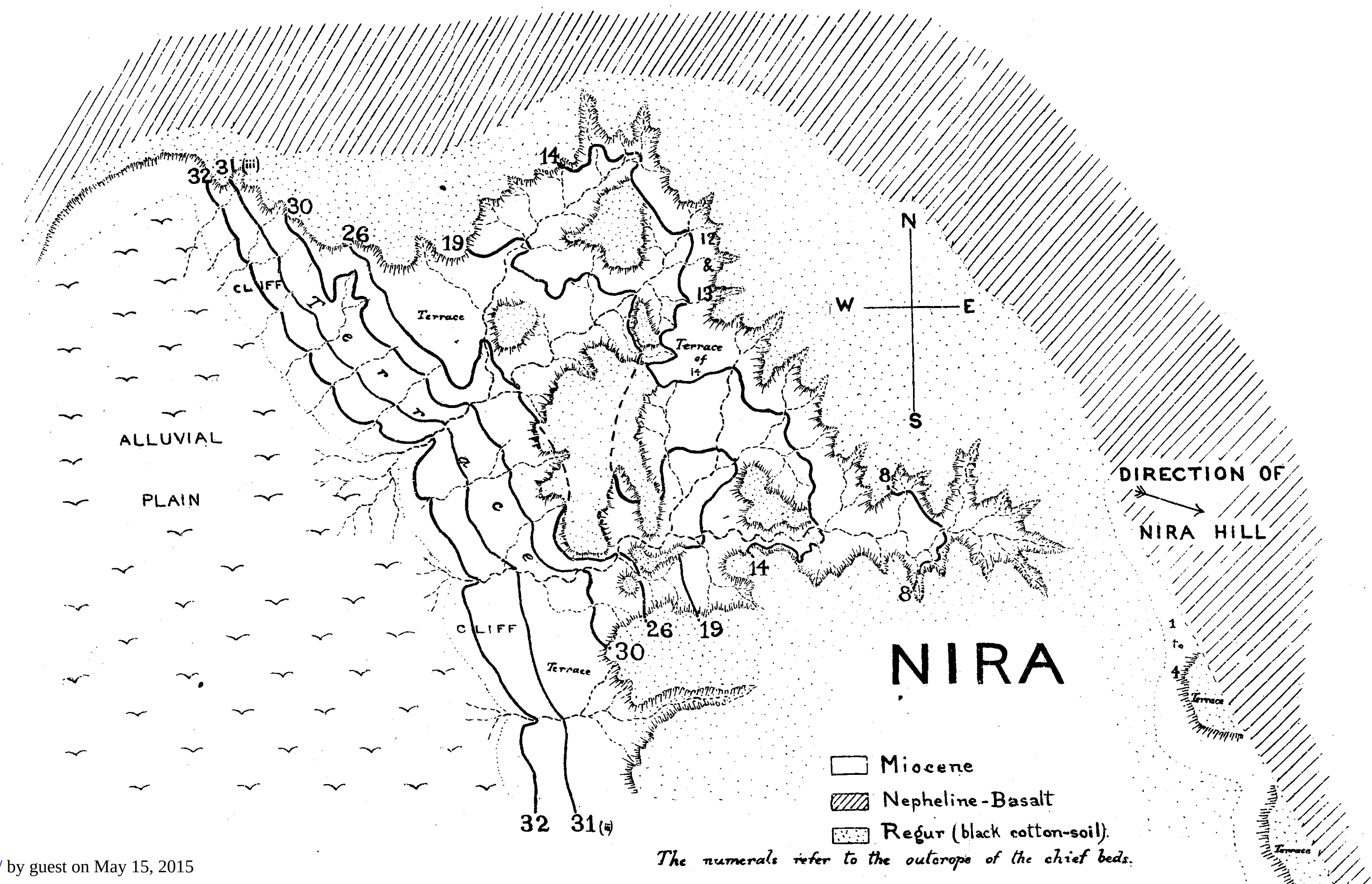
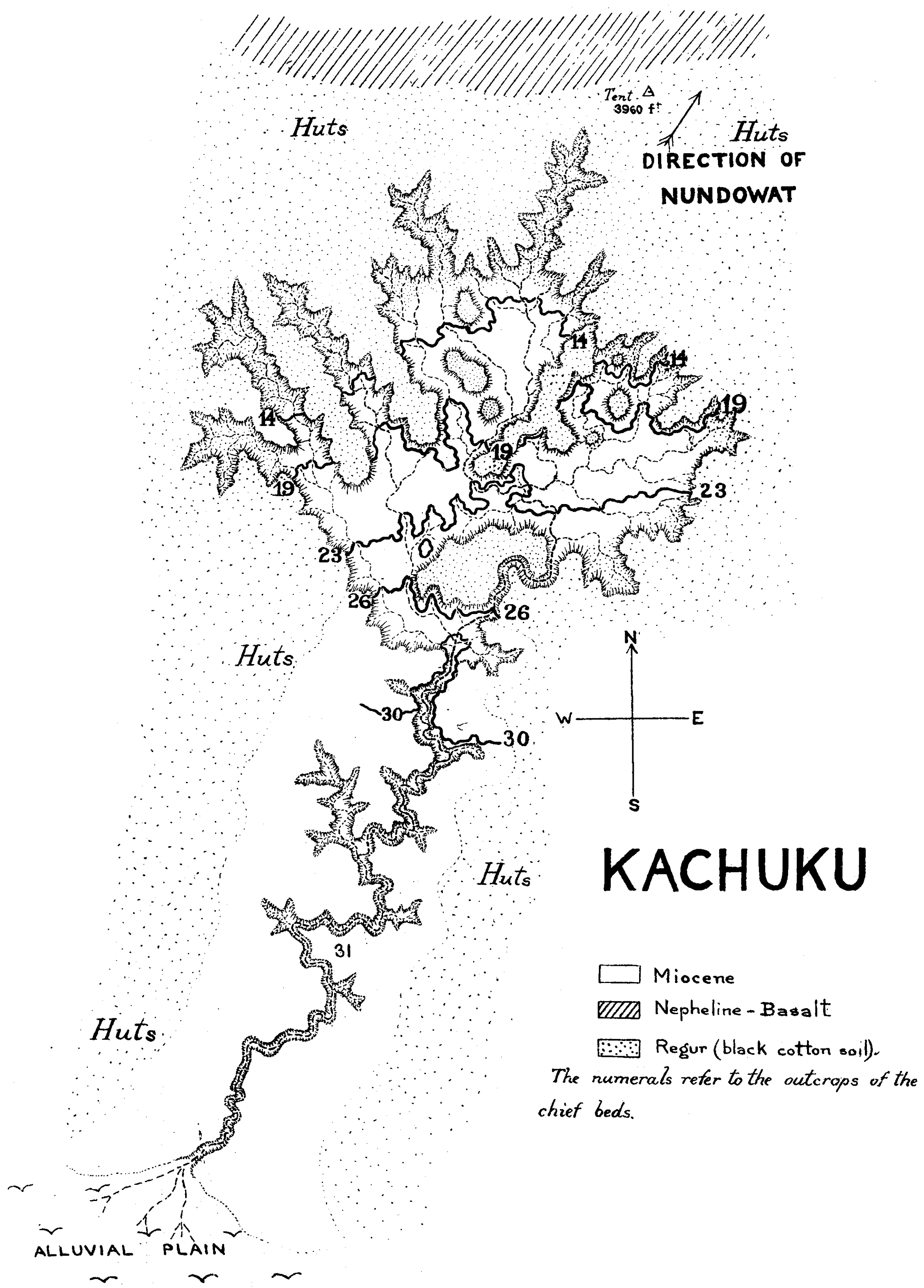

GEOLOGICAL MAP OF THE DISTRICT BETWEEN THE VICTORIA NYANZA AND THE KISII HIGHLANDS.
Pliocene of Homa
Miocene of Karungu
Quartzite of Kisii
Schists of Wire, Vinyo, &c.
Old quartz-porphyry
Karagwe Series
Later quartz-porphyry
Biotite-gneiss
Hornblende-gneiss
Amphibolites & allied rocks weathering into Quartz-ironstone rocks
Dolerite
Augite-andesite
Agglomerate & tuff of augite-andesite
Nepheline-basalt, phonolite, &c.
Alluvial deposits
Author's route (the routes near Karungu are omitted for the sake of clearness)
Scale: 1 inch to 4½ miles, or 1: 285,120
KAVIRONDO GULF
HOMA BAY
720 FT above the sea
Simbi Crater-lake
KISII HIGHLANDS
USWANIA PLATEAU
KISINGERE PLATEAU
NYANGO BAY
MIOCENE BEDS occur along this zone at NIRA, KACHUKU, KIKONGO and MINYERE
VICTORIA NYANZA
AREA OF MAP
RUSINGA
MFWANGANU
KARUNGU
HOMA
WIRE
MWANGORI 7255
KIJAUR 7104
NARANGA 6804
MABASI 7199
GWASI 6384
GEMBE 6208
RURI 5583
WACHURU HILLS
BINGU HILLS
ANGLO-GERMAN FRONTIER
F. OSWALD del.

Fig. 2. PLAN OF THE OUTCROP OF THE MIOCENE BEDS AT NIRA.



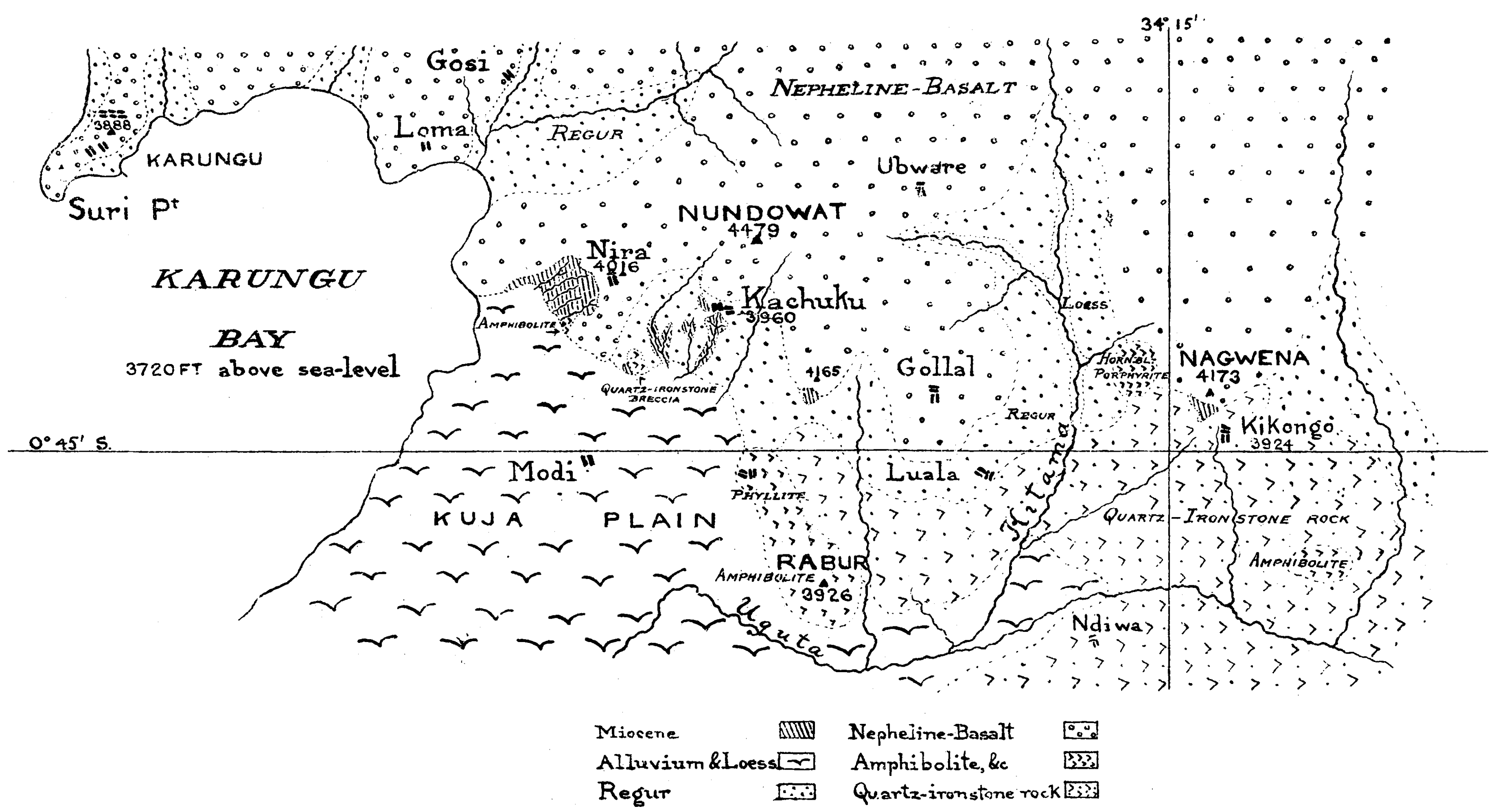
(Scale: 75 yards = 1 inch, or 1 : 2,700.)

Fig. 3. PLAN OF THE OUTCROP OF THE MIOCENE BEDS AT KACHUKU.



(Scale: 75 yards = 1 inch, or 1 : 2,700.)

Fig. 1. GEOLOGICAL MAP OF THE NEIGHBOURHOOD OF KARUNGU, SHOWING THE OUTCROP OF THE MIOCENE DEPOSITS AT NIRA, KACHUKU, AND KIKONGO.



(Scale: 2 miles = 1 inch, or 1:126,720.)