

Report No. 4



MINISTRY OF ENVIRONMENT AND NATURAL RESOURCES

MINES AND GEOLOGICAL DEPARTMENT

GEOLOGICAL SURVEY
OF
No. 2 MINING AREA, KAVIRONDO

**INTERIM REPORT AND MAP
OF NORTH-WEST QUADRANT**

by

**C. STANSFIELD HITCHEN,
Ph.D., B.Sc., A.R.C.S., D.I.C., F.G.S, A.I.M.M., M.A.I.M.E.,
Geologist**

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COLONY AND PROTECTORATE OF KENYA

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MINES AND GEOLOGICAL DEPARTMENT

12 APR 1969

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NAIROBI

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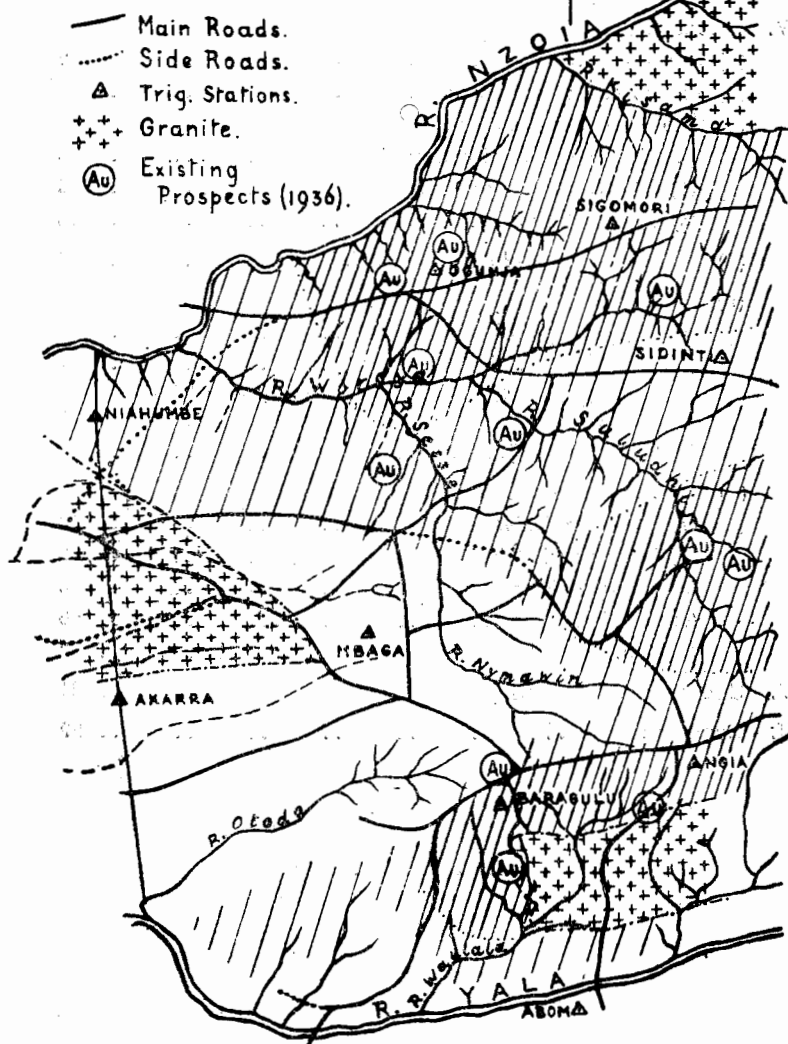
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1:250,000.

SKETCH MAP

showing favourable localities for prospecting, position of existing prospects, etc.



Shading indicates those areas which are considered most favourable for prospecting.

C. Stanfield Hitchen.
 Geologist. — 1936.

FIG. 1

FIG. 1.

EXPLANATORY NOTE.

The area is situated in an auriferous belt, and gold deposits may occur in all parts of it. Nevertheless, according to present knowledge, the areas indicated by shading on the sketch map are regarded as offering the best opportunities to prospectors. Dense shading indicates the most favourable areas, and more open shading, moderately favourable areas.

In the northern section, the best gold values are associated with a variety of blue-grey quartz, which occurs in small veins, 6 in. to 18 in. in thickness, and which contains arsenopyrite and other sulphides. The wall-rock in contact with these veins is often impregnated and frequently carries economic gold values. White varieties of quartz seldom carry more than a trace. Whatever the "make" of quartz, however, the presence of arsenopyrite should be regarded as a favourable indication.

As regards the prospects already in existence, no distinction is made between Protection Notices and Registered Claims. In the majority of cases, however, claims have been registered.

The sketch map is solely intended as a guide to prospectors and in no way reflects upon the value of existing prospects. The latter must, of course, be judged on their respective merits.

I.—INTRODUCTION.

The area dealt with in this report is approximately 200 square miles in size, and is bounded on the west by No. 1 Mining Area, on the north and south by the Nzoia and Yala Rivers respectively, and on the east by a line running due north through Ngia Trigonometrical Station.

The topographical detail is based on the original Mumias map, Africa, Sheet **North, A-36**
W, issued in 1916 on a scale of 1: 250,000. The opportunity has been taken, however, to correct where possible the original sketch topography, while the western and northern boundaries have been corrected by the recent aerial map of No. 1 Area.* The geology and corrections to the topography within the area have been based on the recent Secondary Triangulation of No. 2 Area, carried out by Mr. C. T. Cogle, A.I.M.M.

A plan of the roads is also incorporated, many of which were not in existence in 1913, when the country was originally surveyed.

The present interim report and map are based mainly on field work, and must be regarded as strictly provisional and subject to possible modification when the final coloured map and memoir dealing with the district appear. It is not, however, anticipated that such modification as may be necessary will affect the major features of the geology.

Nearly 300 rock specimens have been collected and microscope slides made of the majority of these. A certain amount of microscope work has already been done in order to meet requirements in the field, but a detailed discussion of the microscopical characters of the rocks must be postponed until the appearance of the final report or memoir.

As regards the general conditions for geological survey, it must be admitted that, while they are not excellent, they are very much better than those prevailing in the Kakamega

* Kindly placed at our disposal by Sir Robert Williams and Co.

District to the east. Major geological boundaries and contacts are, as usual, obscured, and there is a considerable thickness of overburden in the Woroya Valley; on the other hand, exposures are fairly frequent, and fresh specimens of the various rock types can usually be obtained.

It seemed desirable to include in the present report sections dealing briefly with the topography and the previous geological work done in the area. Obviously both these matters can be discussed in greater detail and with better advantage in the final report or memoir, when an opportunity has been taken to correlate the present findings with those of the Uganda and Tanganyika Geological Surveys in adjoining territories.

Finally, it is hoped that this bulletin will be accepted in the sense in which it is issued, namely, to make the information gleaned to date readily and immediately accessible to those operating in the field.

II.—PREVIOUS WORK.

Geological publications dealing with this and adjacent areas are listed below. Where necessary, brief notes are inserted concerning them and reference is also made to unpublished reports and maps:—

- (1) 1895.—Elliot, G. F. Scott and Gregory, J. W.: "The Geology of Mount Ruwenzori and some adjoining Regions of Equatorial Africa." *Quart. Journ. Geol. Soc.*, LI, pp. 669-680, with maps.

Contains the first information regarding the geology of this portion of Kenya.

- (2) 1898.—Hobley, C. W.: "Kavirondo." *Geogr. Journ.*, XII, pp. 361-372, with map. No copy of this paper appears to be available in Nairobi.

- (3) 1908.—Maufe, H. B.: "Report Relating to the Geology of the East African Protectorate." *Col. Rept., Misc. No. 45* (Col. 3828) London, 63 pp. 1 map.

- (4) 1921.—Gregory, J. W.: "The Rift Valleys and Geology of East Africa." London; Seeley Service and Co. An account of the general geology of a greater part of the Colony, together with a detailed bibliography. Special references to the present area are contained in Chapters III (p. 41) and X (p. 120).

- (5) 1927.—Combe, A. D.: *Ann. Rept. Geol. Surv. Uganda for 1927*, pp. 15-17.

- (6) 1928.—Combe, A. D.: *Ibid.*, pp. 9-10.

The items (5) and (6) above are digests of an unpublished report to the Kenya Government on the geology of North-western Kavirondo. A copy of the original report is lodged with the Mining and Geological Department, Nairobi.

- (7) 1929.—Combe, A. D.: *Ibid.*, 1929, pp. 18-19.

Certain green-grey rock referred to in items (5) and (6) above, and originally placed as Post-Karagwe-Ankolean, are found to be Pre-Karagwe-Ankolean.

- (8) 1929.—Ödman, O. H.: "Preliminary Report on the Archaean Geology of Western Nzoia Province, Kenya Colony." *Geologiska Föreningens i Stockholm Förhandlingar*. Bd. 51, H.1, pp. 77-90.

Contains an account and sketch plan of the geology between the Sio River and the Kavirondo Gulf.

- (9) 1930.—Ödman, O.: "Volcanic Rocks of Mt. Elgon in British East Africa." *Ibid.* Bd. 52, H.4, pp. 455-537, with two geological maps.

- (10) 1931.—Wayland, E. J.: "Report on a Geological Reconnaissance of South Kavirondo," with appendices on the petrology and assaying by A. W. Groves. The Government Printer, Nairobi.

This report is largely devoted to the geology, petrology and economics of South Kavirondo, but includes notes on the geological formations between the Uganda border and Kisumu.

- (11) 1932.—Wayland, E. J.: *Ann. Rept. Geol. Surv. Uganda for 1932*, pp. 9 and 12. Reference to a journey by air to Kakamega, with notes on the Kakamega goldfield.

- (12) 1932.—Davies, K. A.: *Ibid.*, pp. 36-40. On the geology of Bukoli Country (Busoga) and Samia Country (Budama), adjoining Kenya Colony. Reference is made to the Karagwe-Ankolean sediments, granites and other intrusive rocks.

- (13) 1932.—Combe, A. D.: "The Geology of South West Ankole." *Geol. Surv. Uganda, Memoir No. II*, pp. 218-219. The Government Printer, Entebbe.

The supposed Karagwe Ankolean rocks of Kavirondo are compared with the Karagwe Ankolean of other areas.

- (14) 1932.—Kitson, Sir Albert E.: "Interim Report on the Kakamega Goldfield, Kenya." The Government Printer, Nairobi. A general account of the geology of the Kakamega area is given, together with notes on the modes of occurrence of gold.

- (15) 1933.—Kitson, Sir Albert E.: "Report on an Application by Messrs. Tanganyika Concessions, Ltd., for an Exclusive Prospecting Licence under the Mining Ordinance, 1931, in respect of an area of 5,900 square miles approx. in North, Central and South Kavirondo Districts, Kenya Colony." The Government Printer, Nairobi.

- (16) 1933.—Davies, K. A.: *Ann. Rept. Geol. Surv. Uganda for 1933*, pp. 21-23. Further notes on the geology of Samia Country (Budama).

- (17) 1933.—Murray-Hughes, R.: *Provisional Geological Plan of the Kakamega Area; Nairobi*. A more detailed edition of this plan, by D. Harverson, is contained in the *Ann. Rept. Mining and Geol. Dept., Nairobi*, for 1934.

- (18) 1933.—Murray-Hughes, R.: "Notes on the Geological Succession, Tectonics and Economic Geology of the Western Half of Kenya Colony." Government Printer, Nairobi.

Includes two sketches illustrating the solid and tectonic geology between the Tanganyika boundary and Lake Rudolph.

- (19) 1934.—Kitson, Sir Albert E.: "Geological Reconnaissances in Kavirondo and Other Districts of Kenya." (Final Report.) Government Printer, Nairobi.

This report includes accounts of road journeys within the area now under review, together with notes on the geology, rocks, and occurrence of gold.

- (20) 1935.—Davies, K. A.: "A Contribution to the Study of the Geology of Kavirondo." Geol. Surv. Uganda, Bulletin No. 2, pp. 30-36. The Government Printer, Entebbe.

The nature and relationships of the chief rock types of Kavirondo are described, and are compared with those that occur in the adjoining portions of Uganda (Budama). The grits, conglomerates, and slates of Kavirondo are believed to represent a series later than the true Karagwe Ankolean of Uganda.

- (21) 1936.—Pulfrey, W.: "Geology of an Area in the Kavirondo District, Kenya Colony." Geological Magazine, LXXIII, pp. 26-38.

The geology and petrology of an area of 35 square miles, situated on the northern slope of the Yala-Edzawa Divide in the vicinity of Kaimosi Mission Station, is described.

Various details concerning the area will be found in the Annual Reports of the Mining and Geological Department, Nairobi, for the years 1932, 1933 and 1934.

Although not directly bearing on the area dealt with in this report, the following publications by the Geological Survey of Tanganyika are noteworthy for purposes of reference, comparison and correlation:—

- (22) 1928.—Grantham, D. R.: Ann. Rept. Geol. Surv. Tanganyika for 1928, pp. 12-15. Includes an account of the rocks composing the Ndembera Volcanic Series.
- (23) 1933.—Teale, E. O.: "Provisional Geological Map of Tanganyika with Explanatory Notes." Bulletin No. 6, Geol. Surv. Tanganyika. Government Printer, Dar es Salaam.
- (24) 1935.—Stockley, G. M.: "Outline of the Geology of the Musoma District." Bulletin No. 7, Geol. Surv. Tanganyika. Government Printer, Dar es Salaam.
- (25) 1935.—Stockley, G. M.: "The Musoma Goldfields, Tanganyika Territory." The Mining Magazine, LIII (July), pp. 9-20.

As regards unpublished reports and maps, reference may be made to an original map of Kavirondo by Hobley, which Davies (12) mentions as being either in the Coryndon Museum or Macmillan Library, Nairobi. Search has so far failed to disclose this document. Material lodged with the Mining and Geological Department in Nairobi includes:—

- (26) 1928.—A copy of the unpublished report by A. D. Combe, entitled "A Short Account of the Geology of part of North-western Kavirondo," prepared at the request of the Kenya Government, and dated 24-2-28. This is referred to above—*see* items (5) and (6).

(27) 1933-34(?)—Two Ordnance maps, Africa, Sheets $\frac{\text{North A-36}}{\text{W}}$ and $\frac{\text{North A-36}}{\text{Q}}$ coloured to show the major geological features, prepared by Mr. Murray-Hughes.

The geology of the Kakamega area was further investigated by the Acting Government Mining Engineer in 1934 and again in June, 1935, the data collected being in the form of field notes and sketch plans.

III.—TOPOGRAPHY.

The area now under review forms part of a large topographical unit which comprises the region stretching southwards from the foothills of Mount Elgon to the Kavirondo Gulf, and westwards from the Nandi Escarpment to Lake Victoria and beyond the Kenya-Uganda boundary.

Within the area mapped, the country is gently undulating and consists of broad, flat-topped ridges and long and gentle valley slopes, the average elevation being about 4,000 ft. above sea-level. At certain points, particularly in the west, residual hills (e.g. Adua, Mbagha, and the Akarra Ridge) rise several hundred feet above the present land surface. Extremely flat areas covered with a cap of lateritic ironstone are common, the most extensive lying to the south of Mbagha Hill in the vicinity of Siaya Rest Camp. These flat areas and the flat-topped ridges or divides are regarded as the remnants of an old peneplane. The flat tops of some of the residual hills—very noticeable in the case of Regeya T.S.,* which lies a little outside the present area—are regarded by some as the last traces of a yet older peneplane.

The drainage system appears to be an ancient one, but it has undoubtedly been modified by earth movements during comparatively recent geological times. Thus, while both the Nzoia and Yala Rivers and their tributaries flow in wide mature valleys, they show unmistakable signs of rejuvenation. In this particular area, the Nzoia and Yala flow swiftly over rocky beds which are everywhere being cut deeper, while there is a marked absence of alluvial flats and terraces. Together with others who have studied the area, the writer believes this rejuvenation to be largely due to the rise of the Nandi Escarpment and its associated earth movements, which appear to have resulted in a tilting of the peneplane in a

* T.S.(s) = Trigonometrical Station(s).

general south-westerly direction. Faulting, and the fall in the level of Lake Victoria during comparatively recent times, may also have been important factors.

The rejuvenation of the Nzoia would appear to have been greater in magnitude than that of the Yala, and to have been accompanied by a rejuvenation of its feeders from the south in Alego—the Woroya, Suludhi, Viratsi, and Siga Rivers. The headwaters of these tributaries have actively cut back their beds and now occupy much of the country that was originally drained by the northern feeders of the Yala, that flow into the latter below Yala Township.

From its source on the Uasin Gishu Plateau, the Nzoia cuts through the Nandi Escarpment and flows in a somewhat tortuous fashion towards Lake Victoria. In spite of many minor bends and curves, the general south-westerly direction of its course is remarkably constant. This constancy appears, however, to be purely fortuitous. Between a little below Broderick Falls and the Kisama River, the Nzoia flows for many miles over the great outcrop of the Mumias granite, while within the area mapped its course is deflected by such minor geological features as dikes, shear-zones, and the local strike and cleavage of the sedimentary rocks. The courses of the Woroya, Viratsi and Suludhi Rivers appear to have been influenced by the middle pelitic facies of the sediments.

The topography probably dates from the commencement of the Kainozoic era, at which period the country appears to have consisted of a vast and extremely flat peneplane, above which rose occasional monadnocks or residual hills of more resistant rock.* The climatic conditions then prevailing (alternating wet and dry seasons or periods) resulted in the formation of a hard capping of lateritic ironstone, the remains of which can still be seen.

At that remote period the Nzoia and Yala Rivers existed, but were wider, grander, and more gently flowing rivers than they are to-day.

From a practical standpoint, the topography renders prospecting difficult. The gentle valley slopes of the principal rivers and streams are generally covered with a thick overburden of soil, while on the flat-topped ridges the laterite cap

* An example of the type of country that probably existed in this area may be seen at the present day in the vicinity of Mtito Andei.

is hard and difficult to penetrate. Dealing with this area in the Annual Report of the Mining and Geological Department for 1934, R. Murray-Hughes writes :—

“ The topography is mature and this maturity is characterized by immensely broad valleys with flat divides. The overburden is deep, and the redistribution of detrital gold by a changing river system results in those conditions which puzzled the prospector in the Kakamega area originally—gold widely distributed in the soil but the source of it obscure.”

IV.—GEOLOGY.

1.—GENERAL FEATURES.

Geologically the area may be regarded as composed of two halves—a northern half consisting of a thick belt of ancient sediments, and a southern half which is occupied by an even more ancient series of andesitic lavas. Small outliers of the sediments occur within the area occupied by volcanic rocks, while, in the extreme south, they again appear as a thin narrow belt adjoining the Yala River, and are there associated with interbedded (contemporaneous) volcanics (lava and ash).

The sedimentary rocks of the northern belt consist of breccias, conglomerates, feldspathic grits (arkose), siltstones, shales, mudstones, and phyllites; but rarely does anything approaching a true quartzite make its appearance. Three divisions of these sediments may be recognized, namely, (a) a basal division which includes breccias, feldspathic grits, siltstones, and large “stocky” lenses of conglomerate; (b) a middle division of shales and phyllites with intercalated mudstones, siltstones, and finer grits; and, (c) an upper division of feldspathic grits.

Unlike the sedimentary rocks of the northern belt, which have been derived from mixed, yet predominatingly acid sources, those composing the narrow belt adjoining the Yala River have been largely derived from the pre-existing lavas, yielding what may be appropriately described as “andesitic” grits and conglomerates. This also applies to the small outliers.

Regarded as a whole, the sediments are unfossiliferous and are almost certainly of Pre-Cambrian age, though whether

they are truly Karagwe Ankolean (or Muva Ankolean)* is doubtful. They were tentatively placed as Karagwe Ankolean or Muva Ankolean by previous workers in the field, who were disposed to regard their distinct lithological characters as due to local causes—i.e., that they represented a peculiar local facies of the Karagwe Ankolean.

Conversations the writer has recently been privileged to have with the Director and Members of the Geological Survey of Uganda, coupled with evidence which has recently come to light, suggest that these sediments form a series later than the true Karagwe Ankolean of Uganda. Not only are they lithologically different from the Karagwe Ankolean of Uganda, but in North Kavirondo they appear to have been in part derived from—and are therefore later than—a series of banded quartzites, which are regarded by Davies as most probably the equivalent of the Karagwe Ankolean (20, p. 32) of the type area.

Having regard, therefore, to these uncertainties, and also to the extent, great thickness, distribution, and unique lithological character of these ancient sediments, it is proposed to refer to them as the *Kavirondo Series*. *When their characters are better understood, it may be possible to equate them with occurrences in Uganda and Tanganyika, but the time is not yet ripe.*

Within the area occupied by the ancient lavas many varieties of rocks occur, the full elucidation and correlation of which will form a distinct research problem. Suffice it to say at present that they are generally andesitic or phonolitic in character, and that they can be conveniently grouped for field purposes into (a) porphyritic and melanocratic andesites, and (b) non-porphyritic (aphanitic) andesites.

Intrusions of granite occur in the north, west, and south of the area, while those prominent topographical features—Mbaga Hill and the Akarra Ridge—are composed of a dense, fine-grained doleritic rock. Minor intrusions, ranging from lamprophyre and dolerite to porphyries and felsite abound in all parts of the area, and occur both in the form of small bosses and of dikes. While the sediments of the Kavirondo

* At the Kigoma Conference in 1931 it was decided to replace the term Karagwe Ankolean by that of Muva Ankolean, the latter signifying a correlation between the Karagwe Ankolean of Uganda and N.W. Tanganyika with the pre-Katanga sediments of the Muva Series of Northern Rhodesia.

Series in the north form a highly compressed, eastwards pitching syncline, the older andesitic lavas appear to constitute a rude yet complimentary anticline.

A tentative geological sequence for the area is given below :—

PLEISTOCENE AND RECENT

High level gravels, laterite cap, M-Horizon and isolated patches of alluvium and gravels.

SUPERCrustal Series

KAVIRONDO SERIES

(*Pre Cambrian*)

Main or Northern Belt :

- (3) Upper Division. Felspathic grits (arkose) with pebble bands containing slate at base.
- (2) Middle Division. Slates, mudstones, and phyllites, with intercalated finer grits and siltstones.
- (1) Lower Division. Conglomerates, breccias, siltstones, and felspathic grits (arkose) containing pebble bands.

Yala or Southern Belt and Outliers :

“Andesitic” conglomerates and grits equivalent to (1) above.

PRE-KAVIRONDO

ANDESITIC SUITE

- (2) Porphyritic and Melanocratic Andesites.
- (1) Non-Porphyritic (Aphanitic) Andesites.

INTRUSIVES

MAJOR INTRUSIONS

	Age
(a) Kanyaboli granite (variable coarse grained hornblende-biotite type)	Post-K.S.
(b) Kisama granite (porphyritic coarse-grained hornblende-biotite type)	Regarded as Post K.S.
(c) Nyarodi granite (variable fine grained hornblende-biotite type)	Pre-K.S.
(d) Quartz Gabbro associated with Nyarodi granite	Pre-K.S.
(e) Akarra Dolerite	Probably Pre-K.S. but intrusive into Pre-K.S. volcanics.

K.S.=Kavirondo Series.

MINOR INTRUSIONS

- (f) Younger Dolerites
 - (g) Hornblende-biotite Lamprophyre ..
 - (h) Felspar Porphyry
 - (i) Black Felsite
 - (j) Banded Felsites and Related Aphanites ..
- Post K.S.
Post K.S.
Post K.S.
Unplaced.
Unplaced.

2.—PLEISTOCENE AND RECENT.

No attempt has been made to make a detailed study of the Pleistocene and recent deposits in this area. As the result of the rejuvenation of the Nzoia and Yala Rivers during comparatively recent times, old river terraces and alluvial flats have been largely destroyed, and the material swept westwards towards the Yala Swamps and Lake Victoria. A few isolated beds of alluvium and gravel, underlain by boulder beds, were noted in the vicinity of Abom Bridge, but, generally speaking, both rivers—and particularly the Nzoia—flow over rocky beds which are still in process of being incised.

An old high level gravel was noted beneath the laterite cap directly below Naihumbe T.S. at an altitude of 4,080 feet. Similar high level gravels have been noted towards the north of the area, and particularly in the neighbourhood of Ogunja T.S. at an altitude of 4,180 feet. Their distribution suggests that they may have been laid by the Nzoia River prior to its rejuvenation.

Attention has already been drawn to the flat, laterite-capped areas which represent the remains of an old peneplane. The laterite itself was formed under a set of special climatic and other conditions which prevailed during past geological times. Such conditions, however, no longer exist, and observation shows that the laterite or "murrum" cap is everywhere in process of destruction.

What is believed to be the M-Horizon of Wayland has been noted towards the eastern half of the area. This horizon here consists of a thin band of rubble (rich in quartz in the vicinity of quartz veins) which bears no apparent relation to the present land surface. It has not been noted in the more rocky western portion of the area, but a little beyond the eastern boundary of the area mapped, it is rich in quartz rubble carrying both free gold and sulphides.

3.—THE KAVIRONDO SERIES.

(a) *The Main or Northern Belt.*—The rocks of the main or northern belt are everywhere characterized by the freshness of their material and the relatively high proportion of angular particles. Moreover, much of the material appears to be of local origin, having been derived from granite and other rocks rich in felspar. In general, the rocks suggest the rapid deposition in a large continental basin, the floor of which continued to sink until a vast thickness of sediments had accumulated.

The general strike of the rocks is between 100 and 110 degrees, but is locally modified, e.g. in the vicinity of Kaluo. The dips are usually very steep and mostly exceed 80 degrees, indicating the magnitude of the subsequent compressional forces which operate from N. by E. or S. by W. directions. This compression also induced a cleavage, more or less conformable with the strike, which often obscures the true direction of the bedding. Most of the rocks composing the northern outcrop break with a conchoidal fracture characteristic of a mild degree of regional metamorphism.

In general the various grades of sediments lens into one another, and in consequence there exists no satisfactory stratigraphical horizon.

The predominating rock of the lower division is a grey, richly felspathic grit or arkose in which clear angular and rounded quartz grains may be usually distinguished with a lens. It suffers local modification, both as regards granularity and the proportion of quartz and felspar present.

Owing to the very high content of felspar, the grits weather easily, and over a greater part of their outcrop are covered with a thick mantle of sandy soil. Even beneath this thick covering of soil, "in situ" decomposition may extend to considerable depth, with the result that outcrops of hard fresh rock are infrequent. Locally, the felspathic grits contain pebble bands composed largely of felsic materials, both clear and opaque quartz particles, and interstitial pyrite. They range from one to ten feet in thickness, and do not form continuous horizons.

Within the area occupied by the felspathic grits occur two large stocky lenses of conglomerate—one in the southern portion of the outcrop at Kaluo, and the second and larger of the two in the north, in the vicinity of Ogunja and Sigomori T.S.s. In view of what has been said and written concerning conglomerates in Kakamega and other portions of the field, the fact should be stressed that both these lenses are composed of water-laid conglomerates and show rounded pebbles set in a matrix of arkose. They are not, however, typical basal conglomerates.

The pebbles are often separated by narrow bands of grit, thus enabling strike and dip determinations to be made. Over the whole of the conglomerate outcrops weathering is very even, and rarely do the pebbles stand out from the matrix or become detached.

These conglomerates constitute one of the most interesting rocks in the field, and are worthy of detailed attention as soon as time and funds become available. There is little doubt that a careful and systematic study of the pebbles would throw much light not only upon the sources of the material but upon the general geology prior to sedimentation. Pebbles themselves indicate a great variety of rock types, including crystalline schists, quartzites, hard phyllite, felsites and porphyries, two varieties of granite, greenstones of various types, ultrabasic rocks, and vein quartz. In size, the pebbles range from half an inch to one foot in diameter.

The northern conglomerate lens, in the vicinity of Nzoia, is not well exposed, but it appears to be a simple lens, more or less conformable with the general strike. On the other hand, the Kaluo conglomerate is structurally interesting. The portions of the lens to the east show a normal east-west strike; at the foot of Adua Hill, however, the strike, as interpreted from the intercalated arkose bands, suddenly swings north. A detailed study of the strikes throughout the lens brings out the structure shown on the map, which suggests either that, (a) the conglomerate lens was laid in a skirting fashion around the corner of the Kanyaboli granite, or that (b) the structure of the lens exerted some control on the intrusion of the granite, these alternatives depending, of course, on the age of the granite relative to that of the conglomerate. The conglomerate lens has doubtless suffered some distortion and fracture by later compressional movements, but in the writer's opinion its structure cannot be wholly attributed to earth forces. The north-south strikes appear to be original and not induced. The Kaluo conglomerate contains frequent pebbles of two varieties of granite—a coarse-grained hornblende granite and a fine-grained mucovite-biotite granite.

Beneath each of the conglomerate lenses a thin bed of breccia has been observed, containing angular fragments of a hard, black, microcrystalline rock, many quartz grains, and sporadic sulphides.

Towards the upper part of the Lower Division there occur layers and lenses of grey banded siltstone, which have often been sharply folded and puckered between the harder beds of grit, so that their strike, as inferred from the banding, is very irregular and complex, and appears in places to transgress the normal strike of the grits. In some localities, e.g. near the Nzoia Bridge, the banding curves through more than 90 degrees within the space of a few square yards.

These banded siltstones are practically identical in appearance with certain dikes of a grey banded felsite (j), which are intrusive into the volcanics in the southern part of the field. Microscopical examination, however, shows them to be typical siltstones, composed of much fine sericite and many detrital grains of quartz and felspar.

The middle division is pelitic in character, though not entirely so; thin bands of slate and phyllite alternating with beds of finer grit and siltstone. Outcrops of the slates, etc., are found mainly in the beds of the Woroya, Sesse, and Suludhi Rivers, but away from the river cuttings, outcrops are scarce. From a study of the distribution of the rocks of the lower and upper divisions, however, it is plain that this pelitic facies is of no great thickness. Moreover, observations along the banks of the Nzoia, where outcrops are very plentiful, show nothing but a few extremely thin shale bands; these occur near the junction with the Woroya.

In the upper division there is a reversion to former conditions, i.e. shallower water and rapid sedimentation. Felspathic grits again appear, and are generally similar to those of the lower division. At the base of the upper grits, several pebble beds have been found, which are notable by reason of the fact that they contain numerous flakes of slate, up to one square inch in size, similar to that found in the middle division. This is regarded as indicative of some degree of contemporaneous erosion, and forms one of the principal reasons for the tentative division of the Kavirondo Series into the middle and upper facies. The felspathic grits of the upper division are well exposed at the base of Rangala Hill and at several points along the Rangala Ridge.

(b) *The Southern or Yala Belt.*—As already stated, the sedimentary rocks of this belt are of an entirely different lithological character, having been derived from the erosion of granite, quartz gabbro, and andesitic lavas—the latter providing the greater part of the material. In common with those of the northern outcrop, however, they are composed of remarkably fresh material and contain a high proportion of angular and sub-angular particles. The proportion of ferromagnesian minerals is high, so that the grits and conglomerates are often light to dark green in colour. The grits are frequently difficult to distinguish from the andesitic lavas, from which they have been derived. The conglomerates tend to occur in long thin lenses, but texturally they are similar to those of the northern belt.

No equivalents of the middle pelitic facies or the upper psammitic facies of the northern belt are found, but relationships are complicated by the presence of contemporaneous volcanics, which include a relatively thin lava flow and ash beds, the latter containing occasional bombs of the lava. The lava itself is wholly different in appearance from any of the rocks of the andesitic suite, and consists of many hornblende phenocrysts set in an equigranular matrix of felspar. In the vicinity of the conglomerate the flow has caught up and engulfed pebbles of granite, quartz gabbro and other rocks.

The structure of this belt is clearly synclinal, but dips are not so steep as in the north. About a mile to the east of Abom Bridge a massive tor of boulder conglomerate occurs which shows horizontal bedding.

(c) *The Outliers.*—The two small outliers of the sediments within the andesitic field were at first confused with certain andesite flow breccias, but closer study revealed their sedimentary character. They are, nevertheless, apparently unconnected with either of the large belts of the Kavirondo Series, and are regarded as having been laid down in small isolated basins in the lava field. Their constituent material is fresh, and has suffered only moderate attrition. In composition they are a curious blend of acid and basic rocks, and include fragments of the andesites, felsitic and cherty matter, and occasional angular grains of clear quartz. Interstitial pyrite and chalcopyrite are not uncommon locally.

4.—THE PRE-KAVIRONDO ANDESITIC SUITE.

In his unpublished report of 1928, Combe mentions certain "light green grey (igneous) rocks of intermediate composition" as stretching in a broad belt from Malanga in a west-south-westerly direction to the Yala Swamp, to the south-east of Lake Kanyaboli. He suggested that they represent altered andesites, dolerites, and possibly phonolites.

A more detailed study of this area has borne out this conclusion, and has shown that these light green grey microcrystalline rocks constitute the most common and widespread member of an andesitic suite, which embraces several contrasted types. Cursory microscopical examination indicates: (a) that propylitization has ensued with the production of calcite, sericite, and chlorite, and (b) that they are actually more basic than their appearance in the field suggests. Many specimens contain much calcite, and effervesce freely on treatment with acid.

These aphanitic andesites occur south of the line running eastwards through Akarra and Mbaga T.S.s, and a number of exposures are seen on the northern slopes of the Otodo Valley. Only very rarely are flow and other structures seen that disclose the "lie" of these rocks. The weathered forms are yellow, and often resemble the weathered arkose of the sediments; they do not, however, afford a residual sandy soil but a dense yellowish-red clay. On the flat-topped ridges they are commonly capped by a layer of hard lateritic ironstone.

Towards the south these aphanitic andesites give place to porphyritic and basic (melanocratic) types, among which two varieties predominate: (a) a rock with small, square, white phenocrysts of felspar set in a greenish-black aphanitic matrix; and (b) a rock with larger elongated white felspar phenocrysts (often very fresh) set in a bluish microcrystalline groundmass. This latter rock resembles certain nevadites and dacite porphyries, and the fact that it may be intrusive has not been overlooked. Other varieties are devoid of phenocrysts and, judging by their dark colour, are extremely basic, though not basaltic.

Types similar to (a) above have been found on the south of the Akarra Ridge and in the valley of the Nymawin; thus the porphyritic types appear to flank the aphanitic andesites on the north and south, and suggest an anticlinal structure.

Flow breccias consisting of highly angular fragments of felsitic and cherty material, set in a lava matrix, are seen in several localities and are indicated on the map. Except for the band of brecciated material (agglomerate) in the lower part of the Otodo Valley, these flow breccias rarely extend for any considerable distance, and appear to be lenticular in form.

In his original report, Combe (5) (6) (26) could not definitely assign an age to these andesitic lavas, but was inclined to regard them as later in age than the Kavirondo Series. Subsequent petrological investigation (7) of specimens of the Kisendo conglomerate, however, revealed the presence of the lavas, and these latter were therefore clearly of Pre-Kavirondo age. Combe believes it possible that these volcanic rocks may correspond with the Ventersdoorp series of South Africa. In his report, No. 3 of 1933, p. 4, R. Murray-Hughes (18) draws attention to the close resemblance between these rocks and those of the N'dembera volcanic series of Tanganyika described by D. R. Grantham (22).

The evidence recently collected confirms their Pre-Kavirondo age. As in so many cases, major contacts are obscured and evidence of age has to be secured indirectly. Pebbles of both porphyritic and aphanitic types of andesites have been noted in the conglomerate lens of Kaluo, while the sedimentary rocks of the southern belt are definitely built up of andesitic and phonolitic material.

5.—MAJOR INTRUSIONS.

The Granites.

Three intrusions of granite are found in the area, namely :—

- (a) The Kanyaboli Granite, which enters from the west (No. 1 Area) and terminates at Adua Hill;
- (b) The Kisama Granite in the north, which is really an extension into this area of the great Mumias granite; and
- (c) The Nyarodi Granite, which lies between Ngia Hill and the Yala River.

Before discussing these intrusions, there is perhaps need to stress the fact that the granites present not only one of the most important but one of the most difficult geological problems of our goldfields. Some have suggested that there are at least four separate granites involved, while others have preferred to regard at least some differences in texture and composition as due to variations within the body of one distinct mass. As usual, the truth probably lies half way, and the geologist has to face a formidable combination of composite intrusion plus textural and modal variation.

(a) *The Kanyaboli Granite* is a coarse-grained hornblende-biotite granite, but exhibits considerable variation both as regards texture and the proportion of the various mineral species present. Towards the west of this area, and in the adjoining parts of No. 1 Area, the granite is inconspicuously porphyritic and shows fluxion structure as a result of the rude layering of the small tabular phenocrysts of felspar. The phenocrysts rarely exceed one inch in length. In the west the granite is definitely intrusive into the felspathic grits of the Kavirondo Series, metamorphosed varieties of these latter being seen in the bed of the Nzoia and north-west of Lake Kanyaboli—both in No. 1 Area. The western portion of the granite is intruded by veinlets of aplite and dikes of dolerite, and contains xenoliths of crystalline schists and the fundamental gneiss(?).

Passing eastwards towards Adua Hill, the granite becomes non-porphyritic and seemingly richer in mafic constituents. The marginal facies is here rich in biotite to the almost complete exclusion of hornblende, but in the centre the two minerals are present in roughly equal proportions. Locally, patches occur in which hornblende predominates over biotite, and vice versa, the latter circumstance being seemingly associated with the presence of half-digested xenoliths of some basic rock.

The bulk of the Kanyaboli granite, lying to the west, is definitely intrusive into the sediments of the Kavirondo Series, but the non-porphyritic variety in the east may represent a remnant of an early Pre-Kavirondo granite. This reservation seems justified on the following grounds:—

- (a) The structure of the Kaluo conglomerate lens rather suggests that the conglomerate was laid around the eastern portion of the Kanyaboli granite.
- (b) The conglomerate contains many granite pebbles of a type not dissimilar to the non-porphyritic Kanyaboli granite.
- (c) The absence, or very mild degree, of metamorphism of the conglomerate and grits in the vicinity of Kaluo.

In spite of careful search, no contact of the eastern portion of the granite with the sedimentary rocks has yet been discovered. This problem is the subject of further investigation.

(b) *The Kisama Granite*.—Only a very small part of the great outcrop of the Munias granite is included in the area under review, and its relation to the sediments is here obscured, since its junction with these latter rocks lies along the course of the Kisama River and is covered by alluvium. A discussion of its age had best be postponed until the adjoining area to the east is studied and mapped.

As seen between the Kisama and Nzoia Rivers, it is a medium- to coarse-grained, grey, porphyritic hornblende-biotite granite, the phenocrysts of felspar ranging between 1 to 3 inches in length, and including many small hornblende crystals. Further work is, however, necessary in order to establish its affinities with the newer porphyritic granites of Kakamega and elsewhere. According to Combe, at a point some miles to the east of the present area a granite of a similar type is intrusive into the sedimentary rocks.

(c) *The Nyarodi Granite and its associated* (d) *Quartz Gabbro.*—In this instance we are dealing, not with a simple granite mass, but with an igneous complex which includes two distinct rock types, granite and quartz gabbro and a number of indefinite hybrids. Here both rocks are definitely intrusive into the ancient volcanics, while the pebbles of both rocks are commonly found in the conglomerates of the Yala belt. Observations in the field suggest: (a) intrusion of the quartz gabbro into the volcanics accompanied by local, peripheral hybridization, and (b) intrusion of the granite on the north and east sides of the gabbro, the composition of the former being modified by assimilation of portions of the gabbro and its hybrids. There is also local peripheral hybridization between the granite and the volcanics.

The granite itself is a fine- to medium-grained, faintly pink, non-porphyrific, hornblende-biotite granite, which is quite distinct in appearance from the Kisama or Kanyaboli granites. In composition it is somewhat variable, some specimens showing hornblende to be present almost to the exclusion of biotite; similarly, the amount of free quartz varies considerably from place to place. This variation is regarded as due, at least in part, to contamination. Multiple sericite zoning in the feldspars is characteristic of this granite, and is regarded as an autometamorphic effect. Microscopically, the granite shows strong similarities to the granite pebbles occurring in the conglomerates of a little to the south.

Over the northern part of its outcrop in the vicinity of Ngia, the granite is not well exposed. Nevertheless, the boundary shown on the map is believed to be reasonably accurate. South-east of Baragulu T.S. a peripheral zone of hybrid rocks (granite plus andesite) are found, while the andesites themselves have been indurated and silicified, yielding a peculiar type of hälleflinta.

The quartz gabbro occurs on the south-west side of the complex, and is a deceptive rock. Examination in the field shows hornblende, feldspar, and a little quartz, and it might be regarded as a quartz diorite. Under the microscope, however, it is found that the plagioclase is basic, and that the hornblende has been largely derived from original pyroxene. The hornblende has, in turn, passed to chlorite, while a fair amount of ilmenite and leucoxene are present. The small amount of quartz is primary. Pebbles of this rock have been obtained from the conglomerates of the Kavirondo Series to the south, and its contact with the andesites can be seen near the Waulala River.

(c) *The Akarra Dolerite* is a hard, fine-grained, dense black rock which forms Akarra Hill and Ridge and Mbaga Hill. Its form is that of a massive dike, exceeding six miles in length and of variable width. A small inlier of this rock is found in the valley of the Nymawin to the east of Mbaga. Under the microscope some specimens exhibit an ophitic texture and others a basaltic texture; all, however, show that the rock has undergone alteration which has incurred bleaching and chloritization of the original ferromagnesian mineral and the deposition of secondary silica.

The rock appears to be intrusive into the rocks of the andesitic suite, and pebbles of a similar rock are found in the Kaluo conglomerate. Its age relative to that of the Kanyaboli granite is at present uncertain, but the bleaching, chloritization and silicification are changes comparable with those brought about by late stage emanations from granite magma.

Owing to its hardness, Akarra Ridge and Mbaga Hill stood up above the level of the old peneplane. It weathers very slowly, to yield deep red clayey soils.

6.—MINOR INTRUSIONS.

(f) *Younger Dolerites*.—However much geological opinion may differ on certain points, it is at least unanimous in regarding the dolerite dikes as "late-comers" and as intrusive into the sediments, lavas, and granites alike. This rock typically occurs as dikes 10 to 30 yards wide and sometimes over a mile in length, but small bosses and lenses of it are fairly frequent, particularly in the areas occupied by the old volcanics. Within the area covered by the sedimentary rocks the strike of the dolerite dikes follows roughly NE.-SW. and NW.-SE. directions.

In strict terminology the rocks are often diabases, since many of them show marked saussuritization of the feldspar and often complete uralitization and chloritization of the original pyroxene. The original rock appears to have been an augite-biotite dolerite showing considerable variation in granularity. The rock is often coarser grained than typical dolerite, the ophitic texture being sometimes better seen in the hand specimen than under the microscope. Some varieties are porphyritic and form distinctive rocks with greenish-white phenocrysts up to one inch in length. The dolerites weather slowly and are extremely tough.

(g) *Hornblende-biotite Lamprophyre*.—Two small outcrops of coarse-grained, bright green, phanocrystalline, hornblende-biotite lamprophyre were noted. In both cases the rock was intrusive into the grits of the Kavirondo Series.

(h) *Felspar Porphyry*.—This rock occurs as dikes, and is definitely intrusive into the felspathic grits in the vicinity of Ogunja T.S. It consists of white phenocrysts of orthoclase, microcline, and anorthoclase, set in a dark brownish-grey aphanitic groundmass which, on microscopical examination, is found to be dominantly felspathic. The rock is believed to be genetically related to the Kisama granite.

(i) *Black Felsite*.—Two principal occurrences of this rock are known. One forms a belt or lens running eastwards from Mbagha Hill, while the other crops out in a similar fashion and runs westwards from Ngia Hill. In both instances the rock has been much sheared and mineralized. In company with other observers, the writer at first considered this rock to be a mineralized (silicified) slate, but a more detailed examination, both in the field and under the microscope, did not tend to sustain this notion. In places where the rock is fresh and where shear has not produced a pseudo-lamination, it presents the characters of a felsite or devitrified rhyolite. No trace of original bedding or even cleavage planes has been found, but the rock is everywhere traversed by innumerable quartz veinlets, and silicification is both widespread and fairly complete. Little information as to the true character of the rock can be gleaned from the microscope. It is seen to be composed of a microcrystalline groundmass of quartz (much of it secondary?), sericite, and possibly small amounts of felspar, and is intersected by numerous microscopic quartz veinlets. Secondary quartz mosaic occurs, flanking the quartz veinlets and as patches or clots in the groundmass. The age and nature of the rock, and its position in the sequence, are at present in doubt. It may be intrusive, effusive, or may represent a silicified volcanic ash.

(j) *Banded Felsites and Related Aphanites*.—This group includes grey, aphanitic igneous rocks that occur as dikes and minor intrusions in various parts of the field. Where they occur as dikes they frequently show a faint banding, probably due to flow, that runs parallel with the strike. Microscopically they consist of minute laths of felspar and muscovite, set in an almost cryptocrystalline matrix. An understanding of their mineral composition must await a chemical analysis, but they appear to be mainly felspathic.

V.—GEOLOGICAL HISTORY AND TECTONICS.

Even a cursory study of the Kaluo conglomerate lens shows that in very early times, this and the adjoining areas were composed of a great variety of igneous and metamorphic rocks. That enormous periods of geological time must have elapsed before the sediments of the Kavirondo Series were laid down is indicated by the presence in the conglomerates of pebbles of quartzite and metamorphosed sediments, incurring at least one previous cycle of deposition, induration and metamorphism, and erosion. No exposures of these ancient rocks are known within the area mapped, but they are said to occur in No. 1 Mining Area lying to the north. That large areas of granite must also have existed in Pre-Kavirondo times is evinced by the presence of many granite pebbles in the conglomerates, and by the dominantly felspathic character of the grits (arkose). Prior to Kavirondo sedimentation there were large-scale outpourings of andesitic and other lavas which presumably covered the rocks of the basement complex.

The sediments of the Kavirondo Series are remarkable for a number of features, among which may be mentioned:—

- (a) Their enormous thickness. The structure of the main or northern belt of sediments is synclinal, and their total thickness in this area must be of the order of 20,000 feet;
- (b) The rapidity of their deposition as indicated by the angularity of the particles in the grits and the freshness of the felspar;
- (c) The erratic character of the sedimentation, as evinced by the lenticular character of the conglomerates, pebble bands and breccias, and the lack of any constant horizon.

Referring to the remarkable stocky lenses of conglomerates, Combe (26) remarks: "The conglomerates seem to have been deposited in a rapidly sinking basin in shallow water around the mouths of large torrential rivers close to their points of issue from mountainous country, formed dominantly of felspathic igneous rocks under conditions analogous to the formation of piedmont deposits. The conglomerates in themselves suggest the presence of high land adjacent to the whole basin. . . ."

The freshness of the felspars can, it is believed, be largely accounted for by rapid transport and deposition, although some have invoked special climatic conditions as an important

factor. It is, of course, true that a temperate or sub-arctic climate would materially assist in the preservation of the feldspars. This point may be borne in mind in considering a possible relationship between the Kavirondo Series and the Bunyoro Series of Uganda.

According to the theory of isostasy, whenever large-scale sedimentation commences, a vicious cycle is set in operation; the basin receiving the sediment continues to sink further under the increased load, while the adjoining land, which provides the sediment, is lightened and tends to rise—to provide even more detrital material. This agrees fairly well with observed facts in various parts of the world, and it is almost a corollary of geology that large-scale sedimentation was eventually brought to a close by orogenic compression—the intense folding and uplift of the sediments to form mountain ranges. The classical example is, of course, the Appalachian Range of North America.

The sediments of the Kavirondo Series appear to support this generalization, and the whole district bears evidence of great compressional forces which operated from a N. by E. or S. by W. direction, or from both. The flat-lying, thick beds of sediments were caught in this compression and folded into their present position. The brief study of cracking in the granite and sedimentary rocks show major open cracks running at 15° to 25° , major closed cracks 80° to 100° , and minor cracks at about 50° and 155° . Naturally the cracking is sometimes modified by local conditions.

It is interesting to note—

- (a) that the direction of strike of the dolerites roughly corresponds with the direction of the minor cracks;
- (b) that in this area the strike of certain quartz veins carrying free gold and auriferous sulphides corresponds with that of the major open cracks.

The geological indications are such as to suggest that in this and the adjoining districts we may be dealing with the bared "roots" of an ancient mountain range, while the newer granites may represent intrusions into the orogenic folds.

In a number of localities shearing has been noted, and the places where it occurs and the general direction of the shear planes have been marked in the map. These shear-zones appear to be disconnected and local, and the majority are, no doubt due to adjustments during and after the compressional movements.

No deposits representing the Paleozoic or Mesozoic eras have been recognized, indicating two alternatives, namely: (a) that if such deposits existed they have been completely denuded away, or (b) that during the greater part of geological time the territory formed land.

Peneplanation was probably complete by the commencement of the Kainozoic Era, during which the area was effected by the tilting and faulting associated with the great Rift Valley movements. Recent volcanic rocks are unknown in the area under review, although they are found some miles to the south associated with Miocene and Pleistocene deposits on the peninsula of Uyoma. In the neighbourhood of Mbaga Hill, two N.S. faults have been inferred, partly from the topography, and partly from the geological formation. The abrupt way in which Mbaga is cut off on its eastern side strongly suggests the presence of a major fault line. These faults are roughly parallel to, and are believed to be connected with, the Nandi Escarpment.

VI.—ECONOMIC.

(Unless the wording otherwise implies, the remarks below must be regarded as applying only to the area mapped.)

Within the area mapped, gold appears to be the only mineral of economic importance, and is at present being worked in two localities, namely: (a) in the country between the Kisama and Woroya (Viratsi) Rivers, particularly in the vicinity of Ogunja T.S.; and (b) a little south of a line joining Ngia and Baragulu T.S.s on the northern contact of the Nyaredi granite.

In the northern locality around Ogunja, the best gold values appear to be carried by small quartz veins, striking in a N. to NNE. direction, which contain both coarse and fine gold and auriferous sulphides (pyrite and arsenopyrite). A recent determination of the refractory gold* contained in the sulphides concentrated from one of these veins yielded 0.06 per cent gold (equivalent to about 20 oz. per ton). These N. to NNE. veins may be genetically connected with the Kisama granite, and may improve a little with depth. They are, however, essentially propositions for the small worker and small private company rather than the larger mining concerns.

* All free gold had been completely removed by amalgamation under hot 5 per cent caustic soda solution.

Here, as elsewhere, arsenopyrite (mispickel, mundic) is associated with good gold values, and the amount of refractory gold contained in the sulphides, and the mineralogical nature of the sulphides,* may be taken as rough guides to the intrinsic worth of a deposit, provided, of course, the length of strike and the width are satisfactory. In some cases, the walls adjoining these veins are impregnated and yield economic gold values over a limited width; in other cases a rude stockwork structure makes its appearance, and economic values may occur over a considerable width though only, perhaps, over a limited length of strike.

In the locality under consideration, quartz veins striking in a roughly east-west direction are not regarded favourably. Any gold they happen to contain appears to have been derived from secondary enrichment of unpayable primary ore, and/or primary enrichment by the N. to NNE. veins, at points where these latter intersect the E.-W. veins. In one case examined by the writer, sporadic gold values in an E.-W. vein were largely due to mere mechanical enrichment.

On travelling south-westwards from Ogunja towards the Kanyaboli granite the showings of auriferous mineralization gradually disappear. On the other hand it is likely that a number of N. to NNE. veins yet remain to be discovered in the area lying between the Kisama River and the Malanga-Rangala Road, and stretching westwards from Sigomori T.S. to a little west of Ogunja T.S. Prospecting in this area will not be easy owing to the frequent occurrence of a hard cap of lateritic ironstone, and to the fact that the veins, being small, afford only a very limited amount of "float".

Indications in the vicinity of the Kanyaboli granite are not particularly promising. This granite and its periphery has, to the writer's knowledge, been independently prospected by one company and several individual prospectors without success.

Two occurrences of gold are known on the northern contact of the Nyarodi granite. One of these consists of small, flat-lying, quartz veins, which contain both free gold and auriferous pyrite and arsenopyrite. They actually occur within the granite itself and run outwards into the surrounding aureole

* From an economic point of view an association of pyrite and arsenopyrite is indicative of good gold values, while the latter have sometimes been found in association with pyrite alone. The writer has, however, never found economic gold values where there is an abundance of pyrrhotite (the "bronzy" sulphide of iron).

of old volcanics. The granite in contact with the veins has been hydrothermally altered and is stated to carry economic gold values. A relatively low-temperature (hydrothermal) type of mineralization is suggested. Prospecting around the contacts of this granite mass may disclose other deposits of similar type; at the same time it is not altogether certain that the two known occurrences are genetically connected with the Nyarodi granite.

Extending from Ngia T.S. a little south of westwards towards the Otodo River, a great belt of mineralized country rock occurs, associated, in the vicinity of Ngia, with a lens of "black" felsite (also much mineralized). The kind of alteration varies at different points along the belt, but is mainly of a low-temperature hydrothermal type. Near Ngia, albitization is found, but further westwards sericitization and intense silicification occur. A number of tests have been made on this belt, particularly in the Otodo Valley, where a totally silicified volcanic agglomerate with interstitial pyrrhotite is found. While traces of gold have been detected, no samples have shown it to be present in economic quantities—even for a large-tonnage low-grade proposition. The only proper method of testing this belt is, of course, by diamond drilling, but it is doubtful whether the surface showings justify such a procedure.

Much of the country lying between the Otodo and Yala Rivers is covered with thick bush, and cannot be prospected except under the greatest difficulties. Much quartz float is seen and in several places small veins are found cropping out. Of a number of samples of float and reef taken from this particular area and assayed, the majority yielded no gold, some showed traces of gold, while one gave 2 dwt. gold and 2 dwt. silver, and another 8 dwt. gold and 24 dwt. silver. The high proportion of silver is not regarded as a particularly favourable indication.

If, as seems not unlikely, gold deposits existed in the complex of ancient rocks which subsequently furnished the material composing the sediments of the Kavirondo Series, these latter should be, in varying degree, auriferous. Much of the gold would, of course, become dissipated in the conglomerates and grits, and occur in wholly uneconomic quantities. On the other hand, a fraction of the gold might, by some curious circumstance of sedimentation, become concentrated in certain layers in the felspathic grits and pebble bands. On general principles, the pebble bands would appear the most likely

mediums to contain such "derived gold". Accordingly, samples of six pebble bands, occurring in different localities, were assayed. Some of these showed much vein quartz and interstitial pyrite. Definite traces of gold and silver were found in four out of the six samples, and a previous assay of a sample from the pebble bed immediately south of the Otodo River yielded 3 dwt. gold. While these quantities are not economic, the possibility of gold occurring in workable quantities in certain bands in the sediments should not be overlooked. The sulphide concentrates (mostly pyrite) from such bands should be roasted, as much of the gold, if present, would probably be in a refractory condition.

Within the area examined there is little for the worker of alluvials for, as a result of the rejuvenation of the Nzoia and Yala Rivers the old gravels have been washed downstream towards the Yala Swamps and Lake Victoria. Moreover, recent investigations tend to show that these "washed down" alluvials are now covered by a considerable thickness of mud and silt.

Localities which, according to present knowledge, are considered most favourable for prospecting are indicated on the small sketch map of the area, Fig. 1.

Only very rarely can the geologist make definite statements with regard to the presence or absence of ore bodies of economic value within the earth. His main function, from an economic point of view, must be to define the degree of probability, and thus help to eliminate much useless expenditure of effort and capital.
