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GEOLOGICAL SURVEY
OF
No. 2 MINING AREA, KAVIRONDO
Interim Report and Map of the South-West Quadrant

by

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Assistant Geologist

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I—INTRODUCTION

The area described in this report comprises the Sakwa Location and part of the Asembo Location of Central Kavirondo. It is bounded on the north by the River Yala, on the east by a true north-south line running through a point about 0.4 miles east of Anyango T.S.,¹ on the west by the shore of Lake Victoria, and on the south by the shore of the Kavirondo Gulf and a line running across the base of the Uyoma Peninsula. The area, which forms the South-West Quadrant of the No. 2 Area of the Kitson Report (8)², is approximately 230 square miles in extent. The whole of the area is included in the Karungu Sheet, Africa, South A 36/E, published in 1916 on the scale of 1:250,000.

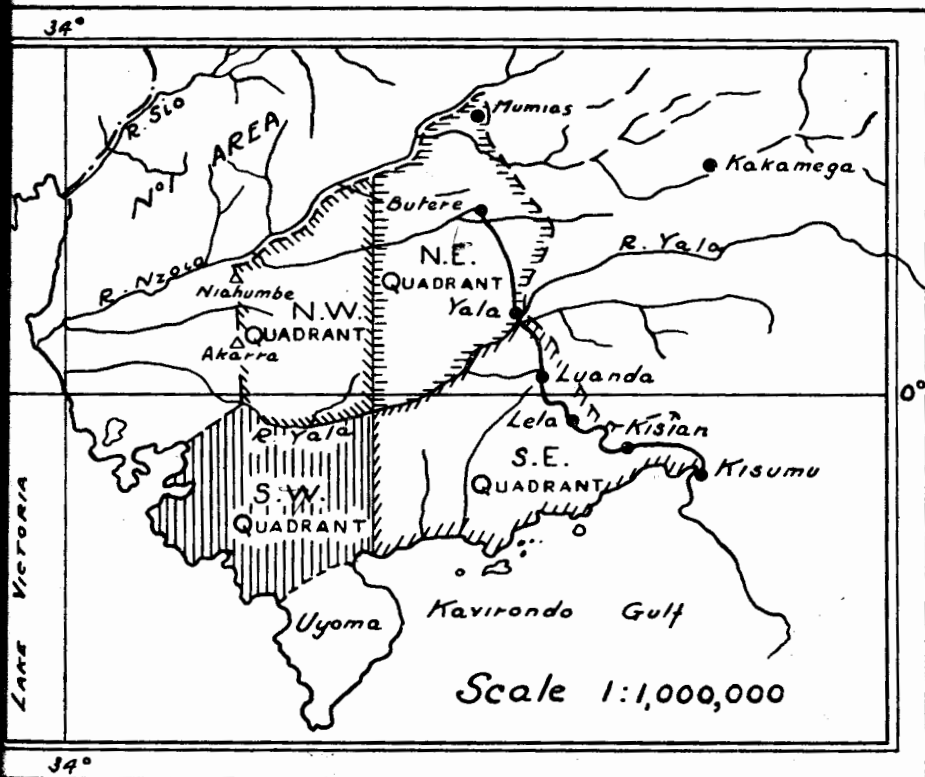


FIG. 1

Sketch map of North and Central Kavirondo, Kenya Colony, showing the position of No. 2 Mining Area. The South-West Quadrant, dealt with in this report, is shaded.

¹ T.S. (s). = Trigonometrical Station(s).

² Numbers (1) to (21) refer to literature listed under Section VIII "Bibliography".

The topography and geology of the present map are based on the secondary triangulation of Central Kavirondo carried out by C. T. Cogle in 1935. The country was surveyed by a series of north-south traverses at two mile intervals, special short traverses with various orientations being made to cut the margins of the Asembo, Abom and Abiru granites. In addition, roads and tracks usable by motor vehicles were surveyed. All other detail was obtained by sketch mapping.

From the geologist's viewpoint the area is variably good and bad. In certain parts, notably the slopes near the River Yala, the southern granite areas, and some areas in Sakwa, rock exposures are prolific. In other large tracts, however, often several square miles in extent and usually on the flat divides of eastern Sakwa and western Asembo, exposures are either very rare or absent, and geological evidence is restricted to loose blocks lying about the surface. Throughout the area critical exposures—junctions and contacts—are extremely rare.

The area is well supplied with roads and car-tracks, especially in south-western Sakwa, yet large tracts are at present accessible only on foot. In the western part of the area access is rendered all the more difficult by the frequency of dense thorn bush or dwarf forest. South-east of a line passing through Abom, Gangu, Nyagoka, Abiru T.Ss. and Nguda Hill the country is usually open and easily traversed. In the remainder of the area thick bush frequently clothes the flat ridges, though the valleys are usually grass-covered, and glades and large areas of cultivation occur among the bush. It is only in the eastern portion of the area that cultivation is extensive, though even there it occupies only a relatively small proportion of the country.

Finally, it may be remarked that the gold production of this section of the No. 2 Area has been relatively high and has increased considerably during 1937. Several properties now show promise of becoming established producers, whilst it is evident that the possibilities of other portions of the area have been by no means fully exploited.

II—PREVIOUS WORK

Prior to the last decade little work appears to have been done in the Asembo-Sakwa area. Gregory (3, 1921) makes no specific reference to it, but on the small scale map (pp. 26-7) shows it to consist entirely of "Eozoic Schist, etc." except Uyoma which is stippled as "Volcanic".

In 1929 Odman (15) published a sketch map showing the south-eastern part of the area to be occupied by granite, and the remainder by "Super-crustal rocks", i.e. members of Odman's "Kavirondo Series", consisting, in this area, of members of a group now referred to as the Pre-Kavirondo Volcanic Series.

Odman's descriptions are concerned mainly with districts north or north-east of the present area. He mentioned, however (p. 85), the Kadimo Conglomerate, which has correlates in the Sakwa Area. He remarked that it is unlike the Kavirondo Series conglomerates of the Yala and Kakamega areas, in that it contains abundant chlorite in the matrix. "If it were not for the roundness of the pebbles" states Odman, "it would be taken for an agglomerate".

Five years later Report No. 3 of the Mining and Geological Department (14, 1933) on the geology of western Kenya was published. The map accompanying the report shows the Asembo-Sakwa area to be occupied by the westward extension of the Maseno granites near Asembo, and by a further extension passing under Asembo Bay to Abiru and the Serawonga areas. A third granite mass is shown as occupying the northern part between Abom and Ramba. Between the Asembo and Abom granites a strip of pre-Cambrian volcanics, extending north-east-south-west is shown, whilst the remainder of the western and central parts of the area is mapped as members of the "Muva-Ankolean" sedimentary system. The Uyoma Peninsula is indicated as Post-Tertiary sediments (Lake deposits, etc.).

In the text (p. 4) Murray-Hughes describes a series of pre-Muva-Ankolean volcanic rocks, which he provisionally names the Asembo Greenstones. He remarks that in type they range from rhyolites to basalts, and he compares them with the Ndembera Volcanic Series of Tanganyika. Describing the major intrusives Murray-Hughes points out (p. 5) that differentiation is to be seen near Abom, where "diorite" and "spessartite" grade into the principal granite mass.

Sir Albert Kitson's final report on Kavirondo (9) published in 1934, contains descriptions of traverses along almost all the then-existing roads in the area. Note is made of the Asembo, Abiru and Abom granite masses, of various minor intrusives and of the ancient volcanic rocks. The Pleistocene and Tertiary accumulations near Uyoma are also mentioned.

Brief mention of the Old Volcanic Series, the granites of Asembo and Abiru and the lavas and sediments of the Uyoma

peninsula was made by Dr. C. S. Hitchen in the Annual Report of the Mining and Geological Department for 1935 (13, pp. 33, 34). In the same report short accounts are given of several of the gold properties in the area (pp. 9-13).

No direct mention of the Asembo-Sakwa area is made in Reports Nos. 4 and 6 of the Mining and Geological Department (5, 1936, and 6, 1937) on the geology of the northern quadrants of the No. 2 Area, but the reports will be found of value insofar as they describe rocks and conditions which also exist in the present area. Government Report No. 5 (17, 1936) describes the Kadimo area which lies immediately west of northern Sakwa.

III—TOPOGRAPHY

The area is one of relatively low relief, the highest point (Rambugu T.S.) being only 728' above mean lake level (3,726' above O.D.). The greater part of the area consists of broad flat valleys and wide divides giving a gently rolling appearance to the country, which is relieved by scattered residual hills, by the rather sudden drop to the Yala River in the north-east and by the plain-like expanses bordering the Lake in the south. Structurally the area is part of the Kavirondo peneplain, which here stood at about 4,000' to 4,500' above sea-level with a gentle tilt to the south-west. The peneplain has been incised, though to a slight extent only in this area.

The only perennial water courses in the area are the River Yala and a few small streams which flow into it in the Abom District. Dry valleys, or valleys containing isolated pools of water, characterize the remainder of the area during the greater part of the year. After heavy and continuous rains, however, several of the larger valleys carry freshets of considerable volume. The valleys are broad and flat, with bottoms often thickly mantled by alluvium, and with slopes which rise gently to the flat divides. Valley-capture is naturally not easy to determine in such an area, though the anomalous course of the upper Utonga valley appears indicative of the capture of the western head of the valley which runs through the Abiru granite mass.

The rejuvenation, so frequently noted in adjacent areas is also difficult to trace, though the upper Nvatome valley (Asembo) is evidently rejuvenated, whilst the River Yala and its small tributaries show slight rejuvenation. Terraces have been noted along the Yala north of Usire and the Bondo Police Post.

Evidence of the variation of Lake level is abundant, especially on the southern littorals. Terraces and gravel deposits, occurring to about 100' above present Lake level are common. The Lake area as a whole is an excellent example of drowned topography, marked by the highly indented coastline and the archipelagos (cf. Gregory, 3, p. 262).

IV—SUMMARY OF GEOLOGY, GEOLOGICAL SUCCESSION AND CORRELATION

The oldest rocks in the area are the gneisses and granulites of the Basement Complex occurring on Kayamo Island, etc., and on the mainland near Tedo. They are invaded by granites, which, however, are of "Younger" type and are possibly similar in age to other granites mentioned below. The greater part of the area is occupied by members of the Pre-Kavirondo Volcanic Suite (5, p. 9) here consisting of lavas ranging from acid to basic in type, tuffs, agglomerates, and, occasionally, conglomerates. This suite is invaded by several large and small granite masses, especially in the south, and by many minor intrusives of various types. In northern Uyoma the Basement Complex and the pre-Cambrian lavas are overlain by Tertiary volcanics and sediments.

The succession of rocks and events may be conveniently summarized as follows:—

RECENT AND PLEISTOCENE :

- 19 Modern denudation, deposition of alluvials, fluctuations of level denudation Pluvial II ; fluctuation of level ; denudation of Pluvial I ; formation of *ironstone* cappings (?).

TERTIARY :

- 18 *Volcanics* of Uyoma—*nephelinite*, *phonolite*, *tuffs* and *agglomerates* ; with *sandstones* in N.E. Uyoma and near Asembo.

PALÆOZOIC TO TERTIARY (?) :

- 17 Long continued denudation and peneplanation accompanied at one stage by the intrusion of *dolerites*.

AGE UNKNOWN ; PRESUMABLY EARLY PALÆOZOIC OR PRE-CAMBRIAN :

- 16 Minor folding. Faulting.
- 15 Incidence of *quartz* veining.
- 14 Intrusion of a few small *granitic* bosses.
- 13 Intrusion of *acid*, *sub-acid*, *intermediate* and *basic dykes* and small bosses.
- 12 Intrusion of Abiru *Granite* (Gb)¹ and possibly of the Asembo and Ndeda Island *Granites* (G).

¹ See 6, p. 8 and map. Gb granites are intrusive into the Kavirondo Series, Ga granites are believed to invade the Pre-Kavirondo Volcanic Series only. The sedimentary Kavirondo Series has not been observed in this area ; if it were present it would appear in the table between 11 and 12.

PRE-CAMBRIAN :

- 11 Presumed folding.
- 10 Some dyke intrusions.
- 9 Intrusion of *Ga granites*—Abom, Tedo, Bondo, Kayamo Island, etc.
- 8 Intrusion of some *Dolerites*—now partly or entirely altered to epidiorites.
- 7 Uplift and folding.
- 6 Extravasation of basic lavas.
- 5 Deposition of *tuffs, agglomerates* and occasional *conglomerates*.
- 4 Extravasation of *Andesites* with occasional *trachy-andesites* and *acid lavas* ; *tuffs* and *agglomerates*.
- 3 Extravasation of *acid* and *sub-acid lavas* with phases of *pyroclastic activity* and some *intermediate lavas*.

} Pre-Kavirondo
Volcanic
Series

BASEMENT COMPLEX ; ARCHÆAN :

- 2 Folding.
- 1 Gneisses and granulites of the south-west.

The general correlation of this sequence with that of adjacent areas is shown in the following table:—

GENERAL CHRONOLOGY	NORTH KAVIRONDO (No. 1 Mining Area)		CENTRAL KAVIRONDO (No. 2 Mining Area)		SOUTH KAVIRONDO		MUSOMA, TANGANYIKA TERRITORY
	W. Pultrey, 17, 1936	South-west Quadrant	North-west and North-east Quadrants	C. S. Hitchen, 5, 1936, and 6, 1937	K.C.G., Ltd. Reports to Government. A. A. Fitch, C. D. Hallam and W. Edgeworth Johnson, 7, 1937.	C. W. Stockley, 18, 1936.	
TERTIARY	—	Volcanics and sediments	—	—	Volcanics and intrusives. Limestone (Miocene) of Homu, etc.	Uvinbara Phonolitic Suite.	
POST KAROO	Dolerites	Dolerites	Dolerites	Dolerites	Dolerites	Quartz and olivine dolerites.	
PALEOZOIC	—	—	—	—	Kisii Series:— 3. Andesites, 2. Quartzites, etc. 1. Basalts.	Ikorongo Series:— Shales, grits and quartzite with intrusives.	
POST KARAOVE ANKOLEAN	Acid and basic dykes Ramogi Syenite Mumias Kanyaboli } Granites Gb	Minor granite intrusion. Intrusive dykes and bosses ranging from acid to basic in type. Abiru Granite Gb. (?) Asambo } Granites Ndeda } G.	Biotite granite. Syenite and allied rocks. Lamprophyres. Kanyaboli Kisumu- Mumias Raulo } Granites Gb.	G2 granites (Wayland, 21, 1931). Kavirondo Series:— 1. Conglomerate.	Acid dykes and lamprophyres. Granites G3 and G4.		
PRE-KARAOVE ANKOLEAN	Kavirondo Series:— 2. Grits, sandstones and mudstones. 1. Thin basal conglomerate.	—	Kavirondo Series:— 3. Grits with pebble bands 2. Slates and mudstones. 1. Grits and conglomerates.	Diorite porphyry. Kiwera granite. Quartz porphyries and felsites (Wire Series). Pink granite and diorite.	North Mara Series:— (Sediments: Muvu-Arkoolean of Central Africa).		
PRE-KARAOVE ANKOLEAN	Greenstone Akarra "Dolerite" Sania Hills Series (volcanics and banded quartzites) Kadimo Volcanics.	Dolerites and epidiorites. Pre-Kavirondo Volcanic Series. 3. Basalts 2. Andesites 1. Rhyolites } With tufts agglomerate and conglomerates.	Pre-Kavirondo Volcanic Series. 3. Basalts and dolerites. 2. Intermediate lavas. 1. Rhyolites and sub-acid lavas, tufts and agglomerates.	Greenstone Series. Acid to basic lavas with tufts and agglomerates.	Basic intrusives. Kuria volcanics. Musoma Series (volcanics, banded ironstone, quartzite, etc.)		
ARCHÆAN	Basement complex of N. Kitesh, etc.	Basement complex of Teto and Kayamo Island, etc.	—	Granites G1 (Wayland, 21, 1931). ?	Foliated granites G2 Crystalline schists and gneisses of East Mara.		

NOTE.—Wavy lines represent unconformities.

V—DETAILS OF GEOLOGY

1—BASEMENT COMPLEX

Rocks believed to be of Basement Complex age occur on the mainland in a belt adjoining the Tedo granite, and on Kayamo, Seki and Ndeda Islands off the west coast. The types present include garnet gneisses, granulites and micro-amphibolites. In view of the fact that some lavas of the Pre-Kavirondo Volcanic suite convert to granulitic and micro-amphibolitic types during metamorphism¹, the reasons for dating these rocks as Basement Complex are stated below:—

1. The granulites are of regional type, with amphibole recrystallized as compact grains.
2. Schistose biotite-amphibole granulites occur in which the biotite is more or less restricted to certain bands.
3. Some of the rocks are gneissose, and contain pink garnet in certain bands.
4. In east Tedo the contact of gneissose granulites and granite is well exposed. The vertical banding of the granulites strikes east-west, and the granite cuts across it almost at right angles.

The rocks of the mainland include schistose and gneissose hornblende granulites, and a hornblende-epidote-clinozoisite granulite. The former are dark grey or greenish grey, banded or unbanded, slightly schistose rocks. In the gneissose types the banding is due to concentrations of hornblende along certain lines. The hornblende occurs as irregular crystals, forming a mesh, and rather rarely as needles and aggregates. The base is a granular re-crystallization of glass-clear albite. Pinkish brown epidote is rare, and is confined mainly to small faults crossing the schistosity obliquely. The more complex granulite was found as a loose block only on the north-western shore of Uyoma.

The types found on Kayamo Island are:—

1. Clinozoisite-amphibole granulite.
2. Schistose-hornblende-biotite granulite.
3. Hornblende-epidote granulite (with a small proportion of garnet in certain bands).
4. Garnetiferous gneiss (granulite bands).

¹ See 6. pp. 27, 28, where aureoles of schistose and granulitised volcanics are described as bordering some of the granites.

The first two are dark grey, fine-grained granulitic types with occasional streaky concentrations of epidote or hornblende. The third is mainly dark grey and granulitic but with epidotic bands containing small developments of pink garnet, whilst the fourth is markedly gneissose with granulitic bands and green and pink bands or lenses containing patches and streaks of garnet.

In thin section the mica-bearing granulite is seen to be schistose. Hornblende, pleochroic from dark blue-green to a faint dun tint or yellow-brown, is common, tending to aggregate into thin bands. Biotite, pleochroic from dull medium brown to pale brown or colourless, is also common and is frequently intergrown with hornblende; it also occurs in biotite rich bands. Epidote occurs as infrequent grains and aggregates, and magnetite is present as small irregular grains, often arranged in trains along the schistosity. The base is glass-clear soda-rich plagioclase with some quartz. Small pools of calcite occur rarely.

In thin section the garnetiferous gneiss is found to consist of mélanges of garnet, epidote, quartz and calcite interbranded with hornblende-epidote granulite. The garnet is a pinkish-brown variety, occurring in massive form, and has not developed crystal faces except when it projects into quartz pools. It is netted by epidote growths, and is usually restricted to the central portion of the bands, being enclosed in massive developments of epidote.

The rocks of Seki and Ndeda Islands are dark grey fine-grained granulitic types which, however, in thin section, are found to be more of the nature of micro-amphibolites than granulites. These more closely resemble altered lavas of the Pre-Kavirondo Volcanic suite than the above types, but in view of their associates and their occurrence in an area apart from any known basic members of that suite, they are provisionally classified here.

The Seki rock is a fine-grained crystalloblastic type containing abundant matted aggregates of fibrous hornblende. Clinozoisite is common in parts, and sphene and iron ores are present. The base is recrystallized feldspar with some quartz. The Ndeda rock is rather coarse-grained and the hornblende often occurs in large fibrous or compact growths. The fibres are sometimes markedly curved and suggest crystallization under stress. Clinozoisite, epidote and magnetite are also present, whilst the base consists of glass-clear recrystallized feldspar.

2—THE PRE-KAVIRONDO VOLCANIC SERIES

The rocks of this series occupy the greater part of the South-West Quadrant, and comprise types ranging from more basic varieties in the east, through intermediate types, widespread in the central part of the area, to acid and sub-acid types in the west. Pyroclastic rocks are developed in the western and central parts, and along the Yala valley. The succession cannot readily be determined owing to lack of junctions and the impossibility of mapping lava flows as separate entities. On analogy with the northern part of the No. 2 Area (5, and 6) and on the evidence of the nature and succession of the pyroclastic rocks, it is presumed that the basic lavas are here the youngest members of the series and that throughout the area the succession is as follows:—

5. Basalts with rare small sub-acid flows (in the east), and rare basic tuffs.

4. Agglomerates and tuffs, impersistent, except in the Yala valley, and conglomerates in the north.

3. Andesitic suite. Andesites, occasional trachyandesites and rhyolitic flows, and sporadic tuffs and agglomerates.

2. Rhyolites and sub-acid lavas with intercalated tuffs and agglomerates.

1. Agglomerates and andesites of south-western Sakwa.

The whole series, though less metamorphosed, bears some resemblance to the Musoma (volcanic) Series described by Stockley (18, p. 9, and 19, p. 11; see also 20, pp. 15 and 41). It is noteworthy that in Tanganyika the Basic volcanics are considered to be the earlier members of the series.

For convenience the various types of the volcanic series are here described together irrespective of age.

(a) *Rhyolites and Sub-Acid Lavas.*

Many of the members of this group are characterized by rather intense decomposition. The more decomposed types are buff and pinky-buff, sometimes creamy or mauve tinted, very fine-grained rocks which are either non-porphyrific or contain small whitish or creamy felspar phenocrysts and, rarely, small quartz phenocrysts. Less decomposed types are light to medium grey and occasionally possess a greenish or bluish tinge. They are siliceous and fine grained and sometimes contain few or many small vesicles. Flow textures are very rarely seen, and spherulitic lavas are known only in western Abimbo.

The more acid types consist essentially of a fine or medium-grained granular mosaic of quartz and felspar, the latter frequently heavily sericitised, and containing rarely small resorbed quartz phenocrysts. They usually display more or less abundant felspar phenocrysts, rarely greater than 2 mm. long, which are often entirely replaced by packed sericite aggregates or by sericite intergrown with chlorite, quartz and, occasionally, carbonates. They are not infrequently impregnated by limonite, which in some cases picks out the felspar phenocrysts. Ilmenite or leucoxene are usually present, and in some, small granules of secondary sphene are developed. Calcite and ferriferous carbonates are often present as small disseminated patches, and in some cases are abundant. Chlorite is fairly common in irregular growths. In a lava near the Lamac camp flakes and crystals of an unusual chlorite, pleochroic from a pale blue or blue-green tint to colourless, were noted. Rarely small flakes of actinolite are present, and in one example small nests of acicular rutile are developed. Unaltered ferromagnesian minerals or pseudomorphs after them were not detected in any acid lava sliced. Small flakes and crystals of a pale golden brown biotite were noted in a mottled felsitic rock on the track north-north-east of Bondo, but they are probably of secondary origin. The vesicles of these rocks contain carbonates, quartz and chlorite and sometimes pyrite. Rarely (an example occurs on the south flank of Serawonga T.S.) small vesicles contain diffuse sericitic cores.

The sub-acid lavas of dacitic affinities are somewhat similar to the above types, but contain recognizable phenocrysts of plagioclase ranging from oligoclase to acid labradorite, whilst lathy crystals of oligoclase-andesine make up a varying proportion of the matrix. Pseudomorphs of, and occasionally unaltered ferromagnesian minerals are commonly present. In a dacite on the southern flank of Abom Hill hornblende is pseudomorphed by calcite-chlorite-epidote aggregates, whilst in an example on the Sakwa road north-east of the Bellamira Properties well-shaped crystals of augite are replaced by chlorite, epidote and calcite. Epidote is not uncommon in these rocks as an alteration product replacing ferromagnesian minerals and occasionally felspars, whilst small developments of actinolite also occur. Quartz phenocrysts are rare, though quartz is always present in the matrix. Some of the dacites are vesicular, the vesicles being occasionally large and irregular.

(b) Andesitic Lavas.

The intermediate lavas vary considerably in composition and degree of alteration. They range from quartz-andesites through normal andesites and trachy-andesites to basic types which are almost basaltic. They are usually porphyritic with abundant small, whitish, or rarely glassy, felspar phenocrysts set in a fine-grained grey matrix in which small dark mafic crystals may or may not be visible. The phenocrysts rarely exceed 2 to 3 mm. in size, but occasionally occur up to 5 to 6 mm. Non-porphyritic types are rare. Flow brecciation and flow structures have been observed at a few places, e.g. Abimbo, whilst propylitization of andesitic types is common in the north-western part of the area. The lavas are variously vesicular or non-vesicular but vesicular types are very frequent. The vesicles commonly appear to be infilled by mauve or purple carbonate.

When decomposed the andesites are usually brown with small white felspar crystals, whilst in extreme cases they are reduced to soft, buff, almost indeterminate rocks. Less decomposed types are usually dark to light grey, and frequently have a greenish, bluish, or occasionally mauve tint. They present a very fine-grained, sometimes almost glassy appearance, but at other times are finely granular. Propylitized types are blotched or streaked by creamy or light green patches. Veining is frequent, the veins containing variously quartz, quartz and epidote, quartz and calcite, quartz and sericite, chlorite and calcite, calcite, calcite and pyrite, and calcite with pyrite and quartz.

Quartz andesites are rare, and only two examples were noted in the area. One, occurring a little south-west of Chausu camp, has rare quartz phenocrysts and a small proportion of interstitial quartz. Andesine occurs as phenocrysts, and the matrix is a pilotaxitic matte of oligoclase-andesine laths associated with chlorite, sericite, carbonate and secondary sphene. The second, from the Chausu track north-north-east of Nangu, has no quartz phenocrysts but quartz, apparently primary, is not uncommon as small irregular pools in the matrix. Oligoclase-andesine phenocrysts are abundant, whilst the matrix contains many laths of medium oligoclase with trachytic arrangement, associated with chlorite, carbonate and magnetite.

The andesites, in thin section, are usually seen to be porphyritic with variously abundant felspar phenocrysts, which not uncommonly occur in glomeroporphyritic groups. The felspars range in type from oligoclase to acid labradorite,

whilst in some members occasional orthoclase phenocrysts are present. These feldspars are rarely fresh and alteration and complete replacement are common. The alteration products include sericite, calcite, chlorite, epidote, zoisite, clinozoisite and quartz. Unaltered ferromagnesian phenocrysts are rare, though in a few cases pyroxene phenocrysts have been preserved, and, in one case only, amphibole phenocrysts. Pseudomorphs of pyroxene composed of chlorite, carbonate and epidote, sometimes associated with actinolite needles, and of serpentine and chlorite with calcite stringers, are somewhat more common. In most cases, however, no trace of original mafic minerals remains, and they are represented by widespread chloritization, carbonation and, occasionally, epidotization of the rocks. Where pyroxene occurs as phenocrysts it is usual to find small crystals of a second generation in the matrix.

The matrices are variable owing to alteration, but normally consist largely of a pilotaxitic, occasionally orthophyric, felt of feldspar prisms or laths. The feldspar ranges about oligoclase-andesine, and rarely andesine, though in some cases it is albite following on albitization. The laths and prisms range in size from 1/6 mm. to 1 mm. in length in different types and when near the larger limit give an almost hypabyssal appearance to the rock. In more altered varieties, traces only of the original pilotaxitic arrangement remain, and the matrix consists of an irregular, granular crystallization of albitic feldspar associated with the decomposition products of the ferromagnesian minerals. Not infrequently the carbonate of the latter crystallizes in rhombs, which occasionally are of such a size as to give a pseudo-porphyritic appearance to non-porphyritic types. In more acid varieties, e.g. at Abimbo, the matrix is a finely granular devitrification product, in which spherulitic textures are traceable. Other minerals appearing in the matrix are secondary quartz, sericite, occasional magnetite, leucoxene, granules of secondary sphene, epidote, clinozoisite, small proportions of actinolite, and occasional apatite. Pyrite occurs sporadically. Small and sometimes large (to 1 inch) primary vesicles are present in many of these rocks and contain various associations of calcite, chlorite, quartz (in some cases replacing chalcedony), epidote, zoisite, and occasionally pyrite and sericite. Irregular "vesicles" produced by the infilling of contraction cracks are not uncommon, and an appearance of vesicularity is frequently given by segregations of carbonates and chlorite, liberated during alteration of the ferromagnesian constituents.

Non-porphyritic andesites are not common. In some there is a tendency for the pilotaxitic laths of felspar to grade to rather large size, so that some crystals might almost be regarded as sub-phenocrysts.

The trachyandesites resemble the normal andesites but contain a fair proportion of alkali felspar among their phenocrysts—in some cases in excess of the soda-lime felspars. Non-porphyritic varieties contain a notable proportion of orthoclase interstitial to the pilotaxitic plagioclases. Such types are uncommon and have been found as small developments only.

The more basic varieties of andesite are of restricted occurrence and have been found bordering the tongue of basalts in the Abimbo area and in the basalt area north-east of Tedo. They are commonly vesicular, rather dark, finely porphyritic rocks, differing from the normal andesites in containing little or no chlorite and carbonates, but with small or marked development of actinolite in acicular, sometimes stellate, aggregates. In some types, dull or weak brown biotite, pleochroic to pale green and, presumably, of metamorphic origin, occurs as scattered flakes or aggregates, occasionally densely concentrated. In these rocks the felspar phenocrysts, which range in different specimens from oligoclase to labradorite, are commonly partly replaced by epidote.

(c) *Basalts.*

The basic lavas display less variety and consist of simpler mineral assemblages than the intermediate lavas. They occupy the greater part of the Asembo location and extend in long arms west-south-west of the main outcrop to Bondo, Abimbo and Tedo. Porphyritic and non-porphyritic varieties occur, though the latter predominate except in the south-west. They are usually fine-grained dark grey rocks, often possessing a greenish tinge, and, when porphyritic, carrying few or many whitish felspar phenocrysts which occasionally attain a size of $\frac{1}{2}$ inch. The more freely porphyritic varieties resemble andesite in hand-specimen, but examination under the microscope reveals their high content of actinolite and betrays their more basic nature. The finer-grained varieties frequently break with a sub-conchoidal fracture. Veining is not so common as among the intermediate lavas, but chlorite-calcite, actinolite, and clinozoisite-actinolite veinlets occur. Rarely, e.g. about 1 mile west of Ramba cross roads, the rocks are given a streaky appearance due to the presence of greenish veinlets and segregations containing clinozoisite or clinozoisite and actinolite. Primary vesicles are rare, except in occasional

flows in Abimbo. The minerals present in the vesicles are variously quartz, calcite, chlorite, zoisite, epidote and combinations of these minerals. Secondary vesicles are also rare: the most interesting examples seen occur in the lava at the granite contact about 2 miles west of Asembo, in which large irregular aggregates of quartz, epidote, clinozoisite, a pale garnet and calcite are developed, and presumably owe their origin to metamorphism by the Asembo granite.

For convenience these lavas are referred to as basalts, though owing to alteration there is little hope of exact identification. Most, especially the non-porphyrific varieties, are now virtually micro-amphibolites. It is rare that original feldspar remains and much is completely albitized. In this, and in the not uncommon occurrence in large outcrops of rude pillows, the rocks bear certain resemblances to spilites (cf. Odman, 15, p. 84). The spaces between the pillows are now commonly infilled by quartz, and, in the case of a lava in the valley three miles north of Asembo Camp, by intergrowths of zoisite, actinolite and epidote. It is interesting to note that Stockley (19, p. 12) records the presence of pillow lavas among the basic lavas of the Musoma Series in Tanganyika and compares them with similar lavas in the Greenstone Schists of the Basement Series of Southern Rhodesia.

In thin section the basalts are relatively simple rocks. The feldspar phenocrysts are always highly altered, being replaced by aggregates of zoisite, epidote and sericite, sometimes associated with actinolite. Ferromagnesian phenocrysts are rare, and again, always pseudomorphed, being replaced by aggregates of actinolite and clinozoisite, chlorite and clinozoisite, or by actinolite alone. The matrix of porphyritic types, and the rock as a whole in non-porphyrific types, is usually highly recrystallized, and consists of a dense mat of fibrous actinolite crystals and needles, often associated with epidote or clinozoisite, set in a base of glass-clear recrystallized feldspar. Traces of feldspar laths rarely remain, and in one case only was it possible to determine the relict feldspars as medium labradorite. Small pools of secondary quartz are not uncommon, whilst small granules and aggregates of secondary sphene are usually present. Sericite occurs occasionally, whilst chlorite is somewhat more common, occurring in small irregular pools. Calcite is rarely present. Iron ores are of irregular occurrence, sometimes frequent, sometimes rare or absent. Many of the basic lavas are lightly pyritized. Biotite was noted in a specimen from the Abimbo area, but is presumably an anamorphic mineral.

From one example only was actinolite found to be absent—a xenolith in the Asembo granite a little south-west of Asembo Camp, in which the mafic constituents appear to have been taken up entirely into chlorite.

(d) Pyroclastic Types and Conglomerates.

The fragmental members of the volcanic series occur at several horizons in the acid and intermediate lava suites, but are extremely rare in association with the basic lavas (c.f. Odman, 15, p. 84). They include agglomerates, tuffs of various types, breccias and conglomerates. The breccias are of very restricted occurrence.

Agglomerates are fairly widespread, and occur in small and large lenticles, a notable example being that about 2 miles south-west of Abom T.S., which has a strike extent of about 2 miles and a maximum width of about $\frac{1}{4}$ mile. They are all very similar in character and are coarse-grained, ill-graded rocks with abundant large fragments, ranging in different occurrences, from $\frac{1}{4}$ inch to 9–10 inches in diameter. The fragments are usually angular, but occasional sub-rounded or well-rounded pebble-like fragments are found. The larger fragments consist mainly of types of andesitic lava and sometimes of tuffs. Occasionally small fragments of granite occur, but are rare. Broken felspar crystals are common in the matrix, whilst pyroxenes are occasionally present. The matrix is frequently highly chloritized and calcitized or impregnated by epidote growths and is sometimes made up entirely of these secondary minerals.

Conglomerates constitute the remaining coarsely fragmental rocks of the volcanic series. They are found as small developments in the Yala valley in the extreme north-east corner of the area, north-north-west of Bondo, and about $\frac{1}{2}$ mile north of Usire T.S., the only large occurrence being a lens extending for about a mile on the Kadimo Road, $5\frac{1}{2}$ miles west-north-west of Bondo. These rocks are of particular interest, as they invite comparison with the conglomerates of the Kavirondo Series (5, pp. 11, 12 and 6, pp. 17, 18). They appear, however, to be part of an entirely volcanic series, as in the Kadimo Area (17, pp. 13–14), and are regarded as water-worn facies of the pyroclastic rocks representing short periods of time during which volcanic activity ceased locally and shallow water resorting of the tuffs and agglomerates occurred. The conditions envisaged are comparable with those which existed in inter-volcanic periods during the Old Red Sandstone volcanic epoch in Scotland (11, p. 133).

The three conglomerates first mentioned above occur as very small lenses. They consist of sub-angular and rounded pebbles, rarely more than 3-4 inches in diameter, of sub-acid and intermediate lavas, and, in the case of that north of Bondo, of hornblende porphyrite in addition. The proportion of matrix is low and consists mainly of secondary quartz, chlorite and calcite. The conglomerate north of Usire is notable insofar as it contains rare pebbles of a granite similar to the Ga Nyarodi type (*see* page 25). The conglomerate south-west of Usire is somewhat coarser than the others and contains rounded and sub-angular pebbles ranging up to six inches or more in diameter. The pebbles consist mainly of very altered porphyritic and non-porphyritic andesites, tuffs and felsites, the latter usually small and angular. Very rarely small fragments of graphic granite are present. The matrix contains angular quartz fragments, crystals and fragments of altered feldspars, and small rock fragments set in secondary growths of quartz, sericite, chlorite and calcite.

Tuffs.—The finer-grained pyroclastic rocks occur especially in a belt running along the Yala River from east of Abom to north of Usire and then south-west towards Utonga, but failing near the Kadimo Road. Others are of restricted occurrence, mainly in the northern, central and western parts of the area. In type they range from crystallo-lithic tuffs, in which comparatively large rock fragments sometimes occur and provide a link with the agglomerates, through crystal tuffs, to rare vitric or pumice tuffs. The fragments of the lithic tuffs consist largely of intermediate lavas though occasional fragments of more basic types occur. The latter include rare variolitic types, unlike any of the basic lavas found in Asembo and southern Sakwa. They may indicate a still older series of basic lavas not yet discovered in this area. The crystal and crystallo-lithic types make up the greater part of the tuff occurrences. In the north-west and west, notably near Usire, Utonga and Kadimo, they are frequently quartzose, containing unrounded quartz crystals or angular quartz fragments—not infrequently in long slivery shapes—and are comparable with the quartzose tuffs of the Kadimo area (17, p. 14). Elsewhere quartz is an uncommon constituent, and the tuffs are characterized by their considerable alteration, and, especially in the Yala valley, by frequent intense chloritization and carbonation, which, although rendering them difficult subjects for microscope examination, provide a ready distinction from the lavas. Some of the tuffs are

less altered and contain crystals and fragments of ferromagnesian minerals, usually monoclinic pyroxene. Occasionally the tuffs are vesicular, e.g. that on the Bondo-Uyoma road about $3\frac{1}{2}$ miles south of Bondo. More basic tuffs, of lithic type, have been observed only underlying the basalts in eastern Abimbo, and as xenoliths in the marginal quartz diorite of the Asembo granite, $2\frac{1}{2}$ miles west of Asembo Camp.

Vitric tuffs are rare and were found only on the higher parts of Serawongo and in a small outcrop on the Port South-by road about $3\frac{1}{4}$ miles south-west of Bondo. Both are considerably altered and have suffered much migration of chlorite, carbonate, etc., but in both vitric and pumiceous fragments can still be recognised.

(e) Conditions of Deposition of the Volcanic Rocks.

It is not possible, with the evidence available, to determine accurately the conditions under which the lavas and pyroclastics were formed. The presence of conglomerates, and pillow-lavas among the basic types, suggests that the area was probably covered in part by shallow water and was possibly an archipelago in which the islands may have been formed around volcanic foci, each building up its separate pile of volcanic material. The foci are now difficult to determine, though the larger occurrences of agglomerates south-west of Abom, south and south-west of Bondo, west of Abimbo, and south-east of Chausu probably indicate the proximity of eruptive vents. The propylitization of the lavas in the north-west is perhaps also indicative of proximity to a volcanic centre. The area west of Abimbo with its successive lenses of agglomerate, and Abimbo itself with lava types ranging from very acid to basic, are particularly suggestive of volcanic centres.

Whether the basic lavas were also poured from the supposed vents situated in the north, central, and western parts of the area is a controversial point. Basic fragments are comparatively rare in the pyroclastic rocks of the remainder of the area, and there appear to be no basic plugs which could be connected with the basic lavas, and no data are available concerning the direction of attenuation of the series.

3—NOTE ON THE KAVIRONDO SERIES

Sediments of the Kavirondo Series have not been identified in this area. They are, however, widespread in the northern part of the No. 2 Area and have been described by Dr. C. S. Hitchen (5, pp. 7-10; 6, pp. 14-20).

4—TERTIARY

Rocks of Tertiary age have been found only in the southern part of the area, at the neck of the Uyoma Peninsula and a little west of Asembo. Outcrops are scanty and no attempt has been made to map the distribution of the types found, especially as over much of the area the Tertiary rocks are covered by superficial deposits. The boundary shown on the map is the northern limit of the area in which outcrops and abundant blocks of Tertiary rocks are present. The succession is doubtful, but appears to be—

3. Nepheline-bearing lavas.
2. Agglomerate and tuffs.
1. Sandstones.

Limestones have not been seen in the area mapped, but are said to occur, often highly contorted, further south in the Uyoma peninsula. It is also reported that fossiliferous marly sediments were found in trenches, somewhere south of Abiru, but these have not been seen by the writer.

Sandstones occur in a bluff underlying a Pleistocene lake terrace, about one mile west of Asembo Bay, and on the lower slopes facing the lake, east of Uyoma Camp. The former, believed by Archdeacon Owen to be of Miocene age, is a yellowish-buff, semi-incoherent, coarse sandstone, with average grain size about 2 mm. The grains include abundant fragments of quartz, dark minerals and rock fragments, some of obsidian-like types. A bromoform separation of the heavier constituents was made with the following result:—

Magnetite.—Very common, large irregular grains.

Ilmenite.—Fairly common, usually altered to leucoxene.

Epidote.—Common, often angular, occasionally well-rounded.

Actinolite.—Rare.

Garnet.—Rare, pinkish-brown.

Mica.—Rare, probably bleached biotite.

Glass fragments.

The crop is heavy, but very poor in species, consisting mainly of iron ores.

The sandstone from Uyoma is much more fine-grained than the Asembo rock, and is evenly graded at about 1/10 mm. It is a light brown rock with thin dark grey bands and wisps in which iron ores are concentrated. The minerals

of the lighter bands include abundant angular and sub-angular quartz, acid plagioclase, some orthoclase, rare anorthoclase, occasional grains of fibrous green amphibole, epidote and flakes of dark green mica.

Agglomerates and tuffs.—Pyroclastic types were observed in situ at the southern end of the Asembo-Uyoma road. The agglomerates are not of very coarse grade, and are soft, rather friable rocks, usually mottled by fragments or patches which have suffered chloritization or oxidation. The tuffs are brownish-grey, with grade about that of a coarse sandstone or grit, with numerous small brownish and whitish fragments and occasional micaceous aggregates and shining crystals. In thin section they are found to contain fairly fresh augite, clear and altered feldspars, rare quartz, rare green hornblende, rare pale brown hornblende, and occasionally fragments of basaltic rocks. The matrix contains much fine-grained opaque matter and is cut by calcite pools and stringers.

Blocks of tuff were also found about 4 miles south of Abiru. Here the tuff is a greenish-cream rock, with grade about $1/4$ – $1/6$ mm., and is cut by common irregular gashes and veinlets of mauve calcite.

Lavas of two types, phonolite and nephelinite, were observed. The former occurs in small outcrops in the central part of the Tertiary belt, the latter near Uyoma Camp.

The phonolite is a dull, dark-grey rock with abundant shining dark phenocrysts up to 6–7 mm. in length, and small whitish phenocrysts. In thin section it is seen to be typically porphyritic and basaltic in texture. Augite is present as colourless or green-blotched phenocrysts, rarely well shaped and sometimes with corroded margins, and as very numerous lathy crystals (up to 1 mm. long), pale brown in colour, and feebly pleochroic. Sanidine occurs in rarer large phenocrysts. The matrix contains common small prisms of aegirine, small felted or trachytic prisms of orthoclase, and nepheline which occurs interstitially and in small prismatic crystals. The nepheline is, not infrequently, replaced by bright yellow cancrinite. Accessories include occasional crystals and clusters of sphene and scattered grains of magnetite, which are occasionally large ($\frac{1}{2}$ mm.). Small vesicles containing calcite and zeolites are present rarely.

The rock is a normal phonolite except in the rather high proportion of magnetite, which is unusual. It may be compared with the phonolite of Gortex (Elgon) which also contains phenocrystic pyroxenes (16, p. 502).

The nephelinite is a heavy, dull dark grey rock with abundant phenocrysts of glassy nepheline and dark augite. In thin section, augite—a pale brownish-yellow, weakly pleochroic, variety—is found to occur in abundant phenocrysts ranging up to 2 mm. in diameter. It is occasionally long and lathy, and sometimes slightly resorbed. Nepheline phenocrysts are somewhat less common than augite, and are, in some cases, partly replaced by cancrinite and zeolites. The matrix contains abundant small crystals of nepheline, microclites of basic plagioclase, small laths of augite, grains of sphene, abundant grains of magnetite, and patches of cancrinite.

This rock is generally comparable with the nephelinites of Mount Elgon (16, p. 476 *et seq.*), where they form the lowest members of the volcanic sequence.

5—PLEISTOCENE AND RECENT DEPOSITS

Brief mention only of these deposits is possible. Traces of gravels of the First Pluvial Period (10, p. 75) have not been recognized, though deposits formed during the Second Major Pluvial have been found in the valleys west of Bondo and in the Yala valley. In the valley crossing the Kadimo Road about $4\frac{1}{2}$ miles west-north-west of Bondo a section of the upper part of Pluvial II is exposed, showing the succession:—

3. Clayey earth.
2. Resorted murrum.
1. Red clays.

The complete Pluvial II sequence has not been seen, but Archdeacon Owen informs me that it is present at places along the River Yala near Abom.

High level gravels have been found along the Yala valley on the Bondo police track and $1\frac{1}{4}$ miles north of Usire T.S. The latter yielded artefacts and occasional nodules of acicular tourmaline. Examination of heavy residues failed to reveal the presence of gold or cassiterite. The minerals detected were:—

Epidote.—Very common.

Magnetite.—Very common.

Zircon.—Very common: colourless and pink.

Limonite.—Common.

Leucoxene.—Common.

Tourmaline.—Uncommon: pleochroic medium blue-green to colourless or pinkish-brown to black.

Rutile.—Rare.

Mica.—Rare; colourless.

Amphibole.—Rare.

Terraces, raised beaches, and gravel deposits are common along the Lake shore. A little west of Asembo Bay, a beach, 55' above present Lake level, is well exposed. Further west, a well-defined, heavily iron-impregnated gravel, 4–5 feet thick, containing abundant artefacts, caps a terrace underlain by the Miocene Sandstone, at about 40 feet above Lake level. Gravel deposits and terraces at similar levels, or lower, were also noted at various localities on the western coast. These levels are comparable with terraces in various parts of the northern Lake basin as a whole. Pebble beds at much higher levels—about 200 feet above Lake level—are reported by Archdeacon Owen to occur in northern Uyoma.

Surface ironstone deposits are found on most of the ridges of the area, but are nowhere thick. It is evident that the ironstone crust is no longer being formed, but is now suffering erosion. It varies from pisolitic and cellular types, through types which consist largely of small local rock fragments cemented by iron oxide, to the incoherent red soily decomposition products of the ironstone (murrum). The age (or ages—for it appears that one horizon of the ironstone may be a re-distributed earlier ironstone) has not yet been determined, though the presence of artefacts in some occurrences points to a Pleistocene age.

The most recent deposits in the area are the alluvials of the valleys and the Lake shore. These are thick deposits of black soils overlying stiff clays. At some places these have been bottomed by prospectors, who state that no gravels have been found resting on the bed-rock.

The soils of the area are of residual type and often provide good indication of the underlying rocks. The granite margins, especially of the Asembo mass, can usually be traced by the contrast of the pinkish sandy soils overlying the granite and the heavier red or brown soils derived from the old volcanics. The basic lavas give rise to a rich red-brown clayey soil, whilst the acid lavas provide a lighter brown or greyish soil. Basic intrusions frequently yield a heavy deep chocolate coloured soil. Small scattered deposits of kunkar of doubtful age are common throughout most of the area.

Traces of pre-historic man are common in the area. Artefacts, usually of flake type, have been found at the following localities:—

1. One mile west of Asembo Bay in the iron-cemented gravel.
2. In the Nvatome Valley, in ironstone, a little north of the first eastern branch valley.
3. In raised Yala gravels, $1\frac{1}{4}$ miles north of Usire T.S.
4. In lake gravels on the north and south shores of the peninsula south-west of Abimbo.
5. In ironstone on the flat divide east of Utonga T.S.
6. On the surface in the valley west of the Abiru granite mass.

Stone implements have also been found at many other localities by Archdeacon Owen and by various prospectors.

It is not proposed here to describe or attempt to date the artefacts found, and it will be sufficient to state that Archdeacon Owen, who has examined most of the tools collected, considers that Levalloisian, Pseudo-Stillbay and Stillbay types are present. Still later ages (? Wilton, Recent) are perhaps indicated by the remains of shell-mounds near the shores on the peninsula south-west of Abimbo.

6—THE MAJOR INTRUSIVE IGNEOUS ROCKS

The major intrusives comprise only granites and their minor modifications. They occur in a broad belt in the south, in the Abom area, and as small cupolas north-east of Gangu and at Bondo. The granites are of three types:—

- (a) Usually non-porphyritic; Abom, north-east of Gangu, Bondo, Tedo and Kayamo Island. (The Nyarodi type, Ga, cf. 5, p. 18 and 6, p. 31).
- (b) Coarse non-porphyritic; Asembo and Ndeda Islands (G of the map).
- (c) Porphyritic or sub-porphyritic; Abiru (Gb type cf. Kisama-Mumias and Raualo Granites, 6, pp. 29–31).

There is no evidence in the present area relative to the close dating of these intrusions. The Tedo, Kayamo and Ndeda granites can only be said to be Post-Basement Complex, though on comparison with other granites which are closely similar in type, and which are intrusive into the Pre-Kavirondo Volcanic Series, they may be taken to be of Post-Volcanic

Series age. The presence of occasional granite fragments of this type in tuffs near Ngiga Mine may, however, indicate an earlier age of some of these granites.

The Abiru granite, on type, may be compared with the Gb granites of the northern No. 2 Area (6, p. 29) and is hence assumed to be of post-Kavirondo Series age. The Asembo and Ndeda granites are somewhat different, and their age will remain problematical until the investigation of the Asembo granite east of Asembo is completed. The non-porphyritic granites of type (a) are closely comparable with the Ga Nyarodi granite of the northern No. 2 Area which is considered by Dr. C. S. Hitchen to be of post-Kavirondo Series, pre-Kavirondo Series age. All the granites are alike, however, in showing little or no sign of compression or stress effects, which may indicate that they are all of post-Kavirondo Series age, since it appears that a considerable degree of folding took place after the formation of the Old Volcanic Series and again after the deposition of the sediments of the Kavirondo Series. The view that these granites are all of one age has also been expressed by Dr. K. A. Davies (2, p. 34).

(a) *Granites of Nyarodi Type.*

Abom Granite.—The granite occupies an area of about 5 square miles, with roughly oval outcrop, in the Abom area. The long axis of the intrusion extends for $3\frac{1}{4}$ miles in an east-north-east direction, i.e. along the strike of the Volcanic Series. The granite is only locally well-exposed, and does not give rise to prominent tors. A small roof pendant of tuffs rests on the granite about one mile east of Abom T.S. From this and the frequency of quartz veins in the granite it is apparent that the cupola has been only slightly denuded. It may be suggested that even if the granite were of post-Kavirondo Series age, it is highly probable that it would not have invaded the Kavirondo Series sediments, which must have lain a considerable distance above the granite roof.

The normal granite is somewhat variable. Typically it is a grey and dark green, mottled, medium-grained rock in which small idiomorphs of felspar can be seen, and with dark crystals of mica and hornblende, the latter occasionally in prisms ranging up to 15 mm. in length. When the Nyarodi texture is developed, the rock is seen, in thin section, to consist of abundant idiomorphs of densely sericitised, frequently zoned, oligoclase in a granitic base of quartz, slightly clouded orthoclase, micro-perthite and often some clear anorthoclase. The

quartz and alkali felspar sometimes grow together in crude graphic fashion, and rarely quartz and biotite are similarly intergrown. The ferromagnesian minerals are hornblende and biotite, of which one is usually partly or entirely replaced by chlorite, epidote, etc. Accessories are magnetite, apatite and sphene, the latter occasionally in large crystals or abundant in small crystal clusters. Varieties occur about $\frac{1}{2}$ mile east of Abom T.S., where the granite is leucocratic and contains no biotite and at about 2 miles south by east of the T.S. where the granite had more normal granitic texture with both plagioclase and alkali felspar forming small idiomorphs and in which quartz occurs in large areas of coarse mosaic.

It is evident that the intrusion is complex. On the southwestern lobe there occurs an altered hornblende-porphyrite, in which flakes and clusters of a brown or pale green biotite of anamorphic origin, indicate that this part of the intrusion preceded the main granite. On the eastern lobe, $2\frac{1}{2}$ miles east of Abom T.S., another hornblende porphyrite, in which the amphibole is replaced by chlorite-calcite aggregates occurs. The porphyrite is here of later date than the main granite, of which it contains large xenoliths. North of the large dolerite intrusion, diorite-porphyrite and porphyrite are developed, but their age relation with the main granite is not apparent. The diorite-porphyrite is a handsome, mauve-grey, felspar-hornblende rock in which the hornblende occurs as long prisms often 7-8 mm. in length. The abundant hornblende phenocrysts are set in a matrix consisting of hypidiomorphic oligoclase-andesine of fairly uniform grade, about $\frac{1}{4}$ mm., with scarce small pools of quartz. Small resorbed felspar phenocrysts are rare. Accessories are magnetite and apatite, whilst chlorite and epidote are present as alteration products of the amphibole. The porphyrite is somewhat similar to the diorite-porphyrite in hand specimen, but in thin slice is seen to have more frequent small felspar phenocrysts and a microgranular quartz-felspar matrix containing epidote grains, small groups of fibrous actinolite and small apatite prisms. The remaining modification of the granite is a porphyritic diorite occurring on the track $1\frac{1}{2}$ miles south-east of Abom T.S. It is a dark grey rock containing abundant small dark salmon-pink felspar phenocrysts. No original mafic mineral remains, and the diorite is presumed to be an earlier member of the intrusive suite.

Granite, East of Gangu.—This granite—a small cupola with lenticular outcrop about $1\frac{1}{4}$ miles east-north-east of Gangu—might reasonably be classed as a minor intrusive, but in view

of its affinities with the Ga granites, is considered here. The normal granite is a medium-grained grey rock with rare felspar phenocrysts ranging up to 10 mm. in length. The texture and constitution are very similar to those of the normal Abom granite. In the southern tip of the intrusion, however, it is markedly sub-porphyritic with small altered orthoclase phenocrysts and common small (2 mm.) phenocrysts of variably altered oligoclase. The matrix is fine-grained and granitic, and contains hypidiomorphic oligoclase. The quartz occurs sometimes in crude graphic intergrowths with felspar. Biotite, or its alteration products, are the only mafic minerals present.

Bondo Granite.—This intrusion, forming a small cupola around Bondo camp, is a pinkish-grey, medium-grained granite, copiously mottled by mafic minerals. In thin slice the dark minerals are seen to be in greater profusion than is usual in typical Nyarodi granites. Hornblende, and, in less proportion, biotite, are present, though largely replaced by markedly pleochroic chlorite, epidote and carbonates. The greater proportion of the felspar occurs in the typical highly sericitised oligoclase idiomorphs, usually with clear rims.

Tedo Granite.—The granite occupies the southernmost peninsula of the area and extends eastwards towards Uyoma, where excellent contacts with the Basement Complex are exposed. It is a light grey medium-grained type, speckled by dark crystals of hornblende and biotite. In thin section the texture is seen to be of Nyarodi type, though in patches it is more normally eugranitic. Crude micrographic intergrowths are usually present, and small proportions of anorthoclase occur interstitially. The ferromagnesian minerals are hornblende and biotite in variable proportions. The biotite is usually present in larger crystals and is commonly partly replaced by chlorite. Epidote occurs rarely, and magnetite, apatite and rare sphene are present as accessories.

Kayamo Island Granite.—The granite occurs on the south-east side of Kayamo Island, and is presumably part of the mass which forms the Tedo peninsula. The normal granite is a grey or creamy medium-grained rock with abundant small crystals and clots of mafic minerals. Oligoclase, variously clouded by sericite, occurs in the usual idiomorphs, occasionally approaching phenocrystic size, and rarely in small sub-hedral interstitial crystals. Microperthite and orthoclase, often fairly clear, occur interstitially with quartz. Brown and green biotite, occasionally radiately grown, is the common ferromagnesian mineral and is usually partly replaced by

chlorite. Hornblende, pleochroic from dull blue-green to yellow-green or green, is less common than biotite and usually occurs in smaller, shapeless or sometimes idiomorphic crystals. The crystals are often somewhat cellular and enclose apatite, feldspar, quartz and iron ore poecilitically. Accessories are magnetite, apatite, sphene and rare zircon.

Associated with the Kayamo granite are small masses of granite porphyry and microgranite, presumably of slightly later date than the main intrusion. The porphyry is a buff rock with phenocrysts of quartz, biotite and feldspar, the latter ranging up to 4 mm. in length and the biotites to 2 mm. diameter. The feldspars (oligoclase) have characteristically a densely clouded core and a clear outer zone in which quartz blebs commonly occur, together with occasional small crystals of biotite. The matrix consists of allotriomorphic quartz, oligoclase, orthoclase and rare anorthoclase. The orthoclase frequently encloses blebs of quartz. Apatite and magnetite are the accessories.

The microgranite is a white or pinkish-white fine-grained rock with, in hand specimen, almost no trace of dark minerals. In thin section it is seen to contain quartz, orthoclase, and oligoclase associated eugranitically. The oligoclase, much less common than the alkali feldspar, tends rarely to idiomorphism. Biotite—pleochroic from deep brown to yellow-brown—in minute crystals and clusters, is rare. Muscovite occurs in minute and small flakes and rosettes. Accessories are limonitized magnetite and pyrite.

(b) *Granites of Asembo Type.*

Asembo Granite.—The granite extends as a broad blunt tongue from the south-east corner of the area, in a westerly direction towards Nyagoka. The intrusion is possibly sheet-like in form, dipping to the south or south-west. This is indicated by the shape of the northern contact, where the margin bellies to the north on high ground, and to the south in the valleys, and by the presence of decomposed granite debris north and uphill of the contact. On the southern margin the contact appears to dip gently to south-west.

The granite is everywhere of coarse-grained non-porphyrific type, usually grey, but locally stained pink. The constitution varies, however, in different parts of the outcrop. The granite near Asembo Camp contains variably altered orthoclase and microperthite, smaller proportions of oligoclase, and quartz, associated in normal granitic texture. The ferromagnesian mineral is biotite, pleochroic from very deep brown

to pale golden yellow, which occurs in large thick plates, sometimes partly or entirely replaced by chlorite. Accessories are magnetite, apatite and zircon. On the old cliff south-west of Asembo Bay the granite is stained pink and shows clearly the effects of cataclasis. In thin section two grades are distinguishable—coarse granular quartz, with orthoclase, microperthite and oligoclase in large irregular crystals, and a “matrix” of quartz, orthoclase, hypidiomorphic oligoclase, and interstitial microcline. Biotite and muscovite are present in small platy crystals, and magnetite is accessory. Cracks and joints are occasionally infilled by acicular black tourmaline. This granite is well sheared on the slope behind the pier.

The granite $2\frac{1}{2}$ miles west of Asembo Camp is a pink and grey mottled type. It contains alkali feldspars (microperthite, orthoclase and rare microcline) and oligoclase in approximately equal proportions, the latter being rarely idiomorphic. The feldspars are often clouded by zoisite and sericite. Biotite, pleochroic from very dark green to medium yellowish-brown, occurs in rather rare, small crystals and is partly replaced by epidote and chlorite. Hornblende is now represented by a few epidote-chlorite pseudomorphs. Accessories are iron ore and apatite.

This granite is margined on the south by a thin zone of intrusion breccia in which fragments of basic tuff (a rock unknown in the basic lava series of the immediate area) and basalt are enveloped in a quartz diorite. The quartz diorite is a handsome rock with abundant crystals of hornblende (up to 5–6 mm. in length) in a pinkish feldspathic matrix. In thin section the amphibole is seen to occur in irregular crystals with crenulate margins, and is usually spotted by magnetite. Smaller crystals are pale green and fibrous and appear to be actinolite. Colourless augite occurs in small crystals, which sometimes edge the hornblendes; much is replaced by actinolite. The feldspars are andesine in prismatic crystals, commonly saussuritized, and interstitial orthoclase, which is sometimes graphically intergrown with quartz. Epidote and chlorite are present replacing the ferromagnesian minerals and magnetite, whilst apatite and sphene occur as accessories.

South of the quartz-diorite is a marginal belt of granodiorite containing augite, biotite and hornblende. In thin section quartz is found to be present in moderate proportion as small interstitial grains. The feldspars are largely tabular plagioclase, ranging about oligoclase-andesine, and usually

have heavily sericitized cores, though the margins are glass-clear. Orthoclase and anorthoclase are present as small interstitial crystals. Biotite, sometimes partly replaced by chlorite, is present in many small plates, pleochroic from pale golden-brown to dark red-brown. It is often intergrown with or moulded on the other dark minerals. Green hornblende is also present, together with colourless augite, the latter being largely replaced by actinolite. Accessories are magnetite, apatite, sphene and zircon.

Owing to lack of critical outcrop it was not possible to determine the relative age of these intrusions, but on petrological grounds it appears reasonable to assume that the granodiorite was first emplaced, the quartz-diorite being produced by assimilation of the basic rocks occurring in the intrusion breccia, and that the "hornblende"-biotite granite followed later.

Locally, the Asembo Granite is heavily enriched in muscovite, notably at the north-western tip of the intrusion and a little west of Asembo Camp. At the latter locality the enrichment in muscovite occurs along cracks and joints in an area of pink staining. It seems probable that the muscovite was formed by hydrothermal action soon after consolidation of the granite.

Minor facies, including aplitic granite and granite porphyry, are developed on the Asembo-Ramba road, and represent intrusions emplaced shortly after the main granite had solidified. The granite porphyry contains hornblende phenocrysts or pseudomorphs (chlorite-epidote) but no biotite, whilst the aplitic granite contains no original ferromagnesian mineral and indeed almost no mafic minerals. A little south of these intrusions a small mass of quartz diorite of doubtful age is present. It is a medium-grained bluish-grey rock with abundant hornblende crystals (up to 10 mm. in length), set in a feldspathic matrix. Examination under the microscope shows that quartz is present in small interstitial pools. Felspar occurs mainly in prismatic crystals ranging up to 2 mm. in length, usually very clouded but with clear margins. The hornblende occurs in large crystals, often with very carious margins, and is slightly or entirely replaced by chlorite, occasionally accompanied by epidote. Actinolite needles and fibres are also present. Biotite is much less common than hornblende, and is sometimes entirely replaced by a deep green pleochroic chlorite. Accessories are apatite, magnetite, sphene and calcite.

The Asembo granite is cut by thin aplite and pegmatite dykes at several localities near Asembo.

Ndeda Island Granite.—The intrusion, which occupies most of Ndeda Island bears some resemblance to the Asembo granite. It is a coarse pink type mottled by patches of white quartz. The feldspars, usually clouded by sericite, consist of hypidiomorphic oligoclase and large allotriomorphic growths of microperthite. The ferromagnesian minerals are pale yellow mica in ragged crystals and flakes, and rare crystals and aggregates of a second mica pleochroic from deep blue-green to weak brown. The yellow mica frequently edges grains and fills in cracks, and appears to be secondary. Accessories are magnetite, apatite, calcite and zircon. Magnetite, often with sagenitic habit, frequently occurs within the micas, and the calcite occupies small pools adjacent to them, suggesting that the original mica was destroyed and recrystallized as a hydrous form under hydrothermal conditions.

(c) *Porphyritic Granites, Gb.*

Abiru Granite.—This granite, occurring as a large boss with oval section in the south central part of the area, is generally comparable with the younger granites of the northern part of No. 2 Area (6, p. 29). It is peculiar, however, in being in part a pyroxene granite, a type not yet found elsewhere in Central Kavirondo. In hand specimens it is a grey or pinkish-grey, porphyritic or sub-porphyritic granite, and is usually fairly abundantly speckled by dark minerals. The feldspar phenocrysts only rarely attain a size comparable with those of the Gb granites in areas further north.

The pyroxene-bearing facies of the granite occurs roughly centrally, in an area about one mile in diameter, extending a little north of the T.S. and for about one mile to the south. Proceeding outwards from this area, pyroxene is gradually replaced by actinolite and the portions within a mile of the margin contain only actinolite or hornblende. Near the eastern margin, intrusion breccias and hybrids are present, together with occasional small intrusions of syenite.

The granite of Abiru T.S. has a rather low proportion of quartz, which is sometimes crudely intergrown with feldspar. The feldspars consist of stoutly prismatic crystals of oligoclase, phenocrysts of orthoclase and interstitial microperthite. The pyroxene, a pale green non-pleochroic variety, occurs in large idiomorphs and is partly replaced by blue-green hornblende or fringes of pale green actinolite. Accessories are large grains

of magnetite, large crystals of sphene and apatite. Sericite, and small pools of calcite occur as alteration products in the felspar.

The pyroxene-actinolite varieties, a little farther south, are very similar except that antiperthite appears as phenocrysts, and occasionally the oligoclase is sub-phenocrystic.

The hornblende granites of the marginal areas are likewise very similar to the pyroxene granite, except that the ferromagnesian mineral is a green or blue-green hornblende which is often partly replaced by epidote and chlorite.

Interesting varieties of the granite occur near the road, $1\frac{1}{2}$ miles north by east of Abiru T.S. These include a graphic hornblende granite, intrusion breccias with hybrid monzonite, a syenite, and a granite containing hornblende, augite and biotite.

The intrusion breccias contain abundant fragments of basic volcanic rocks in normal hornblende granite, which has in patches become reconstituted to form hornblende-augite-monzonite. The monzonite has granitic texture, but contains only a small proportion of quartz and is much richer in ferromagnesian minerals than the granite. The felspars are cloudy orthoclase and plagioclase. The augite is colourless and is partly or entirely replaced by hornblende which is itself partly altered to epidote. Accessories are common magnetite, sphene and apatite, and small pools of calcite.

The syenite is a rather dark grey, medium-grained, rock, cut by pink feldspathic veinlets. The felspars consist of orthoclase and microperthite, usually zonally sericitised, and rare oligoclase. Quartz is uncommon, in small micrographic areas. Brown biotite, mainly unaltered, in crystals and clusters, and occasionally intergrown with hornblende, is common. Colourless or pale green pyroxene is more rare and is mainly pseudomorphed by fibrous or flaky hornblende which is a frequent constituent. Accessories are apatite and magnetite: secondary sphene is present only where biotite is partly altered to chlorite. It is not clear whether the syenite is a distinct intrusion: the constitution rather suggests that it may be a hybrid marginal facies.

The biotite-bearing granite is unusual—the normal Abiru granites do not contain biotite. The biotite occurs in rare small crystals, pleochroic from deep green to weak greenish-yellow. The other ferromagnesian minerals are primary deep green hornblende and pale green pyroxene which, in larger

crystals, is partly replaced by an amphibole indistinguishable from the primary hornblende.

Cognate "basic" clots are somewhat rare in the normal granite. They contain corroded phenocrysts of microperthite ranging up to 4 mm. in length, and granular hypidiomorphic orthoclase, microperthite and some oligoclase-andesine. Quartz is abundant as small interstitial grains. Hornblende is common in large (2 mm.) corroded crystals, small crystals, and clotted groups, frequently enclosing apatite and sphene. Greenish-brown biotite is rare. Magnetite (usually enclosed in the hornblende) apatite and sphene, are common.

7—MINOR INTRUSIVE IGNEOUS ROCKS

Minor intrusives of many types, ranging from acid to basic, are prolific in the area, and it is proposed here to give descriptions of selected rocks only.

(a) *Acid and Sub-Acid Types.*

The more acid types comprise the following:—

Granite.—Biotite granite, about $1\frac{1}{2}$ miles south-east of Gangu, and at Abimbo; mica granite near Ngiga Mill.

Microgranite.—Sericitised microgranite, part of intrusive at Ngiga Mine; biotite microgranite with thin pegmatites, $\frac{1}{2}$ mile south of Anyango T.S.

Granophyre.—On the road north-west of Port Southby.

Quartz Porphyry.—Sakwa Road, near the turn-off to Poole's Camp; about $1\frac{1}{2}$ miles east-south-east of Abom T.S.

Granite Porphyry.— $\frac{3}{4}$ mile west of Anyango T.S.; near Bondo Police Camp; on the track $\frac{3}{4}$ mile north-north-west of Rambugu T.S.; part of the Ngiga Mine intrusion; on the Ngiga-Nangu road; the cupola about 3 miles east of Abiru T.S.; north flank of Unyango Hill; the lenticular cupola $1\frac{1}{2}$ miles north-north-east of Usire T.S.; and north-east Abimbo.

Granodiorite.—Near Nyagoka and $\frac{3}{4}$ mile south-east of Rambugu T.S.

Tonalite.—Marginal facies of the Bondo Police Station cupola.

Acid Porphyrite.—Quartz-hornblende porphyrite near Gangu; dacite-porphyrite south of Gangu; west-south-west of Rambugu; and near the River Yala on the Bondo Police Camp road.

The age of these dykes, cupolas and masses is not definitely known but may be presumed to be early post-granite, i.e. if the Ga granites are eventually proved to be pre-Kavirondo Series in age, the dykes, etc., may have been intruded at two or three periods during the geological history of this area.

Granites.—The granite dyke south of Gangu is a dark grey rock, abundantly sprinkled with small white felspar phenocrysts, with crystals and clots of dark biotite, and rare large hornblendes (up to 10 mm. in length). The lenticular Abimbo mass is a grey medium-grained rock containing little dark mineral. A small amount of biotite, which is sometimes bleached and often replaced by chlorite, and a fair proportion of sericitic mica are present. In its western tip the intrusion is highly sericitized, whilst on the east it contains sericite and muscovite only and no biotite. The granite near Ngiga mill is also a mica variety and contains much sericitic white mica, less frequently a bluish-green mica, and a little deep brown mica.

Microgranites.—Part of a lens-like dyke at Ngiga Mine is microgranitic and consists almost entirely of quartz and sericitized felspar. It is doubtful whether original white mica is also present. The thin microgranite vein, associated with pegmatite, south of Anyango, is also a mica type, but contains brown and green micas, whilst the felspars are fairly fresh.

Granophyre.—The small intrusion, of unknown shape, near Port Southby, is the only example of this type in the area. It is a buff rather decomposed rock, which in thin section is seen to consist mainly of quartz and altered felspar in graphic intergrowth. Chlorite is the only mafic mineral present.

Quartz Porphyries are also rare in the area. That on the Sakwa Road is a greenish-grey rock with abundant small quartz phenocrysts. In thin slice, quartz, usually about $\frac{3}{4}$ mm. in diameter, is seen to be present as numerous, often resorbed, crystals. The matrix consists of coarse allotriomorphic crystals of alkali-felspar enclosing sericite, chlorite, calcite and iron ore. The dyke in the Abom granite mass is a more typical granite porphyry with phenocrysts of quartz, felspar (some of which is medium oligoclase) and calcite-chlorite pseudomorphs of biotite and hornblende, set in a fine-grained granular matrix of quartz and felspar associated with abundant sericite flakes, calcite pools and small apatites. Apatite also occurs in larger crystals and iron ore is present in scattered small, occasionally large, grains.

Granite porphyries are the commonest minor intrusives. They show considerable variation in the proportion of phenocrysts to matrix. In some, e.g. the Unyango dyke, the phenocrysts are very abundant. Mineralogically they include biotite, bi-mica, sericite (Ngiga Mine and Ngiga-Nangu track), hornblende (track north of Rambugu), biotite-hornblende (Unyango) and "augite" biotite types.

The roughly circular boss east of Abiru appears to have been originally an augite-bearing rock. Its constitution and its proximity to the Abiru mass suggest that it is the upper part of a lateral cupola rising from the Abiru mass. The rock is dark grey, fine-grained and flecked by numerous small grey felspar and glassy quartz phenocrysts. Microscope examination shows resorbed quartz phenocrysts, ranging up to 3 mm. in diameter, and clouded orthoclase and oligoclase phenocrysts ranging up to 4 mm. in length. The ferromagnesian mineral is represented by chlorite-clinzoisite-epidote aggregates. The matrix is a granular quartz-felspar mosaic, occasionally micrographic, and contains small irregular crystals of greenish-brown biotite, shreds of sericite, scattered epidote grains, chlorite and calcite. Accessories are apatite, ilmenite and pyrite.

Other large cupolas of granite porphyry occur at the Bondo Police Camp and $1\frac{1}{2}$ miles north-north-east of Usire T.S. They resemble the example described above except that the ferromagnesian mineral is hornblende. The remaining occurrences are small dykes. Those at and near Ngiga are, like the microgranite of the mine, characterized by abundance of sericitic mica.

Granodiorite.—The dyke-like mass near Nyagoka T.S. is now a hornblende-biotite type though originally it may also have contained augite, now represented by actinolite or actinolite-chlorite-calcite pseudomorphs. It is rather similar to the granodiorite at the margin of the Asembo Granite about $1\frac{1}{2}$ miles east-south-east, which, however, contains a larger proportion of alkali felspar.

Tonalite occurs only on the southern margin of the Police Camp intrusion. In thin section it is seen to contain a fair proportion of quartz, and abundant tabular crystals of oligoclase-andesine, together with a low proportion of interstitial orthoclase. The mafic minerals are green hornblende, chlorite and epidote. Magnetite, apatite and sphene are present as accessories.

(b) *Intermediate Types.*

The intermediate minor intrusives comprise four types:—

1. *Porphyrite*.—In the Yala valley north and north-north-west of Bondo and at several localities on the Asembo–Abom road.

2. *Diorite-porphyrite*.—Small bosses on the River Yala 2½ miles and 4 miles east-north-east of Abom T.S.

3. *Diorite*.—At Ramba cross-roads; Bondo Police Camp track; a dyke about 2¼ miles north-north-east of Bondo, and a boss 2 miles south of Serawongo T.S.

4. *Monzonite-porphyry*.—On the hill 1½ miles south-east of Rambugu T.S.

Porphyrites.—The porphyrites are mainly hornblende varieties, and often contain remarkably fresh hornblende. A mica-bearing type occurs ¾ mile north-north-east of Asembo Camp, and a hornblende-augite type ½ mile north of the granite contact on the Asembo–Ramba road. In the field the porphyrites are grey fine-grained rocks with scattered felspar and mafic phenocrysts. Those north of Bondo are commonly stained pink. The phenocrysts are often small, but in intrusions, north of Bondo, range up to 30 mm. in length. The matrices vary considerably, and range from microgranular felspar-quartz mosaics to orthophyric types, and types containing packed hypidiomorphic oligoclase crystals associated with a small proportion of interstitial orthoclase.

Diorite Porphyrites.—Two small bosses of diorite-porphyrite occur in the north-east part of the area. They are rather similar to one another except that the easternmost contains no biotite and has smaller felspars in the base. The intrusion 1¾ miles east-north-east of Abom Bridge is a dark brownish-grey fine-grained rock. In thin section it is found to contain abundant hornblende phenocrysts, often pseudomorphed by chlorite and calcite, and smaller rarer phenocrysts of yellow-brown biotite, which is not uncommonly grown on or near the hornblende. The matrix consists mainly of a coarse anhedral felt of oligoclase, together with some interstitial orthoclase. Accessories are magnetite, epidote, calcite, actinolite and abundant apatite.

The two intrusions may be compared with the diorite-porphyrite facies of the northern lobe of the Abom granite mass, and may represent cognate intrusions.

Diorites.—The diorites are all quartz- and augite-bearing types, though the small boss at Ramba cross-roads also carries

biotite, and the extensive dyke north-north-east of Bondo, biotite and hornblende. That at Ramba cross-roads is a pinkish-grey granitic rock with abundant dark minerals and occasional small "basic clots". In thin section it is seen to be sporadically granophyric. The feldspars, which are considerably altered, consist of stout plagioclase prisms and some interstitial orthoclase. Augite occurs in colourless crystals ranging up to 2 mm. in length, but is mainly replaced by abundant pale green hornblende or chlorite. Brown and green biotite, sometimes chloritized, are also present, and rarely are intergrown graphically with quartz. Accessories are magnetite, apatite and sphene.

The dyke north-north-east of Bondo is a mottled medium-grained rock containing a fair proportion of quartz, which is sometimes graphically intergrown with feldspar. The feldspars, which are considerably clouded, consist of prismatic oligoclase and orthoclase. Augite is rather rare and is partly replaced by hornblende, whilst chlorite tends to replace all the ferromagnesian minerals. Accessories are magnetite, apatite and pyrite.

A small mass of quartz diorite which outcrops near the River Yala north of Bondo Police Camp, is noteworthy insofar as it is granulitized and contains pseudo-microphenocrysts of carbonate.

The diorite which forms the boss south of Serawongo is a dark grey or greenish-grey rock with felted texture, and resembles somewhat the dolerite types of that area. The plagioclase feldspar, however, is of oligoclase-andesine type, and orthoclase is present in larger proportion than in the dolerites, whilst the pyroxene, which is usually replaced by actinolite or a serpentinous mineral, is idiomorphic and non-ophitic.

Monzonite-porphyry.—One example only—a small mass—was observed, on the western flank of the hill $1\frac{1}{2}$ miles south-east of Rambugu. Biotite is common in small scattered crystals and groups, whilst white mica occurs in flakes and plates often intergrown with the biotite. Orthoclase is present in small tabular phenocrysts, and occurs in the matrix in association with allotriomorphic oligoclase and quartz. Small areas of micrographic intergrowth are present. Accessories are magnetite, apatite, actinolite and epidote.

(c) *Basic Types and Lamprophyres.*

Dykes and small bosses of more basic type although very common in the area, comprise but few types, namely dolerites, epidiorites and lamprophyres. There is little information whereby they may be closely dated. Most are intrusive into the old volcanic series, though occasional dykes of dolerite and lamprophyre cut the granite masses. The epidiorites occur as elongated bosses and dykes in the extra-granite areas, and on the evidence of their alteration and of the mass north of Nguda which is apparently cut off by the Abiru granite, are regarded as pre-Gb granite at least, and possibly pre-Ga granite. The dolerites, which are often comparatively fresh, are probably of much later date than the epidiorite and may be compared with other doleritic intrusions of East and Central Africa which are usually regarded as Karroo or Post-Karroo in age (4, p. 39). The lamprophyres are probably correlative with the acid and intermediate intrusives which followed the main periods of granitic intrusion.

Epidiorites and Older Dolerites.—The earlier basic intrusives occur as small dykes, and in three fairly large masses, one south of Rambugu and two in the Nguda–Abimbo area. They are dense dark grey or green-grey rocks, with closely felted texture, and sometimes contain small “phenocrysts” of a hornblendic mineral. In thin slices it is often possible to trace textures which suggest derivation from quartz dolerites, though occasionally original textures are completely destroyed. At Nguda, the constitution varies from doleritic to epidioritic in different parts of the intrusion. Elsewhere relics of augite sometimes remain, but are rare.

The dyke $1\frac{1}{4}$ miles east-south-east of Rambugu may be quoted as a typical epidiorite. In thin section, it is porphyroblastic with large fibrous and semi-compact growths of actinolite, which also occurs as needles and fibres in the base. Chlorite is present in irregular pools of variable size, and epidote occurs in granular clusters. Quartz is present in granular pools, whilst glass-clear recrystallised feldspar constitutes the remainder of the base. Pyrite and ragged skeletal grains of magnetite are the accessories.

Older dolerites, not epidioritized, occur at Chausu Mine and Lamac Mine in western Sakwa. Both are of earlier date than the quartz veining, and are of sub-porphyrific (“augite”) ophitic type. They are distinguished from all other altered dolerites of the area by lack of actinolite. The feldspars are completely recrystallised and in the Chausu intrusion the augite

is entirely replaced by carbonates and chlorite, whilst at Lamac it is replaced by chlorite and epidote.

An actinolite greenstone, part of a mass of epidiorite and altered dolerite north of Usire, which may belong to this group, is characterized by the presence of long plumose and stellate aggregates of actinolite. It is comparable with a pre-granite greenstone noted in the No. 1 Area (17, p. 24).

Lamprophyres.—The dykes and small masses of this class are few in number and comprise:—

(1) *Augite vogesite*.—In granite $2\frac{1}{4}$ miles south-east of Abom T.S.

(2) *Augite-hornblende spessartite*.—West flank of the hill $1\frac{1}{2}$ miles south-east of Rambugu T.S. and on the track $2\frac{1}{2}$ miles east by south of Gangu.

(3) *Hornblende spessartite*.—In the Utonga Valley 3 miles east-south-east of Utonga T.S.

(4) *Quartz-augite spessartite*.— $2\frac{3}{4}$ miles east-north-east of Abiru T.S.

(5) *Augite-hornblende camptonite*.—East flank of the hill $1\frac{1}{2}$ miles south-east of Rambugu T.S.

All are rather dark grey fine-grained rocks, some with small pink or glassy feldspars, and usually contain numerous small crystals of dark ferromagnesian minerals. The spessartite (2) south-east of Rambugu may be described as an example. Idiomorphic augite, sometimes partly replaced by fibrous brown amphibole, is common in crystals ranging up to $1\frac{1}{2}$ mm. diameter, whilst light brown hornblende crystals are also abundant. Actinolite and chlorite occur in large vesicle-like pools and interstitially to the feldspars. The matrix is a felted matte of coarse laths of medium-oligoclase, often sericitized and associated with interstitial orthoclase. Accessories are iron ore and sphene, the latter possibly secondary.

Dolerites.—Dolerites are very frequent in the area, usually as small narrow dykes, but occasionally as large dyke-like sheets (e.g. near Abom). They are evidently more common than is shown on the map for loose blocks and soils derived from doleritic rocks are often seen where no outcrop occurs. Normally the outcrops are of short extent, strikes being frequently about north-east or south-east, though strikes about east-west and north-south also occur. The rocks are usually dark grey or greenish-grey, with felted texture, and sometimes contain abundant dark phenocrysts of augite, ranging up to 5–6 mm. in diameter. Black fine-grained basaltic

types are rare. Microscope examination indicates that the following types are present:—

- (1) Quartz dolerites; very common and comprising the following varieties:—
 - (a) Ophitic.
 - (b) Ophitic, containing brown biotite; not common, mainly in the eastern part of the area and south-east of Nguda.
 - (c) Poecilophitic, e.g. in the peninsula south-east of Abimbo and near Chausu.
 - (d) With porphyritic non-ophitic augite and a second generation of intergranular augite; rare, e.g. the dyke near Bellamira Mine.
 - (e) With intergranular augite only.
 - (f) With felspar phenocrysts; rare, e.g. the dyke $1\frac{1}{2}$ miles south-south-east of Abom T.S.
- (2) Quartz dolerites with a rather high proportion of interstitial orthoclase.
- (3) Granophyre-dolerite; one example only, near Kadimo.

These types cannot be described here in detail, but the following points may be noted:—

- (1) The degree of alteration varies considerably—some are almost quite fresh, others are slightly or much altered, though, in most cases the texture is not entirely destroyed and relics of augite remain. The felspars are clear or variously clouded by sericite, zoisite and epidote, whilst the augite is variously replaced, entirely or in part, by actinolite, chlorite, epidote and serpentinous minerals, and occasionally by a brown hornblende.
- (2) They usually contain some granophyric mesostasis.
- (3) Many are characterized by the presence of large skeletal intergrowths of magnetite and leucoxenized ilmenite.
- (4) No quartz-free dolerites have been observed.
- (5) None of the types carry olivine.

The granophyre dolerite of Kadimo is an unusual type with sub-porphyritic, slightly ophitic, augite and is characterized by an abundance of large areas of micrographic intergrowth of quartz and felspar.

8—METAMORPHISM

The metamorphic history of the area is naturally somewhat complex, though, as is usual in Central Kavirondo, the degree of metamorphism attained at any one period is not considerable. The regional metamorphism exhibited by the Basement Complex gneisses and granulites is of comparatively low grade, whilst regional metamorphism of the old volcanics is slight and mainly of retrograde type. Thermal metamorphism by the larger intrusives is also slight and is restricted mainly to the patchy development of biotite in the lavas and tuffs usually within a short distance of igneous contacts. The development of biotite in lavas and tuffs about 1 mile west of the western Abiru contact may be taken to indicate that, though the granite contact appears to dive steeply at the exposed margin, it slackens considerably in depth.

The minor degree of metamorphism effected by the larger intrusives is well illustrated by the slight alteration of xenoliths. Near Asembo Bay small blocks of basic lavas engulfed in the granite are found to consist largely of chlorite and sericite in a base of recrystallized felspar, with occasional pools of quartz and abundant small disseminated grains of iron ore. Blocks of basic tuff enclosed in the marginal granite two miles further west, also show no sign of anamorphism.

The metamorphic effects of the Abom Granite are similarly slight, as is shown by the lack of anamorphic minerals in the tuffs of the roof-pendant which rests on the granite about one mile south by east of Abom T.S.

The most interesting metamorphic effect has been produced in the basic lavas close to the granite margin about $1\frac{1}{2}$ miles west-south-west of Asembo Camp, where large irregular aggregates of quartz, epidote, clinozoisite and a whitish garnet, cut by calcite-filled gashes, have been formed. The garnet has idiomorphic outline against the quartz. Similar effects have not been noted elsewhere.

VI—TECTONICS

Folding.—At the present stage of knowledge of the area the nature of the folding cannot be dogmatically described, especially as it is evident that folding has occurred at several periods, namely, post-Basement Complex, post-old volcanic series, and, in a minor degree, post-quartz-veining. The folding which followed the formation of the Pre-Kavirondo Volcanic Series is indicated by the distribution of the volcanic suites. It thus appears that, from north to south, there are a

series of folds with approximately west-south-west strike, and pitching to east-north-east, viz:—

Syncline.—Along the Yala valley and through Usire.

Anticline.—Along the higher slopes of the Yala divide, north of Bondo and westwards towards Utonga.

Syncline.—Ramba to Bondo and westwards to Sifu Island.

Anticline.—Gangu to Serawongo.

Syncline.—Central Asembo to eastern Abimbo.

Anticline.—The area between Abimbo and Tedo.

Syncline.—Tedo area.

The diagrammatic section given in Figure 2 indicates the nature of the folding. The shape of the folds is not definitely known, though the rare occurrence of steep apparent dips and comparison with the northern part of No. 2 Area (15, p. 82, and 6, p. 15) may indicate that the limbs are steep, possibly vertical.

Folding of later date than the incidence of quartz-veining is seen only in undergrown excavations and is described in a later section (p. 62).

Faulting.—On the flat divides there is no trace of faulting, and it is only on some of the rather complex hill groups—Usire, Abom, Nyagoka and Abiru—that faulting is suggested by the conformation of the surfaces. No definite evidence of faulting has been obtained, however, and faults are accordingly not shown on the map, though the sketch form lines on the hills mentioned will indicate where it is suspected that faulting occurs.

It is possible that a major fault of late date runs along the shore of the Kavirondo Gulf. The only evidence is the shearing of the granite at Asembo pier and the crumpling of Miocene limestones in Uyoma (south of the present map). The postulated fault may be the western branch continuation of the Nyando and Seme faults. (14, front plate, and 1, p. 10.)

Small faults are not infrequent in mines and excavations, notably at Ngiga (p. 60) and Chausu (p. 62), but the information is too scanty to give any conception of the fault patterns and tectonics of the area.

Shearing.—Widespread cleavage has not been imposed upon the rocks of any part of the area, though local shearing is occasionally seen. In some cases quartz veins have been emplaced along shears or crush zones. The more notable of these are the crush zones running approximately north-south at Bellamira Mine, and through Nangu T.S. where a series of veins occurs in an extensive crush zone.

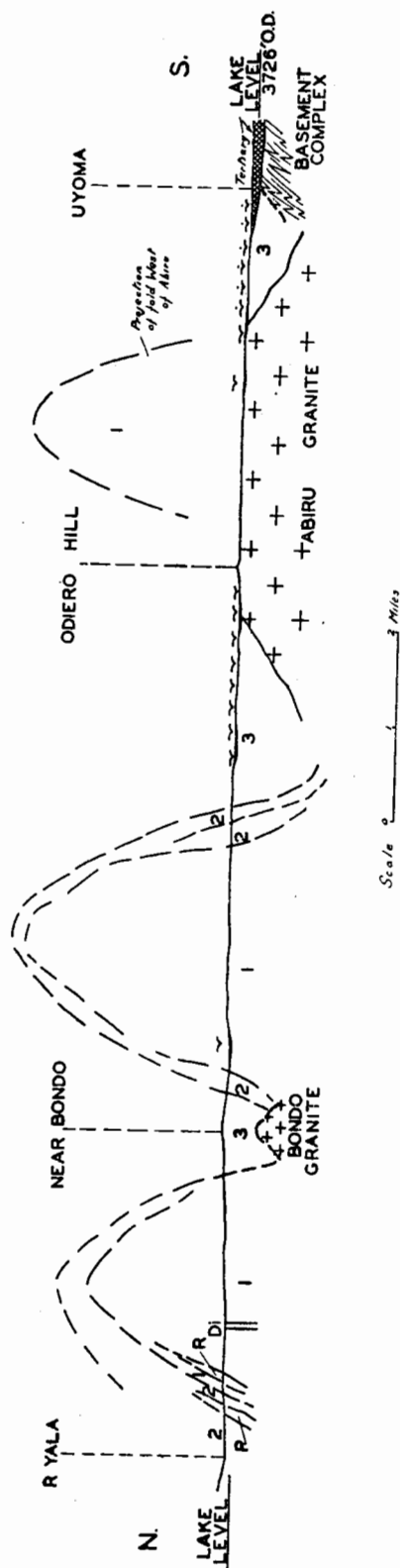


FIG. 2

North-south section of the Sakwa area, passing approximately through Bondo and Odiero Hill.

- 3. Basic lava suite.
- 2a. Agglomerate.
- 2. Tuffs.
- 1. Andesetic suite.

R. Rhyolite.
Di. Diorite Dyke.
P. Porphyrite.

VII—ECONOMICS AND MINERAL RESOURCES

During the present investigation valuable minerals, other than gold, have not been found in commercial quantities. Copper staining was observed in the peninsula south-west of Abimbo, and has been reported elsewhere, but it is apparently of academic interest only, the copper carbonates being derived from disseminated chalcopyrite which occurs sporadically in the old lavas. Galena is present in small quantities in some of the gold-quartz veins, but again has no commercial significance.

Gold has been found in many parts of the area and is being worked by a number of large and small syndicates. The localities at which gold deposits were being developed or exploited during the survey are shown on Figure 3. The area has proved to be the more auriferous part of the No. 2 Area. It is recorded that, since it was opened to prospectors in May, 1934, more than 20,000 ounces of gold have been produced.

1—GEOLOGY OF THE GOLD DEPOSITS

All the gold deposits of the area consist of quartz veins or rubble derived from the disintegration of quartz veins. The quartz of the veins is usually of massive white type, ranging from glassy to sugary in texture. Blue quartz, however, does occur and is sometimes confined to one portion of a vein, though veins composed entirely of blue quartz are uncommon. In some cases the vein quartz is laminated. Sulphides are usually present, consisting of pyrite, chalcopyrite, galena, and—in the case of veins associated with the Abom granite—mispickel. Pyrrhotite is also said to occur in some of the veins.

Examination under the microscope shows that most of the veins are composed of irregular mosaics of quartz, which consist of fine-grained and coarse-grained areas arranged with no apparent order. Occasionally the mosaic is mainly fine-grained, e.g. in the Chausu Main Vein.

The quartz is usually heavily speckled by minute inclusions though less so in the finer grained portions, whilst the coarse grains are edged by thin zones of clear quartz. The whole slice is frequently cut by abundant anastomosing "veinlets" of clear quartz which, however, do not appear to be true veinlets of later date than the main mass of the quartz. In rare cases, notably the laminated quartz of the footwall portion

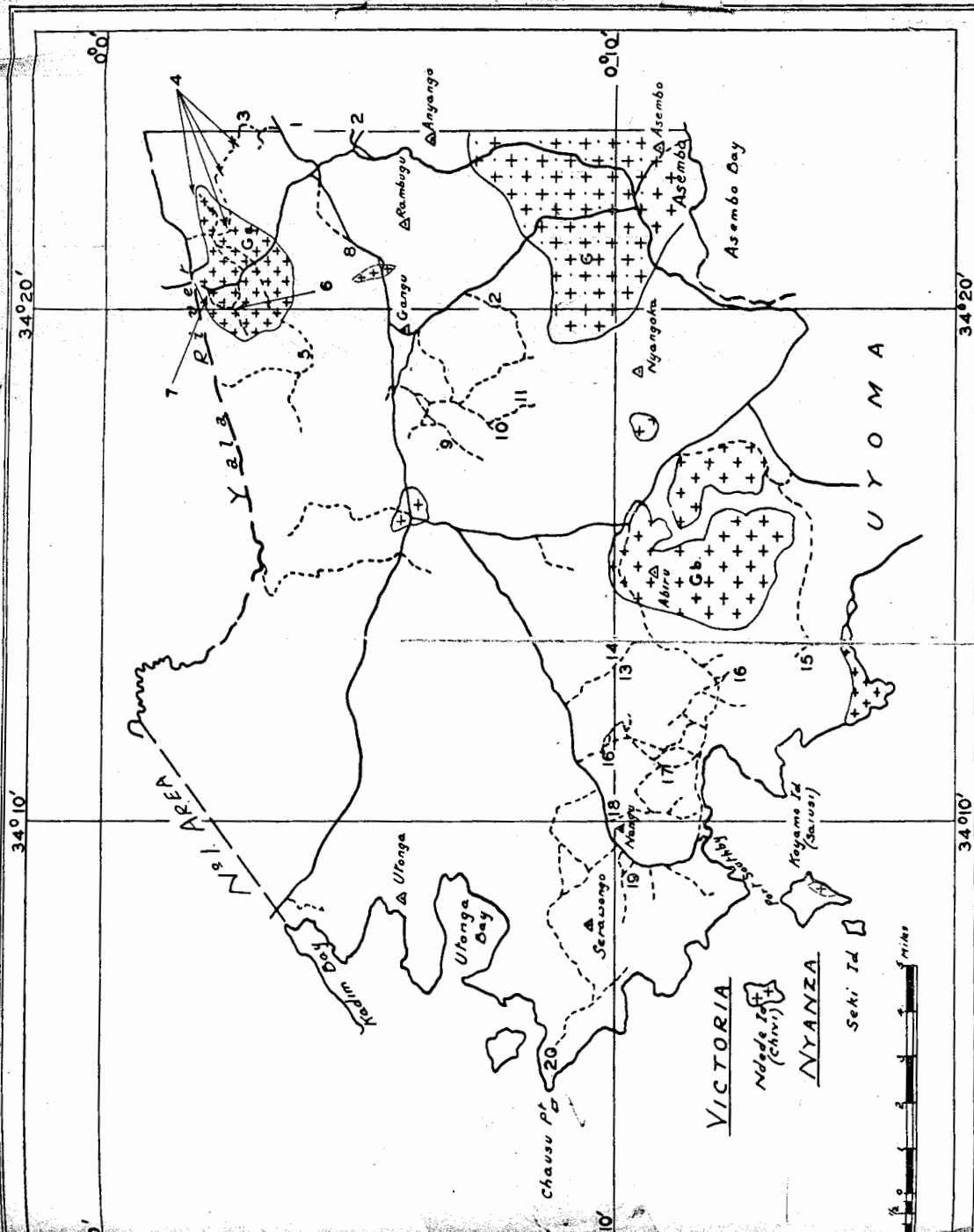


FIG. 3

Sketch map showing position of gold properties in the Asembo-Sakwa area, and their relation to the major intrusives.

- | | |
|--|--|
| 1. Midas Mine. | 16. Bellamira Development & Mining Co., Ltd. |
| 2. Pakaneusi. | 17. Ngiga Mining Co., Ltd. |
| 3. *Quinyala Syndicate. | 18. Nangu Mine. |
| 4. Johnson Starnes Syndicate. | 19. Asembo Mines, Ltd. (Lamas Mine) |
| 5. Johnson Starnes Syndicate (Fabal reef). | 20. Kawirondo Gold Mines, Ltd. |
| 6. Sunshine Syndicate. | |
| 7. *Golden Bend Syndicate. | |
| 8. Bell-bird Syndicate. | |
| 9. Coronation Mines, Ltd. | |
| 10. Lantana, Ltd. | |
| 11. Boiteux and Maxwell. | |
| 12. Barkowino Syndicate. | |
| 13. *Simpson. | |
| 14. Poole. | |
| 15. Hildred. | |

Those marked by an asterisk were abandoned during the course of the survey.

of the Fabal Reef (south-west of Abom), the coarser grained quartz shows a strong tendency to elongation of its grains parallel to the strike of the vein. In all cases examined, with the notable exception of the Ngiga Vein, calcite or sericite, or both minerals, occur grown among, or rarely, enclosed in, the quartz grains. In exceptional cases, e.g. the Bellamira Sybil Reef, the carbonate can be proved to be of later date than the quartz vein. Felspars were observed only in a small portion of the Sybil Reef.

The size and disposition of the veins is very variable. Thicknesses vary from a fraction of an inch to about 10 feet, and the veins are usually characterized by constant swelling and pinching. The average thickness of the workable veins probably lies between 15 to 24 inches. The strike extent ranges from about 100 feet to a maximum of about 1,500 feet. The Quinyala Reef, which enters the area a little north-east of Ramba cross-roads, is said to have a total strike of over 2 miles, but it is to be suspected that several distinct veins occur within a zone extending over that distance. Dips are usually slack, so that in many cases veins have been developed by inclined adits. A notable exception is the Midas main vein near Ramba, which is almost vertical.

The distribution of gold in the veins is in some cases sporadic, but in others, notably at Midas Mine, Barkowino, Coronation Mine and Lamac Mine, appears to be concentrated in shoots. In all cases, however, it seems that the gold is largely confined to the main vein structure in any one vein system. Moreover, values are not in general found in the wall-rocks of the veins, though at a few of the mines, low-grade wall impregnations have been noted.

Examination of Figure 3 will show that the greater number of the mines occur in restricted areas, in close proximity to the major acid or sub-acid intrusives, extending from the Abom granite in the north-east, south through the diorite at Ramba cross-roads to the Asembo granite, and then roughly south-west along the line of the Asembo, Abiru and Tedo granites. In that section of the area lying north-west of a line from Abom T.S. through Bondo to Sifu Island—where major intrusives do not occur at surface—there is a marked lack of valuable or sizable veins.

The disposition of the veins towards the granites varies somewhat. The Abom granite is characterized by numerous relatively small veins which occur within the granite outcrop and frequently strike more or less parallel to the long axis of

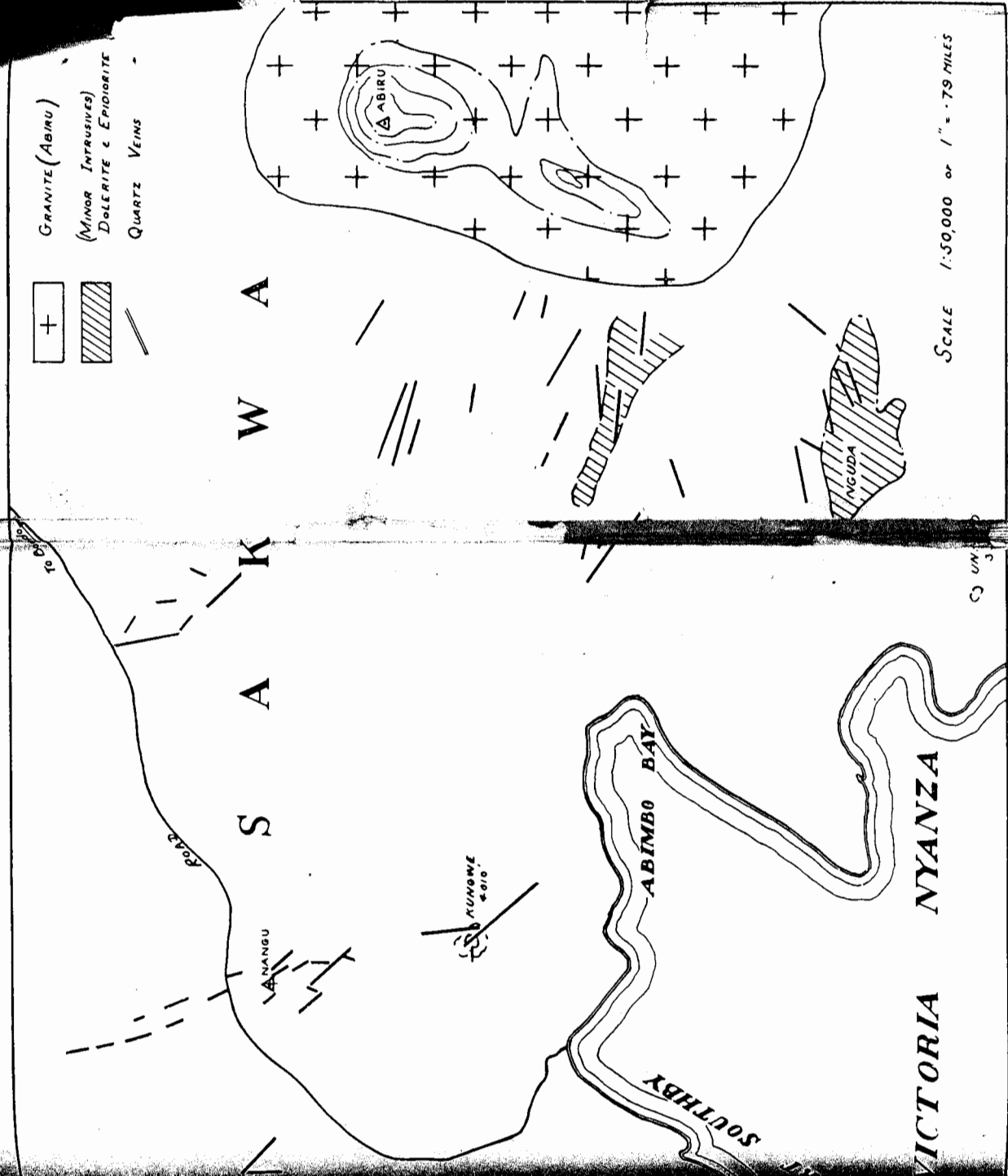
the intrusion, i.e. about east-north-east. There are comparatively few veins outside the granite mass, notably the Fabal, Jambo and Shenzi and perhaps the Quinyala reefs, which also strike approximately parallel to the long axis of the granite. The last-named veins occur south-east of the granite, and dip rather steeply to the south-east, but the Fabal Reef, which is almost on the prolongation of the granite axis dips to the north-west. The tenor of the evidence suggests that the Abom granite is a very slightly denuded cupola, and probably, that the lateral extra-granite veins were intruded during a period of collapse or recession of the granite magma.

The Midas vein is unusual, insofar as it is not close to any major intrusions; it may, however, be connected with the small quartz diorite mass at Ramba cross-roads, which may indicate a hidden granite cupola.

Proceeding westwards, the next marked area in which auriferous veins occur is the Gangu-Waringo district situated between the western tip of the Asembo granite and the smaller granite masses at Bondo and that east of Elijah's. The strikes of the veins in this area are variable, though there is a tendency to group about north-east to north-north-east. Where such strikes obtain the dips are always to the north-west or west-north-west.

Veins apparently connected with the Abiru intrusion are most abundant in a two mile wide belt which adjoins the granite margin on the west. The veins exhibit a marked radial trend with respect to the granite (Fig. 4), strikes varying from about south-west in the Nguda area to about north-west at the northern end of the granite. Few veins of workable size or value have been found north and north-east of the granite.

The veins of western Sakwa—around Bellamira, Ngiga, Lamac and Chausu—cannot readily be connected with the Abiru granite, though the comparative nearness of an underground extension of the granite may be indicated by the acid and intermediate intrusions at Ngiga, Bellamira and on the Port Southby road. The veins of the Chausu area are, however, far from known intrusives of this type, and their origin is doubtful. In an area of about $2\frac{1}{2}$ miles radius around Nangu T.S., most of the veins strike between north-west and north. This is especially marked in the vein system running from Kungwe Hill to north-north-west of Nangu T.S. Exceptions, with east-north-east or north-east strike, are rare. Dips are generally slack, especially at Lamac Mine (5° – 20°), and usually incline to the west or south-west. A notable exception to this is



Sketch map showing distribution of veins around the Aribu granite mass and the west Sakwa. From an early map by Dr. C. S. Hitchen.

the Nangu Mine vein which dips to east-north-east. The general conformation of the veins of this area suggests that they may be connected genetically with a subterranean crease of the Abiru granite running in a north-westerly direction.

The several veins discovered in the Chausu district strike commonly between west-north-west and north-north-west, and may also be connected with the hypothetical extension of the Abiru Granite.

It thus appears that the majority of the veins of the Asembo-Sakwa area are connected with the Abom, western Asembo and Abiru granites. Mineralization accompanying the eastern Asembo, Tedo, Kayamo and Ndeda granites appears to have been negligible.

2—DESCRIPTIONS OF GOLD OCCURRENCES

In this section descriptions are given of the various properties which were being worked or developed during the course of the survey. The order of description is from east to west and the number of each description corresponds with the numbers of Fig. 3.

1. *Midas Mine* (Messrs. Yates and Whitmarsh).

The mine is situated about $\frac{1}{2}$ mile east of the cross-roads at Ramba. The country rock near the mine is entirely composed of altered basalts, though a small boss of diorite occurs at the cross-roads. Four principal veins have been discovered on the property of which the most southerly is a gash vein with an approximately north-south strike (Fig. 5a).

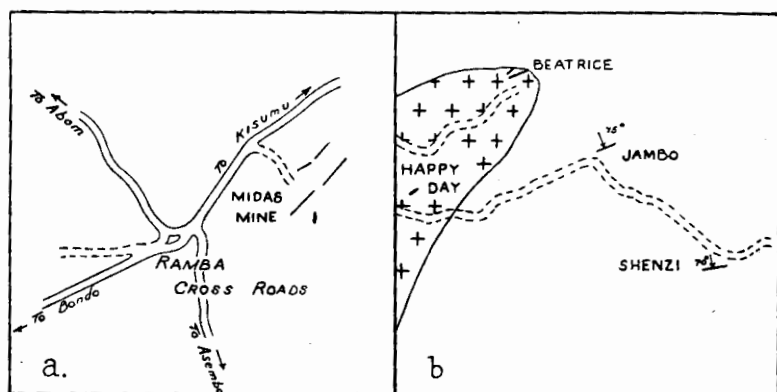


FIG. 5a AND b

Sketch diagrams showing the positions of the quartz veins on properties in the Asembo-Sakwa area. Veins shown by heavy black lines. Scale: 1 inch = 1 mile. Sides of diagrams oriented north and south.

(a) Midas Mine (Messrs. Yates & Whitmarsh).

(b) Johnson Starnes Syndicate—holdings east of the Ramba-Abom Road.

The more westerly of the two northern veins has a strike extent of about 600 feet and runs more or less parallel to the main central vein. The latter has been traced discontinuously over a strike of about 3,000 feet, but only the western 1,500 feet have been followed underground (to a depth of 115 feet). The western portion of the main vein strikes at 55° and the eastern portion at 45° . The western part is almost vertical and is usually a persistent, solid vein varying in thickness from 3-4 feet, occasionally swelling to 10 feet, and occasionally splitting and branching in shear zones. The quartz is a white glassy variety with sporadic pyrite and inclusions of chloritic material, while shattering and marked infillings of gouge are not infrequent. It appears possible that the main vein may be folded and that the change in strike of the main vein and of the two northerly veins may be due to a fault running across the property in a north-westerly direction.

In the main vein, gold is apparently confined to shoots pitching at 35° to 40° to the west, though values are also found occasionally in 2 to 4 inches of the hanging wall. Visible gold is rare and is said to occur only where the quartz is severely crushed or heavily impregnated with iron oxides.

Milling was carried out between January and August, 1935, and recommenced in June, 1937, the production to the end of 1937 being approximately 842 ounces of gold and 116 ounces of silver.

2. *Pakaneusi Prospecting and Development Co., Ltd.* (Government Reef).

The western extremity of the large white quartz vein extends into the present area at the Native School, about a mile south-east of Ramba cross-roads. The strike is approximately east-north-east (12, p. 31 and 13, p. 9).

Mining operations have been confined to the eastern section of this vein which lies beyond the eastern boundary of the present map.

3. *Quinyala Syndicate.*

The western extensions of the large vein system so far explored occur in the area lying immediately north-north-east and north-north-west of Ramba cross-roads. The white quartz veins strike about east-north-east in the eastern section of the system but veer towards north-east near the Ramba-Abom road. Dips range about 60° to the south-east (13, p. 9).

4. *Johnson Starnes Syndicate* (holdings east of the Ramba-Abom road).

The Syndicate has held many properties in the area, mainly in the Abom district (Fig. 5*b*). Properties lying to the east of the Ramba-Abom road comprise:—

- (1) The Beatrice Reef, which consists of small veins emplaced in the granite at its contact with the volcanic series, about $2\frac{1}{2}$ miles east by north of Abom T.S. The veins were followed to a depth of about 40 feet, but gold values were found mainly near the surface and in rubble.
- (2) The Happy Day Reef which is located about 2 miles east by south of Abom T.S. and consists of a lens of white quartz with a strike of 60° , extending over about 100 feet, in granite. Rich values were obtained down to a depth of 60 feet where the vein became very narrow.
- (3) The Jambo Reef which is situated about 3 miles east of Abom T.S. and consists of a complex of veins, striking at about 70° and extending over about 200 feet. The dip of the main vein is about 70° to the south-south-east. It ranges up to 48 inches in thickness east of the shaft. Good gold values were encountered near the surface but decreased with depth in the 60-foot shaft. The country rock—members of the andesitic suite of lavas—also carried values.

5. *Johnson Starnes Syndicate* (Fabal Reef).

The most important holding of the Syndicate is the Fabal Reef, situated about $2\frac{1}{4}$ miles west-south-west of Abom T.S., in an area of altered andesitic lavas.¹ The vein strikes at about 50° ² and extends over a length of about 1,100 feet, with a dip of 55° – 60° to the north-west. The vein, which has been explored to over 200 feet in depth, lenses continuously and has an average thickness of about 30 inches.³ It is in part composite, with a footwall leaf—usually constituting

¹ Mr. Donald Smythe, the manager of the company at present operating this mine, informs me that he considers that the country rock consists of somewhat metamorphosed sediments, possibly with associated inter-bedded volcanics; and that an irregular dolerite dyke, of pre-quartz veining age, occupies the zone of fracture in which the vein was emplaced. He has also noted a dyke of quartz monzonite porphyry which is of later age than the quartz vein.

² Mr. Smythe believes that the true strike of the vein is 35° , an apparent strike of 50° being caused by a number of small faults which have displaced segments of the vein producing an echelon arrangement.

³ The lensing of the vein is believed by Mr. Smythe to be in part due to subsequent faulting, which has caused overlapping of segments of the vein.

about a quarter of the total width—of white or greyish-white, glassy or dull, laminated quartz, which is frequently heavily pyritized and carries free gold. The more persistent hanging-wall leaf of the vein is a dense white or bluish white quartz, sometimes heavily impregnated with pyrite. It is believed by some investigators that the lower leaf is of later date than the upper, this notion being seemingly supported by the fact that in places the two portions of the reef are separated by one to four feet of the country rock. Gold values are highest in the south-western part of the mine, and are mainly restricted to the footwall section of the vein. The hanging wall portion carries values but of relatively low grade, except where the footwall leaf is absent when the hanging wall portion carries good values. Small faults cut the vein obliquely but are apparently of little significance. There appears to be no shearing.

Milling was commenced in August, 1935, and up to July, 1937, when production ceased temporarily, about 3,175 ounces of gold had been produced from the various properties worked by the Johnson Starnes Syndicate.

6. *Sunshine Syndicate.*

The Syndicate operates on claims in the Abom area, the main property being about $\frac{3}{4}$ mile south-east by south of Abom T.S., within the Abom granite. The white quartz vein now being worked strikes at about 70° and is about 12 inches thick at the surface, but thins downwards. Valuable rubble has also been worked. A little west of this vein a second white quartz vein, 12–20 inches thick and striking at 102° over about 200 feet, has also been investigated. Other veins, a little south of the granite margin, are being explored. The gold produced by this Syndicate, between September, 1936, and November, 1937, was approximately 412 ounces.

7. *Golden Bend Syndicate.*

The Syndicate was originally formed to work alluvial deposits in the Yala River near Abom, but later worked lodes on the east flank of Abom Hill. Small and impersistent veins, lying within the granite and often very rich, were worked and were followed to a maximum depth of 50 feet. Work ceased in October, 1937, after a total of about 670 ounces of gold had been recovered since milling commenced in May, 1935.

8. *Bell Bird Syndicate.*

Operates a small property about $2\frac{1}{4}$ miles west-south-west of Ramba cross-roads. The main vein, a massive grey-white or white type, strikes approximately due north and dips to

the west, and has a maximum thickness of about six feet. There is a considerable tonnage of collapsed reef.

9. *Coronation Mines, Ltd.* (formerly de Saram's Mines, Ltd).

The workings are situated on several blocks of claims on the flat divide about two miles south-south-east and south-east of Bondo Camp. The country is here composed of members of the andesite suite of the volcanic series, cut by small basic intrusions.

Several veins and vein systems have been discovered (Fig. 6a) and some of them have been worked. The northern vein (near the camp), lying in a shear zone, strikes at about 32° over approximately 600 feet and dips to the north-west at 60° . Its thickness varies from 8 to 42 inches. In its southern portion, the vein consists of white granular quartz, but on tracing northwards, it grades through white and blue quartz to dense blue quartz with little sign of mineralization at the northern end. Gold values are said to lie in shoots pitching at about 45° to the south-west. The vein has been developed by small opencasts and by shafts to the 100-foot level.

The southern vein, which occurs about one mile south-south-west of the camp is sometimes heavily pyritized. It strikes at about 22° over 1,800 feet, and dips to west-north-west at about 75° . The vein, emplaced in a marked shear zone, lenses, and possesses a maximum width of between 50 and 60 inches. Gold values are said to be greater where the vein is thicker. The vein has been developed by inclined shafts and small opencasts.

Other veins include—

- (1) one, slightly off the strike of, and a little to the north of the camp veins; which is composed of white quartz and dips steeply to the north-west. The values are stated to be low;
- (2) a white quartz vein, occurring about 100 feet east of the camp vein, which strikes north-east. At the northern end the dip is 60° to the north-west, but the vein becomes more steeply inclined towards its southern end. The thickness of this vein varies from 12 to 15 inches;
- (3) a group of veins, displaying strikes similar to those of the main veins, which occurs about midway between the north vein and the south vein. A further vein, with north-west strike, occurs a little to the east of the group.

Between December, 1936, and December, 1937, about 637½ ounces of fine gold were produced from the property, whilst earlier in 1936 some 90 ounces had been produced by the previous owner.

10. *Lantana, Ltd.* (Bonzo Mine).

This prospect is in the early stages of development and is located on claims formerly held by the Kenya Uganda Minerals Exploration Co., Ltd., about 2 miles south of Gangu T.S. The vein now under examination strikes about south-east in its southern part but turns to approximately east-west in its northern section. The total strike is about 1,000 feet, though the vein has not yet been proved in the central portion. In the south it is a white granular quartz vein the dip of which varies from 60° to 85°. The thickness is from 4 to 22 inches and is said to increase towards the bottom of the 50-foot incline. The northern section of the vein, 6-18 inches in thickness, is sporadically pyritic and contains rich pockets of ore. The quartz in both sections of the vein tends to be laminated.

11. *Messrs. Boiteux and Maxwell.*

The property is situated in the broad shallow valley about 3 miles south-west of Gangu T.S. Development was not far advanced at the time of the writer's visit, being confined to trenching and to an inclined adit. A complex of white quartz veins, extending over a width of 96 inches has been exposed near the surface. This complex thins to a vein about 10 inches wide at 80 feet on the incline, but widens to 12 inches at 90 feet. The strike is 150° over about 90 feet, and the dip 35° to 40° to the south-west. Gold values are mainly confined to the wall portions of the vein complex. A little to the east of the vein complex, there appears to be two distinct veins, one of which turns to the south and has been traced over 600 feet. Its gold content is stated to average about half an ounce per ton.

Milling was commenced at the end of October, 1937, and by the end of January, 1938, about 63 ounces of gold had been obtained from 40 tons of ore.

12. *Barkowino Syndicate.*

This Syndicate has operated on various blocks of claims in western Asembo and eastern Sakwa. The most important occurrence is the Good Luck Reef, about two miles south-south-east of Gangu which has been opened up by a large opencast and by vertical shafts. The vein strikes approximately north-south over about 120 feet and dips at 60° or more to the west. It is composite, with a hanging-wall portion

of white glassy quartz and a thinner footwall portion of white or bluish-white, often laminated, quartz, which is frequently heavily impregnated with iron oxides. The vein, as a whole, lenses somewhat, and the footwall leaf tends to lens independently. At the surface the vein had a maximum width of 60 inches and was accompanied by lateral veinlets some of which carried very high gold values. Underground, on the 90-foot level, the maximum thickness is 96 inches, while the average lies between 24 and 30 inches. Below the 90-foot level the vein appears to thin downwards. Locally, the vein splits and branch veinlets occur. Gold values are mainly restricted to the footwall leaf of the vein and appear to occur in a shoot with a steep pitch to the north. The country rock consists of altered basic lavas cut by small basic intrusions, and carries values near the vein.

The milling of ore from this vein was commenced in August, 1936, and about 1,680 ounces of gold had been produced to the end of 1937.

Various other veins have been discovered near the Good Luck Reef. These are of white or bluish-white quartz and strike about north-south or east-west. In addition, veins have been uncovered and worked by shafts and opencasts in the area between Gangu and the Good Luck Reef. One of these, located about $1\frac{1}{2}$ miles south-south-east of Gangu, strikes east-west and dips at 57° to the north, and has been followed to 95 feet inclined depth.

13. *R. Simpson's Prospects.*

Two adjacent massive white quartz veins, 20–30 feet apart, were discovered in the area north of Abiru Hill. One is about 36 inches wide and dips at 45° to the south-west. It has been opened up for about 100 feet along the strike. The second vein is also about 36 inches wide, dips at 30° to the south-west, and has been opened up for about 50 feet. There is a considerable amount of collapsed reef.

14. *J. R. Poole's Prospect.*

The prospect is situated on the flat-topped divide about $2\frac{1}{2}$ miles north by west of Abiru T.S. Two veins have been opened up by trenches, pits and opencasts.

The southern vein is complex and has an apparent strike of 125° and dips at 18° to the south-south-west. It consists of white quartz with sporadic pyrite and in one trench is 12–18 inches thick; in others, however, it splits to form several veins extending over a total width of 84 inches. It is possible that this vein is actually dome-shaped.

The northern vein strikes at 195° and dips at 35° to the west. The quartz is a white sugary variety, which often displays a tendency to lamination. East of the vein there is a considerable extent of collapsed reef from which rich rubble has been obtained. Both veins are emplaced in andesites cut by a dolerite dyke a little to the east of the outcrops of the veins.

Milling was commenced in December, 1937, the ore being carried to the head of the bay at Abimbo.

15. *W. Hildred's Prospect (Nguda).*

Properties formerly held by N. B. van Deventer and by Kenya Development, Ltd., under option, are worked. The main occurrence is about $3\frac{1}{2}$ miles south-south-west of Abiru T.S., in the south-eastern edge of the epidiorite-dolerite intrusion of Nguda. Here, two parallel veins, 80 feet apart, have been opened up over about 250 feet, and are now being explored underground. The strike is approximately 65° , and the dip almost vertical. The northern vein is 6 to 12 inches thick with lateral branches, and the southern averages not less than 12 inches. Values are confined to the quartz veins which are of a bluish-white type. Milling was commenced in March, 1937, and by the end of that year about 550 ounces of gold of average fineness .865 had been produced from 1,327 tons of ore. The previous owners had already extracted some 800 ounces of gold from the property. Other veins south-west of the main occurrence are also being investigated.

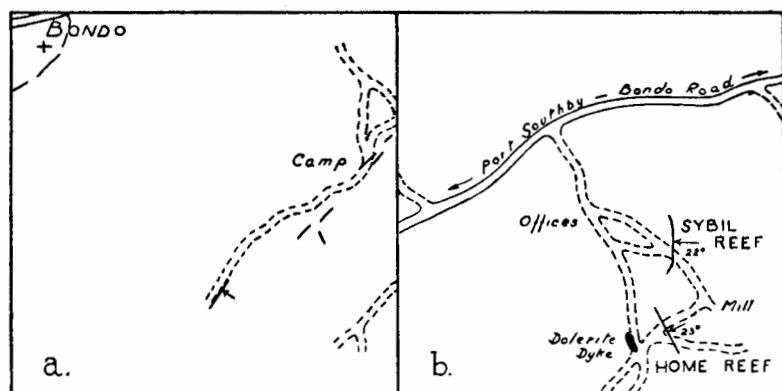


FIG. 6a AND b

Sketch diagrams showing the positions of the quartz veins on properties in the Asembo-Sakwa area. Veins shown by heavy black lines. Scale: 1 inch = 1 mile. Sides of diagrams oriented north and south.

(a) Coronation Mines, Ltd.

(b) Bellamira Development and Mining Co., Ltd.

16. *Bellamira Development and Mining Co., Ltd.*

This Company has operated on several properties in the Asembo-Sakwa area, the principal one being situated on the broad flat divide about two miles east of Nangu T.S. (Fig. 6b). The country, which here consists of dacites, andesites and agglomerates cut by occasional porphyrite and dolerite intrusions, is very poorly exposed and is usually covered by murram ranging up to 15 feet in depth.

Two veins, the Sybil and the Home Reefs have been developed by inclined shafts, the former to a depth of 660 feet in one shaft and the latter to about 155 feet. The Home Reef, consisting of a white quartz vein ranging from 2 to 20 inches in width, strikes at 140° over about 1,400 feet and dips at 23° to the south-west. The Sybil Reef, extending over about 1,100 feet, strikes approximately north-south but curves to the west at its extremities. In the upper levels the dip is about 20° – 30° to the west, but increases to 45° in the main shaft near the fourth level. The reef comprises quartz gashes and stringers in a crush zone. Near the main shaft the zone swells to a width of 84 inches and contains two or three "horizons" of quartz in lenses ranging up to 36 inches in thickness. The quartz is a dull white, greyish-white or pinkish-white variety carrying a small amount of pyrite and, occasionally, galena. In thin section it is seen to be composed of variously coarse and fine quartz mosaic with stringers, patches and individual crystals of calcite. Cloudy felspar is associated with the quartz in some parts of the mine. Gold values are mainly confined to the quartz lenses and to the gouge adjoining them in the crush zones, although the remainder of the crush zones and the wall rocks, where silicified, also carry values. Marked enrichment occurs above water-level. Faulting and shearing is of minor occurrence only.

Milling commenced in March, 1936, and at the end of 1937, more than 4,000 ounces of gold had been produced. Recently, a new vein, having a strike of about north-west and a dip of 22° to the north-east was discovered about $\frac{1}{4}$ mile south-south-east of the main shaft of the Sybil Reef. The quartz resembles that of the main reef.

Other properties examined by the Company include:—

(1) *Messrs. Brown and Barratt's Claims* in the Abimbo area. Many veins are known, one of which, located near the granite lens east of the bay, was worked during 1934–5. This is composed of greyish-white quartz which occurs as stringers and lenses in a shear zone. The

dip is steep to the north-east while the strike extent is short. The country rock consists of andesites cut by several porphyry and granite intrusions.

(2) *Messrs. Button and Ralph's Claims* situated on Kungwe Hill on the north side of the bay at Abimbo. Here a white quartz vein occurs with a strike of 121° and a dip of 35° to the north-east. The country rock is an altered acid lava, variously and sometimes intensely, pyritized.

17. *Ngiga Mining Co., Ltd.*

The mine is situated on the southward-facing slopes of the bay west of Abimbo, and about one mile from the Lake shore. The country rock comprises andesites, tuffs and agglomerates which are invaded by a dyke-like lens of muscovite granite porphyry and microgranite. The lens has an almost east-west strike and a maximum width of 150 feet. The vein cuts both the volcanics and the intrusive. It extends over a distance of at least 900 feet and has a strike ranging progressively from north-west in the western part of the mine to west-south-west in the eastern part. Minor rolls have been traced underground. The dip is variable—usually about 20° – 30° to the westerly or southerly directions.

The vein consists of white, greyish-white or bluish-white, massive, glassy or sub-glassy quartz, carrying sporadic pyrite and occasional galena. The vein is of variable width, ranging from a fraction of an inch up to 60 inches, but averages between 15 and 18 inches. It is usually accompanied by a thin gouge or shear on the footwall and pinches and swells continuously, although it is rarely completely pinched out. Even when this is the case, the "fissure" is marked by a narrow shear.

The vein has been developed by inclines and by vertical shafts sunk to a depth equivalent to 300 feet in the incline. At or near the first level (80 feet vertical depth), a tear-fault with a well-marked shear zone from 2 to 20 feet in width intersects the vein. This fault strikes parallel to the vein in the central part of the mine, but turns away from the vein near the latter's north-western and south-eastern extremities. The hade fluctuates about 5° to the north-east or south-west, whilst the throw to the south-west increases progressively from 5 to 6 feet in the north-west to 40 feet or more in the south-east. Small faults and shears also occur in other parts of the mine. Gold values occur throughout the vein, being poorer where the vein cuts the granite porphyry, whilst notably high values have been encountered in the south-eastern part of the mine.

Milling was commenced in September, 1937, and by January, 1938, about 1,105 ounces of gold had been recovered from 2,035 tons of ore. Previously, some 527 ounces had been obtained by the Njoro-Soy Mining Company—the former owners.

18. *Nangu Mine.*

During the earlier part of the survey this mine was being developed by Messrs. East African Goldfields, Ltd., but was closed down in December, 1936, and has not yet been reopened. The mine, which is situated a little to the south of Nangu T.S., operates on the Kitson Reef—a series of quartz veins and gashes in a heavily pyritized crush zone which is stated to carry workable values over a width of 25–30 feet. The wall rocks are frequently silicified and pyritized while the occasional development of needles of arsenopyrite, both in the quartz and country, is usually indicative of good gold values.

The reef strikes at about 157° and dips to the east-north-east.

A mineralized belt, characterized by a number of individual quartz veins and silicification of the country rock extends across the property in a north-north-westerly direction, and has been traced for a distance exceeding 3,000 yards.

19. *Asembo Mines, Ltd. (Lamac Mine).*

The mine is situated on gently sloping ground about one mile south-east of Serawongo T.S. There are at least two large veins on the property. That being worked at present strikes about 103° over more than 600 feet. A second vein, a little to the north-west of the first, strikes about south by west and dips gently in a westerly direction.

The first vein has been developed by inclines and round pits, whilst a shaft sunk 500 feet west of the outcrop intersected the vein at a vertical depth of 106 feet. The vein is composed of a coarse-grained white, greyish-white or bluish-white, occasionally blue, marbly quartz and contains scattered chloritic spots and, more rarely, pyrite crystals. The width of the vein varies from a fraction of an inch up to 48 inches and averages about 15 inches. Where the vein has pinched out a “fissure” or leader of more decomposed country rock is present: shearing is rare. The dip is variable, usually 5° – 10° to south by west, but in places is as steep as 22° , whilst side-rolls, reversals and flattening-out occur occasionally. In places the vein splits, though normally it is a single vein. Gold values

are stated to be greatest when the vein is thinner and free from iron-staining, and appear to be confined to shoots. The country rock consists mainly of decomposed acid lavas, but in the area of the main shaft there is an intrusion of altered dolerite. The wall rocks of the vein rarely carry values.

Milling was commenced at Port Southby in August, 1937, and approximately 105 ounces of bullion had been produced by the end of the year.

20. *Messrs. Kavirondo Gold Mines, Ltd., Chausu Mine.*

The mine is situated near the Lake in the most westerly part of the area. The country rock here consists mainly of acid lavas but in the mine an intrusion of altered dolerite has been encountered.

The principal vein now being developed strikes at 124° over a distance of about 1,000 feet. The south-westerly dip is about 30° – 32° , but in places varies considerably ranging from 10° – 70° . The vein, which is of lenticular habit and has a maximum thickness of 36 inches, is composed of fine-grained white, occasionally yellowish, sugary, massive or vuggy quartz carrying small pyrite crystals and chlorite in small clots. Where the vein has pinched-out, the "fissure" is marked by a shear, 3–6 inches wide, containing slips of quartz. Calcite occurs in small veins and is common in the joints of the country rock.

The vein is broken between the surface and the 50-foot level by a strike fault, apparently a thrust throwing upwards on its south-west side. The throw is only a few feet in the north-western section of the mine, but increases to 25 feet or more in the south-western section. The hade is about 75° . In places the vein has dragged at the fault, causing reversals of dip. Other small faults and shears also occur.

In the north-western part of the mine the vein is sharply folded, the fold axes running parallel to the strike, and the limbs dipping at 40° – 60° . The thrust fault apparently runs along the crest of the central fold.

Gold values are confined to the lenticular quartz bodies and average values decrease below water level.

Many other veins have been discovered in the vicinity of the mine, but are not yet being developed. Prospecting has also been carried out in the peninsula west of Port Southby.

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