Kaoko-Eruptives and Alkali-Rocks at Cape Cross, S. W. Africa.

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Introduction.

While investigating the salt-deposits of the Cape Cross Pan, the writer, in 1930, mapped its surroundings and encountered two interesting groups of igneous rocks. The first comprises rocks belonging to the *Kaoko eruptive cycle* of uppermost *Karroo* (*Stormberg*) *age*, the other consists of *alkali-rocks* intruded into the former in *post-Karroo* times.[1]

Brief reference to the first group of rocks has already been made by Reuning in several publications dealing with the Kaoko-Sediments and Lavas of the southern Kaokoveld.[2] In a more recent paper he has communicated analyses of the three main rock-types.[3] Mention of the Red Granophyre is further made by Du Toit in his "Geology of S.A.," p. 261. To Reuning we also owe fossil evidence of the Karroo-age of these rocks.[2]

A.—Kaoko Lavas and Differentiates (Upper Karroo (Stormberg) Age).

The following rock-types were encountered:—

1. *Basalts, partly amygdaloidal (Melaphyres).*
2. *Gabbro.*
3. *Red Granophyre and Granophyric Granite.*
4. Small intrusive lenses and narrow dykes of *Augite-porphyrite, Quartz-porphyrite and Quartz-porphyry.*

Their distribution is shown on the accompanying map (Fig. 1).

1. *Basalt (Melaphyre).*—Rocks of this category are by far the most widely represented. They build up the *Lagunenberg*, overlooking the south-eastern end of the Pan. Here they must have a thickness

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[1] Kaiser, E. (Ueber zwei verschiedenartige Injektionen syenitischer Magmen. *Sitz. Ber. Bayr. Akad. Wiss.* Math.-phys. Kl. 1922, p. 258), states that syenitic rocks near Cape Cross were first discovered by E. Reuning.

[2] Reuning, E.: Die Entwicklung der Karrooformation im suedlichen Kaokofeld, S.-W.A. *Neues Jahrb. f. Min. Beilg. Bd.* LII., Abt. B., p. 113.

[3] Reuning, E.: Differentiation der Karroo-Eruptiva im suedlichen Kaokofeld, S.-W.A. *Compte Rendu, XV Intern. Geol. Congress*, S.A., Vol. II, pp. 33 and 36, 1929.

exceeding 200 metres. The Gobobosib Mountainland, some twenty miles to the north-east, is also mainly formed by them. Overlying Kaoko-Sediments they also fringe the Brandberg, a great circular mass of Erongo granite fifty miles away, which is intrusive into them. In the southern Kaokoveld very similar rocks form the basal portion (200 metres thick) of the Kaoko-lavas and overlie Cave Sandstone. They are here followed by a great thickness (over 600 metres) of intermediate and acid lavas—augite-porphyrites and mainly orthoclase-porphyries (Reuning *loc. cit.*).

At Cape Cross two types of rocks are represented:—

(*a*) *Amygdaloidal Basalt* (Melaphyre).—Generally black rock, consisting of a dense ophitic groundmass composed of minute laths of basic plagioclase surrounded by decomposed augite and innumerable small grains of magnetite. In this matrix are set generally not abundant phenocrysts of basic plagioclase, often marginally resorbed; a few of biotite (highly decomposed with the production of abundant secondary magnetite) and of euhedral primary magnetite. No identifiable olivine was found in the sections examined. Numerous amygdales of quartz occur, often with concentric structure.

Along the road to the Brandberg, a few miles north-east of Cape Cross, a dense dark-reddish-brown weathering type was found.

(*b*) *Holocrystalline Doleritic Basalt.*—Fine-grained black rock with typically developed ophitic structure, composed of basic plagioclase-laths with intersertal augite. No olivine. Abundant magnetite in small grains. Very fresh; no alteration minerals; non-amygdaloidal.

This rock builds up the Lagunenberg and appears to form the upper portion of the lavas, the amygdaloidal type constituting the lower. According to Reuning (*loc. cit.*) the succession in the southern Kaokoveld is similar.

Both types of rock are not very representative in macroscopical appearance of typical Stormberg basalts. No individual lava-flows can be recognised.

An analysis of this type will be found in the appended table.

2. *Olivine—Hypersthene-Gabbro.*—Dark, speckled rock, greyish-black to greyish-brown in colour and of medium grain. Texture: holocrystalline, uniformly granular. Composed of hypidiomorphic basic plagioclase (labradorite-bytownite) with abundant diallage with numerous rod-like inclusions of ilmenite causing schiller and mostly intersertal. Abundant olivine, partly serpentinised, and nearly always surrounded by hypersthene and, to a lesser extent, enstatite, rich in ilmenite-inclusions. The abundance of rhombic pyroxene (mostly hypersthene) varies, also that of biotite which, while not sparing, is also generally not abundant. Often it is accompanied by secondary magnetite. Apatite in small crystals and grains.

This rock was found only along the western slopes of the Lagunenberg in the form of elongated lenses in the doleritic basalt. No definitely intrusive contacts are exposed. In a few instances there appears to be a gradual transition between the two types, the gabbro then representing "schlieren" of coarser grain. Since, however, the sections of doleritic basalt examined are free from olivine, and the gabbro contains this mineral in great abundance, the latter rock most probably represents intrusive portions of the deep-seated gabbroidal magma at a slightly different stage of differentiation.

An analysis of this rock is listed in the appended table.

3. *Red Granophyre and Granophyric Granite. Typical Granophyre.*—Pale-reddish to pinkish, holocrystalline rock of medium grain. Composed almost entirely of an intimate granophyric intergrowth of turbid reddish orthoclase and quartz. No plagioclase. Occasional phenocrysts of orthoclase, with Carlsbad twinning and marginal quartz-intergrowth. Less frequently phenocrysts of corroded quartz. Abundant magnetite and red iron-hydroxide, mostly associated with quite abundant pennine, pseudomorph after biotite. In some specimens also biotite not completely chloritised is found. Occasional flakes of muscovite. Epidote as an alteration product. Apatite accessory.

Near Cape Cross Point there occurs a marginal facies of fine grain, greyish-brown colour, but of identical microscopic structure and mineral composition. In addition to occasional phenocrysts of turbid orthoclase and corroded quartz, one of albite was seen in a slide of this rock.

From these typical granophyres, composed practically entirely of a granophyric intergrowth of orthoclase and quartz, there are all gradations to *red granophyric granites*, in which the granophyric intergrowth is subordinate to an interlocking aggregate of orthoclase and quartz. In the latter rock there generally occurs a little acid plagioclase (albite-oligoclase) in hypidiomorphic grains, often as inclusions in orthoclase. A few slides show it to be somewhat more abundant.

These granophyric rocks form a number of small, apparently stock-like bodies in the Kaoko-basalts. They are also later than the gabbro, as shown by mutual intrusive contacts at the Lagunenberg. The largest body occurs at Cape Cross Point. The maximum exposed width of outcrop is 4½ km. In its western portion, at the Point and south of the Sealing Station, it consists of typical granophyre, and at the latter place contains a large number of inclusions and xenoliths of basalt near its contact with that rock. Its eastern portion, near Offen's Salt Workings, is composed of granophyric granite.

Another large body is situated 4-6 km. east of the station. The maximum exposed width is 3½ km. It is composed of a granophyre, intermediate as regards granophyric structure between typical granophyre and granophyric granite.

Another body, only partly exposed, is situated below the Lagunenberg, near the south-eastern end of the Pan.

In mineralogical and chemical composition these rocks are reminiscent of the Erongo granite. Both are highly acid (Table of Analyses) and were consolidated from a residual magma forming the final portion of a long-continued process of differentiation. In regard to texture and structure, the typical Erongo granite is much coarser in grain, while granophyric intergrowth of quartz and felspar, although sometimes present, is not conspicuous.

4. (*a*) *Dykes of Quartz-porphyry.*—In the large body of granophyre east of Cape Cross there occurs (near Brine-pit No. 5 on Map, Fig. 1) a narrow intrusive dyke of considerable length. The texture of the rock is fine-grained to dense and its colour deep chocolate-red. Under the microscope it is found to be highly decomposed and its original composition somewhat difficult to make out. It consists of a turbid, iron-stained groundmass, in which clouded orthoclase, microperthite, a little acid plagioclase, occasional micropegmatite, interstitial quartz, interstitial secondary calcite and chlorite can be made out. In addition, several phenocrysts occur of entirely decomposed felspar and corroded quartz, as well as blotches of chlorite probably resulting from phenocrysts of biotite. Quartz is subordinate to felspar in bulk.

In the granophyre near the Lagunenberg occurs a similar dyke, in the slide of which numerous small corroded grains of quartz are seen set in an iron-stained groundmass consisting of alkali-felspar with Carlsbad twinning, mostly in lath-form, separated by turbid aggregate-polarising, unidentifiable matter, which is not glass and which encloses chlorite and secondary calcite.

While not typical examples of quartz-porphyries, these rocks show most resemblance to this group. They are probably dyke-representatives of an acid magma allied to the granophyre and granophyric-granite.

(*b*) *Augite-porphyrite.*—Along the road to the Brandberg, a few miles north-east of Cape Cross, a number of small lens-like bodies of greyish-brown and reddish-brown augite-porphyrite were found in the reddish-brown weathering amygdaloidal basalt.

Near the western foot of the Lagunenberg there occur a few dyke-like bodies of a similar, but more distinctly porphyritic rock, of which the contact-relations are not quite clear. At the actual foot of the Lagunenberg the rock, while intrusive into basalt and gabbro, also appears to penetrate the granite. Approximately 1 km. to the north-west, however, a dyke of this type does not continue across a dyke-like body of granophyre, and hence appears to be earlier than the latter. The mineralogical composition of the rock supports this.

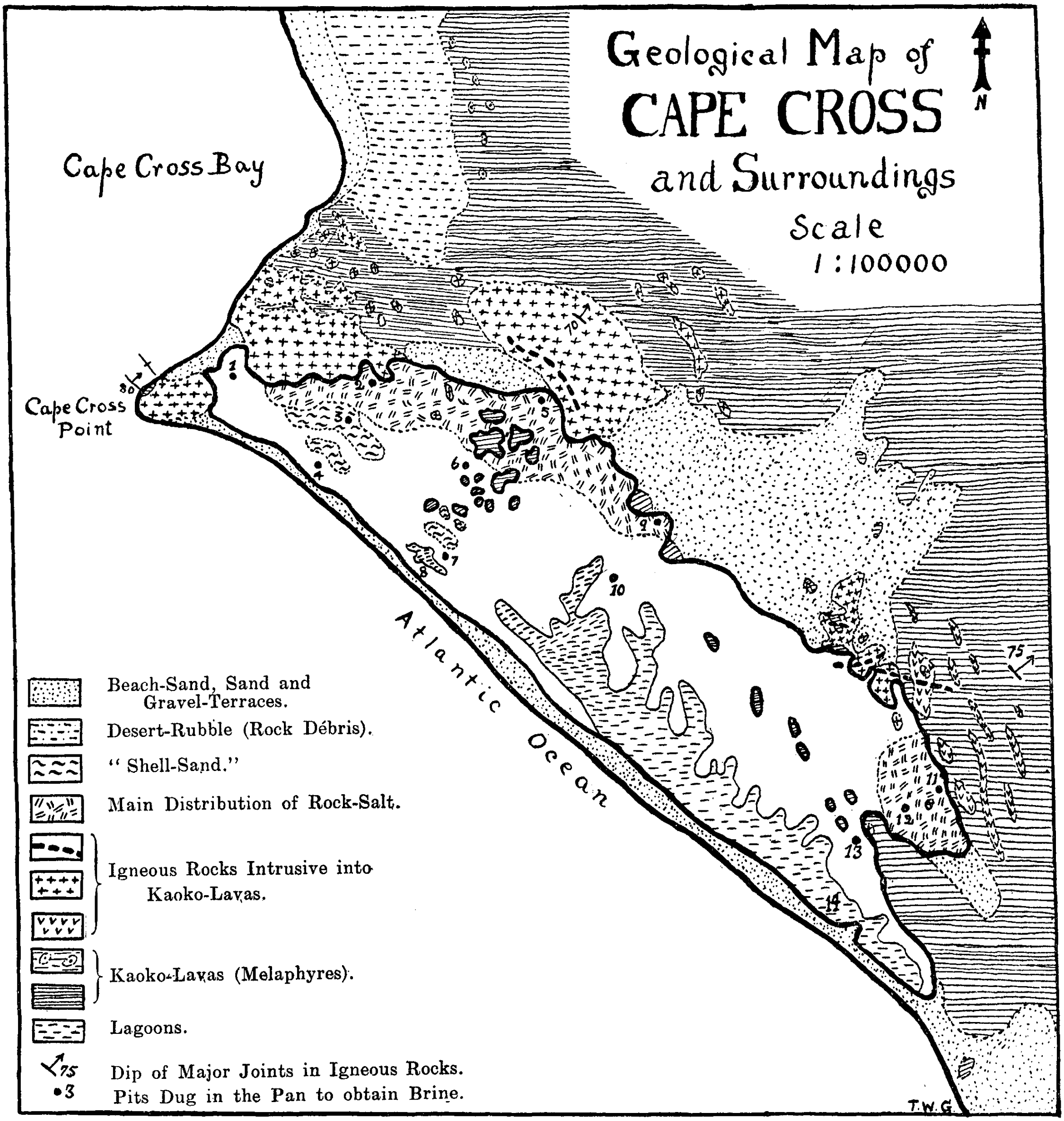

FIG. I.

Supplementary Legend:

The *igneous rocks intrusive into the Kaoko lavas*, reading from top to bottom, are respectively:—Dykes of Augite-porphyrite, Quartz-porphyrite and Quartz-porphyry; Granophyre and Granophyric Granite; Gabbro.

The *Kaoko lavas*, reading from top to bottom, are respectively:—Lens-shaped bodies of Augite-porphyrite in amygdaloidal basalt. Basalt (melaphyre), partly amygdaloidal.

The outcrop of *Soda-Syenite and Sodalite-Micro-Syenite* (post-Kaoko) is situated on the the promontory on the eastern shore of the Pan immediately above Brine-pit No. 9.

The *augite-porphyrite* is a pale greyish-brown or reddish-brown rock composed of a matrix of minute plagioclase-laths and turbid iron-stained interstitial matter containing chlorite and secondary calcite, in which are set quite numerous decomposed phenocrysts of plagioclase and orthoclase and of augite, mostly chloritised, often completely to form pennine. Primary magnetite is common, as well as apatite. One slide showed the presence of small flakes of undecomposed biotite; another a little rhombic pyroxene (enstatite) and basaltic hornblende with deep reddish-brown pleochroism.

(*c*) *Quartz-porphyrite.*—One specimen showed the presence in a similar matrix of quite a number of corroded phenocrysts of quartz, in addition to those of decomposed plagioclase and orthoclase. Augite completely chloritised.

These dyke-rocks are no doubt connected with the intermediate and acid lavas, which in the southern Kaokoveld overlie the basalts.

5. *Age of Rocks.*—In the southern Kaokoveld the basalts (melaphyres) overlie a massive, unbedded sandstone strongly reminiscent of Cave Sandstone, in which the tooth of a mammal (*Archeotherium reuningi*) has been discovered. At the Dorosberg, Reuning has found innumerable scattered bones of *Mesosaurus* in a lower horizon (Dwyka) (*loc. cit.*). The age of the granophyre and granophyric granite is, therefore, at the earliest upper Karroo.

6. *Progressive Differentiation.*—Everywhere in the northern coastal area of South-West Africa (Kaoko-Karroo province) and just as in the Lebombo belt, the volcanic period of upper Stormberg times exhibits a far greater degree of differentiation than in the central Karroo basin. In addition to the basalts and andesites of the Drakensberg and Stormberg, acid rocks ranging up to typical quartz-porphyries have also been extruded.

In the writer's mind this feature is not accidental, but is connected with the different modes of intrusion of the original basic magma in the central portion of the Karroo basin and its marginal portions respectively. In the former a great thickness of sediments ($\pm 30,000$ feet) had accumulated and the original floor had sagged by at least that amount. The sediments were, therefore, brought much closer to the deep-seated magma, which rose along narrow fissures through the highly-heated consolidated underlying floor-rocks and then were able to spread quickly and easily throughout the newly-formed fissile Karroo sediments. The writer[4] has already pointed out that the predilection shown by the very massive dolerite-sills of laccolithic dimensions for the horizon just under the Molteno beds, is most likely due to the fact that the underlying lower and middle Karroo beds had already experienced tectonic stresses and were pro-

[4] Gevers, T. W.: "The Volcanic Vents of the Western Stormberg," *Trans. Geol. Soc. S.A.*, Vol. 31, 1928, p. 58, *et seq.*

bably well-jointed before the deposition of the Stormberg beds. The latter, when intrusion began, were newly deposited, unaffected by tectonic stresses, and hence acted as a barrier to the rising magma. On the whole, the rise of the magma in the central portion of the Karroo basin must have been easy, comparatively rapid and continuous. Large volumes of basic magma were comparatively quickly removed to great distances away from the deep-seated chamber or basic substratum.

In the marginal portions of the basin, conditions were quite different. In northern South-West Africa the Karroo sediments form just a thin veneer on the highly consolidated and enormously thick beds of the Fundamental Complex. The total thickness of the Kaoko (Karroo) sediments at the Brandberg is hardly 500 metres (1,500 feet). In the southern Kaokoveld it appears to be still less. At the Etjo it is also about 500 metres. The floor of these easily penetrated fissile sediments was not, therefore, lowered to anywhere near the same depth as in the central Karroo basin. The basic magma had to work its way through a corresponding thickness ($\pm$28,000-29,000 feet) of highly consolidated archean sediments, gneisses and granites. It is to be surmised that the time required by the magma to reach the surface was far longer in the marginal than in the central portions of the Karroo basin. The original basic magma, therefore, had far better opportunities both for differentiation and assimilation in the marginal areas.

In the Drakensberg and Stormberg areas hosts of volcanic vents, situated in clusters at no great height over laccolithic bodies of dolerite, opened the volcanic outbreak, but were soon supplanted by long-continued fissure-eruptions, which piled up a tremendous thickness of basaltic and andesitic lavas.

In South-West Africa, on the other hand, the lower basaltic lavas are comparatively thin ($\pm$200 metres, at the Erongo much less) and appear to have been mainly erupted from fissures of great depth[5]).

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[5] Reuning (*loc. cit.*) draws a somewhat different picture of the sequence of events. According to him vulcanicity at the Dorosberg already began in Dwyka times, since interbedded with volcanic agglomerates occur conglomerates and sandstones full of bones of *Mesosaurus* (Dwyka). No lavas, however, were erupted. It is possible that the fossil bones were re-deposited and no longer occur in their primary place of burial. Reuning also considers the lower lavas (basalts) of the Southern Kaokofeld to have been erupted from the Doros crater. Considering their very wide distribution, this is hardly likely. In the Erongo area they were certainly not erupted from the Erongo volcano, but were pierced by the latter. According to Reuning (*loc. cit.*), after the outpouring of the acid lavas, activity at the Doros crater was renewed, and basic lavas (melaphyres) were again poured out. Stahl, on the other hand, is of opinion that these basaltic rocks and associated dolerites belong to the same post-Karroo period of intrusion which produced the numerous small scattered bodies of alkali rocks. (Stahl, A.: Eisenerze im noerdlichen S.-W.A. *Neues Jahrb. f. Min. Beilg. Bd.* 64, Abt. B., 1930, p. 181.)

The latter fact is suggested by the complete independence from the structural plan of the Fundamental Complex exhibited by the innumerable diabase- (dolerite-) dykes in the Namib, west of the Erongo and Spitzkopjes. The dolerites fill innumerable rectilinear fissures forming the western extension of the great Waterberg fault. They thus occupy a line of pronounced crustal weakness. Away from this line they are comparatively rare and it is doubtful whether the basalt covering was ubiquitous. The overlying intermediate and acid lavas appear to have been erupted from foci of eruption, which were not numerous and comparatively far apart. After the master-fissures extending down to great depths had become choked, the magma only managed to reach the surface at a few favourable spots, which exhibit a linear arrangement (Erongo, Spitzkopjes, Brandberg, Cape Cross, Dorosberg and probably other sites below the extensive lava-tracts in the Kaokoveld). Dykes of intermediate and acid composition are practically limited to the surroundings of the foci of eruption and follow the local structural plan of the Fundamental Complex. This indicates that in contradistinction to the dykes of dolerite they do not originate from great depth.

During the interval that elapsed between the choking-up of the deep fissures and the perforation of the crust at a few favourable sites, the original basic magma had already changed to one of rather acid composition (porphyrites). This interval was long enough for the lower basic lavas covering the site of the later Erongo volcano to have been denuded away to a considerable extent.

The northern coastal area of South-West Africa is remarkable also for the fact that the deep-seated parent rocks of the various types of lavas are found intruded as small bodies right up into the lavas, which were derived from them. The Erongo-granite (Erongo, Spitzkopjes and Brandberg) and the granophyre at Cape Cross represent the plutonic equivalents of the quartz- and orthoclase-porphyries; the granodiorite and diorite of the Erongo; those of the quartz- and augite-porphyrites. Cape Cross and the Dorosberg mark the only known instances where the plutonic parent-rock (Gabbro) of the basic lavas has also been intruded as small bodies to within shallow depths from the surface.

It may be pointed out that this depth was very shallow indeed. The Erongo-granite, for instance, crystallised as a coarse-grained holocrystalline rock at a depth of not more than about 600 metres ($\pm$1,800 feet) from the surface. This is the approximate thickness of the upper group of intermediate and acid lavas, into which it is intrusive. At the Brandberg, a circular mass of Erongo-granite 30 km. in diameter, the upper boundary of the granite during consolidation probably lay at a still lesser depth.

B.—Post-Karroo Alkali-Rocks.[6]

Only a single isolated occurrence of rocks of this type was found on the promontory on the eastern shore of the Pan, situated immediately above Brinepit No. 9 on the accompanying map. The rocks form a little hill, which unfortunately is to a large extent covered by wind-blown sand. The road to the main lagoon runs past it.

The following rock-types were encountered:—

1. *Soda-Syenite.*—Rather coarse, speckled rock, whitish-grey with numerous black spots (biotite and amphibole). Holocrystalline, granitic texture, roughly equigranular and hypidiomorphic. Consists of: abundant *felspar*—mainly highly *sodic anorthoclase*, abundant *albite* and abundant allotriomorphic *perthite*, occasional grains of *microcline* and *microcline-perthite*, very little anorthitic felspar; abundant hypidiomorphic *biotite;* abundant hypidiomorphic, greenish-brown, yellowish-brown and brown, as well as a little green *hornblende*, often with a core of *augite;* occasionally a few small patches and shreds of greenish-blue amphibole (arvedsonite), a few needles of *aegirine;* abundant idiomorphic *titanite*, generally associated with brown hornblende; very abundant idiomorphic *apatite*, sometimes in large crystals; a little interstitial *sodalite;* no quartz. (See appended volume-composition, under I.)

2. *Sodalite-Microsyenite.*—The typical, most abundant rock is rather fine-grained, of greyish colour, showing small felspar insets and black spots of amphibole. Somewhat coarser varieties also occur. Rock consists mainly of laths of *sodic anorthoclase* with serrated edges, generally also abundant *perthite;* hypidiomorphic greenish-yellow and greenish-brown *hornblende*, in part in irregular grains poikilitically intergrown with felspar and sometimes with core of colourless augite; occasional small patches and shreds of greenish-blue amphibole (arvedsonite); some *aegirine-augite;* deep brown *biotite*, generally not very abundant; abundant interstitial *sodalite; cancrinite* in traces as an alteration-product; *apatite* sparing or absent; *titanite* very sparing or absent; occasional idiomorphic sections of *nepheline* with inclusions. No quartz. (See appended volume-composition, under II and III, and No. 10 in Table of Analyses.)

A somewhat different facies of the same rock is still finer in grain, dark grey in colour, showing small insets of *felspar* (*sodic anorthoclase* and *perthite*, and a few larger insets of *albite*) and numerous greenish-black nodules consisting of *biotite*, *augite* and *magnetite*. It contains abundant interstitial *sodalite* and accessory

[6] The writer is indebted to Mr. F. C. Partridge, Pretoria, for the corroboration of the mineralogical composition of these rocks and for the determination of the appended volume compositions

nepheline. Otherwise the composition is the same. (See appended volume-composition, under IV.)

3. *Sodalite-Tinguaite.*—These two types of rock are intrusive into a black, fine-grained, holocrystalline rock containing numerous black nodules. It consists essentially of numerous serrated laths of *sodic anorthoclase;* numerous small flakes of *biotite;* abundant hypidiomorphic, occasionally idiomorphic *aegirine-augite;* abundant needles of *aegirine; sodalite* in large allotriomorphic aggregates; a few long laths of *albite*, with marginal inclusions of pyroxene, as insets; occasional rare ones of *orthoclase; titanite* and *apatite* sparing or absent. The *nodules* consist of very small flakes of *biotite* with small interstitial grains of *augite.*

4. *Table of Volume-Compositions* (by F. C. Partridge).

	I.	II.	III.	IV.
Felspar	84·4% (10·6% Perthite)	82·5%	76·45%	71·9%
Biotite	6·7%	0·8%	0·5%	1·9%
Hornblende (Augite and Aegirine) ..	6·4%	6·5%	8·3%	14·0%
Sodalite	1·6%	10·1%	14·4%	11·8%
Cancrinite	—	trace	0·05%	Trace
Apatite	0·4%	0·1%	0·2%	0·4%
Titanite	0·5%	Trace	0·1%	Trace

I=Soda-Syenite; II, III, IV=Sodalite-Microsyenite, Cape Cross.

5. *Sequence of Intrusion.*—The sodalite-tinguaite was emplaced first; the coarse soda-syenite is intrusive into it in the form of a very small dyke-like body; the sodalite-microsyenite was the last fraction to arrive.

Age of Alkali-Rocks.—Actual contacts of these rocks with the Kaoko-basalts were not observed on account of the sand-covering. There is no doubt, however, that they are later in age than these lavas, which surround them on all sides. They thus either represent a final phase of the Kaoko volcanic activity or are of post-Kaoko (Karroo) age.

From the Dorosberg, 120 km. to the north-east, Reuning describes a few small dykes of aegirine-bostonite, which he considers to belong to the closing phase of the Kaoko-eruptive period (*loc. cit.*).

From the Gonerub, south-west of Franzfontein, in the same area, Stahl (*loc. cit.*, p. 174) mentions small bodies of alkali-syenite, including cancrinite-syenite and accompanied by phonolite and other allied dyke-rocks, which are intrusive into Kaoko-lavas.

From the Kalkfeld iron mine, Stahl (*loc. cit.*) mentions dykes of bostonite, nepheline-syenite, aegirine-syenite, camptonite, analcime- and cancrinite-bearing rocks and alkali-dolerites. At the iron deposits in the Okorusu hills, near Okaputa, in the same area there occur small bodies of foyaite with associated dykes of camptonite and monchiquite (Stahl, *loc. cit.*).

Small bodies of phonolite, alkali-basalt, limburgite, aegirine- and biotite-trachyte occur south of Windhoek in the Auas Mountains and near Rehoboth.

In the Luederitzbucht littoral similar alkali-rocks are fairly widely represented around Pomona and in the Klinghardt Mountains. According to Kaiser and Beetz,[7] they consist of stocks of syenite and foyaite and dykes of associated rocks (Pomona) and of phonolite-sheets and plugs (Klinghardt Mountains) and are of post-Karroo, either cretaceous or early tertiary age.

In southern Angola similar alkali-rocks are stated to pierce marine cretaceous beds.[7]

It is interesting to note that in the case of all these occurrences limestone or dolomite is found in their vicinity or may be expected below the surface. Quite a number actually break through calcareous rocks.

TABLE OF ANALYSES.

	1	2	3	4	5	6	7	8	9	10
SiO_2	50·87	50·65	49·70	55·46	66·22	68·68	73·42	76·62	62·75	56·92
TiO_2	1·72	·91	·36	1·88	·75	·61	·52	trace	·70	—
Al_2O_3	16·63	16·04	17·15	13·32	14·29	11·91	13·14	11·97	15·75	19·72
Fe_2O_3	8·33	8·08	2·37	7·11	1·23	4·73	2·26	·44	6·98	1·43
FeO	2·77	2·83	6·19	4·02	5·53	1·67	·52	1·59	·43	3·88
MnO	·07	·12	·16	trace	—	—	·03	—	·08	·04
MgO	5·29	8·71	11·42	1·98	1·18	·21	·28	·11	·99	1·15
CaO	6·30	9·63	9·85	5·28	2·15	·74	·75	·62	2·78	3·00
Na_2O	4·37	1·46	1·46	2·46	3·27	3·38	3·24	2·81	8·06	6·84
K_2O	1·00	·98	·65	3·81	4·60	5·35	4·99	5·33	·25	5·31
H_2O+	1·84	·60	·75	2·84	·85	1·89	·72	·30	·61	1·03
H_2O-	·64	·10	·26	—	—	—	·29	—	·35	0·14
P_2O_5	·24	·04	trace	·49	·34	·55	·09	·11	·08	0·00
CO_2	—	trace	—	1·34	—	—	—	—	·14	trace
S	·08	—	—	·06	·08	·06	—	·05	—	—
Cl	—	—	—	—	—	—	—	—	—	0·73
CuO	·04	·05	·06	—	—	—	·04	—	·06	—
	100·19	100·20	100·38	100·05	100·49	99·78	100·29	99·94	100·01	100·19

[7] Kaiser, E.: Die Diamantenwueste Suedwestafrikas. Berlin, 1926, Vol. I, p. 320.

ROCK DERIVATION:

1. Basalt (melaphyre) overlying Cave Sandstone, Southern Kaokoveld.
2. Basalt (melaphyre), Cape Cross.
3. Olivine-gabbro, Cape Cross, Lagunenberg.
4. Augite-porphyrite, Erongo.
5. Granodiorite, Erongo.
6. Quartz-porphyry, Erongo.
7. Granophyre, Cape Cross.
8. Erongo granite, Erongo.
9. Aegirine-bostonite, Dorosberg, Southern Kaokoveld.
10. Sodalite micro-syenite, Cape Cross.

Analyses 1, 2, 3, 7, 9, by Dr. L. Moeser, Giessen (taken from Reuning, *loc. cit.*, p. 36).

Analyses 4, 5, 6, 8, taken from H. Cloos, Der Erongo. *Beitr. z. Erf. d. D. Schutzgeb.*, No. 17, Berlin, 1919.

Analysis 10, by P. W. de Kock, M.Sc., Windhoek.