has crystallized as a glass-bearing mass with microlites, just as the groundmass of the enclosing rocks.

That in many xenoliths the amphiboles exhibit a resorption-rim where they border on the glass-bearing mass alluded to, points out that the amphibole remained stable down to the moment of the eruption of the lava dome. After this the pressure in the lava and the xenoliths decreased rapidly, which made the amphibole instable and augite could crystallize during the time when the temperature of the residual magma fell, and a complete solidification had not yet been effected. This interval may have been longer or shorter for different portions of the dome, hence the resorption in amphiboles of different xenoliths was varying. Already before we accounted for the mineralogical differences between xenoliths and dome-lava of the RUANG [1]) we have assumed that during the eruption of the volcano the outpouring magma enclosed fragments of its completely or partly solidified dioritic crust. The same applies to dome and xenoliths of the Galunggung. The occurrence of pyroxene-poor and pyroxene-rich amphibole-bearing xenoliths may be accounted for by the assumption that they originate from zones at various depths in this crust. It depends on the difference of pressure and temperature of these zones whether amphibole only or first pyroxene and later, on further cooling, amphibole has crystallized. [2])

In that case the pyroxene-bearing xenoliths originate from deeper zones according as they are richer in pyroxene, whereas at a greater depth with a higher temperature much less crystalline components and only pyroxenes occur in the outpouring magma, which does not contain amphibole as phenocrysts.

The amphibole-free xenoliths with different structures described above, may have crystallized already before the eruption at a great depth, so above temperatures, at which the amphibole is stable, while in that case complete crystallization has taken place after the eruption had commenced, when the amphibole was not stable either, in connection with the suddenly modified pressure and temperature relations. Maybe some of these xenoliths have crystallized at a pressure lower than that of the stage of stability of the amphibole and may therefore belong to parts of the magma that have cooled down more slowly, that could crystallize more completely along the walls of the vent and were only then carried along by the outpouring magma.

[1]) H. A. BROUWER, Crystallizations etc. loc. cit. p. 665.

[2]) F. BECKE. Gesteine des Columbretes. Anhang. Tscherm. Min. u. Petrogr. Mitt. XVI. 1897. blz. 327 e.v.

Geology. — *"On the Alkalirocks of the Serra do Gericino to the northwest of Rio de Janeiro and the Resemblance between the Eruptive Rocks of Brazil and those of South-Africa."* By Prof. H. A. BROUWER. (Communicated by Prof. G. A. F. MOLENGRAAFF).

(Communicated at the meeting of January 29, 1921).

On the boundary between the State of Rio de Janeiro and the Districto Federal lies near the station of Maxambomba of the E. F. Central do Brazil, the Serra do Gericino [1]), extending in W.S.W.-N.N.E. direction over a length of about twenty k.m. and a breadth of about eight k.m. It is chiefly composed of nephelinesyenites like the Tingua eruptive province which lies about 30 km. farther to the North and of which the alkali-rocks have been described by GRAEFF [2]) and DERBY [3]). As I could not personally visit the Serra do Gericino during my stay in Brazil, several samples for further investigation were sent me by GONZAGA DE CAMPOS, Director of the "Serviço geologico e mineralogico do Brazil".

Geological Survey.

The alkali-rocks constitute an eruptive centre amidst the old gneisses of the mountain-range Serra do Mar, which runs parallel to the Brazilian Coast. (Fig. 1). We only know that the gneisses are intruded by alkali-rocks which consequently must be younger than the gneisses. No data were obtained concerning the exact geological age.

Coarse-grained, as well as dyke-, and effusive rocks occur, just as in other Brazilian occurrences of alkali-rocks. Although nearly the whole region and especially the highest parts consist of coarse-grained rocks, the occurrence of effusive rocks allied to them, still

[1]) MATHIAS G. DE OLIVEIRA ROXO. Resumé of the preliminar note on the Gericinó eruptive centre. Empresa Brasil Editora 1920.

[2]) FR. GRAEFF, Mineralogisch-petrographische Untersuchung von Eleolithsyeniten von der Serra de Tingua. Neues Jahrb. f. Min., Geol. u. Pal. 1887. II, blz. 222 e.v.

[3]) O. E. DERBY. On nepheline rocks in Brazil. Quart. Journ. Geol. Soc. Vol. XLIII. 1887, blz. 457; Vol. XLVII, 1891, blz. 251.

proves that the Serra do Gericino constitutes the strongly denuded remnant of a volcano or group of volcanoes, like the Serra de Tingua further northward. That remains of lava-flows have been preserved only locally, and only between the eruptive rocks, whereas they do not occur in the surrounding gneisses, points to the circumstance that these effusive rocks, which originally must have extended far beyond the present mountain, have long been protected from erosion through overhead stoping, the roof having locally sunk down. These effusive rocks occur near the station of Maxambomba of the E. F. Central do Brazil, and near the façenda D. Eugenia close to the west of this station.

Dyke-rocks were e.g. met with near the station of Maxambomba (tinguaite), near the façenda Mascarenhas and in the western part of the eruptive province, between Cava and Ypiranga (aegerine- and amphibole-Sölvsbergite).

The coarse-grained rocks, which chiefly compose the eruptive province, are generally characterised by table-shaped felspars; consequently they belong to the foyaites as far as they contain nepheline. Of the western part, known as Serra de Marapicu, samples of nepheline-free umptekite were examined, while among the foyaites, which seem to build up the greater part of the mountain-ridge between the Serra de Marapicu and the station of Maxambomba, also alkali-syenites (partly pulaskites) occur [1])

The granular rocks.

The following types may be distinguished:

1. Foyaites.
2. Alkali-syenites.
3. Umptekites.
4. Pulaskites.

Foyaites.

They seem to be the most common rocks of the Serra do Gericino.

Type 1 is a *pyroxene-amphibolafoyaite*, collected near Cancella Azul along the road which crosses the rivulet Cachoeira. The composing minerals are light-coloured orthoclase and microperthite,

[1]) Most of the samples received, which had been provisionally determined as nepheline-syenite, belonged to the alkali-syenites. The typical foyaites originate from Cancella Azul along the road intersecting the rivulet Cachoeira. Therefore, because many of the rocks have apparently been mistaken for nepheline-syenites, whereas they are actually alkali-syenites, the data occurring on a map on which different types of nepheline-syenites have been separated cannot be relied on.

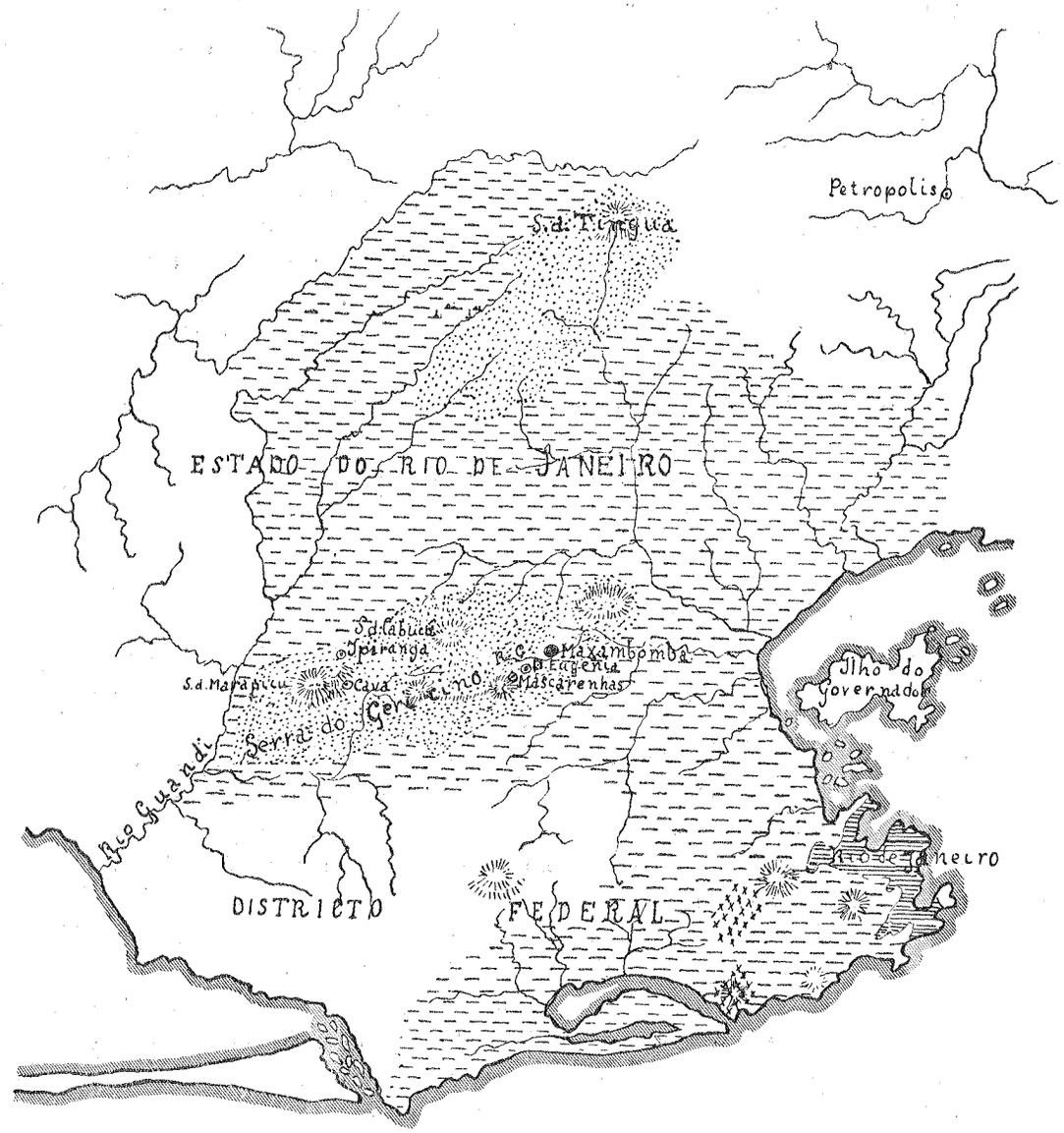

Fig. 1. Geological Sketchmap of the environs of the Serra do Gericinó to the Northwest of Rio de Janeiro. R. C. = Rio Cachoeira, (compiled from observations of Dr. MATHIAS DE OLIVEIRA ROXO).

nepheline, sodalite, aegirineaugite, greenish-brown amphibole with a slight quantum of analcite, lavenite, biotite, pyrite and magnetite, while muscovite and calcite occur as secondary minerals.

Large extinction angles in sections normal to the obtuse bissectrix point to Na-content of the orthoclase. Like the sodalite, the clear nepheline, only slightly altered into secondary minerals (muscovite and analcite), exhibits some idiomorphic crystals. The pyroxene is for the greater part of zonary structure, the central part may be very rich in augite-, the marginal zone very rich in aegirine molecules, but in most crystals the extinction angles for central part and margin do not vary much. The amphibole presents olive-green or bluish-green colours, both kinds are found grown together sometimes with the pyroxene, in which the crystallographic axes of the different minerals do not coincide. The large extinction angles point to amphiboles similar to those described by WRIGHT [1]) and by USSING [2]) and collected respectively from Brazilian and from Greenland alkali-rocks. The lavenite forms highly pleochroic and with strong birefringence crystals sometimes occurring with irregular crystal-form between the other minerals, like the analcite, in so far as this mineral is not an alteration-product of the felspathoids. The absorption-scheme of the lavenite is c (canary-coloured) $>$ b $=$ a (bright yellow); the crystals are often (sometimes polysynthetically) twinned; simple crystals also occur. The plane of optic axes is at right angles to the twinning plane cf. (100) and the cleavage-lines; the axial angle is large. Sometimes the crystals are partly idiomorphic. Pyrite and magnetite occur in separated crystals, but often the pyrite is enclosed by a margin of magnetite and both minerals also occur grown together with the other dark minerals.

Type 2. This rock is more finely grained than the preceding and is composed of white- to light flesh-coloured felspars (chiefly microperthite) with grey or black greenish-coloured liebeneritepseudomorphs after original felspathoids. It was found near the façenda D. Eugenia. Beyond strongly weathered ore no original dark minerals can be recognized in the rock.

Alkalisyenites.

A rock, also collected near the façenda D. Eugenia, consisting for the greater part of light-coloured microperthite which is rich in albite and strongly weathered ore, contains only little of a substance

[1]) F. E. WRIGHT. Die syenitisch-theralitischen Eruptivgesteine der Insel Cabo Frio, Brasilien, Tscherm. Min. u. Petr. Mitt. 1901, XX, blz. 249.

[2]) N. V. USSING. Geology of the country around Julianehaab, Greenland, Meddelelser om Grönland. Vol. XXXVIII, 1911.

consisting of small muscovite-flakes, which may also be alteration products of original felspathoids. These, however, were then present only in a very small quantity.

Umptekites.

The Serra de Marapicu i. e. the Western part of the Serra do Gericino seems to be chiefly built up of these rocks. The composing minerals are for the greater part light-coloured microperthite and amphibole, and small quantities of pyroxene, titanite, analcite magnetite and apatite.

The felspars are microperthites with a variable amount of acid plagioclase, which is sometimes absent altogether. Large extinction angles in sections normal to the obtuse bissectrix point to a Na-content of the orthoclase. The amphibole differs from that of type 1 of the foyaites, the extinction-angles remain smaller and frequently varying colours occur in one and the same crystal; a greenish variety in the marginal zone, a brownish in the central part, but both varieties form separate crystals. The amphiboles are very much like those which WRIGHT [1]) has described in an umptekite near Cabo Frio. In crystals of zonary structure we see in sections normal to the acute negative bissectrix of a small axial angle the following absorption: c central part: reddish brown-green; margin: green) $\pm =$ b (central part: brown with a greenish tint; margin: brownish-green).

In sections parallel to the plane of symmetry the extinction-angle increases towards the green marginal zone up to $\pm 22°$; we often see for the absorption parallel to the a-axis a homogeneous light yellow-brown colour, without any difference for central part and marginal zone. The only slight quantity of pyroxene consists of a green augite with extinction angles as high as 40° relative to the cleavage lines Apatite is present in numerous idiomorphic crystals.

Pulaskites.

This term comprises the alkali-rocks rich in mica, sometimes with a small amount of felspathoids.

Type 1. The felspars have a more reddish tint than those of the rocks described above. The sample was collected along the road from Maxambomba to Mascarenhas, close to the façenda D. Eugenia. Biotite and titanite are visible macroscopically in numerous crystals. The composing minirals are: microperthite and a small amount of plagioclase, sodalite and analcite, biotite, augite with a margin of aegirineaugite, apatite and ore. As secondary product occurs a chlo-

[1]) F. E. WRIGHT. l. c. p. 246.

ritic mineral of rather strong double refraction, which has been formed to the cost of the pyroxene.

The large extinction angles in sections normal to the obtuse bissectrix again point to a Na-content of the orthoclase of the microperthites. The analcite has been formed partly at the cost of the felspar, optic anomalies occur. The biotite is highly pleschroic, the colour ranging from brownish black to brownish-yellow. The pyroxene is almost colourless and is often encircled by a rim of green aegirine augite, but both also occur separately. Biotite, pyroxene, titanomagnetite, titanite and apatite often are grown together, in these intergrowths all or some of the minerals referred to occur.

Type 2. The felspars in this rock are partly green and the dark minerals chiefly occur only in small crystals. It was found in that part of the Serra do Gericino which is known as Serra de Cabuçu, along the road between Mascarenhas and Cabuçu.

The felspars consist of orthoclase or microperthite, which is poor in plagioclase. Not a trace of felspathoids is distinguishable. The markedly pleochroic biotite (from brownblack to light brownish-yellow) has often partly or completely been converted into green mica, while at the same time grains of a light yellow-green highly refracting, isotropous mineral having the properties of garnet, are formed. These grains are also found scattered in the felspars and the conversion may have taken place already before the complete crystallization of the rock.

The rock contains also titanomagnetite which has been entirely or partially converted into leucoxene.

The dyke-, and the effusive rocks.

We distinguish the following types of rocks:

1. Alkalisyeniteporphyries.
2. Nephdinesyeniteaplites.
3. Tinguaites.
4. Sölvsbergites.
5. Trachytes.

Alkalisyeniteporphyries.

If these rocks contained originally felspathoids, the latter have been completely converted into secondary minerals.

Type 1. A rock, collected where the road to the façenda D. Eugenia crosses the rivulet Cachoeira, contains white to bright reddish felsparphenocrysts in a grey fine-grained ground mass.

The felsparphenocrysts consist of orthoclase in which felspar with stronger double refraction is seen in small quantities. Pseudomorphs

also occur. They consist of muscovite flakes; whether the original mineral has partially belonged to felspathoids, which the form sometimes seems to suggest, could not be made out with certainty. In the groundmass the same felspars occur, the laths contain more of the strongest double-refracting felspar mentioned above, this felspar sometimes exhibits polysynthetic twins and occurs also in a few separate crystals. The groundmass contains also muscovite, calcite, rather much apatite and ore, which occurs also in some larger crystals, is strongly weathered and consists partly of pyrite.

Type 2. Near the facenda D. Eugenia a rock was collected with white to faintly reddish coloured felsparphenocrysts in a light-gray, finely crystalline groundmass. The rock is strongly sericitised, although the felsparphenocrysts have been altered very little. Initially it may have contained felspathoids. Ore, leucoxene and titanite occur.

Nephelinesyeniteaplites.

These rocks are known only as boulders near Mount Sapé in the Serra di Marapucu (western part of the Serra di Gericino). Macroscopirally it presents itself as a medium-, to fine-grained light-grey rock, with numerous black points chiefly consisting of magnetite. The constituents are: clear albite, less clear orthoclase and microperthite, nepheline and analcite, magnetite and little pyrite, titanite apatite and green or brownish biotite.

The nepheline is often enclosed by the felspars. The albite reveals itself in a large quantity in polysynthetically twinned crystals. There is an abundance of analcite; a Cl-reaction with a negative result points to the absence of sodalite.

Tinguaites.

Typical tinguaites were collected near Maxambomba, the rocks seem to form a dyke here and also a flow, the latter of a thickness of more than 100 meters. Only a single sample was examined, most likely several varieties and also typical effusive rocks occur here.

The sample contains in a grey finely-crystalline groundmass a few phenocrysts of light-coloured felspar, consisting of Na-bearing orthoclase or anorthoclase. They have been partially converted into natrolite. Microscopically the groundmass seems to consists of felspar laths aegirine, natrolite, analcite and a little nepheline. Some prisms with high refractive indices and strong birefringence, which show parallel extinction and are optically positive, point to zircon.

The colourless substance with low refractive index which exists in large quantity between the felspar laths, is probably chiefly composed of analcite, which is partially an alteration product of original nepheline.

Muscovite flakes also occur as alteration products of nepheline. Larger crystals of aegirine show distinctly a higher augite content in their central part the needles often show a sheaf-shaped or radial arrangement.

Sölvsbergites.

Under this name we have grouped the rocks in which probably felspathoids occurred, but in smaller quantity than in the tinguaites. The felspathoids cannot be recognised any more as such, the secondary minerals, however, are indicative of their having been present originally. Then the rocks approach the tinguaites.

Type 1 (*with pyroxene*). It is distinguished from the above-mentioned tinguaite by the dark grey colour of the finely crystalline groundmass, against which numerous white or light-red phenocrysts, which no doubt consist for the greater part of felspar, are sharply outlined, while also a few larger pyroxene crystals occur. It was collected from a dyke between the Serra de Cabuçu and the Serra de Marapicu.

Orthoclase is the predominant mineral of the phenocrysts; in small quantity polysynthetically twinned felspars occur with small extinction-angles. More or less regularly defined groups, consisting chiefly of acid plagioclase and cancrinite, sometimes mixed with analcite, possibly point to original felspathoids. Beside larger crystals of aegirine-augite with a high augite-content, which decreases in zonary crystals in a narrow marginal zone, also a few phenocrysts of brown amphibole and very little biotite occur together with larger ore-crystals. The groundmass consists of numerous pyroxene-needles sometimes of zonary structure and consisting of aegirine and aegirine-augite. Sometimes the central part of zonary crystals is of a violet colour with a great extinction-angle indicating the presence of titaniferous augite, which was also observed in some large crystals. Very few amphibole prisms occur. In the colourless mass between them felspar can be recognised, originally it probably consisted chiefly of felspar and felspathoids; at present there is an abundance of cancrinite and analcite as products of alteration. Inclosures of ore are numerous.

Type 2 (*with amphibole*). It was collected near type 1 also from a dyke. It is a dark grey fine-crystalline rock with some felspar-phenocrysts. Original felspathoids are not noticeable, but the cancrinite-content of the groundmass points to their former existence. True amphibolephenocrysts do not occur, though we do see accumulations of brown-green amphibole and ore which sometimes show a regular outline.

The groundmass is composed of a good many plagioclase-laths which are sometimes polysynthetically twinned, of markedly pleochroic amphibole, the colour ranging from dark brownish green to light brownish yellow, without large extinction-angles; of ore, cancrinite, analcite, fluorite and little calcite.

Trachyte.

The grey, compact rock was collected from a lava flow more than 100 M. in thickness, near the façenda D. Eugenia.

A microscopic examination shows beside portions, in which crystalline constituents with weak birefringence are scarcely visible, other parts, in which distinctly felsparlaths without polysynthetic twins and with nearly parallel extinction, have been largely developed. There are also larger felsparcrystals; in sections normal to the acute bissectrix they present a rather small axial angle. Some of the larger felspars exhibit polysynthetic twins with small extinction-angles. Parts with a more or less regular form and consisting of muscovite flakes remind somewhat of liebeneritepseudomorphs after nepheline. However, sometimes quartz occurs in large quantity mixed with muscovite flakes. The quartz, which we take to be a secondary product, also occurs scattered in the rock. Finally pyrite must be mentioned as one of the composing minerals.

Resemblance between the Eruptive Rocks of Brazil and those of South Africa.

Rocks, rich in alkalies, some of which have been described above, are of frequent occurrence in Brazil as well as in South-Africa, and the various types in both regions show many points of resemblance, which will be discussed in detail lower down. This resemblance exists also with regard to other eruptive rocks. On a journey through Brazil in 1920 I was struck by the marked resemblance of some groups of sedimentary rocks with which I got acquainted in South Africa in 1910. Anyhow the differences are not greater than are known for adjacent regions of the African continent at a much shorter distance.

As the principal groups of eruptive rocks whose resemblance in composition and geological aspect will be discussed below, we mention:

1. Old granites, intrusive in rocks of probably archaean age.
2. Younger granites, intrusive in deposits of Devonian age and older than permo-carboniferous rocks.
3. Younger rocks, rich in alkali, (nephelinesyenites, alkalisyenites with accompanying abyssal- and effusive rocks).
4. Jurassic volcanic rocks and intrusive dolerites (the determination

of age is connected with the prolonged denudation before Upper-cretaceous time.

5. Kimberlites, alnoites etc. in pipes and dykes, younger than the dolerites mentioned sub 4 [1]).

Old Granites.

The archaean rocks classed together for Brazil under the term Brazilian complex, are granites, gneisses, quartzites, marbles and crystalline schists. They may be compared with the Malmesbury system of the Southern Cape Colony, the Swarzland system of the Transvaal and Rhodesia and the Fundamental complex with intrusive old granites of South-West Africa. Both the east coast of Brazil in the Serra do Mar and the opposite West Coast of South- and Central Africa consist for the major part of these rocks and they often impart to the landscape in both continents a similar topographic aspect. As to the petrographic features of these rocks no data are known sufficient for a minute comparison of the rocks near the opposite shores.

Young granites.

An instance of this type in South Africa are the granites of the "Bushveld Igneous Complex" in The Transvaal, occurring in combination with the gabbros, norites and ultrabasic rocks, the Erongo granite in Hereroland, and the Branaberg granite in the North Western part of Damaraland. The first-named are intrusive in the ? Devonian Waterberg Sandstone; the Eronga-granite has intruded the lowermost division of the ? Cambrian Nama System, hence they are younger than the old granites from which they also differ in petrographic composition, but their exact age is not known.

In Brazil the extensive granite areas and their contacts with the environing sediments have been studied very little. However, here also granites are known as intrusions in the algonkian or old-palaeozoic Minas Serie, as e. g. appears from the gold-bearing dyke of Passagem [2]) in Minas Geraes, ultra-acid granite apophysis, and intrusive in the so-called itabirite-formation of the Minas Series. In the neighbourhood a granite occurs and similar gold-bearing quartz-dykes are known in several places in the States of Minas Geraes and Goyaz. In the southern states mention is made of the occurrence

[1]) For the literature on parts of the coastal regions on either side of the Atlantic Ocean we refer to: J. C. Branner. Geology of Brazil. Bull. Americ. Geol. Soc. 1919. P. A. Wagner. The Geology and Mineral Industry of South-West-Africa Geol. Surv. Memoir N°. 7, 1916.

[2]) E. Hussak. Der goldführende kiesige Quarzlagergang von Passagem in Minas Geraes. Zeitschr. f. Prakt. Geol. 1898. Oktober, blz. 345 e.v.

of granites, intrusive in rocks of probably old-palaeozoic. For instance by E. P. de Oliveira, and according to a communication to the present writer by Gonzaga de Campos also in the State of Sao Paulo granites have distinctly metamorphosed old-palaeozoic rocks. As with the old granites, still too little is known of the petrographic features of the Brazilian young granites to compare them with those of South-Africa.

Alkali-rocks.

First of all we refer to places, where alkalirocks occur at or near the opposite coasts, as in Brazil in a number of places in the Serra do Mar [1]) (Itatiaya, Serra do Gericino, Serra de Tingue, Cabo Trio) and in Africa near the coast of Lüderitzland, and near Cape Cross to the North of Swakopmund. [2]) It is most likely that similar rocks occur out of these better known regions in a number of other localities near the coasts. We know e.g. already pyroxene foyaite from Angola and much farther northward different alkali-rocks, from the Los Islands (9°13′ N.East).

Abyssal-rocks and the related dyke- and effusive-rocks are associated with each other. They are in South-West Africa syenites, nepheline-syenites, essexites, and theralites with phonolites, tinguaites, bostonites, camptonites, monchiquites alnoites. Similar rocks are known to occur in the Brazilian coastal region, we cite only the well-examined foyaites, essexites, phonolites, and basic dyke-rocks, besides tinguaites and bostonites in and near the State of Rio de Janeiro. The association with the related effusive rocks points in both regions to the circumstance that the alkalirocks are in part intrusive into their own effusive rocks and that they have crystallized at a small depth below the earth's surface. Erosion caused the volcanoes to disappear, which formerly existed near the two opposed coasts of the Atlantic Ocean, as they now arise near the East-African Lake-region, where also alkali-rocks are of frequent occurrence. Farther removed from the two coasts alkalirocks exist in various localities. We confine ourselves to mentioning only two largest eruptive provinces, hitherto examined on both continents, viz that of Poços de Caldas [3]) in the South of the State of Minas Geraes, and the that of the Pilandsberg [4]) in the district of Rustenburg (Transvaal). These two large provinces, the

[1]) O. E. Derby. On Nepheline rocks in Brazil. l. c.

[2]) E. Kayser. Bericht über geologische Studien während des Krieges in Süd-West-Afrika. Abh. der Giessener Hochschulegesellsch. II, 1920, blz. 18.

[3]) O. E. Derby. loc. cit.

[4]) H. A. Brouwer. Geology of the alkali rocks in the Transvaal. Journ. of Geology, 1917, XXV, p. 741 sqq.

first with a diameter of about 25 to 30 k.m., the second of about 30 k.m., are both remnants of volcanic centres of large extent. In both provinces the effusive-rocks include phonolites, leucite-rocks, volcanic breccias and tuffs; among the abyssal-rocks foyaites and syenites are known. In both provinces aegirine or aegirineaugite is a common dark constituent and tinguaites occur as independent rocks or as marginal zone of nephelinesyenites.

Volcanic rocks and intrusive dolerites.

The volcanic rocks of the Stormberg-series, whose lavas are widely spread over the whole of South-Africa, point to a volcanic episode in the mesozoic history of this country. At the same time and shortly after this the instrusion of the so-called Karroo-dolorites took place, which occur chiefly as dykes and intrusive sheets. Near the westcoast the Kaoko-formation, composed of horizontal sandstones and augiteporphyrite, extends over a wide area between 18° and 21° S. Lat.

In Brazil similar rocks have a great extent. Dykes and intrusive sheets of diabase occur in various places in the states of Minas Geraes and Sao Paulo in rocks of permian and of triassic age. Just as in South-Africa a thick series of volcanic rock occurs in the upper series of the Sta Catherina System, which is the equivalent of the South-African Karroo-System. These rocks are considered to be of Jurassic age and cover large surfaces in the States of Rio Grande do Sul, Santa Catharina, Parana, Sao Paulo and Matto Groso, even parts of The Argentine, Urugay and Paraguay.

Rocks like those in the above-named Kaoko-formation in South-Africa occur also in Brazil near the opposite coast in the Southern States of Santa Catherina, and Rio Grande do Sul. In both regions these formations overlie for the greater part archaean rocks.

Kimberlites, Alnoites, etc.

The frequent occurrence of these rocks in South-Africa as far as in the Congo State is well-known, in connection with the occurrence of the diamond in some of these rocks, especially in some diamond-pipes which are generally filled up by a volcanic breccia of serpentinised ultrabasic material.

Suchlike rocks have been known long since in Brazil. They have been described by HUSSAK [1]) as picriteporphyrite. He points out a certain resemblance between the diamond-bearing deposit of Agua Suja in West-Minas Geraes and the Kimberlites of South-Africa, while later on Kimberlite was recognized in dykes in the State of

[1]) E. HUSSAK. Uber das Vorkomen von Palladium und Platin in Brasilien. Zeitschr. f. prakt. Geol. XIV, 1906, blz. 284 e.v.

Rio de Janeiro together with picrite porphyrites, alnoites and limburgites, besides similar rocks in dykes and pipes in the Western part of the State Minas Geraes [1]).

Just as the Kimberlite rocks near the West-Coast of South-Africa, the known Brazilian rocks also belong nearly all to the basaltic varieties, which are poor in mica.

Horizontal movement of the Atlantic Coasts.

The resemblance between some groups of sedimentary rocks on either side of the Atlantic Ocean is also striking. We merely mention the South-African Karroo System and the Brazilian Santa Catharina System. The Orleans conglomerate in Sta. Catharina and Rio Grande de Sul agrees with the Dwyka conglomerate of South-Africa and in either continent the higher divisions are built up of the above-named thick series of volcanic rocks, such as those of the Drakensberg in Cape Colony and those of the Serra Geral in Rio Grande de Sul.

When we reconstruct the volcanoes of alkali rocks which existed in earlier periods along the present coasts, and imagine the two continents to be brought close together, we obtain a configuration similar to the aspect of the East-African Lake region, where at the present day the volcanoe Kenia and Kilima Ndsjaro built up of alkali-rich rocks, arise. This picture illustrates WEGENER's [2]) interpretation of the origin of the Atlantic Ocean [3]). More should be known, than has been recorded in the foregoing, about the resem-

[1]) E. RIMANN. Uber Kimberlite und Alnoite in Brasilien. Tscherm. Min. u. Petr. Mitt. 1915. Id. A Kimberlita no Brazil. Annaes da Escola de Minas de Ouro Preto. N° 15, 1917, blz. 27 e.v.

[2]) A. WEGENER. Die Entstehung der Kontinente und Ozeane, Die Wissenschaft. Bd. 66, 1920.

[3]) Still other fissures of the African continent may be reconstructed of similar character to, but of higher geological age than, those of the present East African fractures. We refer to the system of dykes of alkali-rocks with a uniform north-western to northern trend, occurring on either side of the old volcanic centre of the Pilands Berg in the Transvaal and can be traced over a distance of more than 100 K.M., cutting through all older formations. In the part of the earth's crust, which has disappeared here through erosion the fault-system may have exhibited here an aspect similar to that of parts of the present East-African fracture-system; it seems however that the horizontal movements on either side of these faults soon ceased and that they did not produce any considerable gaps. Then the fissures will disappear at greater depths and many similar faults may have existed in an earlier stage of erosion on the African Continent as intruded or gaping, fissures, of which no trace is visible now. (Cf. fig. 2 and p. 765 in H. A. BROUWER, Geology of the Alkali rocks etc. l. c.)

blance of the eruptive rocks and the petrographic provinces near the opposed shores, to lend support to the above interpretation. Still, in any case the resemblance of the rare eruptive rocks, is striking. According to WEGENER the present coastlines of Africa and South-America represent the borders of a fissure, which is supposed by that writer to have gradually widened to the present Atlantic Ocean through horizontal movements of the two present continents.

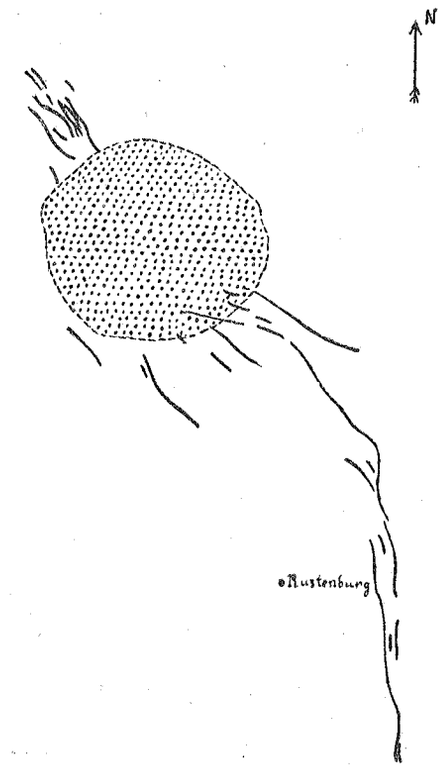

Fig. 2. An older African fault-system.

:::::: The old Pilandsberg vulcano (Transvaal).

——— Dikes of (nepheline) syenitic rocks.

Scale ± 1 : 1100.000.

This hypothesis is at variance with the view that the Atlantic Ocean should have arisen through the subsidence of a continental region, while Africa and America are supposed not to have moved in a horizontal direction.

The vertical movements executed on the surface of the earth are evidenced e.g. by upheaved shore-terraces and reefcaps, drowned river valleys etc. In connection with this the genesis of sea-basins is explained by vertical downward movements, because the horizontal movements are not established in a similar manner and consequently escape our direct observation. But with rising rows of islands the horizontal component of the rate of movement is sometimes much greater than the vertical one. The latter is distinguishable by upheaved coralreefs and shore-deposits whereas the former must be derived from far less distinguishable phenomena such as the form of the reefcaps and the character of the fault-movements.[1]) The mesozoic rows of islands of the Tethys have executed chiefly horizontal and far less significant vertical movements,

[1]) H. A. BROUWER. Uber die horizontale Bewegung der Inselreihen in den Molukken. Nachr. Ges. der Wiss. zu Göttingen. 1920, Math. phys. Kl. Id. Breuken en Verschuivingen nabij de oppervlakte van bewegende geantiklinalen. Versl. Kon. Akad. v. Wet. Amsterdam, XXVIII, 1920, p. 1151.

at present their masses overlie each other in the overthrust sheets of the mountain chains. These movements are explained by the fact that the old continental flocks of Eurasia and Indo-Africa have moved towards each other, in which process continental areas have executed horizontal movements. Similar movements may have co-operated to originate the Atlantic Ocean. Whether horizontal or vertical movements have prevailed may to some degree be made out by comparing the geological composition and structure of the opposed coastal regions. The points of similarity enumerated by WEGENER and contested by SOERGEL [1]) have still retained their significance in some measure and the concordance of the eruptive rocks discussed by us does not clash with the prevalence of horizontal movements.

[1]) W. SOERGEL. Die atlantische „Spalte". Zeitschr. der Deutschen Geol, Gesellsch. 1916, Monatsber. Bd. 68, S. 200 folg.