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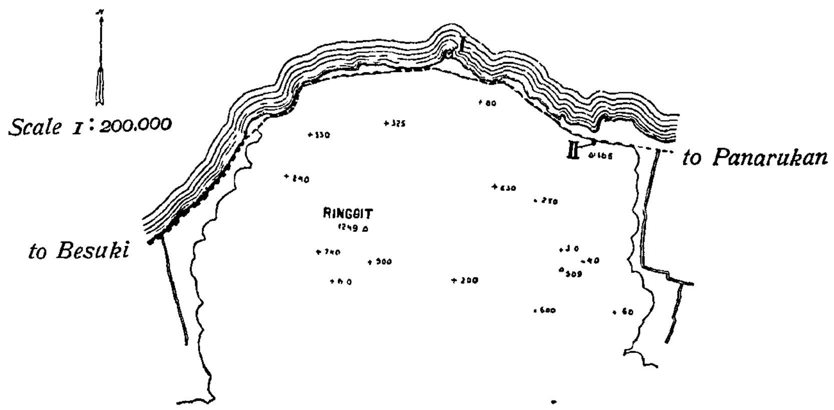
Geology. — *"Leucite-rocks of the Ringgit (East-Java) and their contact-metamorphosis"*. By H. A. Brouwer. (Communicated by Prof. Molengraaff).

(Communicated in the meeting of December 28, 1913).

The following pages will afford new proofs of the intermediary place, which the contact-metamorphosis of the basic leucite-rocks occupies between that of the trachytic and the basaltic rock.

The Gunnong Ringgit (a corruption of the Madurese word renggik=saw-shaped) forms a steep mountain-range with five pointed tops on the northcoast of Java between Besuki and Panarukan; according to Verbeek [1]) the whole mountain-range with the old craterwall of the Gunong Besar south of it consists of lava-cakes and loose blocks of leucite-rocks. During a trip to Madura I visited the north-foot of the Ringgit; along the great postal-road at the north-foot lava is in several places found in situ. Near the 15[th] milestone from Besuki, we see to the North of the road in the flat country one hillock consisting of leucite-lava forming a cape projecting into the sea (marked I on the annexed map). The rock is a leucitite with phenocrysts of biotite which are much resorbed

THE MADURA STRAITS



whilst it is characterized by a great number of enclosures, measuring from a few centimeters to a few decimeters, and consisting, as far as they have been examined, of a reddish andesite. It is in these enclosures that the contact metamorphosis of the leucitites can be studied.

1) R. D. M. Verbeek en R. Fennema. Java en Madoera I. page 71.

Contact metamorphism caused by effusive rocks is eo ipso insignificant, both on account of the low temperature at which the metamorphism takes place, and on account of the escape of the pneumatolytic gases during the eruption. It can however be studied in the enclosures of older rocks on which the magma whilst still under pressure, could react in the same way as if it were a deep-seated rock. LACROIX [1]) had divided the effusive rocks into two groups, according to the character of their contact metamorphosis: the basaltic and the trachytic rocks, differing from each other in either containing or not containing orthoclase and acid plagioclase. The metamorphosis caused by rocks of the former group is chiefly restricted to the influence of heat confined to a narrow contactzone, whereas the rocks of the latter group, in consequence of their greater viscosity during the effusion, and in consequence of the pneumatolytic gases dissolved in these viscous magmas, are in less intimate contact with the inclosures, but, impregnating these inclosures by pneumatolytic substances can cause intensive chemical changes, which are not restricted to the contactzone, but can affect the entire enclosure.

The leucitite containing the enclosures which will be now described, shows besides many phenocrysts of augite, numerous strongly resorbed phenocrysts of biotite. Macroscopically we see both the minerals the augite of a green, the biotite of a brownish red colour contrasting against a greyish-black or brownish-red ground-mass.

The augitephenocrysts are under the microscope colourless or greenish; traverse-twins occur, and also twins according to (100) sometimes with polysynthetic lamels. Greenish and colourless portions alternate without regularity or in zones in the same crystal; sometimes there is a green core surrounded by an uncoloured margin; occasionally one sees a green band between a colourless core and a marginal zone, both of which extinguish simultaneously, but not together with the green transition-zone. Similar zones with varying optical properties occur likewise without observable differences of colour. As a rule the augite is poor in enclosures, only a few little prisms of apatite and flakes of biotite are enclosed.

The biotitecrystals are for the greater part strongly resorbed; some are entirely altered into a black ore which can be proved to represent altered biotite by comparison with crystals, in which still remains of the strongly pleochroitic biotite can be distinguished dimly between the specks of the ore. There is likewise a younger generation of biotite, just as has been described by me from a mica-

[1]) A. LACROIX. Etude sur le Métamorphisme de contact des roches volcaniques. Mémoires présentés par divers Savants à l'Académie des Sciences. Tome XXXI. 1894.

leucite basalt of East-Borneo, discovered by Prof. MOLENGRAAFF [1]). This last-mentioned biotite is not resorbed, and is often deposited in the rock of the Ringgit round the older resorbed crystals, however with different optical orientation of the optical groundmass. These little brownish-red crystals which also occur dispersed through the rock, and as a rule do not show any definite shape, enclose particles of the groundmass. The groundmass consists of leucite, augite and ore. Sometimes the leucite attains somewhat larger dimensions than the majority of the crystals of the groundmass, without forming real phenocrysts, the augites are column-shaped and colourless or light-green, the ore is plentiful in the rock.

Macroscopically one sees already locally in little cavities neogenic minerals of very small dimensions, many of which show the shapes of crystals of leucite or sodalite, or also of feldspar. Under the microscope one sees in these little cavities isotropic crystals, together with neogenic feldspar and sometimes some biotite, whilst the dark background against which the prisms of augite set off between crossed nicols, is often interrupted by anisotropic portions, which for some distance have the same optical orientation, and poicilitically surround the particles of the groundmass. These anisotropic portions sometimes consist of kalifeldspar, twinned according to the Carlsbad-law; polysynthethic twins have not been observed, but the zonal structure which is often distinguishable, points also to the presence of plagioclases. These minerals have been formed after the crystallisation of the groundmass of the rock and point to pneumatolytic elements in the magma, which have been set free after the final crystallisation; consequently they are no normal constituents but products of the autopneumatolysis in the rock. Locally they may occur in considerable quantities.

The enclosures of this leucite are coloured light-red or brownish, and contain little phenocrysts of plagioclase where they have not been altered into a hypo- or cryptocrystalline groundmass.

In some of the enclosures examined the plagioclases show microscopically a well developed zonal structure, in others they are only slightly so, or sometimes not at all. Major twins according to the Carlsbad-law of the polysynthetically twinned feldspars occur. The basicity of the feldspars sometimes decreases regularly from the centre to the margin, in which case transitions were observed from labrador or bytownite to oligoclase or andesine, but alternations of

[1]) H. A. BROUWER. On micaleucite basalt from Eastern-Borneo. These Proceedings, June 26, 1909 p. 148.

more basic and more acid lamellae are very frequent, and sometimes are found repeated several times in one and the same crystal.

Phenocrysts of the dark minerals are not met with as such, but sometimes we find specks consisting of opaque secondary minerals proving by their shape that such phenocrysts may originally have been present. The groundmass is likewise strongly weathered and contains laths of plagioclase, flakes of chlorite and opaque products of disintegration of the ore which is not found in large quantity; moreover often an isotropic substance is found in large quantities, which is considered as glass; in this case the rock must be called an andesite.

Metamorphosis.

The metamorphosis of the enclosures examined encludes in the first place the alterations caused by the magma itself, appearing only at the immediate contact, and consisting, at the utmost, of remelting and recrystallisation after chemical exchange; in the second place the alterations caused by imbibition of volatile substances which penetrate well into the interior of the enclosures. From this the intermediary place becomes apparent, which this contactmetamorphosis occupies between that of the basaltic and that of the trachytic rocks. Especially the intensity of the pneumatolytic influences varies greatly in the different enclosures; sometimes the chemical exchanges in the contactzone can be explained without pneumatolysis. In the examined rocks it is most frequently the case that in part of the enclosures a porous structure has been developed even to a great distance from the contact, whilst in the cavities neogenic minerals have been formed showing great analogy to the autopneumatolytic minerals of the enclosing leucitite, whilst in the contact zone the combined effect of remelting and pneumatolysis can be observed. The formation of a gold-yellow aegirine-augite is characteristic.

As an example may serve an enclosure of a few centimeters in diameter in which to a great distance from the contact a neogenic yellow pyroxene is formed in very small columns, sometimes accumulating locally and then accompanied by an isotropic mineral with low index of refraction and by neogenic feldspar. The angles of extinction of this yellow pyroxene point to aegirine-augites of varying composition. The ore is strongly disintegrated, here and there a reddish substance has been formed pointing to an oxydation to haematite. A small quantity of the yellow pyroxene is also found in the phenocrysts of plagioclase. The transition-zone with the leucitites is characterised by the occurrence of a very great number of little columns of gold-coloured aegirine-augite and of a few larger crystals with yellow margin which are mixed with feldspar, consisting partly of kalifeldspar, partly of plagioclase.

In this transition-zone we find only a very little quantity of ore, whereas the larger augite crystals with yellow margin have after all originated from phenocrysts of the leucitite. Very near to the contact we find the original plagioclases of the enclosure as an opaque central portion in the neogenic feldspars; whereas at a short distance the original plagioclases have been conserved as such, and the neogenic minerals have been crystallized in small cavities of the rock. The appearance of the ore points to chemical interchanging of elements between the lava and enclosures; the gold colour and the modified optical properties of the augite and likewise the crystallization of neogenic minerals to a great distance from the contactzone of the enclosure which has become partly porous, indicate the influence of pneumatolytic gases. Leucite-tephrites of the Somma metamorphosed by fumaroles show very similar modifications.

That in the contact-zone really melting has taken place is in suchlike enclosures often proved by the fact, that the transition-zone penetrates tongue-shaped into the magma which has been crystallized as leucitite. Macroscopically the line of demarcation between the transition-zone which is only a few millimeters wide, and the leucitite can often easily be followed by the rapidly decreasing of the percentage of ore, and by the colour which for this reason becomes lighter.

Among the smaller enclosures there are numerous ones, which have entirely been altered into a very porous rock, have obtained a yellowish colour, and contain besides the colourless neogenic minerals and the yellow pyroxene also a few crystals of haematite which macroscopically are perceptible as little black specks.

In a larger enclosure with a diameter of about 20 centimeters the transition-zone was hardly brighter in colour than the leucitite, and this fact appeared to be accompanied by a much more gradual diminution of the percentage of ore. Moreover the augite shows no change of colour, and neither do we find the gold-yellow augite in the enclosure at some distance from the contact, notwithstanding the porous structure and the crystallization of pneumatolytic minerals. In the transition-zone little, but likewise much larger crystals of neogenic kalifeldspar and zonular plagioclase can be observed, enclosing the ore and the little columns and larger crystals of unmodified augite. In this contact-zone again borders of neogenic feldspar appear around the opaque plagioclases of the enclosure.

The metamorphoses described above, which are connected by all sorts of transitions show great resemblance to those found in blocks of leucite-tephrite of the Fosso di Caucherone (Vesuvius)[1]) which have been altered by the action of fumaroles. The microlithes and phenocrysts of augite have become yellow, and the extinction-angles agree with those of an aegirine-augite, sometimes with those of aegirine. Haematite is abundant with the exclusion of magnetite. The biotite and amphibole show modifications of colour.

In the "sperone" of Latium, likewise a metamorphic rock which by transitions is connected with a normal black leucitite, the normal green augite has been altered into a gold-coloured one, whose angle $c : \mathfrak{c}$ varies between 65° and 85° whilst likewise the original magnetite has more or less completely disappeared. Moreover there is often formed a yellow melanite[2]).

Finally a green-yellow aegirine-augite occurs in varieties of the shonkinite of the Katzenbuckel (Odenwald) which has been modified by pneumatolytic processes[3]). The iron-ore has here been altered into pseudobrookite, the feldspars are more or less zeolitised. Analyses made by LATTERMANN indicate that in the rock modified by pneumatolysis, the percentage of Fe_2O_3 had increased from 5,86°/₀ to 8,51°/₀, whilst in the variety with yellow augite the FeO of 3,23°/₀ which had been found in the original rock, had entirely disappeared. Likewise in the analyses of sperone the Fe_2O_3[4]) dominates strongly over the FeO; evidently the metamorphosing agencies had an oxydizing influence. The modification of the optical properties of the gold-coloured pyroxene tends to prove that the Na_2O percentage has also been increased, which could not be concluded from the different analyses.

In connection with what has been said a second locality of rocks with gold-coloured pyroxene may be mentioned (II of the annexed map) situated directly South of the road from Panarukan to Besuki at mile-post 18. At the northern foot of a bare hill a porous light-grey rock that microscopically proves to be rich in gold-coloured pyroxene, appears between rocks of dark-grey biotite-leucite-tephrite.

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1) A. LACROIX. Etude minéralogique des produits silicatés de l'éruption du Vésuve (avril 1906). Nouv. Archives du Muséum. 4e Série. Tome IX, 1907, pp. 73, 94.

2) A. LACROIX, l. c. p. 95.

3) W. FREUDENBERG. Geologie und Petrographie des Katzenbuckels. Mitt. Groszh. Badische Geol. Landesanstalt V. I. Teil, 1906, p. 81.

4) V. SABATINI. I Vulcani dell' Italia centrale. I. Vulcano laziale. Mem. Carta geol. d'Italia, X, 1900, pp. 150, 163.

In the dark-grey leucite-tephrite one sees, macroscopically, phenocrysts of plagioclase and dark minerals few millimeters in diameter, the former contrasting little against the groundmass. Under the microscope it appears that the plagioclases have a well marked zonal structure, the augite crystals are light-green and often include numerous specks of ore. The little phenocrysts of biotite are sometimes strongly resorbed; the angle of the optical axes is very small, the pleochroism is strong from brown-black to light-yellow. The groundmass is composed of plagioclase with zonal structure, leucite (and some nepheline), green augite, a little biotite and much iron-ore. The latter mineral often obtains somewhat larger dimensions, without forming real phenocrysts. The leucite has likewise somewhat larger dimensions than the majority of the crystals in the groundmass.

The porous light-grey rocks with gold-coloured pyroxene show numerous phenocrysts of white plagioclase (some as long as 0.75 c.m., but usually smaller) and smaller phenocrysts of the dark minerals in a groundmass which is either dense or micro-crystalline; in the cavities neogenic minerals have been formed. Under the microscope we see porphyric crystals of strongly zonal plagioclase and gold-coloured or partly still green pyroxene, in a groundmass of strongly zonal plagioclase, gold-coloured pyroxene iron-ore, an isotropic, sometimes light-brownish substance, and a few little columns of apatite. Further a few rather large broad prisms hexagonal in cross section of an optically negative mineral with one optical axis, with a high refraction index, have been observed, which are slightly pleochroitical with $\varepsilon > 0$; they are almost colourless or tinged very lightly brownish, and include sometimes particles of a black or vermilion-red substance. A cleavage parallel with the axis of the prisms is indistinctly developed. In case originally some leucite has been present in this rock, the mineral is now altered into pseudomorphoses, on account of its feeble resistance against pneumatolytic agents.

Without entering into details about the metamorphosic and preneogenic minerals found in these rocks, it can be mentioned that the aegirine-augites belong to different chemical combinations; we observed e. g. in sections parallel to (010) made across columns twinned according to (100), symmetrical extinctions of 14°, whilst several lath-shaped sections extinguish with angles of 20° to 30°; very small angles of extinction were equally observed. Black iron-ore, blue-black in reflected light, is found in great abundance in the rock, sometimes it surrounds as a border the aegirine-augites, which likewise can include the ore in great quantity.

Moreover one sees elongated sections consisting entirely of black ore, around which a mixture of ore and prisms of gold-coloured aegirine-augite columns is formed.

The metamorphoses described above by which gold-coloured pyroxenes with the optical properties of aegirine-augites are formed, appear to be connected with pneumatolytic processes in magmas rich in alkali.

Finally it may be mentioned here, that to the South of the road Panarukan Besuki, quite near to mile-post 13, a loose piece of a leucitite was found with phenocrysts of leucites as large as 4 m.m., which certainly had come down from the northern slope of the Ringgit and consequently may be expected there in greater quantities; hitherto such types of rocks were not recorded from the Ringgit-mountain.

Mathematics. — "*Expansion of a function in series of* ABEL'S *functions* $\varphi_n(x)$". By Prof. W. KAPTEYN.

(Communicated in the meeting of February 22, 1913).

1. In the Oeuvres complètes of ABEL [1]) may be found the following expansion

$$\frac{1}{1-v} e^{-\frac{xv}{1-v}} = \sum_0^\infty \varphi_n(x) v^n$$

where

$$\varphi_n(x) = 1 - C_1^n x + C_2^n \frac{x^2}{2!} - \ldots + (-1)^n \frac{x^n}{n!}$$

C_p^n representing the binomial coefficients.

These polynomia form the object of the dissertation of Dr. A. A. NIJLAND (Utrecht 1896) and have been treated afterwards by E. LE ROY in his memoir "Sur les séries divergentes" (Annales de Toulouse 1899).

In this paper I wish to examine when a given function of a real variable may be expanded in a series of this form

$$f(x) = a_0 + a_1\varphi_1(x) + a_2\varphi_2(x) + \ldots \ldots \quad (1)$$

2. In this article we collect those properties of the polynomia $\varphi_n(x)$ which we want for our investigation and which we take from NIJLAND'S dissertation.

In the first place we have the important relations

[1]) Oeuvres Complètes II p. 284.