Plagitrachyte, as a dike of 1 m in river-canyon.

Limestone with fossil remains (foraminifera, lamellibranchiatae and gastropodes).

Quartz-diorite, as a boulder on one of the slopes.

As to the relation between the Muriah and the Genuk, in one of the rivers between both mountains the following observations have been made:

a. Where Genuk tuffs and Muriah breccias (the latter characterized by leucite-bearing components) contact each other, these tuffs appear to lie below the breccias. In one place the plane of separation dips 60 degrees South; the breccias have been pushed up against the tuffs.

b. In one place the following vertical section was observed:

Debris and weathered soil.

Tuff bank, with the same type of tuff as on the Muriah, lacking the clearly visible pumice components, characteristic for the Genuk tuffs.

Breccia with leucite-bearing components and pumice.

With these observations on hand, it seems justified to assume, that the Genuk efflata are of older age than the Muriah breccias.

B a k o h i l l.

This hill consists of trachytic rocks. Salic constituents are plagioclase and orthoclase as phenocrysts; the latter predominant. Femic components are augite and a little biotite. One sample contained some sodalite. The average of three samples shows 6.16 % K_2O and 3.87 % Na_2O.

R a g a s h i l l.

Consists also of trachytic rock. In one sample of a trachyte, sanidine phenocrysts in a groundmass of orthoclase and plagioclase with a little biotite were observed. (6.15 % K_2O and 4.86 % Na_2O). Another section shows phenocrysts of sanidine and plagioclase in a groundmass of the same minerals, whereas femic constituents are absent. The analysis of this sample shows 3.88 % K_2O and 3.27 % Na_2O.

Geology. — *The* M u r i a h *Volcano (Central Java) and the origin of its leucite-bearing rocks.* By R. W. VAN BEMMELEN. (Communicated by Prof. J. H. F. UMBGROVE.)

(Communicated at the meeting of May 31, 1947.)

The Muriah, or Murjo volcano, is situated on the North coast of Central Java on the labile border of the Sunda Shelf, Northwest of the oil-bearing area of Rembang (Tjepu).

A vertebrate fauna is found in its Southfoot (Patihajam), belonging, according to VON KOENIGSWALD, to the Trinil fauna, thus dating the age of the volcano as Middle-Pleistocene.

In late quaternary time the volcanic structure was domed up so that a number of radial "sector-graben" were formed (see fig. 1.)

The two most important ones are the cauldrons of Rahtawu and Tempur, which are the catchment basins respectively of the southern and the northern Gelis River.

Together these cauldrons form a SSW-NNE rift across the present volcanic ruin, separated by the divide of the Sutorenggo (1604 m, highest summit of the Muriah complex). In these cauldrons the deepest parts of the Muriah are exposed.

At the North foot, the heavily eroded tuffcone of Genuk is found, which is, according to BOOMGAARD, older than the main cone of the Muriah, whilst the Bako and Ragas are younger parasitic centres of eruption.

The basement of the Muriah complex is exposed in Patihajam and in the Genuk. In the former it consists of Globerina marls and clays, presumably belonging to the Turi Beds (Plio-Pleistocene); in the latter limestones with foraminiferas, lamellibranchs and gastropods are found.

Moreover, KUIPER found in the volcanic rocks of the Rahtawu cauldron large inclusions of contactmetamorphic limestones, sandy limestones and marls, which were microscopically studied by the present author. In some samples the following fossils could be determined: *Katacycloclypeus annulatus* M a r t., large microspheric and macrospheric *Lepidocyclinae*, and *Cycloclypeus* sp.; these limestones belong to the Rembang Layers, which are of Miocene age. Other samples did not contain *Lepidocyclina*, but only small Foraminifera's (*Rotalia, Operculina, Amphistegina, Globigerina,* etc.), indeterminable lamellibranchs, gastropods, echinids, algae (*Lithothamnium*), corals *(Porides)*. These are assigned to the younger neogene (Pliocene) strata of the Rembang sequence.

The clastic constituents of the sandy limestones are cataclastic quartz, undulatory extinguishing felspar-fragments, tourmaline, andalusite, glaucophane, and muscovite. This is detritus derived from the old Sunda land

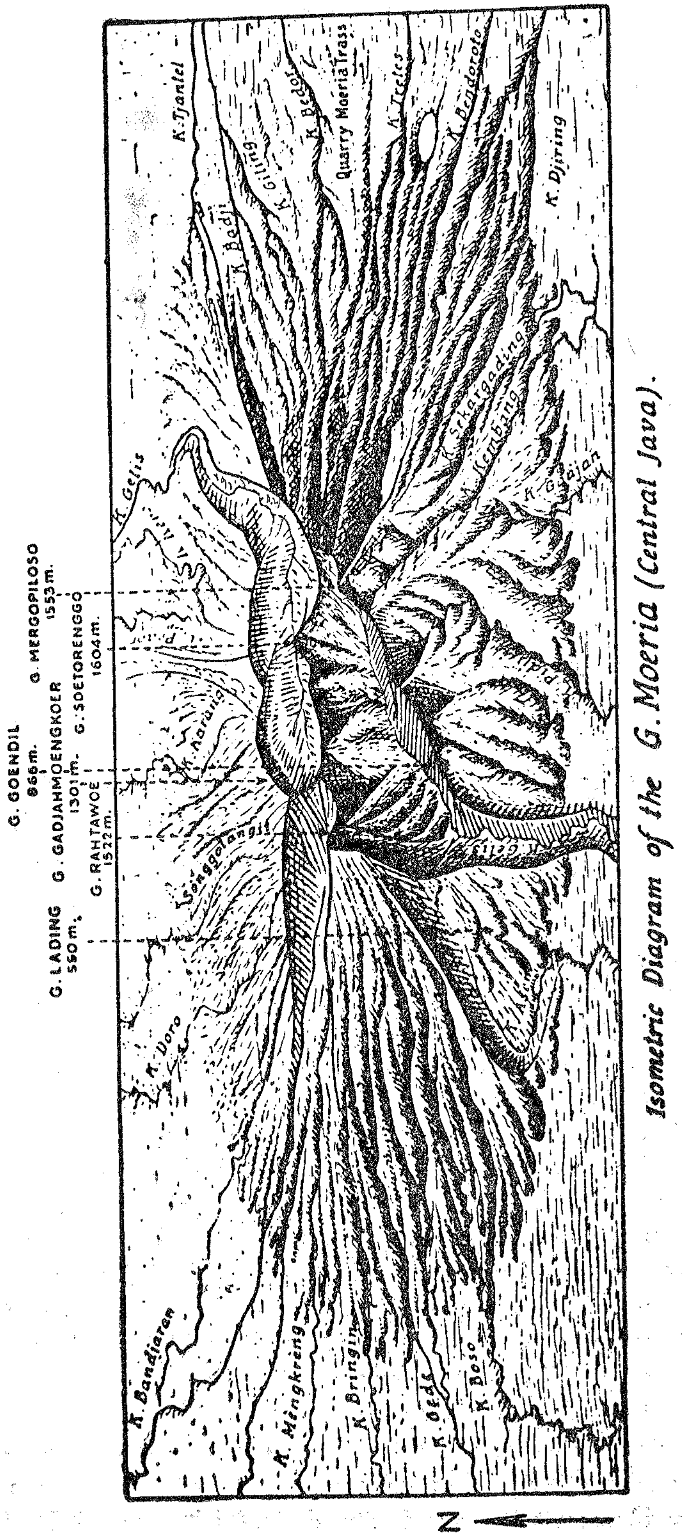


Fig. 1. *Isometric diagram of the Muriah Volcano.*

in the North, which was the source area of the marine deposits of the Rembang geosyncline during the Neogene, and which submerged in late quaternary time, now forming the Java Sea (Sunda Shelf).

The limestones are partly marmorized, containing near the contact recrystallized patches of quartz-mosaic, porphyroblasts of basic plagioclase with broad twinning lamellae and sometimes developed as skeleton crystals intergrown with calcite, besides numerous grains of colourless pyroxene (diopside).

In some slides the direct contact between the volcanic rocks and the limestones could be studied. Near to the contact these volcanic rocks did not contain leucite. It are trachyandesites or latites with phenocrysts of colourless or pale green diopsidic augite (sometimes with polysynthetic twins), biotite (sometimes contorted crystals), basic plagioclase with zonal development, and sanidine with Karlsbad twinning. The latter mineral occurs also in a second generation, together with plagioclase as idiomorphic laths with a fluidal arrangement. The matrix is a turbid glass with pyroxene microlites. Accessory minerals are rather stout and numerous apatite prisms, magnetite and pyrite.

The abundance of biotite and orthoclase indicates a preponderance of potash over soda in the chemical composition.

These potassic trachy-andesitic rocks are separated from the limestone by a narrow chilled edge (about 1 mm thick), in which the turbid glass matrix prevails. This chillface contains further small grains and crystal-agglomerates of pyroxene. These crystals are either colourless, or they show a grading into the green colour of aegirine. Other constituents are idiomorphic laths of alkalifelspar, and rectangular or hexagonal sections of nepheline. Biotite and plagioclase, abundant in the igneous rocks further from the contact, are mostly absent in the chillface. Slender needles of apatite form an accessory mineral.

On account of the presence of aegirine-like pyroxene and nepheline phenocrysts, this chill-face might be called a nepheline phonolite, in which the soda content is presumably higher than the potash. Also in the contactmetamorphic limestones nepheline crystals were found.

The presence of sodium minerals in the chill-face and the contact-metamorphic limestones forms a contrast with the mineral associations of the Muriah volcanic rocks, in which potassium-minerals such as leucite, orthoclase, and biotite are abundant [1]).

This observation is of importance for our insight in the genesis of these Mediterranean suite of the Muriah, as will be explained below.

First the general sequence of the volcanic rocks of the Muriah complex will be given.

The oldest eruption products are common basalts and andesites, mentioned by BOOMGAARD from the Genuk in the North, belonging to the Pacific suite, which is the normal type of magma in these orogenic zones.

Then follows the Mediterranean suite chiefly consisting of leucite-basalts, basanites and tephrites, which form the bulk of the Muriah complex.

The latest eruptions are more leucocratic trachytes, occurring in the parasitic Bako and Ragas cones, further a plagitrachite dike in the Genuk cone, and syenite-porphyry dikes exposed in the Tempur cauldron.

Holocrystalline rocks are represented by a diorite boulder, and a syenite inclusion in leucite tephrite flow, both found by BOOMGAARD, and a sanidinite boulder (collected by the forester of the Muriah area in 1937 and presented to the Geological Museum). The chemical analyses 1—7 were made by the Chemical Laboratory of the Geological Survey, from a collection made in 1937 and microscopically studied by the author. (Nos 1—6 from leucite bearing rocks [2]) and No 7 appertains to the above mentioned sanidinite). Nos 8—15 are taken from IDDINGS & MORLEY (1915) [3]). See table.

The formation of this Mediterranean suite can be explained by DALY'S theory of limestone assimilation.

The contact metamorphic limestone inclusions in the Rahtawu cauldron indicate that the magmatic hearth of the volcano had apparently risen into the neogene Rembang series, which are rich in limestones. Therefore, the roof of the magma chamber was situated at that time (i.e. Lower-Middle Pleistocene) at a depth of some kilometres below the surface. In the initial stage of the volcanic activity, some flows of basalt and andesite were still issued (in the Genuk volcano), which proves that the original composition of the magma corresponded with that of the Pacific kindreds. But, thereafter, the composition was changed by limestone assimilation, which caused a desilication of the magma according to the following theoretical equation:

$$\underset{\text{limestone}}{\overset{(Mg\,Co_3)}{Ca\,Co_3}} + \underset{\text{magmatic compounds}}{2\,SiO_2\,(+\,MgO)} \rightarrow \underset{\text{diopside}}{Ca\,Mg\,(SiO_3)_2\downarrow} + \underset{\text{resurgent gas.}}{CO_2\uparrow}$$

Besides diopside also basic plagioclase occurs, not only as phenocrysts, but also as porphyroblastic contact mineral. The CaO content of the phenocrysts may be partly derived from the limestone, but as contact mineral it may entirely be formed by the constituents of the marly limestone ($Ca\,CO_3$ and clay-minerals):

$$\underset{\text{limestone}}{Ca\,CO_3} + \underset{\text{clay minerals or magmatic compounds.}}{2\,SiO_2 + Al_2\,O_3} \rightarrow \underset{\text{anorthite}}{Ca\,Al_2\,Si_2O_8} + CO_2\uparrow$$

[1]) A similar observation was made by IDDINGS and MORLEY (J. of Geol. 1915, p. 237), who found nepheline (and stilbite) only in the numerous cavities of the lavas.

[2]) The author's report with the petrographical descriptions of these rocks was lost during the occupation of the Geological Museum at Bandung by the Japanese.

[3]) J. IDDINGS and E. W. MORLEY, "Contributions to the petrography of Java and Celebes." Journal of Geol. 23, 231—245 (1915).

TABLE 1.

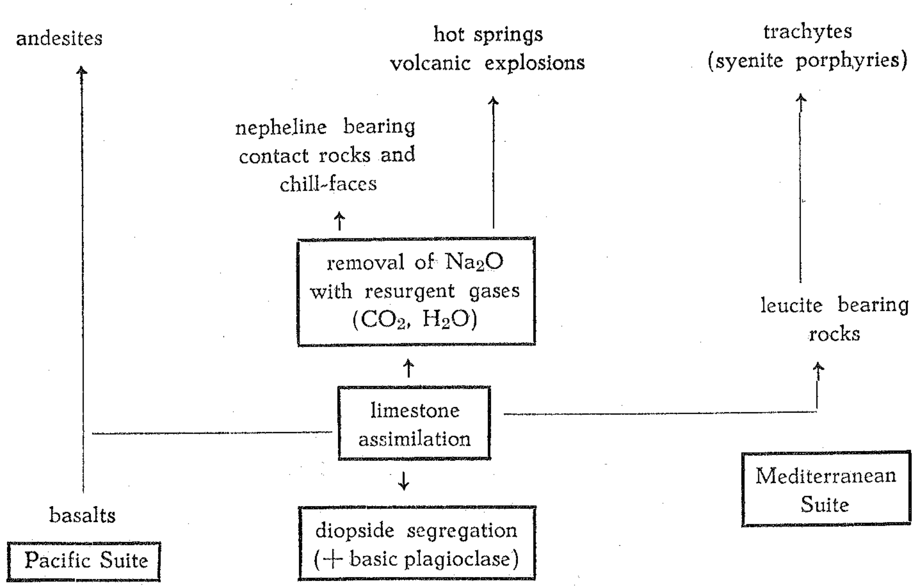
No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SiO_2	44.36	48.45	48.80	49.22	51.21	56.67	62.86	45.03	46.54	46.60	47.73	48.32	48.66	50.18	51.85
Al_2O_3	13.98	18.52	19.64	16.81	20.84	18.09	19.06	16.59	15.95	16.73	17.93	17.81	17.69	17.82	19.08
Fe_2O_3	3.98	3.73	2.88	5.21	3.06	3.94	1.15	4.55	5.24	4.17	4.47	4.65	4.66	4.04	4.25
FeO	5.48	4.17	3.26	4.19	1.95	2.59	0.15	6.37	5.51	4.78	4.58	4.62	4.40	3.89	2.69
MnO	0.17	0.20	0.22	0.17	0.19	0.15	0.07	0.64	0.18	0.41	0.96	0.41	1.49	0.30	0.51
MgO	10.26	2.98	1.72	4.21	1.00	1.74	0.10	3.95	4.70	4.69	4.27	3.37	3.03	2.88	1.48
CaO	12.35	8.39	6.05	9.67	5.58	5.63	1.57	11.09	10.69	10.82	9.58	9.15	6.43	7.19	5.81
Na_2O	2.64	4.47	3.98	2.63	4.85	3.92	3.88	3.53	2.28	2.62	3.62	3.14	3.93	3.29	4.46
K_2O	2.94	5.51	8.32	3.81	6.91	5.10	9.50	5.29	4.44	5.47	4.81	4.79	6.10	6.65	6.61
H_2O+	1.50	1.02	3.33	1.71	2.41	0.57	1.11	0.34	0.52	0.71	0.44	0.82	0.80	0.96	0.55
H_2O-	0.56	0.62	0.46	0.86	1.36	0.52	0.36	0.15	0.59	0.45	0.24	0.17	0.58	0.55	0.47
TiO_2	1.21	0.77	0.58	1.13	0.46	0.73	—	0.10	1.11	0.95	0.86	0.88	0.81	0.76	0.66
P_2O_5	0.93	0.68	0.26	0.44	0.04	0.33	0.04	0.96	1.18	1.50	0.52	0.82	0.79	0.76	1.23
Total	100.36	99.51	99.50	100.06	99.86	99.98	99.85	99.59	98.93	99.90	100.02	98.95	99.37	99.27	99.65
Spec. Density	2.900	2.729	2.607	2.799	2.460	2.673	2.379	Leucite shoshonite	Leucite basalt	Leucite tephrite	Biotite vicoite	Leucite tephrite	Leucite tephrite	Leucite tephrite	Leucite shoshonite

Meanwhile part of the soda of the magma escaped with the resurgent gases into the contact aureole, or by volcanic explosions, because soda has a greater affinity to carbondioxyde than potash. This escape of the soda appears from the presence of sodic minerals, such as nepheline, in the above described chill-face and in the contact metamorphic limestones.

It is conceivable that especially along the contact an upward current of resurgent gases occurs, carrying along Na_2O as a chemical compound. This marginal contact zone was suddenly cooled down during the eruption and consolidated into a chill-face, in which the sodium-felspatoid (nepheline) could crystallize, whilst also the diopsidic pyroxene phenocrysts were partly altered by a kind of autopneumatolysis into a sodium-rich, aegirine-like pyroxene. Consequently, this chill-face assumed the appearance of a sodium-rich Atlantic rock type. Such in contradistinction to the bulk of the magma, which belongs to the Mediterranean suite. In the latter the potash felspathoid (leucite) could be formed, due to the desilication and the passive enrichment of the potash content.

In the later stages of the eruption cycle more leucocratic rocks were produced (trachytes, syenite-porphyry dikes). These rocks might be interpreted as the result of progressive crystallization differentiation in the hearth.

On account of these observations and considerations it seems to be very probable, that the Mediterramean kindreds of the Muriah complex were derived from the Pacific magma type by a "pathological" side branch of differentiation caused by intensive limestone assimilation, according to the following scheme:



Oceanography. — *On the desirability of a research into certain phenomena in the region of upwelling water along the coast of South West Africa.* By MARGARETHA BRONGERSMA—SANDERS, D.Sc. (Communicated by Prof. H. BOSCHMA.)

(Communicated at the meeting of May 31, 1947.)

In some bays on the coast of South West Africa (especially in Walvis Bay) and sometimes also in the open sea outside of them a mass mortality of fish takes place periodically. Some mortality takes place every year; very great mortalities, however, occur in some years only. They occur always in the southern summer; very great mortalities occur mostly in December and especially at Christmas time.

The surroundings of Walvis Bay are further characterized by a very peculiar sediment on the sea bottom (see VON BONDE, 1928; MARCHAND, 1928; COPENHAGEN, 1934). The peculiarites of this sediment are the following: the presence of a great quantity of H_2S; a high organic content; nearly complete absence of living organisms (benthonic invertebrates, the scavengers of the seabottom are absent!), anaerobic bacteria excepted; abundance of fish remains; a very high % of skeletons of diatoms. I must stress the fact, that the peculiarities of this sediment are not caused by stagnation of the lower water layers. Besides in the Walvis Bay itself the sediment occurs also in the open sea outside it; and there is, as far as I am aware, no barrier preventing circulation whatever. The area, in which this sediment occurs, stretches nearly from Cape Cross to south of Conception Bay (21° 30′—24° 30′ S), a distance of approximately 200 miles and from the coast line 25—30 miles west (i.e., about to the 77 fathom line). On account of the absence of living organisms in the sediment the area is called the Azoic zone of the West coast. In this area there is a coastal belt between the Azoic zone and the shore extending from Pelican Point to 23° 38′ S where the bottom consists of fine grey sand, and the absence of green sulphurous mud being noteworthy.

Hypotheses put forward in recent publications (REUNING, 1925; MARCHAND, 1928; CLASSEN, 1930; COPENHAGEN, 1934) agree in the supposition, that H_2S is the cause of the mortality, although opinions differ as to the origin of the gas. Except COPENHAGEN the authors agree, that the H_2S derives from sulphur compounds of the land, and is brought to the sea by the river Kuiseb; the coast region being very rich in sulphur minerals. According to MARCHAND sulphides and sulphates are carried down as such by the Kuiseb and broken up by chemical action with the sea water setting free noxious compounds and gazes fatal to fish. The periodicity of the mortality is explained by MARCHAND by the periodical rainfall in the hinterland and consequently by the periodical emanating of water of the Kuiseb