Geology. — *On rocks from Karimon (Riouw Archipelago).* By B. V. RAADSHOOVEN and J. SWART. (Communicated by Prof. L. RUTTEN.)

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Introduction.

The examined material has been given to the "Min.-Geol. Inst." at Utrecht by Dr. P. M. ROGGEVEEN, who in 1930, in charge of the Billiton Mij., made geological researches on some islands of the Riouw Archipelago. We are indebted to this company for having placed ROGGEVEEN's reports at our disposal.

For a list of publications concerning the tin-islands we refer to BOTHÉ (1). R. EVERWIJN assisted by J. A. FLEURY made during 1863/1864 explorations for tin-ore on some islands of the Riouw Archipelago (2). He established that the greater part of Karimon consists of granite and some protogene and a rock apparently a greisen. With the exception of quaternary deposits there are no sediments. As the rich tin-ore deposits of Banka are mostly found in sediments, he supposed that Karimon would prove to be poor in tin.

The more extensive report of A. CHR. D. BOTHÉ (1, 3) is based on observations by BOTHÉ, BOERS, DE KROES and LOTH. W. F. GISOLF determined the rocksamples. He concluded that the surface of Karimon has cut the upper part of a granite-batholith, consisting of granites, biotite-, aplitic biotite-, and tourmaline-granites and also of greisen. Sediments are found on the N.E. part of Karimon and on Karimon Anak. They are strongly contact-metamorphic slates, quartzites, cherts, conglomerates and limestones, enclosed as roofpendants in the granite. Possibly the contact-metamorphic limestones of Malarco are of the same age as the Raub Series of Malaya (Carboniferous).

According to ROGGEVEEN (in his Reports), the oldest formation is formed by the schistose hornblende-schists of P. Temblas and the amphibolitic rocks of P. Merak and Tandjong Malolo, which are probably synchronous with these schists. The rocks of P. Merak have been injected by granitic rocks (pegmatites, aplitic graphic granites etc.). He considers the rocks of Temblas as regionally metamorphosed sediments; the amphibolitic rocks of Merak and Tg. Malolo probably, according to him, belong to the same sediment-formation; they have been metamorphosed by the Karimon-granite.

The determination of the samples taught us, however, that all these rocks are not of para-, but of ortho-nature. Gabbros, altered gabbros and diallagites with their metamorphics could be distinguished. ROGGEVEEN's granitic injections proved to be gabbro-aplites and plagi-aplites.

As sediments, following in age on the amphibolites, ROGGEVEEN regards the strong contact-metamorphic calcareous and argillaceous sediments of Karimon Anak and Malarco. He places them in the Carboniferous, for their resemblance with the carboniferous limestones of Malaya. The only fossil found (Malarco) is a not determined coral. At Karimon Anak the sediments are changed contact-metamorphically by the granite into calc-silicatehornfelses. The contactzone is parallel to the strike of the sidements (N. 90 E., 13 N.). At Malarco these rocks occur as inclusions in a formation, called by ROGGEVEEN microgranite.

A sediment-formation that is probably triassic, on the base of fossile-finds in Malaya in a similar formation, is found on Karimon at the surroundings of Tg. Sebatak and at Malarco. The rocks of Tg. Sebatak are argillaceous and sandy; they are strongly weathered and show lateritization. Their strike is parallel to the coast. The contact with the granite is nowhere disclosed. The sediments of Malarco, the samples of which are lacking in our collection, are described as grey sandy shales with a general strike N. 160 E., dipping 27° to the W. They have not been changed by the microgranite, which occurs in the direct neighbourhood. ROGGEVEEN regards these sediments as older than the micro-granite, because they occur in a topographic lower level than the surrounding rocks.

Post-triassic are the granites of these islands. The granite of Karimon and Karimon Anak consists of a biotite-granite of medium grain. At Karimon Anak a fine-grained porphyritic variety is also found. Basic differentiations have not been observed by ROGGEVEEN. The samples show us, however, that the rocks of Semamal and Semampang are altered quartz-diorites. We suppose, that they are probably a part of the marginal area of the granite-batholith. At different places aplitic complexes have been found (e.g. N. and S. of Semamal and N. Karimon). Aplite-veins are common in the granite (e.g. N. of Semamal and P. Moedoe). Sometimes the aplite-veins contain tourmaline, fluorite and sulphidic ore. Pegmatites and pneumatolytic rocks have also been found in the granites. At some places nests of quartz, tourmaline and muscovite occur (e.g. N. Karimon, Karimon Anak at the sediment-contact and S. of Semamal). Greisen is found at Upper Pelambong and S. of the Boekit Djantan.

The peninsula of Malarco and Karimon Anak partly consist of a micrograníte with many inclusions of different origin. They are at Malarco porphyritic eruptives and contact-metamorphic ? carboniferous sediments, as mentioned above. Sometimes the inclusions show an arrangement parallel to the tectonic direction: the micrograníte has possibly intruded according to the bedding, changing the sediments into exogeneous inclusions. BOTHÉ thought these micrograntes to be the roof-breccia of the batholith; ROGGEVEEN supposed them to be a post-granitic intrusion.

Determination of these micrograntes showed, however, that they are quartzporphyrites and fine-grained tuffs, up to agglomeratic tuffs of quartzporphyritic composition, with inclusions of metamorphic limestones at Malarco. Some of these rocks show pneumatolytic alteration: they contain many small tourmaline crystals. Therefore they may be regarded as older than the granite.

Description of rocks.

1. *The basic plutonic rocks with their veins and metamorphics, from P. Merak, P. Temblas and Tg. Malolo.*

1a. *Amphibole-gabbros, amphibole-saussurite-gabbros and their veins* (215—220, 245—252, 455, 457, 462, 463, 495—503, 505—508, 615—617) [1].

This group contains fine-grained dark rocks and coarser grained darkgreen and white spotted rocks with large dull-grey parts and light-coloured veins. Microscopically there is, with exception of their crystal-size, no difference. They are holocrystalline, hypidiomorphic rocks, with as main constituents a basic plagioclase and amphibole, which alternate quite irregularly.

The plagioclase is always labradorite or labradorite-bytownite; the crystals are hypidiomorphic, broadly prismatic and sometimes allotriomorphic. There is often polysynthetic twinning; in many crystals the twinning-lamellae wedge out and crystals without twinning are also seen. The felspars are often bordered by a corona of very small light-green amphibole needles, which also occur as numerous inclusions in the felspar. Only exceptionally the felspar has been decomposed into sericite and kaolin; the most frequent alteration being saussuritization. Many felspars are clouded with zoisite-epidote grains, and some parts of the rocks — the macroscopically grey parts — contain only saussurite, with rare secondary quartz between the grains.

The amphibole is a green to lightgreen feebly pleochroitic variety. It appears in prismatic hypidiomorphic crystals, most of them badly terminated, and also in small needles and fibrous complexes. The larger crystals often contain inclusions of magnetite. A more

[1]) The numbers of the samples correspond with those of the year-catalogue of 1941 of the "Min.-Geol. Inst." at Utrecht and with those of the map.

dark-green and strongly pleochroitic variety occurs in small veinlets in 220 and 616.

Apatite and zircon are accessories.

In 217, 220, 249, 250, 455, 498 and 507 we observe cataclastic phenomena. The felspars are crushed or the lamellation is bent; so is the amphibole.

It is evident that most of the gabbros are somewhat altered and it is sometimes difficult to state whether the rock is a gabbro or an amphibolite.

In 218 phillipsite occurs, crystallized in small fissures.

A vein of gabbro-aplite occurs in 508. It consists of andesine in hypidiomorphic crystals, some allotriomorphic quartz and some amphibole in needles and prisms; saussuritization is rather strong. The veins in 245 and 251 are plagi-aplites with quartz. The main constituent minerals are quartz in often strongly crushed grains and albite in better formed crystals, also often crushed or with bent lamellation. Amphibole needles as well as epidote and saussurite occur in small amounts.

The samples 223, 224, 227, 229, 234, 456, 509, and 510 are greyish-greenish rocks. They consist of irregular shaped quartz, in mozaic-like complexes and often strongly crushed and of felspar, which is mostly albite, with and without twinning and rather clear; in few cases there occurs oligoclase. Zoisite is very abundant in large crystals and as a component of granular complexes; amphibole is rare. In 227 and 509 there occur large rock inclusions, consisting wholly of amphibole crystals; they are regarded as altered inclusions of the bordering gabbro. All these quartz-albite-zoisite rocks probably are altered plagi-aplites, or, when there occurs much zoisite, strongly decomposed gabbro-aplites.

221, 222, 225, 226, 230, 231 and 238 are amphibolitic rocks. The configuration of the amphibole and felspar (a labradorite) is not gabbro-like. The minerals group together and the amphibole crystals are much larger than in the gabbros. The felspar has for the greater part changed into saussurite; secondary albite occurs between the zoisite grains. Because of their mineral composition and their occurrence together with gabbros and changed gabbros, it is almost certain that these rocks are ex-gabbros.

1b. *Uralite-diallagites* (228, 232, 233, 241, 504, 505).

These rocks are dark-green and wholly built up by large crystals. Microscopically they consist of large diallage crystals, prismatic, with distinct rectangular cleavage and feeble pleochroism. They are strongly uralitized, whole parts are changed into green amphibole and sometimes into actinolite. The uralitization starts at the terminal ends of the crystals and there often remains a core of unchanged diallage. Inclusions of many small grains of titaniferous ore are situated in the directions of cleavage. There occur also small amounts of sulphidic ore.

1c. *Amphibole- and actinolite schists* (235—237, 239—244).

The only constituent of these rocks is a green, pleochroitic amphibole, in large tabular crystals, with inclusions of magnetite and in fibrous complexes. Instead of amphibole feebly coloured actinolite may occur, often in fine, nephritic aggregates (239, 241, 244). Between the amphibole or actinolite there is a small amount of zoisite grains; in 237 zoisite occurs in a veinlet.

It is very probable that these rocks are metamorphosed diallagites.

1d. *Schistose amphibolites* (606—613).

These dark-green rocks are schistose and some are finely foliated (608, 610). Microscopically the schistosity is clearly pronounced by the parallel orientation of the minerals.

Between long prisms and needles of a dark-green pleochroitic amphibole, there occur small zones with orientated clear albite crystals, without twinning, and some quartz grains. If the amphibole occurs in larger crystals, they are often broken. Zoisite and epidote grains are also distributed in parallel zones (608, 609, 613). In 610 there occur saussurite and kaolin. In all rocks there are small grains of sphene and ore. In 607, 612, and 613 veins are cutting through the schistosity, containing albite, quartz, chlorite and zoisite.

It is very probable, that these rocks are ex-gabbros, changed by regional metamorphosis in the meso-zone.

2. *Contact-metamorphic ? carboniferous sediments from the granite-contact.*

2a. *Calc-silicate-hornfelses, all from Karimon Anak* (363—372, 377, 379, 398).

These rocks are well stratified. Different layers are to be distinguished: *a*) green bands with columnar crystals and round grains, *b*) blue-grey compact layers, which contain a sulphidic ore, c) light-coloured, pink, hard bands, consisting of pink grains with a lustre of glass, situated in a light-coloured groundmass. Microscopically the bounderies of the bands are not sharp.

The pink layers of the rocks mainly consist of garnet (grossularite), mostly in not well-bounded complexes. Among the garnet-groups and as inclusions wollastonite occurs; the crystals are small and twinned. Prehnite is found just like wollastonite. A little calcite and some grains of quartz are lying among the garnets. Besides garnet, several rock-samples contain vesuvianite, sometimes typical zonal. The garnet-complexes contain grains with high-refraction, undeterminable. Some samples show some Mg-diopside.

The components of the green-coloured layers are variable. Most of the samples (371, 363, 365, 369, 377, 379) contain vesuvianite, showing anomalous interference colours and sometimes beautiful zoning (365). On the other hand 378 contains some xenomorphic quartz crystals, besides prehnite. The sample 368 shows a groundmass of wollastonite, which is often twinned, enclosing rounded grains of garnet. Other rock-samples contain garnet, wollastonite, prehnite, calcite and quartz in variable quantities.

The compact blue-grey layers (364, 372) mainly consist of wollastonite and prehnite, and small quantities of quartz, garnet, calcite and ore grains. The sample 370 mainly contains calcite with mosaic- and partly interlocked structures. Moreover garnet, vesuvianite, quartz and ore occur.

2b. *Hornfelses with prehnite, wollastonite and garnet, from Karimon Anak* (373, 374).

These are dark-grey, finely-stratified rocks, consisting for the greater part of a finely-crystalline groundmass, composed of quartz and an acid, lath-shaped felspar. Some layers contain prehnite and wollastonite; others are composed of garnet with inclusions, prehnite, wollastonite and undeterminable grains with high-refraction. Further sericite, sulphidic ore and epidote occur.

2c. *Mica-hornfelses, all from Karimon Anak* (375, 376, 378).

Compact stratified rocks, consisting of small quartz-grains, acid lathshaped felspar and sericite. In small quantities muscovite, chlorite, sulphidic ore and limonite have been found. Accessories: apatite-needles.

3. *? Triassic rocks from Tg. Sebatak, S. from Kasiabang, P. Assan and P. Temblas* (451, 494, 603, 604, 614).

In his Reports ROGGEVEEN mentions the occurrence of Trias in a small outcrop from S. Malarco and from S.E. Karimon (Tg. Sebatak). From the first locality there are no samples in his collection. From the second locality there are two samples (451 and 604). 604 is a strongly limonitized and hydrargillitized rock, which contains large crystals of quartz, giving the impression of phenocrysts, and hydargillite-complexes, which may be pseudomorphic after felspar. The rock is probably an altered quartzporphyritic tuff. 451 is a strongly limonitized rock with many splinters and grains of quartz. It is possible that the quartzs are porphyritic ones, but this is much less certain than in 604. We may call the rock a limonitequartz sandstone.

The character of these rocks does not at all prove that they are of triassič age. It may be that they belong to the tuffs of E. Karimon, which will be described afterwards.

In the collection there are two rounded pebbles from P. Temblas (494, 614), which are very similar to the graywacke sandstones of propably triassic age from Soegi [1]). They contain as clastic grains: quartz (often cataclastic), quartzite, ? chert and sericitized fragments; moreover rare felspars. They contain veins with sericite; the rocks therefore must have undergone sericitization.

One sample, seemingly from an outcrop at P. Assan (603) is a limonitic quartz-sandstone; the clastic components are quartz and muscovite. On the map only granite has been indicated at this locality.

[1]) These Proceedings, XLIV, 1941, p. 1223.

4. *Quartzporphyrites and quartzporphyrite-tuffs, more or less contact-metamorphic, from Karimon Anak, Malarco and Tg. Batoe Besar* (361, 362, 385—388, 391—393, 396, 397, 399—415, 417, 431, 443—445).

These rocks are both macroscopically and microscopically very variable. The general characteristics are often dimmed by secondary processes, which almost certainly are due to contact-metamorphosis.

4a. *Quartz-porphyrites* (392, 393, 400, 408, 415, 425, 426, 430, 431).

These rocks consist of a groundmass, containing very fine grained quartz and very small, undeterminable felspars and distinct phenocrysts of quartz and plagioclase. The quartz-phenocrysts are clear, hypidiomorphic and often strongly corroded. The felspar, in more or less idiomorphic crystals, often with lamellar twinning, has a composition ranging from albite-oligoclase to oligoclase. Silicification of the groundmass and sometimes also of the felspar-phenocrysts occurs in the samples 400, 408, 415, 425, 426, 430, and 431. In 426 there are no quartz-phenocrysts, whereas the rock is prehnitized and epidotized. 392 and 393 contain also prehnite and epidote; they are in contact with a "quartz-prehnite-hornfels": a dark, fine-grained rock, containing quartz-grains, rather many prehnite-strings and some calcite. These hornfelses are probably metamorphic, fine grained tuffs. 408 is pneumatolytically altered: numerous small tourmaline-crystals and sometimes a tourmaline-sun occur in the groundmass. Epidote, zoisite, calcite and apatite are accessories.

4b. *Quartzporphyrite-tuffs.*

These tuffs show microscopically rather strong variation with regard to structure and composition. They range from a very fine recrystallized ash-tuff (414) to crystal-tuffs (401, 402, 404, 406) and pass gradually, with the strong increase of rock-fragments and decrease of "groundmass" into coarse agglomeratic tuffs (361, 362, 443, 444, 445).

The "groundmass" consists always of fine grained quartz and felspar. At the side of this "groundmass" occur many larger fragments of quartz and plagioclase. The quartz is clear and the form of the fragments is angular: they are splinters of phenocrysts. The felspar is hypidiomorphic and most times strongly sericitized and epidotized; the composition varies from albite to albite-oligoclase. The rock-fragments are almost always of quartzporphyritic composition: a groundmass containing plagioclase-laths and quartz, with quartz and albite-oligoclase phenocrysts. Sometimes there occur fragments of a strongly silicified groundmass or wholly epidotized fragments. In 443 a xenolithic quartzite fragment (!) has been found. Silicification of the "groundmass", the felspar-fragments and the rock-fragments is often observed. This is prominent in the samples 385, 386, 397, 399, 405, 406, 413, 426, 428, 430. The felspar of the "groundmass" has disappeared, whereas at some places the "groundmass" becomes quartzitic; the felspar-fragments and the plagioclase-phenocrysts of the rock-fragments change into fine-grained quartz, but preserve their primary form. Sometimes there is a rather strong prehnitization of the rocks. This is very evident in 387, 388, and 426. Secondary prehnite crystals are scattered throughout the whole "groundmass"; they too occur grouped together and form rather large complexes; they are accompanied by epidote-zoisite, some diopside, scarce wollastonite and calcite. Actinolitization is seen in 444, 445 and 361. The actinolite has crystallized in small needles and sometimes there occur nests, containing larger crystals. 401, 404, 406 and 444 have been pneumatolytically changed. Throughout the whole "groundmass" many small tourmaline-crystals and needles are found. 428 is biotitized, whereas 427 and 428 contain small chlorite crystals. In almost all the samples there is some secondary epidote-zoisite. Magnetite, sulphidic ore, apatite, zircon and some sphene-grains are accessories.

A typical group is formed by the tuffs of E. Malarco, Karimon (407, 409—413, 417—421 and 423). With the naked eye we can already distinguish large inclusions of crystalline limestone, bordered by a green mineral. The limestone has been changed into epidote-marble: large irregular calcite crystals, between which occur many epidote grains, diopside, prehnite, wollastonite, quartz and a dark-green strongly pleochroitic amphibole. 420 is an inclusion, wholly formed of large prismatic wollastonite crystals with anomalous garnet (grossularite) and other contact-minerals. All these limestone-inclusions are bordered by a reaction-zone, containing dark-green, pleochroitic amphibole, in prisms and needles. Prehnite occurs in large allotriomorphic crystals. At some distance of the contact with the limestone, we see the ordinary tuff-configuration, but there remains always a little calcite, amphibole and prehnite, scattered through the slide.

5. *Granitic rocks from Karimon, Karimon Anak, P. Moedoe, P. Assan and P. Tengkorak.*

5a. *Granites* (180, 183, 186, 380—382, 384, 389, 390, 394, 395, 424, 442, 448, 450, 452, 454, 458, 465, 466, 472, 475, 479, 481—487, 493, 587—590, 595—600, 602, 605, 657—659, 662, 663).

The samples of these light-coloured rocks show a varying grain-diameter. The texture of 658 is porphyritic; 383, 466 and 590 show pegmatitic intercalations. Clear quartz, white felspar and dark mica are macroscopically visible. Microscopically the greater part of the rocks prove to be biotite-granites and their aplitic varieties. Beside them, bi-mica granites (454, 482) and a number of aplitic granites occur. The rocks mainly consist of quartz, orthoclase, biotite and in some samples a small quantity of muscovite. Quartz shows xenomorphic development, with undulatory extinction and cataclastic zones. In a number of rock-samples graphic intergrowths with orthoclase have been found (381, 383, 390, 395, 398, 483, 493, 587—589, 596, 597, 663). Orthoclase generally forms large crystals, often with perthitic textures. Sericitization occurs in many cases. Plagioclase (albite up to albite-oligoclase) appears as small crystals with twinning lamellae which are sometimes bent. Biotite, in green, frequently bent crystals, is often bleached and transformed into chlorite. Accessories: apatite, zoisite, zircon and leucoxene. A number of rock-samples are stressed (180, 442, 454, 479, 483, 486, 487). The features are: cataclastic quartz and bent crystals of plagioclase and dark mica. A part of the samples contain pneumatolytic minerals: fluorite, in grains and complexes (450, 454, 479, 481, 483, 485, 587, 595, 598—600, 602, 659), topaz (390, 479, 481, 483, 598, 658), tourmaline (481, 484, 485, 596, 598, 599, 605), cassiterite (481, 596). At the contact between the biotite-granite and hornfels (380—382, 395, 663), the crystals become smaller and are orientated perpendiculary to the contact.

5b. *Granite aplites* (183, 184, 188, 375, 435, 438, 441, 449, 453, 457, 461, 464, 473, 474, 476, 480, 488, 591—594, 601, 660, 661).

Light-coloured, fine-grained rocks, sometimes with pegmatitic intercalations (474, 476) and with a porphyritic texture (461). The composition of these rocks is quite the same as that of the granite, only the quantity of the biotite is smaller. Most of the samples are a little stressed (quartz with undulatory extinction). A number of these rocks contain pneumatolytic minerals: fluorite (441, 473, 474, 476, 480, 488), topaz (188), tourmaline (473, 599, 661). One of the samples (488) shows a transition between a granite aplite and a mica-quartz rock (both with fluorite).

5c. *Granite pegmatites* (191, 465, 475, 489, 662).

They contain the same minerals as the granite, with the exception of biotite. In a few samples muscovite is found, others show a strong kaolinization (191, 489). Some rocks contain pneumatolytic minerals: tourmaline (191), fluorite (475).

5d. *Greisen* (185, 187, 189, 190, 192, 193, 432, 434, 437, 446, 447, 477, 492, 511).

They are to be distinguished after the composition into:

a) *Mica-greisen* (192, 434, 477, 492). Light-coloured, coarse-grained rocks, consisting of clear quartz-grains lying in a white powder-like mass, besides of muscovite. Quartz occurs in large xenomorphic crystals, mostly with an undulatory extinction and also in little grains. Further occur muscovite in little scales and biotite (434). Fluorite is found in some quartz-grains (477, 492). Accessories: magnetite, zircon and topaz (434).

b) *Topaz-greisen* (185, 187, 437, 511). Light-yellow, coarse-crystalline rocks. Quartz and black ore are macroscopically visible. Large xenomorphic quartz crystals often show undulatory extinction. Further, accumulations of small topaz-grains and colourless mica-scales as inclusions in quartz, and topaz occur. The crystals of the mica are often bent. Ore and limonite are present in different quantities. Accessories: tourmaline, biotite and cassiterite.

c) *Tourmaline-greisen* (189, 190, 193, 432, 446, 447). Hexagonal tourmaline-columns, pleochroitic and sometimes with zonal arrangement, occur in varying quantities. Moreover the rocks contain quartz, a small amount of colourless mica, fluorite (189, 190), topaz (432, 447), cassiterite (189, 432) and felspar-fragments (447).

5e. *Tourmaline-mica-rock* (478).

The rock-sample is mainly composed of dark columnar tourmaline and much scaly and radiated mica. Further we find green chlorite and limonite.

5f. *Mica-rock with tourmaline* (440).

This sample mainly consists of mica. Besides, tourmaline-columns and some quartz-grains occur.

5g. *Quartz diorites* (467, 468, 470, 471).

Strongly-weathered, grey-green, coarse-grained rocks. They consist of allotriomorphic to hypidiomorphic plagioclase (albite up to albite-oligoclase). Twinning lamellae are badly developed and the crystals are usually broken. The felspar is often chloritized and sericitized. The second main constituent is chlorite, in large, compact, green, fine-grained complexes. A little quartz with undulatory extinction has been found. All the samples contain fluorite in different quantities and 468 biotite. Sericite occurs in strings; further a small amount of zircon, magnetite and limonite appears.

5h. *Quartz with fluorite* (490).

Consists of large, interlocked quartz-grains and aggregates of small grains. The second constituent is formed by fluorite, the crystals show a good cleavage. Further in small quantities limonite and muscovite.

5i. *Brecciated quartz-rock* (433).

The rock mainly consists of large, mostly broken and small angular quartz crystals. At some places zonal structures have been found. Also a little limonite and sericite occur.

SUMMARY.

The metamorphic basic igneous rocks of Tg. Malolo, Kasiabang, P. Merak and P. Temblas probably belong to the oldest formation. Their schistosity at P. Temblas and their minerals point to metamorphic alteration in the meso-zone.

The strongly contact-metamorphically altered limestones on Karimon Anak resemble the carboniferous rocks of the Raub Series on Malaya. To the same formation probably belong the inclusions in the effusives at Malarco. Similar inclusions may have existed in the tuffs of Karimon Anak; they may have been resorbed by following contact-metamorphosis by the granite. This process would explain the abundance of prehnite in these tuffs.

Most probably the quartzporphyrites and their tuffs on Karimon Anak and Malarco, called by ROGGEVEEN microgranites, are of prae-granitic age: they have been contact-metamorphically and pneumatolytically altered by the granite. The effusives contain at Malarco the above mentioned inclusions of ? carboniferous rocks. These porphyrites and

tuffs resemble components of the Pahang Volcanic Series; accordingly, their age may be carboniferous to triassic.

We feel not at all sure that the rocks regarded by ROGGEVEEN as triassic, indeed belong to that formation. The only rocks of any importance we could study, were the limonitized sandstones from Tg. Sebatak, which possibly are altered tuffs.

The granite of the islands in the Riouw Archipelago is regarded to be of post-triassic age; although nowhere a contact with the triassic sediments is exposed, the granite of Karimon may be of the same age. The batholith is composed of feebly-stressed biotite-granite, with aplitic- and pegmatitic varieties. All over the island pneumatolytic alterations of the granite (formation of greisen and the occurrence of tourmaline, topaz, fluorite and cassiterite) are observed.

LITERATURE.

1. A. CHR. D. BOTHÉ, Geologische verkenningen in den Riouw-Lingga Archipel en de eilandengroep der Poelau Toedjoeh (Anambas- en Natoena-eilanden). Jaarboek van het Mijnwezen in N.O.I., 1925, Verh. II, page 101—152 (published in 1927).
2. R. EVERWIJN, Verslag van een onderzoek naar tinerts op eenige eilanden behoorende tot de residentie Riouw. Jaarboek van het Mijnwezen in N.O.I., 1872, Deel 2, page 72—123.
3. A. CHR. D. BOTHÉ, Het voorkomen van tinerts in den Riau Archipel en op de eilandengroep van Poelau Toedjoe (Anambas- en Natoena-eilanden). Verslagen en Mededeelingen van den Dienst van den Mijnbouw, No. **18**, 1925.


GEOLOGICAL SKETCHMAP OF KARIMON.
Granitic Rocks.
Sediments, ?Triassic.
Quartzporphyrites and their Tuffs, partly contactmetamorphic.
Contactmetamorphic ?Carboniferous sediments.
Basic plutonic rocks with their veins and metamorphics.
0 1 2 3 4 5 Km.
N
KARIMON ANAK
MALARCO
ASSAN
TENGKORAK
MOEDOE
S. PELAMBONG
Bt. DJANTAN
SEMAMAL
Tg. BATOE BESÀR
S. BATI
Tg. SEBATAK
KARIMON
SEMAMPANG
Tg. MALOLO
KASIABANG
MERAK
TEMBLAS