Geology. — *Contribution to the petrography of Bintan (Riouw-Lingga Archipelago).*

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The Billiton Mij. donated to the "Geologisch-Mineralogisch Instituut" of Utrecht, Holland, a collection of rocks and the reports of Dr. P. M. ROGGEVEEN, who, in 1930, made geological investigations on several islands of the Riouw-Lingga Archipelago. The material from Bintan and surrounding islands has been examined by the authors.

Historic review.

EVERWIJN (lit. 3) already noticed that plutonic rocks seem to dominate in the N part of Bintan. The mountain Bt. Bintan Besar consists of a fine grained diorite, while several hills along the coast and in the inland generally are built up by very coarse grained granite. Iron ore is widespread; it occurs partly as a fine-grained magnetical sand in all the valleys, partly in large quantities as brown iron ore.

BOTHÉ (lit. 1, 2) states that a biotite granite, sometimes containing amphibole occupies important parts of the island. From the Bt. Batoe Besar and G. Lengkoeas he mentions alcaligraniteporphyry, and from Bt. Bintan Besar diorite, which he considers to be differentiates of the granitic magma. GISOLF (in BOTHÉ 2) is of the opinion that the granite of Bintan forms the top of a batholith. LOTH (in BOTHÉ 2) distinguishes the Batam and Bintan type of granite, the former, from the western part, having flesh-coloured orthoclases and greenish plagioclases, the latter colourless felspars. BOTHÉ mentions diabase close to the granite on P. Boeau. Furthermore liparite (G. Kidjang) and black porphyries (G. Bintan Ketjil) occur, whose connection with the granite is still obscure. If they correspond with the eruptive rocks from the Pahang Volcanic Series, they are older than the granite. On the other hand quarzporphyries from Batam (Tering Bay) are considered to be younger than the granite, because they contain sharp-edged granite inclusions. BOTHÉ found pneumatolytic phenomena (tourmaline-greisen, probably with cassiterite) in the granite of the N coast of Bintan, P. Soempat, P. Ngiri and P. Ranggas. Unweathered sedimentary rocks are only exposed on a small scale, the greater part of Bintan being covered by rocks of bauxitic and limonitic composition. Fossils have not been found. The sediments belong to two formations. The older one is strongly folded and is built up by dynamometamorphic arenaceous and argillaceous rocks: phyllites, metamorphic liparite- and dacite-tuffs and quartz schists which are regarded by WESTERVELD (5) as triassic. According to BOTHÉ they have been intruded by the granite. The younger formation, which occurs only in the S and SW, is much less folded and consists of clay shales and sandstones with streaks of coal. They lie disconformably upon the older formation (Tg. Enim). BOTHÉ (2) states that the younger formation resembles the tertiary "Plateauzandsteen" of W Borneo.

ROGGEVEEN, in his report, mentions the existence of numerous inclusions in the granite between Tg. Tondang and Tg. Said, on P. Mantjin and on P. Noembing. At Tg. Gading and on P. Noembing dark granite is intruded by a lighter one. In contradiction with BOTHÉ's opinion, pneumatolysis is not important in the granite massive of N. Bintan, where, W of Pengoedang tourmaline is observed in the granite, nor is the NW part of Bintan rich in greisen. In SW Lobam the granite is traversed by lamprophyric dykes. The granites from Lengkoeas, N Boeton and Poto show transitions to quartzporphyritic rocks. BOTHÉ's opinion that rocks of Lengkoeas are alcalic is unestablished, as alcalic minerals do not occur. Only chemical analysis might confirm his opinion. Pneumatolytic phenomena do not occur in the granites of Lengkoeas, Boeton and Poto. Noembing and surrounding islands are built up exclusively by granite. On the E coast of Telang

a black quartzporphyritic rock has been found. Contactmetamorphic sediments of Pengoedang prove the granite to be younger than the sediments; there are no samples of this locality in our collection. ROGGEVEEN states that black quartzporphyries occupy the principal hills of Bintan (Bt. Bintan Besar, Bt. Bintan Ketjil and G. Kidjang); he did not find the diorite mentioned by former authors from Bt. Bintan Besar. Furthermore, black quartzporphyries are mentioned from the SW part of P. Mantang, E part of Telang Ketjil, SE part of Boeton and P. Mepoeroe. On the last two islands they occur together with granite. On P. Ranggas (S Bintan) strongly tourmalinized rocks occur. They might be altered quartzporphyries. ROGGEVEEN states that the geologic appearance of the quartzporphyries indicates a genetic connection with the granites. They form the highest tops in regions where the granite appears on a lower level. The granite shows transitions to the quartzporphyries which have a much more acid composition than the permocarboniferous porphyries of W. Batam and environs. Permocarboniferous sediments have not been found. This leads to the conclusion that the black quartzporphyries are probably the quickly cooled top of the granite massive. They may correspond with the black quarzporphyry of the Tering Bay (Batam) which, moreover, has the same habit.

ROGGEVEEN mentions slightly folded sand- and claystones from the SW part of Bintan and from the E part of P. Dompak; they contain thin coallayers with unrecognizable vegetable material. These rocks correspond with rocks from N Batam. On P. Seraja the same formation presents conglomeratic intercalations; the pebbles consist of arenaceous and siliceous material. It is a pity that these pebbles do not occur in our collection. On P. Los, Pangkil and S of Tg. Sebong white and grey-white sandstones were found. A formation with quite another habit is mentioned from P. Sekiri. It consists of argillaceous sandstones and sericiteshales. These rocks make the impression to be altered effusiva. This formation shows a great resemblance to the permocarboniferous of W Batam. ROGGEVEEN supposes that all the sand- and claystones of Bintan belong to one formation because the contactmetamorphics S of Pengoedang show low dips. This argument appears to us rather poor as BOTHÉ mentions the existence of an angular disconformity from one place in the S, whilst from other localities in the N high dips were reported.

Description of Rocks.

Among the abyssal rocks we can distinguish granitic, granodioritic and syenitic ones. We shall describe them separately.

The *granitic* type is represented by the following samples: 41, 42, 45, 46 from P. Noembing, 92, 94, 96, 101, 102, 105, 107, 108, 111 from P. Telang, 267, 271 from P. Mantjin, 515, 516 from Tg. Gading, 517, 518, 519, 520 from Tg. Tondang, 544, 545 from Tg. Bintan, 548, 549 from P. Ranggas (N Bintan), 551 from P. Marawang, 552, 553 from Tg. Said, 732 from P. Dompak. They are generally fresh, phanerocrystalline, leucocratic rocks, consisting of partly pink and green, partly grey to green felspars, quartz and biotite. Amphibole and muscovite may occur but biotite is the leading femic mineral. The slides consist chiefly of quartz and perthitic, sometimes sericitized orthoclase. Albite-oligoclase, always present, often shows twin lamelling and occasionally zoning structures. Biotite, sometimes bleached, is found in modest quantity, with zircon in pleochroitic haloes. Amphibole and muscovite occur in a few cases. Accessories are zircon, apatite and magnetite. The femic minerals are sometimes changed into an aggregate of chlorite and epidote. Fluorite and cassiterite give witness of pneumatolytic action. Generally the texture is hypidiomorphic, though, in 108, 266, 516, 517, 544, graphic textures were observed. Cataclastic phenomena are not rare: undulatory extinction of quartz, bent mica flakes and, in 105, a mylonitic zone. Summarizing we have mostly leucocratic biotite-granites, amphibole-biotite-granites and muscovite-biotite-granites. The two types of granite as described by BOTHÉ could be distinguished in our collection. It must be observed that 732 has been collected on P. Dompak, where ROGGEVEEN only indicates "sediment". Possibly sample 732 is a pebble from a conglomerate.

Grano-diorites: 86, 88, 97, 98, 99, 103, 104, 106 from P. Telang, 543 from Tg Bintan, 546 from S of Pengoedang, 557 from P. Soempat, 573, 574, 582 from P. Lobam. They are fresh, phanerocrystalline rocks, consisting of quartz and grey to green felspars. The slides are chiefly composed of quartz, mostly twinned albite-oligoclase, often sericitized, and of varying quantities of sometimes perthitic, sometimes sericitized orthoclase. Biotite and less amphibole are the dark constituents. Accessories are zircon, apatite, magnetite and leucoxene. Fluorite and cassiterite bear witness of pneumatolytic action. Beautiful graphic textures are widespread: sometimes the whole rock is micropegmatitic. We can subdivide the granodiorites into two transitional groups. The first group, occurring on P. Telang, generally has a propylitic habit, the femic constituents being converted into a mass of chlorite and epidote, the felspars getting dull. It is noticeable that the more important the graphic textures are, the more important is the change into chlorite and epidote. The second group, occurring in the N of Bintan, has a much fresher habit; chlorite and epidote are rare; graphic textures are not frequent. Cataclastic phenomena, as undulatory extinction of quartz and bent mica plates are not rare. A very remarkable feature was represented by 575, from Selat Kidjang, a granophyric rock, which has been completely replaced by hydrargillite. (Plate, fig. 3, 4.)

The *syenites* 266, 268, 269 and 270 are all from P. Mantjin, where they occur together with granite (267, 271). They are phanerocrystalline rocks, consisting of yellowish grey to brownish red felspars and dark-green amphibole. In the slides the principal constituent is a sometimes perthitic orthoclase. The amphibole is green, with unusually strong pleochroism from yellowish brown and green to very dark green. Anorthoclase occurs in a few grains, which show twin lamelling. Filling the spaces between the other constituents, albite-oligoclase occurs. The albite must have been crystallized after the orthoclase and sometimes apparently on the expense of it. This might point to hydrothermal origin. Nepheline and quartz are absent. Some dark green mica's occur. A rather great amount of pyrite is found. Accessories are apatite and zircon.

General review and details about contacts. The granites and granodiorites merge into each other; the granodiorites are poorer in orthoclase and show more graphic intergrowths. Clearly, these groups belong together. The occurrence of granites and syenites on P. Mantjin seems to prove that also the syenites are differentiates from a granitic magma. 557 from P. Soempat, N of Bintan shows a contact between a granodiorite and a quartzporphyrite: the first seems to be an inclusion in the second which, on the other hand, is metamorphosed, as minute secondary amphibole crystals, filling corrosion-cavities of quartz, occur. 111, from P. Telang is again a contact between a granite and a quartz-porphyrite, which contains a grain of tourmaline. 44, from P. Noembing, is a granite pegmatite with inclusions of granodioritic material. 46, from the same island is a granite with granodioritic parts. 94 from P. Telang shows a contact of a granodiorite merging into a rock composed of quartz, epidote, some garnet and large nests of magnetite.

Aplitic and pegmatitic dykes. 45, 48, 49 from P. Noembing and 89, 91, 109 from P. Telang are aplites. With the exception of 91, they show transitions into aplitic granites. They are grey-white to pink rocks with quartz, sometimes perthitic orthoclase and albite-oligoclase. The felspars are slightly sericitized. Accessories are biotite, zircon and magnetite. The occurrence of fluorite proves pneumatolytic action. Graphic textures are common. In 109 the aplite is an inclusion in a malchitic rock. In 91, a granodiorite aplite, albite-oligoclase is predominating. In this sample a fair amount of fluorite occurs.

Only two samples of granite pegmatite were at our disposal, 43 and 44, both from P. Noembing. They are coarse-grained rocks with grey-green felspar, quartz and biotite. The slides consist of quartz, perthitic orthoclase and some albite-oligoclase. The felspars are sometimes sericitized. Biotite, partly chloritized, occurs rather rarely. Accessories are apatite, zircon and magnetite. Some fluorite and pyrite occur. 43 shows graphic texture. 44 contains inclusions of granodiorite.

Graniteporphyry. 550, from P. Ranggas (N Bintan), is a light coloured rock with phenocrysts of quartz and felspar. The groundmass consists of orthoclase, albite-oligoclase and quartz. The texture is microgranitic. Phenocrysts of quartz, idiomorphic and corroded, of perthitic orthoclase, albite-oligoclase and biotite occur.

Granodioriteporphyrite. 90, from P. Telang, is a grey-pink rock with phenocrysts of quartz and felspar. The groundmass consists chiefly of lath-shaped felspars and quartz, showing micropegmatical intergrowth. Phenocrysts of felspar are albite-andesine with inclusions of epidote. Fluorite occurs locally. 579, 580 and 581 from G. Koe are transitional between granodioriteporphyrite and quartzporphyrite. Macroscopically they strongly resemble 90. Microscopically their groundmass appears to be finer grained. Beside quartz and albite-andesine, biotite phenocrysts, partly altered into magnetite and limonite occur. In 579 epidote and zoisite are found. Biotite is also found in the groundmass.

Rocks of "malchitic" composition from N Bintan. 518, 519, 552, 553, 554, 555. They are dark, greenish rocks, in which we can distinguish felspar, biotite and amphibole in about isometric grains. The slides consist of twinned oligoclase-andesine laths, sometimes more acid, of partly chloritized biotite and of less green amphibole. Quartz is accessorial. Where it occurs, it fills the spaces between the other minerals, in that case showing simultaneous extinction over large areas. Zircon, apatite and magnetite are accessorial. All these rocks are in some way connected with granitic rocks. 518 clearly shows the "malchite" to be an inclusion in the granite. As to the other rocks, we could not establish the connection with certainty; in one sample, however, inclusions of pegmatitic quartz-diorite occur within the "malchite". ROGGEVEEN mentions from the same area inclusions in the granite, rich in mica, which he considers to be resorbed parts of the roof of the batholith. We assume our rocks to be identical with these inclusions. In 552 in one place a very large quartz crystal is found, much larger than the phenocrysts of the "malchite". It is rounded and shows a reaction rim, formed by concentrations of amphibole and biotite, accompanied by apatite and titanite. The quartz contains some inclusions of irregular, sericitized felspar, which locally seems to have penetrated the quartz. 738 is a "malchite" from P. Dompak, which shows the same composition as the rocks described above. ROGGEVEEN in his map, indicates on P. Dompak only sediments and at locality 738 a conglomeratic sandstone. Possibly our sample is an element of this conglomerate, although its habit does not give the impression (compare granite 732).

The *malchite* 572 from P. Lobam differs from the foregoing samples. It is a dense, blue-black rock, which consists of weathered oligoclase-andesine laths, abundant amphibole, from small crystals to phenocrysts and some quartz. Zircon and many magnetite grains are accessorial. It differs from the foregoing in the content of quartz, the absence of biotite, the more weathered state and the more porphyritic texture. Moreover, it is treated apart as ROGGEVEEN indeed mentions lamprophyric dykes from P. Lobam, so, in this case we have to do with a real malchite. 81, 82, 84, 85, 87, malchites, from P. Telang are fine-grained, dark, blue-black rocks, which consist microscopically of a very fine-grained groundmass of quartz and abundant amphibole in small idiomorphic prisms and in irregular masses, and of albite-oligoclase. In this groundmass we find phenocrysts of quartz, ? albite-oligoclase and amphibole. The felspars are thoroughly silicified and kaolinized. A few grains of apatite occur. In one case (82), secondary quartz occurs in idiomorphic bipyramids. In 87 needleshaped amphibole and albite are found along joints. 84 shows a concentration of zoisite. With 84 a problem arises as to the nature of these malchites. Here we find angular very fine grained parts, practically without amphibole. We got the impression that we have to do with a tuff breccia in which the amphibole might have originated by contact metamorphism. On the other hand the facts that we find in five samples the amphibole in regular distribution and that 95, a quartzporphyrite, also from P. Telang, contains a malchitic vein, support our opinion that we have to do with true malchites. ROGGEVEEN's report only indicates black porphyries from this place.

Three samples of *greisens* (83, 100, 110) from P. Telang were found to be tourmaline greisens. They consist of abundant quartz, tourmaline and a colourless, spherulitic mica in varying proportions, a few grains of cassiterite and accessorial zircon. Topaz was not found. The transition from granite to greisen could be observed.

A *diabase*, (50) from P. Boeton is a blue-black aphanatic rock, which chiefly consists of sericitized albite laths. Here and there twinning was observed. The space between the felspars is occupied by tiny sericite flakes and ore grains. Accessories are zircon and abundant apatite. The rock might be a sericitized and albitized diabase.

Some samples consist principally of *ore*. 36 and 38 from P. Ranggas (S. Bintan) are manganite which, metasomatically, has replaced a quartzporphyrite. 735 from P. Dompak is magnetite with some limonite. 35 from P. Ranggas (S. Bintan) and 570 from P. Soempat are limonite.

558, 565, 567 from P. Soempat and 93 and 94 from P. Telang are *epidote rocks*. They consist chiefly of epidote, partly in idiomorphic crystals with good cleavage, partly in aggregates and of some quartz, which occupies the space between the epidote. 93 contains beside epidote and quartz rather much fluorite.

Quartzporphyries. 261 from P. Mantang and 547 from P. Ngiri. The first is a black rock with some phenocrysts, the second is light green (epidotisation). In the somewhat devitrified fluidal groundmass of 261 many small quartzsplinters, and corroded quartz- and felsparphenocrysts occur. The latter are partly sericitized or altered into epidote and chlorite. Perthitical orthoclase dominates among the felspars. Probably part of the epidote and chlorite is pseudomorphic after biotite. Some magnetite and titanite were observed. 547 is epidotized on a greater scale. The very clear and corroded quartzphenocrysts often are cataclastic and show undulatory extinction. The orthoclase and acid plagioclase phenocrysts are dusty. Epidote and zoisite are abundant.

Quartzporphyri(t)es. 29, 30, 31, 32, 33, 36, 37, 39, 40 from P. Ranggas (S. Bintan), 583, 584, 585 from Selat Kidjang, 713, 715, 718, 721, 722, 723, 724 from P. Sikiri, 714, 717, 719, 720, 725, 726, 727 from Bt. Manok. These, generally grey-white to pink rocks are very much altered. Microscopically the felspars appear to be altered to such a scale, that they can not be definitely determined. The less altered 31 and 32 have a groundmass of quartz, sericite and kaolin; the phenocrysts are corroded quartz and felspars, altered into sericite concentrations. Veinlets of secondary quartz indicate the beginning of silicification. This process is already advanced in 713, 715 and 721, the groundmass being silicified, while in 713 quartz is probably pseudomorphic after felspar. Sericitization is also found in 722, 723, 726. In some samples from P. Ranggas, tourmalinization occurs. In 33 the tourmaline appears in veins and in irregular masses; in 29, 30, 37 tourmalinization has advanced, and here even the felsparphenocrysts are partly tourmalinized. The tourmaline occasionally displays spherulitic textures. In 30 we observed idiomorphic quartz in a tourmaline veinlet. In 39 and 40 the tourmaline is clearly younger than the quartz, the latter being often surrounded by tourmaline aggregations. Many of these pink-coloured rocks show hydrargillitization, often accompanied by limonitization. Microscopically we see in 583, 584, 585 and 586 clear, corroded quartz and sometimes quartzsplinters in a hydrargillitized and limonitized groundmass. Beautiful lamelled hydrargillite often occurs in the quartz along many fissures and in corrosion-cavities. These remarkable features strongly point to hydrargillitization of the quartz (Pl., fig. 1, 2). Limonite concentrations, in 584 containing a felspar-relic, are pseudomorphic after felspar. 714, 717, 718, 719, 721, 722, 725, 727 and 731 are hydrargillitized quartzporphyri(t)es which contain less limonite than previous samples; felspars, here, have also been altered into hydrargillite.

Quartzporphyrites. 51 from P. Boeton, 262, 272, 274, 275 from Bt. Bintan Ketjil, 559, 560, 561, 562, 563, 564, 568, 569, from P. Soempat, 736 from P. Dompak. They are black and light-grey rocks. The groundmass is generally fine grained. The felsparphenocrysts (albite to andesine, partly replaced by epidote, chlorite and even amphibole) are sometimes sericitized, the quartzphenocrysts often corroded. Some orthoclase may occur. In 262, the groundmass is partly vitreous; fluidal texture occurs. The groundmass of the metamorphosed quartzporphyrites of P. Soempat (559, 560, 561, 562, 563, 568, 569) always contains epidote, sometimes biotite and often amphibole, which occurs also in large crystal-skeletons. Occasionally silicification occurs. In 569 amphibole occurs in veinlets; epidote and zoisite in large crystals. In 560 and 562 they form veinlets; 563 contains some

garnet. In 562 the quartzporphyrite is in contact with a dark rock, chiefly composed of brown and blue-greenish amphibole, epidote and zoisite. Approaching the contact the coloured minerals of the quartzporphyrite gain in importance. 564 is an albite rock, probably an altered quartzporphyrite, penetrated by an amphibole veinlet. 272, 274 and 275 are equally metamorphosed rocks rich in amphibole, in the groundmass arranged in streaks, while large crystals often occur together with epidote, titanite or biotite. They give the impression of having replaced felsparphenocrysts. Other ones have been replaced by sericite, calcite and epidote. Epidote and biotite, moreover, occur in the groundmass. 272 contains an inclusion of a silicified black porphyrite with veinlets, consisting of amphibole, epidote, quartz, biotite and felspar. 274 contains an inclusion of a fine grained quartzporphyrite with a vein, filled nearly exclusively with amphibole at the outside and epidote-zoisite in the centre.

Quartzporphyritical tuffs. 576, 577, 578 from P. Mepoeroe. They are metamorphosed rocks, containing components, which in their groundmass all show secondary biotite and amphibole, partly in crystal-skeletons, often arranged in streaks. Phenocrysts of quartz (strongly undulatory) and felspar are common. One component of the tuffs containing less phenocrysts, shows fine fluidal textures, another component consists of an intergrowth of acid felspar laths with amphibole.

Porphyrites. 263 and 264 from Bt. Bintan Besar are black porphyritic rocks, with devitrified and locally fluidal groundmass. Felspar (albite to andesine, often cataclastic, sericitized and sometimes with calcite) and amphibole (sometimes with titanite and epidote) are the phenocrysts. Magnetite, apatite, zircon and chlorite are accessories.

Hydrargillite-limonite rocks ("Bauxites"). Our collection contains different hydrargillite-limoniterocks, the original nature of which could not be stated: 730 from P. Dompak, 733 from the S of Pengoedang, 734 from Sengarang, 716 from P. Sikiri.

Sediments: Only five samples of sediments were available, all being of an arenaceous nature. It is a pity that so few samples have been collected. Without doubt this is caused by the fact that ROGGEVEEN's exploration was in the first place a prospection for tin; also the fact that exposures are rare has certainly influenced the number of samples. 729 from P. Dompak and 739 from an unknown locality are quartzitic arkoses, consisting of rounded, isometrical quartz grains, being partly cemented by silica. The rocks contain many rounded, brownish grains (probably ex-glauconite). 729 contains an inclusion of black shale and 739 of vegetable material. Some sericite concentrations (? ex-felspar) occur. Accessories are zircon and tourmaline. 276 from Bt. Bintan Ketjil is a quartz-sandstone made up of isometrical quartz grains, with a single prism of tourmaline, secondary biotite and possibly some amphibole. 556 from NW Bintan is a quartz-mylonite, consisting of great, strongly undulatory quartzes. In some places crushing has produced mosaic texture. The cement between the quartzes is locally triturated to a great extent. Some tourmaline grains occur. 728 from G. Manok (W Bintan) is a sericite quartzite, composed of isometric quartz grains and sericite. Secondary tourmaline (yellow to brown) occurs in many small prisms.

SUMMARY.

In connection with the facts, that samples are relatively scarce and the field notes of ROGGEVEEN were not available, a definite account of the age relations of the different rocks can not be given. We will review the petrographic units separately, at the end trying to establish their mutual relations. The intrusive rocks consist of granites and granodiorites, with their dykes, and syenites. The first two groups belong together, as they gradually merge into each other: epidotization, chloritization and graphic textures increasing to the basic side. They are accompanied by pegmatitic and aplitic dykes, and in one case by a malchite (P. Lobam). A granite porphyry from P. Ranggas (N Bintan) and a granodiorite porphyrite from P. Telang probably belong to the granites and granodiorites. The occurrence of syenites on P. Mantjin is remarkable, syenites being very

rare in the Netherlands East Indies. As they occur together with granites, they have probably been derived from the same magma. From N Bintan a couple of rocks of "malchitic" composition were examined, which were identified with the dark inclusions in the granite mentioned by ROGGEVEEN. On P. Telang malchitic rocks of an uncertain nature are found. A veinlet of malchite in a quartzporphyrite points to true dike rocks. On the other hand one of the malchites was built up by different components, thus pointing to a metamorphosed quartzporphyritic tuff. In one case a contact of a granite with a quartz-epidote-garnet rock was met with (P. Telang). An albitized and sericitized diabase has been sampled from P. Boeton. The effusive rocks show many varieties. We found quartzporphyries, quartzporphyrites and porphyrites. Occasionally they are strongly altered. Beside amphibolization, tourmalinization, epidotization and chloritization, also hydrargillization was observed. Some rocks, which consisted exclusively of hydrargillite, limonite and some quartz ("Bauxites") are probably thoroughly altered quartzporphyri(t)es. With regard to the hydrargillitization two remarkable facts have been found. Firstly hydrargillite-bearing solutions have apparently changed the quartz of quartzporphyri(t)es partly into hydrargillite (Pl., fig. 1, 2). Secondly the granophyric rock 575 has been completely changed into hydrargillite, the original nature of the rock being proved by its textural features (Pl., fig. 3, 4). Pneumatolytic phenomena were often met with in our material: fluorite was present in the intrusiva, three tourmaline greisens were found, and quartzporphyri(t)es from P. Ranggas show advanced tourmalinization. As to the connection between the granites and effusive rocks, facts seem to be contradictory. 1. On P. Soempat a quartzporphyrite, 557, contains an inclusion of granodiorite. On the other hand the quartzporphyrite was metamorphosed, which was shown by abundant small secondary amphiboles. 2. Quartzporphyri(t)es from P. Ranggas show advanced tourmalinization. 3. Amphibolized quartzporphyrites occur on Bt. Bintan Ketjil. 4. On P. Mepoeroe amphibolized quartzporphyritical tuffs were found. These facts lead to the following assumption. The quartzporphyrites contain homogeneous inclusions of an older granite and were afterwards metamorphosed. It is a pity that only five sediments were sampled. They were all of an arenaceous character, varying from quartzitic sandstones and arkoses to, in one case, a sericite quartzite with tourmaline. All contained some tourmaline. The relations between sediments and abyssal rocks still remain uncertain. According to our opinion the sediments may belong to two formations, two samples 728 and 276 are contactmetamorphic; they contain secondary tourmaline; 728 moreover secondary sericite and 276 secondary biotite and possibly amphibole. Two of the other samples, 729, 739 are rocks, which have originated from glauconitic arkoses. They have quite another habit than the foregoing samples. It is uncertain whether they are younger or older than the granite of our region; the tourmaline prisms of 729 may be authigeneous or clastic. Their value can only be judged at a time when ROGGEVEEN, now away from Europe, will be in the possibility to give more field evidence.

LITERATURE.

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J. J. HERMES and D. R. DE VLETTER: CONTRIBUTION TO THE PETROGRAPHY OF BINTAN (RIOUW-LINGGA ARCHIPELAGO).

Fig. 1. 20 ×
Parallel Nicols.

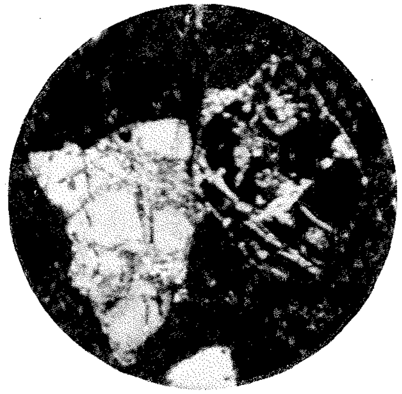


Fig. 2. 17 ×
Crossed Nicols.

Fig. 1, 2. Quartzporphyr(ite); no. 584, Selat Kidjang, S. Bintang. (Phenocrysts of quartz with veinlets of hydrargyllite).

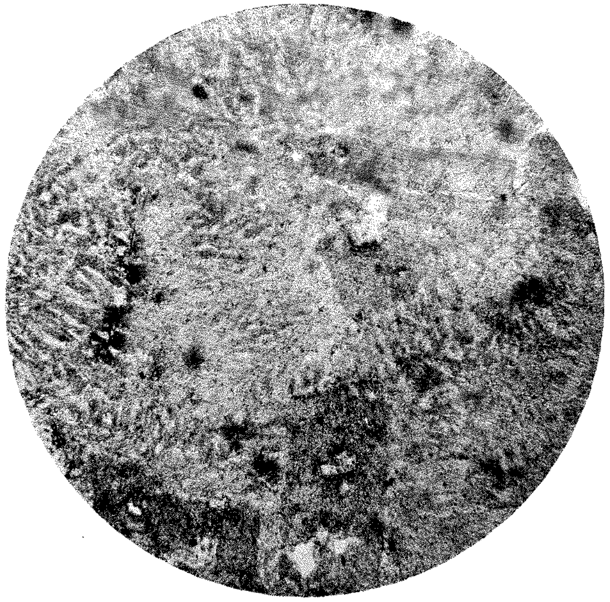


Fig. 3. 90 ×
Parallel Nicols.

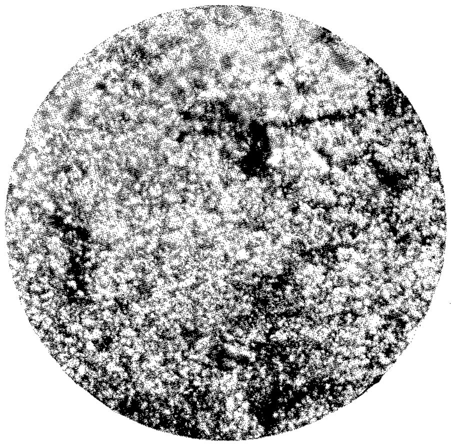
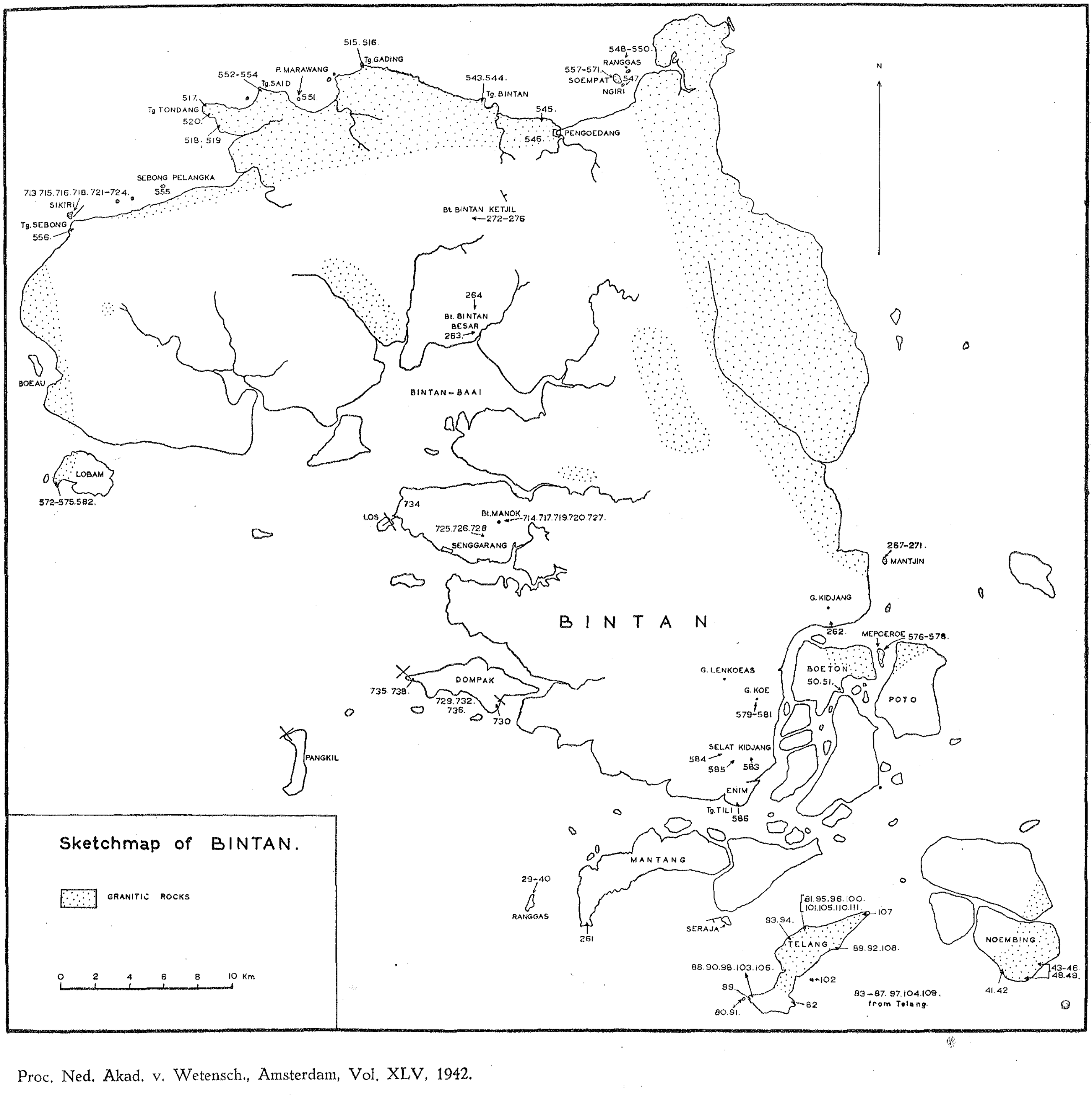


Fig. 4. 65 ×
Crossed Nicols.

Fig. 3, 4. Granophyric Rock, entirely hydrargyllitized. Selat Kidjang, SE Bintang.


Sketchmap of BINTAN.
GRANITIC ROCKS
0 2 4 6 8 10 Km
N
BINTAN
BINTAN-BAAI
Tg. GADING
P. MARAWANG
Tg. SAID
Tg. TONDANG
Tg. BINTAN
PENGOEDANG
RANGGAS
SOEMPAT
NGIRI
SEBONG PELANGKA
SIKIRI
Tg. SEBONG
Bt. BINTAN KETJIL
Bt. BINTAN BESAR
BOEAU
LOBAM
LOS
Bt. MANOK
SENGGARANG
DOMPAK
PANGKIL
G. KIDJANG
MANTJIN
MEPOEROE
BOETON
POTO
G. LENKOEAS
G. KOE
SELAT KIDJANG
ENIM
Tg. TILI
MANTANG
RANGGAS
SERAJA
TELANG
NOEMBING
from Telang.