# 23. *Preliminary Note on Basalt from Aziro, Idu.*

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## I. Introduction.

This paper forms a part of the report of my geological and petrological study of the volcanic district of north Idu, conducted under the auspice of the Earthquake Research Institute of the Imperial University of Tokyo. Here we are only concerned with a rock from Aziro. Special attention is directed to the occurrence of interstitial cristobalite in this rock, the composition of groundmass pyroxene and the contrast between the bulk composition of the rock and the composition of its groundmass.

My thanks are due to Professor Dr. Seitarô Tsuboi who has given me valuable suggestions and encouragements throughout the study.

## II. Petrography.

The rock specimen (51227) now in question was collected by Dr. Seitarô Tsuboi on the main road from Aziro to Itô, at the spot immediately south of Aziro, or 7 km. south of Atami. It constitutes one of the numerous thin lava flows associated with bedded alternation of volcanic ash, scoriae, lapilli and bombs, probably of the upper Tertiary or the lowermost Quaternary age, to which I have given the name "Aziro beds."

The series of lavas of Aziro beds were microscopically examined and two petrological types have been distinguished: olivine-augite-anorthite basalt and olivine-augite-hypersthene-bytownite basalt. The rock under consideration belongs to the latter type.

Megascopically the rock is gray, slightly vesicular, and carries phenocrysts of abundant whitish plagioclase and subordinate yellowish olivine, dark greenish augite and dark brownish hypersthene, each crystal being usually 1 mm. and sometimes up to 2 mm. in diameter.

Under the microscope, there are phenocrysts of plagioclase, olivine, augite and hypersthene, scattered through a fine-grained compact groundmass consisting of plagioclase, pigeonite, magnetite, pale brown glass and cristobalite. There is no sign of alteration. (Figs. 2 and 3.)

*Phenocrysts* :—

(a) Plagioclases are of two types, A and B. Plagioclase A is euhedral, short prismatic, broadly twinned according to Carlsbad and albite laws and is distinguished from plagioclase B by its larger size, generally 2 mm. in length and by having insensibly zoned calcic core surrounded by a strongly zoned thin sodic shell.

The most calcic part of the core has $n_1=1{\cdot}5798$,[1] corresponding to $Ab_1\ An_{99}$, while the average composition of the core as determined by observing $n_1$ of a great number of cleavage-flakes corresponds to $Ab_7\ An_{93}$. The most sodic part of the marginal shell has $\beta \fallingdotseq 1{\cdot}575$, corresponding to $Ab_{15}\ An_{85}$, as determined in thin section.[2] Consequently the bulk composition of the crystal is estimated as $Ab_8\ An_{92}$.

(b) Plagioclase B does not differ from A in any respects except of its smaller size, less than 1 mm. and of its marked zonal structure which is especially strong toward margin.

The most calcic part has $\beta \fallingdotseq 1{\cdot}580$ corresponding to $Ab_6\ An_{94}$ and the most sodic part of the margin $\beta \fallingdotseq 1{\cdot}568$ $Ab_{29}\ An_{71}$, as determined in thin section as before. The minimum value of $n_1$ on the cleavage-flakes including all kinds of plagioclase phenocrysts is determined as 1·5659, corresponding to $Ab_{29}\ An_{71}$ which coincides fairly well with the most sodic composition of the plagioclase B. Consequently its bulk composition is estimated as $Ab_{18}\ An_{82}$.

Both of the plagioclase phenocrysts are poor in inclusions except opaque glassy substance often elongated in rectangular form parallel to the elongation of the crystals and infrequent augite grains.

The plagioclase *B* may have been formed in a later generation than plagioclase A, probably under a condition where more rapid cooling prevailed.

(c) Olivine is most prominent among the porphyritic ferromagnesian minerals, forming slightly rounded crystal up to 1 mm. in diameter and surrounded by a thin rim of minute pyroxene grains of the groundmass. Frequently it is much resorbed and replaced by a thick aggregate of granular pyroxene.

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1) By $n_1$ of plagioclase is meant the lower refractive index on (010) or (001) cleavage-flake, determined by Tsuboi's dispersion method. S. TSUBOI, *Miner. Mag.*, 20 (1923), 108.

2) The actual method is as follows: a thin section of the rock was put in benzol for a day to wash away the balsam, then pasted upon a slide glass and examined by the ordinary immersion method.

The refractive index was measured on five crystals taken from the hand specimen:[3]

(1) $\alpha=1{\cdot}675$–$1{\cdot}679$ (2) $\alpha=1{\cdot}690$ (3) $\alpha=1{\cdot}690$ (4) $\alpha=1{\cdot}690$
(5) $\alpha=1{\cdot}689$

Composition range: $Fo_{80}\ Fa_{20}$—$Fo_{72}\ Fa_{28}$ (in mol. %)[4]

The average composition is estimated as $Fo_{73}\ Fa_{27}$. The olivine is colorless and almost free from inclusions. Only in one case, however, a prismatic hypersthene has been found included in olivine.

The pyroxene aggregate around olivine may deserve special mention. It forms either a simple rim with rounded outline, or when the resorption of olivine is more advanced, a coarser aggregate containing vermicular rods of iron ore which are radially disposed from the core of the aggregate but not reaching to its margin.

These pyroxenes are of monoclinic variety as far as observed, showing multiple twinning on (100) and resembling in size and habit to pigeonite occurring as microphenocryst, to be refered to later; while the optical examination reveals that only some of them are truely identical with the microphenocrystic pigeonite, and others with the porphyritic augite.

The measurements were made on two crystals in a single aggregate:

(1) $2V=51°$ (by the conoscope, assuming $\beta=1{\cdot}700$) $2V=51°$ (by the universal-stage), optical plane parallel to (010), optically positive.

(2) $2V=0°$ optically positive.

The measurements on the crystals of another aggregate gave also the same results as above.

(d) Augite is euhedral, short prismatic up to 2 mm. in length, twinned on (100) and free from inclusions except sporadic rounded olivine. It is slightly greenish without sensible pleochroism.

The refractive indices were measured on three crystals taken from the hand specimen:

(1) $n_1=1{\cdot}695$–$1{\cdot}696$ on (110) (2) $n_1=1{\cdot}693$–$1{\cdot}698$ on (110)
(3) $n_1=1{\cdot}693$–$1{\cdot}695$ on (110)

A slight zonal structure is discernible by the difference of extinction angle: $Z\wedge c$ on $(010)=42°$ in the margin,

3) The refractive indices of mafic minerals were determined by the ordinary immersion method, measuring $\alpha$ on (001) cleavage-flake for olivine and smaller refractive index $n_1$ on (110) cleavage-flake for pyroxenes.

4) The composition is estimated by Winchell's diagram; WINCHELL, *Optical Mineralogy*, Part II (1927), 168.

Z∧c on (010)=43° in the core.

The optic axial angle was measured on three crystals in the sections:

(1) 2V=51° (by the conoscope, assuming $\beta=1{\cdot}699$) 2V=49° (by the universal-stage)

(2) 2V=49° (by the universal-stage in a crystal with an inclusion of olivine)

(3) 2V=48° (by the universal-stage)

Optically positive, optic plane parallel to (010), the dispersion of optic axial angle insensible.

The values of the optic axial angle coincide with those for the augite found in the aggregate around olivine as well as with those for the augite pseudomorph after hypersthene, to be refered to later.

From the average values of the optical constants ($\beta=1{\cdot}699$ as estimated from $n_1$, 2V=50°) we have the approximate composition according to Barth's diagram[5]: $Wo_{35}En_{47}Fs_{18}$[6] (in mol. %)

(e) Hypersthene forms a prismatic euhedral crystal up to 1·5 mm. in length and is free from any inclusions, but is surrounded by a thin rim of minute monoclinic pyroxene of the groundmass. It is slightly pleochroic: Z=pale greenish, Y=pale brownish.

The refractive index was measured on three crystals taken from the hand specimen:

(1) $n_1=1{\cdot}687$–$1{\cdot}691$ on (110)

(2) $n_1=1{\cdot}688$–$1{\cdot}692$ on (110)

(3) $n_1=1{\cdot}689$–$1{\cdot}694$ on (110) (grouped phenocryst of hypersthene and augite)

Composition range: $En_{81}Fs_{19}$—$En_{77}Fs_{23}$[7] (in mol. %) Consequently the average composition is $En_{79}Fs_{21}$.

The optic axial angle as measured by the universal-stage in a crystal enclosed in olivine is as follows:

2V=80° optically negative, optic plane parallel to c-axis.

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5) T. F. W. Barth, *Amer. Jour. Sci.*, **21** (1931), 385. I have plotted several analysed augites from Japan containing sesquioxides and $TiO_2$ on his diagram and found that they have always slightly higher refractive indices than those expected in the diagram. Such a fact has been already noted by Winchell (*op. cit.*, p. 188) and it was taken in consideration in the present case for the estimation of the composition.

6) Fs is used here for the molecule $FeSiO_3$, according to the Washington's recent proposal of its use for the normative mineral. H. S. Washington, *Tsch. Miner. Petro. Mitt.*, **43** (1932), 63.

7) The composition was estimated by Tomida's diagram, though recalculated here in molecular percentage. T. Tomida, *Jour. Geol. Soc. Tokyo*, **31** (1924), 375.

Composition: $En_{78}Fs_{22}$, according to Winchell's diagram[8]

In a section there is found a closely packed aggregate of twinned augite, with an outline of a prismatic crystal and resembling in many respects to that forming the rim around olivine. It may be a pseudomorph of augite after hypersthene. This augite has 2V=49° (by the universal-stage) and is identical with the isolated porphyritic augite.

*Groundmass*:—

The groundmass is fine, compact and intergranular or intersertal in texture. The plagioclase crystals sometimes assume an indistinct fluidal arrangement, between which granules of pigeonite and magnetite occur. Minute interstices are filled with glass and cristobalite. Microphenocryst of pigeonite is a conspicuous feature of the groundmass.

(f) Plagioclase is euhedral, lath-shaped or short prismatic up to 0·1 mm. in length. The twinning and zonal structure are very common. It shows a range of refractive index from $\beta=1{\cdot}568$ to $\beta=1{\cdot}562$, corresponding to $Ab_{30}An_{70}$—$Ab_{42}An_{58}$, with the average composition estimated as $Ab_{37}An_{63}$.

(g) Pigeonite is of two types. Pigeonite A represents the microphenocryst with euhedral prismatic habit up to 0·2 mm. in length (Figs. 2 and 3.). Multiple twinning on (100) is common. It shows a weak pleochroism: Z=pale green X=Y=slightly brownish green. It is fairly uniaxial and positive in every crystal. $Z \wedge c$=40°–43° on (010)

It represents the early formed crystal in the effusive stage.

(h) Pigeonite B is very fine and granular or prismatic, occurring between plagioclase laths, and is too minute for precise determination, but the conoscopic examination shows that it has at least a small optic axial angle.

(i) Magnetite occurs as minute octahedral grain, commonly in association with pigeonite.

(j) Glass fills the interstices between other crystals and is pale brownish in color with the mean refractive index N=1·503, that is, slightly higher than that of the average rhyolite obsidian and pointing to a dacitic or trachytic composition.

(k) Cristobalite also fills the interstices and sometimes occurs as minute rounded patch about 0·1 mm. in diameter. It is clear and free from inclusion and easily distinguished from the glass by the presence of cleavages and characteristic twinning.

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8) WINCHELL, *op. cit.*, 177.

The rock may be called as hypersthene-bearing augite-olivine-bytownite basalt.

## III. Chemical Composition.

The result of chemical analysis of the rock by Mr. Senzaburo Tanaka of the Earthquake Research Institute of the Tokyo Imperial University is cited below. It is given in Table I, with the norm calculated from it.

Table I.

Chemical composition and norm of the basalt from Aziro, Idu. Hypersthene-bearing augite-olivine-bytownite basalt. S. Tanaka analyst.

| | | | | | |
|---|---|---|---|---|---|
| $SiO_2$ | 51·10 | Q | 6·48 | | |
| $Al_2O_3$ | 18·90 | Or | 1·67 | | |
| $Fe_2O_3$ | 3·56 | Ab | 17·82 | | |
| FeO | 6·52 | An | 41·14 | | |
| MgO | 5·03 | | | Wo | 4·87[9] |
| CaO | 10·80 | Di | 9·49 | En | 2·90 |
| $Na_2O$ | 2·14 | | | Fs | 1·72 |
| $K_2O$ | 0·32 | Hy | 15·64 | En | 9·70 |
| | | | | Fs | 5·94 |
| $H_2O+$ | 0·50 | | | | |
| $H_2O-$ | 0·28 | Mt | 5·34 | | |
| $TiO_2$ | 0·83 | Il | 1·52 | | |
| $P_2O_5$ | 0·13 | Ap | 0·34 | | |
| MnO | 0·13 | | | | |
| Total | 100·24 | | | | |

It must be noted that a considerable amount of excess silica is found in the norm in spite of a calcic composition of feldspar, and that the amount of normative feldspar exceeds that of mafic minerals. The rock has all the chemical and mineralogical characteristics of the common volcanic rocks of Japan, generally called pyroxene-andesite.[10]

## IV. Volumetry and Calculation of Mode.

The volume percentages of the constituent minerals were measured by means of the Leitz's "Integrationstisch," counting their liniar proportions in thin sections. The weight percentages, obtained by assuming proper specific gravities for these minerals, are shown in Table II.

9) The change of the calculation of norm after Barth and Washington.
T. F. W. BARTH, *Tsch. Miner. Petro. Mitt.*, 42 (1931), 1.
H. S. WASHINGTON, *op. cit.*
10) S. TSUBOI and H. KUNO, *Bull. Volcanological Soc. Japan*, 1 (1932), 20.

Table II.

The volume and weight percentages of the constituent minerals.

| minerals | | composition | volume % | sp. gr. | weight % |
|---|---|---|---|---|---|
| phenocryst | plagio. A. | $An_{92}$ | 9·2 | 2·7 | 8·3 |
| | plagio. B. | $An_{82}$ | 8·9 | 2·7 | 17·1 |
| | olivine | $Fa_{27}$(mol.) | 1·9 | 3·6 | 2·3 |
| | augite | $Wo_{35}En_{47}Fs_{18}$ (mol.) | 0·7 | 3·3 | 0·8 |
| | hypersthene | $Fs_{21}$ (mol.) | 0·1 | 3·4 | 0·1 |
| groundmass | plagioclase | $An_{63}$ | 28·0 | 2·7 | 25·4 |
| | pigeonite A and B.[11] | unknown | 19·7 | 3·4 | 22·5 |
| | iron ore | $Fe_3O_4+TiFeO_3$ | 7·4 | 5·0 | 12·4 |
| | glass | unknown | 7·4 | 2·4 | 6·0 |
| | cristobalite | $SiO_2$ | 6·7 | 2·3 | 5·2 |
| | | | 100·0 | | 100·1 |

In calculating the mode, the analysis was recalculated as water-free, and then the molecules necessary to form those minerals of known composition to the amount given in the last column of Table II were first subtracted and the rest of them alloted to pigeonite and glass with the assumption that all available alumina left form the feldspar molecules in the glass and that the glass contained no ferromagnesian components. The results are shown in Table III.

Table III.

The calculated composition of the modes.

| the bulk composition recalculated as water-free | | the calculated modes | | | |
|---|---|---|---|---|---|
| | | phenocryst | wt. % | groundmass | wt. % |
| $SiO_2$ | 51·38 | plagio. A $An_{92}$ | 8·30 | plagio. $An_{63}$ | 25·44 |
| $Al_2O_3$ | 19·00 | plagio. B $An_{82}$ | 17·11 | pigeonite $Wo_{21}$ (mol.) $En_{53}$ $Fs_{26}$ | 21·53 |
| $Fe_2O_3$ | 3·58 | olivine $Fa_{27}$ | 2·32 | | |
| FeO | 6·56 | | | | |
| MgO | 5·06 | augite $Wo_{35}$ $En_{47}$ $Fs_{18}$ | 0·80 | iron ore | 6·86 |
| CaO | 10·86 | | | | |
| $Na_2O$ | 2·15 | hypersth. $Fs_{21}$ | 0·10 | glass $An_{27}$ $Ab_{57}$ $Or_{16}$ (mol.) | 10·30 |
| $K_2O$ | 0·32 | | | | |
| $TiO_2$ | 0·83 | | | glass $SiO_2$ | 1·79 |
| $P_2O_5$ | 0·13 | | | cristobalite | 5·20 |
| MnO | 0·13 | | | apatite | 0·34 |
| Total | 100·00 | | | | 100·09 |

11) Two kinds of pigeonite were counted together.

## V. Interpretation of the Result.

The observed amount of the iron ore is about twice as much as the calculated one, even though all the available $Fe_2O_3$ and $TiO_2$ were alloted to it. This must be due to that the iron ore occurs as minute grains usually attached to pigeonite and is apt to be overestimated in volumetry. On the other hand the observed amount of the glass is too small. When it fills the minute intersitces between the pigeonite, it can scarcely be discriminated from the latter, and consequently it may be counted together with pigeonite.

*The composition of the groundmass pyroxenes*:—

It is possible to abtain a theoretical value of refractive index for the calculated composition of the glass after the method employed by C. E. Tilley.[12] The composition of the glass (feldspar + silica) is shown in Table IV, together with the norm and the specific refractivities of the normative constituents.

Table IV.

The calculated composition of the glass.

| | wt. % | norm | | sp. refr. |
|---|---|---|---|---|
| $SiO_2$ | 66·6 | Q | 15·00 | 0·2074 |
| $Al_2O_3$ | 20·6 | Or | 13·34 | 0·2056 |
| CaO | 4·9 | Ab | 47·16 | 0·2053 |
| $Na_2O$ | 5·6 | An | 24·46 | 0·2132 |
| $K_2O$ | 2·3 | | | |
| | 100·0 | | | |

The interstitial glass under consideration has N=1·503, corresponding to the specific gravity d=2·40–2·43.[13] It is calculated according to Tilley, that N=1·498 if d=2·40 and N=1·504 if d=2·43, that is, a close agreement with the observed one. It is therefore probable that the anorthite molecule in the calculated composition of the glass does not enter into the natural pigeonite to any great extent.

Now that the calculated composition of the glass was found to be fairly correct, the composition of the groundmass pyroxene is considered to be equally so. It is plotted upon the triangular diagram showing the relation between composition and optical properties according to

12) C. E. TILLEY, *Miner. Mag.*, 19 (1922), 291.
13) C. E. TILLEY, *op. cit.*, 282.
W. O. GEORGE, *Jour. Geol.*, 32 (1924), 367.

Barth,[14] together with those of the porphyritic minerals; augite, hypersthene and olivine (olivine regarded as metasilicate). (Fig. 1)

The uniaxial pigeonite occurring in the groundmass as microphenocryst, of which I have already described, must have the composition lying upon the line 2V=O in the diagram. It is understood that pigeonite poorer in lime crystallised as an early mineral from a melt approximately with the calculated composition of the groundmass pyroxene, i.e. somewhat higher in lime, under the condition of the effusive stage, that is, the condition B according to S. Tsuboi.[15]

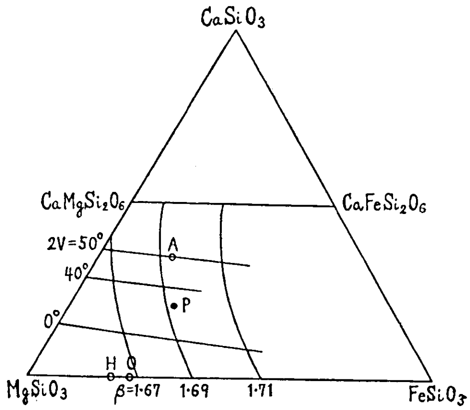


Fig. 1.

H....hypersthene
O....olivine
A....augite
P....pigeonite

The crystallisation of pyroxene under the condition B is comparable to that in the investigated system: diopside-forsterite-silica.[16] In this system, a certain liquid whose composition is represented by a point in the lower part of the pyroxene field will become, if quenching occurs, a crystalline aggregate of cristobalite and a monoclinic pyroxene with a certain composition of the diopside-clinoenstatite solid solution. But on the other hand, when the same liquid is slowly cooled, the first mineral to crystallise will be a monoclinic pyroxene with a composition somewhat higher in clinoenstatite molecule than that of the pyroxene formed by quenching.[17]

*On the normative quartz*:—

It has long been recognised as one of the characteristics of the common Japanese effusive rocks, that a notable amount of excess silica appears in their norms in spite of the calcic nature of the feldspar. In

14) T. F. W. BARTH, *Amer. Jour. Sci.*, 21 (1931), 385.
15) S. TSUBOI, *Jap. Jour. Geol. Geogr.*, 10 (1932), 78.
16) N. L. BOWEN, *Amer. Jour. Sci.*, 38 (1914), 245.
17) The similar type of the crystallisation of pyroxene as noted here was emphasized by A. Holmes and H. F. Harwood in the Whin Sill magma type. A. HOLMES and H. F. HARWOOD, *Miner. Mag.*, 21 (1928), 506.
18) J. P. IDDINGS, *Igneous Rocks*, 2 (1913), 111.

emphasizing this characteristics some petrologists have given special names for them, viz., bandaite by J. P. Iddings[18] and miharaite by S. Tsuboi.[19]

Recently, Professor S. Tsuboi and I noted on the common occurrence of silica minerals (cristobalite, tridymite and quartz) in the groundmass of basic effusive rocks and remarked that this may explain the presence of normative quartz.[20] The rock now under consideration is a typical example.

There is 6·48 percent of normative quartz, while the cristobalite actually present is 5·2 percent of the rock. In addition there is a low-refracting glass, which probably contains a considerable amount of silica. Thus the normative quartz may correspond in amount to the sum of the modal cristobalite and the silica contained in the glass.

*The comparison of the bulk analysis with the composition of the groundmass*:—

An approximate composition of the groundmass was calculated from its actual mineral composition: plagioclase $An_{62}$, pigeonite, iron ore, glass, cristobalite and apatite. The result is shown in Table V.

Table V.

The calculated composition of the groundmass.

| | wt. % | norm. | | | |
|---|---|---|---|---|---|
| $SiO_2$ | 53·4 | Q | 9·84 | | |
| $Al_2O_3$ | 14·4 | Or | 2·22 | | |
| $Fe_2O_3$ | 5·1 | Ab | 20·44 | | |
| FeO | 8·4 | An | 27·24 | | |
| MgO | 5·7 | | | Wo | 6·73 |
| CaO | 8·9 | Di | 13·14 | En | 3·90 |
| $Na_2O$ | 2·4 | | | Fs | 2·51 |
| $K_2O$ | 0·4 | Hy | 17·26 | En | 10·40 |
| | | | | Fs | 6·86 |
| $TiO_2$ | 1·1 | Mt | 7·42 | | |
| $P_2O_5$ | 0·2 | Il | 2·13 | | |
| Total | 100·0 | Ap | 0·34 | | |

It shows a marked contrast with the bulk analysis given in Table I. A smaller content of alumina and a greater content of iron oxides are especially striking, which may be attributed to the presence of calcic

19) S. TSUBOI, *Jour. Coll. Sci. Imp. Univ. Tokyo*, 43 (1920), 87.
20) S. TSUBOI and H. KUNO, *op. cit.*, 34.
See also my preceeding paper in this bulletin.

plagioclase and magnesia-rich ferromagnesian minerals as phenocrysts included in the bulk analysis. We have here a very similar relation as found between *the Non-Porphyritic Central Magma-Type* and *the Porphyritic Central-Magma-Type* in the Mull rocks,[21] the bulk composition of the latter type was reasonably explained by N. L. Bowen as a possible effect of crystal sorting in the course of its formation.[22]

It must be noted too that the composition of the groundmass representing a possible magmatic liquid has some resemblances to that of the plateau-basalt described by H. S. Washington.[23] The difference is only in the amounts of $SiO_2$ and of the normative quartz and the degree of oxidation of iron. The siliceous nature of the Japanese effusive rocks seems to be inherent, even in the basic varieties.

Then it may be understood that the Japanese basic effusive rocks are very similar or closely related to the well-known plateau-basalt. The bulk compositions of the Japanese rocks may be however, often controlled by the accumulation of calcic plagioclase crystals in the magma.

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## 23. 伊豆網代產玄武岩に就いて（豫報）

地質學教室　久　野　　久

この論文は筆者が行ひつゝある北伊豆地方火山岩の地質學的並に岩石學的研究の結果の一部の報告である.

伊豆網代附近を構成する古い火山體の一部に熔岩流をなして產する紫蘇輝石普通輝石橄欖石亞灰長石玄武岩の顯微鏡的觀察, 特にその構成鑛物の光學的研究の結果を記載し, これらの構成鑛物の推定成分並にその量比の測定値とを, この岩石の化學分析の結果より計算したる鑛物成分と比較した.

この結果より, 石基輝石の結晶作用を論じ, 又この岩石の化學分析結果に現はれたるノルム石英はその石基中に存在するクリストバル石並にガラスに負ふものなる事を明にし, 最後にこの岩石の石基のみの化學成分を計算し, これとその總化學成分との關係に就いて注意した.

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21) "Tertiary and Post-Tertiary Geology of Mull, etc.," *Memoir of Geol. Surv. Scotland*, (1924), 16 and 23.

22) N. L. Bowen, "The Evolution of the Igneous Rocks," (1929), 134.

23) H. S. Washington, *Bull. Geol. Soc. Amer.*, **33** (1922), 705.

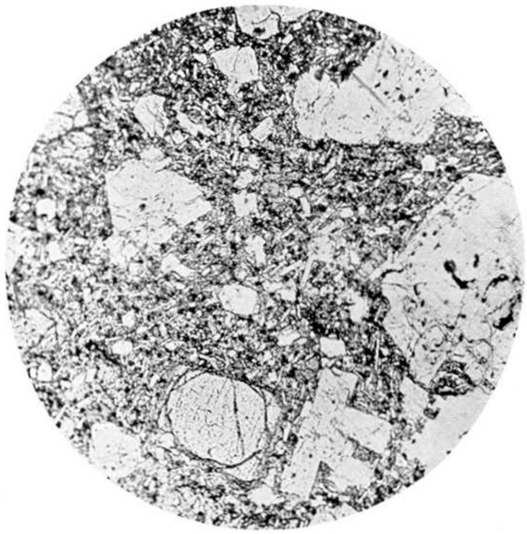

Fig. 2. Hypersthene-bearing augite-olivine-bytownite basalt from Aziro, Idu, (51227), showing phenocrysts of plagioclase and olivine (lower part), and microphenocryst of uniaxial pigeonite (slightly above the center). ×51

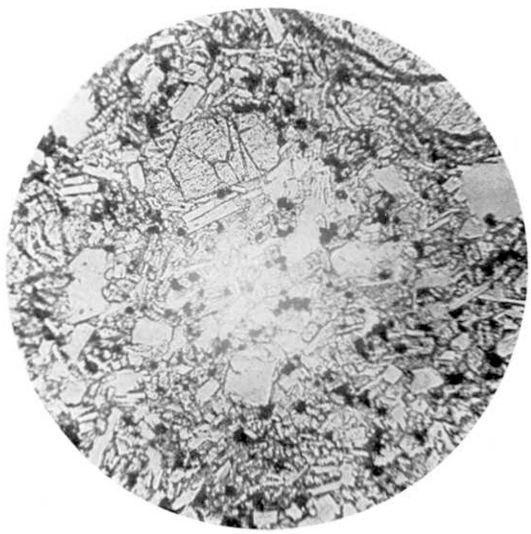

Fig. 3. Ditto, showing the groundmass and the prismatic microphenocryst of uniaxial pigeonite (upper part). ×167

（震研彙報、第十一號、圖版、久野）