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The Ephemeral Volcanic Island in the Iwôjima Group.

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With Plates I–XII.

INTRODUCTION.

In the course of December 1904 (the 37th year of Meiji) a volcanic island was newly formed in the vicinity of Minami-Iwôjima which is situated at the southern extremity of the Fuji volcanic zone. The news was first reported in February of last year (1905) by some inhabitants of Iwôjima, and, as is fresh in our memory, was for a while an absorbing question with the public. In June last, at the request of the Earthquake Investigation Committee, I proceeded to the said island by the *Hyôgomaru* with a view to make an inspection there. But when I came near, to my great disappointment, I found it impossible to set foot upon the island, since the greater part of it was already worn out, leaving above the water a low reef just on the point of sinking. Moreover, the sea then raging, prevented me even from approaching the reef and obliged me to return without attaining the desired end. And if the present report gives the reader an impression that it is a long way from satisfactory or complete, I hope these circumstances will offer an excuse for that. Here I must express my heart-felt gratitude to Prof. Kotô who was kind enough to give me several valuable suggestions in studying my collected specimens, and without which, I fear, my report might have fallen still farther short of the mark.

The New Island was nothing more than a submarine volcano, heaved up above the level by eruption, and was situated about 3 nautical miles northeast of Minami-Iwôjima. It may safely be inferred from its position, that this submarine volcano was one of the Iwôjima volcanic islands representing part of the so-called Fuji volcanic zone; and for this reason it appears convenient to make a statement respecting the present volcanic islands of Iwôjima or Sulphur Island group before entering into the main question.

IWÔJIMA GROUP.

The volcanic islands of Iwôjima group, also called Volcano Islands (Plate I) comprehend three volcanic islands ranged nearly north-south between 141° and 141° 30′ east longitude and between 24° and 25° 25′ north latitude. Of these three islands the central one is the largest and bears the name of Naka-Iwôjima[1] or simply Iwôjima (Sulphur Island); the one to the south Minami-Iwôjiwa (San Augustino Island), and the one to the north Kita-Iwôjima (San Alessandro Island). Kita-Iwôjima is situated 90 nautical miles southwest of Hahajima (Hillsborough Isl.) or 660 nautical miles distant from Yokohama, and Minami-Iwôjima, which is the southernmost limit of the Empire in this direction, is 740 nautical miles from Yokohama.

1. Kita-Iwôjima (San Alessandro Isl.)

Kita-Iwôjima is situated 25° 25′ north latitude and 141° 16′ east longitude. It is a volcano standing 2534 feet above the surface of the sea, about 12 km. in circumference, and 545 hectare in area. The coast line has become known in some measure, from the survey effected by Mr. Okamoto and others in 1904, but the topographic survey of the interior has not yet been made.

Fig. 1, Pl. II. is a topographic map of the island drawn from the survey made by Mr. Okamoto and from my own sketches. It will be seen therefrom that the outline of the island is nearly elliptical

1) Naka-Iwôjima means Middle Sulphur Island.

with no remarkable irregularities of coast line. The mountain is generally precipitous, and the summit is divided into two prominent peaks, north and south. The one to the south is the higher (2534 feet) and its top, being nearly always covered with dense clouds, is said to be rarely visible from its foot. In consequence, it is not yet certain that this summit has any hollow vent as seen in most volcanoes. However, besides the two above-mentioned peaks, there is a somewhat low isolated one to the northeast of the south peak, and the deep valley skirted by this low peak and the north and south peaks has a white-decayed precipice in the middle part, as if influenced by solfataric action, suggesting the trace of explosion crater.[1)]

The mountain sides are very steep and directly lead to the sea without leaving any coastal plain around the island. Along the shoreline, however, there is a gravel beach of from 80 to 100 meters wide, with scattered big pebbles. It is a very noticeable fact that at the distance of about 100 meters from the water's edge the sea is very shallow, being only 2 or 3 fathoms deep, and even a small boat cannot approach the shore easily, owing to the waves usually raging there.

This submerged platform, or wave-cut terrace, together with the said gravel beach along the shore, marks the space which the water has conquered by dint of wave-cutting, since the formation of the island. Moreover, the steepness of the mountain sides (far steeper than the inclination of lava or tuff strata composing the volcano) must also be attributed to this rapid wave-cutting as well as the rapid formation of sea-cut cliff, for in such cases erosion plays a more important part compared to weathering which generally tends to reduce the angle of the slope; and the more resistant the material, the steeper the slope of the mountain, as is the case with Kita-Iwôjima.

Our landing and inspection being confined to the small sphere of Higashi-Ishinomura and neighbourhood on the eastern coast, I must confess that I could not obtain sufficient materials to show the geolo-

1) The position of the supposed exploration crater is shown by a dotted line in Fig. 1, Pl. II.

gical construction of the island. But, so far as I could observe, the greater part of the mountain is composed of a comparatively hard kind of volcanic agglomerate containing a sheet of lava, which is cut in every way by dykes of dark-coloured andesite. In the precipice along the shore, about 200 meters south of Higashi-Ishinomura, there are exposed four or more dykes of great dimension, some reaching about 300 meters in length, the grand appearance of which can be seen from the far distant sea (Fig. 2, Pl. II.).

(i) *The agglomerate-forming augite-andesite* is a hard and somewhat vesicular rock which contains abundant phenocrysts of feldspar in dark gray-coloured ground-mass. Its external appearance greatly resembles the agglomerate-forming andesite of Hahajima which is seen alternating with Nummulite-tuff. Under the microscope, it is found to be of holocrystalline-porphyritic structure, containing phenocrysts of plagioclase and altered augite (Fig. 3, Pl. IX.). The plagioclase, though it is fresh and transparent, contains in inclosures a small quantity of augite besides magnetite and some glassy substances. These inclosures are arranged zonally along the cleavage face of the plagioclase. Polysynthetic twin of albite type is very common and pericline twin is also occasionally found. Considering that the extinction angle at P face reaches even —37°, it is safely inferred that it belongs to the most basic anorthite. The porphyritic augite is usually altered into a bastite-like substance of greenish brown or yellowish brown colour, with dark secreted grains perhaps of magnetite on its peripheries and cracks. The same phenomenon presents itself in the agglomerate-forming augite-andesite of Hahajima. The ground-mass is composed of lath-shaped plagioclase, augite grains and magnetite, with no trace of glass-basis.

(ii) *The Dyke-andesite* is a porous dark gray-coloured rock of basaltic appearance. Those marginal parts which are in contact with agglomerate are especially glassy and abounding in pores. As phenocrysts there exist a great number of plagioclase and a very few of augite, but no olivine. The plagioclase is transparent and full of glass inclosures, and polysynthetic twinning of albite type well developed in it. The wide extinction angle shows that it is of soda-lime feldspar of basic composition. The augite is of light yellow-gray colour and weak pleochroism, with well-developed prismatic cleavages. The ground-mass is of hypocrystalline structure and is composed of microlites of plagioclase, augite and magnetite, with a small amount of some glassy substances. The pores of various sizes which exist in the rock are generally fringed with yellow oxide of iron (Fig. 4, Pl. IX).

Though the whole island except the southern side (with its steep inclination) is covered with a thick forest, the trunks are all short on account of the strong sea-wind which prevails. Only near the beaches and in the valleys less exposed to wind, tropical trees of evergreen broad leaves, such as Calophyllum inophyllum *L.*, Terminalia Catappa *L.*, Hibiscus tiliaceus *L.*, Hernandia peltata *Meisn.*, &c. are seen in comparatively good growth. Slow inclining talus places in the island, such as the neighborhood of Higashi-Ishinomura, are thickly covered with red laterite, and there sugar-canes, maize, sweet potatoes, gingers, etc. are cultivated. On the beach and the talus ground above mentioned, decomposition of soil is complete and no substance which bears any sign of recent eruption is to be found. This, to my mind, goes to prove that the island lost its activity long ago, in which respect it resembles Minami-Iwôjima and widely differs from Naka-Iwôjima.

I may add here that this island, like the other two, had been long uninhabited, till, in 1899 Mr. Ishino, an inhabitant of Hachijôjima, set his hand to the reclamation. Since then, the population has increased year by year, so that at present there are 36 families and 178 inhabitants in the east and the west Ishinomura.

Submarine Volcano near Kita-Iwôjima.

At the distance of about 3 nautical miles northwest of Kita-Iwôjima there is a submarine volcano. Once it emitted steam and displayed a very grand spectacle.[1] With the earthquake of 1889, the emission came to an end, but a shoal covering the space of about 2 miles from north to south still remains to mark its site, where the sea-water is always found muddy and disturbed.

2. *Iwôjima (Sulphur Island).*

This island, situated in the centre of the Iwôjima group, is the largest of the three sister islands.[2] It was discovered, along with the north and south Sulphur Islands, in the year 1784 or thereabouts, by Captain Gore who, after the death of the famous explorer Captain Cook, explored the Pacific Ocean on board the *Resolution.* As Captain Gore christened it Sulphur Island it bears the name of Iwôjima, but has come to be called Naka-Iwôjima, viz., Middle Sulphur Island in distinction to the north and south Iwôjima.

This island is like a gourd in shape, extending from southwest to northeast. It is more than 24 km. in circumference and 1895 hectare in area. Except at the neck, the island is surrounded by precipices facing the sea. The coast-line of the island, together with that of Kita-Iwôjima, was made known by the survey of Mr. Okamoto in the year 1904, but the relief of the interior has not yet been ascertained. Fig. 1, Plate III is a topographical map drawn on the basis of the contour of the island by Mr. Okamoto, to which I have added contour lines with the assistance of my own sketches and investigations of part of the island. From a scientific point of view, the construction of this island is of great interest. There stands a low tuff-volcano called Motoyama, which occupies the greater part of the island, in the southwestern extremity of which rises a cone-shaped volcano called Suribachiyama or Mount Pipe. These two volcanoes present a peculiar contrast, the sight of which is very impressive. Fig. 2, Plate III shows the view of the island in the southeastern direction from Nishiminato, the anchorage of regular

1) A sketch at the time of its activity is shown in a chart.

2) 24° 28′ north latitude and 141° 13′ east longitude.

liners; Fig. 3[1] shows the view of the island due east on the way from Nishiminato to Minami-Iwôjima; and Fig. 4 is a distant view from the southeast. This last figure is drawn from sketches by the late Prof. Y. Kikuchi, who visited the spot in 1888. A comparison of these three figures will make it easy to picture the topography of the whole island. In natural features, as mentioned above, Naka-Iwôjima is of a unique character and no doubt the most interesting member of the Iwôjima group; but unfortunately we had not time for a close examination, spending only a few hours in inspecting a part of Motoyama. As regards Mt. Pipe, we had no opportunity of climbing it, and it is a matter of great regret that I cannot make a full report of this interesting volcanic island. We have, however, a report published in the "Tôyôgakugei-zasshi"[2], by the late Prof. Y. Kikuchi who landed the island and inspected more especially Mt. Pipe. Again, Dr. Johannes Petersen published, in his "Beiträge zur Petrographie von Sulphur Island, Peel Island, Hachijô and Miyakejima" (1890), a short report of Dr. Warburg (who visited and collected rocks there in 1887) together with a detailed account of his own microscopic investigation of the rocks. Although Motoyama occupies 96% of the whole island, it is a low plain hill only about 430 feet high above the sea and 200 feet lower than the Pipe; and it is entirely composed of yellow tuff, with no trace of lava-flows. Indeed, such another pure tuff-volcano is not found in any other parts of our country's possessions.

Motoyama-tuff is a light friable pumiceous tuff of pale yellowish red colour, the greater part consisting of decomposed pumice powder. Of this tuff, two different kinds may be recognised: one is fine-grained and homogeneous with minute black spots, and the other is somewhat coarse-grained, so that the component pumice fragments can be clearly observed with the naked eye. The latter is usually found forming a thin layer in the former.[3]

1) Mt. Pipe is seen near in front.

2) A scientific journal written in Japanese. Kikuchi's report appears in No. 77 of this journal.

3) The former was mentioned by Dr. Petersen as tuff.

On pounding these two kinds, washing off the clay part produced by decomposition of pumice, removing the magnetite[1] from the remaining sand, and then separating them by Thoulet's solution, it was found that there existed no distinction between them in point of mineral composition; that is to say, the minerals were apatite and monoclinic pyroxene that were separated by dense solution, the specific gravity of which was from 2·8 to 3·1.

The apatite is of a colourless transparent long prismatic crystal of very distinct outline. It is often 1 mm. long and is composed of ∞P, P and rarely oP. What is most wonderful in it is the glass-inclosures, which often assume the form of parent mineral after the style of negative crystal. Most of them contain immovable bubbles (Fig. 1, Pl. XI). Inclosures are occasionally light brown, but generally colourless, some with a dark opaque substance in one part. Dr. Petersen says that some of the inclosures are liquid.

The monoclinic pyroxene is generally separated in irregular broken pieces. It is fresh and sharply edged, and is composed of ∞P, $\infty P\bar{\infty}$, $\infty P\breve{\infty}$, P and rarely oP. The pleochroism is uncommonly conspicuous and varies between $\mathfrak{c}$ smaragd-green, $\mathfrak{b}$ olive-green and $\mathfrak{a}$ grayish green. $c : \mathfrak{c}$ in the symmetrical plane varies from 50° to 54°. It contains a great quantity of acicular apatite, magnetite and glassy substances in inclosures.

The feldspar may be separated by a solution of from 2·5 to 2·37 specific gravity and is obtained in cleavage slices or in irregular broken pieces. It is in most cases decomposed, and some of the pieces are covered with colourless micaceous scales, nearly hexagonal with round margins and with a gray-coloured spot in each centre, as shown in Fig. 4, Plate XII, or partly altered into clayey substance. Dr. Petersen infers this feldspar to be orthoclase from the absence of twin laminae and from the

1) Magnetite occurs in great quantity in octahedral crystals or in irregular grains.

optical orientation on *P* and *M*; but, besides this questionable orthoclase, twinned feldspar unobserved by Dr. Petersen can be found in considerable abundance. This twinned feldspar is in all probability oligoclase as judged by optical relation. It contains brown and colourless glass with gas bubbles and apatite needles in inclosures.

In short, this rock is of an entirely different nature from those ejected from the Pipe with respect to the nature of its augite and feldspar, and the absence of olivine; neither does any relation seem to exist between the rock in question and those of the New Island with the exception of the resemblance of the apatites.[1)]

As has already been said, though Motoyama-tuff is uniform in texture, yet some coarse-grained parts are imbedded everywhere; so, as a whole mass, it clearly presents marks of bedding, and the whole stratum descends obliquely in all directions, dipping slowly from the central part of the mountain. This stratum towards the sea assumes a terrace-like form, with precipices presenting remarkable traces of wave abrasion.[2)] The flights of these terraces, of tuff consolidated at the sea-bottom, terminating in the afore-said manner or found in the form of "Tischstein," are shown in Fig. 2, Plate VI. The formation is a relic of abrasion, and is a clear proof of the upheaval of ground in Motoyama. I have also discovered two other wonderful facts strongly confirming my inference. One is that, as is shown in Fig. 1, Plate VI, at the height of some 430 feet in the mountain, madrepore corals cluster together here and there, forming thin coral reefs, most of which belong to the living Stylophora species (Plate VII). These coral reefs struck me with delight when I found that they bore very little mark of weathering, still retaining their life appearance though blackened on their surface, and standing in bold relief upon the tuff. This goes to show that the elevation of the

1) Compare Fig. 1 and Fig. 2 in Plate XI.

2) Vid sketches of Plate III.

volcano is of much later occurrence than is generally supposed. The other fact is that, together with these coral reefs, many tuff-pebbles, which assume the round flattened form so characteristic of a surf-beaten beach, are found everywhere on the mountain. Thus there is no room for doubt that this island was formed with suddenness not long ago, and from this fact it is also clear that the tuff of Motoyama is a sedimentary deposit of the sea-bottom.

I may here add that according to some inhabitants who immigrated here some years ago, the land is still uprising, most conspicuously so at the neck, east of Mt. Pipe. Its northern shore was formerly the anchorage of vessels which visited the place, but owing to the gradual rising of the sea-bottom, it ceased to afford shelter for vessels, and mariners have been obliged to choose Nishiminato instead.

Thus we see it is of comparatively recent occurrence that the whole mass of Motoyama volcano was elevated above the surface of the sea; but the formation of tuff on the sea-bottom is no doubt anterior to that of Mt. Pipe, as will be proved below. Since the formation of tuff, Motoyama has gradually diminished in activity, till at present it has only about ten solfataras on the top. As is shown in the topographical map in Plate III, the solfataras are scattered in a comparatively large area; moreover, each solfatara seems to have had its own fate, and frequently changed its position. It may also be inferred by the presence of the above-mentioned corals in their midst that some of these solfataras were produced after the appearance of the volcano above the surface of the sea. Among these solfataras, the central Motoyama-solfatara and Furuyama-solfatara about 150 m. north of the above are ejecting sulphurous vapours in the greatest abundance at the present time. Again, on the shore of Nishiminato, the only landing place of the island, a hot spring is said to be seen.

It is a fact no less noticeable that the entire surface of Motoyama is covered with volcanic sand or lapilli varying in size from a rice-grain to that of a pea. These volcanic sand and lapilli are composed of various volcanic ejectamenta, such as black obsidian, spongy pumice, reddish lava scoriæ, dark-coloured lava fragments with phenocrysts of feldspar and isolated feldspar crystals, etc. They are evidently not from Motoyama, but from Mt. Pipe, seeing that the petrographical nature of the sand bears no resemblance to the ejectamenta of the former but is similar to those of the latter, and bigger grains are found in greater quantities as we approach Mt. Pipe. Dr. Warburg and Dr. Petersen were certainly mistaken in surmising that feldspar crystals and other ejecta had been separated from Motoyama-tuff by weathering.

The most interesting of these volcanic sands is the crystal bomb of feldspar coated with a thin crust of black glass, some samples of which are so large as to reach 15 mm. in length. The crystal habit is tabular owing to the development of *M* face, and in most cases two or three crystals penetrate each other obliquely, thus forming a kind of twin. The surfaces of the crystals are generally rough, and both their angles and edges are worn and more or less rounded, though not utterly obscure. In them *M* is best developed, *P*, *T* and *l* are in narrow belts, and Carlsbad twin is invariably developed. From their extinction angles which are $-1°$ on *P* and $-5°$ on *M*, it may be inferred that they are of a kind of andesine. The crystals, though quite fresh, are full of yellowish brown glass-inclosures which are arranged zonally along the cleavage-face. In these respects, they bear affinity to the feldspar in the pumice of the New Island.

As mentioned before, this feldspar sand is generally crusted with a thin black glassy coating; even where part of the coating is worn out by weathering, a sponge-like glass still remains glittering in the reentrant angle of the crystals. This glass coating is very similar to the ground-mass of glassy andesite forming part of Mt. Pipe, from which we see that this feldspar sand, as is the case with the anorthite bomb at Miyakejima[1] already studied by the late Prof.

1) On Anorthite from Miyakejima. The Journal of the College of Science, Imper. Univ. Vol. II.

Kikuchi, was once floating in magma at the crater bottom of the volcano Pipe, and was ejected together with other volcanic sands during the subsequent eruptions. Thus the feldspar bombs in these two places—one andesine and the other anorthite—are different in composition and crystal habit, but the same in the manner of ejection. It is an interesting fact that similar feldspar bombs are also found in Ôshima and Hachijôjima, so that this phenomenon seems to be characteristic of the Fuji volcanic zone.

The volcanic sand mixed with feldspar crystals is found lying thicker on the ground as we approach Mt. Pipe, at some points reaching even the thickness of 10 or 12 inches. In the vicinity of the Pipe there are scattered lava blocks of various sizes and shapes, half buried in the sands. They are somewhat scoriacious and have tabular phenocrysts of plagioclase in the ground-mass of dark gray colour. Petrographically they are of the same quality as a kind of lava which composes the cone of the Pipe. The most noticeable thing about these lava blocks is that wind ablation[1] is very conspicuous in them, and is expressed in various stages: thus some of them have their exposed parts considerably erroded into a peculiar conical form whilst they almost keep their original form only in the lower parts buried in the sands; some have a crown-like top whilst they have the feet of their exposed portions greatly worn; and others have lost even their crowns through the influence of the wind, so that their surface is reduced to the same level as that of the sands.[2]

To conclude: Motayama is an elevated submarine volcano, which once ejected a great quantity of pumiceous ashes and formed the so-called Motoyama-tuff under water; soon after the formation of the tuff was completed, Motoyama became weakened in volcanic activity without effusing any lava, and at the same time heaved itself up at a rapid rate, until its top got to the height of 430 feet above the

1) The prevailing wind in the island is from the south.

2) cf. Journal of Geography (in Japanese), No. 202. "Geographical Trip to the New Sulphur Island" by Mr. Satô (*Rigakushi*).

sea level. This upheaval of the mountain, be it remembered, seems to be still going on.

Suribachiyama or Mt. Pipe.—We found no opportunity of inspecting this mountain, of which, however, an exploration was made by both the late Prof. Kikuchi and Dr. Warburg.[1] The former's report appeared in the "Tôyôgakugei-zasshi" and the latter's in Dr. Petersen's "Beiträge", as before mentioned, and it is to these reports as well as Petersen's studies on rocks that I owe the following description of the structure of the volcano.

Mt. Pipe, entirely different from Motoyama in all respects, is a strato-volcano composed of ash layers and lava sheets. It forms a truncated cone, standing about 640 feet above the sea-level and 200 feet higher than Motoyama. As is the case with many volcanoes, it has in its top a crater in the shape of a bowl or the Japanese "suribachi"; hence the name. There are two crevices ejecting steam, one on the south and the other on the west side; and the former has a sublimate of sulphur, alum, gypsum and potassium salt. On the northern side of the crater a deep valley (perhaps barranco) opens upon the sea. Alternating strata of ashes and lavas are found sloping down from the crater on all sides. Prof. Kikuchi writes that the founaation of the volcano Pipe is a horizontal layer of gray sandy volcanic ashes, which is composed of glassy substance probably sedimented in the water (Fig. 5a, Pl. III). The professor, as it seems, considered that it was of the same origin as the so-called Motoyama-tuff, but, I must venture to say, there is not sufficient reason to believe in their brotherhood. Covering this fundamental ash layer, there are some lava beds, which form a precipice of about 100 feet in height (Fig. 5b, Pl. III), partly cracked into a vertical prism. It is these lavas that are mentioned by Dr. Petersen as *glasiger Augitandesit, Bimssteinartiger Augitandesit, Schwefelfuhrender Augitandesit,* &c. Most of them are in the form of black vitrophyric rocks, containing tabular crystals of plagioclase in a compact or porous ground-

1) loc. cit., p. 7.

mass. Under the microscope, oligoclase, monoclinic augite, olivine, apatite and magnetite are recognizable. Of the ground-mass, some are hyalopilitic and the others glassy, all containing augite-microlites and other devitrified products. Those parts of the lava which were subjected to the influence of solfataric action are now bleached into white or light gray colour. Overlying these lava beds, and composing the greater part of the volcano, are gray ashes containing plagioclase, augite, olivine, magnetite, apatite, besides compact or pumiceous glasses, together with various decomposition products.

In a word, Mt. Pipe, very different from Motoyama, is a strato-volcano active until recent times. After the first ejection of volcanic ashes, hard lava-sheets were formed, which made the mountain solid and precipitous, forming itself into a truncated cone quite unlike that of Motoyama; and it is of recent occurrence that it ejected the above-mentioned feldspar crystals and various volcanic sands now covering the whole island.

Though we may assert that these two volcanoes entirely differ from each other in their structure and composition, we cannot say that they have no relation whatever to each other. Indeed, the fact that after throwing out volcanic ashes, Motoyama became inactive without any effusion of lava, may have been the result of the subterranean magma finding its own way, which culminated in the formation of the present strato-volcano of Mt. Pipe.

3. *Minami-Iwôjima (San Augustino Island).*

Minami-Iwôjima or South Sulphur Island is the southern-most of the three principal islands of Iwôjima group, and its geographical position is of 24° 14′ north latitude and 141° 29′ east longitude; being in about the same latitude as the middle part of Formosa.

This island, 3039 feet high, is a strato-volcano of a conic form and of the same type as the volcano Pipe in Naka-Iwôjima and the volcano of Kita-Iwôjima. The outline of the island is almost spherical and it is only 8 km. in circumference. The mountain sides are all very steep and slope precipitously to the sea with an inclination of about 40°, without leaving any level ground at the foot. The top is almost always invisible from the sea, being covered with dense clouds. (Fig. 2, Pl. V and Fig. 1, Pl. IV.)

The mountain sides are overgrown with small bushes down to the middle height, but below no vegetation is found and bare agglomerates and lavas rise above the ground at a dip of about 20°. Only the northeastern side with no verdure is entirely of rust colour from the ashes which, it is said, covered it, at the time of the eruption of the New Island.

This island has not been inhabited for a long time, so that our knowledge of it is very limited.

THE NEW ISLAND.

History of its Eruption.—This island, the exploration of which was the chief object of our trip, made its appearance in November 1904, 3 nautical miles northeast of Minami-Iwôjima. On approaching it, as mentioned in the Introduction, I found the greater part had already been abraded away, and lost for ever the opportunity of inspecting it in person, so that I am in no position to give any detailed account of its formation, and all I can now do, is to state my scientific inference on the subject from the report of an exploration effected by some inhabitants of Iwôjima soon after the eruption. The following is a translation of some extracts from their report (in Japanese):

"A noise like the roaring of a cannon was heard from the south of Iwôjima on and after November 14th, the 37th year of Meiji (1904).

On the 28th of the same month, at 8 p.m. a feather of smoke was seen about 3 nautical miles east of M.-Iwôjima. At first, we thought that it was the smoke from a man-of-war at sea, and it was about an hour later when dark smoke came to be seen hurled up in greater quantities that we realised the cause of the phenomenon. That day, however, there was no such noise as had been heard before. After a while, the dark smoke changed its colour now into white and then into red, sometimes rising in full force and the next moment subsiding. At night, however, nothing could be seen.

On the 5th of December, we first caught sight of an islet lying amidst the smoke.

On the 8th of the same month, the said new island had the appearance of three smaller ones grouped together; but of-course it was not certain whether a group of three really existed or simply appeared to exist, owing to the presence of vapour brewed by the eruption.

On the morning of the 12th of the same month, the sky cleared up and the island made its full appearance. It was then single, looking somewhat higher in the eastern part, and level in the western.

On the 14th of the same month, the island assumed the appearance of a long one, at one time emitting white smoke and at another dark smoke from the middle.

On January 2nd of the 28th year of Meiji (1905), the island changed in shape growing higher in the western part, and emitting a little white smoke from the mid part. About 3 o'clock p.m., however, there burst forth voluminous dark smoke which was followed by white after twenty or thirty minutes.

On the 5th of January, the immigrants in Iwôjima met together and decided to attempt an exploration there and report its result to the island-office. When volunteers for the proposed adventure were called for, ten men responded, all determined to sail to the island in a boat and a canoe.

They commenced preparations on January 6th, and made several attempts to put to sea, failing each time on account of bad weather.

The weather becoming fine on January 31st, they at last succeeded in getting to M.-Iwôjima. This island being near the new volcanic island, nearly the whole surface was covered with ashes and the plants had all withered, except in a small part in the south-west. Much débris of pumice was found thrown up on the coast round the island.

On the 1st of February, they sailed out from M.-Iwôjima and arrived at the New Island. The high waves on the shore made landing very difficult; moreover, as it was only a few days after the eruption, the party was exposed to great danger in the attempt.

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They then made a step survey and sketch of the island, and collected samples of stones. The island, as will be seen from the sketch in the appendage (Fig. 4, Pl. IV.), was about 3 miles in circumference, the highest portion standing about 480 feet above the sea. There was a small pond in the northern flank about half a mile in circumference, where vapour was rising profusely. In all probability it had been a crater. The north bank of the pond being only 3 or 4 feet high, the sea-water probably had used to run into the pond when high waves came. The south bank was precipitous and its highest portion formed the summit of the island. Though the island was composed of hardened rocks, the surface was all covered with loose ashes about 5 or 6 inches in thickness. It was about 200 acres in area and almost flat on the top, surrounded by narrow shore-plain 120 or 240 feet wide. * * * * * * "

The report of the immigrants above quoted tells us that they had heard sounds like cannon since the 14th of November—a very common phenomenon foreboding the coming eruption of a volcano; and it may be safely inferred that the vapour at the bottom of the crater was already growing active, its expansion causing the movement of the magma. At last the eruption began in earnest at 10 a.m. on the 28th of the same month with the bursting forth of smoke; and the island made its appearance on the 5th of December, though it changed its shape and the colour of its smoke very often. The white smoke showed that mere vapour unaccompanied by volcanic ashes was then being ejected, and the change of its colour into black or red told that volcanic ashes together with vapour had begun to be thrown forth in large volumes. As regards the changes in the shape of the island during its eruption, they may be accounted for by the conjecture that, while large quantities of new ashes were accumulated at one point, those which had already been accumulated at another were blown away by explosions. In other words, the balance of these two controverting processes, constructive and destructive, must have determined the shape of the island. I feel still more confirmed in this conjecture when we consider that its centre of eruption seems to have changed from time to time.

What makes me more regretful than anything else is that we are unable to ascertain the component materials of the island, since no rocks were collected there, except pumice-débris which had been beached by the waves. It seems that these pumice-débris are part of what were effused in a lava-flow into the sea-bottom during the eruption and were broken off and thrown upon the beach by the waves. Mr. Azuma, one of the explorers, told me that what is mentioned as "rock" in the report, which formed the frame of the island, was of the same quality as the yellow tuff of Motoyama in Iwôjima. Though of course it is not to be believed that the rock was entirely of the same class as the tuff of Motoyama, at least it is evident that the New Island was not composed of any resistant hard lava. On examining the "ashes" which are described in the report as having covered the "rock" to the thickness of 5 or 6 inches, I found that they were a fine silt of light gray, or nothing but pumice in powdery form; and under the microscope, I also found them to contain the same plagioclase and augite as are seen in the pumice blocks collected. It is most probable that the New Island was constructed of loose volcanic products as is the case with many marine volcanoes, considering that the shape of the island often changed during the eruption, as mentioned in the report of the explorers.

The next subject which demands our investigation is the shape of the island. According to the report and the sketch by the explorers, the island was at first of egg-shape about 3 miles in circumference and 200 acres in area. The highest point, 480 feet above the surface of the sea, was in the northern part, which formed the bigger end of the egg, the surface of the island slowly inclining toward the south (the dip being about 12° according to the explorers' sketch) with no ragged contours, while the northern is very steep, nearly vertical. Beneath this precipice, there was a long elliptical pond about 2400 feet in circumference, the northern side surrounded with a barrier only 3 or 4 feet high; and from some parts of the pond vapour was rising. From this fact, we may clearly conceive that the pond of the northern end was the centre of eruption or crater, that the island was but a portion of the crater rim appearing above the surface of the sea, and that the barrier bordering the north margin of the crater pond was of pumice-débris, drifted upon the island by the wind like those forming the beach round the island. The formation of such a pumice barrier was probably owing to the presence of a hidden reef forming a portion of the crater rim in the north of the pond. It is also obvious, from the explorers' report, that explosion had played an important rôle in the eruption of the New Island, that the greater part of the crater rim once formed there had been demolished by the explosion, and that the New Island was nothing more than that portion of the crater wall which remained free from the influence of explosion.

I believe that the pumice which was brought back by the explorers is part of the lava effused from the crater after its chief explosion. This may be proved from the nature of the lava which will be referred to below, as well as by the fact that the substance composing the body of the island was, as above mentioned, not rock of this kind, but loose volcanic ashes or tuffs. The vomited lava did not amount to such a large quantity as to form part of the island above the sea, and yet was sufficient to form a belt of gravel beach round the island with its broken pieces by aid of the waves. An enormous quantity of pumice fragments was also scattered about like shrapnel bullets by the eruption and carried away by the current to considerable distances, arriving at the Bonin Islands and even as far as the eastern coast of Honshiu and Riukiu Islands. In April 1906, I collected a number of pieces of drift pumice on the eastern coast of Awa Peninsula, of which the petrographic similarity with those of the New Island has been proved by myself by microscopical investigations. Also, according to the report of Dr. Nakamura, Director of the Central Meteorological Observatory of Japan, a great amount of pumice-débris arrived at the coast of Ishigakijima in Yayema Group, Riukiu, from the middle of May 1905 to the beginning of June of the same year.

Petrography of the Lava of the New Island.

(Olivine-augite-andesite)

a.) *Microscopic Features.* The samples given me for investigation are a dark brown vitrophyric rock, consisting of two different parts, obsidian and pumice. The former, as its pores increase, gradually passes into the latter, so that the manner of gradation is observable in one sample. Plate VIII is the photograph of one of these samples, the lower part being of obsidian, the upper part of pumice, and the middle of both in a transitional condition. Such an orderly transition of these two parts goes to prove that they were originally of the same lava. Perhaps the upper portion of the lava, which naturally comes in contact with sea-water, was consolidated into a sponge-like pumice on account of its sudden cooling, while the lower portion where the cooling must have been comparatively slow, was consolidated into compact obsidian. Under the microscope, no substantial difference can be found between the two.

1.) Obsidian Section.—It is of a brownish black colour and pitch-like lustre, and presents conchoidal fracture as is usual with this class of rocks. It bears comparatively large cracks, occasionally 3 mm. wide, looking as if cut out by a knife, besides smaller ones running across in every direction. These cracks, however, are comparatively shallow (none being deeper than 2 cm.), and confine themselves within the section of obsidian, never extending into that of pumice. The ends of the cracks are never sharp, but always dull.

When the lava was about to cool and consolidate itself into masses in the water, large cracks were at once formed by the contraction of the masses, and no sooner were the walls of cracks suddenly cooled by the intrusion of sea-water, than the second cracks were produced, and so on. This may be clearly proved by the right angle at which the later-made cracks run to the surface of those which were made immediately before. If the cracks had not been formed, the obsidian would then have remained lying forever at the bottom of the sea and might not have come to our hands.

2.) Pumice Section.—It has a light brown colour, with somewhat silky lustre, and has large irregular pores, the greatest diameter o the largest one reaching 2 cm., besides smaller but deeper ones quite close to one another like those of a sponge. Both larger and smaller pores are generally lengthened at right angles to the surface of the boundary near the obsidian section, and turn in every direction at some distance from the boundary. But those forming a set go parallel to each other, as is seen in ordinary pumice. This is worthy of notice, because it is intimately related to the origin of pores. To my thinking, this is how the pores came into existence. When lava streamed out, the water in the molten lava turned into vapour, went up in innumerable bubbles, and formed viscous masses full of bubbles on the upper part of the flow. Thus, these masses of lava were consolidated into pumice in that condition. Larger bubbles were formed in the masses by accidental amalgamation of smaller ones, and subsequently consolidated into larger pores.

In the pumice section, as in the obsidian, tabular phenocrysts of feldspar and rarely small phenocrysts of augite and olivine can be seen with the naked eye. The feldspar is of a dull colour containing numerous glass inclosures, which are usually crowded in the middle of the crystal. The tabular form of the feldspar is very pronounced, owing to the development of brachypinacoid. Binary Carlsbad twin is not uncommon.

In the pumice section there is no sign of the presence of distinct cracks as in the case of the obsidian section, but this section is somewhat more easily fractured perpendicular to the longitudinal direction of its pores.

Some of the pumices which were abundantly found on the coasts of the Bonin Islands differ a bit in nature from that above mentioned. Prof. Kotô made microscopic examinations of some of these pumices, and found that they contain a great quantity of rhombic pyroxene rare in that of the New Island; from which it becomes quite clear that divers kinds of pumice arrived at the Bonin Islands. We can assume from this fact that there are frequent submarine eruptions at the bottom of the great ocean especially in the neighborhood of the Fuji volcanic zone, which escape our attention.

b.) Microphysiography. For the purpose of microscopic examination, I cut the obsidian section into thin slides, and treating the pumice section by Thoulet's solution, examined the two separately. This revealed to me that its mineral components were magnetite, apatite, olivine, monoclinic pyroxene, rhombic pyroxene and plagioclase (here named in order of individualization). These occur in phenocryst in the groundmass of light brown colour (Fig. 1, 2, Pl. IX; Fig. 1, 2, 3, Pl. X).

Magnetite occurs either in irregular grains or in cubic crystals with more or less rounded margins. It is often enclosed within other essential components, especially augites. This readily leads to the conclusion that it is the first of the individualization products. Apart from this no metallic mineral can be found.

Apatite occurs in prismatic crystals of a regular outline and its transverse section is hexagonal. It terminates either in P or in P and oP, and has a cleavage characteristic of this mineral crossing the main axis. It demands our special attention in this that it has glass inclosures of a light brown colour having the form of negative crystal as in the case of apatite in Motoyama-tuff. Many of the inclosures contain immovable air-bubbles (Fig. 2, Pl. XI.).

Olivine, though less than one fifth of augite in quantity, is found within almost every thin slide, and is separated together with augite and apatite, by means of Thoulet's solution of 3.1 or 3.2 in specific gravity. It does not exceed 2 mm. in diameter. The surface of the crystal is corroded for the most part, showing sections of imperfect square or of an utterly irregular outline. Observed faces are $\infty\bar{P}\infty$, $\infty\breve{P}\infty$, ∞P, $\bar{P}\infty$, oP, P, etc. It is characterized by its strong refracting power and its vivid polarization colour. Though it contains glass and apatite needles as inclusions, the quantity is not so great as in the case of feldspar, and there is rarely seen a pocket-like intrusion of glassy ground-mass as shown in Fig. 1, Pl. XII. It is always fresh and no trace of serpentinization is found.

Monoclinic pyroxene in phenocryst, is next to plagioclase in quantity and equal to olivine in size, occurring in short prismatic crystals surrounded by sharp margins, in which ∞P, $\infty\bar{P}\infty$, $\infty\grave{P}\infty$, $-P$ (or P) are found (Fig. 3–6, Pl. XI). Sometimes it is twinned on $\infty\bar{P}\infty$ (Fig. 7, Pl. XI). The colour is very characteristic, and varies between $\mathfrak{a}$ yellowish gray, $\mathfrak{b}$ and $\mathfrak{c}$ yellowish green, though not distinct. The polarization colour is strong, and the maximum extinction angle on $\infty\grave{P}\infty$ measures 46°–48°. Prismatic cleavage appears in coarse lamellar sutures, besides other irregular fissures. Inclosures are very frequent. As in the case of olivine, glass with air-bubbles, apatite prisms of comparatively large size and magnetite crystals are the most common of inclosures. These inclosures do not run either zonally or centrally as in plagioclase, but some of apatite crystals and glass-inclosures lie parallel to some domal faces (Fig. 7, Pl. XI). This is rather singular. The deep intrusions of ground-mass may sometimes be seen, as is the case with olivine. Its specific gravity is about 3.2.

Beside the monoclinic pyroxene just mentioned, there are occasionally yellowish blue rhombic pyroxenes which exhibit parallel extinction Pleochroism is distinct, varying between $\mathfrak{c}$ yellowish blue and $\mathfrak{a}$, $\mathfrak{b}$ bluish yellow. Some of them represent hypidiomorphic relation with plagioclase.

Plagioclase occurs in tabular crystals on account of the large development of *M*, and the largest diameter sometimes measures 6 mm.

towards the brachy-axis. It has four faces *P*, *y*, *T* and *l*, besides *M*; but *y* is sometimes wanting and *r* (?) seems to take its place. The outline is regular, usually fresh and transparent, but it contains plenty of acicular or short prismatic crystals of apatite and brown glass with air-bubbles in inclosures. Most of the glass-inclosures extend flat along the faces of basal or brachypinacoidal cleavage with edges parallel to a crystal face. In some cases they continue without interruption in a peculiar manner along cleavage faces as shown in Fig. 3, Pl. XII. Large crystals contain so many of glass-inclosures that the plate about 1 mm. thick can hardly transmit light. Thus large crystals usually present a dark gray colour to the naked eye. Even in such crystal as abounds in inclosures, the inclosures crowd the centre, leaving a narrow transparent zone in its periphery. In this transparent zone only a few rows of glass-inclosures run parallel to the crystal face, and many lines of growth can be seen. The twin-lamellæ of albite type can clearly be observed in the section of *P*–*y* zone or in the cleavage slice along *P* face. In large crystals, twins of Carlsbad type are commonly developed, but no pericline twins are seen. Extinction angles on *P* and *M* in a cleavage slice are on the average of $+1.7°$ and $+7°$ in Schuster's meaning respectively. This number shows that the plagioclase is oligoclase near $Ab_{78}\,An_{22}$ (Fig. 3, Pl. X.).

Ground-mass is composed of glass of light brown colour. Fluxion structure is indistinct, and no kind of crystallites could be seen. Nevertheless, it is of special interest that the quantity of microlitic prisms of monoclinic pyroxene (Fig. 5, Pl. XII.) are irregularly scattered. The largest of these augite-microlites is $\frac{1}{5}$ mm. long and $\frac{1}{20}$ mm. wide, and the smallest does not reach $\frac{1}{60}$ mm. in length. The longitudinal section is rectangular, and each end of it always curved and often indented. The indentation rarely runs deep into the crystal, partly in the form of glass-enclosures. The cross section is octagonal or square. What is most interesting in it is that two or more crystals by intersecting each other form penetration-twins of the shape of the letter X, of a cross or of a wheel. A few examples are illustrated in Fig. 5, Pl. XII. It is of light yellowish green colour with no pleochroism. The largest extinction angle is 52° to the main axis. These little augite crystals are not found in enclosures even in feldspars which are of later crystallization than porphyritic augite and undoubtedly belong to the second phase of crystallization.

Here it must be added, that in the phenocrysts of augite there is rarely found such a phenomenal crystal as is illustrated in Fig. 6, Pl. XII, which shows the face of clinopinacoid. It should be noticed that that part of the face which is covered by the diagonals drawn through the antagonistic angles of the rhombic crystal face is particularly prominent and presents a smooth shining appearance while the remaining part of the face between these diagonals is rough, sunken and imperfectly developed. This imperfect crystal makes us recall skeleton crystals (Fig. 7, Pl. XII) of monoclinic pyroxene which are found in glassy augite-andesite of Mt. Pipe in Iwôjima, to which Dr. Peterson called special attention.

In a word, the lava of the new island in question was vitrophyric rock of intermediate composition rarely found in the volcanoes of our country, and bore family resemblance to the glassy andesite of Mt. Pipe in Iwôjima described by Dr. Petersen, in the crystal habit and the optical properties of its plagioclase, in the nature of its augite, especially of its skeleton crystal, in its abounding in apatite, and also in the nature of its ground-mass. But on the other hand it was different in every respect from the agglomeratic andesite of Kita-Iwôjima.

Disappearance of the New Island.—On the 16th of June, we sailed toward the point where the new volcano was said to have lain, but to our wonder and disappointment nothing of the island came in sight. At two in the afternoon, when our steamer at last proceeded to a spot 5 nautical miles distant from Minami-Iwôjima, Captain Nielsen discovered at a great distance something like the white crest of an angry wave dashing against a reef. As we drew near, an island became visible by aid of a telescope. It looked like the back of a whale half hidden by the waves, and we were given to understand that the new-born island which had been reported to be 480 feet high was now reduced to a low reef of less than 10 feet high (Fig. 2, 3, Pl. IV.).

The Captain, calculating the position and size of the sinking island at 3 nautical miles N.N.W. thereof, found that it was situated 24° 16′ 30″ north latitude and 141° 30′ east longitude, and 3 nautical miles north-east of the coast of Minami-Iwôjima, and that it was 8 to 10 feet high and 1500 feet long (Fig. 2, Pl. IV).[1] When seen from the west at the same distance, the island lessened in length nearly one third (Fig. 3, Pl. IV), from which we may infer that the present island is elliptical, somewhat longer east and west. This shape corresponded to that of the former head of the island described in the explorers' report, and reminded us of its form of half an year before. This is a noteworthy fact since it will prove a help to us in considering the cause of the disappearance of the island.

The explorers' report says it was on the 5th of December 1904, that the New Island was first discovered by the inhabitants of Iwôjima, and it was on the 1st of February 1905, that an exploration and survey was effected by them. Thus we see that during the one-hundred and thirty-six days following the latter date (Feb. 1st), a volcanic island, 480 ft. high and 3 miles in circumference, was demolished almost to nothing. The speediness of its demolition is really beyond conception. What is more, some of the inhabitants of Iwôjima told us that they had already lost sight of the New Island in May. If that was really the case, the island was even more short-lived.

Now, there are three chief actions to be considered as the causes of the extinction of volcanic islands; namely, the action of the waves, its own explosion and depression of the volcanic body. Of these three, the first is known to have not infrequently brought about a phenomenon of this sort up to the present day. Graham's Island or Isola Ferdinandea in the Mediterranean Sea, and Falcon Island and Metis

1) My sextant measurement, however, set its length at less than 500 feet.

Island in the Pacific Ocean furnish remarkable instances. These islands were, however, nothing but accumulations of very loose cinders ejected during their own eruptions, and no wonder that they should have been affected by the waves so soon. Yet, Falcon Island (2 miles long and 250 feet high, heaved up in October 1885 and submerged in 1897) which was similar to the New Island in shape and size, vanished after 12 years, and Metis Island (150 feet high and created in 1875) still smaller as it was, passed away in no less than 24 years. There has been no island so short-lived as the New Island. However, it is not to be supposed that the New Island was composed of more fragile substances than the said two islands; and this consideration will naturally dispose us to think that the speedy extinction of the island in question cannot properly be ascribed to the bare action of the waves.

Then the question arises, is it attributable to the explosive action of the volcano? As was the case with Bandaizan and Krakatoa volcano, this action has often demolished a huge mass of mountain with inconceivable force and suddenness; and it may seem to be the very explanation for the present question. But further consideration will make it clear that this is far from being the case since there is not a single proof of the island being subjected to such explosion, and if there had been any such terrible eruption at all, the inhabitants of Iwôjima who witnessed the rising of the New Island would certainly have taken notice of it, and even if dense clouds or fogs prevented the sight, they must have heard the thunderous noise of the explosion or felt shocks of earthquake. Another point that demands our notice is that that part of the island which remained above the sea, as we saw it, was almost of the same shape as is described in the islanders' report, which fact seems to prove that the island kept the same shape until its submergence, scarcely experiencing any considerable explosion. Mr. Satô, one of my fellow-explorers, being told in the Bonin Islands that three weak earthquakes were felt at that island on the 12th of April, 9th and 21st of May respectively, and a strange noise like a distant gun was often heard from the west on the 18th of May, suspected that these phenomena might have had some connection with a supposed explosion of the island. But I am not inclined to agree with him, because, if an earthquake had occurred at the island, it is not to be supposed that it should not have been felt in the Middle and North Sulphur Islands only 30 or 70 nautical miles distant from the New Island, but in the Bonin Islands only which is so much as 200 nautical miles therefrom. The above conjecture will sound even more absurd when we reflect that he must have meant a volcanic earthquake, which is as a rule comparatively small in extent, and that he supposed it to have taken place in a new volcano which belongs to the same zone as the Middle and North Sulphur Islands. From these considerations, it is safe to say that the earthquakes felt in the Bonin Islands had nothing to do with the New Island, but were special ones occurring in the vicinity. Thus, there is not a single fact that proves any explosion in the New Island in connection with its disappearance.

Lastly, the action of depression demands our consideration. When a great mass is poured forth in volcanic eruption, the result will follow that density in that part will become lessened and the pressure will consequently decrease; then it is quite possibile that the whole or part of the volcanic body may fall down by its own weight. It is said that large craters such as those of Aso and Hakone, are produced by the depression of part of the crater. According to Mr. Iki,[1] the extension of the crater of Aso now unparalleled in dimension is ascribable to the outflow of an immense mass of "Aso-lava," which, he thinks, caused a depression of the vent. If this is true, it may safely be said that the fall of a crater wall is possible in submarine volcanoes as well as terrestrial. The only difference is this, that since in the case of a terrestrial volcano there is no unerring standard with which to compare its fluctuation, little or no attention is paid; while in the case of marine volcanoes sea-level serves as an unmistakable standard.

In short, although I have no absolute proof or datum to demon-

1) Geology of Aso Volcano, by T. Iki. Reports of the Imperial Earthquake Investigation Committee in the Japanese Language. No. 33.

strate the vanishing of the New Island, having found no opportunity to make any personal exploration of it, I think I may safely ascribe the phenomenon to the action of the waves, of which we have so many instances. Nevertheless, I rather hesitate to say this was the only cause of its submergence, considering its exceptional rapidity; and if there was any cause besides the action of the waves, it must be either explosion or depression; but since in this case there is no proof of explosion, the occurrence of which would naturally have attracted the attention of the people in Iwôjima, I venture to say that the phenomenon in question was due to a depression of the volcanic body (which is in most cases apt to escape our notice) as well as the action of the waves.

SUMMARIES.

1. Considering both its geographic position and the nature of its ejecta, it is clear that the New Island was a volcano belonging to the same volcanic line as the other three principal volcanic islands of the Iwôjima group.

2. The eruption was no doubt explosive, and ejected, most of all, the fine débris of pumice at the first stage of eruption, but afterwards vitrophyric lava composed half of obsidian and half of pumice. And though it is certain that other substances composed the body of the island, it remains doubtful whether they were subaerial ashes loosely accumulated or tuffs previously consolidated at the sea-bottom before the eruption; the latter being the case with Motoyama in Iwôjima. Pumice fragments transformed from lava came drifting to the shore of the island and formed a gravel-beach, 120 or 180 feet wide.

3. Petrographically the lava is of olivine-augite-andesite. It greatly resembles, as a whole, the glassy lava of Mt. Pipe in Iwôjima. and widely differs from the agglomeratic lava in Kita-Iwôjima.

4. In point of materials and structures, as Peel Island and Hillsborough Island in the Bonin group are of two different volcanic types, so the volcanic islands of the Iwôjima group may be divided into two

different types. To speak more concretely, Minami-Iwôjima and Kita-Iwôjima (San Augustino Is. and San Alessandro Is. respectively) which became inactive long ago, are composed of the same kind of agglomeratic rock of Hillsborough Island type, are very similar in mountain shapes, and seem to belong to one volcanic type peculiarly their own. On the contrary, Mt. Pipe, Motoyama, the New Island and the submarine volcano in the neighborhood of Kita-Iwôjima, which are all still active and explosive, eject chiefly glassy ashes and rarely vitrophyric lavas, but never to such an extent as to augment themselves. Mt. Pipe alone, however, poured forth a comparatively great quantity of lava, so as to assume a conic shape. These four volcanoes are of the other type.

5. On the 1st of February 1905, the New Island was 3 miles in circumference, 200 acres in area, and about 480 feet in height; but, on the 16th of June of the same year, that is, only 136 days after the above-given date, it was reduced to a low reef, only 1500 feet long and less than 10 feet high. The causes of its subsidence remain uncertain, but the chief of them seems to be the encroaching action of the waves. But what brought its submergence so soon? That is the question. It may be that the aforesaid agency was accompanied by a depression of the crater rim.

According to Mr. Hagiwara, Captain of the *Hyôgomaru* which sailed about the adjoining sea of Minami-Iwôjima in the course of June of the present year, the New Island was entirely buried in the sea, and though he inspected the spot where the island had once lain and also its neighborhood, he saw nothing unusual in the condition of the waves. This leaves no room for doubt that the island was but ephemeral as we had expected and that it had sunk down to the depth of more than 10 feet below the surface of the sea.

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T. Wakimizu.

APPENDIX.

Eruption of a Submarine Volcano Near the Bayonnaise Rocks.

As I have stated in the present paper proper, I was shown the pumice blocks that had come drifting to the Bonin Islands for some time past and found that they are of several different kinds. I was disposed to think that there might have been eruptions of some unknown submarine volcanoes near the "Fuji volcanic zone"; and I found afterwards that I had not been mistaken in this consideration or rather surmise, for I got a report from the crew of the *Okinawamaru*,[1] who chanced to be at work near the scene, to the effect that on the 14th April of last year there was a great eruption of a submarine volcano near the Bayonnaise Rocks,[2] an isolated islet in the sea between Aogashima and Smith Rock. A description of the eruption which is said to have been given by Mr. Kajiura, Engineer of the Department of Communications, who was on board the ship, runs as follows:

"The men in the *Okinawamaru* while working near 31° 59′ north latitude and 140° 7′ east longitude on the 14th of April last year, about 11 o'clock a.m., saw a huge volume of white smoke rising up near the Bayonnaise Rocks, at a spot less than 10 nautical miles distant to the S. S. E.—that is, about 20 ri southeast of Aogashima. By the rough measurement of the crew, the pillar of smoke seemed to be more than 300 feet in diameter and to range from 400 feet to 1000 feet in height, according to the power of the wind and the eruption. The grand spectacle presented by the continuous ejection of white vapor was absolutely beyond the power of pen or tongue to describe. The rocks in front were entirely hidden from view by smoke,

1) *Okinawamaru* is a submarine-cable vessel belonging to the Department of Communications.

2) The Bayonnaise Rocks consist of three big rocks and many small reefs, all of pointed conical shape, of which the highest is less than 30 ft. above the sea-level.

except at short abatements of ejection. Smoke did not cease arising till the *Okinawamaru* left there the following day. There was no knowing when the eruption had begun; but, as the phenomenon was not noticed on the 4th, it probably began abruptly after that day. I regret that we could not approach it, as our duty called us in a different direction, but I saw pumice rising in a great quantity from the spot of eruption and floating eastward with the current. It covered the sea to the breadth of nearly two miles, looking like a large sheet of white cloth spread, or like innumerable white foams floating."

The collected samples of the above-mentioned pumice was put at my disposal through the kindness of Prof. Kotô. They are all of pure white colour, less than one centimeter in diameter, and contain black augite and transparent colourless feldspar as phenocryst. Microscopic examination of thin sections shows that their air-vesicles are not long and flat as in common pumice, but elliptical pores ranged side by side, and what is most remarkable and curious is that some larger and longer vesicles are ranged radially round phenocrysts of feldspar and augite (Fig. 4, Pl. X). This peculiar arrangement of vesicles may be explained by the following consideration:—

It is obvious that the pumice in question is basic, considering that its phenocrysts are all of basic minerals like bytownite and hypersthene as stated below, and that magnetite is contained in a comparatively large quantity. It is generally accepted that basic magma is viscous and is slower in cooling and consolidation than acid magma; but, no doubt, as the magma was ejected into the sea-water, a better conductor of heat than the atmosphere, it was naturally cooled and consolidated in less time than in the atmosphere in spite of its being basic, and was turned in to spongy pumice. Now, this magma contained phenocrysts already crystallized and as it undoubtedly emitted latent heat as it grew cool, a small part surrounding the crystal kept some heat and was in a semi-fluid condition even after the other part became consolidated. Thus we see the cooling and consolidation of this small part was completed a moment later than the others; and while this was going on, the air-bubbles of a comparatively small number contained therein being stretched by the attraction passing between the central phenocryst and the surrounding walls, assumed the present tubular form and ranged themselves radially. I must confess that this explanation is not quite satisfactory even to myself and further study is necessary for the complete solution of the problem.

As porphyritic ingredients, augite, feldspar and magnetite occur in idiomorphic crystals, each less than 1·5 mm. The feldspars are fresh and transparent, and have but a few inclosures of colourless glass in the shape of negative crystals and acicular crystals of apatite; and zonal structure may be recognized by its manner of extinction. Carlsbad twin is frequent but albite twin is rare. The extinction angle on oP face is about −24.° Perhaps the feldspars are of bytownite. The augites belong to the rhombic family and occur in prismatic crystals. They are strongly pleochroic and vary in colour between 𝔞 greenish yellow, 𝔟 yellowish brown and 𝔠 olive-green. Perhaps they are of hypersthene. Feldspar and augite are often combined into aggregate, together with magnetite. In respect to the quantity of phenocryst, feldspar comes foremost, then augite and then magnetite. Besides, there are non-transparent masses which appear to be absorbed residue of some minerals. They are surrounded by radially arranged vesicles as in the case of phenocrysts of feldspar and augite.

Thus, microscopic examination shows us that this rock is hypersthene-andesite. Last of all, let me add that this pumice quite differs from that of the New Island from the petrographical point of view.

PLATE I.

The Geographical Position of Iwôjima (Sulphur Is.) Group.

Plate I.

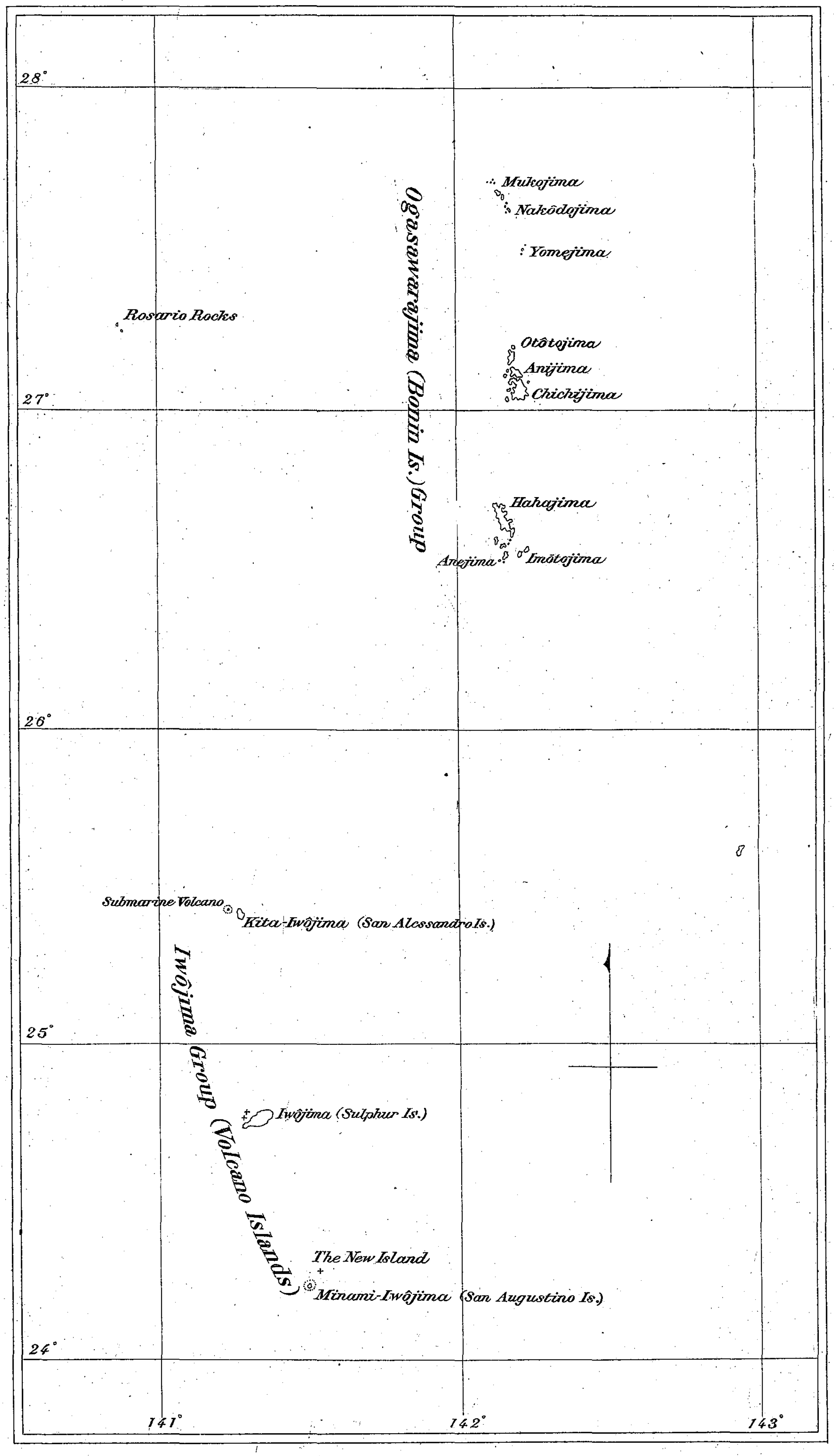

28°
27°
26°
25°
24°
141°
142°
143°
Ogasawarajima (Bonin Is.) Group
Mukojima
Nakôdojima
Yomejima
Rosario Rocks
Otôtojima
Anijima
Chichijima
Hahajima
Anejima
Imôtojima
Submarine Volcano
Kita-Iwôjima (San Alessandro Is.)
Iwôjima Group (Volcano Islands)
Iwôjima (Sulphur Is.)
The New Island
Minami-Iwôjima (San Augustino Is.)

PLATE II.

Kita-Iwôjima (San Alessandro Is.)

Plate II.

Fig. 1.

Map of Kita-Iwôjima

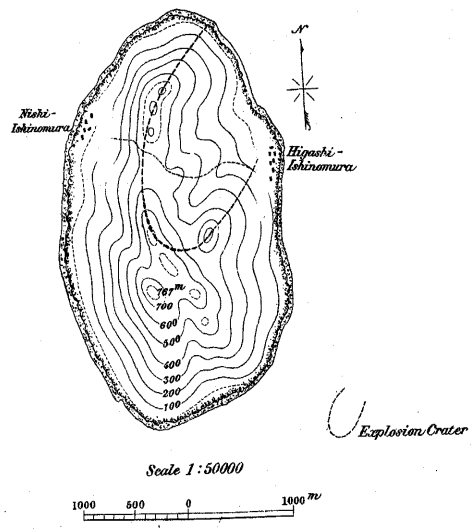
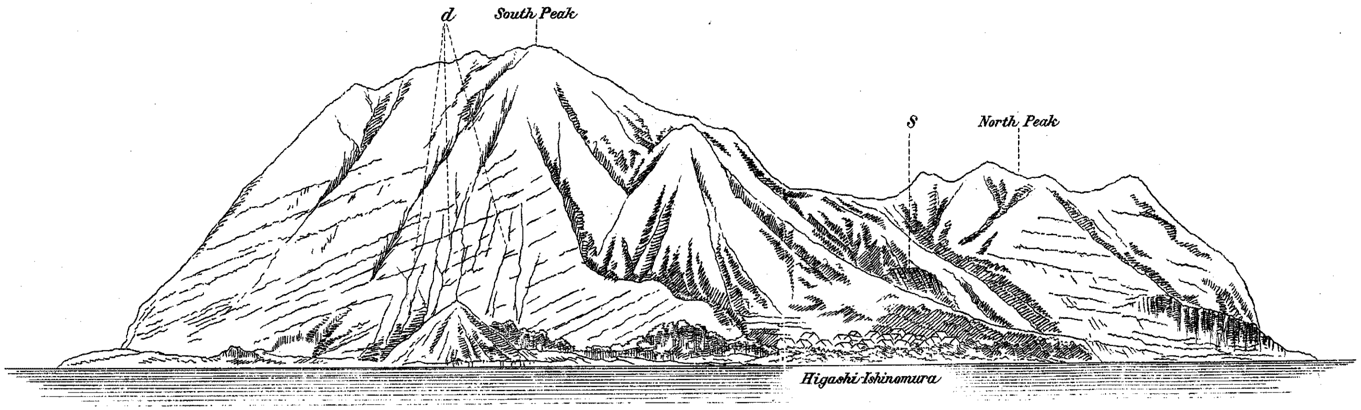
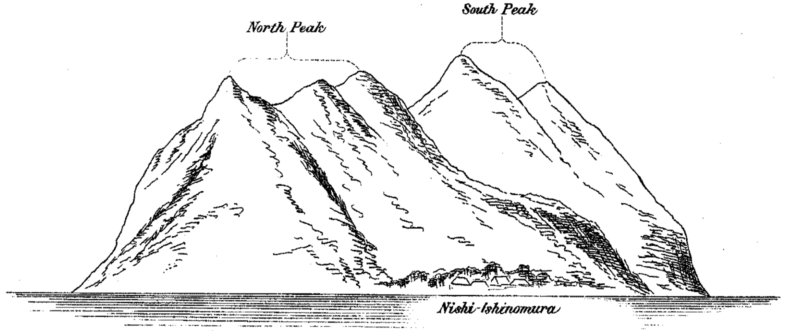


Fig. 2.



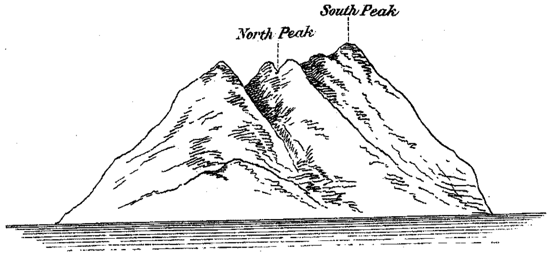
Kita-Iwôjima, S 70° W. ¼ Mile (Naut.)

Fig. 3.



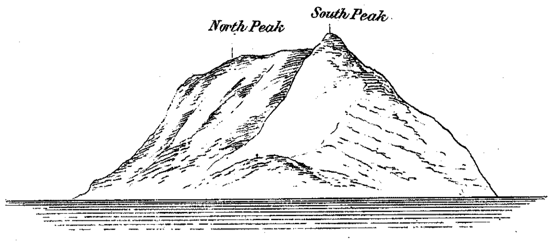
Kita-Iwôjima. S 70° E. 1 Mile (Naut.)

Fig. 4.



Kita-Iwôjima. S 50° E. 1·5 Mile (Naut.)

Fig. 5.



Kita-Iwôjima, Due S. 1·5 Mile (Naut.)

PLATE III.

Iwôjima (Sulphur Is.) or Naka-Iwôjima.

Plate III.

Fig. 1.

Map of Iwôjima

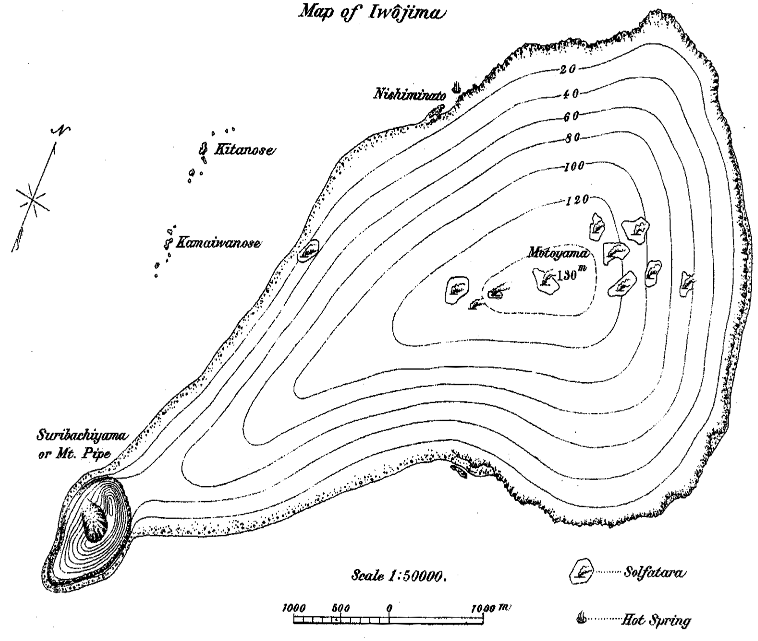
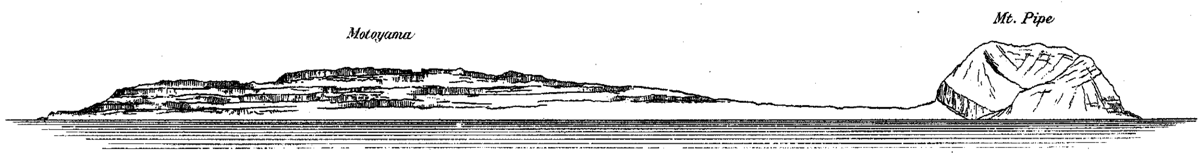
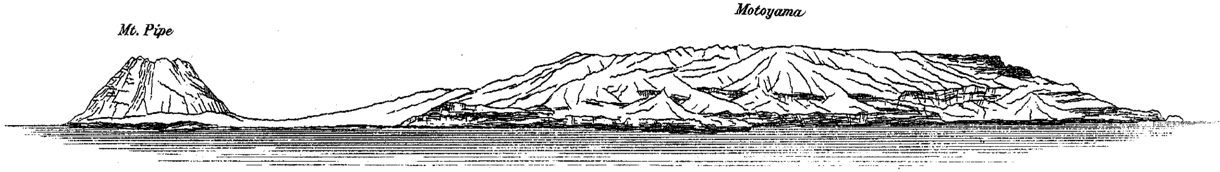


Fig. 3.



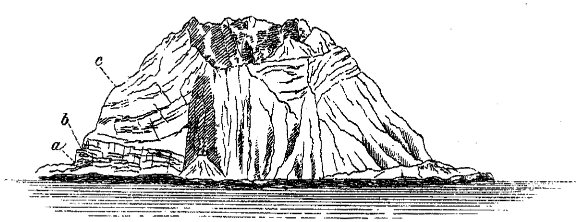
Iwôjima, E. 2 Miles (Naut.)

Fig. 4.



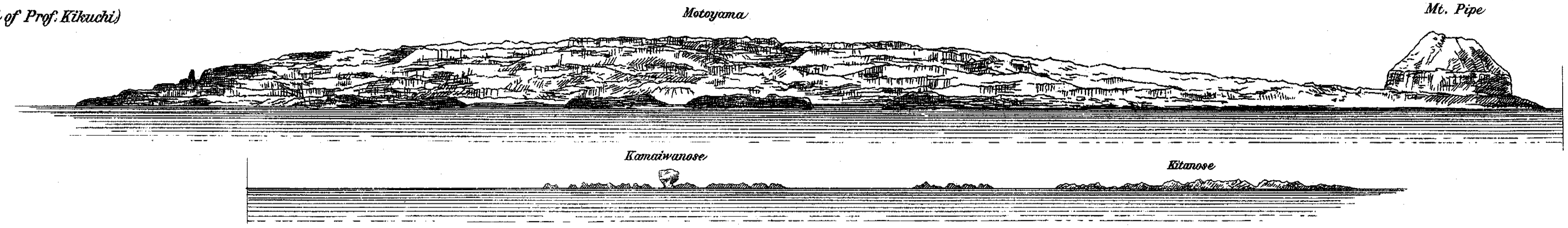
Iwôjima. N.W. (Original Sketch of Prof. Kikuchi)

Fig. 5.



Mt. Pipe. (Original of Prof. Kikuchi)

Fig. 2.



Iwôjima S.S.E. ½ Mile (Naut.)

PLATE IV.

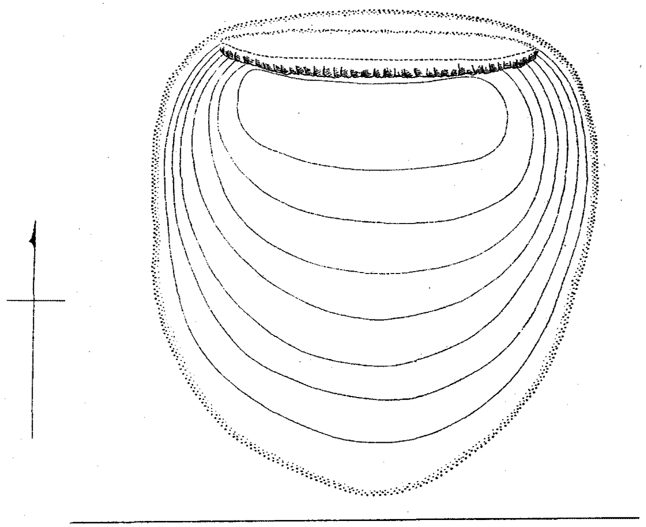
Minami-Iwôjima (San Augustino Is.) and the New Island.

Plate IV.

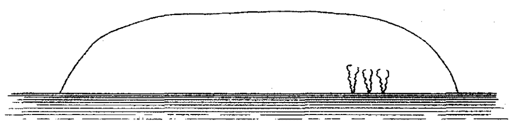
Fig. 4.

Map of the New Island drawn by the Explorers of Iwôjima in Feb. 1st, 1905.

Scale 1:12000.



Side View from the North.



Side View from the West.

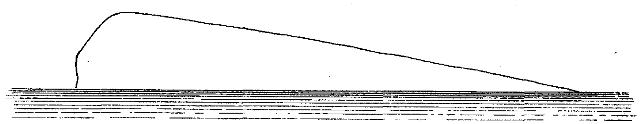
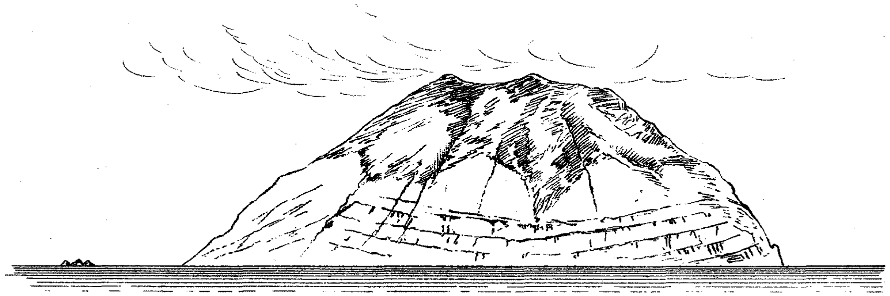


Fig. 1.



Minami-Iwôjima. Due E. 2 Miles (Naut.)

Fig. 2.

The New Island. S 40° E. 3 Miles (Naut.) June 16th, 1905.

Fig. 3.

The New Island. Due E. 3 Miles (Naut.) June 16th, 1905.

PLATE V.

Fig. 1. Kita-Iwôjima (San Alessandro Is.). N.N.W. 3 Miles (Naut.). Photographed by the Writer in June 16th, 1905.

Fig. 2. Minami-Iwôjima (San Augustino Is.). S.E. 2 Miles (Naut.). Photographed by the Writer in June 16th, 1905.

Fig. 1.

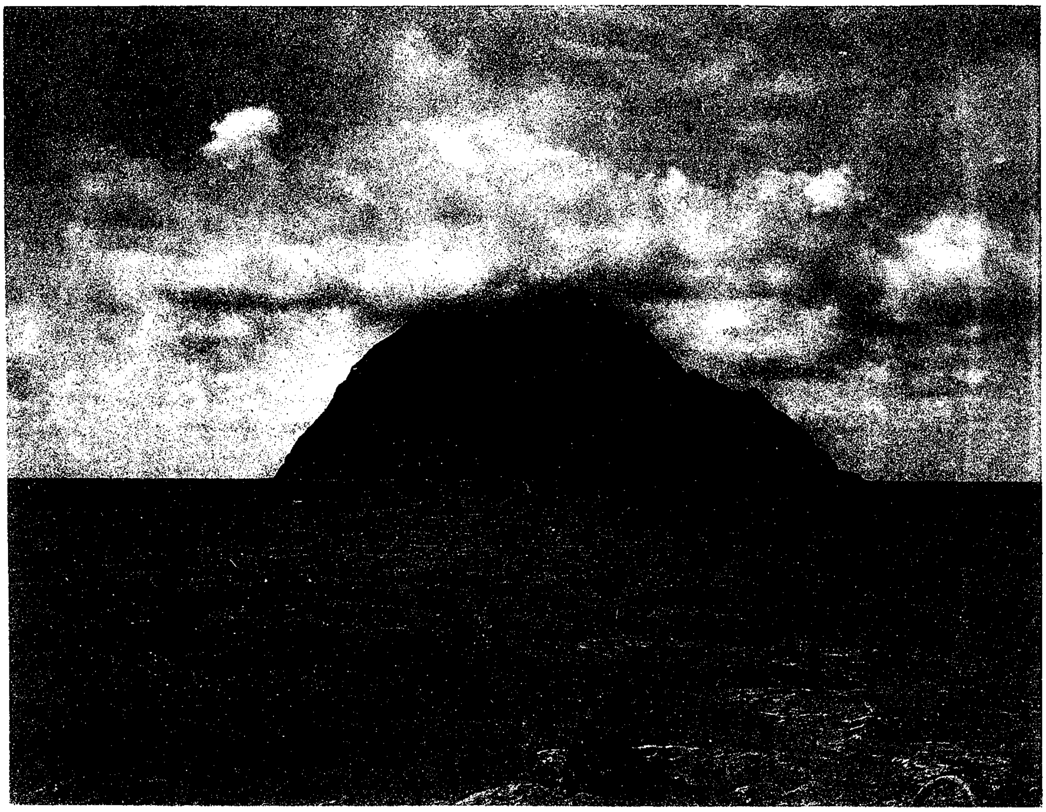


Fig. 2.

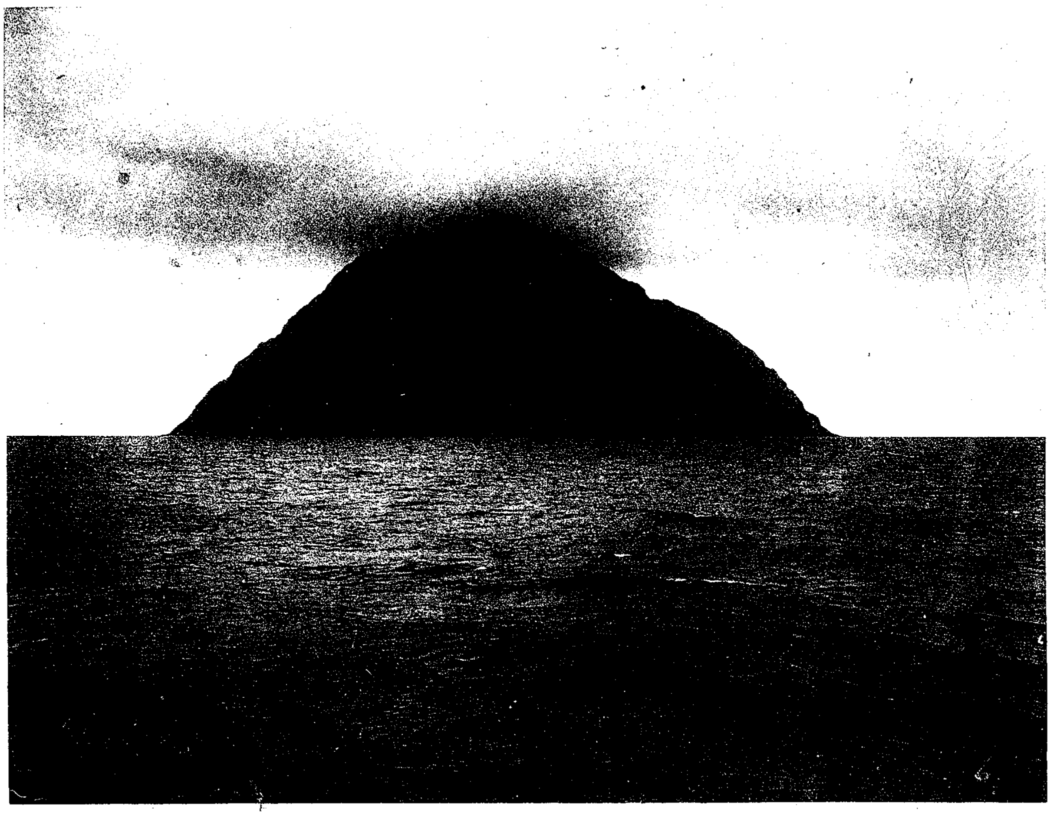


PLATE VI.

Fig. 1. Coral Reefs on the Summit of Motoyama in Iwôjima. Solfatara on the Left.

Fig. 2. "Tischstein" and Wave-worn Terraces in Iwôjima.

Plate VI.

Fig. 1.

Fig. 2.

PLATE VII.

Fig. 1. Reef-forming Coral (Stylophora sp.) with Black Coating on the Summit of Motoyama in Iwôjima.

Fig. 2. Ditto with Bleached Surface.

Fig. 1.

Fig. 2.

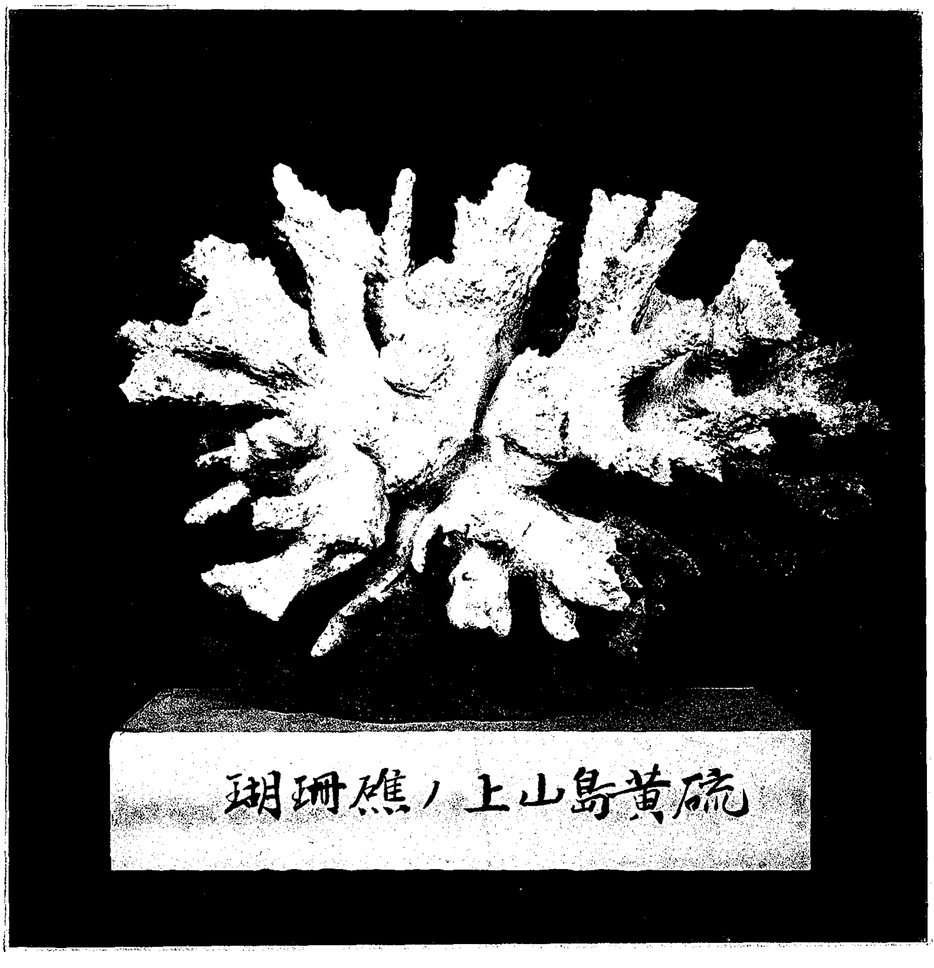


PLATE VIII.

Plate VIII.

A block of the lava of the New Island, investigated by the author. This block is pumiceous in the upper part, and gradually passes into obsidian in the lower part. About $\frac{7}{10}$ times of the natural size.

Plate VIII.

PLATE IX.

Plate IX.

Fig. 1. Obsidian (Olivine-augite-andesite) of the New Island. ×16.

An irregular octagon on the left-hand side of the figure is the section of monoclinic augite, cut near oP. Prismatic cleavage is distinct. The periphery is fringed by augite-microlites and other minute opaque substances. A cubic colourless crystal on the right side opposite to the one mentioned above, is plagioclase (oligoclase). It contains brown glass as inclosures crowding the centre. Rod-like individualized substances universally scattered through the ground-mass, are of microlites of light yellow monoclinic augite.

Fig. 2. Ditto, much more magnified. ×147.

Cross section of monoclinic augite in the centre. Among the augite-microlites in the ground-mass, some penetration twins of stellate form are seen.

Fig. 3. Agglomerate-forming augite-andesite in Kita-Iwôjima. ×50.

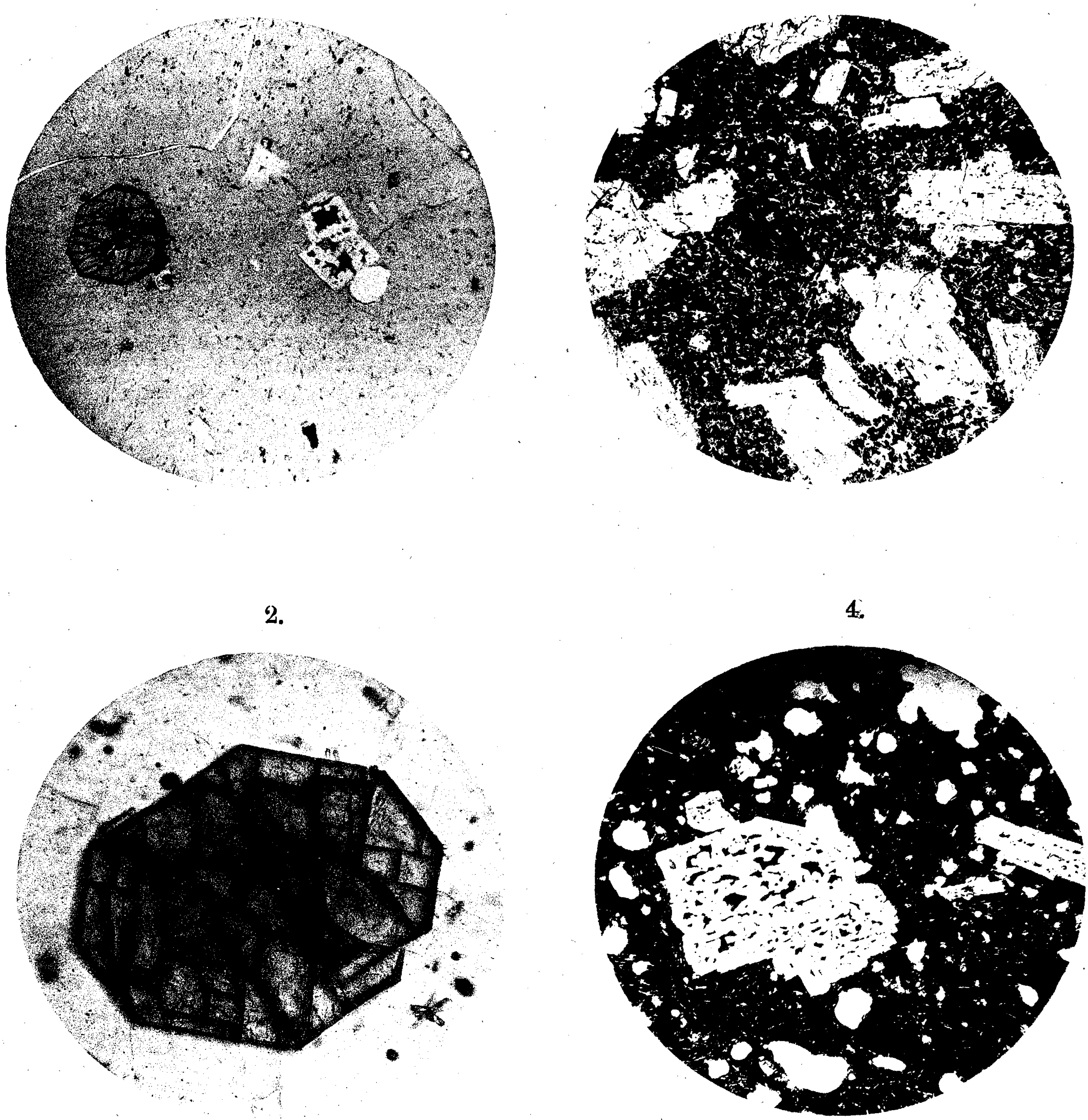
The colourless rectangular phenocrysts seen in abundance are of plagioclase (anorthite). The rhombic crystal at the centre is of altered monoclinic augite. The ground-mass is holocrystalline, and is composed of lath-shaped plagioclase, augite grains and magnetite granules.

Fig. 4. Dyke augite-andesite in Kita-Iwôjima. ×50.

The large colourless phenocryst of tabular form is plagioclase that contains abundant glass-inclosures. The ground-mass is holocrystalline, consisting of microlites of feldspar, augite and magnetite, together with a few glass bases.

Plate IX.

1. 3.



2. 4.

PLATE X.

Plate X.

Fig. 1, 2. Monoclinic augite in the pumice of the New Island, separated by Thoulet's solution. $\times 50$.

Crystals are well defined. In Fig. 2., a crystal is twinned on $\infty\bar{P}\infty$.

Fig. 3. Brachypinacoidal section of oligoclase in the pumice of the New Island. $\times$ ca. 30.

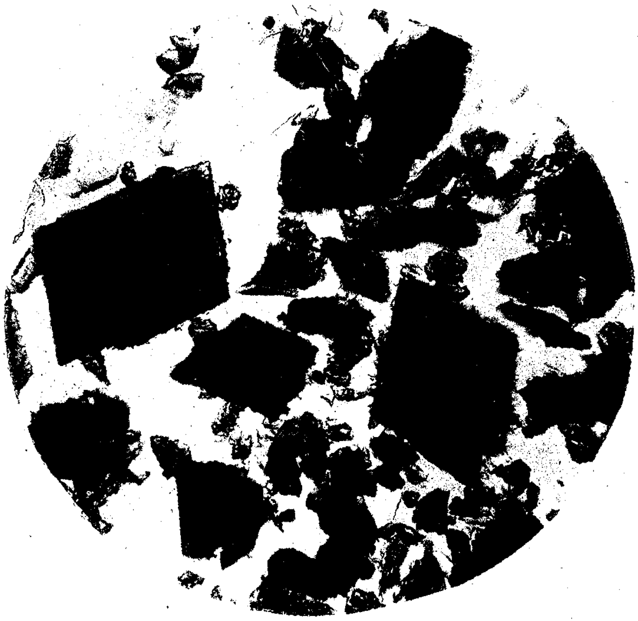
Take notice of the development of basal cleavage and zonal arrangement of glass-inclosures.

Fig. 4. Section of the pumice ejected by a submarine volcano near the Bayonnaise Rocks. $\times 50$.

This figure shows the radial divergent arrangement of air-vesicles around a well-defined feldspar-phenocryst.

Plate X.

1.



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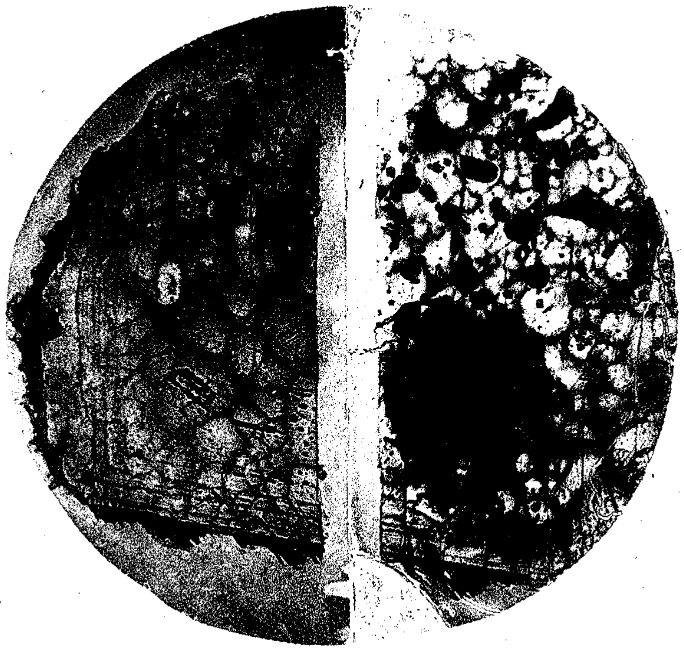

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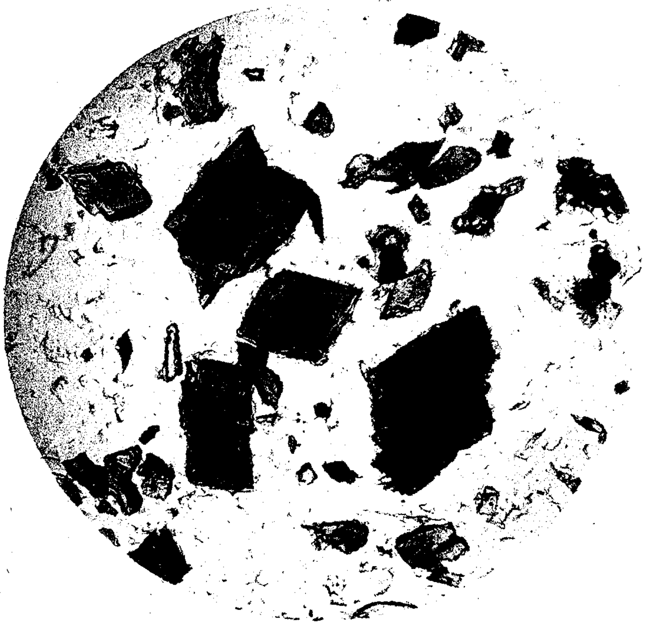


4.

PLATE XI.

Plate XI.

Fig. 1. Apatite crystals in Motoyama-tuff of Naka-Iwôjima.

They contain remarkable glass-inclosures, elongated in the direction of the principal axis. Most of the inclosures possess one or more immovable air-bubbles.

Fig. 2. Apatite crystals in the pumice of the New Island.

Compare them with those in the preceding figure.

Fig. 3, 4, 5, 6. Well-defined crystals of monoclinic augite in the pumice of the New Island.

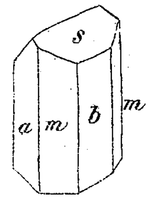
$s = -\mathrm{P}$, $b = \infty\grave{\mathrm{P}}\infty$, $m = \infty\mathrm{P}$, $a = \infty\bar{\mathrm{P}}\infty$.

Fig. 7. Twin-crystal of ditto. Twinned on $\infty\bar{\mathrm{P}}\infty$. This figure also shows the mode of occurrence of apatite- and glass-inclosures in the crystal.

Apatite needles and elongated glass-inclosures are so placed that their longitudinal axes lie parallel to some domal faces of the crystal.

Plate XI.

6



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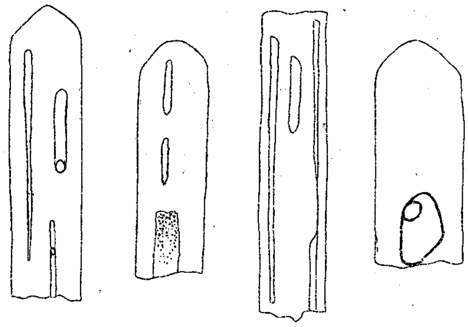

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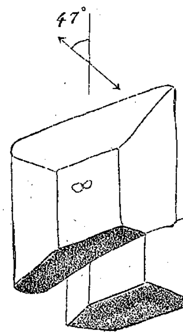

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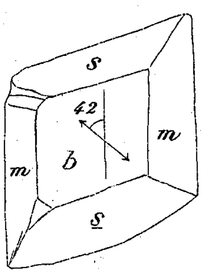

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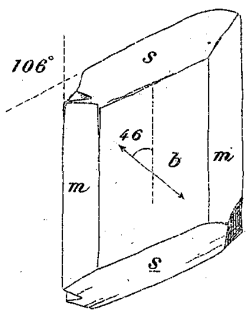

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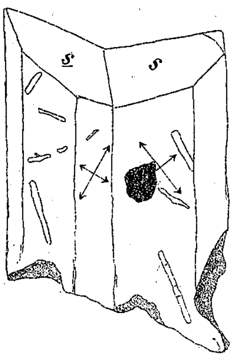

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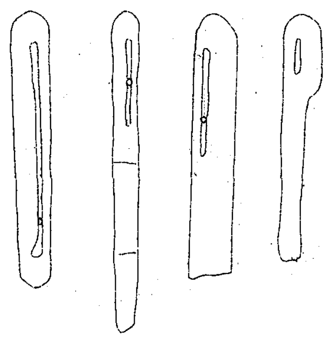


PLATE XII.

Plate XII.

Fig. 1. Olivine in the pumice of the New Island.

The crystal is considerably corroded, and sometimes intruded by ground-mass.

Fig. 2. A basal section of oligoclase in the pumice of the New Island.

Apatite needles and coloured glass-inclosures are abundantly enclosed.

Fig. 3. Some of the glass-incloures in ditto.

The edge of the inclosures in part runs parallel to some crystal faces of the encloser; they are thinly flattened along the cleavage faces of the latter.

Fig. 4. Colourless hexagonal scales of muscovite (?) coating the face of orthoclase in Motoyama-tuff as the decomposition product of the latter.

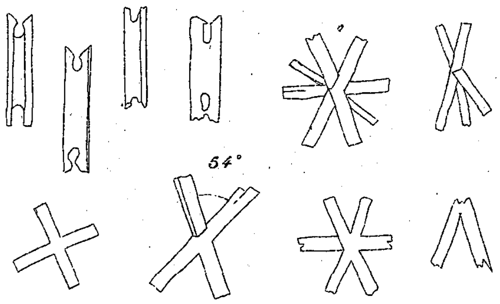
Fig. 5. Microlites of monoclinic augite (greatly magnified) scattered in the ground-mass of the obsidian of the New Island. Both extremities of prisms are commonly indented or irregularly truncated. They are often twinned in various manners, as shown in the figure.

Fig. 6. A peculiar crystal of monoclinic augite in the obsidian of the New Island. The two diagonals connecting opposite angles mark a well-developed shining face, while the remaining part of the crystal face is slightly grooved and of dull lustre.

Fig. 7. Skeleton crystal of augite in the glassy augite-andesite of Mt. Pipe, Naka-Iwôjima, described by Dr. Petersen. (This is a original figure of Dr. Petersen.) Note its near resemblance to the preceding.

Plate XII.

5



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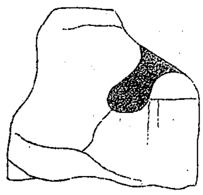

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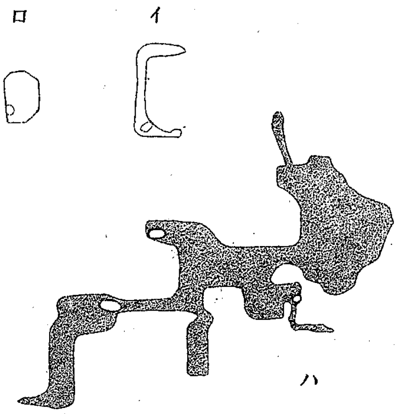

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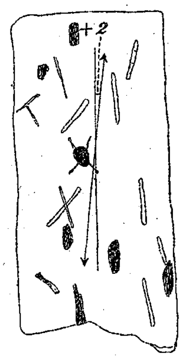

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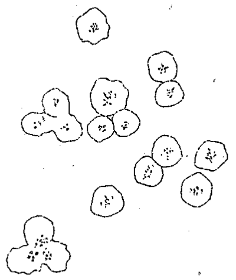

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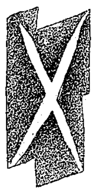

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