augite are present in small quantity. The ground-mass is partly micro-felsitic, and consists of dark bands of micro-felsite which alternate with bands, clearer bands, in which the micro-felsitic matter passes into a finely micro-crystalline aggregate with red granules.

The rock which forms the island of Motutaiko is a bluish-grey laminated lava, with semi-vitreous glaze along the surface of the joints. The thin parallel laminæ of which the rock is composed are often very distinct, and are alternately more or less glassy, but in other parts the laminæ blend together, as the glass becomes more fully devitrified. The macroscopic crystals are not numerous, and are chiefly sanidines; plagioclase is, however, also present, as well as augite, magnetite, and apatite. The ground-mass is chiefly a pale-glass, crowded with slender microliths and black granules, but it is marked here and there by dark-brownish patches and streaks of indefinitely granular or micro-felsitic matter, giving a banded character to the rock.

It is unnecessary to mention here the pumice, which occurs in such vast quantities in the district. A nearly pure obsidian was obtained by Mr. Cussen on Ngauruhoe. It has a perfect conchoidal fracture, and no macroscopic crystals. In thin flakes it shows a greenish-smoky colour and bands of a darker shade. The general mass of the rock is quite free from microliths, but the bands derive their darker appearance from the presence of multitudes of parallel microliths.

ART. XLI.—*Notes on the Rocks of the Kermadec Islands.*

By A. P. W. THOMAS, M.A., F.L.S., Professor of Natural Science in the Auckland University College.

[*Read before the Auckland Institute, 14th November*, 1887.]

THE following notes are descriptive of the various rocks collected by Mr. Percy Smith during the recent visit of the *Stella* to the Kermadec Islands. Most of the specimens were obtained from Sunday Island, the largest of the group.

The rocks, with one curious exception, are unmistakably of volcanic origin, and consist of fragmental materials in the form of scoriæ and fragments from the tuffs, and of lavas from the streams which alternate with the tuffs, or from the dykes which intersect the islands, and bind the loose beds and lava streams together.

The lavas are of a basic character, and consist of basalt and augite-andesite, together with glassy varieties of basic rocks.

Basalt.—One of the most characteristic types occurs in a stream on the east coast of Sunday Island. It is a dark porous rock in which the larger crystals can just be seen with the naked eye. In microscopic sections these are seen to consist of numerous plagioclases and olivines, with yellowish-green augites. The plagioclases are in slender prisms, and seldom show any inclusions. The ground-mass of the rock is very finely crystalline, and is composed of felspar, crippled augite grains and crystals, and minutely octahedral magnetite. No amorphous matter can be distinguished between the elements of the base. The magnetite is so abundant as to render the ground-mass very dark, and the crystals are frequently grouped along lines at right angles to one another, so as to form the most beautiful branched figures.

The recent lava from the Cascade, in Macaulay Island, differs considerably in its macroscopic crystals. These consist chiefly of plagioclases reaching 0·25 inch in diameter, which, in striking contrast to those in the former variety, are in short stout crystals, showing a zonal structure, from the abundance of the inclusions of glassy matter. These inclusions are often accurately rectangular, their longer sides being parallel to the neighbouring face of the crystal. Even the minutest inclusions, which occur in such abundance as to appear under a low power like dusky clouds, generally show this rectangular form. The only other crystals which reach any considerable size are a small number of olivines, containing magnetites. The ground-mass is much like that of the rock first described, the magnetite, however, though equally abundant, does not form the branched groups of crystals.

The scoriæ from the recent crater on Macaulay Island are also basaltic, differing chiefly from the lava at the Cascade in containing a good many augites of the first order of separation. Another basalt which occurs on the east coast of Sunday Island is rich in olivine crystals, and has a ground-mass of more coarsely crystalline granular structure. The large macroscopic plagioclases have numerous inclusions of brown glass, often arranged in long streaks alternating with the lamellæ of the crystals.

The common grey lava from the north coast of Sunday Island has a rather light-grey and finely crystalline ground-mass, in which small augites and felspars can be seen with the naked eye. The felspars seem to be all plagioclases, and are fairly rich in glass inclusions. The rock contains no olivine, but must be considered as a basalt, as the ground-mass is of a distinctly basaltic type, consisting of a crystalline aggregate of plagioclase, augite, and not very abundant magnetite, the individual elements being unusually distinct. No glass can be recognised with certainty in the ground-mass.

A somewhat similar rock, which occurs as a dyke on Meyer Island, an outlying part of Sunday Island, has a darker-grey ground-mass in which augite cannot be seen with the naked eye. The microscope shows a few augite crystals of moderate size, but there is no olivine. The ground-mass is more finely-grained than in the previous rock, and small patches of pale glass can be detected. The felspars include a few sanidines.

The next rock is one the identification of which is a little uncertain, as it approximates in its characters to the augite-andesites. Mr. Percy Smith states that it is the commonest type of lava on Sunday Island. It is a rock with a black ground-mass of resinous lustre, in which are scattered numerous white felspars reaching 0·2 inch in diameter, giving the rock a conspicuously speckled appearance. Less conspicuous are a few equally large dark-green augites. The microscope shows that the felspars are nearly all plagioclases; there are, however, a few sanidines in Carlsbad twins. The ground-mass consists of numerous small slender felspars and less abundant augite, cemented by a glass containing pellucid microliths and dusty grains of magnetite. The proportion between the minute crystals and the glass with microliths varies considerably in the specimens from different parts of Sunday Island. In some varieties the ground-mass consists so largely of glass containing microliths, that this character, combined with the total absence of olivine and the presence of a small proportion of sanidines, entitle the rock to the name of augite-andesite. There appears, therefore, to be a transition amongst the Kermadec lavas, from basalt rich in olivine, through basalt poor or wanting in this mineral, to a characteristic augite-andesite.

In the yellow volcanic tuff of the cliffs on the north side of Sunday Island, and also along the shore below the cliffs, were found nodular masses of dark-green augite, yellowish olivines, and glassy plagioclase crystals. The augite predominates, and forms crystals reaching an inch in length. Microscopic sections of these nodules show their origin, for here and there between the crystals may be detected a small amount of a volcanic glass with microliths, etc. The nodules are simply aggregations of the large crystals formed in the lavas, and have probably been ejected as bombs during an eruption.

Glassy rocks.—Rounded bomb-like masses, and irregular fragments of a black rock with pitchy lustre, occur in the recent crater on Sunday Island. There are a few minute crystals visible to the naked eye, but not enough to take away from the lustre of the stone. Under the microscope, the rock is seen to consist chiefly of a brownish glass, finely spotted and clouded with grey. The grey parts are closely charged with rod-like pellucid microliths, and also finer indefinite granules. The brown parts of the glass are not so fully devitrified, and here

and there are to be seen quite pure and free from microliths. Octahedral crystals of magnetite occur in the grey spots, the glass being, as it were, cleared and bleached around the magnetite, suggesting that the bleaching of the glass in spots is due to the withdrawal of the iron oxide from an originally brown glass. In this ground-mass are embedded a small number of crystals of plagioclase, some sanidines, augite, and magnetite. These secretions, however, form but a small proportion of the whole mass of the rock. Reduced to powder, and digested with hydrochloric acid, the rock yields a quantity of iron in solution, but is otherwise only imperfectly decomposed. Rosenbusch has divided the basic glassy rocks into tachylite soluble in acids, and zyalomelane insoluble in acids. The present variety will therefore be a zyalomelane, and not a normal tachylite.

Several varieties of glassy lava are found in the pumiceous tuff on Macaulay Island. Amongst these is a pitch-stone, much resembling the one above, but richer in microliths. It shows a yellowish-brown glass, in which are colourless spots: in the coloured glass the pellucid microliths are fairly abundant, but the colourless spots consist of dense nests of microliths and magnetite dust. In other specimens the devitrification has extended further, so that the nests of microliths join with neighbouring patches, giving the rock a mottled or cloudy appearance, and finally converting it into a grey mass of felted microliths and magnetite dust imbued with glass.

In the recent crater of Sunday Island were found masses of finely-porous rock of a dark-brown colour. The rock is almost porous enough to be called a pumice, and under the microscope shows a brown glass with very numerous steam cavities. The glass contains vast numbers of slender pellucid microliths, the largest of which polarise, and a few minute magnetites. The larger crystals are very few in number, and are like those in the last mentioned rock.

Another kind of glassy rock from the pumiceous tuff of Macaulay Island has the full vitreous lustre and black colour of a true obsidian. It shows, however, none of the conchoidal fractures of the typical obsidian related to acid rocks, but breaks into irregular little pieces with uneven surface. Towards the edge this glass becomes porous, and passes into a brownish-grey pumice. Microscopic sections show a glass which is yellowish-brown even in their section. This glass is nearly pure, containing only a small number of pellucid microliths of felspar, and probably augite. Some crystals of felspar (both plagioclase and sanidine), augite, and magnetite are embedded in the glass, as well as slender columns, which are rather strongly dichroic in longitudinal section, and appear to be hypersthene. Specimens of a pale-reddish or yellowish-grey pumice from the recent crater of Sunday Island are the frothy condition of a volcanic

glass similar to the one just described. This glass cannot be termed a tachylyte proper, for it does not gelatinise on digestion with hydrochloric acid, though the acid decomposes it to a certain extent, extracting a good deal of iron. It seems to be of an intermediate character, and to be the glassy form of a rock of less basic character than basalt, probably of augite-andesite.

It has already been stated that, with one exception, the rocks found on the Kermadecs were of distinctly volcanic origin. The exception is formed by pebbles and boulders of a light-coloured rock, found only on the beach at Sunday Island. It can be recognized by the naked eye that the rock is a crystalline granular aggregate of a dull white felspar, quartz, and hornblende. The microscope shows, in addition, grains of magnetite. The felspars are chiefly orthoclase, but plagioclase is present in smaller proportion. No trace of any ground-mass appears between the crystalline elements, and the rock is therefore one to which the name of hornblende-granite would naturally be given. Another variety of the same rock is very poor in hornblende and richer in quartz, which shows a distinct granulitic, or almost micro-granulitic, character.

The occurrence of a granitoid rock on these islands in mid-ocean is somewhat unexpected, and is one to which much interest is attached, when considered in connection with speculation as to the former extension of land in the Pacific Ocean, especially as the Kermadecs are situated along the submarine ridge which stretches out from New Zealand to the north-north-east. The fact that the rock is found only in detached masses on the beach, suggests the question whether they can be of foreign origin; whether, for instance, they have been brought as ballast by some ship. The number of the boulders, and their size, (attaining a diameter of 2 feet or more,) forbids this supposition. Until more information is gained by the further examination of the islands, the most probable explanation of their presence on the Kermadecs is to suppose them to be portions of deep-seated rocks, possibly rocks which represent lavas which have solidified at great depth from the surface, and that they have been torn off from below and brought up to the surface during an eruption. If this be the case, blocks of the rock may yet be found, either embedded in the lava streams or lying in the volcanic tuffs of the islands.